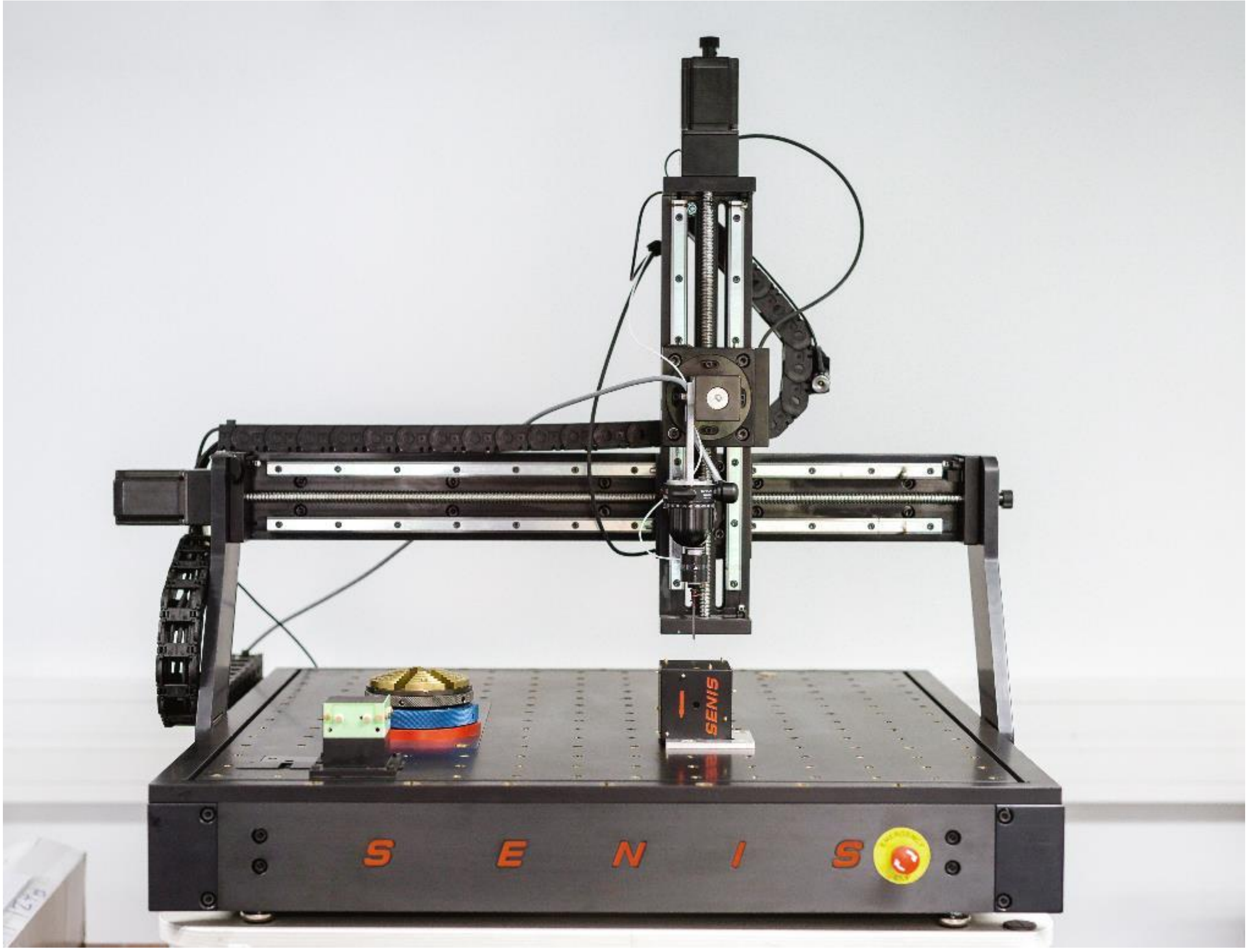
Operation Manual



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1. Contents

2. Table of Revisions

Date	Manual release	Software version	Description
09/2020	4.0	3.0	New template New: full screen interface description Removed: Mapper software design, project specific information, Detailed software installation instructions, technical data, Key features and applications Replaced: Maintenance instructions with reference to producer documents where possible Added: Troubleshooting, Additional resources

3. Safety Precautions

Read the manual before operating the mapper.

Do not connect the device to any power source other than the one delivered by manufacturer and specified in this document.

Do not use any cables other than the ones delivered by manufacturer and specified in this document.

Do not touch the system or magnet under the test during the measurement.

If you discover any abnormalities while checking the device, before operation or during operation, stop using the device immediately and inform manufacturer.

Do not disassemble or modify the device. Only manufacturer approved technicians are allowed to repair, disassembly and perform device modifications.

Remove the power plug prior to carrying out device maintenance and/or device checks.

Do not expose the device, especially Hall probe and optical encoders mounted on linear modules to the direct sunlight or to strong light sources.

Do not subject the device to impacts.

Keep the top of the device and interior of the protective cabinet (if delivered) clear of all foreign objects. only magnets under the test are allowed inside the cabinet.

Use device in a place where it can be maintained in the horizontal position.

When moving the device, first lift it and then carry it. Do not move the device by pulling the cables.

When removing the plug, hold and pull the plug itself. do not remove it by pulling the cable.

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

Do not unplug any cables while measurement is in progress. always stop the software program prior to unplugging the cables.

Do not use abrasive means for cleaning the scanning surface.

The PC cards must not be removed or the hardware drivers uninstalled. Always consult manufacturer before attempting to install devices.

Do not put objects of more than 20kg weight onto the mapper table unless it was declared for higher weights.

Do not put objects of more than 7kg weight onto the rotary stage of the mapper table unless the special rotary stage was integrated for heavy objects.

Do not change the measurement probe while electronic box is turned on.

If the border switches on the linear modules were hit, the electronic box will turn off and the probe movement will stop. To continue working, manually move probe in opposite direction to the one when probe was hit the boarder switch (in order to neutralize following software error) and turn on the electronic box.

When mapper is in operation (scanning or calibration), do not activate (press) movement commands on the keyboard.

4. Information

Magnetic Field Mapper MMS-1A-RS / MMS-1X-RS is the high-end version of the SENIS Magnetic Field Mapping Systems. It allows users to perform a fast, high resolution mapping of magnetic flux density around permanent magnets, electromagnets or electronic circuit boards. The map of the magnetic field can be presented as color coded 2D or 3D visual displays on a PC screen and as a table of numerical measured values. Measured data are analyzed in real-time, which provide data analysis capabilities for an advanced inspection, characterization and quality control of permanent magnets.

Due to unique features of the applied fully integrated 3-axis Hall probe, all three components of the magnetic field (Bx, By, Bz) are measured simultaneously at virtually same point. The magnetic field sensitive area of the applied Hall probes is within a 150 µm x 150 µm square, which allows measurements of the homogeneous and highly inhomogeneous magnetic fields. The mapping system is controlled by an extremely easy-to-use-software, built on MS Windows platform and LabVIEW. Magnet scanning profiles are fully customizable.

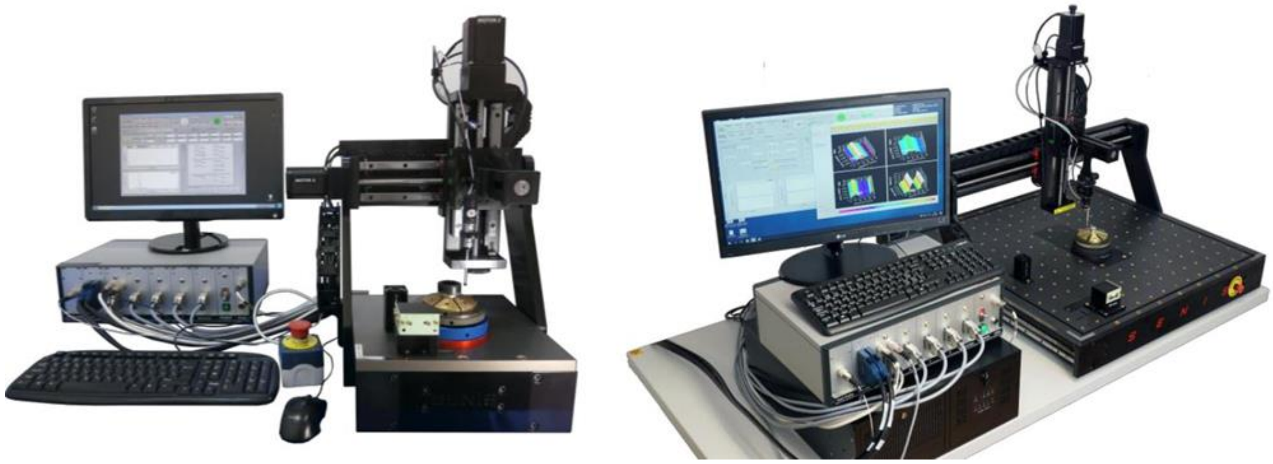


Figure 1: Magnetic Field Mapping System – MMS-1A-RS (standard size) and MMS-1X-RS (large-size mapper)

5. Preparation for use

5.1 Unpacking and drive unblocking

5.1.1 Unpacking Procedure

For protective Cabinet installation, refer to the document Installation of the Protective Cabinet for the Mapping System.pdf

The Hall Probe is very fragile. Take extra care when unpacking it and handling it manually.

It is highly recommended that the system unpacking and operation setup procedure is performed by a certified SENIS engineer or by an authorised SENIS partner. If this is not the case, SENIS cannot be held responsible for any system malfunction or damage.

The process of unpacking the Mapper is described on the following figures. Please take care when moving the device in order not to damage the cables, switches or other Mapper parts.

Figure 2: The Mapper is delivered in a suitable wooden box

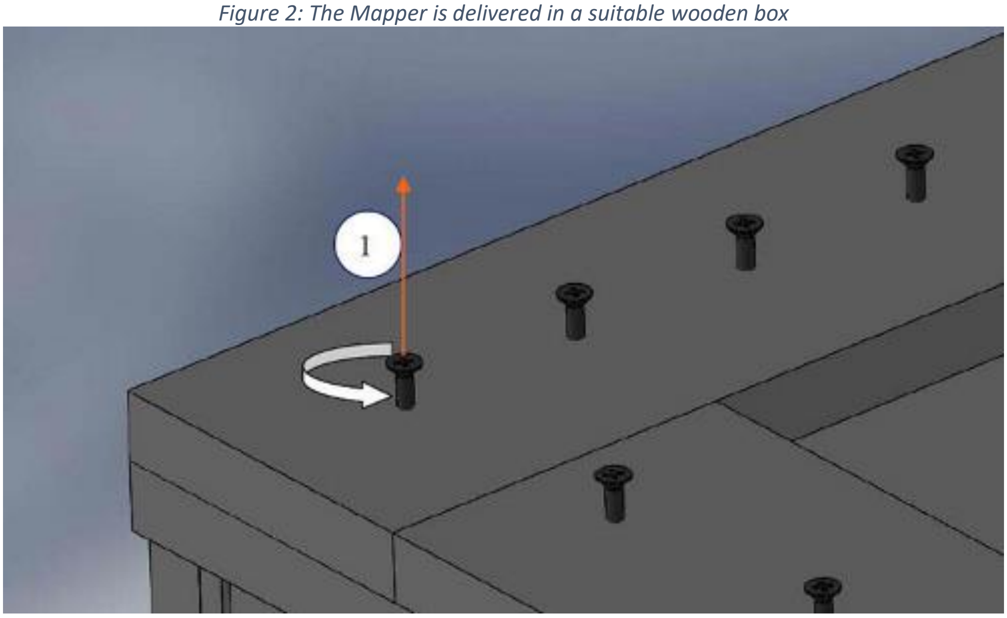


Figure 3: Unscrew the top cover of the box

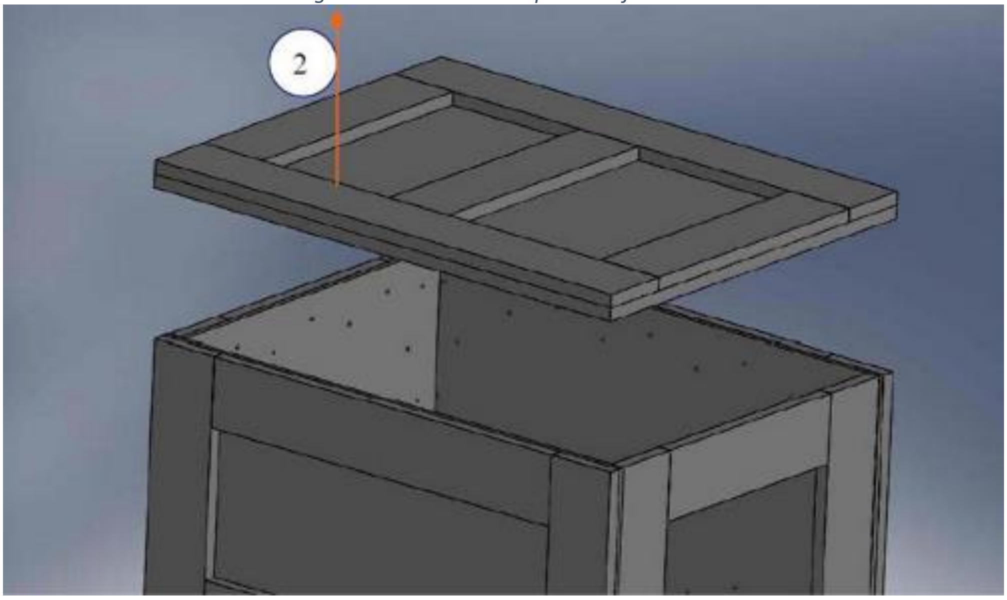


Figure 4: Remove the cover

Figure 5: Mapper System packed in the wooden box

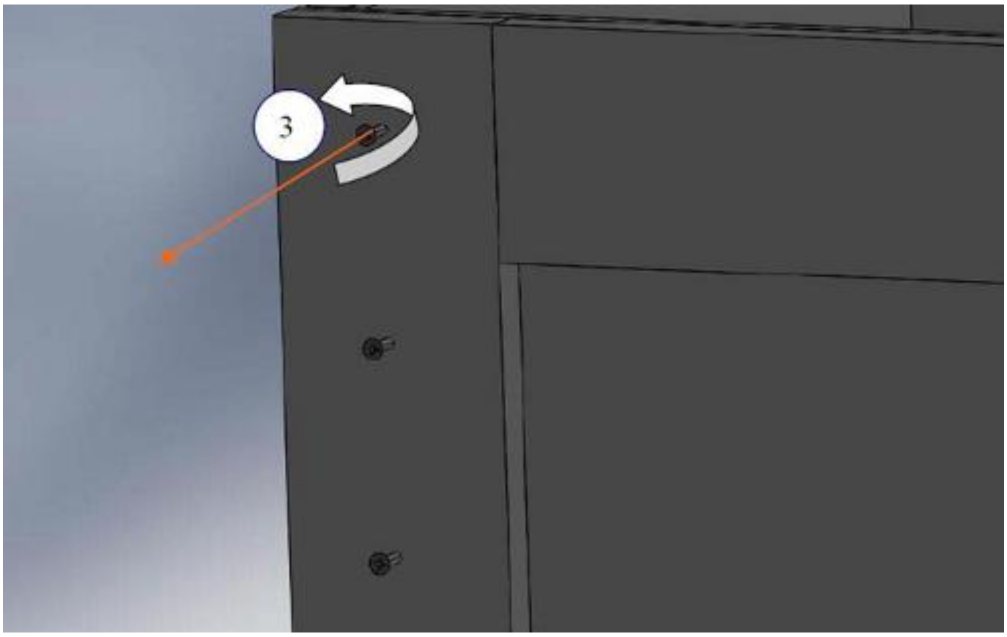


Figure 6: Unscrew the front side of the box

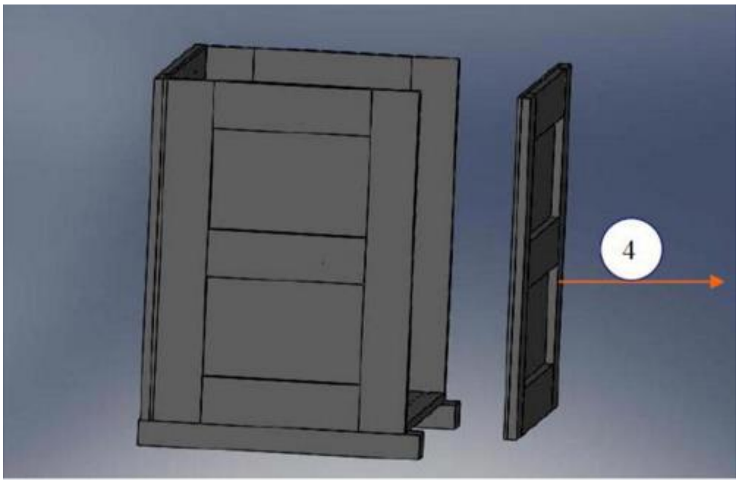


Figure 7: Remove the front side of the box

Figure 8: Mapper is fixed on the mapper holder board

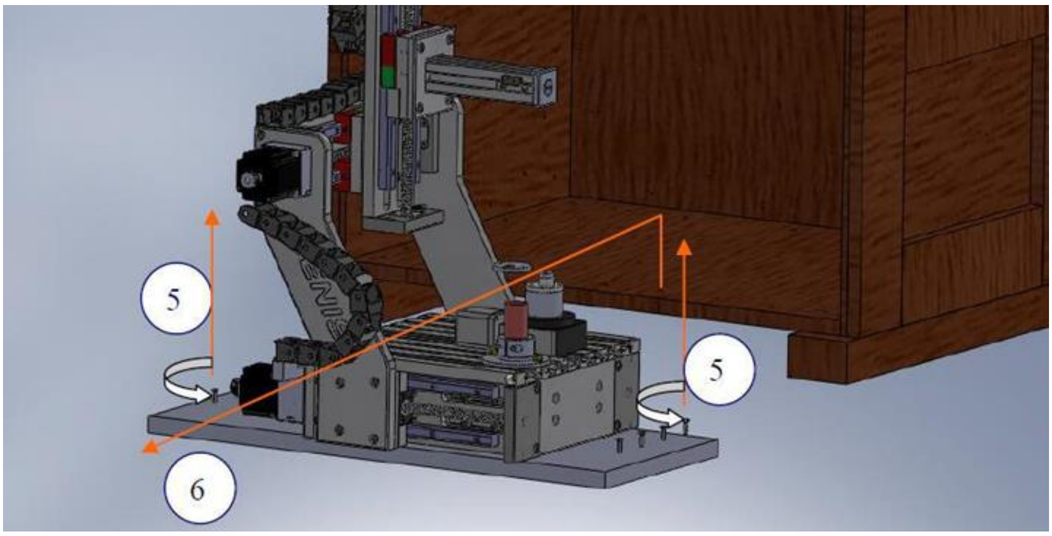


Figure 9: Unscrew the Mapper holder board from the top and pull-out the bord with the Mapper

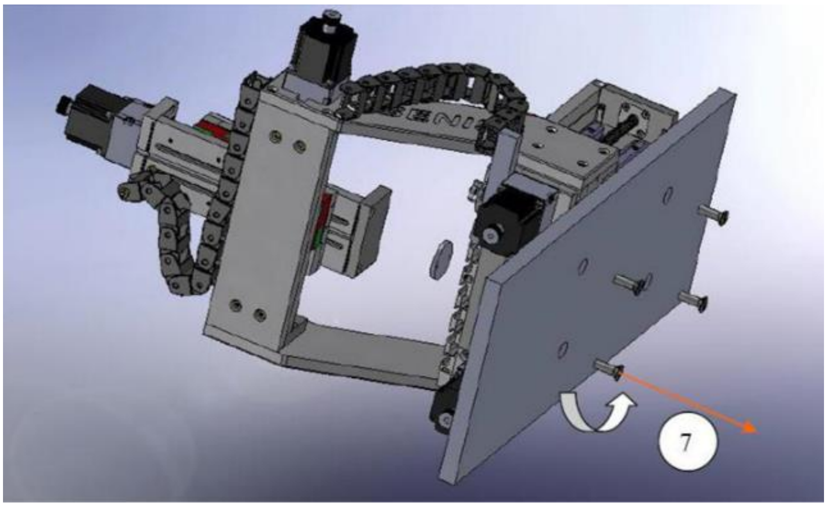


Figure 10: Turn the mapper and lay it on the side. Unscrew the M10 screws.

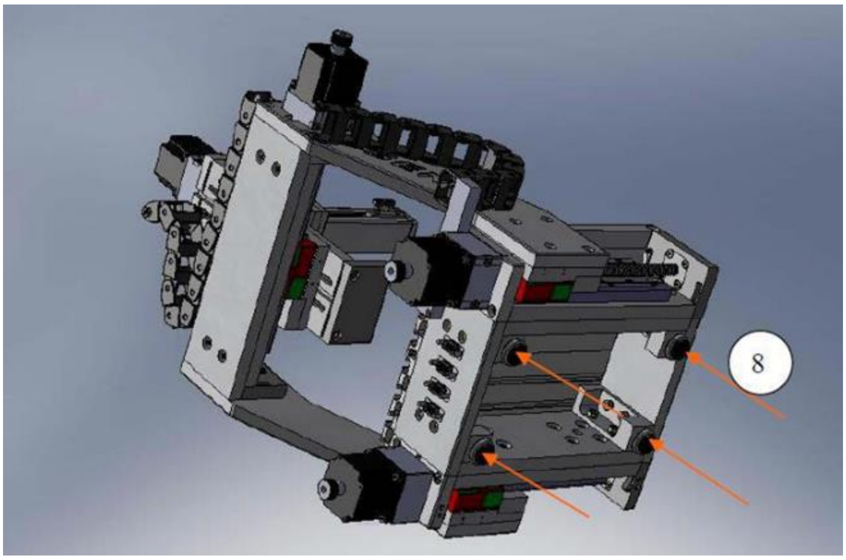


Figure 11: Screw-in the adjustable feets, which are delivered with the machine

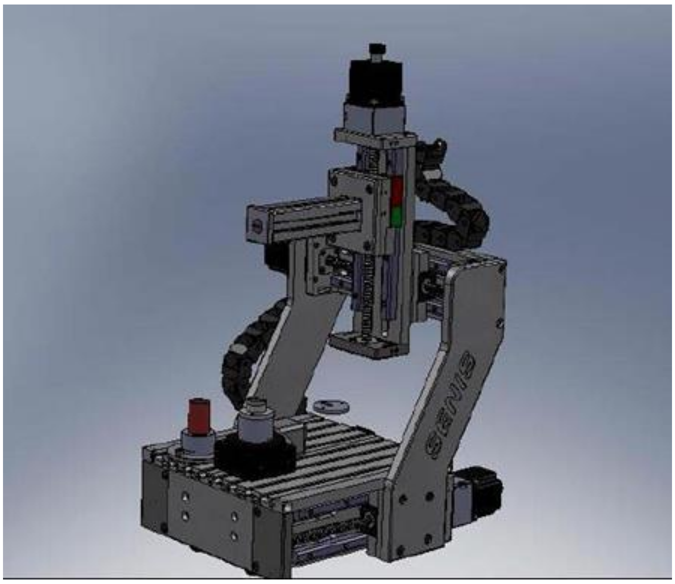


Figure 12: Place the Mapper on the firm and stable table

5.1.2 Unblocking Procedure

The unblocking procedure is described in the following figures. Blockers have to be carefully removed from all three linear modules (X, Y and Z axes). Please pay attention during the unblocking in order not to damage the border switches.

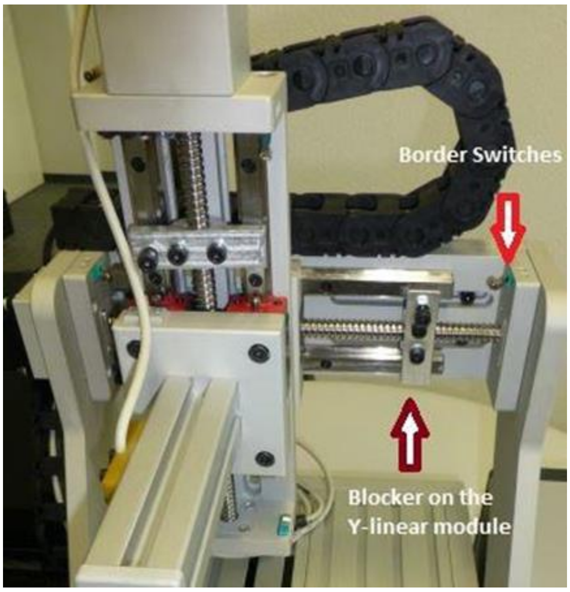


Figure 13: Blocker and Border Switch on the Y-axis

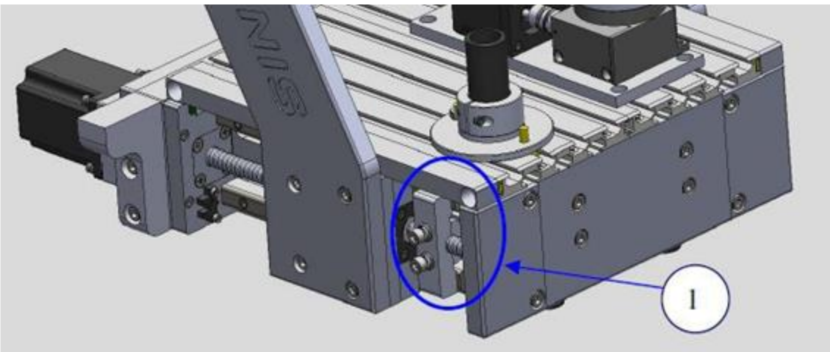


Figure 14: Linear module in blocked state

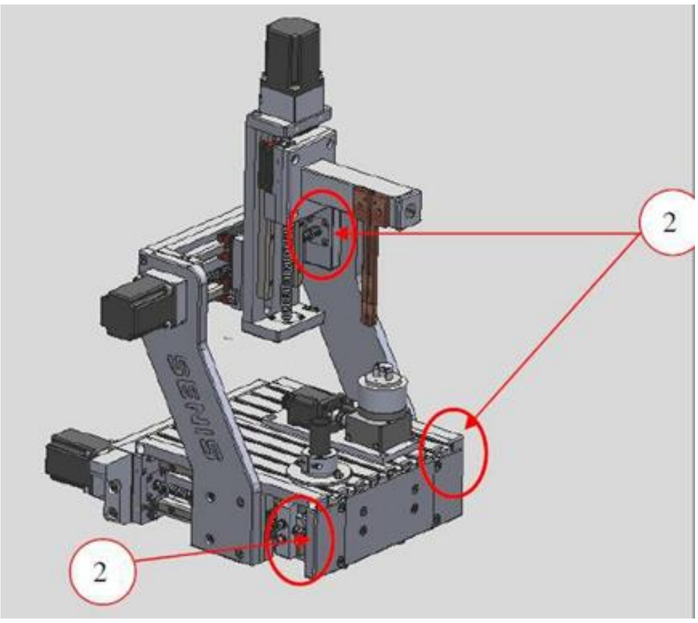


Figure 15: Position of blockers

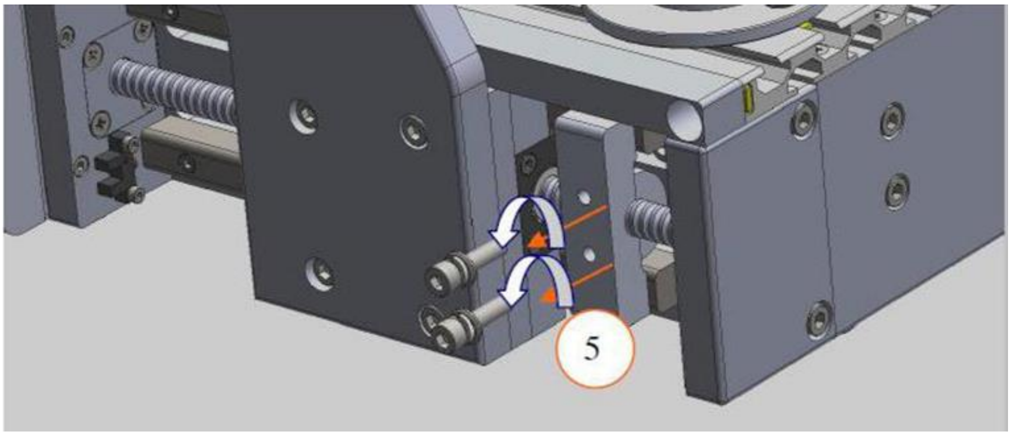


Figure 16: Unscrew the hexagonal screws

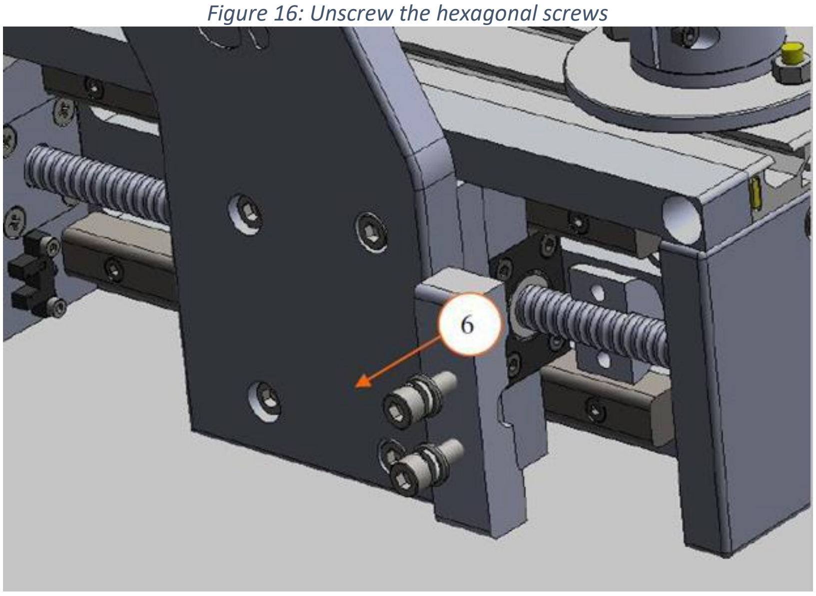


Figure 17: Pull out the blocker

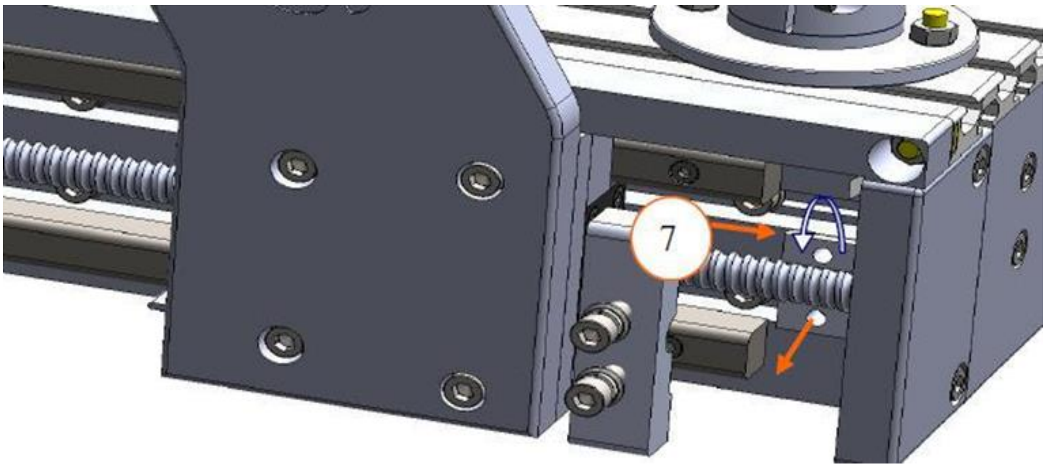


Figure 18: Rotate and remove the screwing part

5.2 Installation and Setup

5.2.1 Standard Package Content

- Mechanical Probe Positioning System includes: Cartesian Moving Platform, Touch Sensor with Probe Holder and Hall Probe, Rotation Stage, Zero Gauss Chamber, Magnet Holder and FSV Calibration Tool.

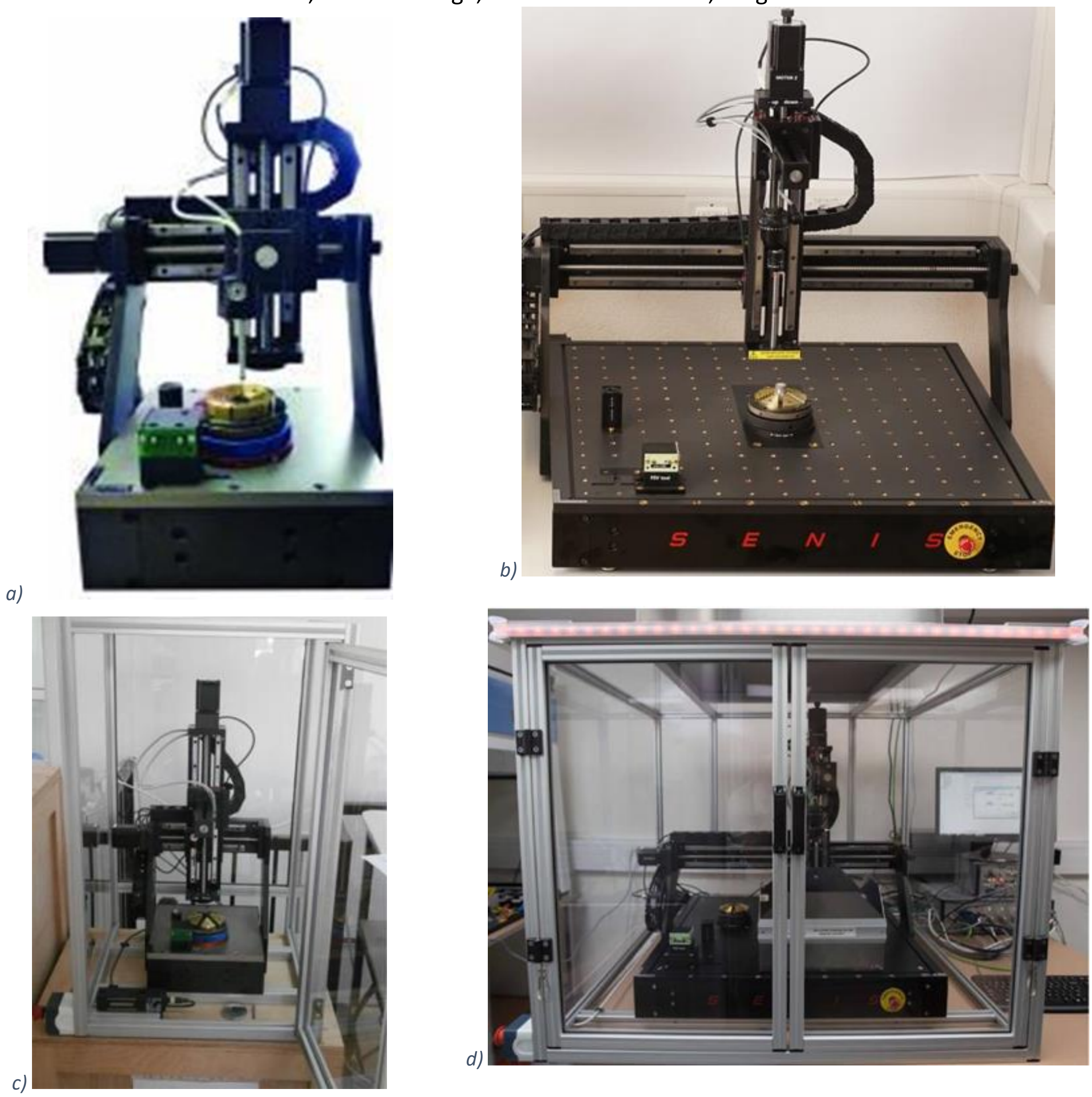


Figure 19: Mechanical Probe Positioning System or Cartesian Moving Platform
a) Standard-size Mapper with scanning volume (135x135x135) mm
b) Large-size mapper with the scanning volume (500x500x300) mm
c) Standard-size mapper in the protective box
d) Large-size mapper in the protective box

- Electronic Box (WxDxH: (32x45x14)cm / 5kg), including the power cord

Figure 20: Electronic Box (configuration of the electronic box may differ)

- Desktop Computer (WxDxH: (15 x 47 x 37) cm / 5 kg) with a Windows 7/10 operating system and mapper software installation on it (CD is included), USB cable, keyboard, mouse and display.

The keyboard language shall remain English since other languages might introduce issues (e.g. decimal point issue).

- Cables for connecting the Cartesian Moving Plaform, Electronic Box and Computer

Figure 21: Connecting Cables

- Emergency Stop Taster

Figure 22: Emergency Stop Switch

- Documentation: Operation Manual, Command Syntax, Calibration Certificates, Testing reports

5.2.2 Connecting the System

Since most of the modules are already connected inside the Electronic Box (control units, motor drivers, power supply, motherboard), only a few connections are required to make the system fully operational. A proper way to connect the Electronic Box to the Cartesian Moving System and to the PC is shown in the Figures below (connector positions on the Electronic Box may differ depending on the system configuration). All cables/connectors and corresponding slots are marked, so that the connecting procedure is user friendly and straight forward.

Figure 23: Electronic Box Connectors

Figure 24: – Connectors on the back side of the cartesian moving platform

Figure 25: Computer Connectors, including NI DAQ and NI Motion Control cards

5.2.3 Connecting Instruction

- Connect the Hall probe, the touch sensor, step motors, FSV tool supply, encoders, X/Y/Z linear modules and the rotating stage (from the Cartesian Moving Platform) to the electronic box.
- Connect the Emergency Stop Switch to the Electronic Box.
- Connect the NI Motion Control and the NI DAQ (Data Acquisition Card) from Electronic Box to PC.
- Connect the keyboard, the mouse and the monitor to the PC. The PC and the monitor have its own power supply.
- On the rear side of the Electronic Box there is the IEC connector along with the electronic fuse (250 V(a.c.) / 110 V (a.c.), (20x5)mm). Plug-in the power cord into the IEC socket on the back panel of the Electronic Box and then into the wall socket.

All inputs/outputs are labelled (label plates) on the Electronic Box, on the PC and on the back panel of the Mapper.

In case a Magnetic Field Mapper is labelled by a CE mark, it has its validity only if the Protective Cabinet is mounted. CE can be provided also in the case that customer guaranties the mechanical protection (operator cannot touch linear modules during the operation).

The keyboard language shall remain English since other keyboards might introduce issues (e.g. decimal point issue).

5.2.4 System Setup

It is highly recommended that the system setup is performed by a certified SENIS engineer or by an authorised SENIS partner. If this is not the case, SENIS will not be held responsible for any system malfunction or damage. The set files (configuration and calibration) on the installation disk will not match your system if the system was disassembled after shipping. Each time a system component is physically moved or replaced; set files must be changed!

After the system is unpacked and fixed on the stable table, all system components should be visually inspected. A special attention has to be paid to the boundary switches located on both sides of each linear module (X, Y, Z) of the mechanical probe positioning system.

After the system is successfully inspected, it is ready for startup procedure:

- Turn on the computer.
- Do not start the Mapper software program before turning on the Electronic Box. Prior to turning on the Electronic Box, make sure the Emergency Stop Switch is not closed (otherwise the Electronic Box cannot be turned on).
- Make sure the Emergency Stop Switch is released.
- Turn on the Electronic Box by setting the on/off switch on the front panel of the Electronic Box to "on". Note, this doesn't turn on the Electronic Box yet and no LED indicators are turned on. After the switch is in "on" position, press the green button to turn the system on. This procedure is required in order to protect the system from an unattended startup (e.g. after a power blackout). Once the system is on, one red LED and five green LEDs on the front panel of the electronic box will be on.
- ONLY FOR THE VERSION OF THE MAPPER WITH THE CE SIGN (PROTECTIVE BOX OPTION): The Protective Cabinet door has a lock with the magnetic switch, which ensures that the door is closed while the system is moving. When the system is turned on, a green switch light is on. When the door is closed, a yellow light starts flashing. If the door is open, the yellow light is off. While the system is in operation (probe is moving), the door is locked and can't be opened. In this situation, the yellow light is fully on. All software buttons which move the linear modules are disabled as long as the protective cabinet door is open. To enable these controls close the door of the protective cabinet.

For protective Cabinet installation, refer to the document Installation of the Protective Cabinet for the Mapping System.pdf

- After turning on the system, the Mapper software can be started on the PC. Note, each time the program starts, it will check if any of the boundary switches and touch sensor are closed and the system initialization will be automatically performed.
- Verify the functionality (See chapter Functional Verification)
- The MMS-1A-RS Mapping System is delivered in the fully calibrated state. The system software has several built-in functions for the self-calibration (such as offset cancelling and position calibration).

You need to recalibrate the system (See chapter Calibration) only after a mechanical displacement or by connecting the new Hall probes.

5.2.5 Mapper Software Installation

The System has been delivered with the pre-installed Mapper software. Use the following procedure ONLY for setting-up a new system (PC).

- Insert the installation CD into the CD-ROM drive
- Go to Install -> MMSEN_XYZ01 Installer -> Volume
- Double click on the setup icon
- Follow the on-screen instructions
    - Select the destination directory
    - Use the default settings (recommended)

5.3 Operational Conditions

- The room temperature is kept stable
- The system is not exposed to an external magnetic or electric field
- There are no ferromagnetic objects close to the system
- The mapping system must be fixed on a stable table; no mechanical vibrations shall be allowed
- Do not expose the Hall probe to the direct sunlight or to strong light sources
- Do not expose the optical encoders (linear modules) to the direct sunlight or to strong light sources
- Do not touch the system while in operation
- Do not pull any cables while in operation
- Do not unplug any cables while in operation
- The scanning surface is clean (no dust or fluids)
- The Electronic Box is turned on at least 3 minutes before starting the measurement.
- Do not put objects of more than 20 kg weight onto the mapper table (unless a special mapper version is delivered for heavy objects).
- Do not put objects of more than 7 kg weight onto the rotary stage of the mapper table (unless a special rotary stage is delivered for heavy objects).

6. General description

6.1 Overview

MMS-1A-RS / MMS-1X-RS is fully computer controlled magnetic field scanner. It allows motion in all four axes simultaneously (X-, Y-, Z-direction and rotation). The three-axis Hall probe measures magnetic field flux density of permanent magnets or electromagnets and delivers measured data for visualization and analysis in the Mapper software.

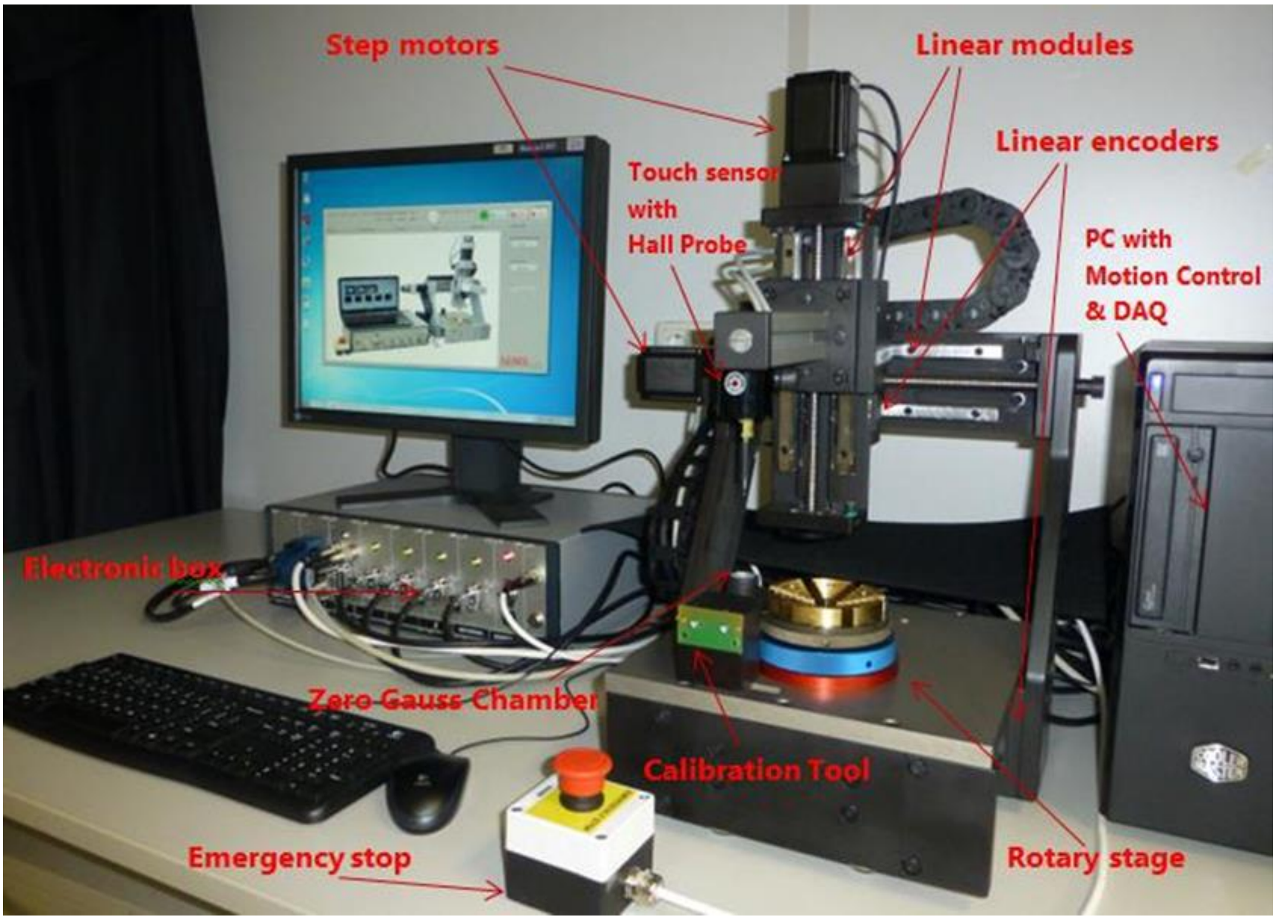


Figure 26: MMS-1A-RS

6.1.1 SENIS high-resolution magnetic-field-to-voltage transducer (in short: magnetic transducer)

Consisting of one tree-axis Hall or AMR probe and an electronic module for analog signal processing. It also provides the interface to the data acquisition and visualization system.

Do not expose the Hall probe to the direct sunlight or to strong light sources.

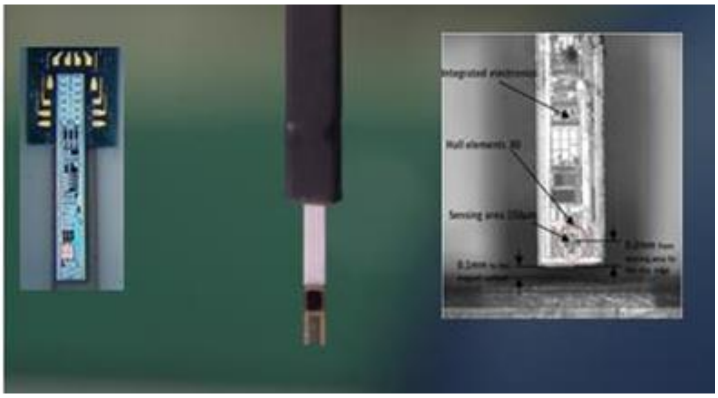


Figure 27: SENIS' integrated Hall Probe; left and right- Photos of the Si-chip

The magnetic transducer is enclosed into the electronic box that houses the power supply, step motor drivers, encoder electronics, touch sensor control and current supply for calibration tools.

Figure 28: Electronic Box

The Hall probe is mounted on a touch sensor (tactile sensor), that reacts whenever the probe touches an object. This feature provides an effective protection from the probe mechanical damage (motion is stopped as soon as touch sensor reacts, i.e. when the probe touches an obstacle); it also allows an absolute magnet positioning, i.e. the precise definition of the scanning starting point; and touch sensor can be used, in combination with an optional stylus, for the dimensional measurement of objects under tests, transforming in that case the magnetic field mapper into easy-to-use coordinate measuring machine (CMM).

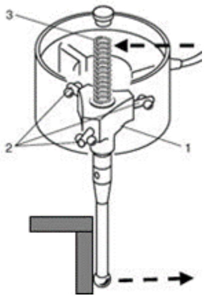


Figure 29: The Touch-trigger sensor is a mechanical device that has the ability to return the stylus ball to the same repeatable position following any deflection. For the touch-trigger function, the probe is moved in the direction of the object under test, until it is touched. For instructions on assembly and maintenance of the touch sensor check the Appendix.

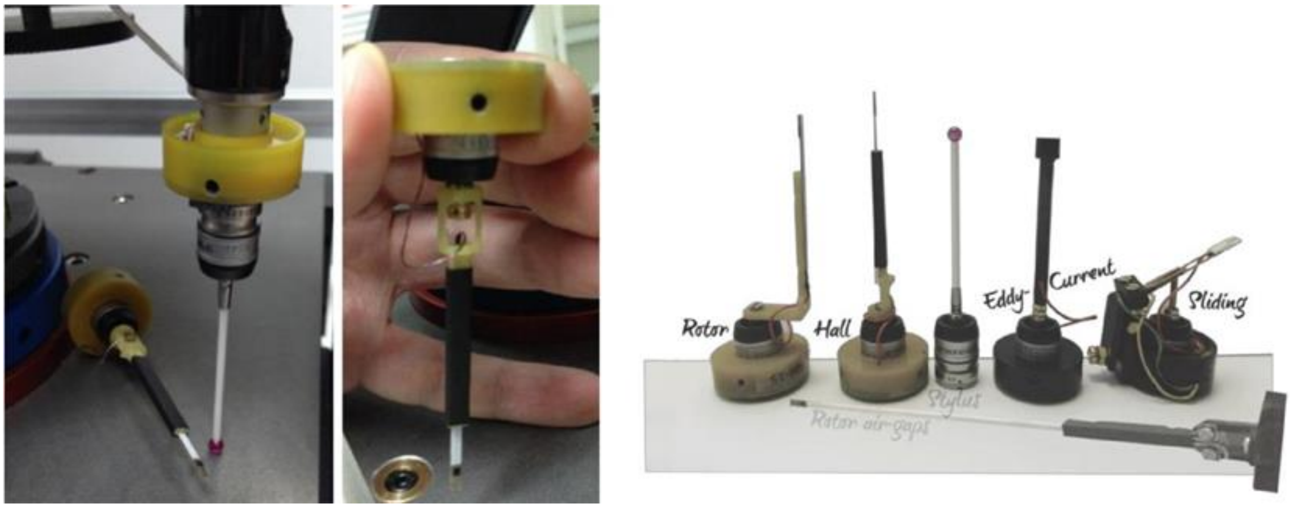


Figure 30: Touch Sensor with Hall probe mounted on it. It has an adapter with connecting pads and with integrated RFID for automatic probe recognition for an easy probe interchangeability

The MMS-1A-RS / MMS-1X-RS is also equipped with an Emergency Stop taster (as safety equipment) that, when activated, breaks the power supply for the motor drivers.

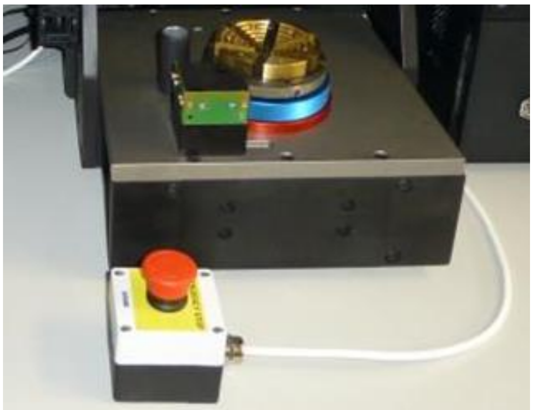
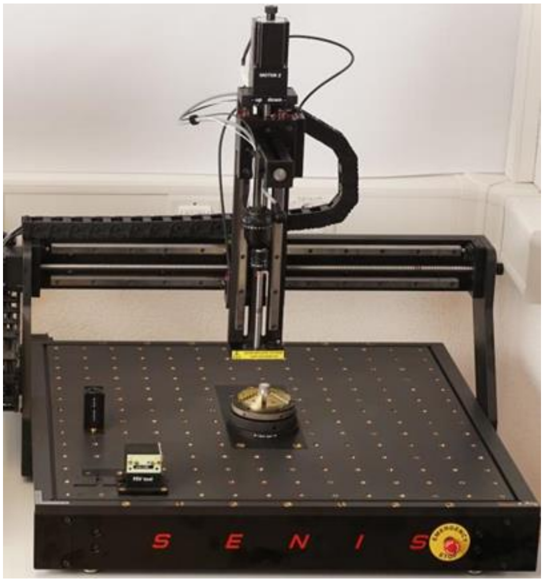


Figure 31: Emergency stop taster

6.1.2 Cartesian Moving Platform (CMP)

CMP is used for automated positioning of the Hall probe at desired locations around the customer's magnet assembly that needs to be measured. The CMP consists of three linear modules driven by step motors and controlled through the high-resolution linear encoders.

a)



b)

Figure 32: Mechanical Probe Positioning System or Cartesian Moving Platform
a) MMS-1A-RS - standard-size Mapper with the scanning volume (135 x135 x 135) mm;
b) MMS-1X-RS large-size Mapper with the scanning volume (500 x 500 x 300) mm
Applied encoders help determine the exact position of the probe and help eliminate mechanical transfer elements, such as bearings.

Figure 33: Optical encoders mounted on each linear module

The rotary stage is positioned on the mapper base table. It is driven by a step motor and controlled through the incremental rotary encoder. A non-magnetic multi-jaw scroll chuck is mounted on the rotary stage as a very precise magnet holder.

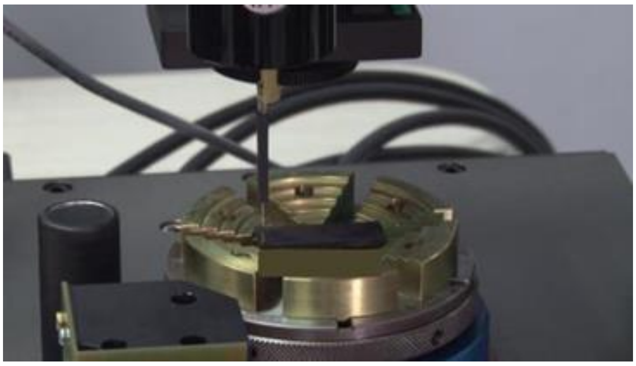


Figure 34: Rotary stage with the multi-jaw scroll chuck (jaws and contra-jaws set available)

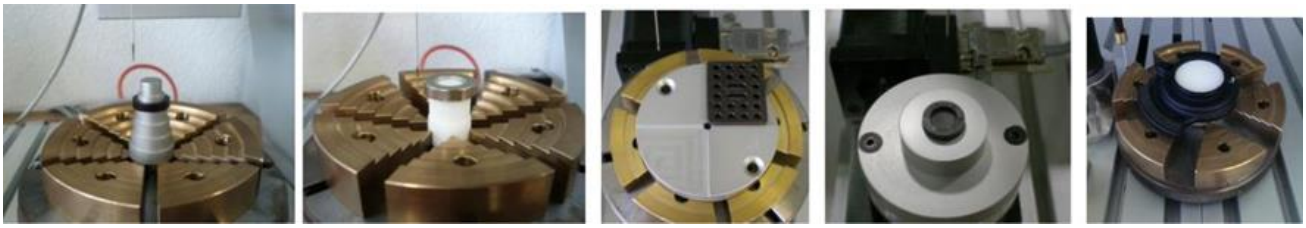


Figure 35: Different probe holder tools for accurate magnet holding for production tests

A Tool for the on-site calibration of the Hall probe's magnetic field sensitive volume (FSV) position is mounted on the mapper base table. This calibration tool consists of two mutually orthogonal PCBs with a current carrying conductor. The calibration is achieved by measuring the well-defined magnetic field above the current conductor. The two PCBs are fixed on a mechanically well-defined cube, providing for a precise holder for rectangular-form magnets.

A Zero Gauss Chamber (ZGC) for Hall probe offset cancelling is mounted on the mapper table.

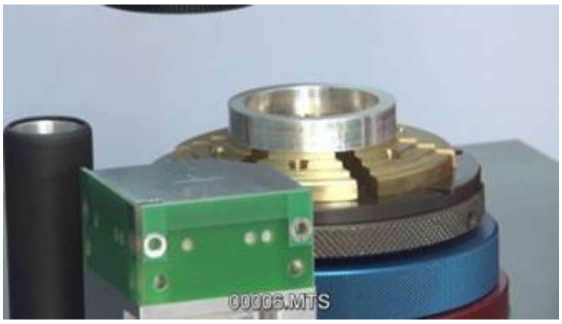


Figure 36: Field Sensitive Volume (FSV) Calibration tool and Zero Gauss Chamber

6.1.3 Data acquisition and signal processing

A customized data acquisition and digital processing system that triggers the magnetic field measurement at desired location, converts the analog signals of the Hall probe into digital numbers, combines these numbers with the appropriate position coordinates, and provides the consolidated function of Magnetic Field Vector as a function of the Probe coordinates for further visualization, analysis and reports. The mapping system is controlled by a Computer (PC) that includes the Motion Control (NI 73xx), which controls the motor drivers for all three mechanical axes and for the rotary stage; and DAQ (NI 62xx) that receives data from magnetic transducer.

6.1.4 Motion Control

Motion Control (NI 73xx) provides a simultaneous control of all four axes and allows the definition of complex scanning paths (circles, 3D contouring, etc.). A direct synchronization (position vs. measured magnetic field) between Motion Control and NI DAQ is provided through the on-board real-time system integration bus.

6.1.5 MH8 Rotation Probe Head (only MMS-1X-RS)

For the large-size mapper MMS-1A-RS there is an additional option - the improved version of touch sensor – MH8. The advantage of this touch sensor is the possibility to turn the probe in different positions, i.e. 0° (vertical position) and 90° (horizontal position).

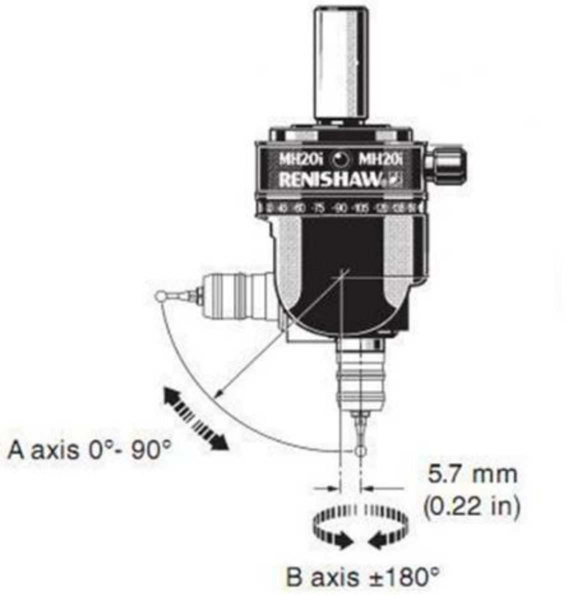


Figure 37: MH8 probe head

The Hall probe can rotate along two axes: A and B, with resolution of 15 degrees, though only two positions are supported from the software side: 0° and 90 degrees. The operator needs to manually change the probe angle position. After turning on the electronic box, the RFID process will perform to automatically identify the attached probe. The actual probe angle (0 or 90 degrees) has to be manually set at the mapper program start or on turning ON the electronic box.

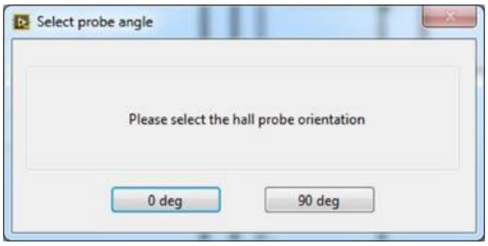


Figure 38: Manually set the probe angle after RFID process

Figure 39:Button for manually switching the probe angle position

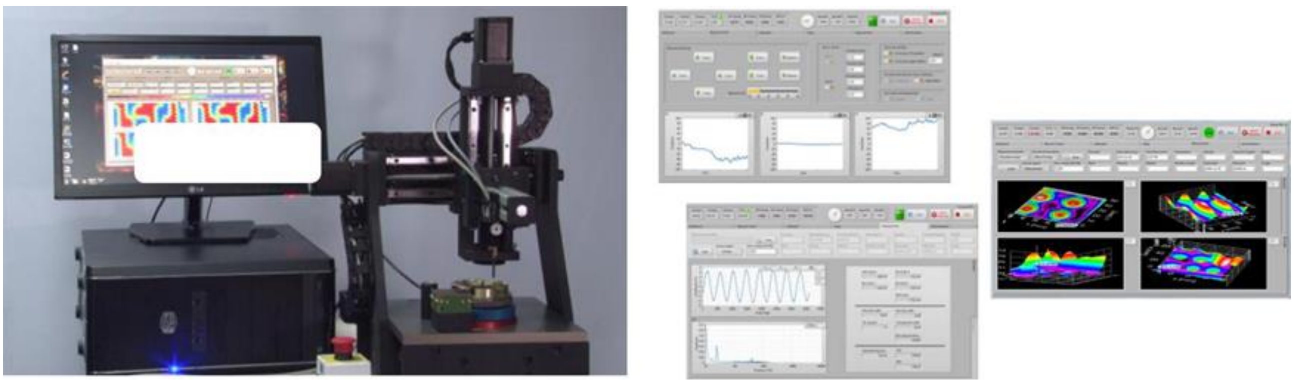


Figure 40: Computer with the mapper software running on it

Several calibration algorithms are implemented in the mapper software, such as calibration of the field sensitive volume, of rotation axis, of homogeneity, orthogonally calibration, vertical calibration, etc.

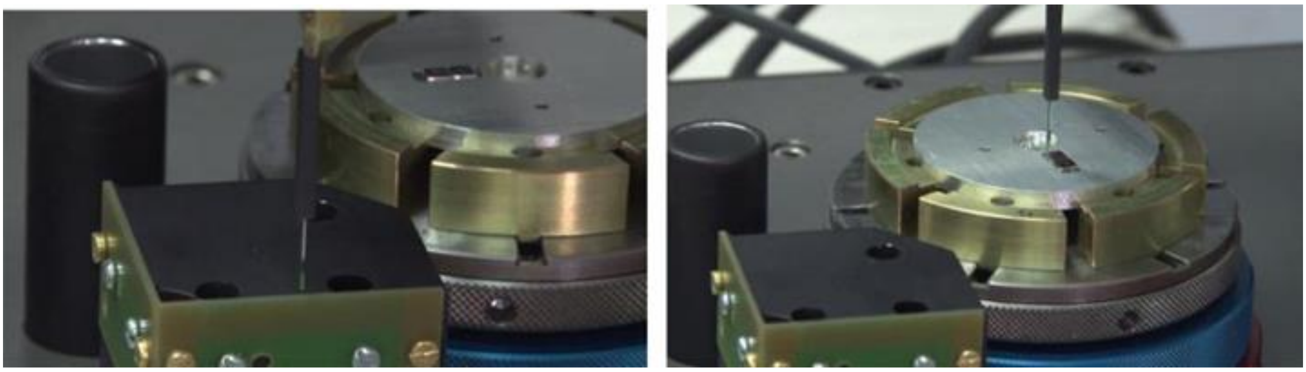


Figure 41: Mapper Calibration Tools

6.2 Folders and files

The Mapper program files, calibration and measurement data are organized in a directory structure, which helps an intuitive software usage. SENIS provides following folder structure on each delivered PC configuration.

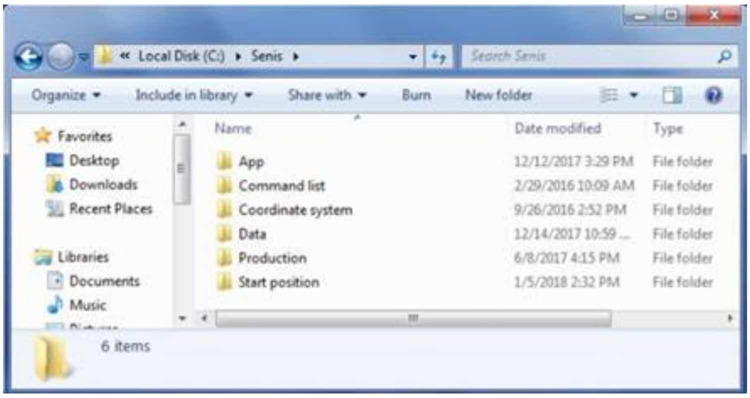


Figure 42: Mapper Software Folder Structure – All executables are stored under Application folder, which can be stored everywhere in the customers directory structure

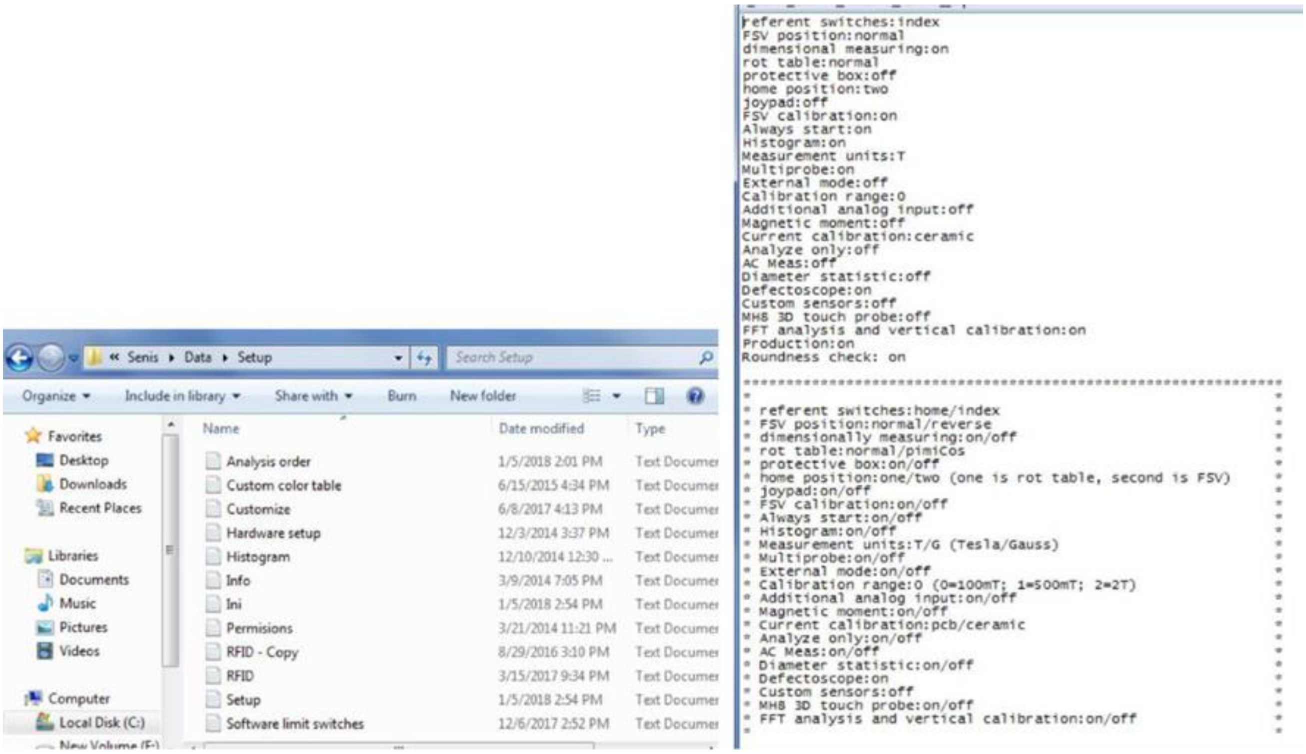


Figure 43: Customize.txt file (located in the Setup folder) contains data that describe customers mapper configuration. The customizing includes the special rotary stages, protective box, special measurements, etc.

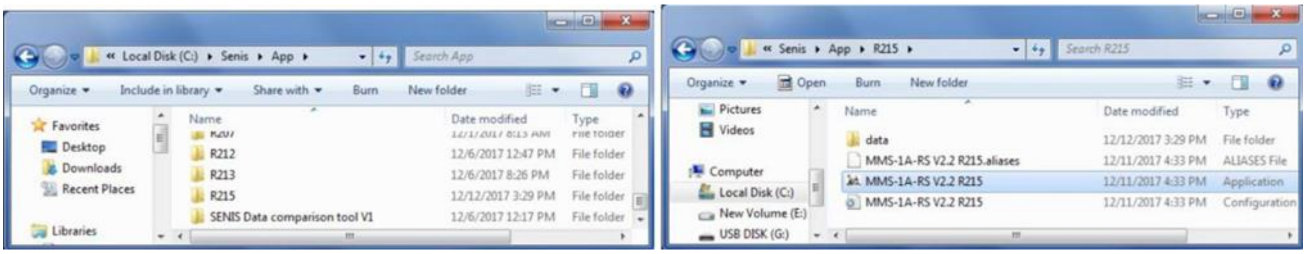


Figure 44: App folder and mapper software executable file (example only)

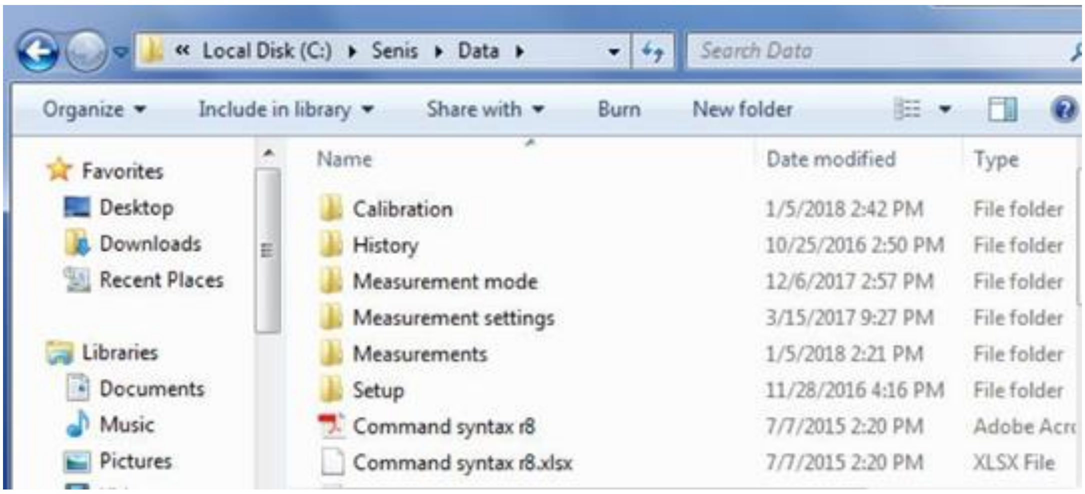


Figure 45: Measurements and Calibration data are stored under data folder

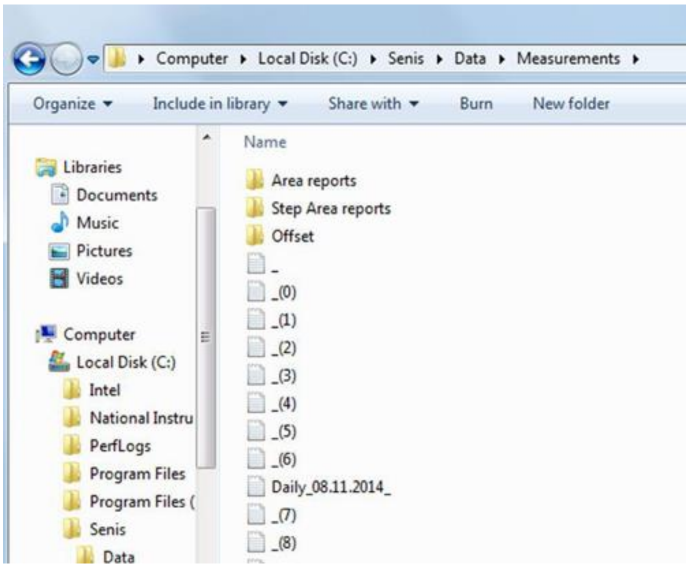


Figure 46: Measurement data in the Measurements folder

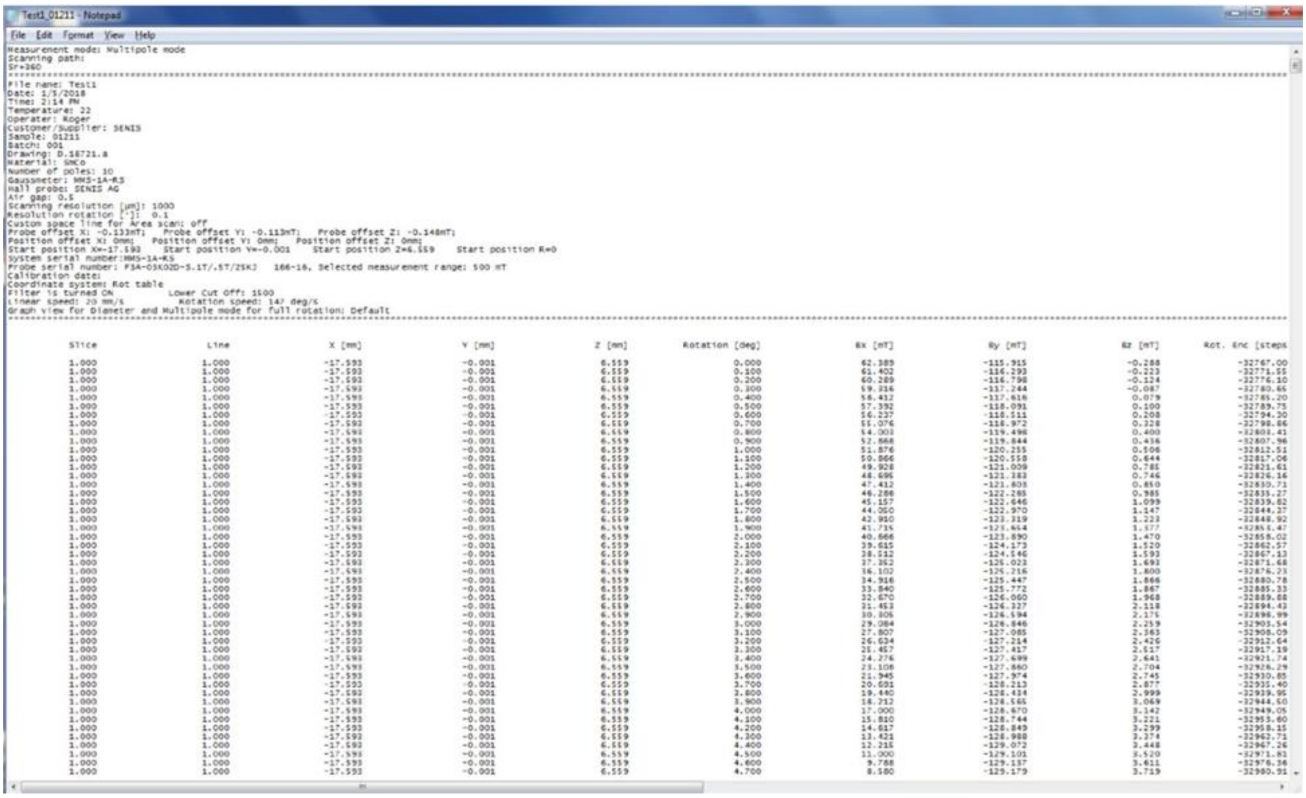


Figure 47: Example of a measurement file (scanning path and header data, followed by the table with Bx, By and Bz with the correponding X,Y,Z,Theta coordinates, and the analysis data at the end of the file.

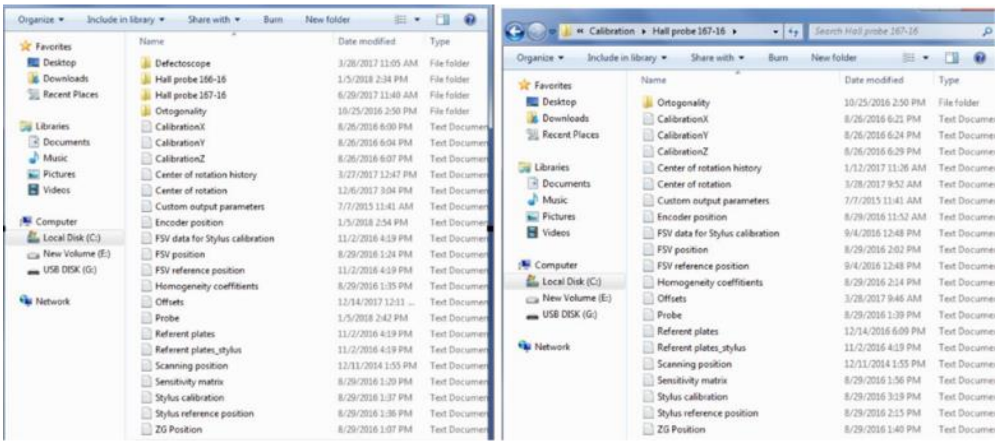


Figure 48: Actual calibration data in Calibration folder (current configuration, i.e. the working Hall probe data are copied to the Calibration folder whenever the probe was exchanged and recognized by the RFID)

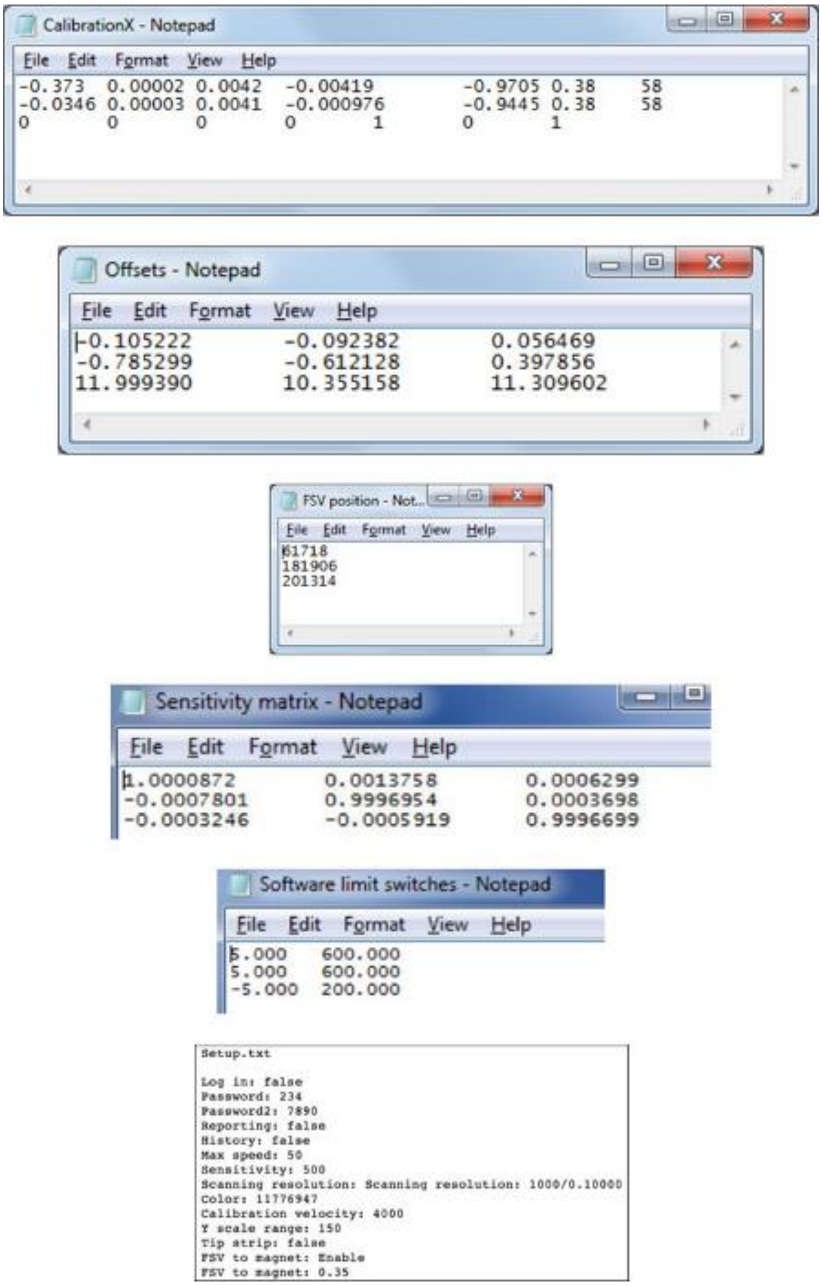


Figure 49: Examples of calibration files

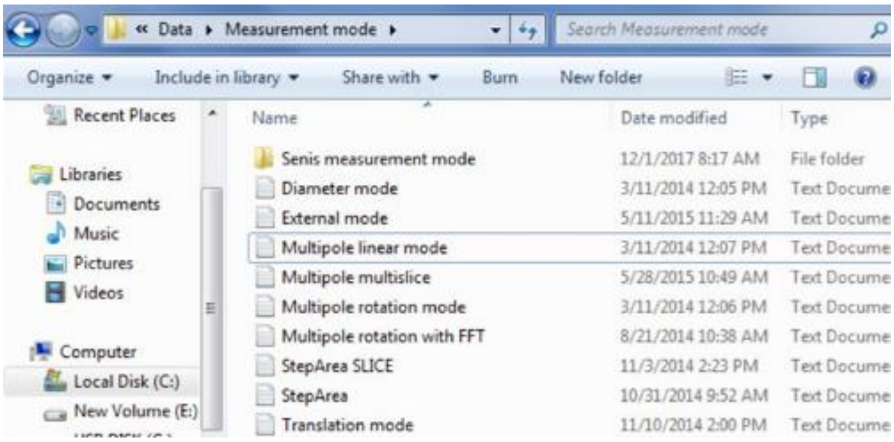


Figure 50: Scanning paths and measurement profiles are stored under Measurement mode folder

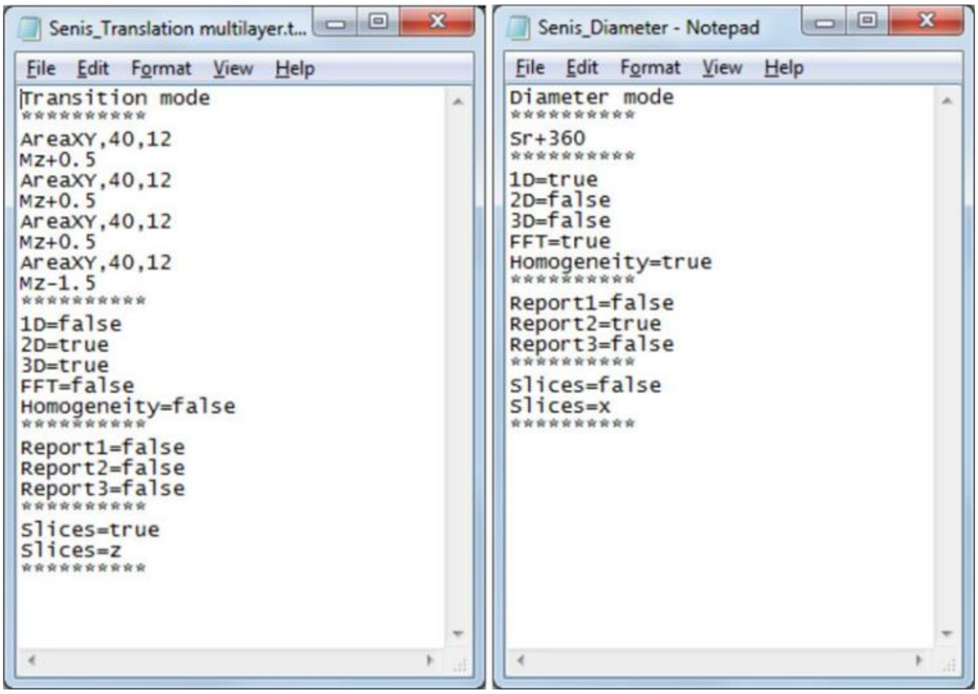


Figure 51: Examples of measurement profile files

6.3 Connection Diagrams

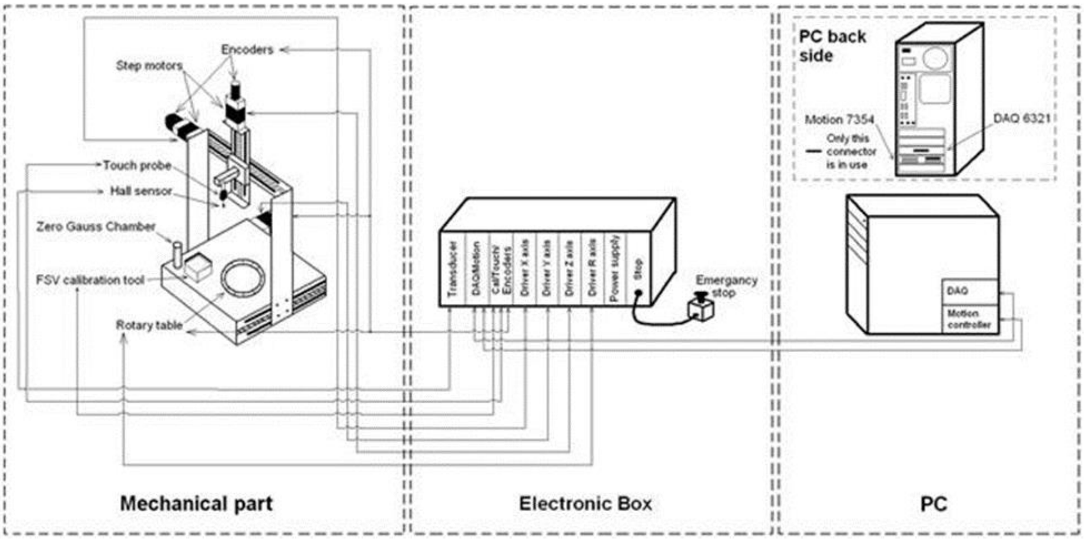


Figure 52: Connection Diagram – Overview

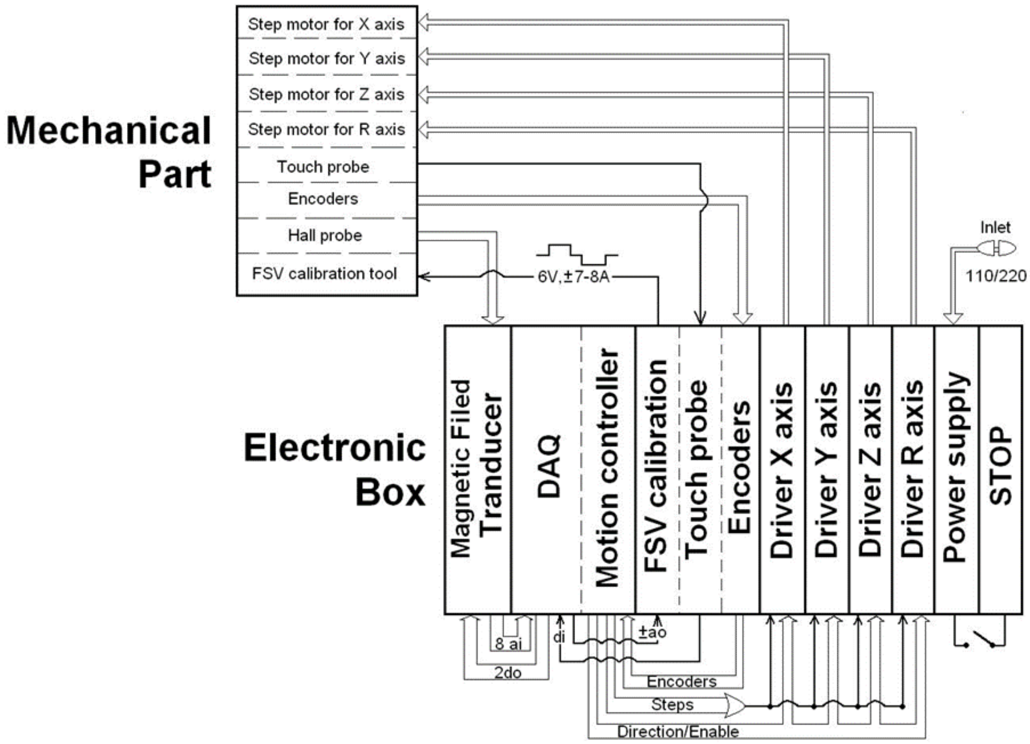


Figure 53: Connection Diagram – Electronic Box

6.4 Functional verification

After the Mapper software is started, the "Initialization…" message will appear on the Dashboard screen. During the Initialization, the Motion Control and the DAQ will be initialized and made ready for operation.

If there are several probes ordered (spare probes, touch stylus, eddy-current/defectoscope probe, AMR probe, etc.), a similar dialog as below will appear for the probe selection and its confirmation. Probes have built in RFID chip, so program can automatically detect mounted probe and load all necessary files for it. There is the possibility of manual selection of probes (if you have probe without RFID function, or if RFID fails detecting the probe)

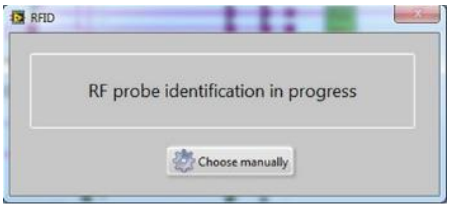


Figure 54: Pop up window for probe RFID process

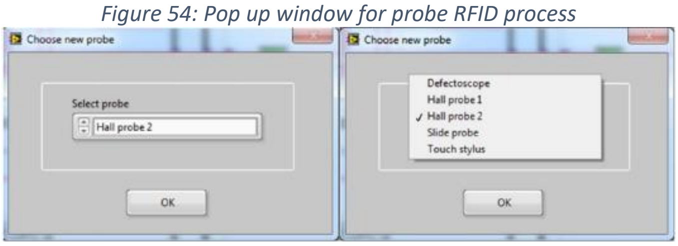


Figure 55: Manual probe selection

After Initialization process, the Power ON/OFF indicator will turn from red to green.

Figure 56: Dashboard Tab after initialization

To continue with functional verification of the system, go to "Manual Control" screen by selecting the appropriate tab. The screen shows eight buttons for triggering the probe movement in various directions, as showed below.

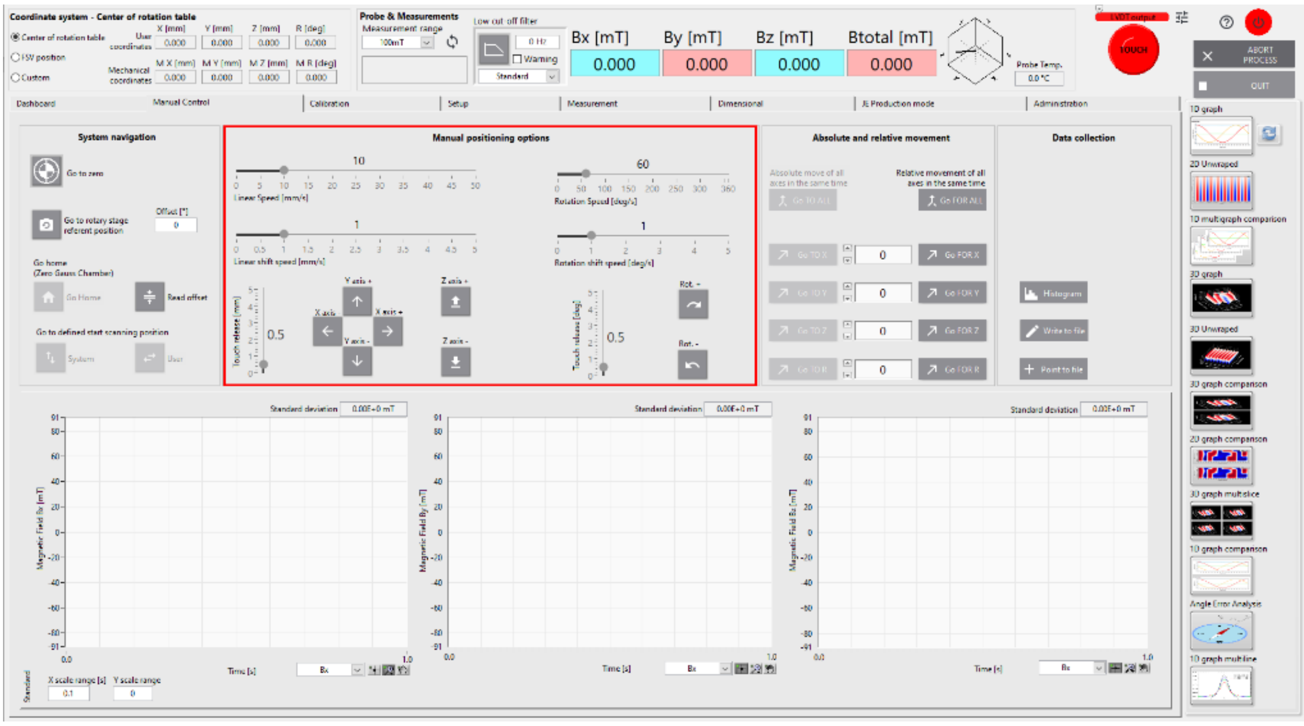


Figure 57: Manual Control Tab. This screen is used for manual control of the mapper.

Verify the correct movement by selecting the "Linear Speed" slider at approx. 5 mm/s position (slow). Then click and hold the "Z axis +" button until the probe comes out from the Zero Gauss Chamber (previously check that the protection around the probe was removed). Click and hold for few seconds each of the mentioned arrows and make sure that the system is moving in the appropriate direction. Also, note that each linear module is equipped with the linear encoder and two boundary switches. The encoder markers and switches are used as positioning reference and as mechanical system protection. To make sure that the switches are working properly click and hold each arrow (except for rotation, since the rotation table has no boundary switches). Hold each arrow until the linear module moves to the boundary switch. Upon hitting the switch, the module will automatically stop, the power supply will be disconnected; and any further movement of the system in the previous direction will be disabled. The system has to be moved in opposite direction manually (by turning the corresponding wheel by hand on each linear module – for Z-module at the top, for X-module on the right and for Y-module at the rear panel).

Repeat the same procedure for all remaining arrows (directions). Be very careful not to hit or damage the probe (especially when using “Go TO” and “Go FOR” commands).

The Emergency Stop is very important safety equipment; therefore, its functionality has to be checked. The role of the emergency stop switch is to immediately stop any system movement. Also, this switch terminates the power supply of the system and indicates to the software that unexpected circumstances have been occurred. The system will not function unless the Emergency stop switch is properly connected to the Electronic Box. To check if the Emergency Stop is working properly, activate this switch while the system and the software are on. The system will stop moving immediately, and all LEDs on the Electronic Box will turn off, indicating that the system has no power supply.

To put the system back in operation, release the emergency switch and turn on the system by pushing the green button again (note that the on/off switch is in the “on” position and there is no need to toggle it). After the power is restored, the software will wait for ten seconds at most, before confirming the normal operating conditions.

To turn off the system, the user should first exit the mapper software program and then turn off the Electronic Box. The only appropriate way to exit the program is by using the “QUIT” button in the top right corner of the mapper software window. This icon is disabled while any measuring task is in progress. A task in progress can be aborted by clicking the “ABORT PROCESS” button (or by pressing keyboard shortcut Esc button).

Figure 58: QUIT and ABORT PROCESS Buttons

After exiting the Mapper software program, turn off the hardware simply by moving the on/off switch to “off” position.

The next check is to navigate the Probe to Mapper’s Zero coordinate. During this the system will locate the index pins of the incremental encoders. Please click “Go to zero XYZ position” button:

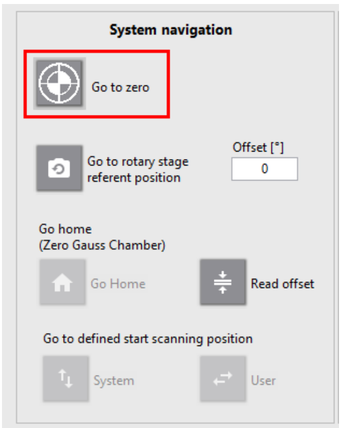


Figure 59: Position the probe in the absolute (machine) zero position

The probe will be positioned in the absolute (mechanical) zero coordinates (with the positioning tolerance of +/-3 um). Also, the rotary stage will be positioned in its 0° position.

NOTE: You can optionally use software limit offset (probe will be position at zero coordinate plus software limit offset when you go to mechanical 0 position)

The next check is to position the Hall probe in the Zero Gauss Chamber.

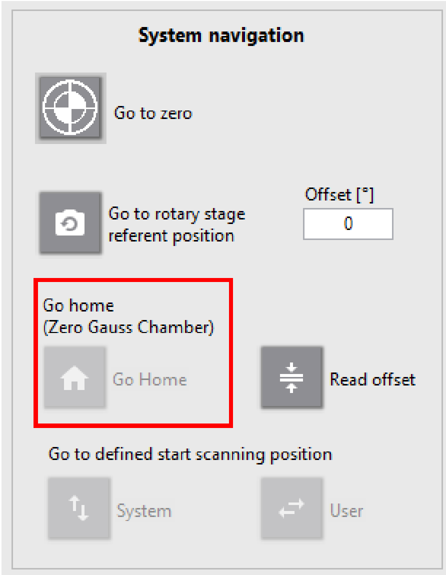


Figure 60: "Go Home" button positions the probe in the Zero Gauss Chamber

After clicking the "Go Home" button, the probe will move to the Z reference and then will navigate in to the Zero Gauss Chamber in the position that was in-factory calibrated. This position is stored in the calibration file ZG Position.txt in the Calibration folder.

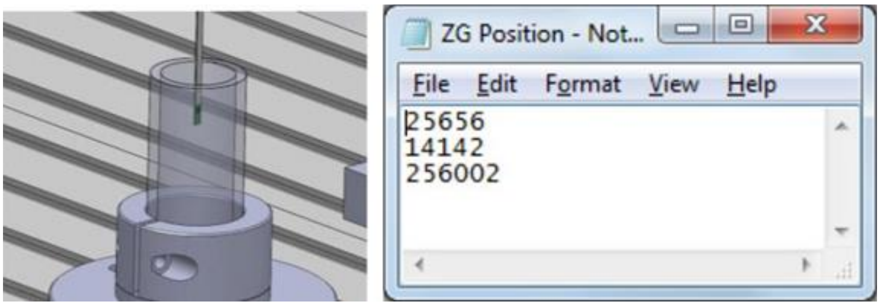


Figure 61: Probe positioned in the Zero Gauss Chamber in the position stored in the calibration file

After clicking the "GO HOME" button, closely monitor the probe movement. If the calibration files are false, there is the possibility that the probe could collide with an object. Prevent this happening by terminating the program using the "Emergency Stop" switch.

After the probe is positioned in the Zero Gauss Chamber, the Hall Probe Offset will be read and the readings in the fields "Offset Bx", "Offset By" and "Offset Bz" will update.

The last check is to put a permanent magnet close to the Hall probe and to see that all three magnetic field components (Bx, By, and Bz) are reacting to the magnetic field.

7. Operation instructions

7.1 Dashboard tab

Figure 62:Dashboard Screen appears on the software start

7.1.1 Top level controls (always visible)

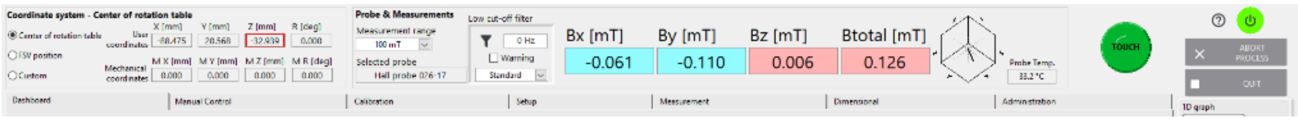


Figure 63: Basic controls

Coordinate systems:

- The Coordinate system selector allows to select preconfigured or custom coordinate systems.
- User coordinates show the current position with reference to the selected coordinate system.
- Mechanical coordinates show the position with reference to the index pins of the encoders.

Probe and Measurements:

- Measurement range selector allows selection the active measurement range.
- The refresh button next to the Measurement range selector allows manually starting the probe selection. This button starts the RFID probe detection process. The probe detection process can be aborted to allow selecting a probe manually.
- The Selected probe field shows the currently active probe.
- Low cut-off filter allows switching on and off a digital 2nd order Bessel low pass filter and selecting the cut off frequency.
- If the Warning checkbox is activated the system will calculate the cut off frequency based on the selected spatial resolution and the scanning speed and will display a warning with the option to set the suggested cut off frequency.
- The selector below allows selecting a no phase filter instead of a standard filter.

- Bx, By, Bz and Btot show the currently measured magnetic field. The background colour of the fields changes from blue (negative/south) to red (positive/north). A red blinking field indicates overrange values.
- The 3D compass shows the current direction of the magnetic field.
- Probe Temp. provides the Hall sensor (on chip) temperature. Note that the Hall sensor temperature is usually several degrees higher than the environment temperature.
- Touch shows the status of the touch probe (green = released, red = triggered)
- The (**?**) icon opens the manual.

7.2 Manual Control Tab

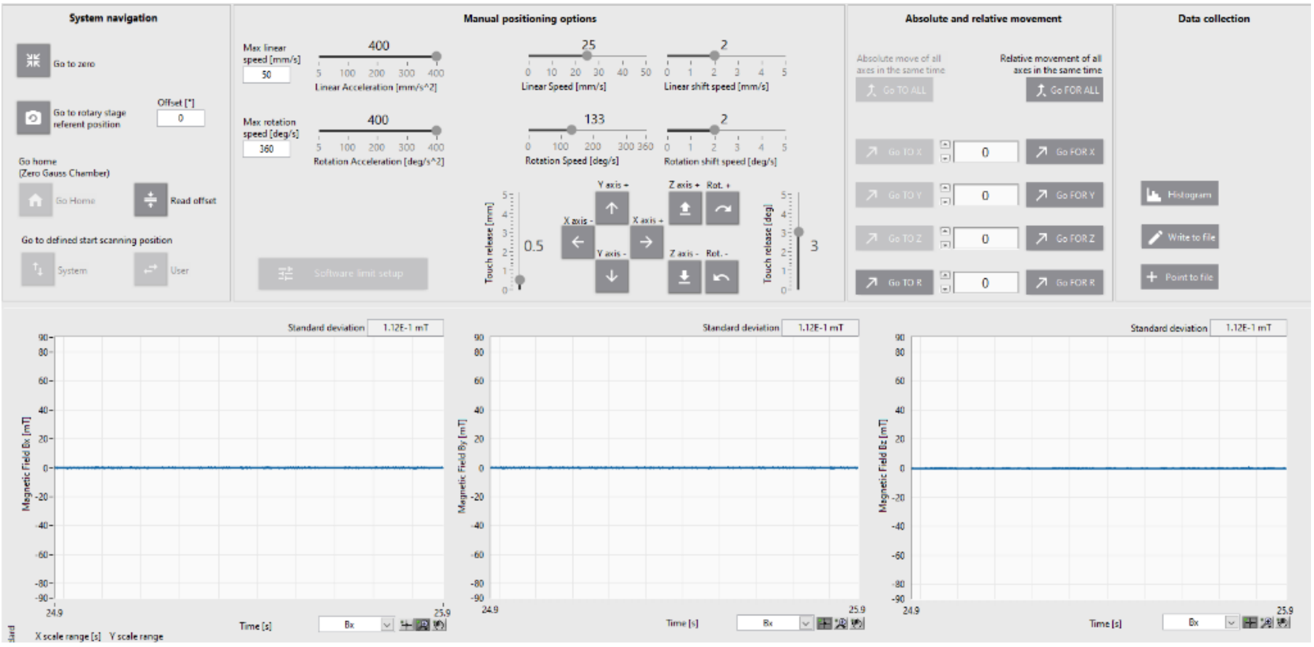


Figure 64: Manual Control tab

7.2.1 System navigation

- Go to zero: The system is equipped with incremental encoders and does not know its absolute position at startup. Go to zero will cause the system to drive in a predefined direction until it locates the index pins on the encoders. This is the mechanical zero of the system. The mechanical zero is on the top-left-back of the system and close to the end switches of each axis (X, Y, Z).
  Should this command cause the system to trigger an end switch, make sure that all axis have sufficient distance to the end switches (by moving away from the switch) and make sure no direct sunlight falls on the encoders (an intensive light can affect the reading of the integrated optical encoders).
- Go to rotary stage reference position: Finds the index pin of the rotary stage encoder. Offset will set the zero of the rotary stage at the position defined by the provided number in degrees.
- Go home: Moves the probe into the Zero Gauss Chamber and performs the zeroing (cancellation of offsets) of the probe.
- Performs the zeroing of the probe at the current position
- Go to start scanning position – positions the probe at predefined starting coordinates for a measurement (Measurement start position). If activating the “System” button, the probe will be positioned in the system-set position (usually X = 10, Y = 10, Z = 10). On “User” button activation, the probe will be position in the user defined scanning position. This position can be set in the Calibration Tab or in the Setup Tab and is stored in a user defined file under C:\Senis\Start position.

7.2.2 Manual positioning options

- Max speed allows setting the maximally selectable speeds for linear and rotation movements
- Acceleration sliders set the linear and rotation acceleration. This can help reduce vibrations by avoiding mechanical resonance frequencies.
- Software limit setup allows setting software limits at both ends of each linear axis. The system will stop when manually driving into these limits. The user can still continue moving into that direction by pressing a button again.
- Speed sliders allow setting the speed for linear/rotation movement.
- Shift speed sliders allow setting the reduced speed for linear movement when pressing the shift button. Only touch objects at the shift speed.
- Touch release sets the distance the system will move in the opposite direction after a detected collision. Whenever the touch system triggers, the system will stop immediately. A message will be displayed to the user. When confirming, the system will move for the defined distance in the opposite direction.
- X±, Y±, Z±, R± allow moving the system in all directions.

7.2.3 Absolute and relative movement

- Go For X/Y/Z/ALL moves the system by the defined distances from the current position. Example:
    - Start position: X=10mm, Y=10mm, Z=10mm, R=10°
    - Go For X: 20mm
    - End position: X=30mm, Y=10mm, Z=10mm, R=10°
- Go To X/Y/Z/ALL moves the system by the defined distances from the current position. Example:
    - Start position: X=10mm, Y=10mm, Z=10mm, R=10°
    - Go To X: 20mm
    - End position: X=20mm, Y=10mm, Z=10mm, R=10°

7.2.4 Data collection

- Histogram samples data for a defined time and provide a histogram of the data. This allows to check the functioning of the probe. It is recommended that the probe is in the Zero Gauss chamber.
- Write to file allows sampling the magnetic field at high sampling rate of up to 50kS/s. The values are directly written into a text file.
- Point to file writes a single measurement value (point) into a text file.

7.2.5 Field Graphs

- Show the magnetic field on Y and time on the X axis.
- Component selector allows selecting the magnetic field.
- X scale range allows setting the time range (X axis) for all the graphs.
- Y scale range allows setting the magnetic field range (Y axis) for all the graphs.

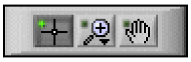
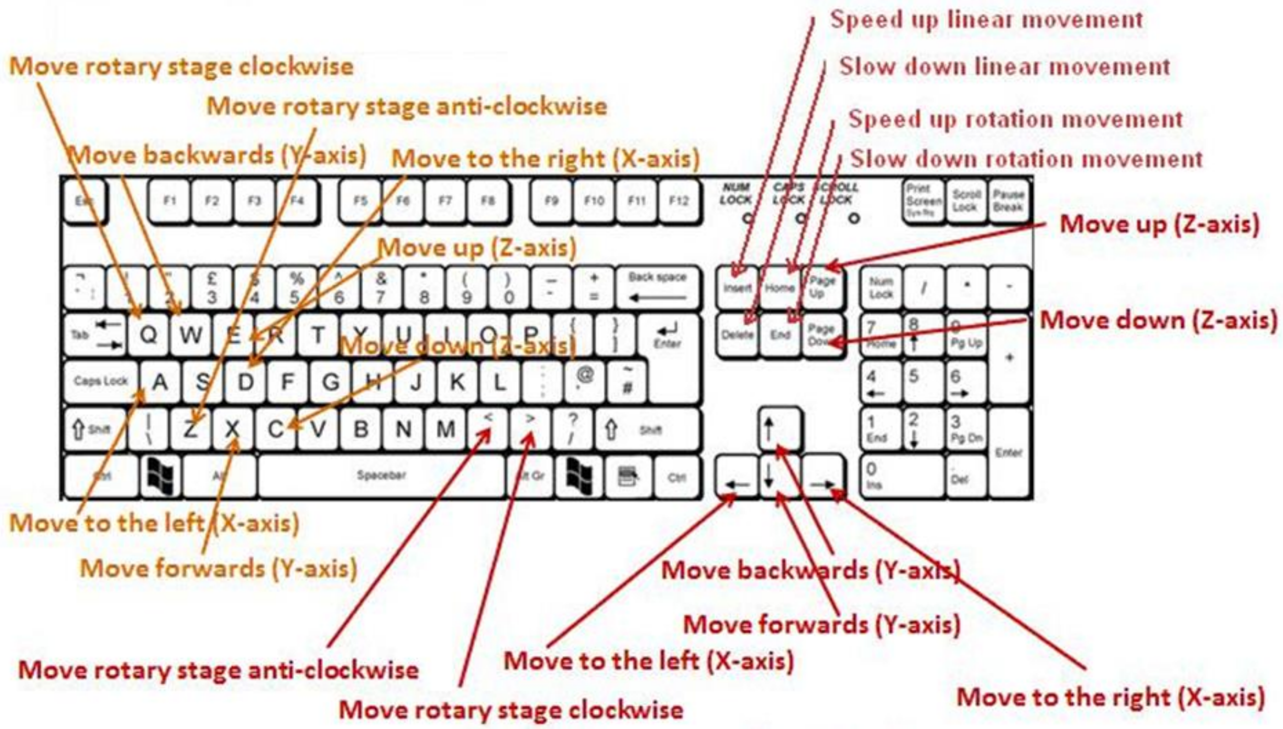


Figure 65: Graph Palette

- The Graph Palette:
    - Cursor Movement Tool—Moves the cursor on the display. This button applies only to graphs.
    - Zoom—Zooms in and out of the display.
    - Panning Tool—Picks up the plot and moves it around on the display.

7.3 Keyboard Controls



SHIFT + Red Controls: slow movement of the of the probe (i.e. for touching)

Orange Controls allow moving in small steps (5um) when pressing SPACE.

Holding SPACE overrides the touch sensor. This allows moving the probe with the Orange Controls when the touch sensor is triggered.

7.4 Calibration Tab

The calibration tab features various on-site calibration procedures: The calibration procedure selector allows selecting different calibration procedures

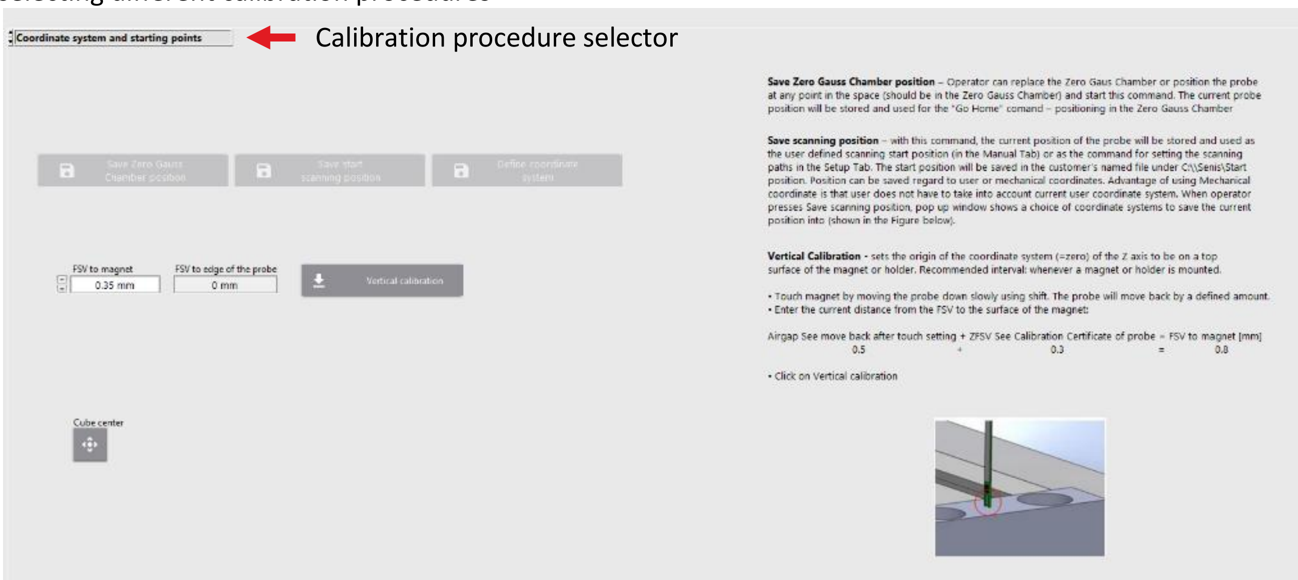


Figure 66: Calibration tab

7.4.1 Coordinate system and starting points:

Save Zero Gauss Chamber position sets the position of the Zero Gauss Chamber for the mounted Hall probe. This is only necessary after replacing a probe or changes to the mechanics. The probe is positioned in a Zero Gauss Chamber and the button is clicked.
By executing the above command, the current probe position will be stored and will be used as the target position for the “Go Home” command – positioning in the Zero Gauss Chamber
Recommended calibration period: Only when required.

Save scanning position: with this command, the current position of the probe will be stored and used as the user defined scanning start position (in the Manual Tab) or as the command for setting the scanning paths in the Setup Tab. The start position will be saved in the customer’s named file under C:\\Senis\Start position. The probe position can be saved using the user or mechanical coordinates. The advantage of using Mechanical coordinate is that users do not have to take into account the current user coordinate system. When an operator presses Save scanning position, a pop-up window shows a choice of coordinate systems to save the current position into (shown in the Figure below).
To use the stored positions, go to the Manual tab and activate Go to scanning position or use the corresponding text command (See command syntax).

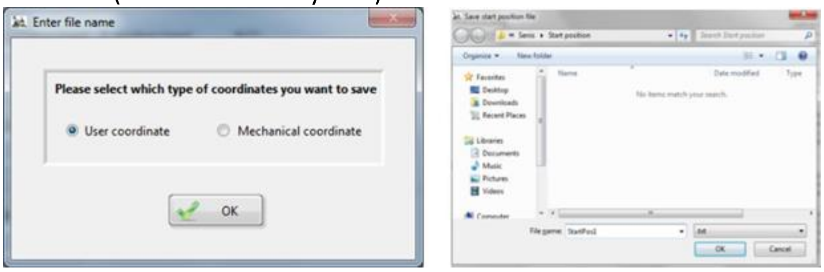


Figure 67: Pop up window for saving scanning position. Operator can choose between the user and the mechanical coordinate (recommended) for saving position in space.

Save coordinate system allows defining the origin of the coordinate system at the current position of the axis (X,Y,Z,R) in a text file. A coordinate system can then be loaded by selecting “custom” in the top level commands.

Vertical calibration: Set the origin of the coordinate system (=zero) of the Z axis to be on a top surface of the magnet or holder.
Recommended interval: whenever a magnet or holder is mounted.

- Touch the magnet by moving the probe down towards the magnet, slowly using the shift key on the PC keyboard. After touching the magnet, the probe will move back (up) by a defined amount (Touch release in the Manual Control Tab).
- Enter the current distance from the FSV to the surface of the magnet (as per calibration certificate):

Airgap See “move back after touch setting” (Touch release)	+	FSV to edge of the probe See Calibration Certificate of probe	=	FSV to magnet [mm]
0.5	+	0.3	=	0.8

- Click on Vertical calibration

7.4.2 Center of rotary stage calibration

- Defines the origin (=zero) of the center of rotary stage coordinate system in X and Y axis.
- Senis recommends using the multipole or basic dipole method due to higher repeatability.
- When calibrating a probe for the first time the basic calibration method has to be used.

- In addition, it is recommended to compare the results with the result of the last execution. In case of significant differences, it is recommended to repeat the calibration.
- Recommended interval: weekly or before a measurement if high precision is required.
- Check deviation of old and new values. Repeat calibration if the difference is high.

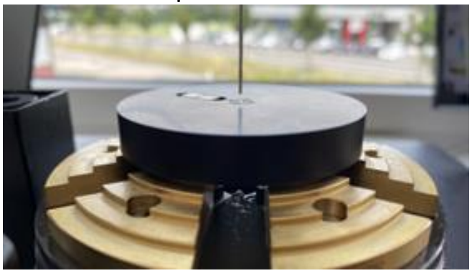


Figure 68: Starting position for the basic center of rotation calibration

Center of rotary stage dipole

- Mount the center of rotation calibration tool and position the probe above its center (X=0, Y=0) with an airgap of around 2mm in Z above the tool. (If the system has never been calibrated, position the probe by eye above the reticule). Press the Center of rotary stage calibration button.
- The calibration will be conducted automatically, and the center of rotation will be updated.

Center of rotary stage zero crossing

The instructions are identical to the dipole method

Center of rotary stage multipole

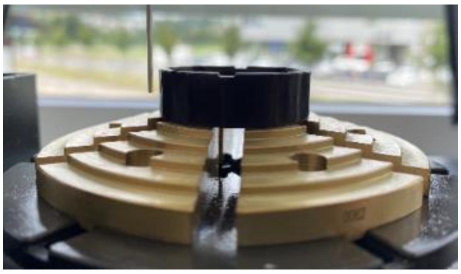


Figure 69: Starting position for the multipole center of rotation calibration

- Mount a multipole magnet (ideally >6 poles) on the rotary stage. Senis uses a plastoferrite encoder ring magnet and delivers one along with every mapper.
- Position the probe on the left of the magnet: Y=0, X on the left of the magnet with an airgap of around 2mm airgap to the magnet. If you're using the ring magnet delivered by Senis X=-18.8mm is a good value.
- Position the probe in Z-axis, so that the FSV is approximately at the middle of the magnet.
- Rotate the magnet and check that the pole maxima reach around 40…80% of the full field range. If the 100mT range is used the field should be around 40…80mT. Else, reposition the probe in ±X accordingly

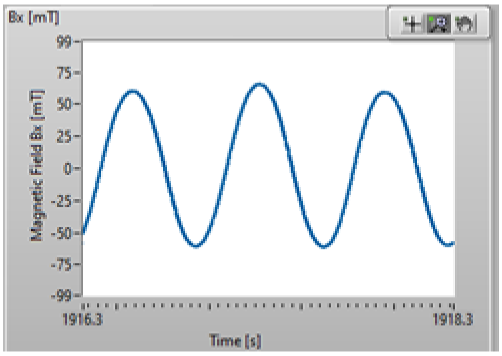


Figure 70: Radial field of magnet at good distance from the multipole magnet

- Optional: Click on: “Save start position for multipole center or rotation” This will define the current position as the start position and the probe will automatically drive to the position when you start the calibration, without the need to search for the correct position
-
- Click on “Start center of rotation calibration”
- If a higher magnet is used and the probe collides with the magnet when moving from left to right, the Z movement value can be adjusted to increase the Z travel.

7.4.3 FSV calibration

- Function: Define the origin (=zero) of the FSV tool coordinate system.
- Recommended interval: daily to monthly

FSV Calibration

- The calibration is fully automated and can be started by pressing the FSV calibration button.
- Check deviation of old and new values. Repeat calibration if the difference is above 20um.

Set new FSV Calibration start position

This command shall be executed only if necessary, i.e. if the new probe is delivered. Storing the wrong coordinates might cause the FSV Calibration not to work properly.

- Function: Defines the start position of the FSV calibration
- Recommended interval: Only necessary for new Hall probes or if the FSV tool was relocated.
- Set touch release to 0.5mm in the Manual tab
- Touch FSV plate from top in Z- while holding shift. Confirm the message. The probe is now at the correct Z position.

Figure 71: Touching FSV from top

- Move the probe in X and Y above the reticule in the top of the FSV tool.

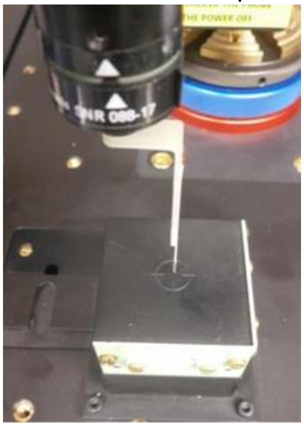


Figure 72: Position probe above FSV reticule

- Press the Set new FSV Calibration start position button

7.4.4 Stylus calibration

- Function: Determines the stylus offset. Distance in X, Y, Z in between the FSV and the center of the ruby ball of the stylus
- Recommended interval: daily to monthly

Figure 73: Stylus Calibration

Stylus Calibration

- The calibration is fully automated and can be started by pressing the FSV calibration button.
- Check deviation of old and new values. Repeat calibration if the difference is above 20um.

Set Stylus reference position

This command shall be executed only if necessary, i.e. if the new probe is delivered. Storing the wrong coordinates might cause the Stylus Calibration not to work properly.

- Function: Defines the start position of the Stylus calibration
- Recommended interval: Only necessary for new Hall probes or if the FSV tool was relocated.
- Set touch release to 0.5mm in the Manual tab
- Touch FSV plate from top in Z- while holding shift. Confirm the message. The probe is now at the correct Z position.
- Move the probe in X and Y above the reticule in the top of the FSV tool.
- Press the Set new FSV Calibration start position button

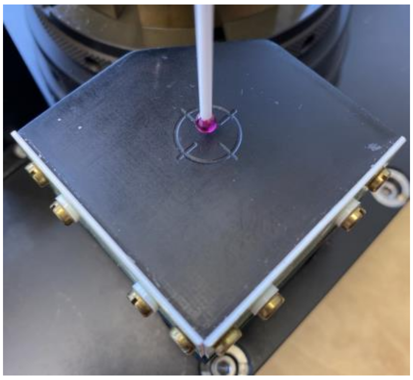


Figure 74: Position probe above FSV reticule

7.4.5 Defectoscope calibration

Defectoscope calibration allows zeroing the defectoscope.

7.4.6 Rotation alignment

Allows aligning an object on the rotary stage to satisfy a magnetic field condition:

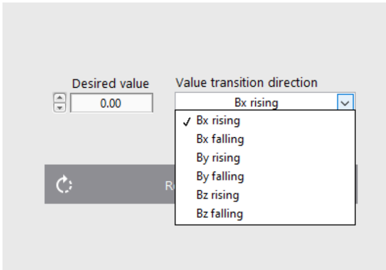


Figure 75: Rotation alignment

7.4.7 Touch alignment

Allows aligning a flat surface of an object mounted on the rotary stage with the X/Y axis. This requires a touch stylus.

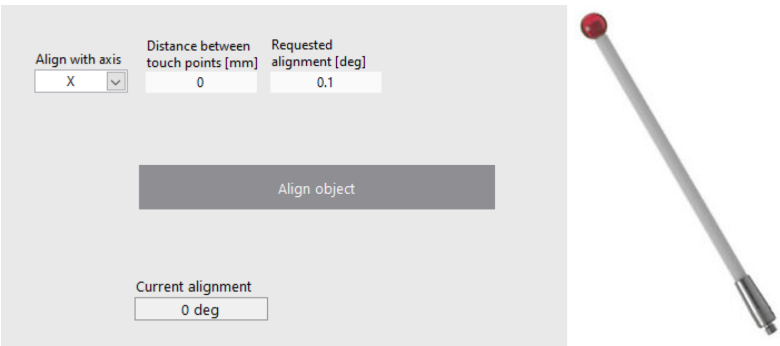


Figure 76: Rotation alignment and touch stylus

The probe will move in the axis perpendicular to the axis that should be aligned and touch the object at two points at the defined distance. It will then correct for the measured angle and repeat the process until the requested alignment is achieved.

7.4.8 Cube Calibration

Function: Orthogonalization of the sensitivity vectors Bx, By and Bz and aligns them with the mechanical axis X, Y and Z.

Recommended interval: monthly to yearly

Required components

- Calibration Cube
- Calibration certificate of calibration cube
- Holder for rotary stage (only for MMS-1A-RS)
- Right angle corner tool (only for MMS-1X-RS)

Preparation MMS-1A-RS

- Remove all jaws from the Maprox JF rotary stage
- Mount the calibration cube holder on the rotary stage with 3 brass screws
- Mount the calibration cube on the holder. Press down gently.

Preparation MMS-1X-RS

- Place the calibration cube in the corner tool

The Cube calibration process is semi-automated and user guided. Go to the Cube Calibration tab and start the process with start button.

Settings

- Z movement: Leave as is and reduce if cube hits Z limit switch during process
- X movement: Leave as is and reduce if cube hits X limit switch during process

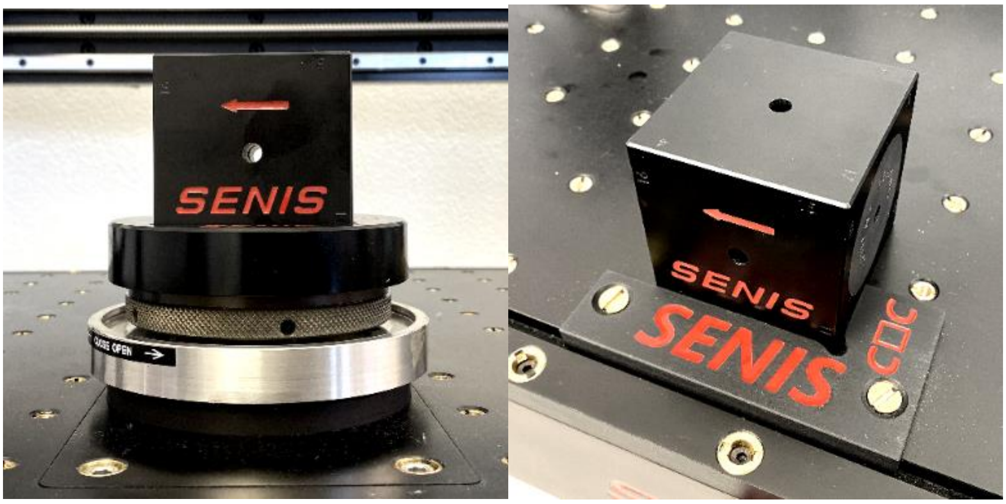


Figure 77: Calibration cube on rotation table holder (left; MMS-1A-RS) and on Corner Tool (right; MMS-1X-RS)

After the calibration you are given the following choices:

- Update the sensitivity matrix. This will orthogonalize the Bx, By & Bz components and align them with the moving axes X, Y & Z. This is recommended.
- Recalibrate the probes sensitivity. If your calibration cube has been calibrated recently, you may use this to calibrate the magnetic field transducer on your mapper. The combined uncertainty will be higher compared to a calibration in the SENIS laboratory. Make sure to have the calibration certificate of the calibration cube ready and enter the correct value in the specified field. Then the sensitivities for each component and each measurement range can be updated one by one or all together.

7.4.9 Sliding probe calibrations (Option MMS-SLIDE)

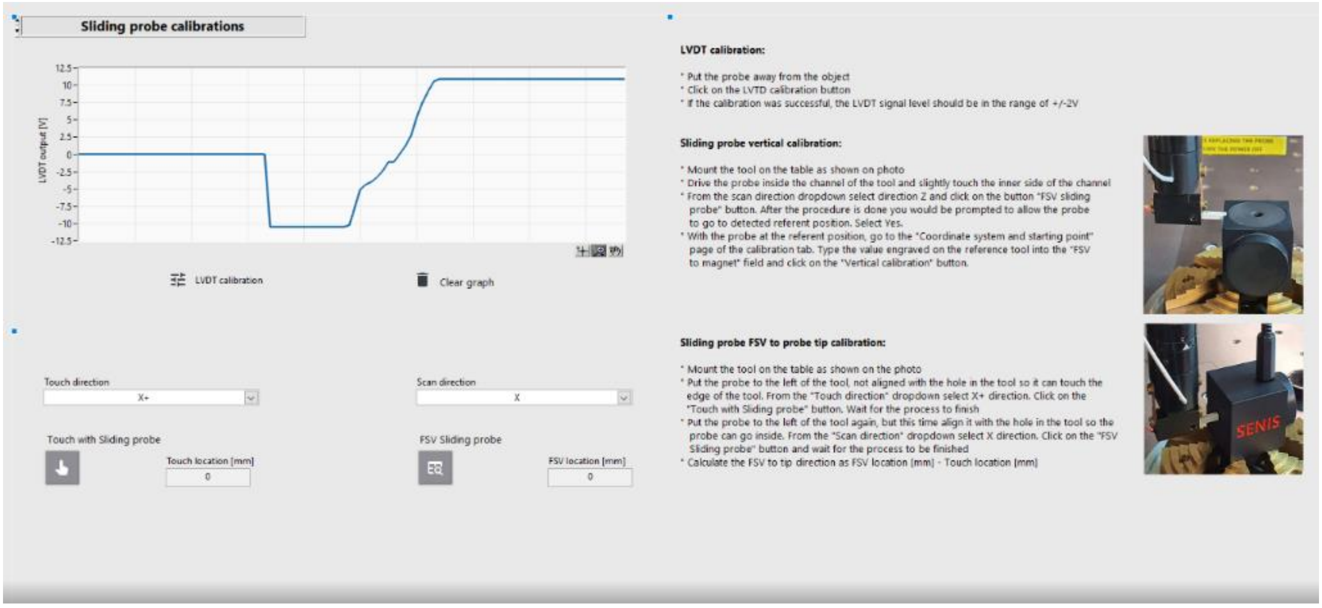


Figure 78: Sliding probe calibrations

Sliding probe deflection calibration

- Move the probe away from any object
- Click on the Sliding probe deflection calibration button
- If the calibration was successful, the LVDT signal level should be in the range of +/-2V

Sliding probe vertical calibration

- Mount the calibration tool on the table as shown on photo
- Drive the probe inside the channel of the tool and touch in X direction until the deflection indicator is green.
- From the scan direction dropdown select direction Z and click on the button “FSV sliding probe” button. After the procedure is done you will be prompted to allow the probe to go to the detected referent position. Select Yes.
- With the probe at the referent position, go to the “Coordinate system and starting point” page of the calibration tab. Calculate the offset from the required Z origin using value engraved on the reference tool and enter the value into the “FSV to magnet” field.
- Click on the “Vertical calibration” button.

Figure 79: Start position for sliding probe vertical calibration

Sliding probe FSV to probe tip calibration

- Mount the calibration tool on the table as shown on the photo
- Put the probe to the left of the tool, not aligned with the hole in the tool so it can touch the edge of the tool. From the “Touch direction” dropdown select X+ direction. Click on the “Touch with Sliding probe” button. Wait for the process to finish
- Put the probe to the left of the tool again, but this time align it with the hole in the tool so the probe can go inside. From the “Scan direction” dropdown select X direction. Click on the “FSV Sliding probe” button and wait for the process to be finished
- Calculate the FSV to tip direction as FSV location [mm] – Touch location [mm]

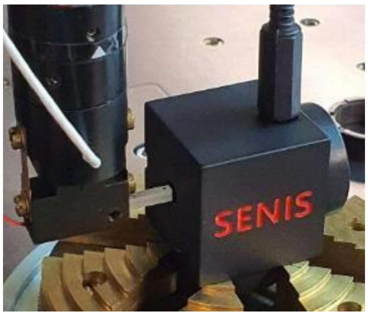


Figure 80: Sliding probe FSV to tip calibration start position

7.5 Setup Tab

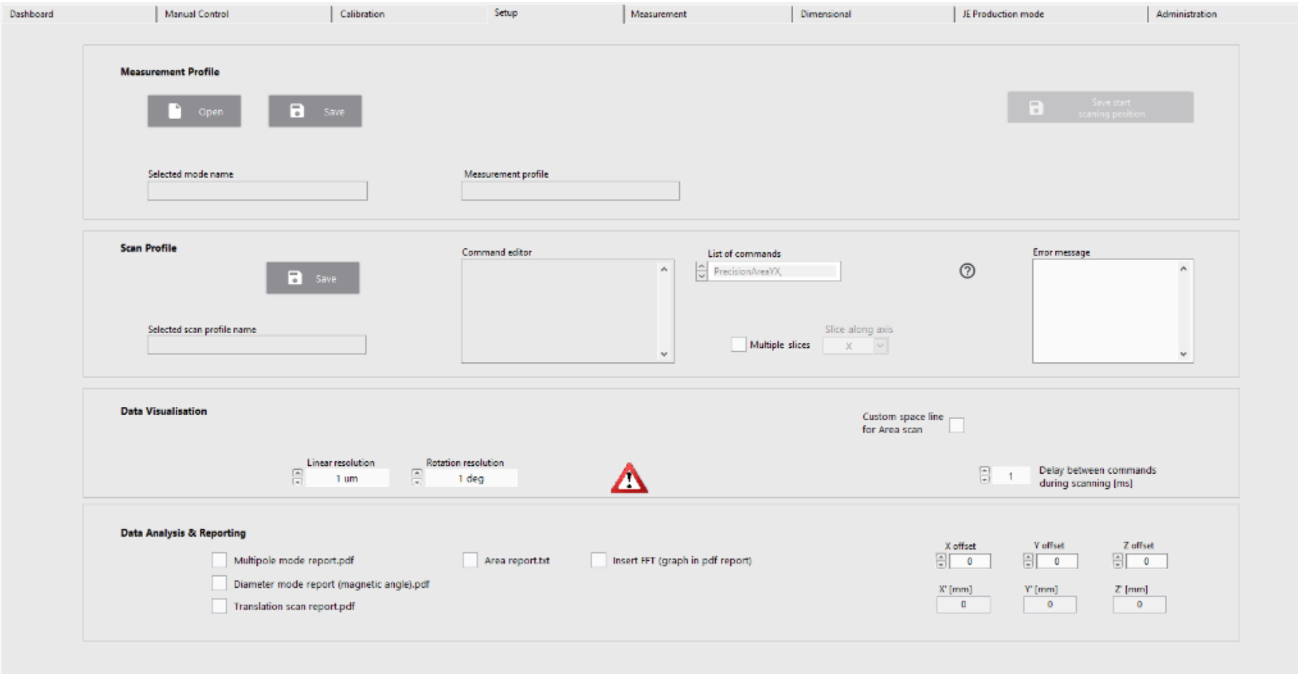


Figure 81: Setup Tab for Measurement Profile definition

The Setup Tab allows user to define a measurement profile, which consists of a feasible combination of the scanning path, the data visualization type (measured data display) and the PDF report type.

Scanning paths can be loaded, modified and stored. There are predefined scanning paths that cannot be modified and should be used for a standard measurement profile or as a template for user-defined measurement profiles. The system defines profiles are stored in the Measurement mode folder.

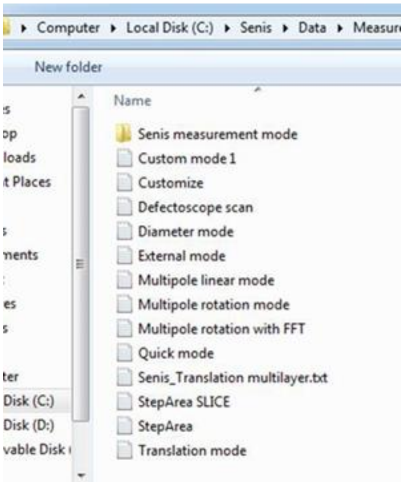


Figure 82: System-defined Measurement Profile files

7.5.1 Measurement Profiles

A measurement profile defines all relevant settings for a measurement. Typical predefined measurement profiles with feasible combinations of data visualization and reports are listed below. All measurement modes can be processed in a number of slices (distance in the Z-axis) and presented on the multiple diagrams. Please note that not all of measurement profiles are necessarily included in the delivery scope.
The user can modify any measurement profile and save it with another file name at any customer’s folder. When saving the profile, a profile type shall be selected to setup the required measurement environment.

7.5.2 Measurement modes (Legacy)

- Diameter mode – In this mode the probe is fixed in a desired distance from the center of a ring magnet or a disc magnet and the rotary stage turns, typically for 360°. The magnetic field is measured and the results (Bx, By, Bz, Bxy, Btot, Inclination, Declination) are presented on 1D plot (Amplitude vs rotation angle). The FFT (Angle harmonics) and homogeneity (angle error) visualization, as well as several measured data analyses are also available in this mode. The measurement can be processed in Multiple slices mode. The maximal scanning resolution is 0.1°.
- Multi-pole rotation mode – In this mode the probe is fixed on a desired distance from the center of a ring magnet or cylindrical magnet (rotor) and the rotary stage turns, typically for 360°. The magnetic field is measured and the measured results (Bx, By, Bz, Bxy, Btot, Inclination, Declination) are presented on 1D plot (Amplitude vs rotation angle) and in multislice and 3D plot for several slices. The FFT (“angle harmonics+) visualization, as well as several measured data analyses are also available in this mode. The measurement can be processed in Multiple slices mode.
- Multi-pole Linear mode – During this measurement, the probe moves above the magnet, while the magnet remains in a fix position. The probe starts measuring from a starting point, continues for the defined distance. After the distance is reached, the probe moves back to the starting point. The magnetic field is measured and the results (Bx, By, Bz, Bxy, Btot, Inclination, Declination) are presented on 1D plot (Amplitude vs distance). The FFT (“distance” harmonics) visualization, as well as several measured data analyses are also available in this mode. The measurement can be processed in Multiple slices mode.
- Translation single layer mode – During this measurement, the probe moves above the magnet, while the magnet is fixed. The probe starts measuring from a starting point, continues for the defined grid in X-Y plane. After the grid is scanned, the probe moves back to the starting point. The magnetic field is measured and the results (Bx, By, Bz, Btot) are presented on 2D and 3D color graphs.
- Translation multi-layer mode – During this measurement, the probe moves above the magnet, while the magnet is fixed. The probe starts measuring from a starting point, continues for the defined grid in X-Y plane in the defined number of slices (Z distances). After the grid is scanned, the probe moves back to the starting point. The magnetic field is measured and the results (Bx, By, Bz, Btot) are presented on 2D and 3D color graphs for several slices. This mode is used for Area, PrecisionArea and BidirectionalArea commands.
- StepArea – During this measurement, the probe moves above the magnet step-by-step, while the magnet is fixed. The probe starts measuring from a starting point, continues for the defined grid in X-Y plane with a defined time interval between each step, which is defined by the scanning resolution. After the grid is scanned, the probe moves back to the starting point. The magnetic field is measured and the results (Bx, By, Bz, Btot) are presented on 2D and 3D color graphs for several slices. The measurement can be processed in Multiple slices mode.
- StepArea SLICE – During this measurement, the probe moves above the magnet, while the magnet is fixed. The probe starts measuring from a starting point on continues for the defined grid in X-Y plane with a defined time interval between each step, which is defined by the scanning resolution. The scanning is done in the defined number of slices (Z distances). After the grid is scanned, the probe moves back to the starting point. The magnetic field is measured and the results (Bx, By, Bz, Btot) are presented on 2D and 3D color graphs for several slices. The measurement can be processed in Multiple slices mode.
- External mode – This mode might be used if the measurement is controlled by, or used for an external device. All commands available, including PrecisionArea and BidirectionalArea.
- Custom Mode – allows user to define the custom measurement profile setting and store it for further use. The reports and visualization can be modified (all combinations).
- Quick mode - allows user to define the custom measurement profile setting. The reports and visualization can be modified (all combinations). In this mode operator cannot save measurement mode.

7.5.3 Command Editor (List of Commands)

Find the command syntax file for reference included with this manual as a function reference explaining all the commands.

If an operator sets the resolution value that is not a divider of the selected scanned area (Area command), a warning will appear in the Error message

The commands have to be edited in the correct syntax, otherwise the measurement will not execute. The empty spaces or empty lines can contribute to the wrong syntax.

Due to Operating System limitations, 2’000’000 measurement points can be stored per one scan. This limitation shall be considered when defining the scanning resolution and the scan area.

The scanning path can be created or modified using the command editor. It provides a list of the available commands, which can be used for setting up a scanning path. The commands will be written in a txt file. To load the file, click on the browse icon and select the file. If the syntax in the file is not correct, the user will get the error message. Each command needs to be written in the new line.

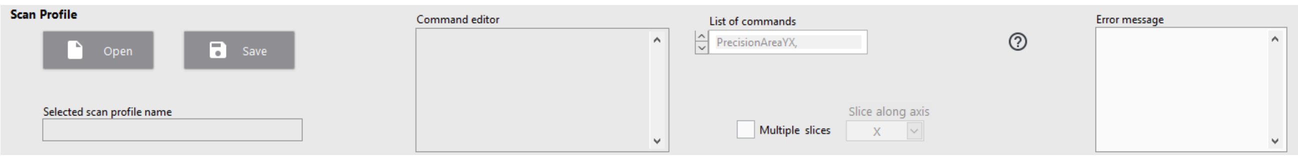


Figure 83: Command editor, list of commands and error message

- Open/Save allows saving and loading the measurement path (content of the command editor)
- The command editor allows editing the measurement path using text commands
- The list of commands shows and allows selecting possible commands.
- The (**?**) icon opens the command syntax.
- Error message displays possible warnings based on the entered commands
- Multiple slices indicates the system that a scan contains multiple levels.
- Slice along axis indicates along which axis the multiple scans are shifted.

7.5.4 Rotary scan path examples

Example 1: Simple scan of a single rotation of a multipole magnet

Preparation: Mount object on rotary axis and position the probe manually at the measuring position.

Scan path	***Explanation***
Sr+360	*Scan while rotating +360°: The system rotates the object on the rotary axis by 360° while measuring.*

Example 2: Semi-automatized scan of a single rotation of a multipole magnet

Preparation: Mount object on rotary axis

Scan path	***Explanation***

Go to scan pos,multipole1	*Go to start position stored in file: C:\Senis\MMS-2A-ROT\Start position\multipole1.txt. See **Error! Reference source not found.**.*
Sr+360	*Scan while rotating +360°*
My-10	*Move away from the probe to allow unmounting and mounting of the next sample.*

Example 3: Multislice scanning: Scanning of a cylindric surface with diameter=20mm and height=10mm

Preparation: Position the probe at the position Y=-10

Scan path	***Explanation***
Slice10	*Repeat the commands in between Slice10 and End slice 10 times. Usage is similar to the FOR loop programming command.*
Sr+360	*Scan while rotating +360°*
Mz+1	*Move 1mm in Z+ direction (up)*
End slice	*End repetition*
Mz-10	*Probe moves back to start position*

Alternative Solution Example 3:

Preparation: Position the probe at the position Y=-10

Scan path	***Explanation***
Cylinder+,10,1	*Identical to the Scan path above*

7.5.5 Linear scan path examples

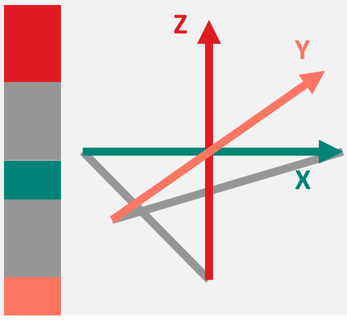
Defines the movement and measurement of the probe by a list of scan commands.

Example 1: Scanning the volume of a cuboid of 50x50x5mm (XxYxZ)

Commands	***Explanation***
Slice5	*Repeat the following commands 5 times, until the command "End slice". Usage is similar to the FOR loop programming command.*
PrecisionAreaXY,50,50	*Scan an area of 50x50 mm in the XY plane. The spatial resolution of the measurement spots is set in the Scan Setup tab (Linear Resolution field).*
Mz+1	*Move 1mm in Z+ direction (up)*
End slice	*End repetition*

Example 2: Scanning 3 lines in the shape of a 3-dimensional cross.

Commands	***Explanation***
Sz+5	*Scan 5mm in Z+ direction. The spatial resolution of the measurement spots is set in the Scan Setup tab.*
Mz-2.5	*Move 2.5mm in Z- direction (down).*
Mx-2.5	*Move 2.5mm in X- direction (left).*
Sx+5	*Scan 5mm in X+ direction.*
Mx-2.5	*Move 2.5mm in X- direction (left).*
My-2.5	*Move 2.5mm in Y- direction (to the back).*
Sy+5	*Scan 5mm in Y+ direction.*



7.5.6 Report types

Figure 84: Report types

There are following reports available:

- Multiple mode report – PDF report for multiple mode (with or without FFT)
- Diameter mode report – PDF report for diameter mode (with or without FFT)
- Translation scan report – PDF report for translation mode
- Area report – TXT file report for Area type scanning (matrix form)

7.5.7 Multilayer Scan (Slices)

Since there are three directions that the user can choose: X, Y and Z, the two directions define the scanning area and the third one defines the distance between two scanning planes. If the number of slices is one, the third direction is ignored.

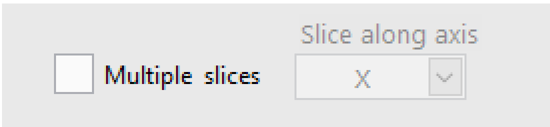


Figure 85: Defining multiple slices

For example, if the Translation mode and the X-Y plain is chosen, and X=3, Y=5, Z=1, the X and Y controls define the scanning area (3 mm x 5 mm). Further, if for instance, the chosen number of slices is two, the probe will scan the area 3 mm x 5 mm in the X-Y plane, move back to the starting point and then move up from the magnet surface for 1 mm in the Z axis direction, and scan another 3 mm x 5 mm area. In this way, the probe has scanned the area 3 mm x 5 mm in the two parallel planes with 1 mm distance between them. The graphical display of the measured results will appear from left to right for each new plane. After the scan is finished, the probe will move back to the starting point of the first plane. In this way, the measurements can be repeated, without re- adjusting the probe position.

If the multiple slice mode is selected, additional options show when you select Multiple Slices button. After selecting it, ‘Referent line’ button appears. This option is used for selecting the referent slice among the multiple slices scanned. If the Referent line is selected, the two additional commands show up: Slice no for the referent line (defines the referent slice number, e.g. if 10 slices are scanned, the second slice might be declared as the referent slice/line), Component field for ref line (defines the magnetic field component to be used for the referent slice) – this referent line will be differently presented in the graph as in the figure below.

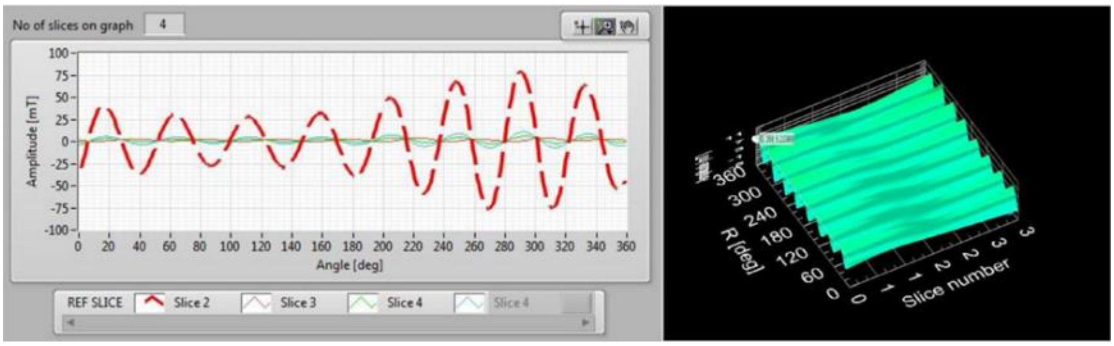


Figure 86: Visualization of the referent line

7.5.8 Scanning Resolution

Scanning resolution is user selectable. Keep in mind that better resolution means longer scanning time. It is not recommended to use better scanning resolution than 0.1 mm since it would take too much time to finish the scan (except for the very small scanning area) and will generate a large raw data file. The positioning (scanning) resolution can be selected for the linear modules (X, Y, Z) and also for the rotary stage. If an area is scanned, the Scanning resolution refers to the main axis and the user can select a different resolution for the auxiliary axis (Space between scanning lines).

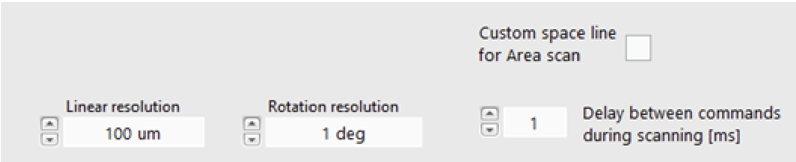


Figure 87: Scanning resolution settings

7.6 Measurement Tab

The Measurement Tab features 1D, 2D and 3D visualization options for single or multiple slices, as well as analysis options for multipole magnets (encoder magnets, permanent magnet rotors), dipole encoder.

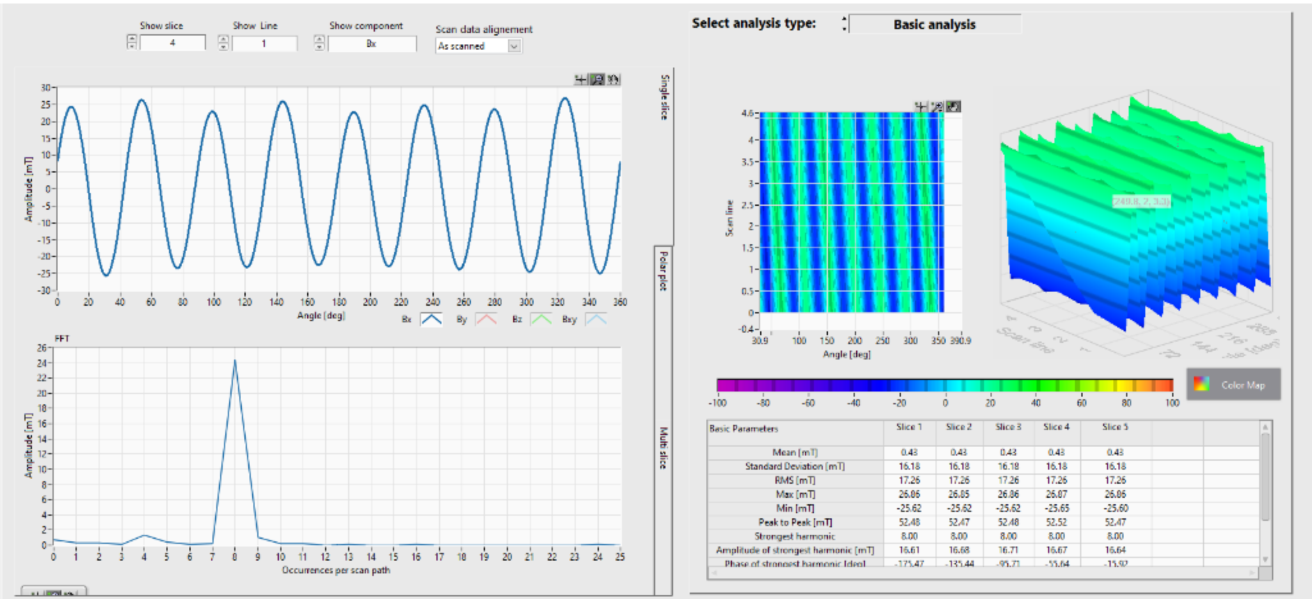


Figure 88: Measurement tab

- Show slice: Select the slice number to be shown
- Show line: Select the line number to be shown
- Show component: Select component to be shown
    - B_x, B_y, B_z
    - $B_{xy} = \sqrt{{B_x}^2 + {B_y}^2}$
    - All components
    - $B_{tot} = \sqrt{{B_x}^2 + {B_y}^2 + {B_z}^2}$
    - $\text{Inclination} = \text{atan}\left(\frac{B_y}{B_x}\right)$
    - $\text{Declination} = \text{atan}\left(\frac{B_z}{B_x}\right)$
- Scan data alignment: Select the alignment of the signal on the X axis
    - As scanned: Signal start reflects the start of the measurement

  - Zero crossing: Signal is shifted so it starts at a zero crossing
  - Maximum: Signal is shifted so it starts at the maximal positive pole peak.
- Select analysis type:
  - Basic analysis
  - Multipole analysis
  - Diameter analysis

7.6.1 Single slice visualization

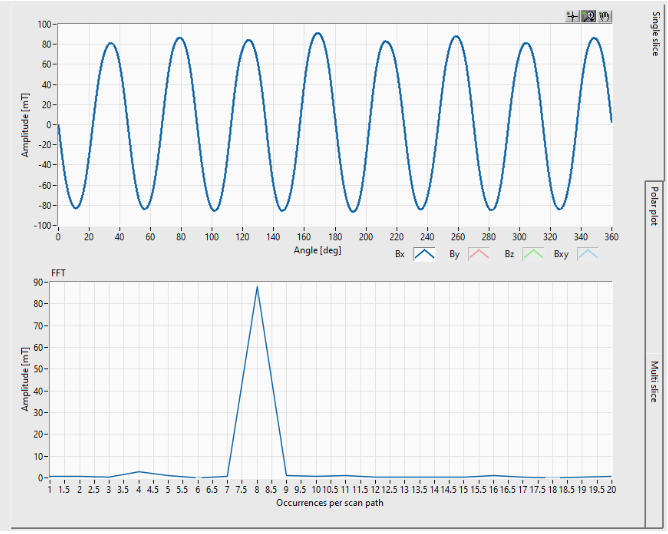


Figure 89: Single slice visualization shows the selected slice/line/component. As well as the magnitude of the FFT

7.6.2 Polar plot visualization

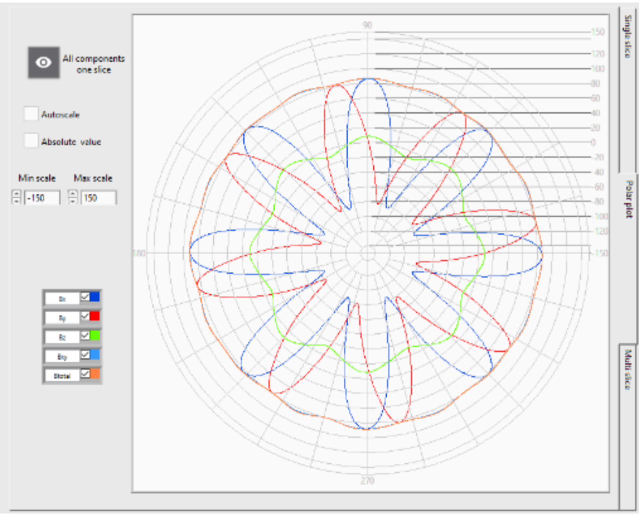


Figure 90: Visualization in polar coordinates

7.6.3 Multi slice visualization

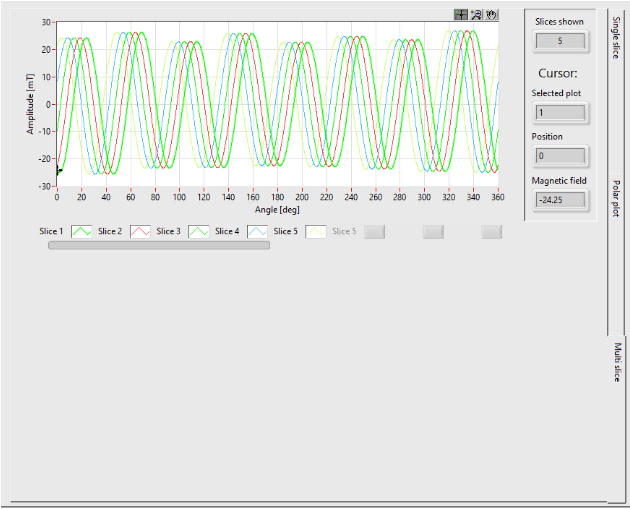
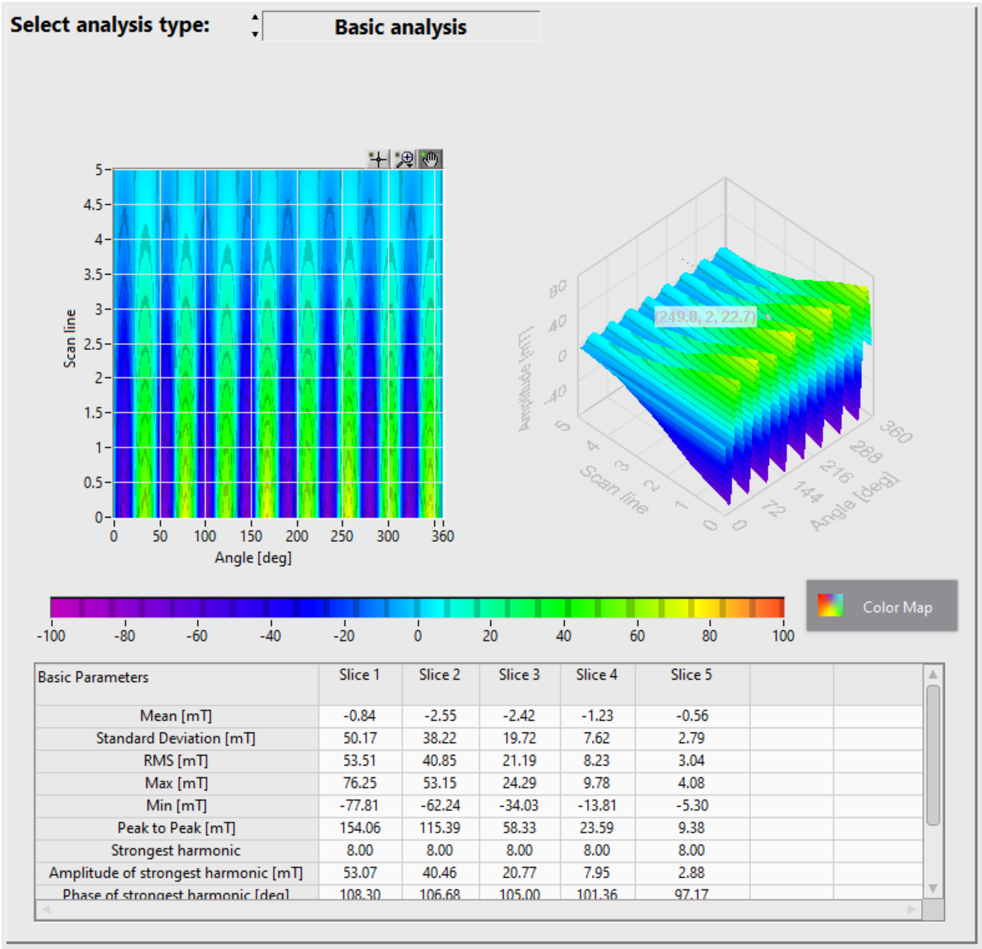


Figure 91: Visualization of multiple slices

7.6.4 Basic analysis

The basic analysis returns typical signal processing results



Basic Parameters	Slice 1	Slice 2	Slice 3	Slice 4	Slice 5
Mean [mT]	-0.84	-2.55	-2.42	-1.23	-0.56
Standard Deviation [mT]	50.17	38.22	19.72	7.62	2.79
RMS [mT]	53.51	40.85	21.19	8.23	3.04
Max [mT]	76.25	53.15	24.29	9.78	4.08
Min [mT]	-77.81	-62.24	-34.03	-13.81	-5.30
Peak to Peak [mT]	154.06	115.39	58.33	23.59	9.38
Strongest harmonic	8.00	8.00	8.00	8.00	8.00
Amplitude of strongest harmonic [mT]	53.07	40.46	20.77	7.95	2.88
Phase of strongest harmonic [deg]	108.30	106.68	105.00	101.36	97.17

Figure 92: Visualization of multiple slices

- Mean: mean value of the signal in mT
- Standard deviation: standard deviation of the signal in mT
- RMS: root mean square value of the signal in mT

- Max: maximal value of the signal in mT
- Min: minimal value of the signal in mT
- Peak to Peak: maximal value – minimal value of the signal in mT
- Strongest harmonic: index of the highest magnitude of the FFT of the signal.
- Amplitude of the strongest harmonic: highest magnitude of the FFT of the signal in mT
- Phase of the strongest harmonic: phase of the FFT at its highest magnitude in degrees
- SINAD: Signal-to-noise and distortion ratio of the signal in dB
- Total Harmonic Distortion (THD) is a measurement of the harmonic distortion present in a signal and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency.
- Single Harmonic Distortion (SHD) is the ratio of the power of the specified harmonic (the highest) to the power of the fundamental frequency with the fundamental frequency being the detected frequency of the signal.

7.6.5 Multipole analysis

The Multipole analysis provides typical results for multipole encoder magnets (linear or rotary) or permanent magnet rotors for electric motors or similar.

The analysis is based on assumptions and was tested with typical industrial magnets. It assumes a harmonic signal with zero crossings in between poles (no large offsets). For rotary measurements it assumes a periodic signal (start and end of the signal are at the same position). It might not work for any specific magnets (magnetizations). If the analysis is unsatisfactory a customer specific analysis might be required to be implemented by SENIS.

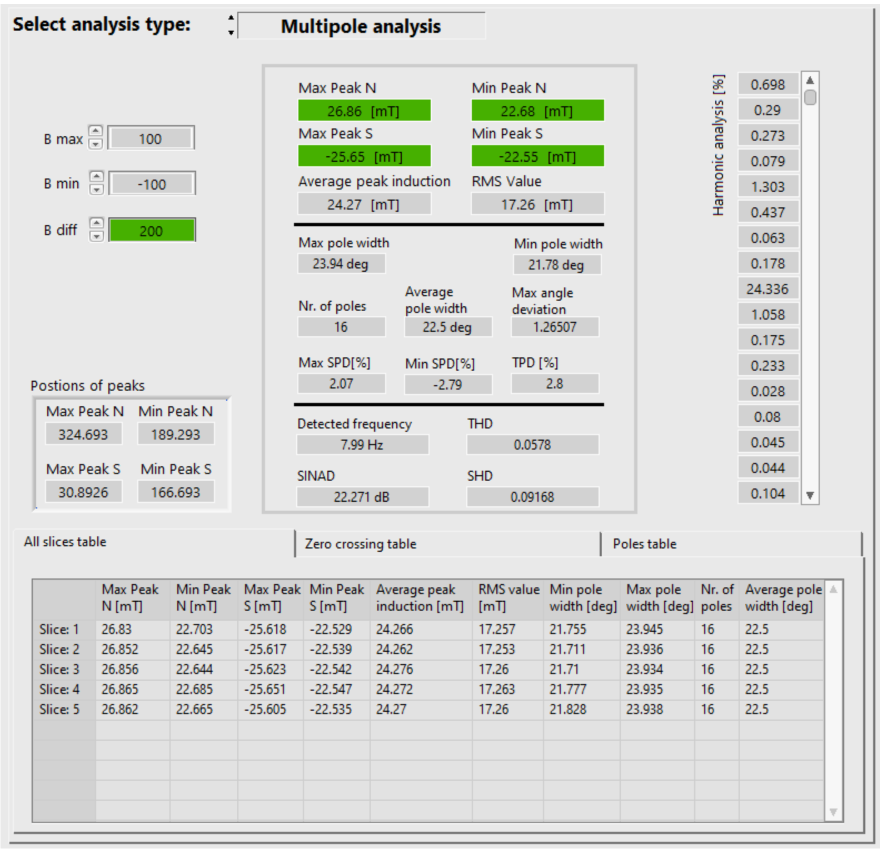


Figure 93: Multipole analysis

- The Bmax/Bmin controls allow setting max and min values for the fields. The corresponding values will be displayed on a green/red background.
- The B diff control allows setting a required maximal peak to peak value. If the measured peak to peak value is above B diff its background turns red.
- Average peak inductions shows the mean of the absolute value of all peaks.
- B_{RMS} is the root mean square of the measured signal.
- Pole width is the distance in degrees in between two zero crossing to zero crossing.
- Single Pitch Deviation (SPD) is the percentage of pitch error of each pole pair to reference pitch.

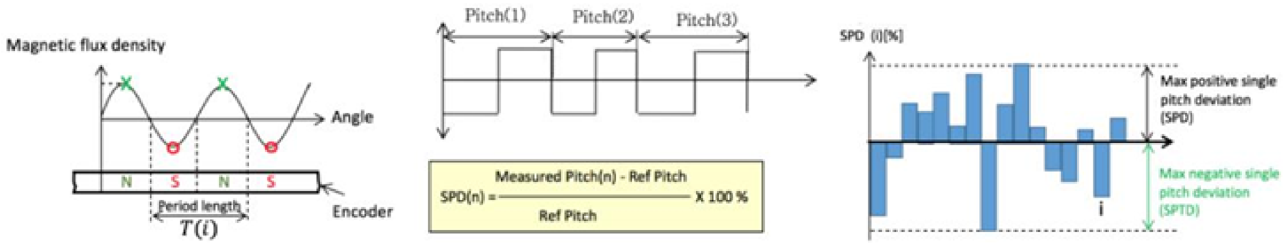


Figure 94: SPD calculation

- Total Pitch Deviation (TPD) is the calculation of the single pitch as an accumulate sum, and then the calculation of the difference between the greatest and smallest values of the accumulated TPD.

$$TPD(n) = \sum_{k=1}^{k=n} SPD(k)$$

$$TPD = Max(TPDn) - Min(TPDn)$$

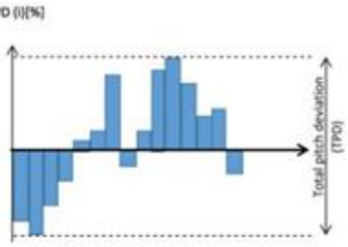


Figure 95: TPD calculation

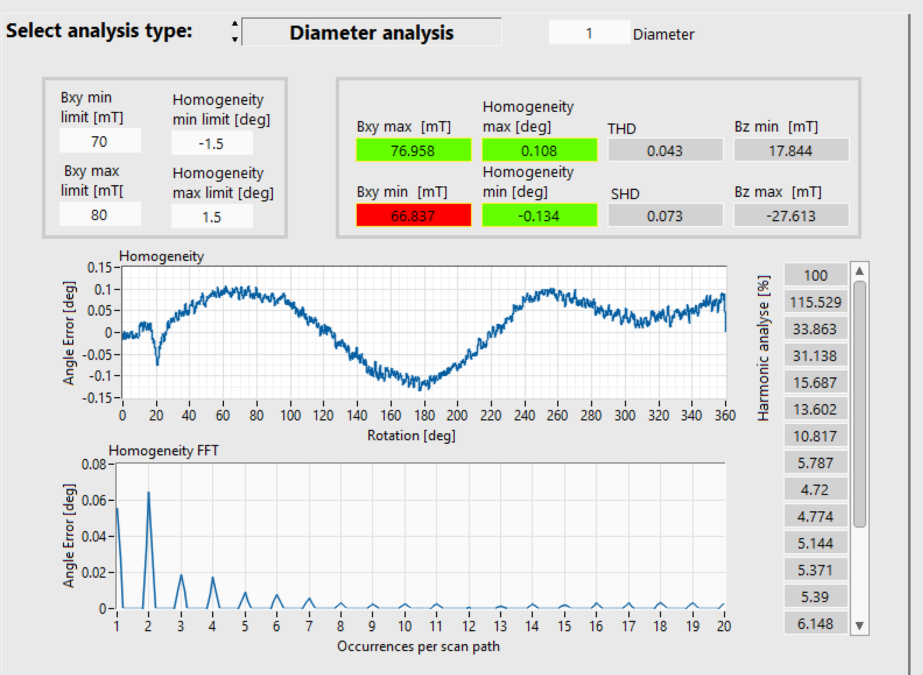
- SINAD: Signal-to-noise and distortion ratio of the signal in dB
- Total Harmonic Distortion (THD) is a measurement of the harmonic distortion present in a signal and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency.
- Single Harmonic Distortion (SHD) is the ratio of the power of the specified harmonic (the highest) to the power of the fundamental frequency with the fundamental frequency being the detected frequency of the signal.

The Zero crossing table shows all the detected zero crossings. To improve the zero-crossing detection, the signal is linearized over 5% of the pole width.

The Pole table shows information for all the detected poles

7.6.6 Diameter Analysis

The diameter analysis provides tools to evaluate diametrically magnetized dipole magnets for angle sensor applications.



	Bxy max [mT]	Bxy min [mT]	Homogeneity max [deg]	Homogeneity min [deg]
Slice 1	76.868	75.967	0.323	-0.013
Slice 2	76.958	66.837	0.108	-0.134

Figure 96: Diameter Analysis

- B_{XY} min/max allows setting the tolerance for the planar field component B_{XY}.
- Homogeneity max/min allows setting the tolerance for the Homogeneity.
- Total Harmonic Distortion (THD) is a measurement of the harmonic distortion present in a signal and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency.
- Single Harmonic Distortion (SHD) is the ratio of the power of the specified harmonic (the highest) to the power of the fundamental frequency with the fundamental frequency being the detected frequency of the signal.
- Homogeneity shows the angle error. This is defined as the difference between the magnetic field direction and the encoder of the mapper

7.6.7 2D graph visualization

For each graph, the magnetic field component can be selected.

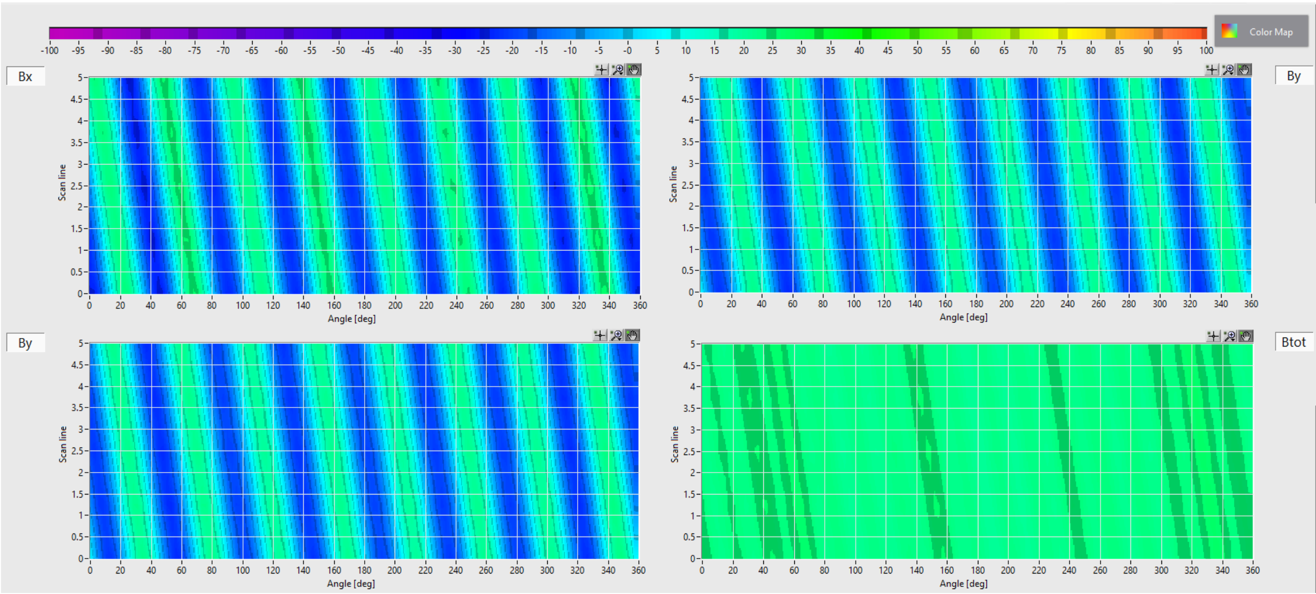


Figure 97: 2D graph visualization of 4 components

7.6.8 3D graph visualization

For each graph, the magnetic field component can be selected.

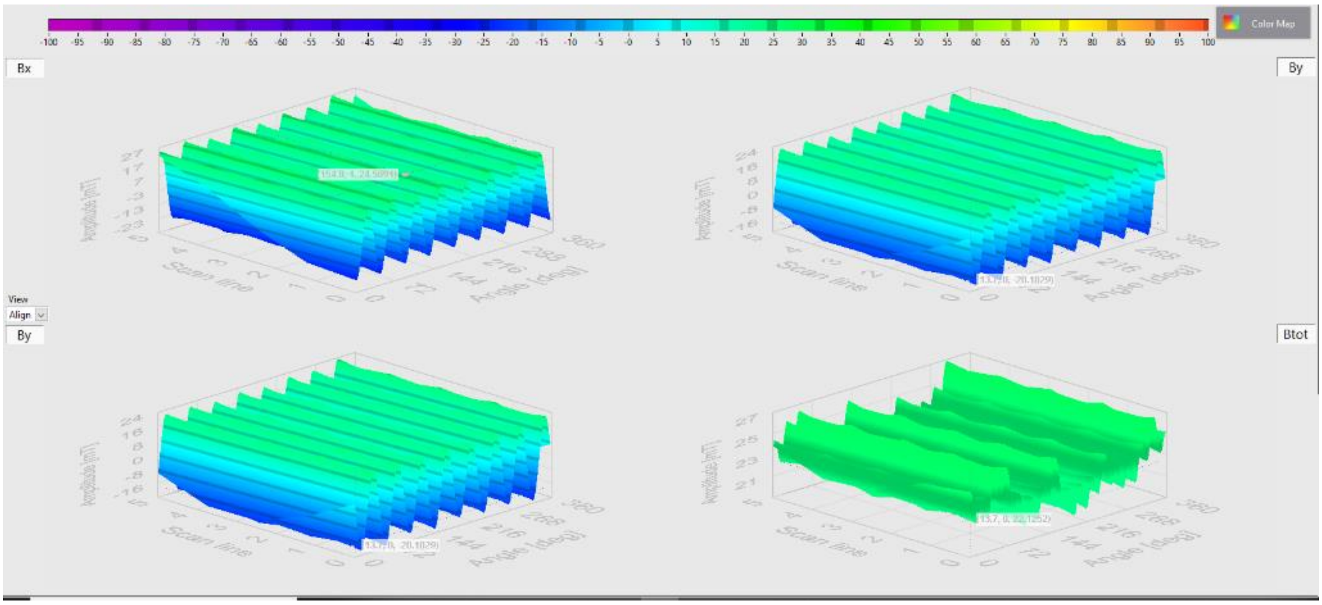


Figure 98: 3D graph visualization of 4 components

7.7 Additional Analysis Software (Option MMS-ANALYSIS)

MMS-ANALYSIS is an additional software module of the MMS-1A-RS magnetic field mapper software that can be used for the analysis of the measured data. It visualizes the measured data and calculated magnet parameters in various, customized and intuitive color-coded displays and tables.

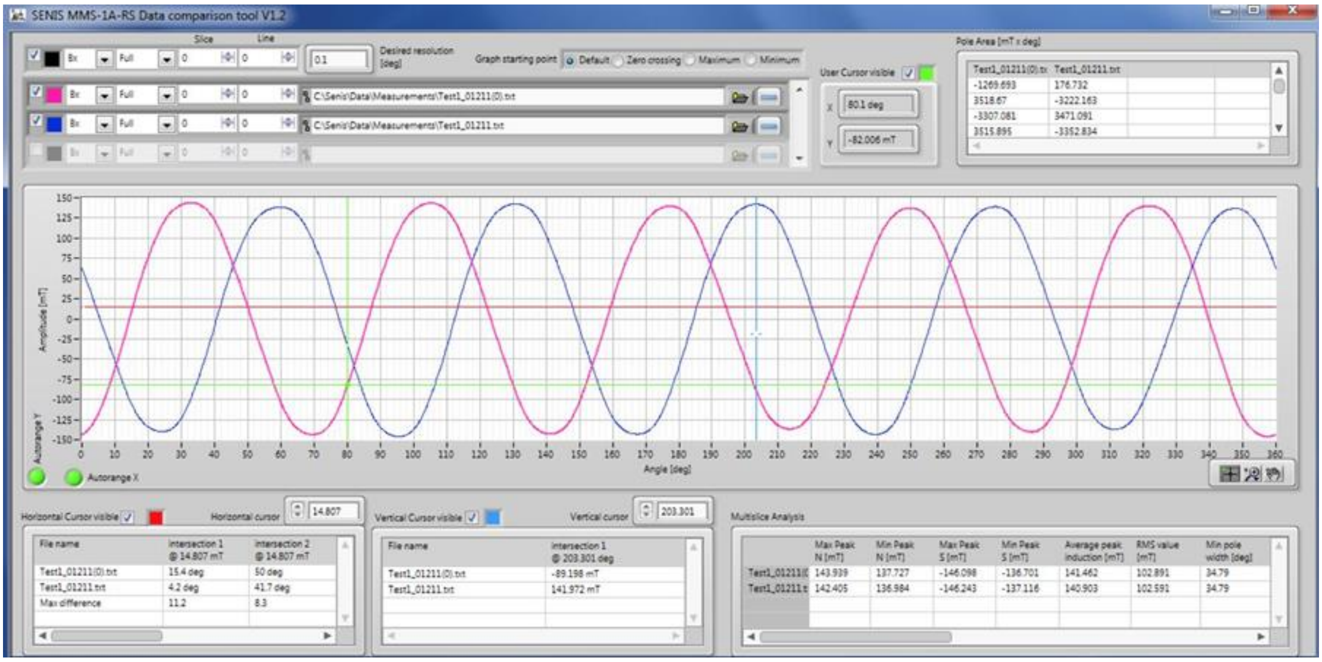


Figure 99: Software module for measured analysis and comparison, including cursor features

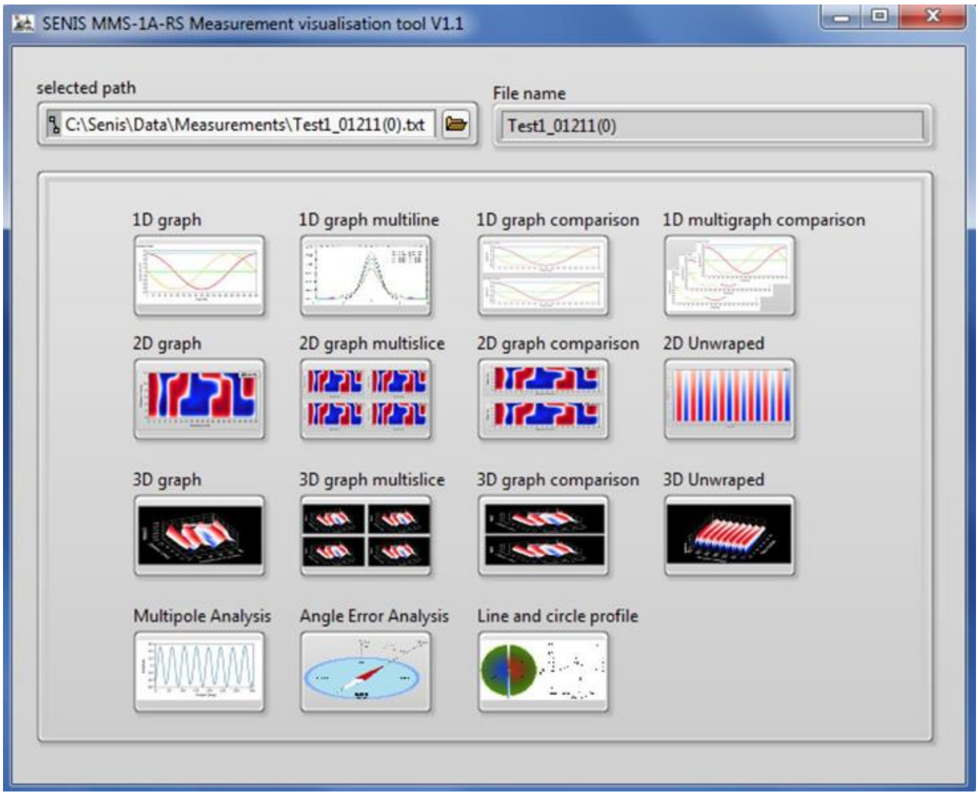


Figure 100: Software module for measured data visualisation, analysis, comparison

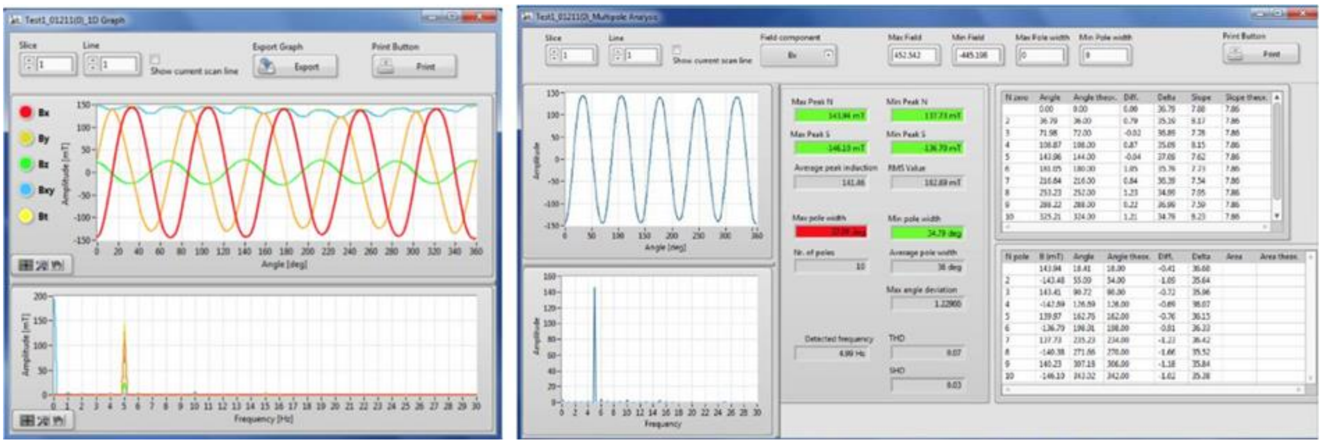


Figure 101: Various 1D data analysis and visualisations

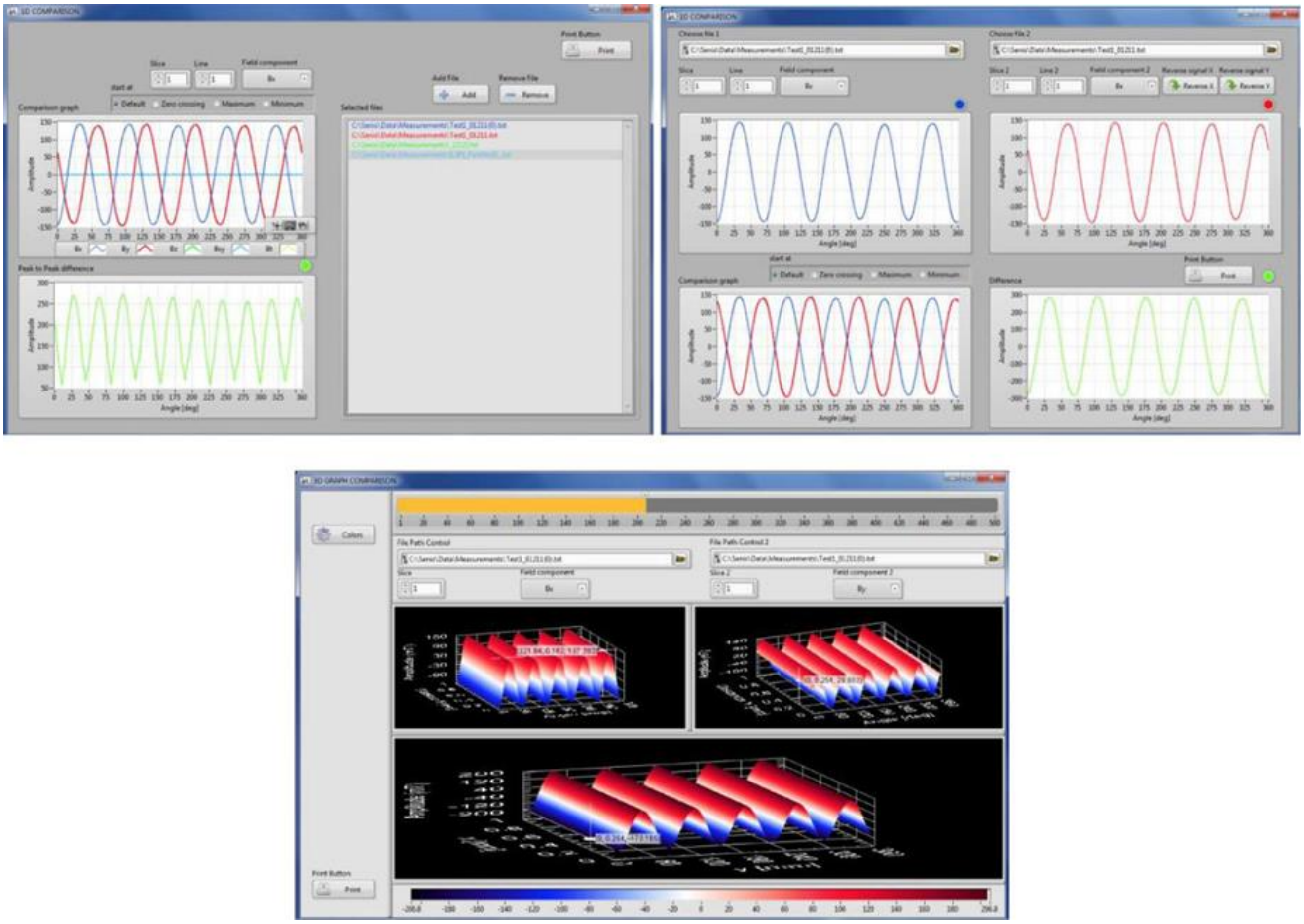


Figure 102: 1D and 2D Data comparison with the visualisation of the differences

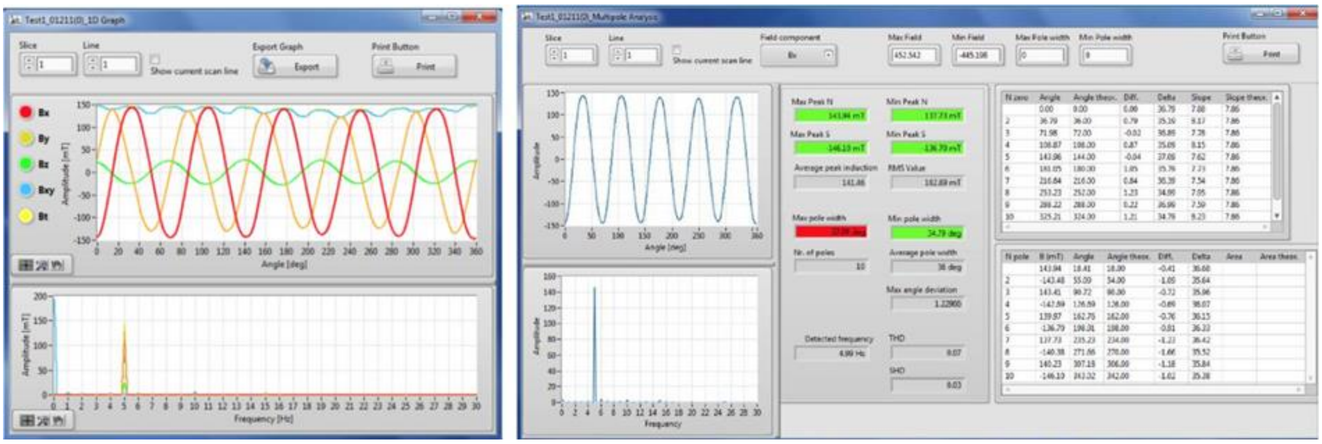


Figure 103: Various 1D data analysis and visualisations

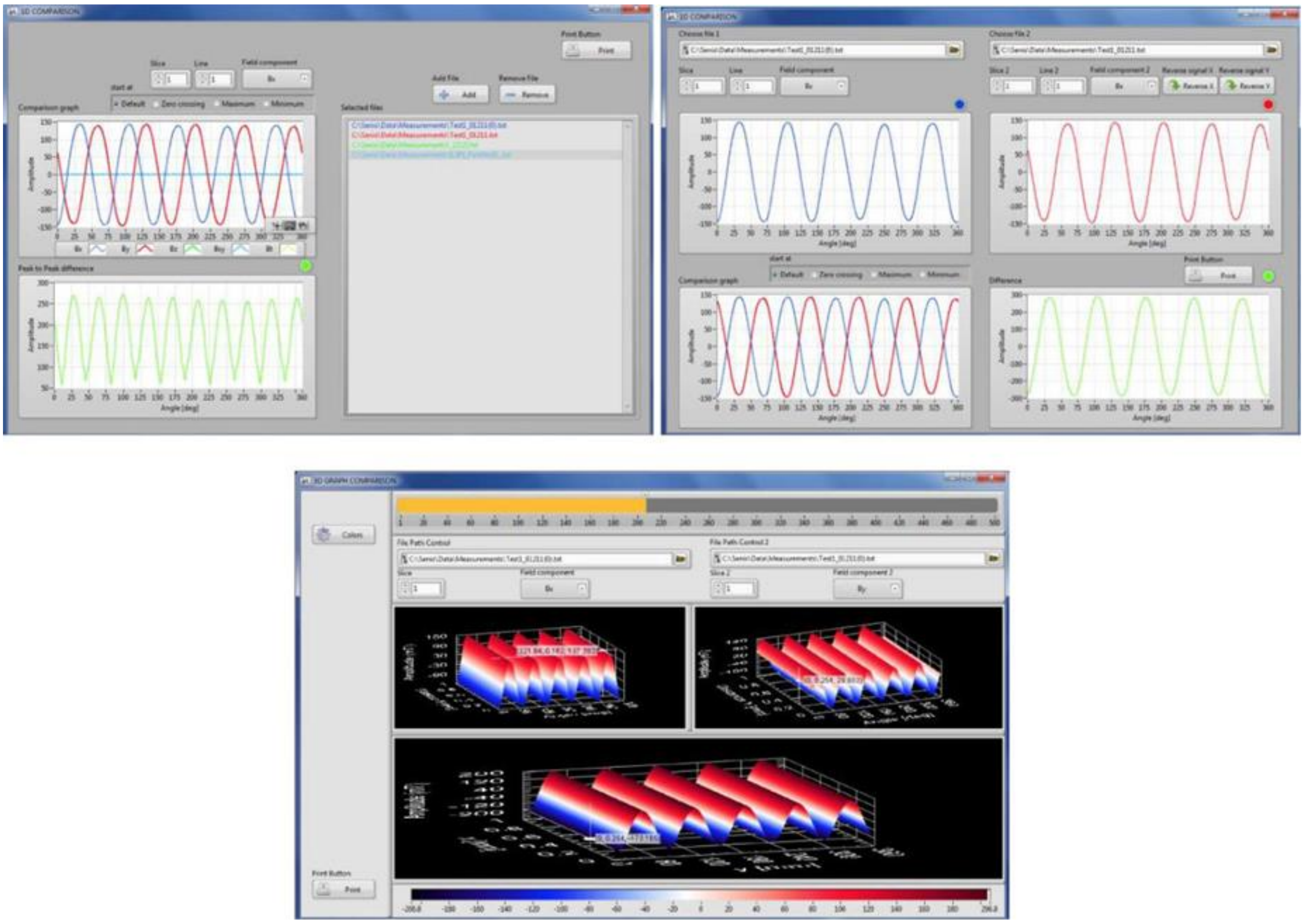


Figure 104: 1D and 2D Data comparison with the visualisation of the differences

7.8 Dimensional Tab (Option MMS-CMM)

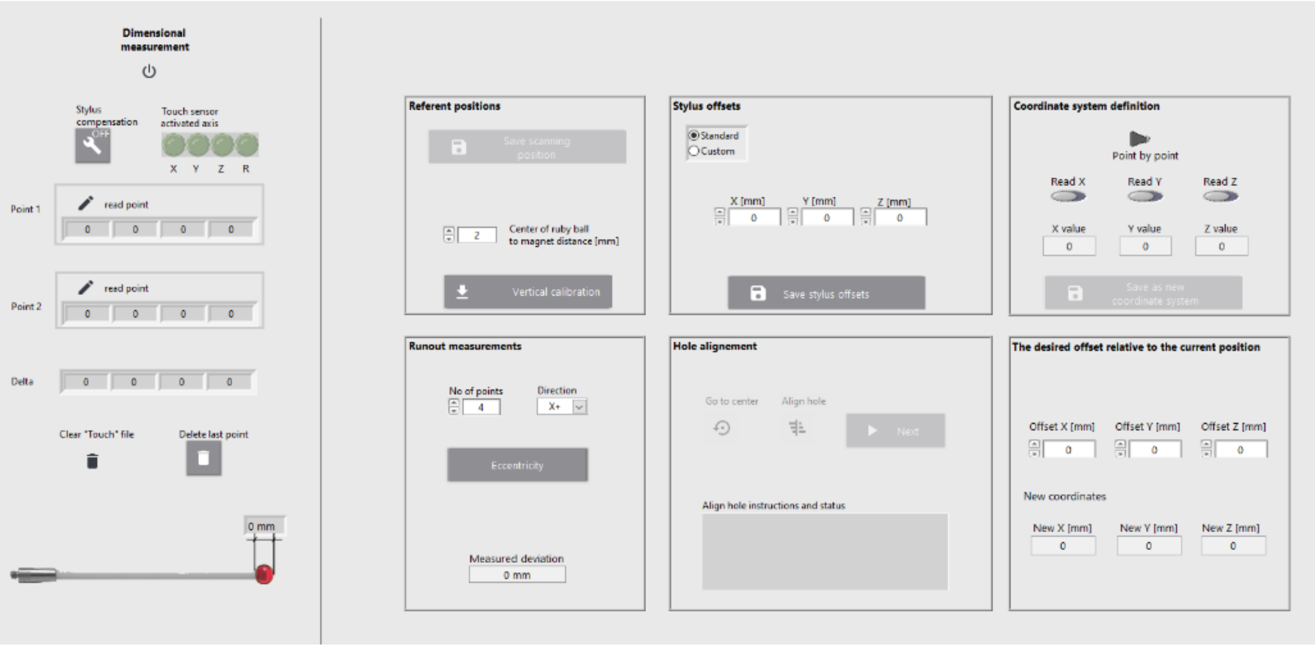


Figure 105: Dimensional Tab

Measurement probes are mounted (mechanically connected) to the touch sensor, which is fixed on the Mapper moving console. During the magnetic field mapping, the touch sensor is used to prevent probe damage. As soon as the Hall probe touches an object, the touch sensor triggers and stops the probe movement. The Touch sensor is a mechanical device that returns the stylus ball to the same repeatable position following any deflection. The touch sensor is connected to the controller, so that the movement of the probe is stopped when it touches an object.

If the Dimensional Measurement Option was ordered, a touch stylus and a dedicated software module is delivered to be used for the dimensional measurement. Due to application of linear and rotary encoders, the probe position coordinates are accurately measured.

For the dimensional measurement of an object under test (e.g. a permanent magnet), the touch-stylus has to be mounted on the touch-trigger sensor, so it replaces the Hall probe. It can be well used for simple measurement of the magnets under test (radius of a ring or disc magnet), length and height of a square magnet etc.

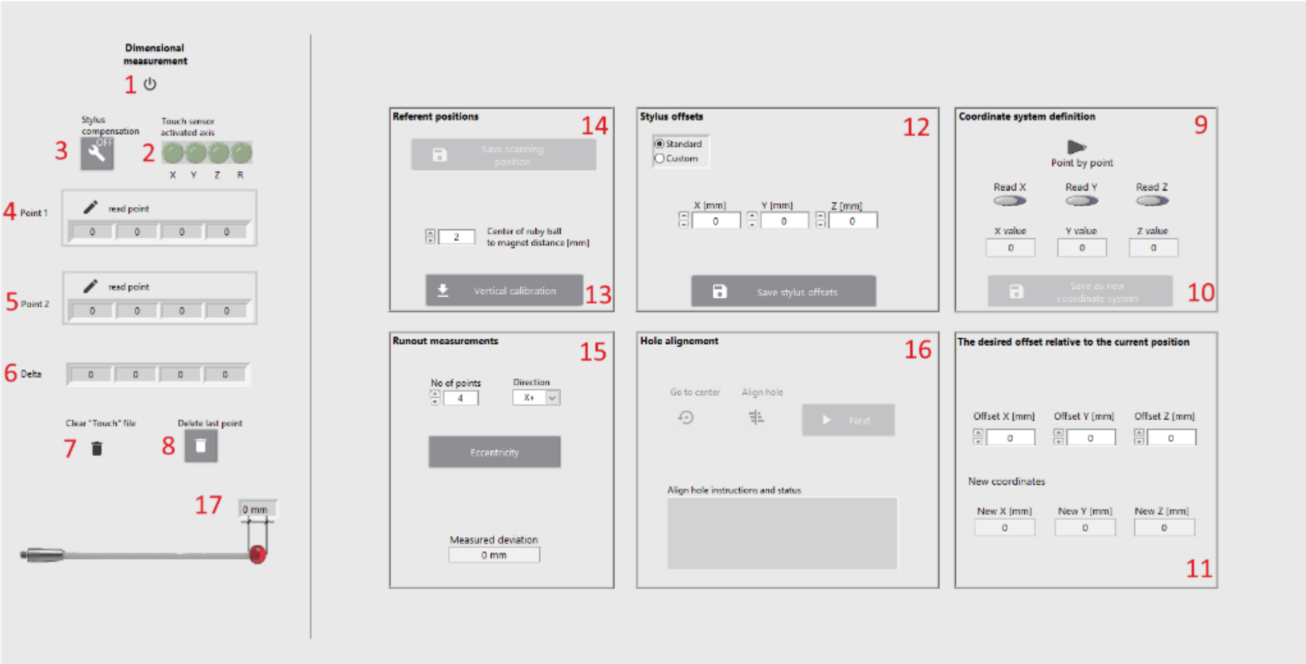


Figure 106: Dimensional Tab controls

1. Dimensional measurement: In standard operating mode, when a probe hits some object, the system will stop the movement and detach/move the probe in the opposite direction. The movement continues for an additional distance that is set in the Administration Tab (default is 0. 5 mm). Turning on the Dimensional measurement button (control 1 in Fig. 148) the probe will no longer make the additional movement, i.e. it will just detach the object, without triggering the touch sensor. By default, this button is always ON when the dimensional tab is open.
2. An indicator will show the axis to which the probe is moved as it touches an object.
3. Stylus compensation used to determine the dimensions of the object using touch stylus. Since the sapphire ball of the touch stylus has a diameter of 4mm it will affect the measured dimensions. By turning the control ON, the result of dimensional measurement is compensated by the diameter of a sapphire ball.
4. With read point 1 the coordinates of the current point will be stored. If Stylus Compensation is on the position will be corrected by half of the stylus diameter (Control 17).
5. With read point 2 the coordinates of the current point will be stored. If Stylus Compensation is on the position will be corrected by half of the stylus diameter (Control 17).
6. Shows the difference between point 1 and 2
7. Each time the touch stylus touches an object, the coordinates are written in the file C:\Senis\Data\History\Touched.txt. Activating the control, this file will be deleted.
8. Delete last point deletes the last saved coordinate in C:\Senis\Data\History\Touched.txt.
9. Allows setting X, Y and Z values of a new user coordinate system. There are two ways to perform this function – position the touch stylus in the desired location and press Save as new coordinate system, or defining each coordinate separately (all at once), i.e. All at once or Point by point. For Point by point option, each coordinate (X,Y,Z) will be firstly defined separately and saved by Read control. This option is useful to determine the edges of a the cube.
10. Coordinate system definition allows saving a new coordinate system

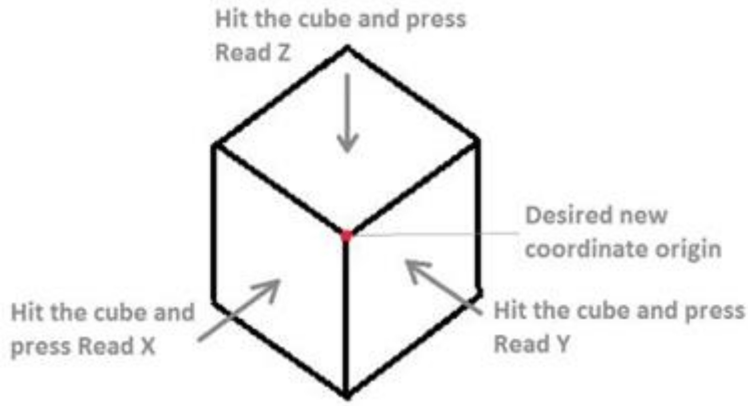


Figure 107: Setting a coordinate system on the corner of a cube

11. Allows setting offsets for the setting a new coordinate system.
12. Stylus offset describes the distance between the center of the ruby ball and the FSV of the respective Hall probe in X, Y and Z. Custom offsets can be set.
13. Vertical Calibration: The stylus can be also used for an accurate vertical calibration of the system (distance between the magnet and the sensitive spot of the probe). The procedure is the same as the one described in the Calibration Tab.
14. Save scanning position saves the current the touch stylus position will be stored as the scanning start position (including the offset between the probe's FSV and the center of the ruby ball of the touch stylus).
15. Runout measurements allows measuring the runout/eccentricity of an object measured on the rotary stage. The object will rotate, and the touch stylus will move into the selected direction (±X, ±Y, ±Z) touch at this point and measure the position. This will be repeated for the selected number of points during a full rotation and the result (peak to peak eccentricity) displayed.
16. Align an object on the rotary stage by a furrow, notch or hole.
    Example: Align a furrow with the mapper X axis:
    - Press Go to Center: The stylus will be positioned above the center of rotation.
    - Rotate the object until the furrow is more or less aligned with the axis.
    - Move the probe in Y so it is above the furrow and down into the furrow.
    - Press align hole, select 1 hole and follow the instructions.
    - After the procedure the furrow will be precisely aligned with the X axis.
17. Allows changing the diameter of the ruby ball.

7.9 Administration Tab

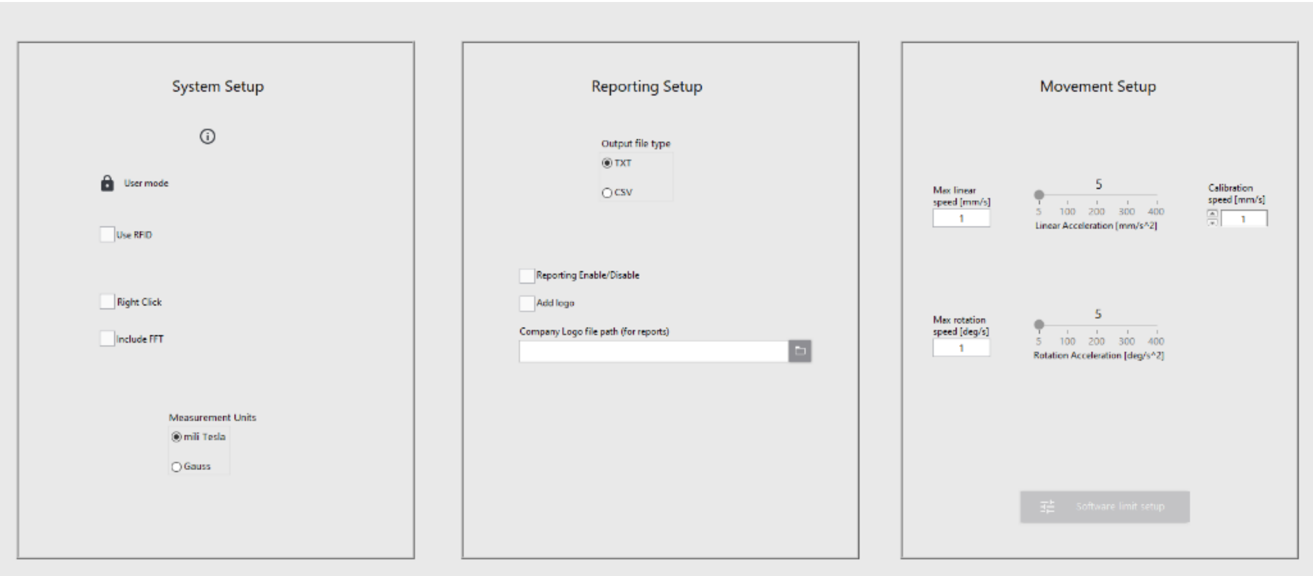


Figure 108: Administration Tab for system settings

7.9.1 System Setup

- About (ⓘ) shows mapper software information
- User mode enables a restricted mode. In standard mode only certain tabs are available. To disable the user mode the password (see Setup.txt file) is necessary.
- Use RFID switches on/off the use of RFID for probe identification.
- Include FFT enables FFT during scanning
- Measurement units allows changing the measurement units to Gauss. This function is in development and while the measurements would be correct, it is possible that mT instead of Gauss is shown on some plots.

7.9.2 Reporting Setup

- Output file type allows choosing between tabulator separated (TXT) or comma separated (CSV) raw data files.
- Reporting Enable/Disable allows enabling/disabling reporting
- Add logo and Company Logo file path allow adding a customer logo for the PDF reports.

7.9.3 Movement Setup

- Max speed allows to change the maximal settable speed in the Manual tab.
- Acceleration allows to change rotation/linear acceleration.
- Calibration speed allows setting the speed during automated calibration procedures. Recommended speed is 10…15mm/s
- Software limit setup allows setting software limits at both ends of each linear axis. The coordinates are in mechanical coordinates. If the user drives the system into a limit the system will stop. To move further in that direction the user has to release and repress the button.

8. Options

8.1 Defectoscope (Option MMS-DEF)

An eddy-current probe can be used for detecting cracks and inhomogeneity in conductive materials, i.e. in magnets (NdFeB, SmCo, Alnico, sintered materials) and in magnet blanks (prior to magnetization).

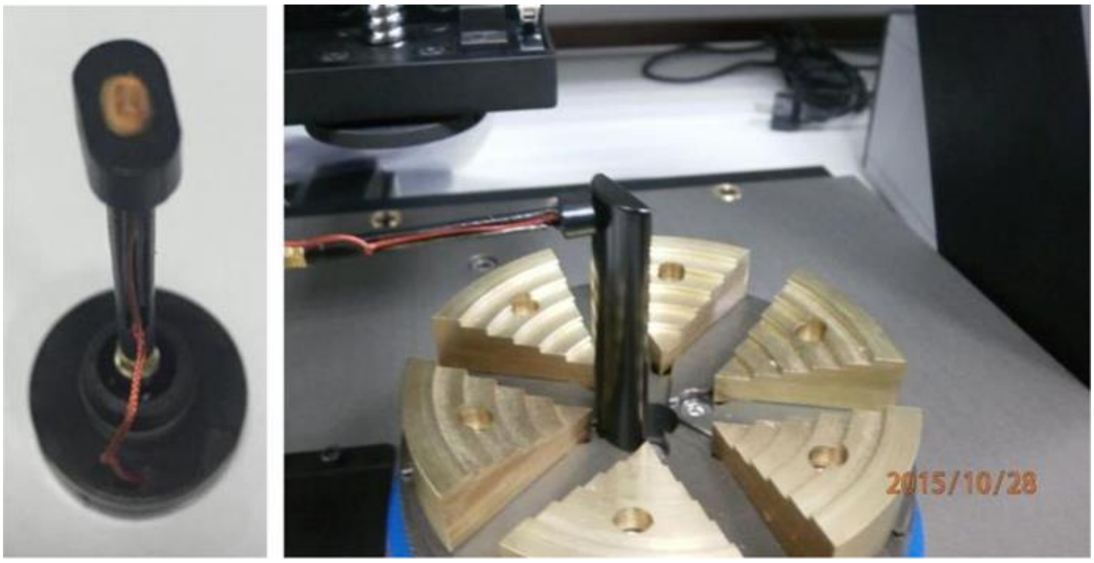


Figure 109: Left: Eddy-current Probe, containing one excitation and two pick-up coils; Right: Measurement on a segment magnet using SENIS eddy-current probe

A measurement with the defectoscope is performed in the same manner as for the magnetic field mapping. After attaching the defectoscope probe on the touch sensor/holder, the mapper software will read the probe RFID code and identify it accordingly. All settings for a measurement with the eddy-current probe are done automatically. The operator can select the scanning mode in the Setup tab and start the measurement in the Measurement tab. Output files are reduced and contain only information relevant for defectoscope measurement (only the position coordinates and the output from the eddy-current probe are saved). The probe output is the voltage (+/-10 V) that represents the eddy-current distribution within the conductive material. If there are no cracks/inhomogeneity, the output is constant, while a crack generates a sinusoidal signal.

The eddy-current probe needs to be positioned as close as possible to the scanned material in order to increase the sensitivity.

The measurement with eddy-current probe does not require any standard calibration procedure. The defectoscope calibration shall be performed in the Calibration tab once the defectoscope shall be used. During the calibration, the output signal is set around the zero value.

The defectoscope calibration can be found in the Calibration Tab.

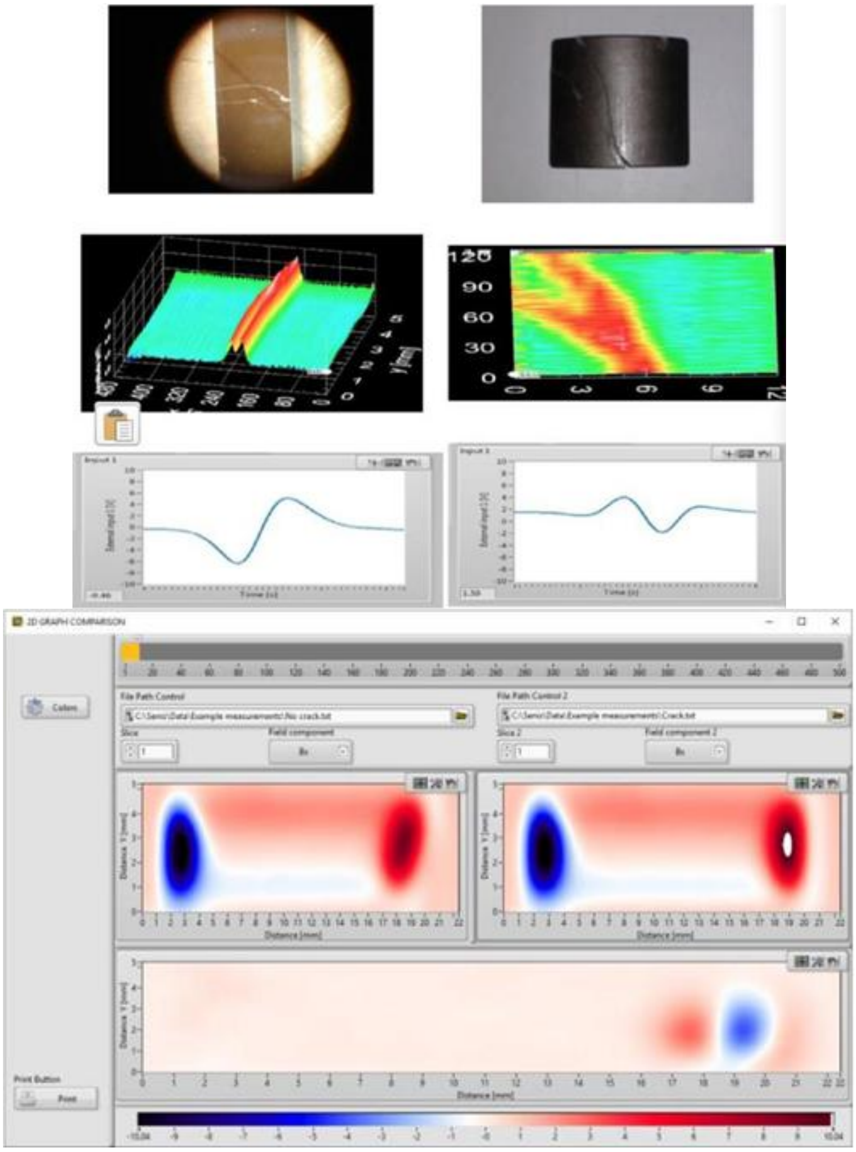


Figure 110: Magnet cracks/inhomogeneity visualisation. Top: Visualisation in the Manual Tab and Measurement Tab; Bottom: Presentation in the additional module (switched on in the Setup tab), which compares good/bad materials

8.2 Anisotropic Magneto Resistant (AMR) probe (Option MMS-AMR)

SENIS can provide a customized configuration that is suitable for low magnetic fields, e.g. for the measurement of the demagnetized parts, weakly magnetized parts, environmental magnetic fields, etc. Following modifications are made to the standard mapper for this capability:

Integration of the SENIS Nanoteslameter with a of the high-resolution, integrated 3-axis AMR sensor (Honeywell HMC1053.

The AMR sensor is mounted on a non-magnetic, low-weight carbon-fiber holder and can be interchanged with the standard Hall sensor. Both, AMR and Hall sensors are controlled from the same electronic unit: The integrated RFID chip automatically identifies the attached probe and applies the corresponding calibration data for the later measurements. The RFID is switched off by the software as soon as the probe is identified to avoid electromagnetic disturbances generated by the RFID chip.

The AMR probe is mounted on a touch sensor for probe damage protection and positioning. The AMR sensor wiring is inside the fiber glass rod (holder).

The large-size mapper with the scanning volume (500x500x300) mm is utilized to allow enough distance between the working area and the ferromagnetic parts integrated in the mapper construction; the console that carries the probe is extended to provide enough distance to the ferromagnetic parts of the mapper; several ferromagnetic parts are replaced or displaced.

The working (scanning) area on the mapper table is shielded by an uncovered Mu-Metal box (Low-Gauss-Chamber – LGC).

The Mapper software is configured to present and visualize the low magnetic fields (uT instead of mT).

Figure 111: Mu-Metal shielding box

Figure 112: AMR sensor mounted on the carbon glass holder and connected to the touch sensor

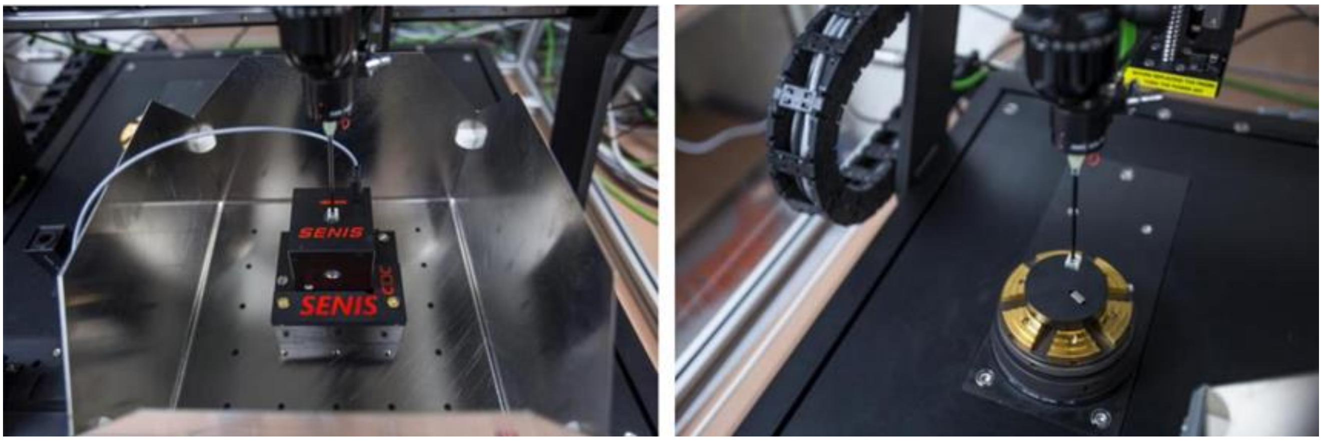


Figure 113: Left: Modified Calibration Cube tool (with integrated Helmholtz coils); Right: The standard tool for the centre of rotary stage calibration

8.3 Clean room Compatibility (Option MMS-CR)

SENIS provides a clean room compatible mapper configuration. Following modifications are made to the standard MMS-1A-RS mapper to achieve the clean room compatibility. The following changes can be implemented on a project specific base:

- Large-size mapper with the scanning volume (500x500x300) mm
- Protective housing made of transparent antistatic acrylic glass in an anodized aluminum frame (dimensions: (1150x1050x1150) cm)
- On the top of the protective housing the two clean-room fans and a HEPA filter are integrated in the stainless steel (INOX) box. The manually regulated fans pump the air through the HEPA filter into the protective box.
- Mechanical parts are made of anodized aluminum or of high-quality non-magnetized stainless steel.
- Clean room compatible ball bearings are applied.
- All cables (Teflon-made), connectors and cable carriers are clean room compatible.
- Mapper table made with the reduced holes/inserts.
- All mechanical parts are washed in the ultrasonic bath prior to assembly.
- All small parts are cleaned in a plasma etching chamber prior to assembly.
- Using clean room compatible lubrication grease and oil.
- Anti-static clean-room packaging.

9. Troubleshooting

9.1 Mapper cannot be turned on

- Check if the emergency off button is released.
- When green reset button is pressed red light switches on for 2 seconds. The other lights remain dark.
- Make sure that all 8 limit switches at the end of each axis are free.
- Press each switch lightly until you can hear a click.
- Press the reset button again.

9.2 Mapper hits the limit switch during operation (Go to Zero, Go to start position, …)

- Increase the linear acceleration (administration tab).
- Clean the linear encoders.
- Avoid direct light incidence on the encoders.

9.3 Touch sensor is taking too long to open

Be very careful when moving the Z axis with the handwheel. The probe can be broken easily when it is pushed downward onto an object

- Shut down the electronic box.
- Manually move the probe very carefully away from the object using the handwheel on the corresponding axis.
- Switch on the electronic box.

Alternative: move the probe away by holding SPACE button on the keyboard and using the step control. See chapter keyboard controls.

9.4 FSV calibrations fails

Set new FSV Calibration start position. See 7.4.3 FSV calibration.

9.5 No magnetic field values are displayed

Check the regional/number format settings of the operating system. Make sure the decimal symbol is set to '.' (point) and not to ',' (comma).

9.6 Magnetic field values are wrong

- Offset is too high or high field is shown even though no magnet is close to the probe.
- Press the Go Home button, let the probe drive into the zero gauss chamber. Note the offset values. The offset values should not be higher than 1% of the current range. (Take a screenshot)
- Check, if the values are better.
- Check if the pogo connection pins in between probe holder and the probe connection PCB are good. (Take a picture). Example picture below.
- Send pictures/screenshots and the folder C:\Senis\Calibration\ to SENIS.
- Field is higher than the selected range. Change to an appropriate measurement range.

Figure 114: Pogo pin connection of the Senis Hall probe

9.7 High measurement noise

- Check the filter settings (see: 7.1.1 Top level controls (always visible))
- Ensure all connectors are well plugged and the screws tightened.
- Make sure there are no sources of magnetic field close to the probe (transformer, coil, cables)
- Remove all other cables (especially of switched devices) in in the vicinity of the mapper, the electronic box, the connection cables and the PC.
- Move the probe into the Zero Gauss chamber. Select the 100mT range and switch off the filter. Press the Histogram button on the Manual Tab. Take a screenshot of your entire screen showing the result and the filter settings. Send the screenshot to Senis.

9.8 Axis does not move/movement is interrupted

- Ensure all motor and encoder connector are well plugged and the screws tightened.
- Check the linear encoders direct exposure to light.
- Clean the linear encoders. Instruction see maintenance.
- Check the connectors of DAQ/MOTION connecting the electronic box to the PC. Make sure that on both sides of each cable no pin is bent. If a pin is bent carefully try to straighten it.
- For larger mapper sizes, it is possible that local oscillations occur at high movement speeds. These oscillations can can trigger the touch probe and interrupt the movement. In such a case the speed should be lowered.

9.9 Technical support

- mappers@senis.ch
- +41 43 550 02 70

10.Maintenance

10.1 Maintenance intervals

Maintenance point	Periodicity	Reference/Instructions
Cleaning and lubrication of ball screw linear drives	Monthly depending on usage	Below
Greasing of ball screw linear drives	Monthly (200…600 hours)	Below
Scroll chuck lubrication	6 months or whenever changing the jaw types	MAPROX AG_Instruction manual_Lubrication and cleaning chucks type JF.pdf
Linear guideways	1…12 months depending on mapper usage (every 1000 km)	HIWIN lubrication guidelines for HG15
Touch trigger TP20 probe cleaning	Check regularly	Renishaw guidelines for TP20 Cleaning material
Linear encoder glass scale cleaning	When necessary	Below

10.2 Ball screw lubrication

Regularly clean and lubricate linear guides. The objective is to keep the ball screw assembly and drive screw clear of any debris that may increase friction, torque, or decrease efficiency that could have a negative impact on the life of the assembly.

Before applying or reapplying lubricant, make sure to wipe the assembly down thoroughly with a clean, dry, lint-free cloth.

Use a lightweight, three in one machine oil (i.e. sewing machine oil). There are many lubricant products on the market that are ideal and offer an operating range of -65…375F or -54…190C. The ball screw manufacturer recommends NOT TO USE penetrating lubricants or other lubricants that contain either moly disulphide or graphite. Further, the manufacturer warns that insufficient lubrication may result in in as much as a 90% reduction in the lifetime!

10.3 Ball screw greasing

For greasing a mineral oil-based grease with the quality K2K, DIN 51825 is recommended. The determining factor for re-greasing is: (0.7 to 0.8) cm^3 of grease for each 10mm of spindle diameter for single ball nuts. Lubricant can be applied generously so that a light film covers the entire drive screw. Move the nut along length of the nut while greasing to ensure that the ball nut is completely greased.

If the system is exposed to a dirty work environment or the operator notices the machine is not running smoothly, the frequency should be increased.

10.4 Linear encoder glass scale cleaning

Clean the graduation of the scale tape and scanning head with a lint-free cloth and distilled spirit or isopropyl alcohol. Do not touch the graduation!

11. Additional resources

Document	Content
Command syntax	A function reference of the possible text commands for automatized measurements.
Probe calibration certificate	Certificate traceable to international norms
Calibration supplement	Contains calibration coefficients probe dimensions and FSV position.
Mechanical Calibration Report	Contains the pre-shipment test results.
Calibration Cube Calibration Certificate (Optional)	Certificate traceable to international norms
MAPROX: Change top jaws	Changing the jaws of the Maprox JF chuck.
MAPROX: Correct workpiece clamping	Clamping a workpiece on the Maprox JF chuck.
MAPROX: Lubrication and cleaning chucks type JF	Maintenance of the Maprox JF chuck
Installation of the Protective Cabinet for the Mapping System (Optional)	Instruction for installing the protective cabinet.
Technical drawings of system	Dimensions etc.
HIWIN HG15 linear guides	See HIWIN website
Renishaw Touch probe components: TP20, PH6, MH8	See Renishaw website