The MagTest Software

Software for magnetic field immunity tests

Version 1.2.8

Operating manual

Index

1.1 Overview of the MagTest Software and system´s requirements

The Schwarzbeck´s Mess-Elektronik MagTest software can be used to perform magnetic field immunity tests according to several standards, such as, for example: MIL-STD-461E, ISO 11452-8, DIN EN 61000-4-8 and many others. The MagTest software can control the hardware to produce a magnetic field with defined field strength. Automatic and stepwise work routines are possible. The software can also be used for the calibration of monitoring loops and for scientific applications.

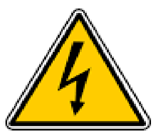
The MagTest software offers the following features:

- Integration of different hardware components like Helmholtz coils, radiating loops, monitoring loops, RMS voltmeters and function generators. The measuring system can be flexibly configured;
- possibility to define limits freely. The unit of the magnetic field strength can be handled in "dBuA/m", "dBpT" and "A/m";
- use of INES, National Instruments, Agilent GPIB interfaces for the communication with RMS voltmeters and function generators;
- magnetic field curves can be shown, saved and loaded;
- test requirements can easily be adapted by setting start and stop frequency, frequency steps, the offset of the magnetic field strength, the maximal error of magnetic field strength, the value of shunts and timing values;
- scalable print output;
- possibility to design test protocols with individual comments;
- possibility of the manual control of RMS voltmeters and function generators;
- possibility to compare two different magnetic field curves.

For the use software the following equipment is required:

- PC with IEEE 488 (GPIB) interface with Windows operating system (for example Windows 98, Windows XP, Windows 7 are supported);
- GPIB interfaces of National Instruments, INES, Agilent-VISA are supported by the MagTest software. Other manufacturers can be supported on request;
- Helmholtz coil or radiating loop for the generation of magnetic fields;
- shunt resistor with e.g. 0.5 Ω/0.5 kW for indirect measurement of the magnetic field strength and for better impedance matching;
- monitoring loop (optional) for direct measurement of the magnetic field strength;
- function generator with an IEEE 488 interface for the generation of the signal for the Helmholtz coil or the radiating loop;
- two RMS voltmeters or a dual channel RMS voltmeter with an IEEE 488 interface;
- amplifier;
- laboratory cables.

ATTENTION! HAZARD WARNING!



The power cables must be disconnected __every time__ if wires are being connected or disconnected.
Attention: during operation dangerous to life high voltages occur at the terminals of the power amplifier. If used in an inappropriate way this could lead to a life-threatening situation for the user. The magnetic field produced by the Helmholtz coils and the radiating loops can be dangerous for people with magnetic-field-sensitive implants (e.g. pacemakers). Read the instruction manual and the security notes of the MagTest components which are included in the scope of the delivery carefully!

1.2 The MagTest software installation

To install the MagTest software double click on the installer program (for example: MagTestSetup_V.1.2.8.exe, as shown in Figure 1) which is provide with the installation CD.

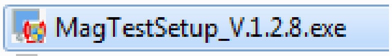


Figure 1: the MagTest software installer.

The setup wizard will then be opened; to proceed click on the “Next” button, to exit click on the “Cancel” button, as shown in Figure 2.

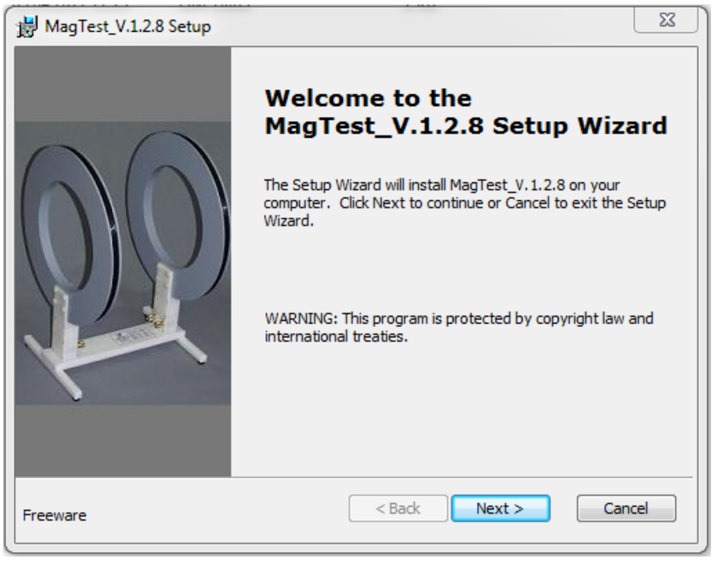


Figure 2: welcome window of the installer.

In the next window (see Figure 3) it is possible to use a predefined destination folder for the installation. The user can also select a different installation path.

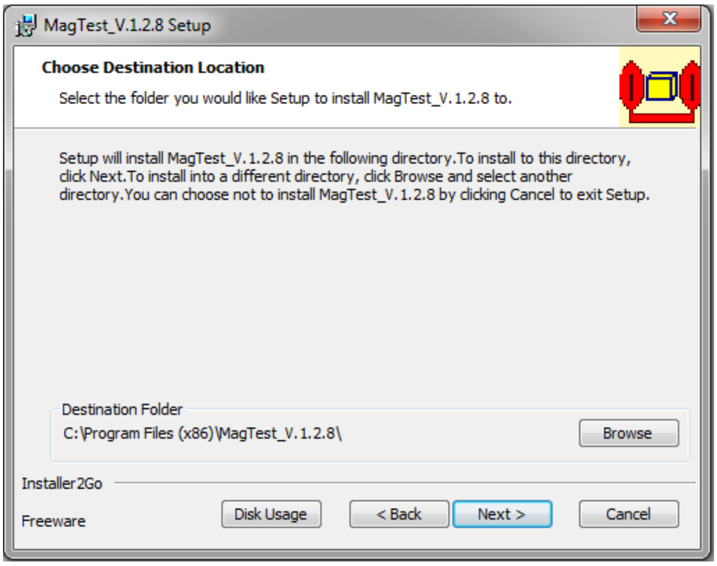


Figure 3: settings for the installation path of the MagTest software.

In the following panel (Figure 4) click on “Install” to proceed with the installation.

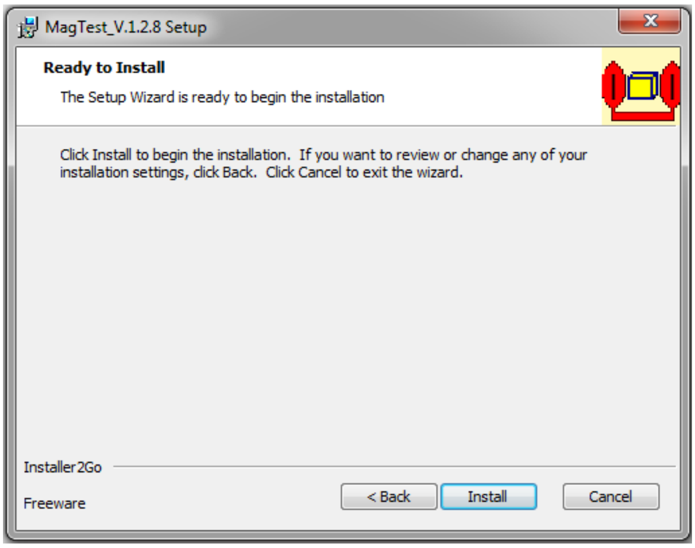


Figure 4: starting the installation of the MagTest software.

The installation status can be followed by checking the panel shown in Figure 5.

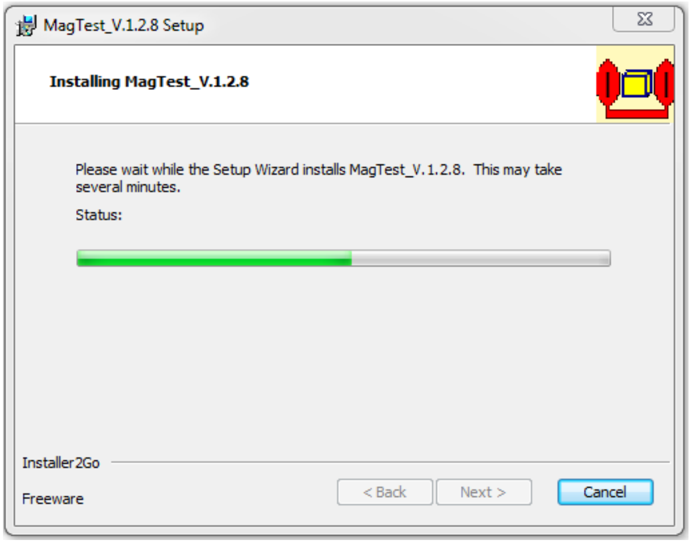
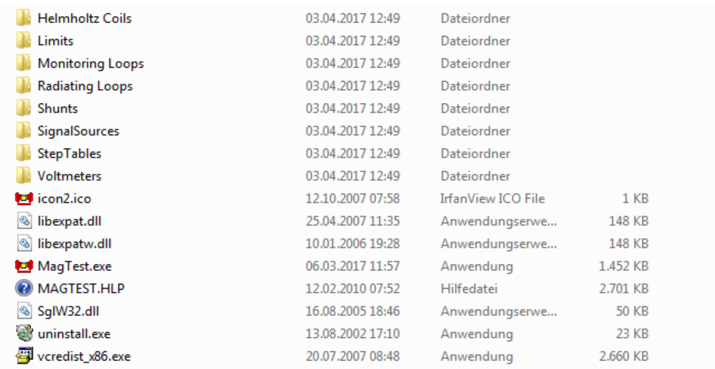


Figure 5: installing the MagTest software.

At the end of the installation process, the following files and folder´s structure (see Figure 6) will be created.



Helmholtz Coils	03.04.2017 12:49	Dateiordner	
Limits	03.04.2017 12:49	Dateiordner	
Monitoring Loops	03.04.2017 12:49	Dateiordner	
Radiating Loops	03.04.2017 12:49	Dateiordner	
Shunts	03.04.2017 12:49	Dateiordner	
SignalSources	03.04.2017 12:49	Dateiordner	
StepTables	03.04.2017 12:49	Dateiordner	
Voltmeters	03.04.2017 12:49	Dateiordner	
icon2.ico	12.10.2007 07:58	IrfanView ICO File	1 KB
libexpat.dll	25.04.2007 11:35	Anwendungserwe...	148 KB
libexpatw.dll	10.01.2006 19:28	Anwendungserwe...	148 KB
MagTest.exe	06.03.2017 11:57	Anwendung	1.452 KB
MAGTEST.HLP	12.02.2010 07:52	Hilfedatei	2.701 KB
SglW32.dll	16.08.2005 18:46	Anwendungserwe...	50 KB
uninstall.exe	13.08.2002 17:10	Anwendung	23 KB
vcredist_x86.exe	20.07.2007 08:48	Anwendung	2.660 KB

Figure 6: directories and files created by the installer in the destination folder.

The folders contain the configuration and calibration files for the field generating devices (Helmholtz coils, radiating loops) and the measuring devices (monitoring loops, voltmeters), as it will be explained in the following pages of this manual. To use the MagTest software, insert the USB key (which has been provided in the scope of the delivery and contains the license to use the software) in a free USB port and double click on the shortcut that has been created on your Desktop (Figure 7) or on the link that is available in the Windows Start menu.

Figure 7: MagTest software´s shortcut.

1.3 General features of the MagTest software

Figure 8 shows the main window of the MagTest software: it can be mainly divided in different sections, which will be described in details in the following.

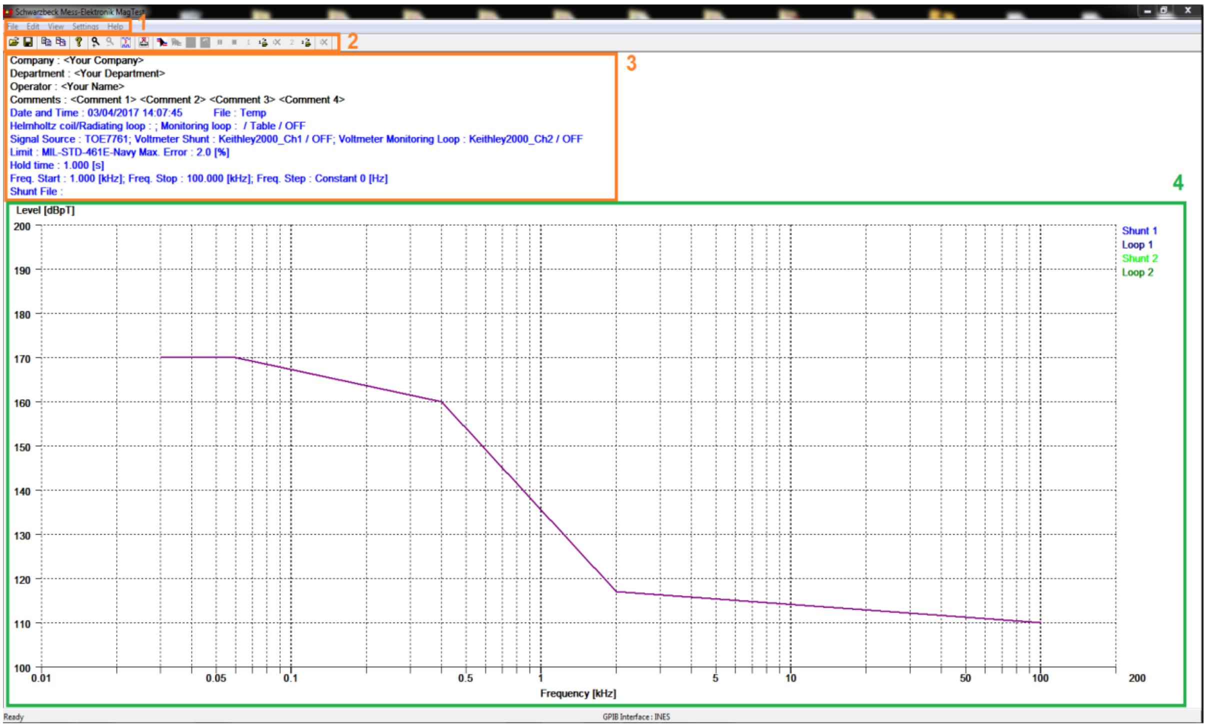


Figure 8: the main MagTest software operating panel.

- **section 1** is dedicated to the setup of the system´s options;
- **section 2** can be used to load and save software´s configurations and data;
- **section 3** is used to summarize several information associated to the laboratory and to the hardware´s configuration in use;
- **section 4** occupies the main area of the software´s window and it shows the limit (from the normative) and the produced magnetic field levels (in Figure 8 the magnetic field strength is shown in dBpT) as a function of the increasing frequency (in kHz). On the top-right area of this section, a legend provides the information relative to the measuring devices (resistive shunts and monitoring loops), which are used to measure the field and will be described in the dedicated paragraph.

In the following pages the different sections of the MagTest software will be described in details, using an "operative" approach: in particular, the description of the software will be provided following the steps that the user must follow to setup the software and start to use it to make tests. In other words, the user will be guided in order to setup the software and to start a test in an efficient way.

1.3.1 Changing the range view settings

By selecting the "View Range" option from the "View" menu in Section 1 (see Figure 8), it is possible to change the start-stop frequencies (in kHz) on the horizontal-axis, the unit of measurement of the magnetic field levels (which can be displayed in dBuA/m, dBpT and A/m) and the minimum-maximum magnetic field levels (in the previously selected unit) on the vertical axis. An example is shown in Figure 9. After having set all the wished numbers and unit, it is then possible to set these values clicking on the "OK" button. This will consequently change the aspect of the Section 4, which is shown in Figure 8.

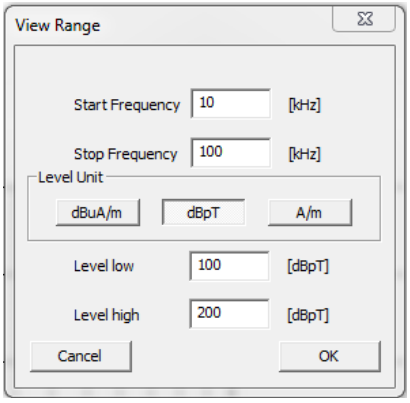


Figure 9: the view range panel.

1.3.2 Changing the legend settings

The MagTest software allows to measure the produced magnetic field using different devices, as explained in Section 1.3. In particular, it is possible to use resistive shunts and/or monitoring loops. During the tests the measured magnetic field strengths are displayed in the 2-dimensional plot described in the previous paragraphs. In particular, on the top-right section of the plot, a legend is available and it allows to distinguish the curves by using different colors. The user can change the colors of the measuring devices, using the "Set Color" panel which can be opened from the "View" menu. The user can then click on the measuring device ("Shunt 1", for example): this will open the color panel from which it is possible to pick the wished color for the legend (see Figure 10).

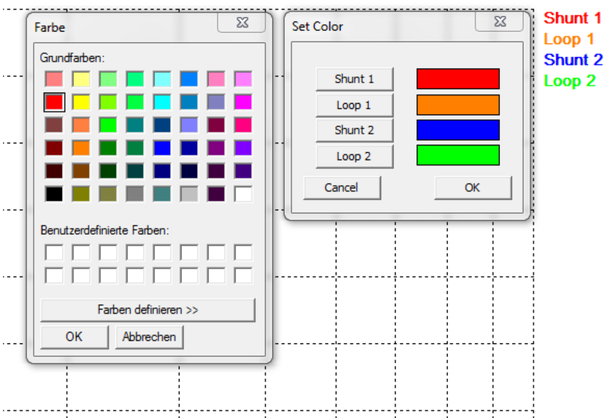


Figure 10: the legend color panel.

1.3.2 Changing the font sizes

It is possible to change the size of the text which is displayed in Section 3 (see Figure 8) and alongside the X and Y axes. To do that the user should select the option “Font size text” from the “View” menu; then it will be possible to enlarge the text clicking on it with the mouse left-button or to make it smaller, clicking on the text with the mouse right-button. The font on the axes can be modified in an analogous way, after having selected “Font size graph” from the “View” menu.

1.3.3 Adding comments to the test window

The user can add details about the company, the name of the department, the operator and several other comments, which can be helpful to trace the results during and after the tests. After clicking on the “OK” button, the information will be displayed in the main screen (see Figure 11 and 12).

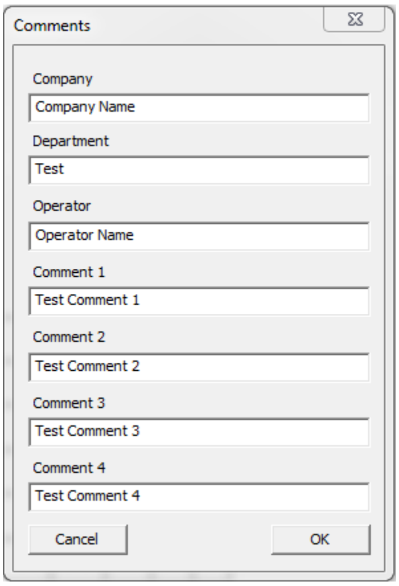


Figure 11: the comments panel.

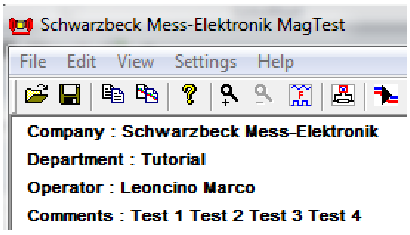


Figure 12: the comments are displayed in the main screen.

1.3.4 Help/version window

Clicking on “Help” it is possible to retrieve some basic information about the current version of the software in use, as shown in Figure 13.

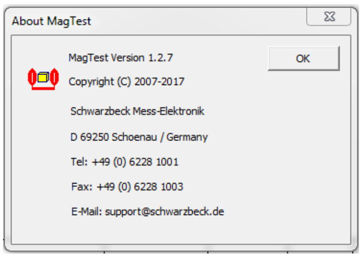


Figure 13: the software´s version window.

1.4 Setting the field´s limits

The MagTest software is intended to produce well defined magnetic field strengths. The produced magnetic field must be checked and compared to the theoretical limits, which are prescribed by the specific normative in use during the test. For this reason, the software allows to set predefined or custom limits. The limit panel (which is also shown in Figure 14) can be opened by clicking on “Limits” from the “Edit” menu. It is possible to select between different standards, just by clicking on the file name and selecting the wished one, which will appear in the list. Each limit is characterized by a defined level (selectable in dBµA/m, dBpT, A/m) for each value of the frequency (here reported in Hz).

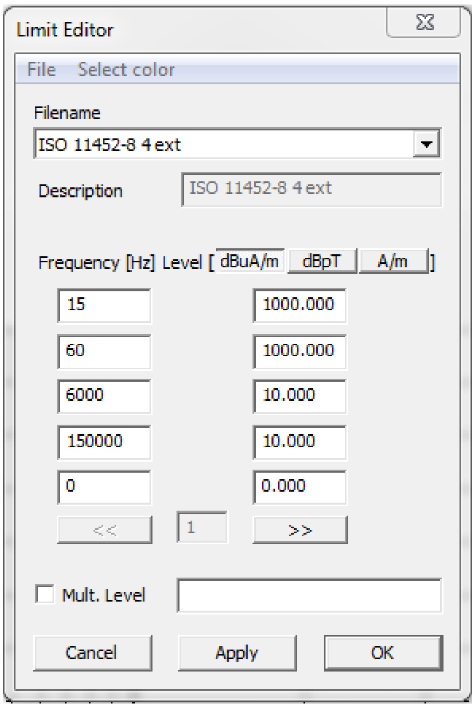


Figure 14: the limit editor.

After having selected the proper standard it is possible to click on “Select color”, to choose the color of the limit´s curve. Then, clicking on “OK” the selected options will be applied and the limit curve will be displayed in the plot´s area. The user has also the possibility to create a custom curve, selecting “New” from the “File” menu. It is mandatory to add a name to the created limit and to add a level for each frequency point. It is then possible to export a limit in a file with .LIM extension and to import the .LIM file from a defined path. A .LIM file contains the name of the standard (in the first line) and then a line for each limit´s point. Each line contains the frequency separated from the level by a “;”. A .LIM file can be opened with a text editor and is saved by default in the “Limits” folder, which is created by the installer (see Figure 6).

1.4.1 Multiple test levels

An interesting feature is the possibility to perform multiple test levels. The multiple test levels must be defined in the limit dialog. The check-box "Mult. Level" must be activated and the multiple level values must be inserted in the tab, separated by a comma. A command such as: “75, 85, 95, 100, 102” means that the DuT will be checked with 75%, 85%, 95%, 100% and 102% of the magnetic field strength based on the current limit. A test with multiple levels is shown in Figure 15.

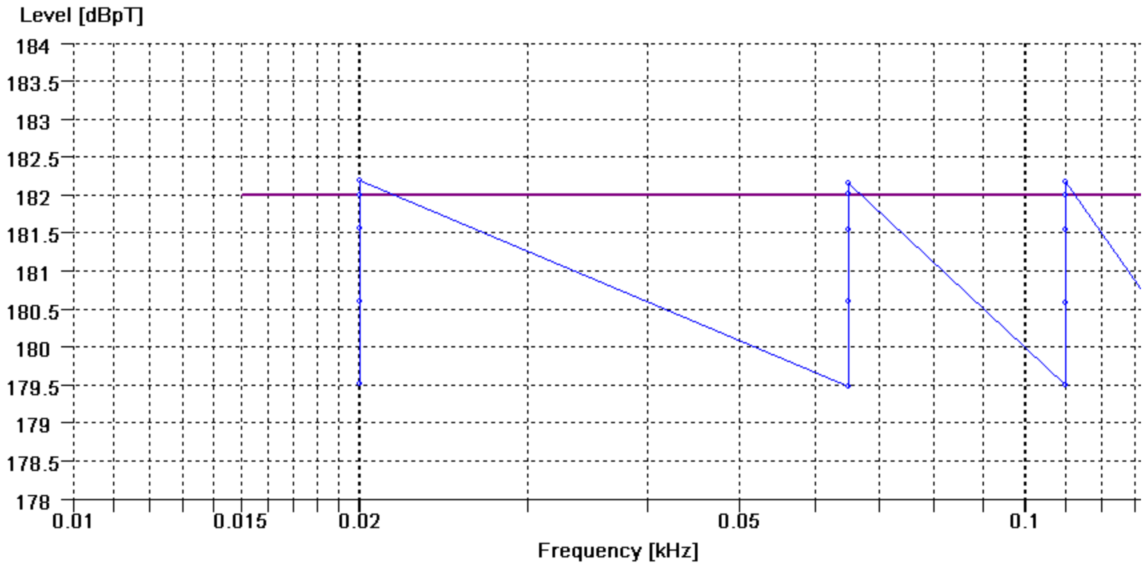


Figure 15: example of multiple tests levels.

1.5 GPIB interface configuration

In order to use the devices (function generators, voltmeters and compensation network) which are controlled by the MagTest software via the GPIB protocol, the GPIB interface card must be installed and configured. To open the GPIB control panel (see Figure 16), click on the "GPIB-Interface" button available in the "Edit" dialog.

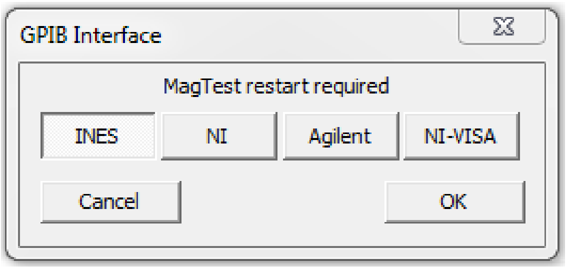


Figure 16: the GPIB interface control panel.

The MagTest software allows to select between different manufacturers of GPIB cards: INES, National Instruments, Agilent and National Instruments-VISA GPIB cards can be used. To use the Agilent GPIB interface the current Agilent interface ID should be set to "GPIB1" in the Agilent Connection Expert utility. When a new GPIB card is chosen, the software **must be restarted**.

1.6 Signal source configuration

The MagTest software requires an arbitrary function generator which is used to provide an input signal to the power amplifier. The signal source must be compliant with the following specifications:

- It must be equipped with GPIB (IEEE 488) interface;
- the output level should be in the range 10 mV - 10 V (peak to peak), or better;
- the signal frequency should be in the range 10 Hz – 200 kHz, or better.

To open the signal source panel select the "Edit Signal Source" from the "Edit" dialog: this will open the panel shown in Figure 17.

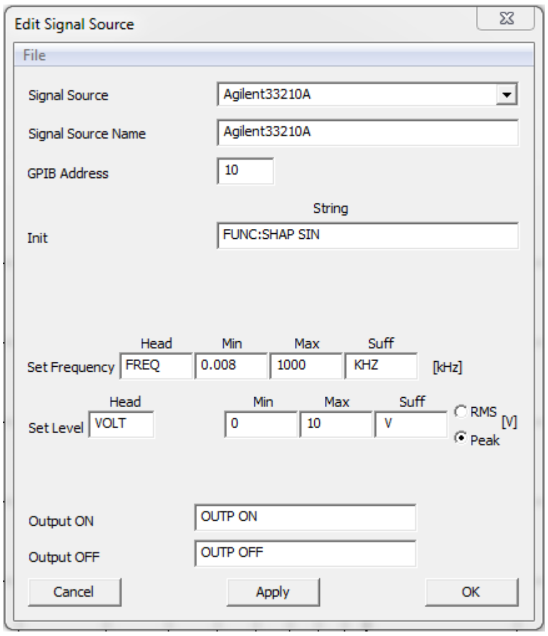


Figure 17: the signal source control panel.

The settings of several function generators (**Agilent 33210A, Keysight 33511B, HP 3314A, HP 8165A, TOE 7761**) are already configured and installed in the software. If the user owns a function generator which is in the previous list, the only setting which is required to be set is the GPIB address, which is defined by an integer number. The GPIB address is displayed on the starting screen of the function generator and should be inserted in the corrensponding field in the control panel of the signal source. If the function generator ***is not included in the list***, the following commands must be defined:

Init, *SetFrequency*, *SetLevel, OutputOn and OutputOff*.

For further Information about the specific settings of the signal source in use refer to the related pages of the signal source manual. The *"Init"* is a string. The set commands contain "head", "suff", "Min" and "Max" values. "Head" and "Suff" are strings which have to be sent at the beginning and at the end. The "Min" and "Max" Real-values represent the valid area for the frequency or the level. The instruction are stored in XML-format file which is available in the "Signal Sources" folder which is created by the installer (see Figure 6).

1.7 Voltmeters configuration

The field strength which is produced by an Helmholtz coil or a radiating loop, is measured with different devices such as an induction monitoring loop or a resistive shunt. In both cases the physical quantity which must be measured is a voltage. The MagTest software can be used to control one or more voltmeters. The voltmeter must be compliant with the following specifications:

- It must be equipped with GPIB (IEEE 488) interface;
- possibility to measure the RMS in the range 10 Hz - 200 kHz.

Select the "Edit Voltmeter" from the "Edit" dialog: this will open the panel shown in Figure 18.

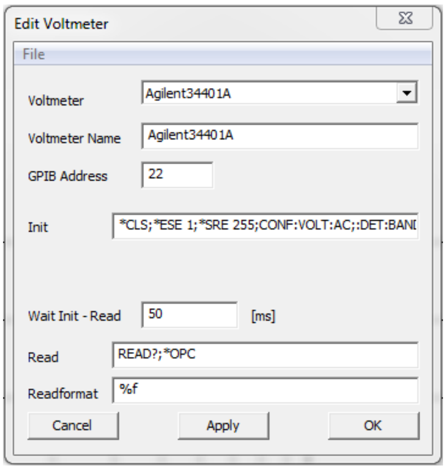


Figure 18: the voltmeter control panel

The settings of several voltmeters (**Agilent 34401A, Keysight 34465A, HP 3478A, Keithley 2000, LeCro y9354, R&S URE3, Tektronix 3303B**) are already configured and installed in the software. If the user owns a voltmeter which is in the previous list, the only setting which is required to be set is the GPIB address, which is defined by an integer number. The GPIB address is displayed on the starting screen of the voltmeter and should be inserted in the GPIB address field in the control panel of the signal source. If the voltmeter ***is not included in the list***, the *Init* and *Read* commands must be defined. It has to be ensured that the "Require of Service (SRQ)" signal is only sent after the measured value is ready. For this reason the commands *Init* and *Read* must be defined in a way that the voltmeter can only send the SRQ after a successful measurement. The measuring value is expected as a string with a defined format. This format is a simplified form of the commands *printf* or *scanf* (defined in ANSI C) and in an abstract syntax it looks as follows: <string> <% [f|d|s]> <string>. The string can also be empty. The middle part includes the sign ,% and alternatively one of the letters "f", "d" or "s" which stand for "real", "integers" and "strings". The wait_INRD information defines the time interval, between the *Init* and *Read* commands. The instruction are stored in XML-format file which is available in the "Voltmeters" folder which is created by the installer (see Figure 6).

1.8 Manual control of the function generator and voltmeter

The MagTest software allows to perform some simple tests to validate the correctness of the settings relative to the function generator and voltmeters, as described in Paragraphs 1.5-1.6.

1.8.1 Validation of the function generator

The first step requires the validation of the function generator: in Section 2 (see Figure 8) click on the button . This action will open the dialog "Signal Source Control" shown in Figure 19.

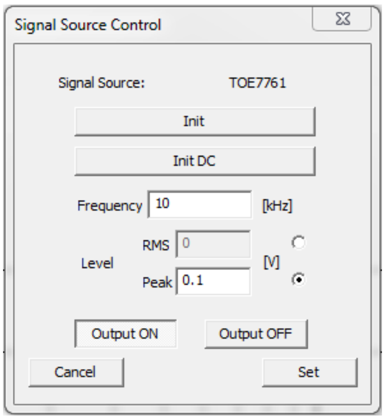


Figure 19: the signal source control panel.

The signal source shows the name of the currently used function generator. It is possible to set a reference test frequency (e.g. 10 kHz) and level (e.g. 0.1 Vpp). After having activated the output (clicking on the “Output ON”), it is possible to send the information to the function generator (clicking on the “Set” button). If all the setting which have been described in the Paragraph 1.6 are correct, it will be possible to read the set frequency and level values on the function generator´s display. If it is not possible to read the settings on the function generator, check in the following order: the correct working of the GPIB interface, the proper connection of the GPIB cable, the GPIB address of the function generator.

1.8.2 Validation of the voltmeter

The second step requires the validation of the voltmeter: in Section 2 (see Figure 8) click on the button . This action will open the dialog “RMS Voltmeter Control” shown in Figure 20.

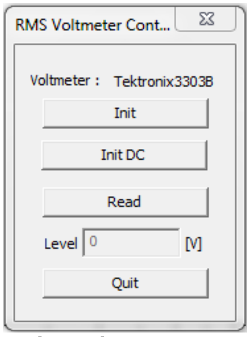


Figure 20: the voltmeter control panel.

The dialog shows the name of the currently used voltmeter. Click on the button “Init” and then on “Read”: if all the setting which have been implemented in the Paragraph 1.7 are correct, it will be possible to read the actual level measured by the voltmeter in the field “Level”. If the input of the voltmeter is connected to a monitoring loop and at that time no magnetic field is produced, the measured level will be very low, in the order of 10^{-5}-10^{-4} Volt. It is also possible to connect the voltmeter under validation to a reference source and check the consistence of the measurement. If it is not possible to perform any voltage reading, check in the following order: the correct working of the GPIB interface, the proper connection of the GPIB cable, the GPIB address of the function generator.

1.9 Hardware configuration

1.9.1 Calibration data

In order to successfully work with the MagTest system, all the components which are used during the tests must be correctly configured in the software. As shown in Table 1, some devices are individually calibrated by the Schwarzbeck´s laboratory, before they are delivered to the user. The calibration data must be loaded correctly in the software, in order to assure the proper working of the equipment. In the first part of this paragraph the content of the calibration files will be shown and described in detail, in the second part it will be explained how to load them in the software.

Device	Manufacture´s code	Cal. file
Compensation network	NFCN 9731, NFCN 9734	**individual data**
Resistive shunt	SHUNT 9571 or built in shunt in NFCN 9731/NFCN 9734	**individual data**
Current probe	CP 9610	**individual data**
Monitoring loop	FESP 5134/40, FESP 5133 7/41	**typical data**
Radiating loop	FESP 5132…	**typical data**
Helmholtz coil	HHS 5206-16, HHS 5204-12…	**typical data**

Table 1: the table shows for which device it is needed to load the calibration file.

1.9.2 Compensation network

As explained in the documentation of the MagTest system, the purpose of the capacitive compensation network is to reduce the imaginary component of the impedance. This task is performed using a network of switchable capacitors. With this technique it is possible to reach high magnetic field strengths with lower output voltage than in the case in which a compensation technique is not used. As a consequence it is possible to reduce the power needed at the output of the amplifier. The individual calibration data is extremely important (especially for higher frequencies) when the compensation network (NFCN 9731 or NFCN 9734) is used. An example of the NFCN 9734 calibration file is shown in Figure 21. The first lines report the file encoding information and the S/N of the device in use, the following ones the value of the capacity (in Farad) of the capacitors used in the compensation network.

NFCN9734_00001.txt

```
<?xml version="1.0" encoding="UTF-8"?>
<!-- file for Schwarzbeck Matching NetworkNFCN 9734 -->
<!-- -->
<NFCN name="NFCN 9734 SN 00001">
<!-- -->
<CNULL val="248.0e-12"></CNULL>
<C0 val="62.7e-12"></C0>
<C1 val="124.1e-12"></C1>
<C2 val="243.5e-12"></C2>
<C3 val="495.2e-12"></C3>
<C4 val="1051e-12"></C4>
<C5 val="2094e-12"></C5>
<C6 val="4078e-12"></C6>
<C7 val="7947e-12"></C7>
<C8 val="16319e-12"></C8>
<C9 val="32629e-12"></C9>
<C10 val="64669e-12"></C10>
<C11 val="128.999e-9"></C11>
<C12 val="247.7e-9"></C12>
<C13 val="486.8e-9"></C13>
<C14 val="989.3e-9"></C14>
<C15 val="1.989e-6"></C15>
<C16 val="3.995e-6"></C16>
<C17 val="7.952e-6"></C17>
<C18 val="16.047e-6"></C18>
<C19 val="31.77e-6"></C19>
<C20 val="60.18e-6"></C20>
<C21 val="122.71e-6"></C21>
<C22 val="245.4e-6"></C22>
</NFCN>
```

Figure 21: sample NFCN 9734 calibration file.

To compute the capacity of the compensation network, at a specific frequency, the Thomson equation is used and implemented in the software:

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

In the previous formula *L* is the inductance of the Helmholtz coil/ radiating loop, *f* is the resonant frequency of the resonant circuit, and *C* is the required capacitance. As consequence of this formula, the required capacitance is frequency-dependent. This explains why the compensation network is controlled by the MagTest software via the GPIB interface.

1.9.3 Resistive shunt

The impedance of the SHUNT 9571 or built in shunt in NFCN 9731/NFCN 9734 is individually calibrated, as a function of the increasing frequency. An example of the calibration file is shown in Figure 22. **The resistive shunt must not be loaded with 50 Ohm**.

Shuntfile_NFCN_9734_SN001.txt

```
57
0.010 1.00995
0.020 1.01205
0.030 1.01205
0.040 1.01251
0.050 1.01251
0.060 1.01298
0.070 1.01205
0.080 1.01263
0.090 1.01309
0.100 1.01356
0.200 1.01403
0.300 1.01414
0.400 1.01496
0.500 1.01555
0.600 1.01613
0.700 1.01695
0.800 1.01672
```

Figure 22: extract of the SHUNT 9571 calibration file: the impedance (second column, in Ω) is reported as a function of the increasing frequency (first column, in kHz).

1.9.4 Current probe

The conversion factor of the current probe CP 9610 is individually calibrated, as a function of the increasing frequency. An example of the calibration file is shown in Figure 23. **<u>The current probe must not be loaded with 50 Ohm</u>**.

Shuntfile_CP9610_SN00001.txt

```
67
0.010 0.04843
0.030 0.04838
0.050 0.04840
0.070 0.04840
0.100 0.04837
0.300 0.04843
0.500 0.04848
0.700 0.04848
1.000 0.04845
3.000 0.04848
5.000 0.04848
7.000 0.04845
10.000 0.04843
20.000 0.04832
30.000 0.04820
40.000 0.04825
50.000 0.04837
```

Figure 23: extract of the CP 9610 calibration file: the conversion factor (second column, in V/A) is reported as a function of the increasing frequency (first column, in kHz).

1.9.5 Monitoring loop

The monitoring loops (FESP 5133 7/41 and FESP 5134/40) can be used with typical data (obtained in a reference magnetic field of 100 A/m) which report the voltage across 50 Ω as a function of the frequency. An example of the FESP 5133 7/41 calibration file is shown in Figure 24. **<u>The monitoring loop must be loaded with 50 Ohm</u>**

FESP_5133-7_41.loop

```xml
<?xml version="1.0" encoding="UTF-8"?>
<!-- file for Schwarzbeck monitoring loop FESP 5133-7/41 -->
<!-- diameter [mm] resistance [Ohm] inductance [uH] capacitance [pF] -->
<loop name="FESP 5133-7/41" diameter="133" loopnumber="36" resistance="10.52" inductance="310" capacitance="83.5">
<info1 data="Usable Frequency Range: 0-200 kHz"></info1>
<info2 data="Resonance Frequency: 1 MHz"></info2>
<!-- freq [Hz] fieldstrength [A/m] voltage [mV] -->
<tab freq="10" fieldstrength="100" voltage="3.23"></tab>
<tab freq="20" fieldstrength="100" voltage="6.47"></tab>
<tab freq="30" fieldstrength="100" voltage="9.65"></tab>
<tab freq="50" fieldstrength="100" voltage="16.19"></tab>
<tab freq="100" fieldstrength="100" voltage="32.23"></tab>
<tab freq="200" fieldstrength="100" voltage="64.49"></tab>
<tab freq="300" fieldstrength="100" voltage="96.92"></tab>
<tab freq="500" fieldstrength="100" voltage="160.2"></tab>
<tab freq="700" fieldstrength="100" voltage="221.2"></tab>
<tab freq="1000" fieldstrength="100" voltage="309.1"></tab>
<tab freq="2000" fieldstrength="100" voltage="591.8"></tab>
<tab freq="3000" fieldstrength="100" voltage="861.6"></tab>
<tab freq="5000" fieldstrength="100" voltage="1385"></tab>
<tab freq="7000" fieldstrength="100" voltage="1873"></tab>
<tab freq="10000" fieldstrength="100" voltage="2572"></tab>
<tab freq="20000" fieldstrength="100" voltage="4432"></tab>
<tab freq="30000" fieldstrength="100" voltage="5676"></tab>
<tab freq="50000" fieldstrength="100" voltage="7065"></tab>
<tab freq="70000" fieldstrength="100" voltage="7800"></tab>
<tab freq="100000" fieldstrength="100" voltage="8339"></tab>
<tab freq="120000" fieldstrength="100" voltage="8533"></tab>
<tab freq="150000" fieldstrength="100" voltage="8832"></tab>
<tab freq="170000" fieldstrength="100" voltage="8922"></tab>
<tab freq="200000" fieldstrength="100" voltage="9074"></tab>
<tab freq="250000" fieldstrength="100" voltage="9074"></tab>
</loop>
```

Figure 24: calibration file of the FESP 5133 7/41 monitoring loop.

1.9.6 Helmholtz coils, radiating loops

The devices which are used to produce the magnetic field during the tests, don´t necessarily need an individual calibration because of the following two reasons:

1. Helmholtz coils and radiating loops are used in a closed-feedback setup: the software will regulate the levels, until the field strength is reached using the measurement provided by the monitoring loop;
2. The mechanical tolerances allow to use the same (typical) data.

Therefore the user must load the typical data (and not the individual calibration data) to the software.

1.9.7 Loading the configuration in the MagTest software

This section is dedicated to the configuration of the MagTest software. The implementation of the following settings is very important to assure the proper working of the system: **please read the following pages carefully!**

Loading the compensation network calibration file

The first step requires the loading of the compensation network data. As explained in section 1.9.2, the compensation network (NFCN 9731, NFCN 9734) is delivered with individual calibration data. From the menu "File" (available in Section 1, see Figure 8) click on the button "Set NFCN File". This will open the dialog window shown in Figure 25.

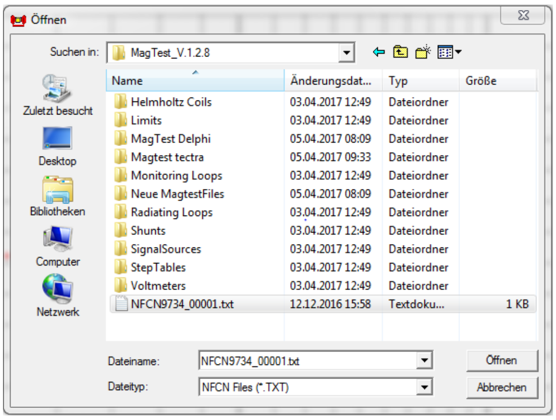


Figure 25: dialog window for the configuration of the calibration data of NFCN compensation network.

Select the proper compensation network that has been delivered. The NFCN can be identified by the S/N which is printed on the label in the back panel of the device and in the calibration certificate. Click on the "Open" button to load the calibration file.

The hardware configuration control panel

By clicking on "Settings" -> "Hardware configuration" it is possible to open the hardware control panel, which is shown in Figure 26.

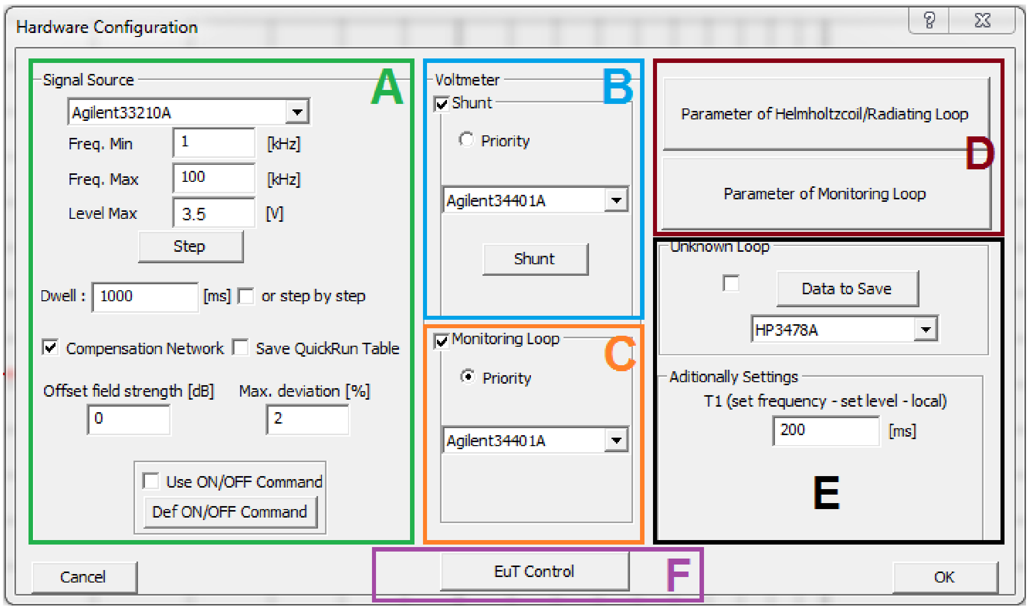


Figure 26: the hardware configuration control panel.

The hardware configuration control panel (see Figure 26) can be divided in different areas, which are marked with a letter from A to F and highlighted with different colors in order to improve the description. In particular, each area is dedicated to a well-defined function:

- **area A** (highlighted in **green**) allows to set several options related to the function generator;
- **area B** (highlighted in **blue**) and **area C** (highlighted in **orange**) are dedicated to the control of the voltmeters, which are used to measure the voltage at the output of the shunt and the monitoring loop:
- **area D** (highlighted in **red**) is dedicated to the configuration of the magnetic field generating devices such as Helmholtz coils and radiating loops and to the setup of the monitoring loop;
- **area E** (highlighted in **black**) is dedicated to additional settings such as the calibration of an unknown loop and the waiting time;
- **area F** (highlighted in **violet**) can be used to control the Equipment under Test (EuT).

The detailed description of the settings will be presented in the following sections.

“Area A” settings

Using the options available in this area (see detailed view in Figure 27) it is possible to select the proper function generator from the list. The function generator will be used to provide the input signal to the power amplifier. It is also possible to set the minimum and maximum working frequencies (in kHz) and the maximum output level (in Volt, peak to peak). It is suggested not to exceed the 3.5 V_{pp} in order to avoid to overload the power amplifier.

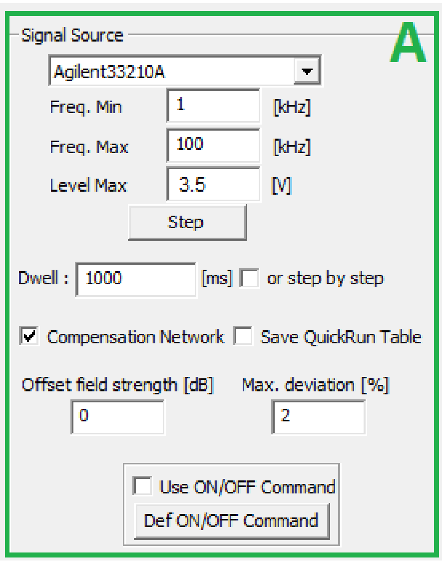


Figure 27: detailed view of Area “A”.

The user has the possibility to define the step size, which is defined as the number of data points taken in a determined frequency interval. By clicking on the “Step” button (see Figure 27), the frequency step setting panel (shown in Figure 28) will be opened. In this panel it is possible to select between different options, which allow to choose the proper number of frequency steps:

- **constant steps**: if this option is selected, data will be taken using a constant spacing between each two consecutive data points. The user can set the spacing between the steps (in Hz);
- **percent steps**: with this option the user can select a defined step size, defined as percent of the tuned frequency (for example: 5%, 10%, 20%...);
- **table**: by selecting this option, it is possible to take data at selected frequencies. By clicking on the “Table file” button, the table file window will be opened (see Figure 29, left). The user can select between a predefined table or a customized one. The syntax used in the table files is

very simple: each line in the step file corresponds to a different frequency point (in Hz) that will be used during the test (see Figure 29, right);

- **per octave**: the user can choose a number of steps per octave of frequency (an integer number must be used);
- **per decade**: the user can choose a number of steps per decade of frequency (an integer number must be used);

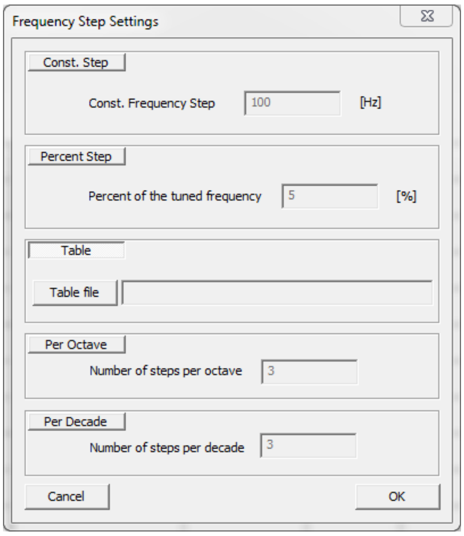


Figure 28: the frequency step settings panel.

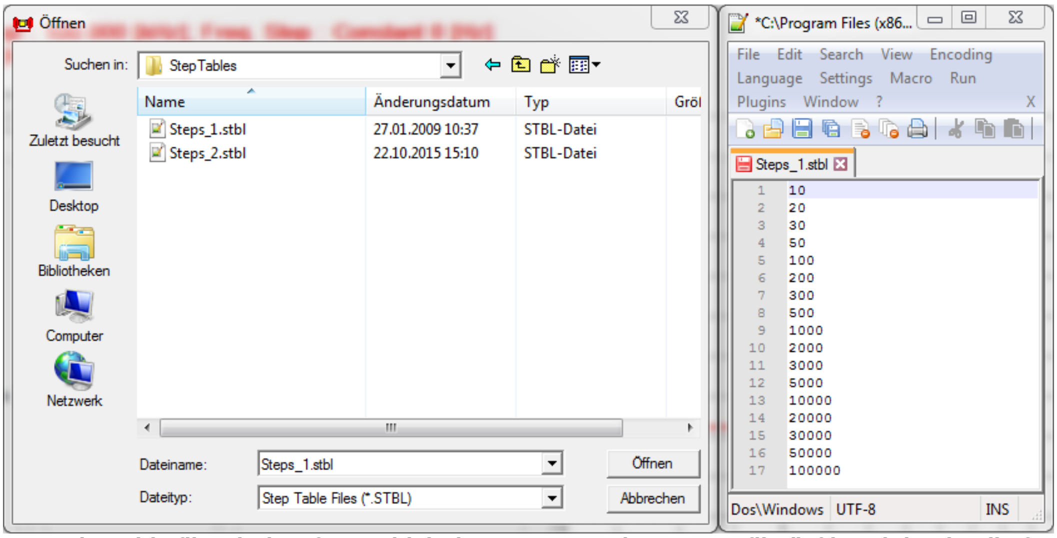


Figure 29: the table file window from which the user can select a step file (left) and the detail of a .stbl step file (right): the test frequencies are expressed in Hz.

The user has the possibility to expose the EuT to the magnetic field produced by the Helmholtz coil or the radiating loop, using two different modalities:

1. **automatic mode**: the EuT will be exposed for a defined time at each test frequency; the transition to the following test frequency will be performed automatically. If the tests must be performed using this mode, the user must only define the **Dwell** time, by entering the wished time interval in the dedicated field (See Figure 27). The Dwell time is expressed in milliseconds (1 ms = 10^{-3} s);
2. **manual mode**: by clicking on the “step by step” option, the manual mode will be activated when the test will be started (see Figure 30). The user can activate the magnetic field by clicking on “Field ON” and performing the test for the wished time. The magnetic field can be

deactivated by clicking on “Field OFF” and one can proceed to the following frequency. This procedure must be repeated until the last test frequency has been tested.

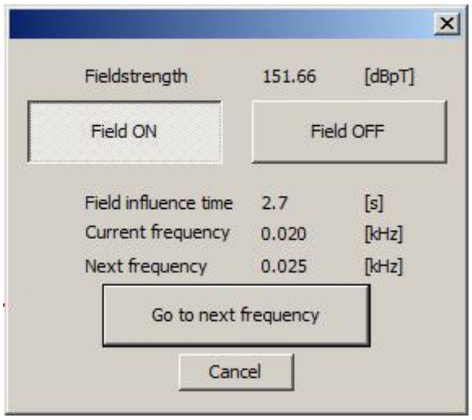


Figure 30: the manual mode testing.

The automatic and manual mode cannot be used simultaneously: when the manual mode is selected the automatic one is disabled (and vice-versa).

If the **compensation** network (NFCN 9731 or NFCN 9734) is used, the corresponding check-box “Compensation network” must be selected, as shown in Figure 31.

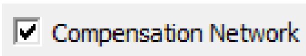


Figure 31: compensation network check-box.

The "**QuickRun**" file can only be created if in the "Hardware Configuration" dialog the "Save QuickRun Table" box is set, as shown in Figure 32. More details about the quick run table will be given in the following sections.

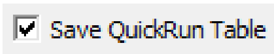


Figure 32: save quick run check-box.

The **level offset** defines the distance from the actual limit to the actual field strength and it is expressed in decibel (dB).

The **maximum deviation** is the maximum allowed divergence of the current (which circulates in the Helmholtz coil or in the radiating loop) to the calculated current value. Smaller allowed deviation causes more regulation cycles and increases measurement time. This parameter is expressed as a percentage. The level offset and maximum deviation parameters can be modified using the field shown in Figure 33.

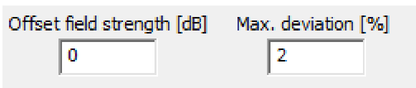


Figure 33: level offset and maximum deviation parameters.

If the EuT is driven by a power supply equipped with a GPIB interface, there is a possibility to switch the EuT ON only when the magnetic field is reached (and not during the adjustment phases). This is required, for example, when it is necessary to reduce the heating of the EuT. When the prescribed magnetic field strength is achieved, the output of the power supply is activated, while it is deactivated during the time interval needed to reach the following frequency field strength. In order to activate this feature the "Use ON / OFF Command" box must be activated, as shown in Figure 34.

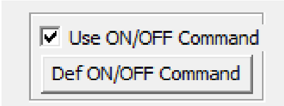


Figure 34: the "Use ON/OFF Command".

By clicking on the button “Def ON/OFF Command”, it is possible to open the panel in which the user can define the parameters which are required to communicate with the power supply (GPIB address, Init, ON and OFF command). An example of the parameters is reported in Figure 35 (HP8165A). It is important to use a GPIB address which is not yet assigned to another device. Please read the manual of your GPIB power supply to use the proper settings.

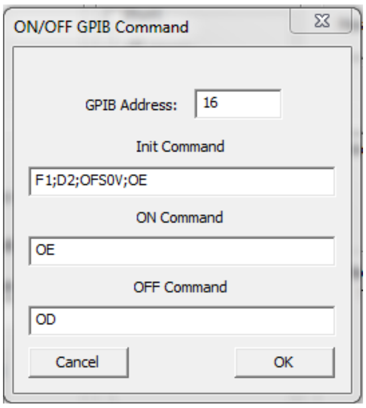


Figure 35: settings to control the power supply which provides power to the EuT.

“Area B” settings

The purpose of this area (see a detailed view in Figure 36) is to select the voltmeter which is used to measure the field strength with the shunt (SHUNT 9571, which is available separately or included in the compensation network) or the current probe (CP 9610). In order to activate the voltmeter the user must click in the check-box and select the proper device from the menu. The option “priority” defines the voltmeter which is used for the regulation of the magnetic field strength. The priority must be selected, but it is possible to give it only to one measuring device. In this case, the priority will be given to the monitoring loop and not to the shunt/current probe (see also “Area C” settings).

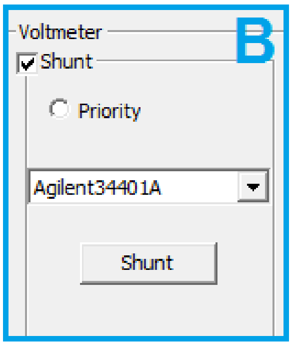


Figure 36: detailed view of Area “B”.

In order to load the shunt/current probe calibration data, the user must click on the “Shunt” button. This will open the dialog panel shown in Figure 37.

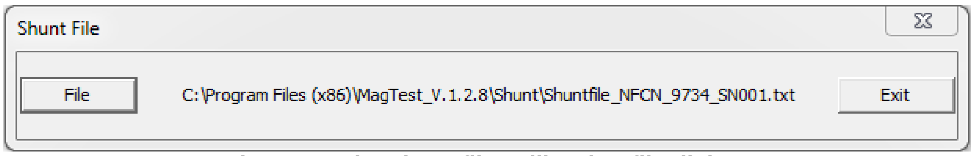


Figure 37: the shunt file calibration file dialog.

To select the calibration file, it is necessary to click on the “File” button, this will open the window shown in Figure 38.

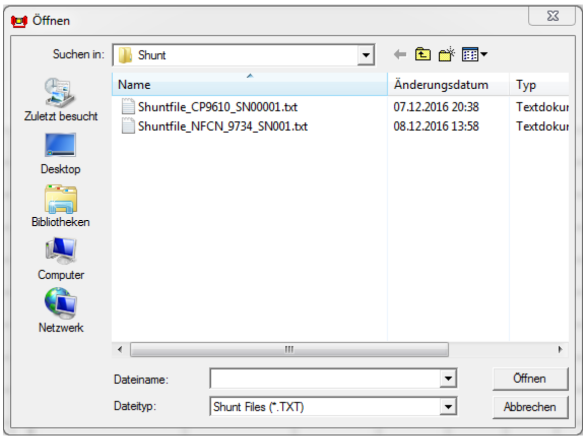


Figure 38: from this panel it is possible to select the proper calibration file.

The proper shunt calibration data can be identified by the prefix “Shuntfile” and the following digits are associated to the measuring device. In this case “Shuntfile_CP9610_SN00001.txt” refers to the current probe CP 9610 S/N 1, while “Shuntfile_NFCN_9734_SN001.txt” is the calibration file of the SHUNT 9571 which is included in the compensation network NFCN 9734 S/N 1. The shunt file will be loaded to memory by clicking on the “Open” button.

“Area C” settings

The purpose of this area (see a detailed view in Figure 39) is to select the voltmeter which is used to measure the field strength with the monitoring loop (FESP 5133-7/41 or FESP 5134-40).

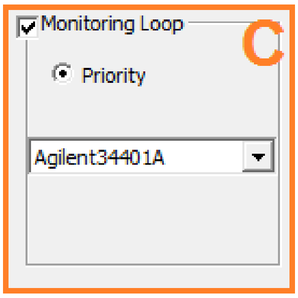


Figure 39: detailed view of Area “C”.

In order to activate the voltmeter the user must click in the check-box and select the proper device from the menu. The option “priority” defines the voltmeter which is used for the regulation of the magnetic field strength. The priority must be selected, but it is possible to give it only to one measuring device. In this case, the priority is given to the monitoring loop. The calibration file of the monitoring loop is loaded using the options available in “Area D”.

“Area D” settings

The “Area D” (see a detailed view in Figure 40) is dedicated to the setup of the parameters of the Helmholtz coil / radiating loop and the monitoring loop. As it was explained in paragraph 1.9, the Helmholtz coil / radiating loop and the monitoring loops require the typical data.

- **Helmholtz coil / radiating loop setup**: the parameters can be loaded by clicking on the button “Parameter of Helmholtz coil / radiating loop” (see Figure 40). This will open the window shown in Figure 41, left. It is then possible to select the proper device by opening the file explorer (typical data are required), by clicking on the “File” button. After the correct file has been selected, it is necessary to click on “OK” to load it in memory and to close the panel;

- **monitoring loop**: the parameters can be loaded by clicking on the button “Parameter of monitoring loop” (see Figure 40). This will open the window shown in Figure 41, right. It is then possible to select the proper device by opening the file explorer (typical calibration data are required), by clicking on the “File” button. After the correct file has been selected, it is necessary to click on “OK” to load it in memory and to close the panel.

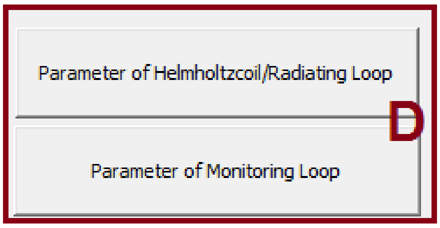


Figure 40: detailed view of Area "D".

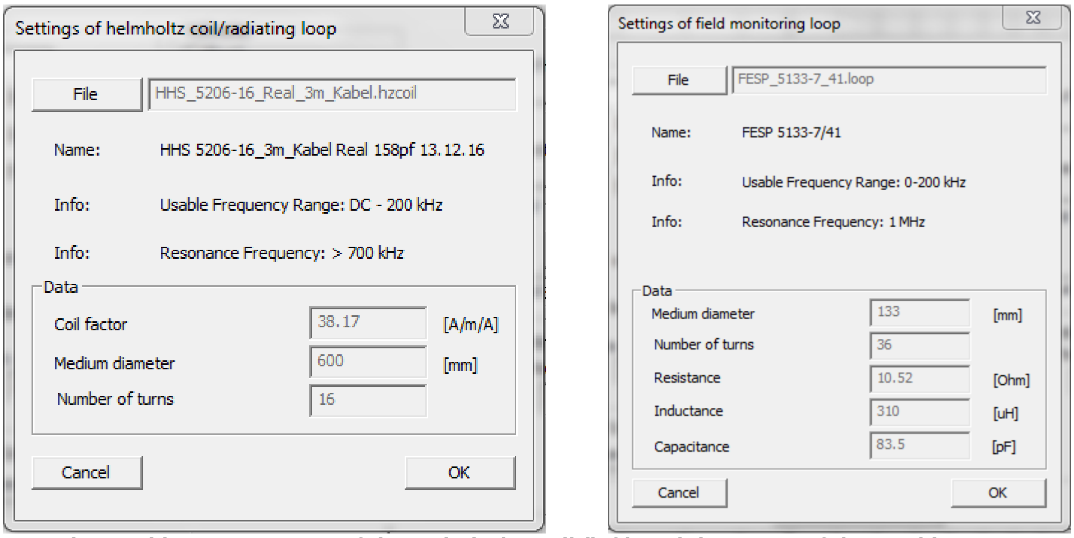


Figure 41: the working parameters of the Helmholtz coil (left) and the setup of the working parameters of the monitoring loop (right).

In the panels shown in Figure 41 it is possible to check the working parameters of the coils, but not to modify them.

“Area E” settings

“Area E” (see a detailed vied in Figure 42) is dedicated to the setup of special features, which are described in the following pages.

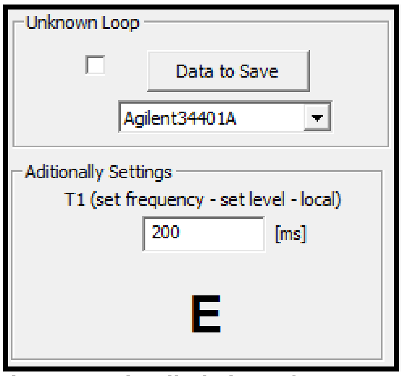


Figure 42: detailed view of Area "E".

Calibration of a generic monitoring loop

With the MagTest software it is possible to calibrate a generic monitoring loop. A defined magnetic field is produced using an Helmholtz coil or a radiating loop. When the defined magnetic field strength is reached, the voltage at the output of the monitoring loop is measured with a voltmeter. In order to use this function the check box “Unknown loop” must be checked and the voltmeter must be selected, as shown in Figure 43.

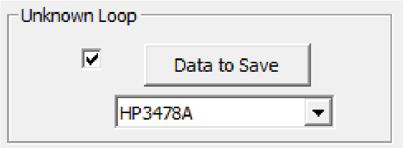


Figure 43: settings for the calibration of a generic monitoring loop.

It is required to create a new file with .txt extension called, in this example, “GenericLoop.txt” and saved in a defined directory. By clicking on “Data to Save” button it is then possible to open the window shown in Figure 44 and the previously created .txt file must be loaded using the File dialog.

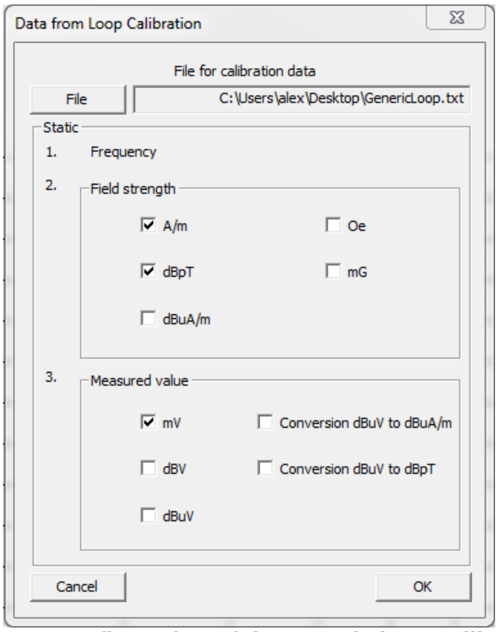


Figure 44: configuration of the generic loop calibration.

During the execution of the test the field strengths and measured voltage values (selectable in different units) will be saved as a function of the tested frequency, in the text file defined by the user.

T1 (set frequency –set level –local)

This setting, which can be found in the bottom part of the “Area E” is required because different devices may have different timing requirements. T1 is the time between the commands of signal source set frequency, set level and local. If the value of T1 is too small then the frequency or level can be set incorrectly. If the value of T1 is too large then the test time may become unnecessary long. The typical value of T1 is 200 ms.

“Area F” settings

The “Area F” (see a detailed vied in Figure 45) is dedicated to the monitoring of the EuT working parameters (in this case the voltage).

Figure 45: detailed view of Area "F".

By clicking on the “EuT Control” button (see Figure 45), it is possible to open the EuT control panel which is shown in more detail in Figure 46. It is possible to monitor the output voltage of up to three devices. To activate a channel it is necessary to click on the left check-box and to choose the corresponding voltmeter. It is also possible to set the threshold (in Volt) which defines the “PASS” or “NOT PASS” condition. In particular, it is possible to decide that the EuT passed the test if the measured voltage is lower OR greater (and equal) than the selectd threshold.

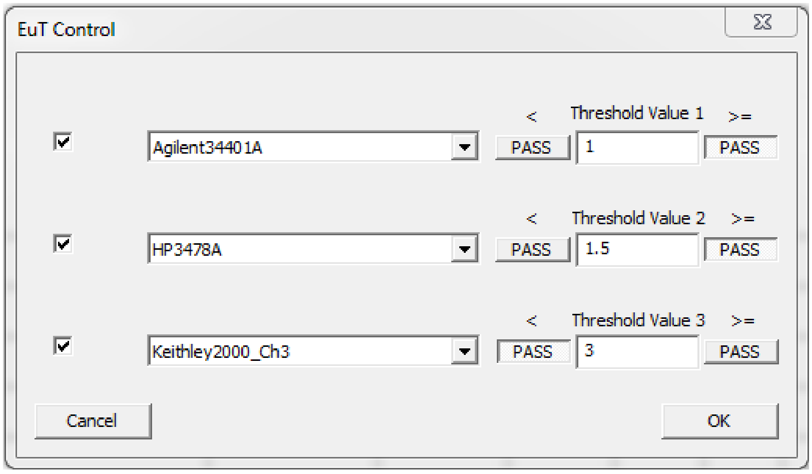


Figure 46: the EuT control panel.

The settings are finally summarized in the Section 3 of Figure 8, as shown in Figure 47.

Date and Time : 06/04/2017 14:21:28 File : Temp
Helmholtz coil/Radiating loop : HHS 5206-16_3m_Kabel Real 158pf 13.12.16 12:00; Monitoring loop : FESP 5133-7/41 / Table / OFF
Signal Source : HP8165A; Voltmeter Shunt : Keithley2000_Ch1 / OFF; Voltmeter Monitoring Loop : Keithley2000_Ch2 / OFF
Limit : ISO 11452-8 2 int Max. Error : 2.0 [%]
Hold time : 1.000 [s]
Freq. Start : 1.000 [kHz]; Freq. Stop : 100.000 [kHz]; Freq. Step : Constant 0 [Hz]
Shunt File : C:\Program Files (x86)\MagTest_V.1.2.8\Shunt\Shuntfile_NFCN_9734_SN001.txt

Figure 47: summary of the configuration.

2.0 Performing tests with the MagTest software

2.0.1 Introduction: hardware description and configuration

The MagTest software is a powerful tool and it can be used to perform tests with a broad combination of hardware components. The execution of a test will be described in the following pages using a well-defined setup. In particular, the following equipment has been used to obtain the results which will be presented in the following pages:

- Helmholtz coil **HHS 5206-16**: http://www.schwarzbeck.de/Datenblatt/k5206-16.pdf;
- power amplifier **LFPA 9733**: http://schwarzbeck.de/Datenblatt/k9733.pdf;
- compensation network **NFCN 9734**: http://schwarzbeck.de/Datenblatt/k9734.pdf with built-in resistive **SHUNT 9571**: http://schwarzbeck.de/Datenblatt/k9571.pdf
- monitoring loop **FESP 5133-7/41**: http://schwarzbeck.de/Datenblatt/k5133741.pdf;
- 1 Function generator, to provide the input signal to the power amplifier;
- 3 Voltmeters which are used to measure the output voltage of the shunt, monitoring loop and EuT;
- GPIB to USB interface, IEEE 488 cables to connect the GPIB devices to the PC;

- **MagTest** special **cables** to connect the power amplifier to the compensation network to the Helmholtz coil.

Device	Scope	GPIB address
Function generator	signal to the amplifier	**7**
Voltmeter 1	measuring the shunt	**23**
Voltmeter 2	measuring the loop	**22**
Voltmeter 3	measuring the EuT	**8**

Table 2: GPIB devices and used addresses. The codes are reported here just as example to remark the importance to setup the proper address. The user can of course use different addresses.

Table 2 reports the GPIB addresses used to configure the function generator and the voltmeters used in this example test. The user can use own addresses: the example reported here has just the scope to remark the importance to use a different address for each device (see paragraphs 1.7-1.8).

IMPORTANT: when the power amplifier is switched on, the output level is set by default on MUTE (0%). Turn the black knob on the front panel of the amplifier and set the level between 50-70% (of the total output power). Read carefully the amplifier´s manual to learn how to increase the level. The output level is shown on the front display of the power amplifier (see Figure 48).

Figure 48: the power amplifier display. The output level (in percentage of the total power) is visible in the bottom-right corner).

The above setup has been used to perform a test according to **ISO 11452-8** and using the frequency points reported in Table 3. The frequency points are saved in the Step file as explained in the previous chapter.

Test point	Frequency (kHz)
1	0,15
2	0,1
3	1
4	10
5	100

Table 3: tested frequencies (in kHz).

The hardware has been configured as explained in the previous chapter. In particular, the configuration is summarized in Figure 49. The “Save QuickRun Table” check-box has been activated and the file in which the quick run parameters are expected to be saved has been named “QRTest.txt”.
The Eut Control panel has been configured as shown in Figure 50. The test is passed (PASS) if the output voltage at the EuT is smaller than 3 Volt, not passed (FAIL) if the output voltage at the EuT is greater/equal than 3 Volt.

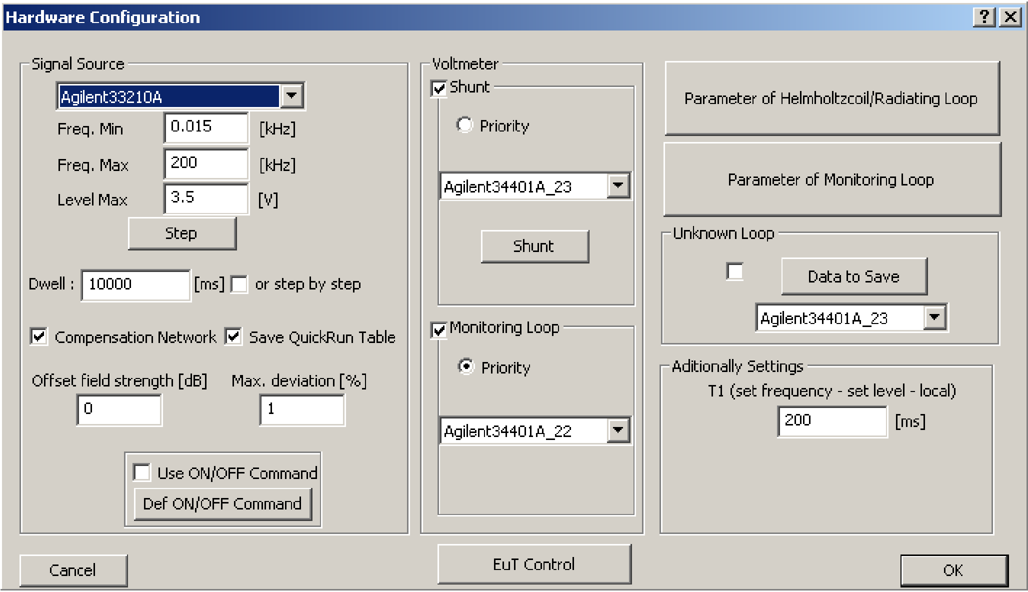


Figure 49: detailed view of the hardware configuration panel, valid for this example.

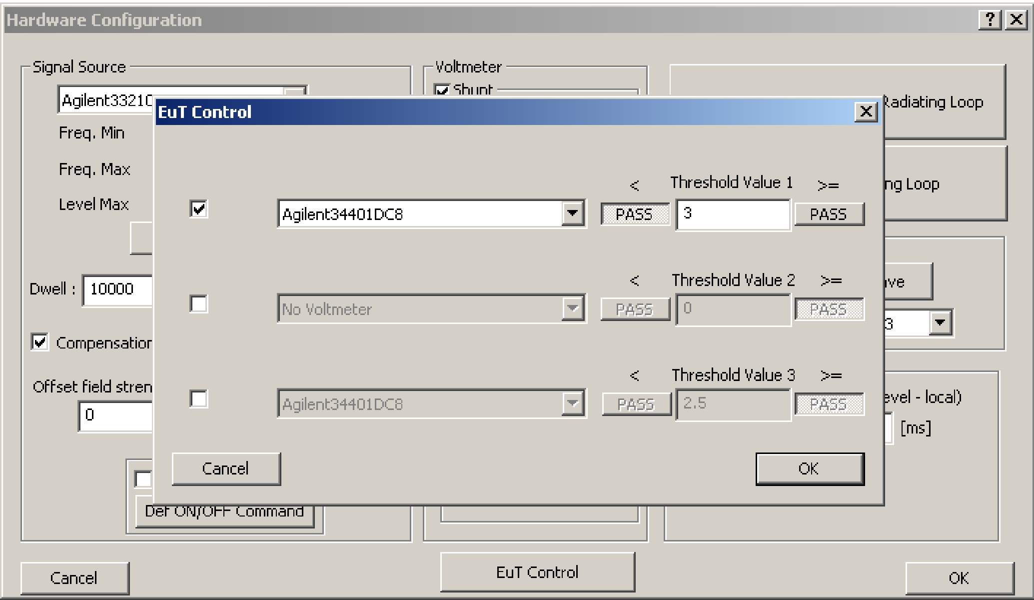


Figure 50: configuration of the EuT control panel.

2.0.2 The calibration run

The calibration run should be performed by the user at least once per day. The scope of the calibration run is to measure the current which is needed to achieve the required magnetic field strength. This task is fully automatized and performed by the software. In this phase the monitoring loop is located in the centre of the Helmholtz coil. The working area of the MagTest software is reported in Figure 51. The test parameters are visible in Figure 52. In particular, the ISO 11452-8 curve is plotted as a function of the increasing frequency. **Remember to set the level on the amplifier panel. The starting value used in this test is 50% of the total power of the amplifier.** It is then possible to start the calibration run by clicking on the “Start test” button . The software will then measure the field and compute the parameters to reach the required magnetic field strength, as shown in Figures 51-52.

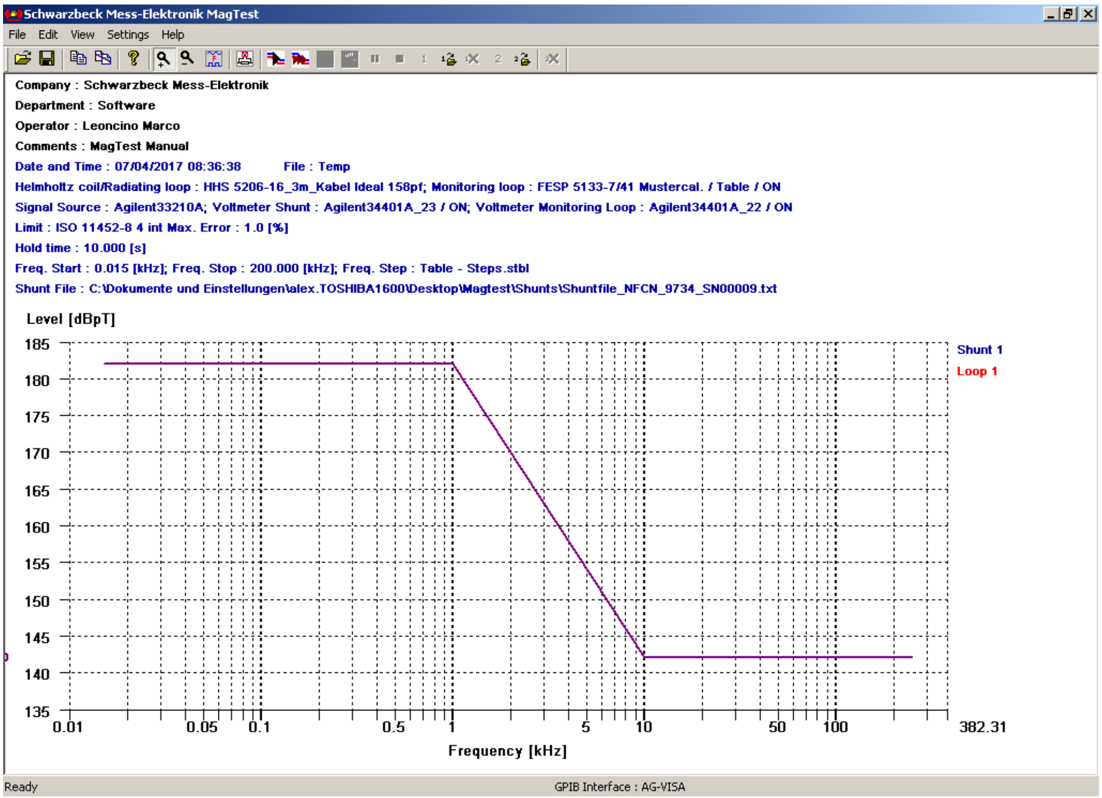


Figure 51: the MagTest working area before the beginning of the calibration run.

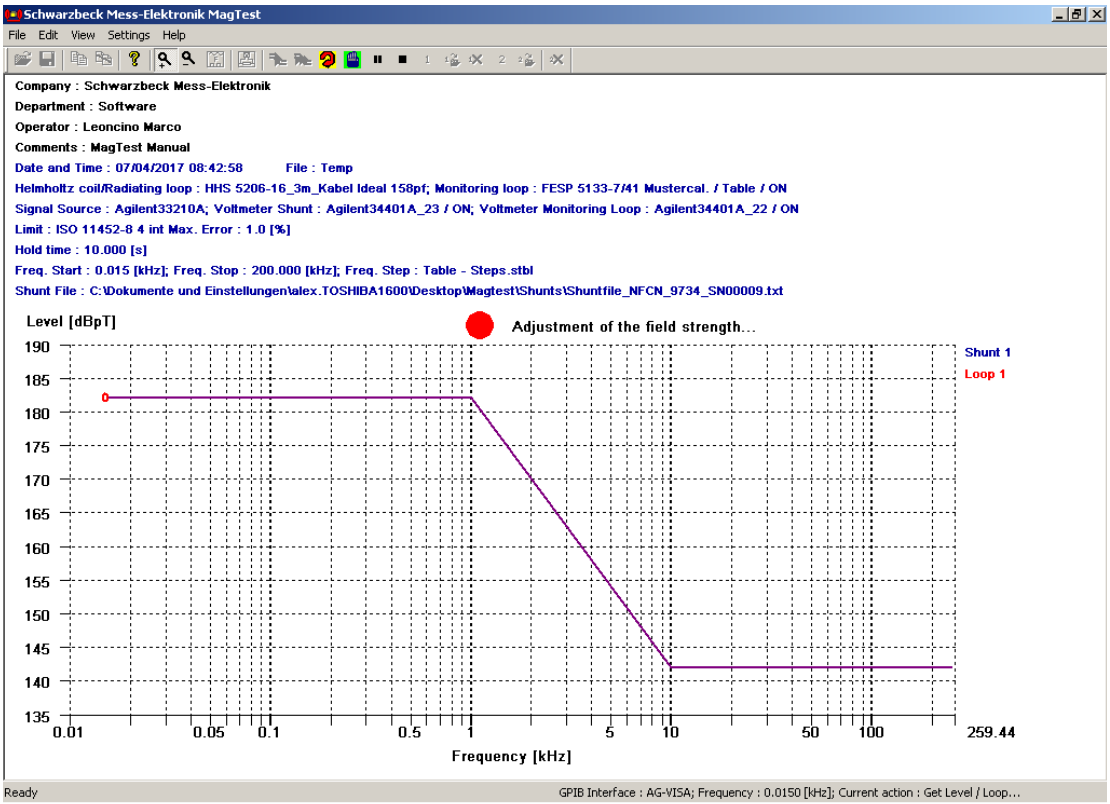


Figure 52: when the test has been started, the software measures the field and compute the parameters to reach the required magnetic field strength.

In the case in which the level provided by the amplifier is not sufficient to reach the target field strength, the following windows, shown in Figure 53, will appear on the user´s screen.

Figure 53: the set up output level (in this example 50% of the total power) is not sufficient to reach the target magnetic field.

The user can then click on the “Yes” button and the window, shown in Figure 54, will be opened. It is then possible to click on “Calculate current offset and continue” and then to increase the level on the power amplifier. The test can be continued by clicking on “Try again”. Another solution consists to close the panels shown in Figure 53, to increase the output level on the power amplifier manually and to restart the calibration run. **In this example, the output level has been increased from 50% to 70% of the total available power at the output of the amplifier**. It is not worth to use gain greater than 90% in order to exploit the dynamic range of the function generator.

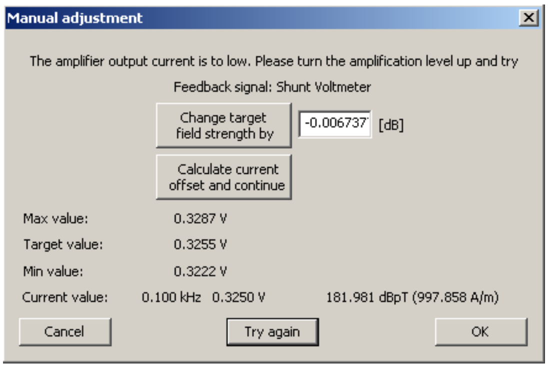


Figure 54: amplifier output level adjustment control panel.

Figures 55 and 56 show the final stages of the calibration run.

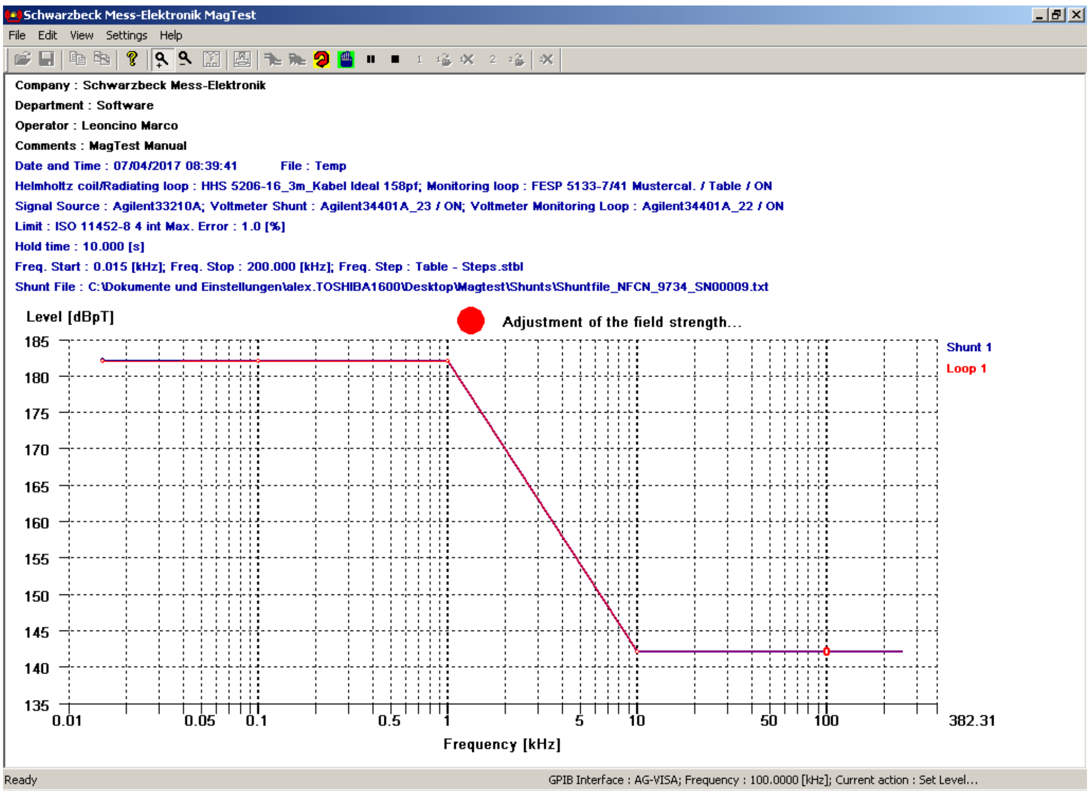


Figure 55: adjustment of the field strength during the calibration run.

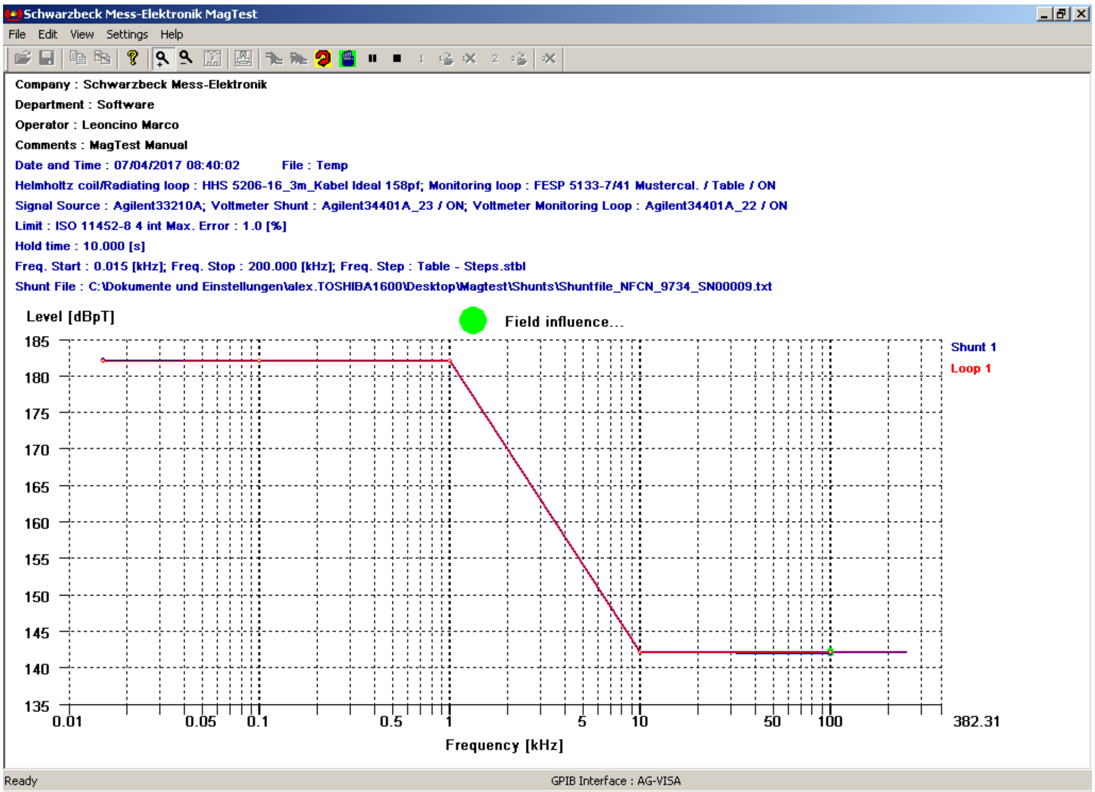


Figure 56: the required field strength has been reached and the field is produced.

It is possible to zoom in and out the measurement area using the  and the  button respectively.

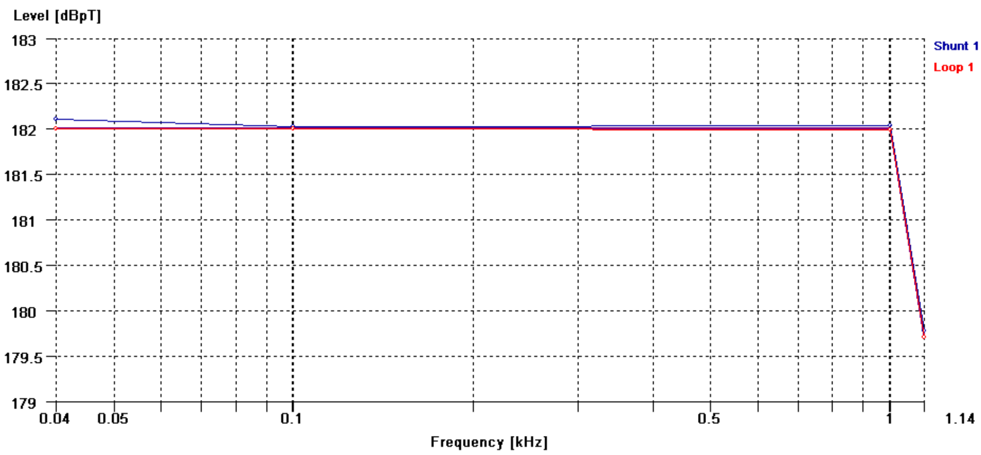
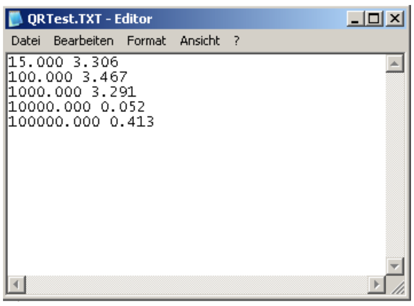


Figure 57: enlargement of the test area. Minimal deviation between the measurement performed with the shunt and the monitoring loop could be visible.

At the end of the calibration run, the Quick run has been created (see Figure 58).


QRTest.TXT - Editor

Datei Bearbeiten Format Ansicht ?

```
15.000 3.306
100.000 3.467
1000.000 3.291
10000.000 0.052
100000.000 0.413
```

Figure 58: the quick run file.

2.0.3 The EuT testing run

The Quick run file contains the values of the voltage provided by the function generator (second column) as a function of the frequency (first column). During the EuT testing, the software uses the information stored in the Quick run file instead of reaching the magnetic field with the iterative process used during the calibration run. This allows to perform the EuT testing faster than during the calibration run. In this phase, the EuT is inserted inside the Helmholtz coil and, eventually, the monitoring loop should be removed (*substitution method*). In that case, the monitoring loop must be deactivated, since the magnetic field outside the Helmholtz coil is negligible compared to the one measured inside the coil. To start the quick run it is necessary to click on the button: . At the end of the Eut testing run, it is possible to save data in several formats. By clicking on "Save" from the "File" menu, it is possible to save the data in .MAG and txt format, in a directory defined by the user, as shown in Figure 59. The .MAG file can be opened with the MagTest software, while the .log file can be inspected with any text editor.

IMPORTANT: when using the quick run procedure, the user MUST NOT change the gain settings of the amplifier (the black knob that is used to set the volume on the amplifier must not be turned anymore). If the gain will be changed, the quick run file will not be valid anymore and the calibration run must be repeated.

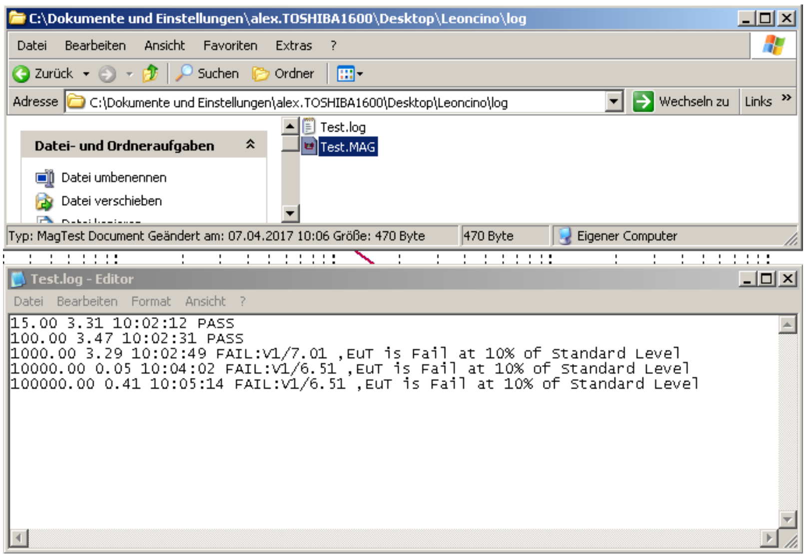


Figure 59: output measurement data.

The .log file (Figure 59) contains the tested frequency in the first column, the current in the second one, the time of the test in the third, and the PASS or FAIL information in the last one. When the test is failed, the output voltage and the percentage of the standard level is also reported. The user can export the result to the clipboard as text file by clicking the button . In this example, the output is the following:

Company : Schwarzbeck Mess-Elektronik, Department : Software, Operator : Leoncino Marco, Comments : MagTest Manual
Date and Time : 07/04/2017 09:44:07 File : Temp
Helmholtz coil/Radiating loop : HHS 5206-16_3m_Kabel Ideal 158pf; Monitoring loop : FESP 5133-7/41 Mustercal. / Table / OFF
Signal Source : Agilent33210A; Voltmeter Shunt : Agilent34401A_23 / ON; Voltmeter Monitoring Loop : Agilent34401A_22 / OFF
Limit : ISO 11452-8 4 int Max. Error : 1.0 [%]
Hold time : 10.000 [s]
Freq. Start : 0.015 [kHz]; Freq. Stop : 200.000 [kHz]; Freq. Step : Table - Steps.stbl
Shunt File : C:\Dokumente und Einstellungen\alex.TOSHIBA1600\Desktop\Magtest\Shunts\Shuntfile_NFCN_9734_SN00009.txt
Data 1 Shunt:
[kHz] [dBpT]
0.015 182.192
0.100 182.030
1.000 182.036
10.000 141.946
100.000 141.963

Data 1 Loop:
[dBpT]
0.015 181.997
0.100 181.998
1.000 181.992
10.000 141.916
100.000 142.002

While clicking the button the screenshot will be stored as vector graphic image in the clipboard and can be inserted in most text and picture processing programs (Microsoft Word, OpenOffice, Paint, Gimp etc.) and be processed externally.

2.1 Additional features of the MagTest software

Open document

While clicking the button the file dialog will be opened to load the data at position 1. Files can be loaded on two positions. If the file will be opened by clicking, the data will be loaded on position 1.

Stop test

While clicking the button the current test will be stopped.

Pause

While clicking the button the current test will be paused.

Open file 1

While clicking the button the file dialog will be opened to load the data at position 1.

Open file 2

While clicking the button the file dialog will be opened to load the data at position 2.

Close file 1

While clicking the button the data on position 1 will be closed.

Close file 2

While clicking the button the data on position 2 will be closed.

Switch to 1

By clicking the button 1 the test setting at the position 1 will be shown.

Switch to 2

By clicking the button 2 the test setting at the position 2 will be shown.

Repeat the previous frequency step

The previous frequency step can be repeated by clicking on the button on the task bar. It is only active if the frequency scan is still active.

2.2 Additional material

More information about the MagTest system can be found on our website at the following address:

http://www.schwarzbeck.de/en/magtest-system.html in particular, the technical datasheets and manual of the MagTest components are available. The MagTest software is also described in details with five videos, which are available on the Schwarzbeck´s Mess-Elektronik YouTube channel:

https://www.youtube.com/playlist?list=PL6UX-oBoEnKMk5wqJCZzUIHfIUpZWQSn-

The description of the videos is briefly reported in the following:

Part 1: this is a general overview to the software and an introduction to its main features;

Part 2: the setup of the hardware´s components is explained in an effective way in just few minutes;

Part 3: the components of the system communicate to the PC by means of the GPIB protocol: in this video it is explained how to set the GPIB devices

Part 4: in this video you will learn how to configure the advanced settings of the software in order to be ready for a test;

Part 5:in this episode we will finally perform a test with the Mag Test System.

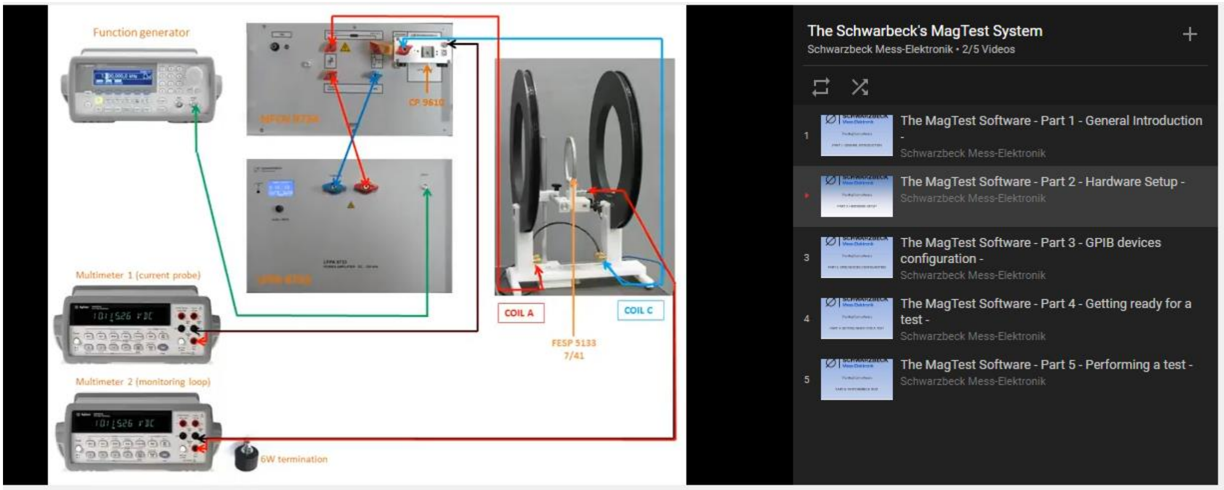


Figure 60: the five videos dedicated to the MagTest system.