TRUE GERMAN QUALITY

Operating Manual

Surge Tester ST 4000A/B

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1 General information

1.1 Information on this operating manual

This operating manual is part of the technical documentation for the surge testers ST 4000A/B of SPS electronic GmbH.
This operating manual contains all the information on how to operate this device properly, safely and economically, how to prevent dangerous situations, how to reduce repair costs and downtimes and how to prolong the service life of these devices.

Should you, while perusing this operating manual, find any misprints, any information you do not understand or which are incorrect please do not hesitate to inform SPS electronic GmbH about same.

Pictograms and symbols

Warnings are symbolized by warning triangles with danger symbol, they warn of possible personal injury and/or damage to property.

General warning

Dangerous electric current or voltage

Pointers are symbolized by the information pictogram and give recommendations or additional information.

You can order accessories directly from SPS electronic GmbH.

1.2 Requirements for the operation of this device

1.2.1 Regulations for application

The tester must be in an operational and reliable condition.

Only personnel having completely read and understood this operating manual and who are authorized skilled electricians or who have been instructed in electrical engineering are allowed to perform any operations with and at the testers.

The tester is not to be operated if or for:

- operations are performed which are not specified in this operating manual or which have not been recommended by *SPS electronic GmbH* concerning installation, operation, maintenance and service.
- unauthorized alterations and/or repairs
- dismantling and/or avoiding of safety devices
- use of components, tools, additional installations, supplements and working material which have not been approved or recommended by *SPS electronic GmbH*
- building in of spare parts which are not original *SPS electronic GmbH* spare parts or of spare parts from suppliers not recommended by *SPS electronic GmbH*

1.2.2 Product liability

The testers have been produced, adjusted and tested according to the state of the art and the approved safety requirements.
The devices comply with the conditions agreed upon by contract of the confirmation of order concerning execution, single parts and accessories selection.

SPS electronic GmbH will be liable for errors or omissions to the extent of the guarantee liabilities of the confirmation of order.
Applicable are the general conditions of delivery of the Central Association of Electrical Engineering and the Electronics Industry, registered association (ZVEI).

The contents of this operating manual is in compliance with the condition of the tester on the date when same was drawn up.
Subject to change are technical alterations because of further developments and improvements of these products by SPS electronic GmbH.
Liability claims can therefore not be derived from the contents of this operating manual (data, descriptions, graphs, misprints, etc.).

Errors and omissions excepted!

SPS electronic GmbH will only be liable in case of application of the testers according to regulations (pl. see 1.2.1).
If those regulations have not been applied the operator is solely responsible for risks of hazard to body and life of the user or a third party and impairments of the tester and other material assets!

1.3 General safety regulations

The surge tester ST 4000A/B has been manufactured according to the state of the art at the time of its delivery.

Nevertheless the tester is not without hazards if it is applied by untrained personnel, applied improperly or not applied according to regulations.

In addition to this operating manual the generally applicable legal regulations and other binding instructions concerning safety regulations, regulations for preventing accidents and regulations for the protection of the environment must be adhered to.

Beware of high electronic voltage and electromagnetic fields

In case of defective test objects, like e.g. arc-overs, there can occur electromagnetic fields. This is of particular concern to persons with active or passive medical devices, like e.g. cardiac pacemaker.

1.3.1 Obligations of the operator

- The tester is only to be operated according to regulations and in operational condition (see chap. 1.2.1)
- Protective and safety devices, locking devices and couplings, etc. have to be inspected by an expert at least once a year.
- A protocol on the test results has to be drawn up in form of a **test report** same has to be retained.
- Instructions on operations with or at a machine or installation as to hazards to health and/or life of persons are obligatory.
- Persons who operate with or at an ST 4000A/B have to confirm by their signature to have read and comprehended this operating manual especially in regard to the operating instructions.
- Dangerous zones resulting from the integration of the tester into a system or a device have to be located by the operator and safeguarded against.
  When assembling or installing devices, systems or items of equipment of different manufacturers or suppliers and after modifications by company or service personnel where changes within the electric equipement were made the operator has, before putting into operation, to perform a precise inspection according to the accident prevention regulations VBG 4 in compliance with the individually applicable rules of electrical engineering.

1.3.2 Operating instructions for personnel

- Operating instructions, general instructions and regulations are part of the tester and have to be accessible, readable and complete for all those who operate with or at the ST 4000A/B.
- Before operating with or at the ST 4000A/B questions have to be answered or uncertainties have to be explained by the personnel in charge.
- Any operations with or at the ST 4000A/B may only be performed by workers skilled in electrical engineering or trained in electronic engineering and who have been given instructions for such operations and thus been authorized by the operator.
- Testing personnel may only operate the ST 4000A/B when a skilled electrician is in charge.
- Adjustments, service and inspections have to be performed according to the instructions specified and according to schedule.

1.3.3 Safety installations

The ST 4000A/B testers are, for the safety of the operating personnel, equipped with below safety equipment:

- safety current limiting for insulation test and high voltage test
- electric charge < 350 mJ (only standard device with 18 nF surge capacitor)
- EMERGENCY-STOP switch
- Interfaces for external EMERGENCY-STOP (only for external devices) and external safety circuit (this must always be active/closed)

Capacitive DUTs and DC high voltage

When testing with DC high voltage, capacitive DUTs are getting charged. At the end of an insulation test or HV-DC test, the test object is discharged, the PASS / FAIL signal is output only after the end of the discharge. That's why tests with DC high voltage always have to go through to the end in a controlled manner. If the contact is prematurely disconnected (or if the tester is switched off, mains voltage failure, etc.), the test object is not discharged and may still be charged with dangerously high energy!

This also applies to safety current-limited testers (<10 mA DC)! Although the test voltage / current of these devices is not dangerous as such in direct contact, capacitive DUTs can still be charged with dangerously high energy!

If such conditions are met by appropriate DUT types, the personal safety measures according to EN 50191 must be observed, even with safety-limited test equipment.

1.3.4 Note on possible disorder of USB devices

When testing with high-voltage, it is possible that failing testpieces may cause disorder of USB devices in close surrounding of the test field.

1.3.5 Information on further publications

For the protection of persons the trade associations and unions have published below literature:

• DIN EN 50191	Installation and Operation of Electrical Installations
• DIN EN 50274	Protection against Electric Shock – Protection against unintended direct contact of dangerous active parts
• DIN 40 008 part 3	Safety Signs for Electrical Engineering; Warning Signs and Additional Signs
• DIN 40 050	IP-Protective System, Protection against Contact, Foreign Matter and Water for Production Equipment
• DIN 57100	Specifications for the Installation of Power Plants with Nominal Voltages of up to 1000 V
• BGI 891	Establishing and operation of electrical test plants

2 Description

2.1 Device functions

You can perform safety tests at electric devices according to standard test regulations (EN, IEC, VDE etc.) with the safety tester ST 4000A/B.

Below tests can be performed:

Standard tests:	ST 4000A	ST 4000B
Surge Test	100 up to 6000 V	100 up to 6000 V
Partial discharge measurement	———	Acc. to IEC 61934
IS: Insulation test	100–6000 V DC / 10 mA	100–6000 V DC / 10 mA
HV: High voltage test	100–6000 V DC / 10 mA	100–6000 V AC / 10 mA
Optional: Resistance measurement	20 mΩ up to 200 kΩ	20 mΩ up to 200 kΩ

The test device works with a fully electronic high-voltage generator. The high voltage is readjusted fully automatically during the test operation, depending on the load, once the test voltage has been correctly adjusted.

2.2 Technical Data

Measurements and Weights	
Width / depth / height	ca. 550 / 600 / 320 mm (19" / 6 HU)
Weight	ca. 54.0 kg

Ambient	
Temperature	operation: 15 °C – 40 °C storage: 5 °C – 60 °C
Air humidity	max. 70 % (non-condensing) (allowed for general operation)
ambient conditions to comply with the stated technical specifications	23 °C (± 5 °C) and max. 50% relative air humidity (not condensing)

Connection Data	
Power supply	wide range 90-253 V / 50-60 Hz
Power input	max. 660 VA (typical ~185 VA)
Blowing fan	integrated (at the rear panel, pulling inwards, with filter mat)

Surge Test	
Voltage	100 V up to 6000 V
Sample rate	250 MHz
Recording time	1 µs up to 160 ms
Resolution	8 / 12 Bit, 4 ns
Surge capacity	default 18 nF, optional 40 / 100 / 200 nF
Rise time	3.5 ns
Evaluation methods	- error area - differential error area - tolerance band method

Partial Discharge Measurement	
Frequency range	1 GHz … 2 GHz
Sensitivity	ca. -90 … -30 dBm
Damping of restricted area	120 dB
Time base	1 ns (1 GS/s)
Memory	256 MS
Evaluation methods	- limits partial discharge - PDIV inception voltage / RPDIV "repeatable" inception voltage - PDEV extinction voltage / RPDEV "repeatable" extinction voltage

High Voltage Test			
Test voltage	free programmable from 100 up to 6000 V DC residual ripple DC: < 1% acc. VDE 0432 / EN 61180		
Short circuit current	< 12 mA DC, safety current limited acc. EN 50191		
Voltage output	Reproducibility of end value: 100-6000 VDC: 1.5% ± 2 V		
Measuring range I	**Range (automatic)** 10mA DC	**significant bits (resolution)** 3 (10.0 mA / 0.01 µA)	**accuracy (of meas. value)** 1.5 % ± 1.5 µA
Measuring range U	**range** 6000 VDC	**resolution** 1 V	**accuracy (of meas. value)** 1.5% ± 2 V

Maximum capacitive load should not exceed 1µF per second of ramp time. Otherwise there is chance for ringing (over-voltage).

The total capacitive load must not exceed 10µF, otherwise correct discharge can not be guaranteed.

Insulation Test			
Test voltage:	free programmable from 100 up to 6000 V DC residual ripple DC: < 1% acc. VDE 0432 / EN 61180		
Shortt circuit current:	< 12 mA DC, safety current limited acc. EN 50191		
Voltage output *	Reproducibility of end value: 100-6000 VDC: 1.5% ± 2 V		
Limit values:	Free programmable 250 kΩ - 600 GΩ		
Measuring range:	**range (automatic)** 0.25 MΩ - 600.00 GΩ (max. 1 GΩ/kV)	**significant bits (resolution)** 3 (0.01 MΩ / 10.0 GΩ / 100 GΩ)	
	accuracy (of value)	**corresponding GΩ/kV**	
	pure ohmic load:		
	5 % ± 3 digits**	0.250 MΩ/kV – 10.0 GΩ/kV	
	15 % ± 3 digits**	10.0 GΩ/kV – 100.0 GΩ/kV	
	load with reactive portion:		
	10 % ± 3 digits**	0.250 MΩ/kV – 10.0 GΩ/kV	
	30 % ± 5 digits**	10.0 GΩ/kV – 100.0 GΩ/kV	
	No rating.	> 100.0 GΩ/kV	
	*** on last significant bit*		
Voltage measurement:	**range** 6000 V	**resolution** 1 V	**accuracy (of meas. value)** 1.5% ± 2 V

Maximum capacitive load should not exceed 1µF per second of ramp time. Otherwise there is chance for ringing (over-voltage).

The total capacitive load must not exceed 10µF, otherwise correct discharge can not be guaranteed.

Resistance measurement (option)			
Meas. range	**Resolution**	**Current low**	**Current high**
20.000 mΩ	1 µΩ	1 A	1 A
200.00 mΩ	10 µΩ	100 mA	1 A
2.0000 Ω	100 µΩ	10 mA	1 A
20.000 Ω	1 mΩ	10 mA	100 mA
200.00 Ω	10 mΩ	1 mA	10 mA
2.0000 kΩ	100 mΩ	100 µA	1 mA
20.000 kΩ	1 Ω	100 µA	100 µA
200.00 kΩ	10 Ω	10 µA	10 µA

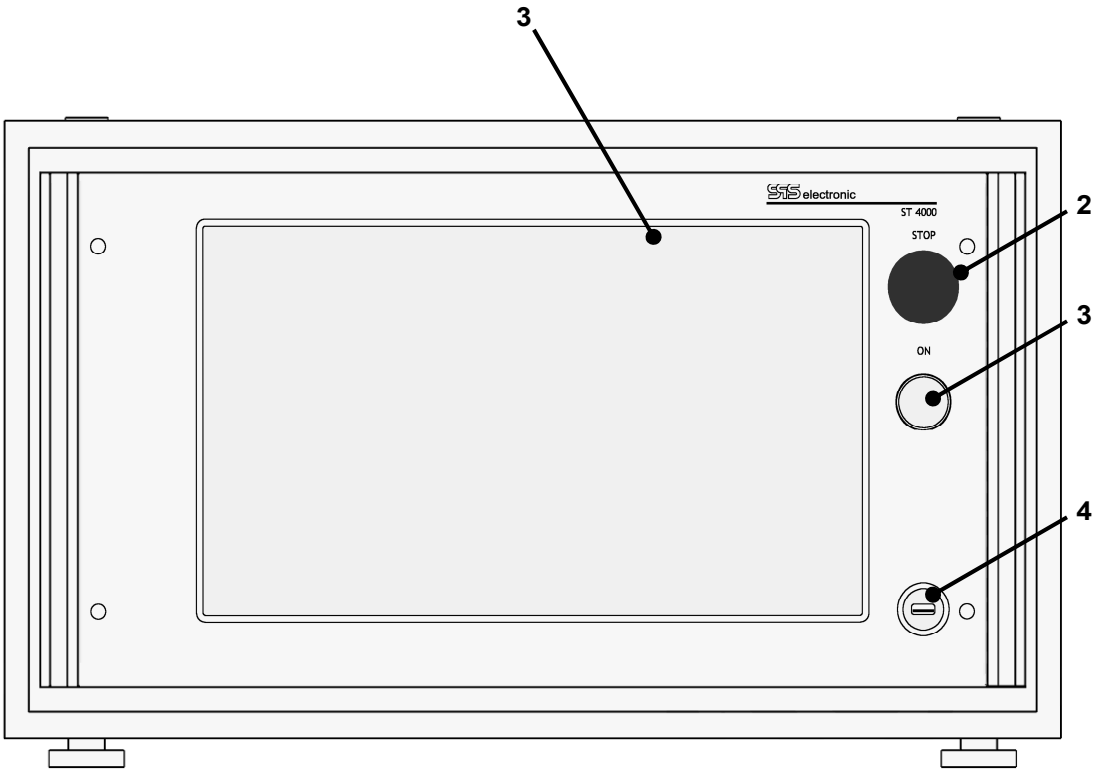
Accuracy:

20 mΩ – 20 kΩ: ± 0.03% (of meas. range) ± 3 Digit
200 kΩ: ± 0.5% (of meas. range) ± 3 Digit

Connection setting		
X1 DUT	BU22	Connection for DUT A 1 / 2 PE / PE' B 1 / 2 N / N' C 1 / 2 W / W' D 1 / 2 V / V' E 1 / 2 U / U' G 1..10 Signals for connection desk
X2 EXT	BU22	Connection for external supply A 1 / 2 SO+ / SO+' B 1 / 2 SO- / SO-'
PD Sensor A/B	TNC connector	Input partial discharge antenna 50 Ω Impedance / ±20 V Peak max.
PT100	EPG.1B.306	Connector for PT100 sensor Mating plug FGG.1B.306.CLAD52Z
Ethernet	RJ45 2x	Control Modbus TCP / DAT Software
Ethernet PoE	RJ45 1x	Connection for US40 environmental sensor
USB	USB A 3.0	2 x rear side, 1 x front side
DP	DisplayPort	for external monitor
NH	M8 3pin	external signal ON/STOP
SK	M8 3pin	connector for external safety circuit (interlock)
Power		Power supply

2.3 Set-up of device

2.3.1 Front panel



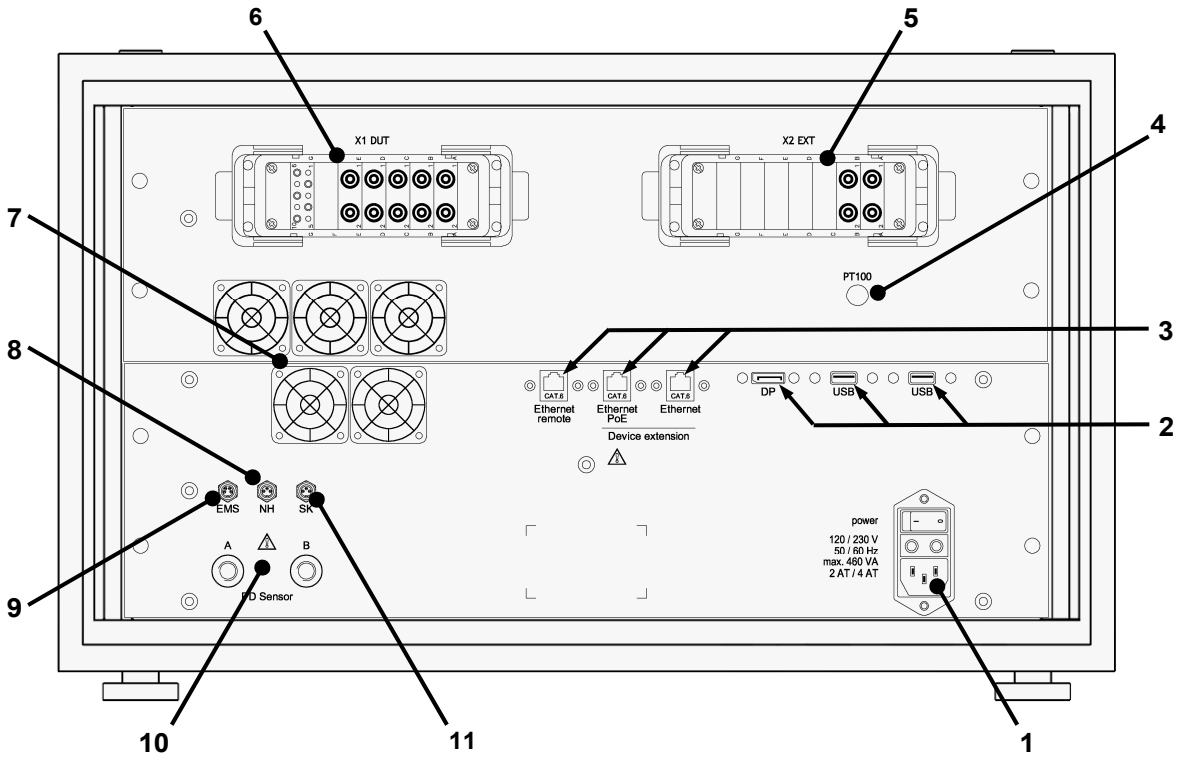
1 LC touch display – *the touch display provides easy & comfortable user interaction.*

2 lightswitch "STOP" – *sets device inactive, instantly switches off all output voltages in case of emergency*

3 lightbutton "ON" – *sets device active (generation of high voltage enabled)*

4 USB socket – *for connection of external devices (keyboard, mouse, ...) or storage media*

2.3.2 Rear panel



1 cold equipment socket for power supply cable (X0), with fuses (115V: 4A / 230V: 2A , slow)

2 2x USB ports, 1x connector for external monitor (DP – display port)

3 2x RJ45 Ethernet socket for LAN-connection,
1x RJ45 Ethernet PoE for connection of environment sensor (US40, optional equipment)

4 connector for PT100 temperature sensor

5 X2 EXT: connector for external feed-in (e.g. HV-AC generator)

6 X1 DUT: connector for the DUT

7 ventilation grids – keep free of obstruction!

8 NH: 3-pole connection socket for ON/STOP signal (EMERGENCY STOP, to be transmitted to external SPS devices)

9 EMS: ***)** 4-pole connection socket for external EMERGENCY STOP signal

10 TNC sockets A/B for connection of the partial-discharge antennas

11 SK: 3-pole safety-circuit signal for transmission to external SPS devices

***)** This connection is factory-fitted with a jumper plug, meaning the external emergency stop circuit is inactive/bypassed. This connection must be wired (by a jumper plug or an external protection circuit). As long as this connection is "open," no test operation is possible.

When actively connected to an external emergency stop circuit:

Pins 1↔2 and 3↔4 are normally closed (NC). Disconnecting pins 1↮2 and/or 3↮4 deactivates the device and immediately shuts off all output voltages. However, the device's integrated PC remains powered on.

This is the same function as pressing the STOP button on the front panel.

3 Putting into operation

3.1 Requirements

Tester ST 4000A/B as well as all of the electric connections and lines must be in operational and reliable condition.
The General Safety Regulations (pl. see chapter 1.3) and the generally applicable legal rules as well as other binding directives for industrial safety, for accident prevention and for the protection of the environment have to be adhered to and persons staying in the area of operation must be informed respectively.

There is danger to life caused by electric current or voltage in case of handling electric installations inappropriately!

3.2 Connection of device

1. switch off power switch at tester
2. plug power cable of tester into cold equipment socket (X0) at back of device
3. connect power cable to power supply
4. If provided for, connect external devices to interfaces

3.3 Switching the device on

The ST 4000A/B is switched on with the toggle switch at the rear of the device (pos.1).

The test device then is starting its internal operating system. This takes several seconds.
When finished, the device is showing the login screen, and is ready to perform tests.

3.4 Switching the device off

Before switching off the device, the EM4000 application should be closed.
When finished, the Surge Tester ST 4000A/B can be switched off with toggle key switch at the rear of the device (pos.1).

In case of tests with high voltage (IS- and HV-test) the DUT has to remain connected until a test result is displayed. At the end of the test time the DUT is discharged.

If the ST 4000A/B is switched off prematurely, the DUT cannot be discharged!

4 Description of the Software

4.1 Program start, program end

Starting the program

The application software EM4000 of the ST4000 starts automatically after the operating system has started.

The application EM4000 consists of three modules: the editor, the testing module and the results module. The program module last opened will be reloaded.

First, the LOGIN window appears:

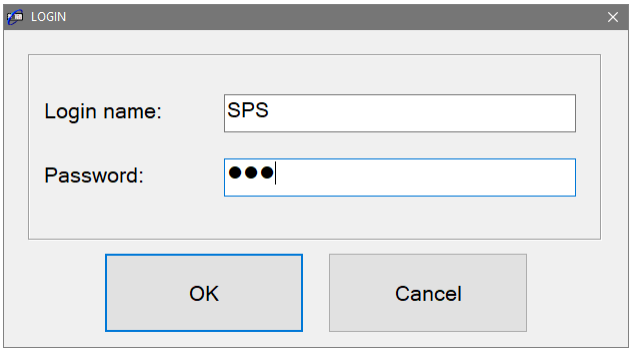


Fig. 1: LOGIN

To be able to start the program, you will have to enter a registered name in combination with a valid password.

After having installed the software, "*SPS*" is set as default name and password. You should edit these settings via *Options / Users & rights* to suite your needs.

Program end

Before powering down the testing system, you should close the running application. To do this, you can either press Alt+F4, click on the ☒ in the upper right corner of the window, or choose *"end program"* from the drop-down menu *"end"*. By closing the user program properly it is safeguarded that all the relevant data is stored.
If you wish to change the user/tester of the program on-the-fly without having to close and restart the program, choose *"log off"* from the menu *"end"*. A new login will appear.

4.2 The menu bar

Menu	*Menu item*	*Function*
File	***New***	To create an all-new, “empty” test program.
	Load	Load an existing test program from disk
	Save	Store the current test program to disk
	Save as	Store current test program with a new name
	Print	Prints the current test program, with all parameters
	Product list	Starts the Product List editor. See chp. 4.3.
Module	***Editor***	Starts the program module "Test program editor"
	Testing	Starts the module "Testing"
	Results	Starts the module "Results"
Options	***General settings***	General settings about test program selection, DUT serial numbers, etc. See chp. 4.2.2.
	Hardware settings.	Here the hardware settings can be adjusted. See chp. 4.2.3
	Environment	Other options about pathnames, results management, default settings, etc. See chp. 4.2.4.
	Printer setup	Configuration of the printer to use for printing & protocolling.
	Users & rights	Management of registered users and their rights. See chp.4.2.5.
	Change password	Here the current user can change his password.
Language	***German***	Sets the software to appear in German language.
	Englisch	Sets the software to appear in English language.
About	—	Shows general information about the software EM4000.

4.2.1 Menu "File"

All the file functions like e.g. loading or storing of test programs are realized via the WINDOWS typical file dialogs.
Fig. 2 shows the dialog for loading or opening test programs:

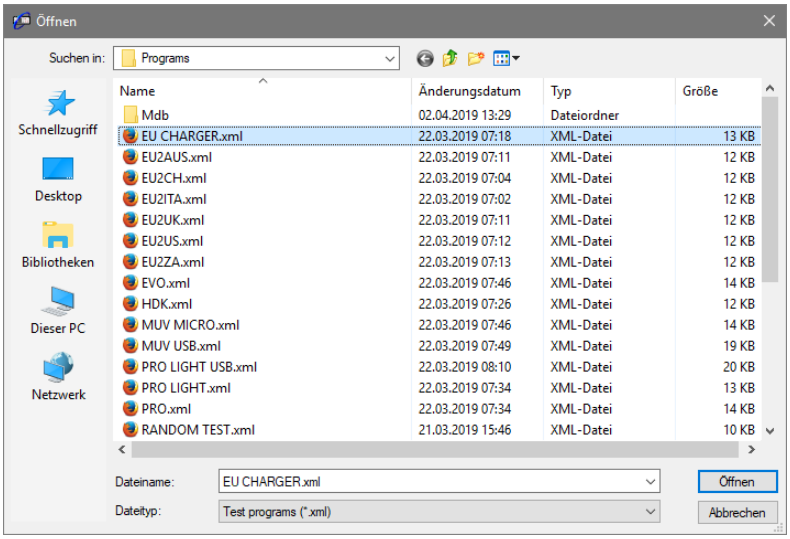


Fig. 2: Dialog window "open program"

Exception: Barcode Operation

In case one of the options "scanned filename" or "scanned product ID" is chosen in *Options / General / Test program*, then the test program will be loaded according to the data scanned from DUT's barcode:

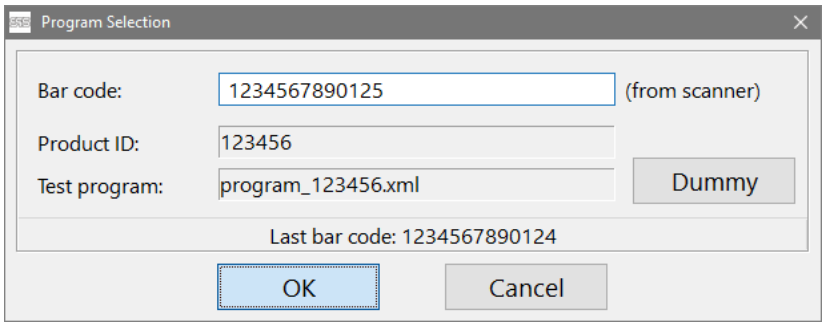


Fig. 3: Reading of a barcode

If a test program with the name generated from the read data is found in the test program folder, it will be loaded.
If that test program doesn't exist, or if the product-ID can't be found in the product list, an according error message will be shown, which must be acknowledged.

In the editor module the standard dialog window (Fig. 2) will then open, to allow manual loading of a test program.

In the "Testing" module it is not possible to manually load a program if barcode reading failed (for this it would be required to switch back to "manual loading", see next page), instead it is waited for scanning of the next barcode. This is to ensure that only authorized test programs can be used.

4.2.2 General Settings

Tab "General":

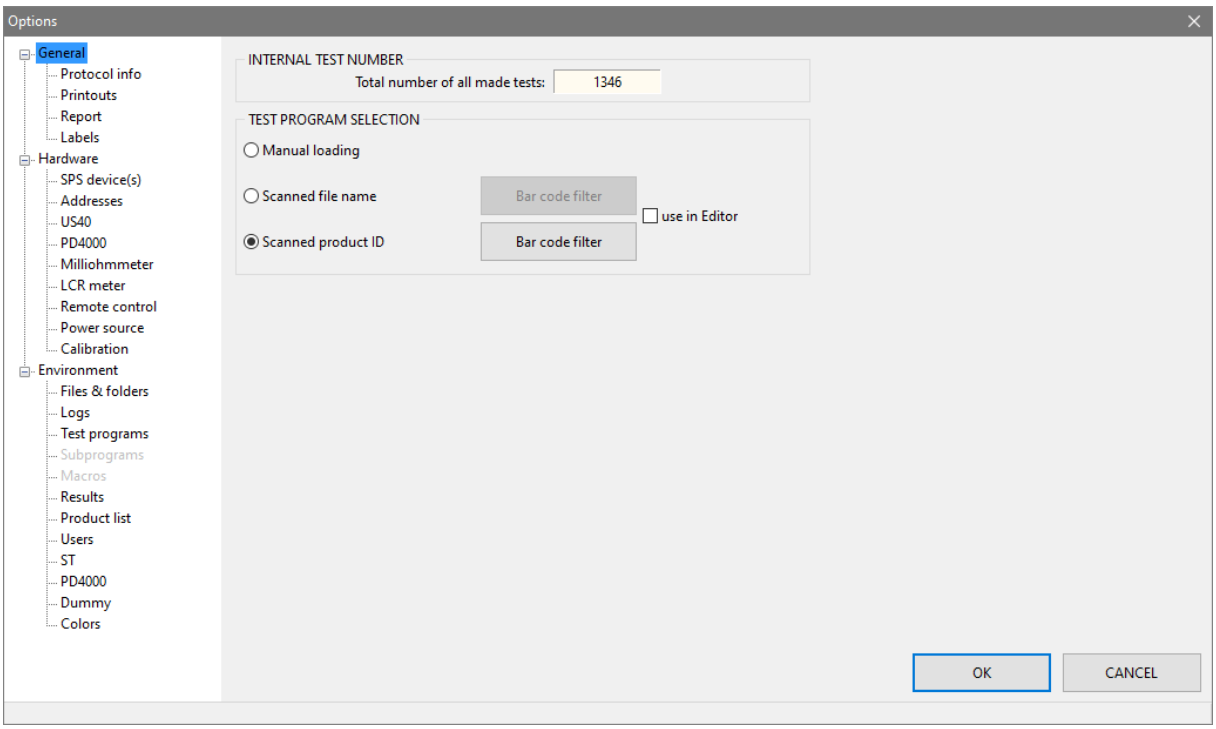


Fig. 4: Tab "Test program"

The field *Internal test number* shows the total number of all tests performed so far.

In the field *Test program selection*, it is specified how the required test program is determined:

- *Manual loading*: when changing the used test program, the user will have to load the new one manually
- *Scanned file name* : The filename is taken directly from the specified positions of the scanned barcode.
- *Scanned product ID* : Here the product list deals as a "lookup table". Based on the product ID, the according test program is determined and loaded from the product list.

The button "Bar code filter" opens a dialog, where one can specify how the barcode data is evaluated:
(The item "Product ID" changes to "File name" if *program selection* is set to "scanned file name".)

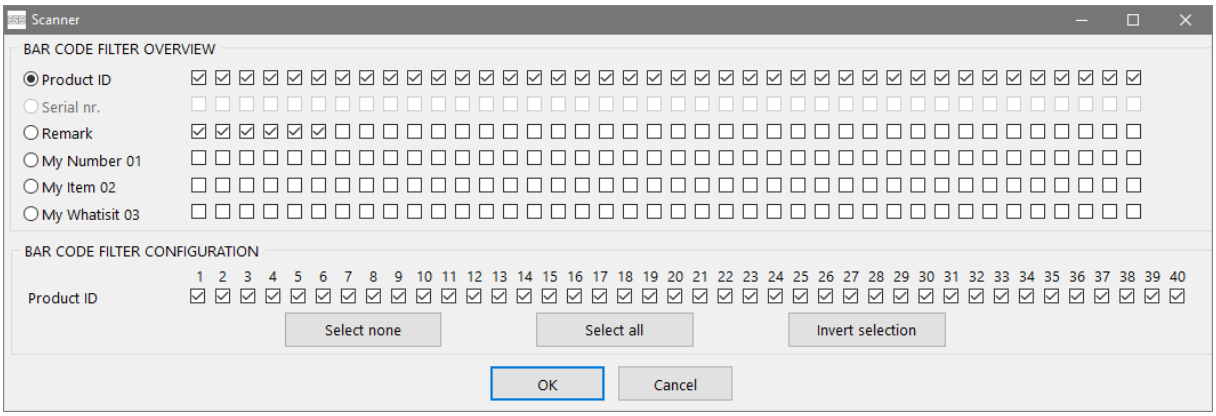


Fig. 5: Definition of barcode evaluation

Tab "Protocol Info":

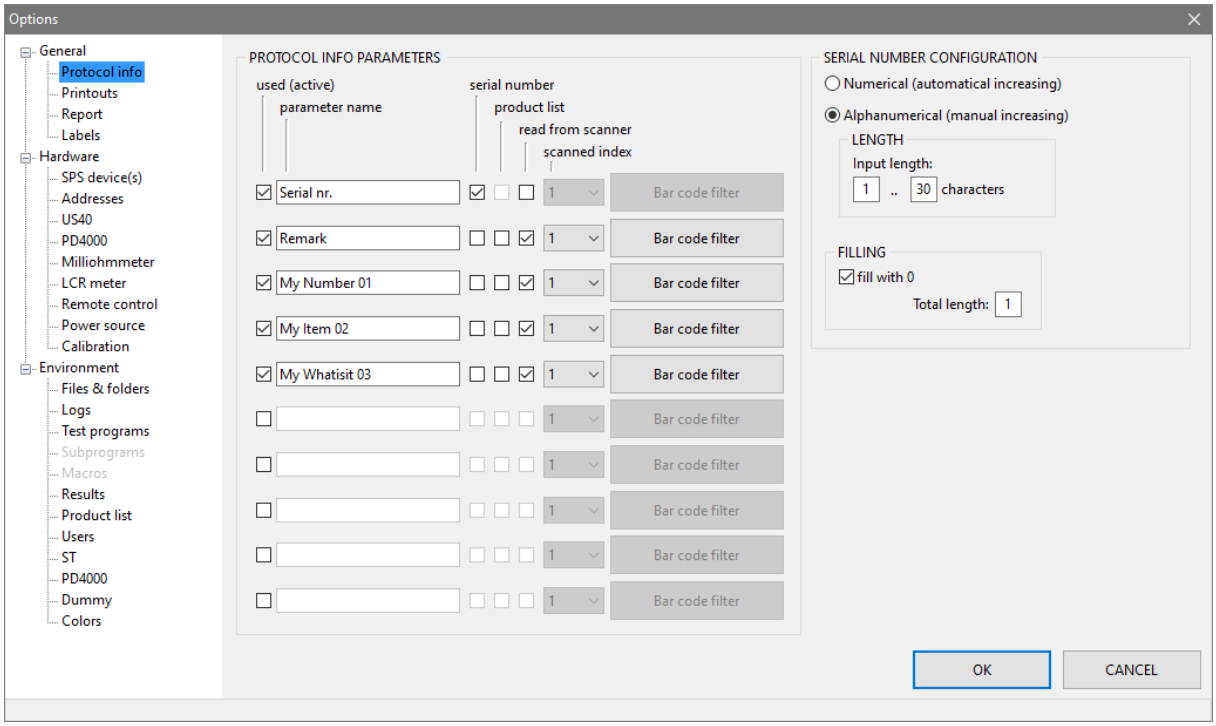


Fig. 6: Tab "Protocol info"

In this register it is specified which informations about the DUT will be included in the test protocolling, and where they are taken from.

Generally, only positions that have the leftmost checkbox activated are included in the protocol.
When unchecked, the respective position is **not** inclued in the protocol.

Positions whose value should be read from a scanned barcode are determined by activating the "scanner" check box. However, if the value is to be taken from the product list, the "product list" box must be checked.

The "Serial Number" position is determined by checking the "serial number" checkbox. This position can only be activated once.

The serial number can either be read from the barcode, or be handled numerically/alphanumerically:

- Numerical serial numbers are automatically increased by »1« with each test.
- if alphanumerical serial numbers are used, then one can assign an individual serial number for each new DUT.

Additionally, for all positions set to »Scanner input«, the number of the scanning operation to retrieve the respective data with can be chosen by the "scanned index" dropdown fields.

Example: DUTs may carry multiple barcode lables, and one might want to read the test program from the first barcode label, but the serial number and DUT description from a second barcode label. In this case, one would set the »nr.« field for »device« to »1«, and the fields for serial number and remark to »2«.

For protocolling purposes, the various items can be renamed individually. The according items in the register *"Test program"*, as well as those in the product list and in the result protocols, will automatically reflect the change.

Tab "Printouts":

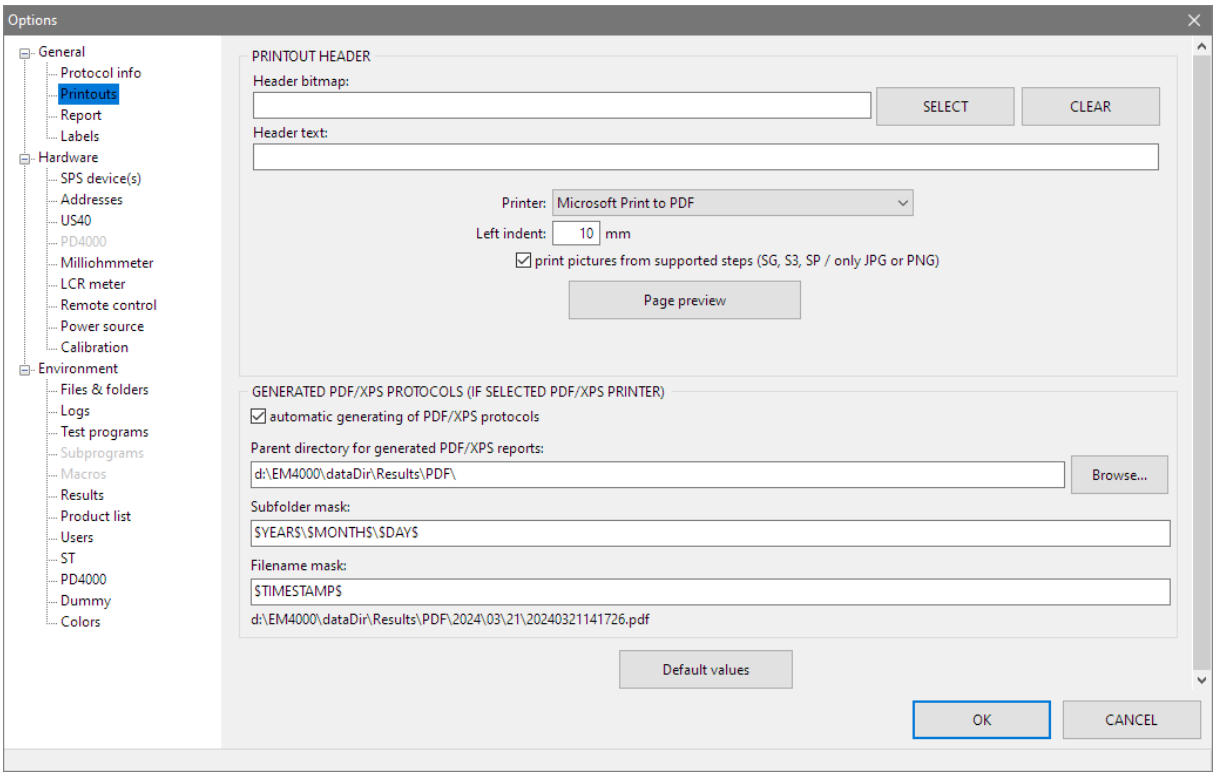


Fig. 7: Tab "Printouts"

With the dialog "Header bitmap" you can use a previously created picture file as protocol header.

(Note: There is no feature for scaling or positioning of this picture, it will automatically be scaled to reach full width of the paper size. E.g.: if you want a small logo in the upper-right of the page, then this picture file must contain an accordingly big white space on its left side.)

With "Header text" you can enter any text which will be put at the top of each new test.

"Page preview" will show a visualization of how the printed protocol will look like later on.

4.2.3 Hardware Settings

Notice:
The ST 4000A/B is delivered with correctly preset hardware settings. These hardware settings only exist because the EM4000 software is based on our standard DAT3805 software.
Do not change any of the default hardware settings without a compelling reason!

Tab "Hardware":

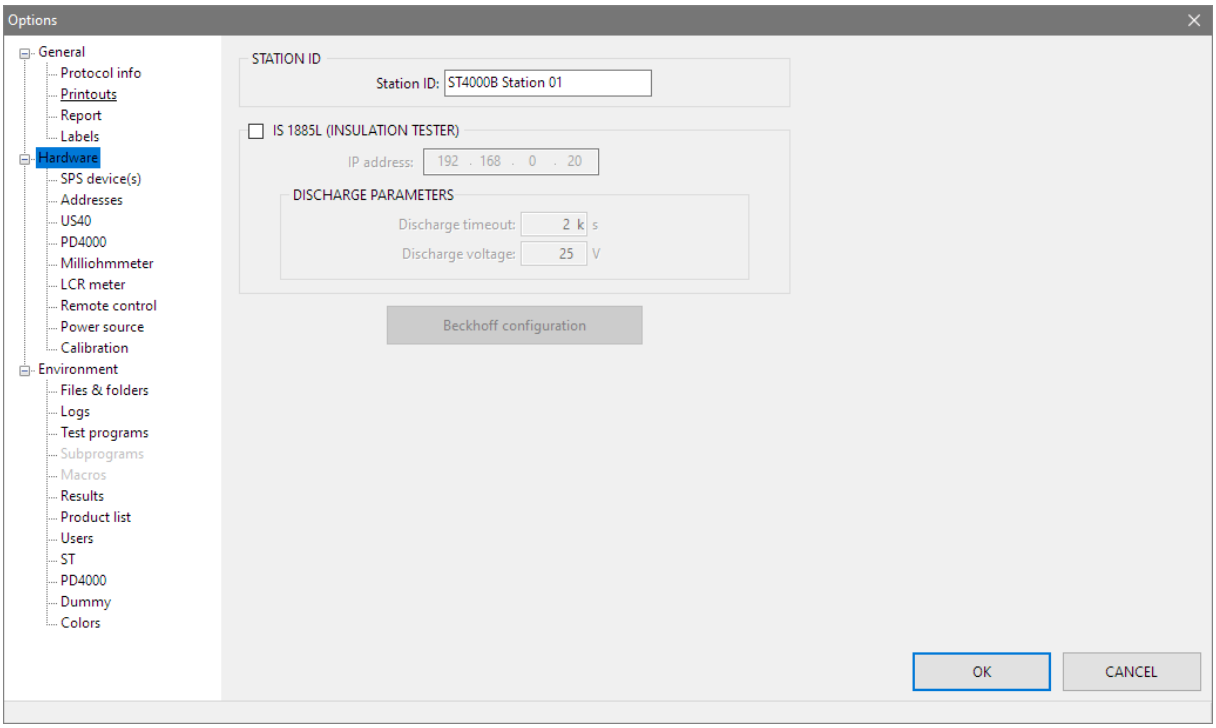


Fig. 8: Tab "Hardware"

The "Station ID" deals for identification of the test station, and is included in all test protocols. If several test stations are connected in a network, and all results are stored in one central database, the test results can easily be back-tracked to the test station on which the test has been performed.

Tab "Device 1 / Common":

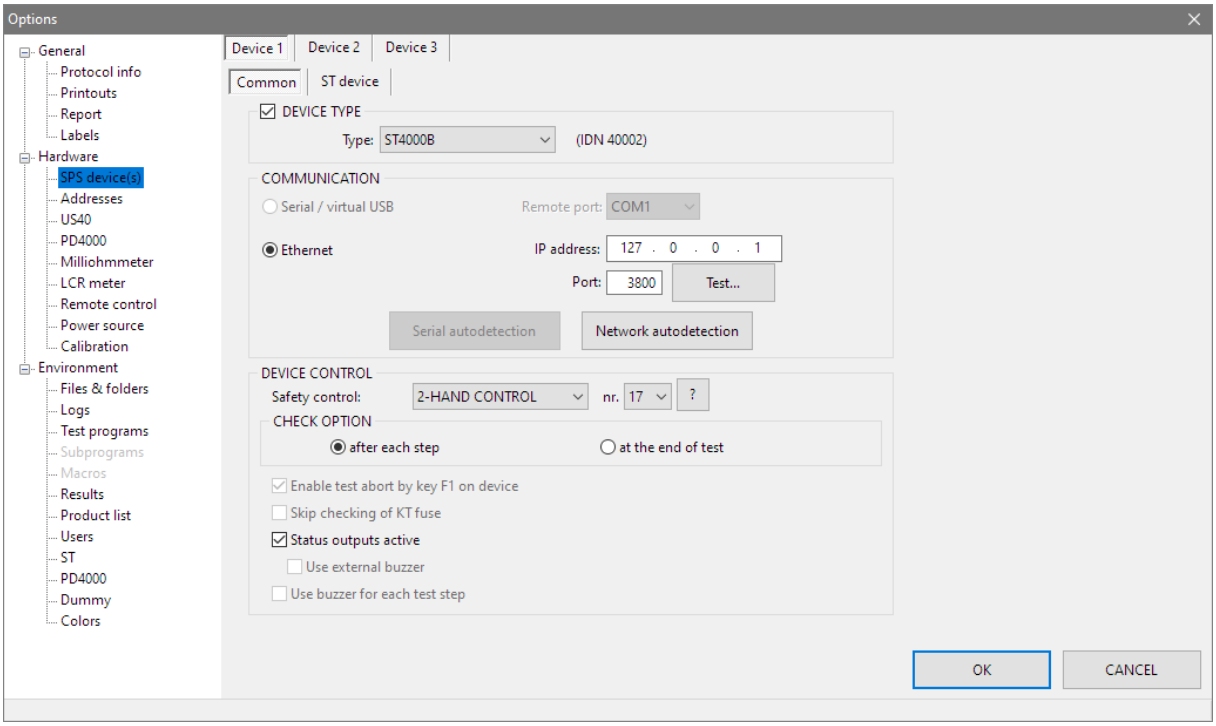


Fig. 9: Tab "Device I / Common"

– Under *Device type*, the ST 4000A or ST 4000B tester is selected

– Under Communication, the IP address 127.0.0.1 and port 3800 must remain set.

– Device Control:
The safety control list field can be used to specify how the tester starts the test procedure or how the test object is contacted.
If an external start sensor is used, the digital input used can be specified in the "No." list field

Tab "Device 1 / ST device":

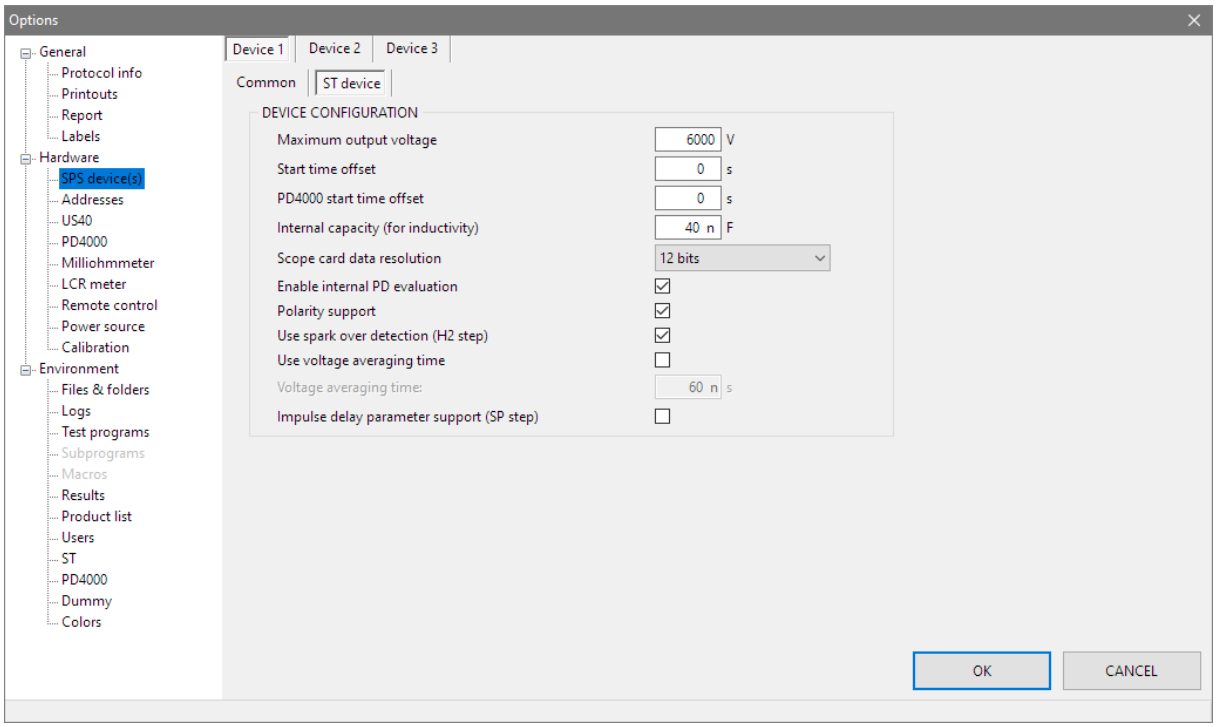


Fig. 10: Tab "Device I / Common"

- Device Configuration
  - *Maximum output voltage*

    Here, the maximum test voltage for the surge test can be limited to a value lower than 6000V (standard). (See safety note below!).

  - *Start time offset*

    Defines the delay time after initiating the surge impulse, before the measuring is started.
    The possible range is 0s – 10 µs.

Safety note:

According to EN 50191, devices without safety circuit may be operated only if the following conditions are met:

DC : Current < 10 mA and electric charge < 350 mJ

Depending on the capacity of the surge capacitor in the ST4000, this limit is reached at:

18 nF: never (> 6200 V)
40 nF: ~ 4180 V
100 nF: ~ 2640 V
200 nF: ~ 1870 V

When operating without additional safety measures, the output voltage must not be set higher than the values specified here!
To use voltages higher than specified here, it is necessary to install additional safety measures acc. to EN 50191 !

- **Tab "Device 2"**

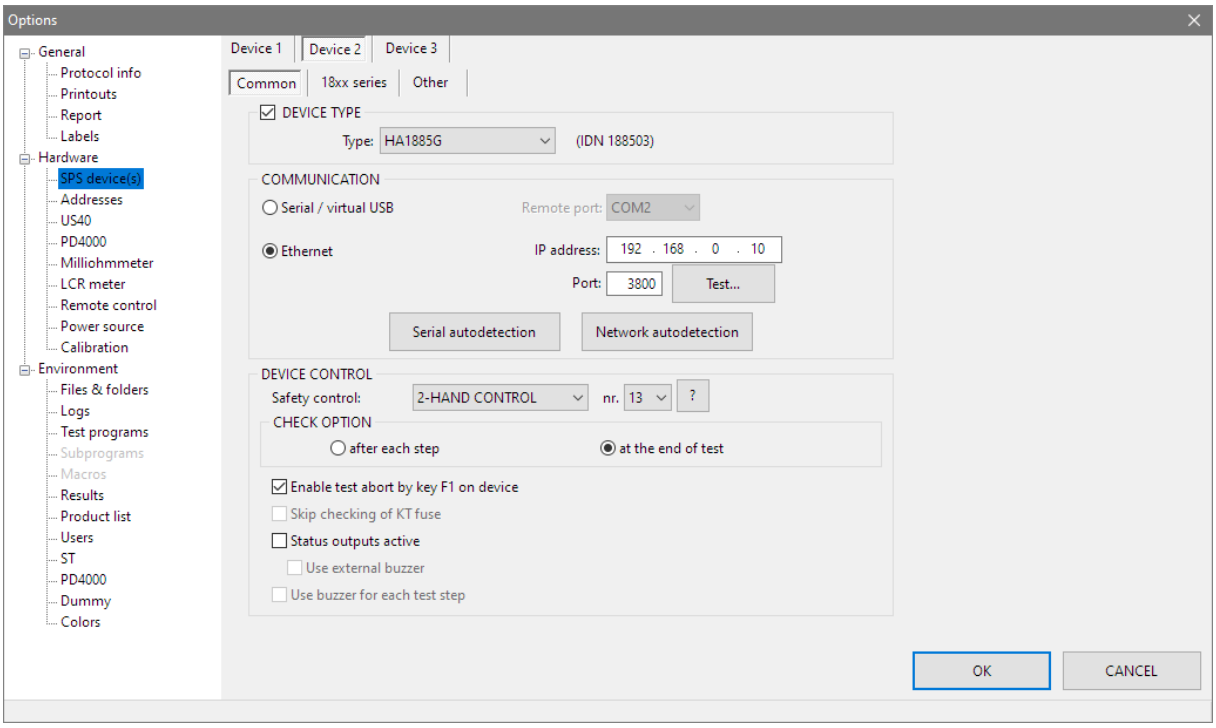


Fig. 11: Tab „Device 2 - Common“

This tab is intended for use if a second SPS test device is to be controlled (e.g. HA 1885B/G/J as an AC high-voltage generator).

Tab "US40":

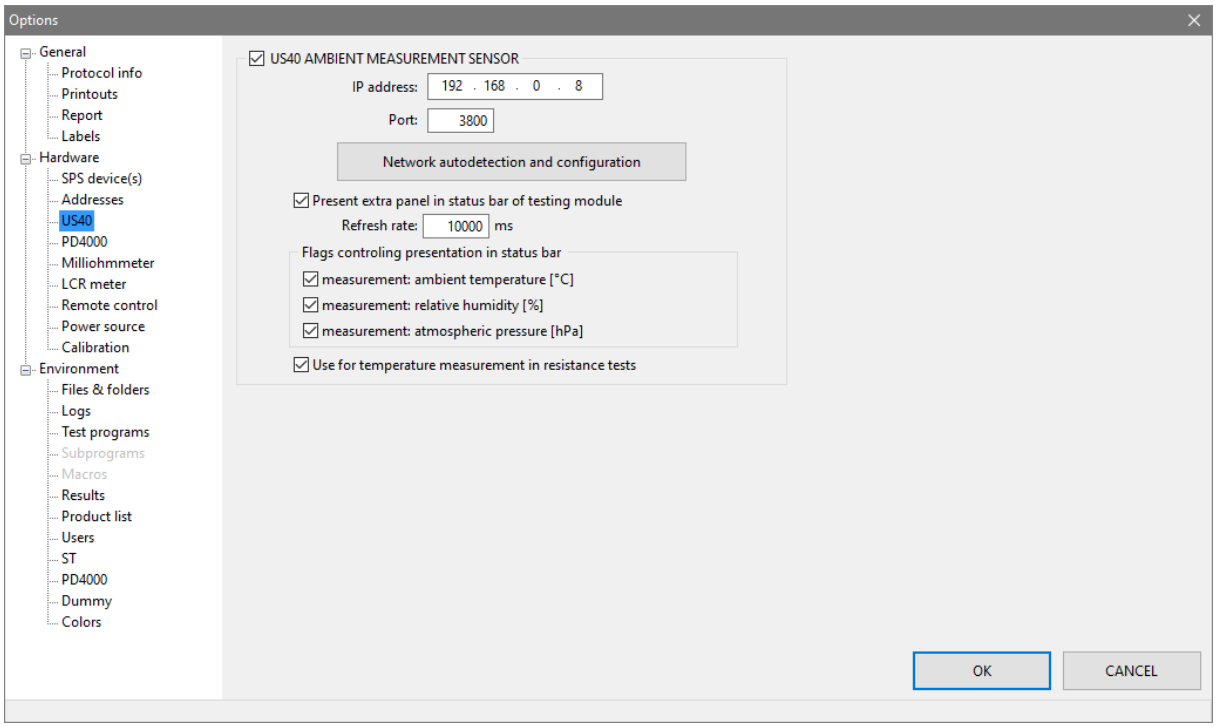


Fig. 13: Tab "US40"

Here the set-up of the temperature sensor is done.

Most important, the correct IP-address 192.168.0.8 must be specified. (It's "fixed" in the device)

The further options control which environment measurements are shown in the lower status-bar of the testing module.

Tab "PD4000" and "Beckhoff":

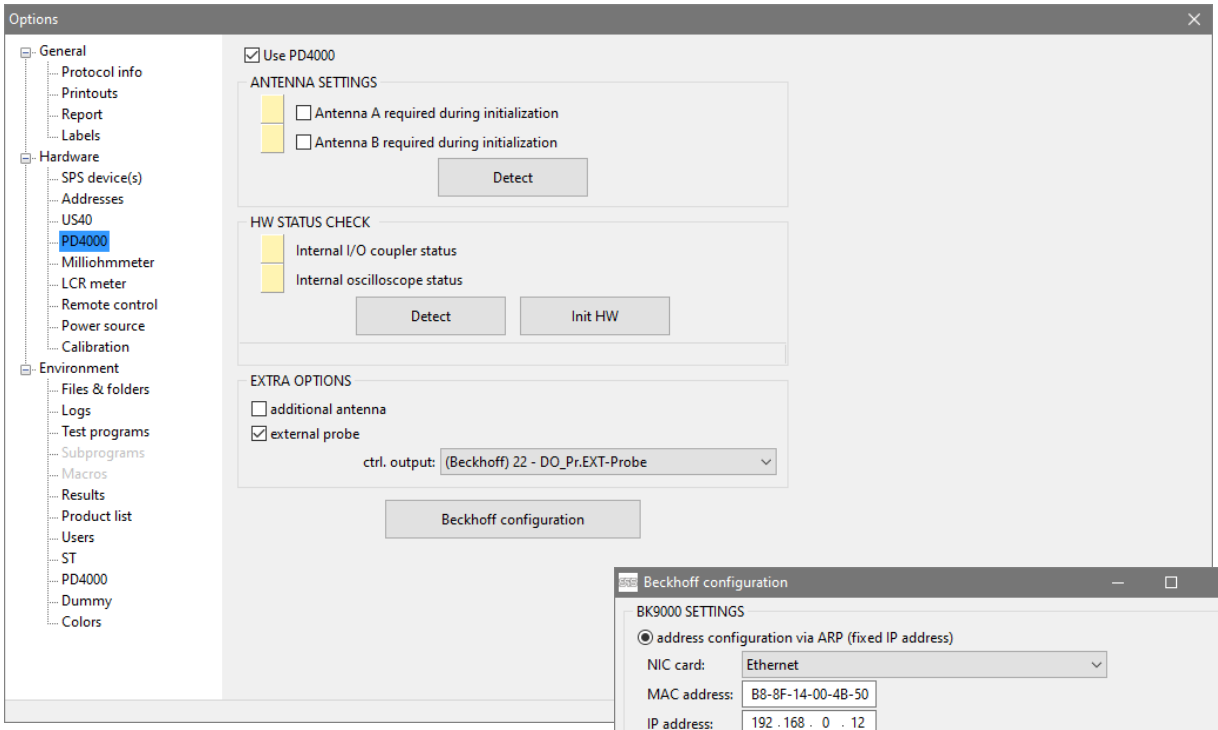


Fig. 14: Tab "PD4000"

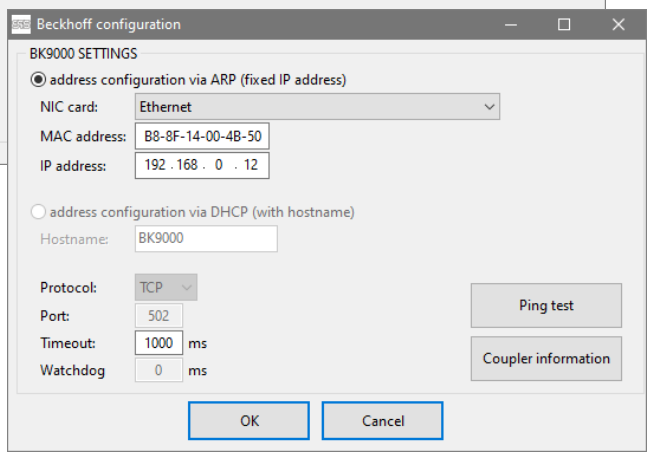


Fig. 15: Tab "Beckhoff"

In this tab, the (external) PD 4000 partial discharge meter is activated and set up.
The IP address and MAC address are fixed and must not be changed.

In the ST 4000B, partial discharge measurement is already integrated internally. Still, the "Use PD4000" option must also be activated here in order to be able to carry out partial discharge measurements.

Tab "Milliohmmeter":

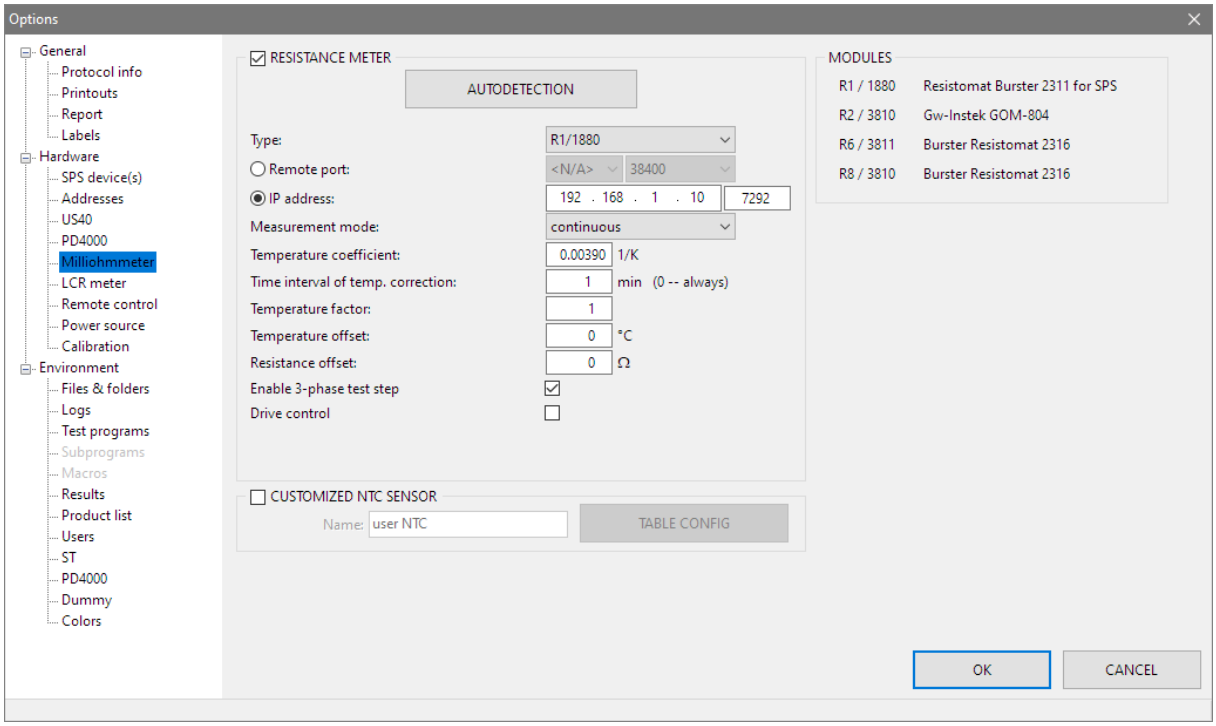


Fig. 16: Tab "Other"

Fig. 17: Tab "Spec"

If the ST 4000B is equipped with the "Resistance measurement" option, then "resistance Meter" must be activated here and the "R1/1880" device selected.

4.2.4 Environment settings

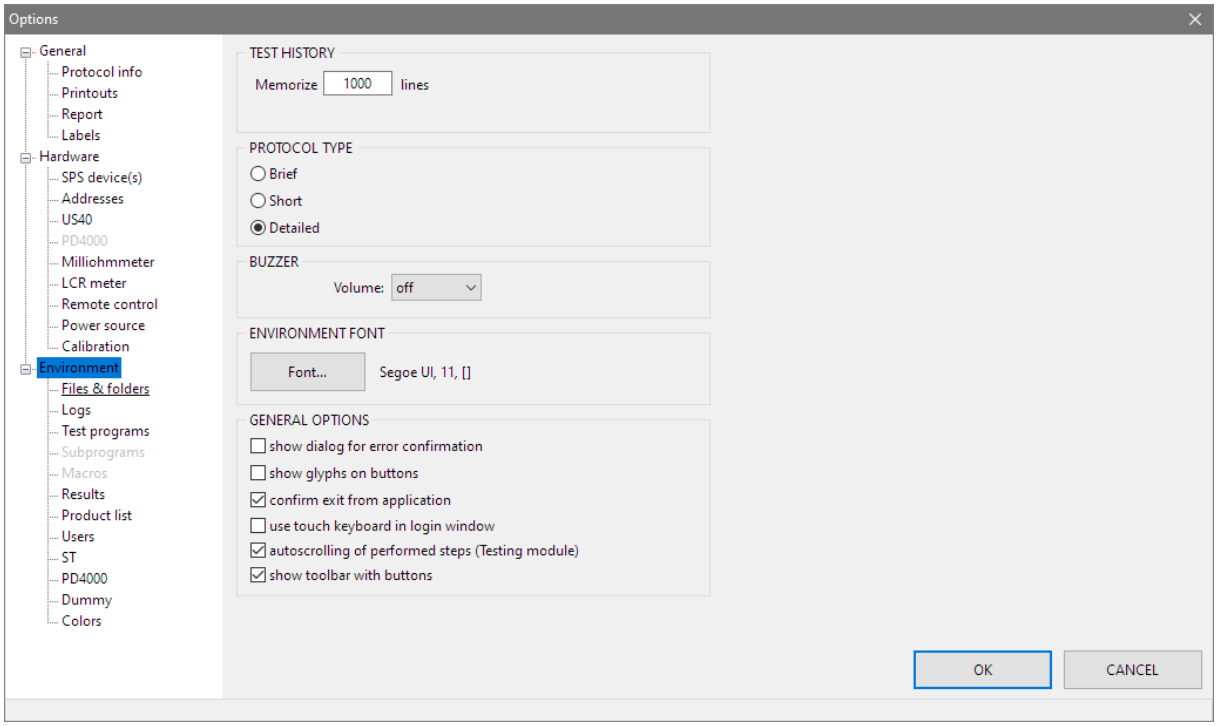


Fig. 18: Tab "General"

Tab "General":

- In *Test History* it can be set how many test runs will be memorized in the log window of the testing module.
- The *Buzzer* of the testing device can be adjusted.
- *Protocol Type* switches between "Brief" (only results) and "Detailed" (results with detailed test information)
- With *Show dialog for error confirmation* it can be forced that a "fail" testing must be manually acknowledged by an additional OK-dialog.
- *Confirm exit from application* shows a confirmation prompt before the application gets closed.
- With *Show glyphs on buttons* the ✓/× symbols on the software buttons can be enabled or disabled.

Tab "Files & folders":

This register specifies the default folders where picture and text files will be stored.

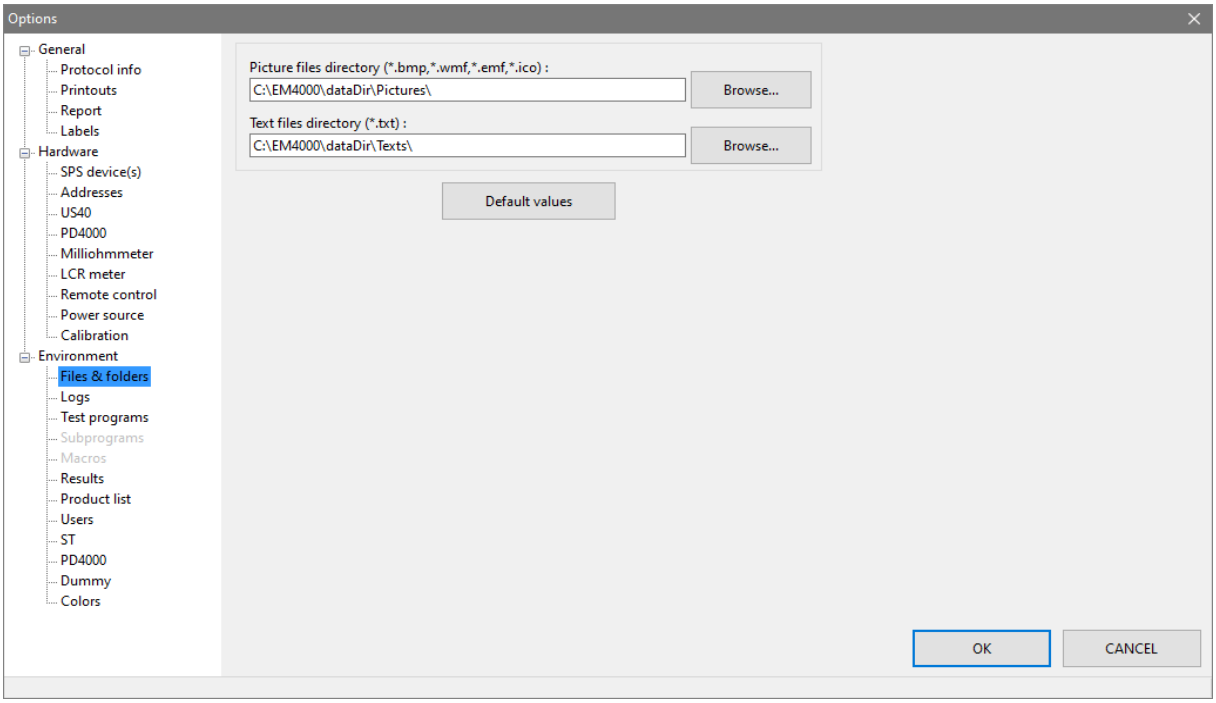


Fig. 19: Tab "Files & folders"

Tab "Logs":

In this tab, the debug mode of the application can be activated. This is only required for service matters or troubleshooting, and should be switched off during normal operation.

Note: If the debug function was switched off and is then getting activated, the application software should be restarted to ensure the correct functionality.

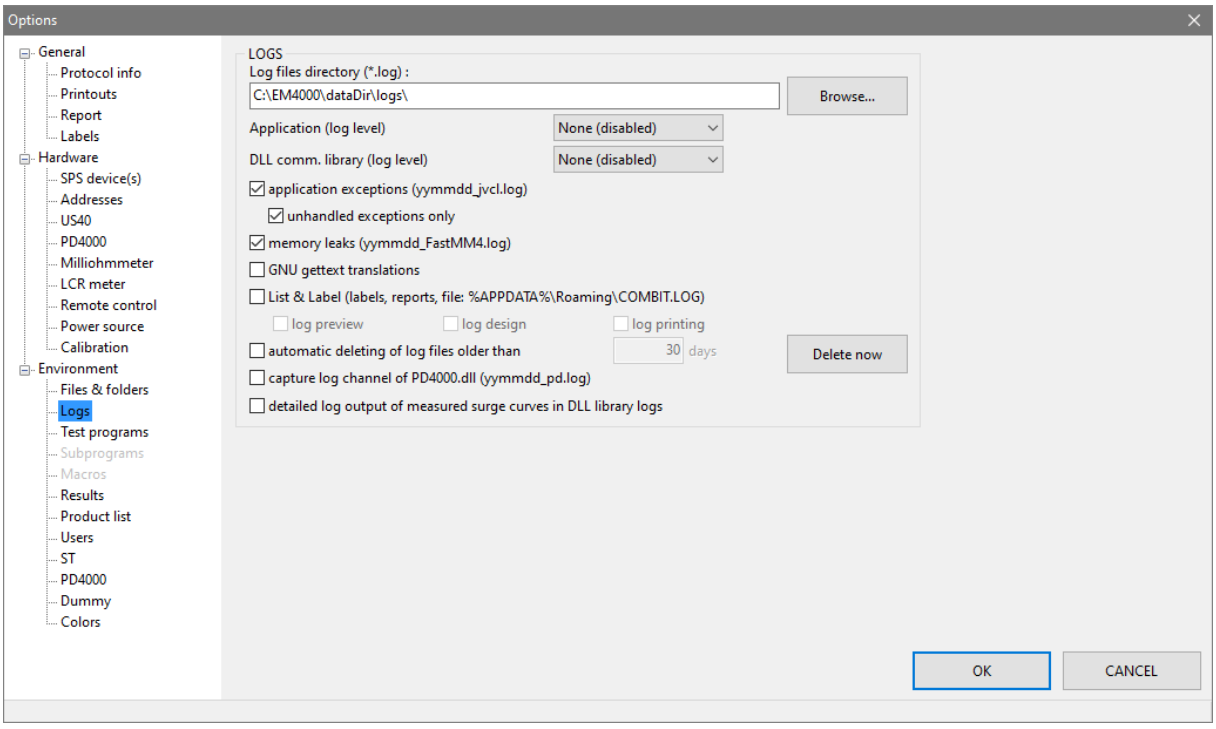


Fig. 20: Tab "Logs"

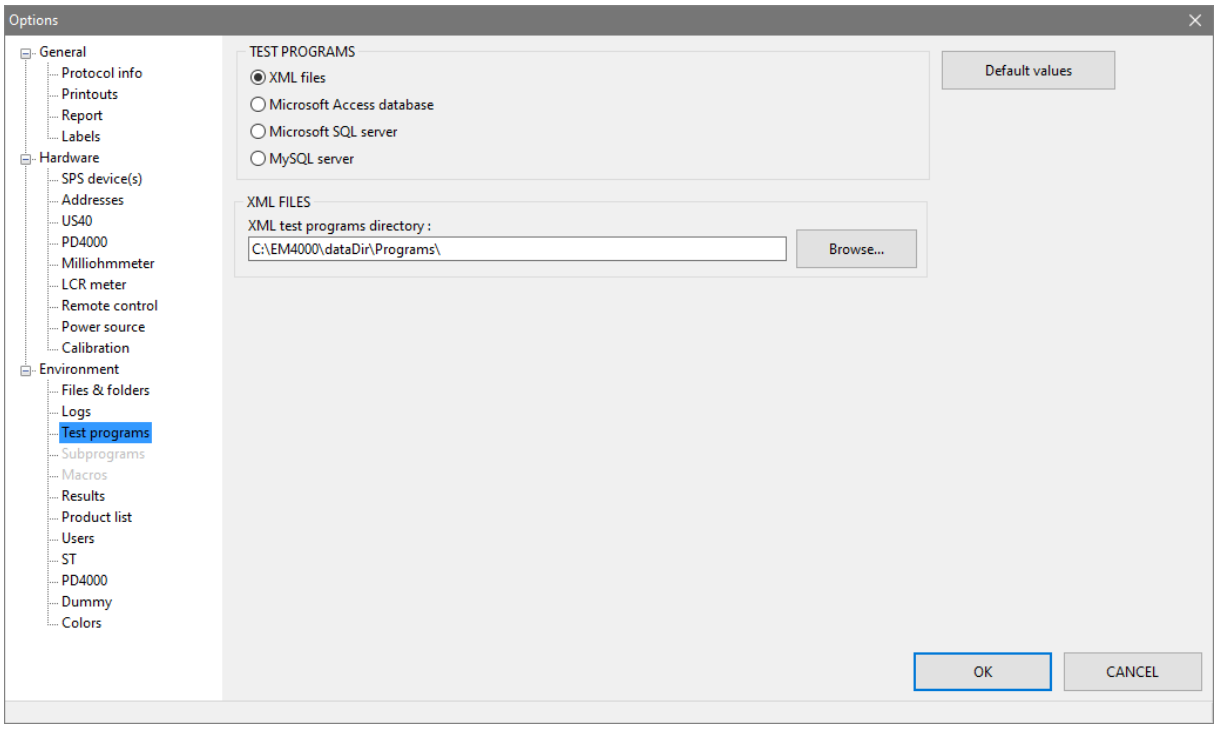


Fig. 21: Tab "Test programs"

Tab "Test programs":

Here one can choose whether the test programs shall be saved as XML data files (each test program is saved in an individual *.xml file), or if all test programs shall be stored in a data base.
Depending on the choice, the according options are enabled, where the storage path for the XML files, resp. the target data base can be chosen.

If program storage in a data base is chosen, there is the possibility to keep a certain number of "previous versions" when a test program is edited.

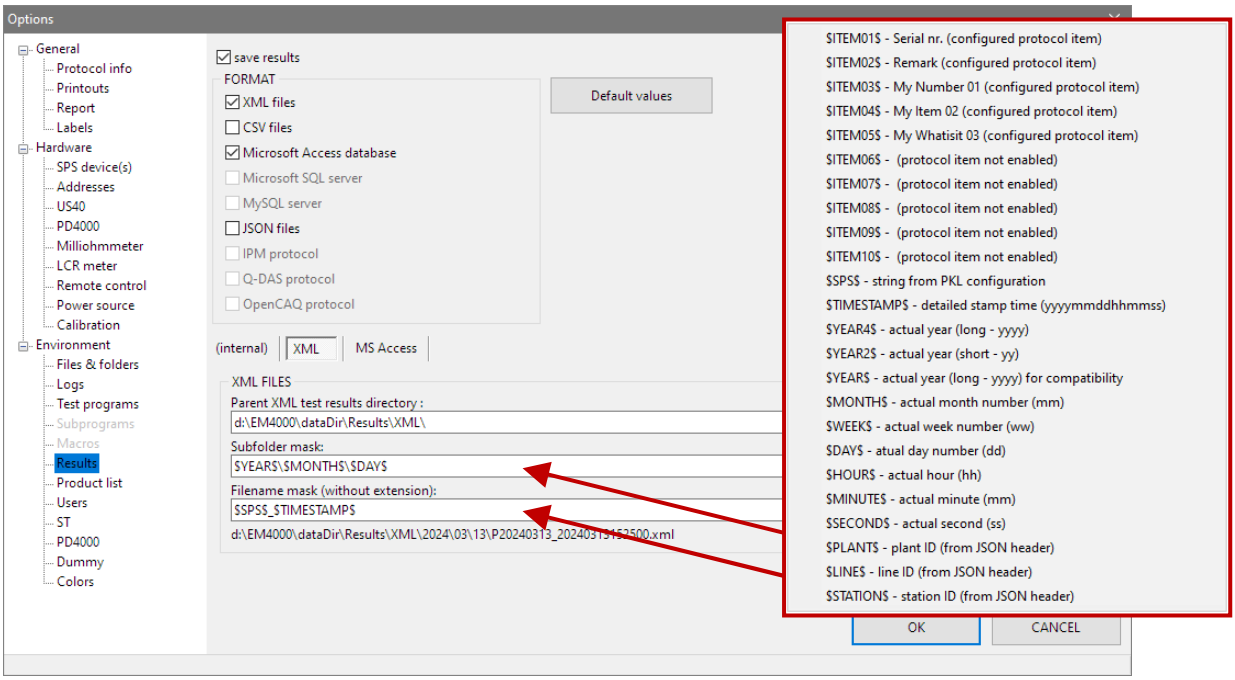


Fig. 22: Tab "Results"

Tab "Results":

Here one can choose whether the test results shall be saved as XML data files (each result protocol is saved in an individual *.xml file), be stored in a data base, or both together.

Depending on the choice, the according options are enabled to specify the base folder (parent folder) for the storage location of the result files.

In addition, so-called “tokens” (placeholders) can be used to create additional subfolders in the base folder and, if necessary, to individualize the file names.

The token SPS plays a special role: instead of this placeholder, the naming configuration is used that was specified in the editor under "Protocolling" (all files will be placed in the base/parent folder).
The difference: the settings here in the "Results" tab apply globally to all result files, regardless of the test program. However, the “Protocolling” settings in the editor are saved separately with each individual test program, so you can use different protocolling setting for different test programs.

By disabling the checkbox "save results" it is possible to completely switch of the results protocolling. This may come handy e.g. for set-up operation with new DUT types.

Note:
If the results are saved in *.xml files, and a file path *other than the default* is specified, then it is necessary to copy all files from the folder EM4000\Data\Results manually into the new destination folder!
These files (res_style_*.* and xhtml*.*) are required for showing the test protocols in the results module!

Tabs "Product List" & "Users":

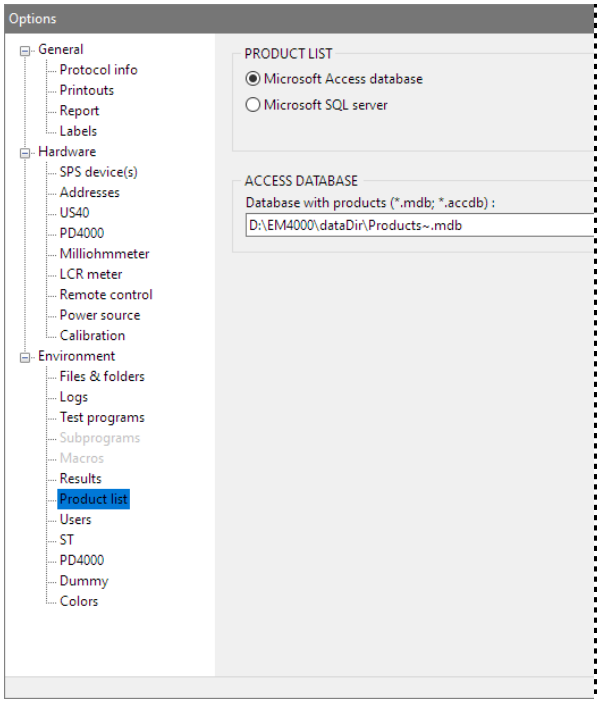


Fig. 23: Tab „Product list“

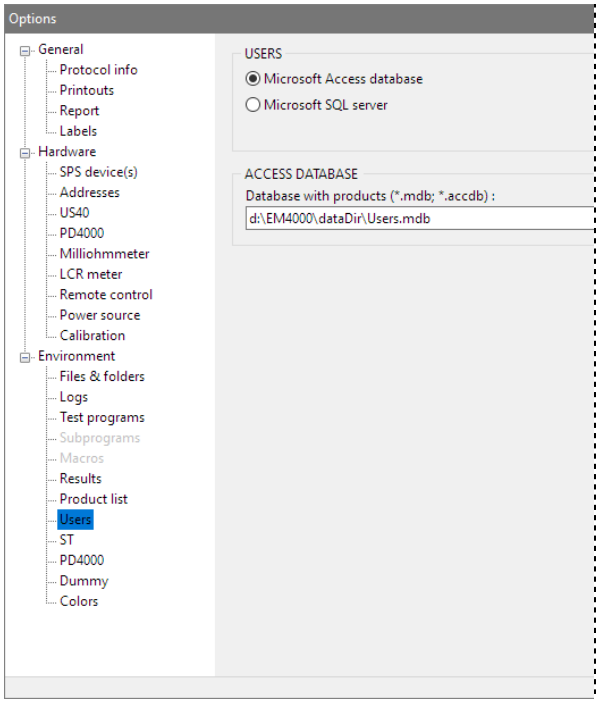


Fig. 24: Tab „Users“

In these tabs, the databases are defined in which the product list and the list of registered users with their passwords are saved.

Tab "ST3800":

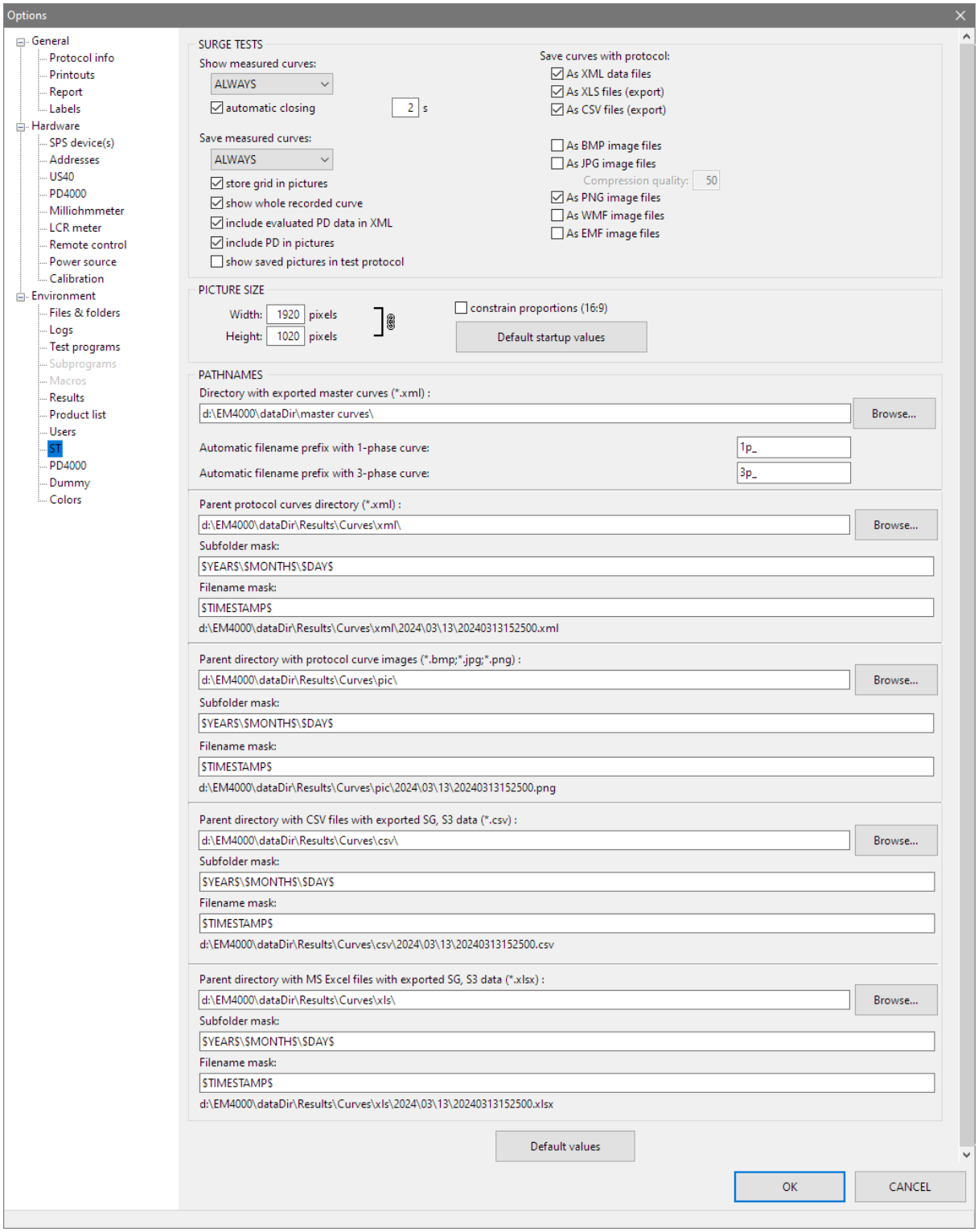


Fig. 25: Tab "ST3800"

- Within the field *SURGE TEST* the following settings can be made:
  - Under »Show measured curves« one can choose under which conditions the curves measured during a surge test actually shall be displayed. Possible settings are *ALWAYS, IF GOOD, IF FAIL,* and *NEVER*.
  - Under »save measured curves« one can choose under which conditions the measured curves will be saved. The possible settings are also *ALWAYS, IF GOOD, IF FAIL,* and *NEVER*.

- "include evaluated PD data in XML": With this, the evaluated data of the partial discharges are included in the XML log of the surge curve.

- "include PD in pictures": If the surge curves are also saved as an image file, the measurement of the partial discharges will also be included in the image here.

  Additionally, it can be specified in which format the curves will be saved. Available are the plain data formats *.xml, *.xls and *.csv, and the picture formats *.bmp, *.png, *.wmf and *.emf.

- In the field *PICTURE SIZE* the standard resolution (in pixels) for the curve images can be set. If the checkbox *Constrain Properties* is checked, the software will calculate the remaining value for width or height automatically as a new value is entered.

- In the field *PATHNAMES* the default storage paths for the various data- and image file types can be chosen. Here - as with "Results", see previous page - the same placeholders can be used to define path names and file names

Tab "PD4000":

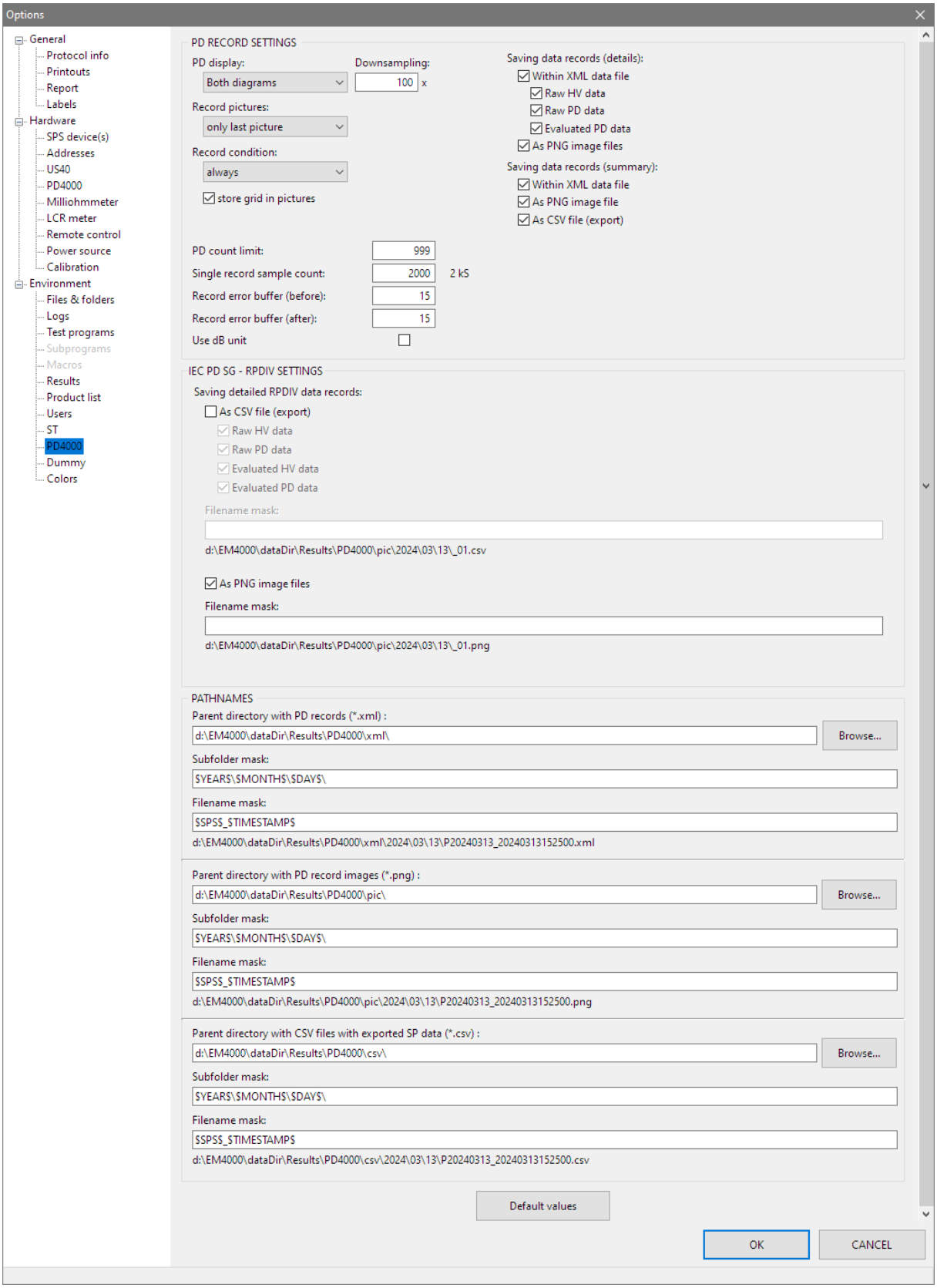


Fig. 26: Tab "PD4000"

In this tab, settings are made as to how and what data is stored during the partial-discharge evaluation.

PD display: determines which graphic is displayed during a high-voltage test:
Record diagram – only shows the graphs of the individual measurement intervals,
Summary diagram – only shows the graph of the test course,
Both diagrams – displays both graphs at the same time,
Only values (no diagram) – displays only the numerical values.

Record pictures: if the saving of the graphs as PNG images is activated, this specifies how many images are saved in the event of an error: Either only the last picture at the moment of error, or a series of pictures before and after the error (acc. to "Record error buffer before/after" further below).

Record condition: Determines whether the XML data and/or PNG images should be saved only in case of of "GOOD" tests, only for "FAILED" tests, or "Always" or "Never".

Saving data records:
Here you can specify if and which data will be included in the XML files. Both the values of HV voltage and PD partial discharges can be stored as "RAW data" (if necessary for a later detailed evaluation), with "evaluated PD data" only the summary of the evaluated data is written.
The checkbox "As PNG image file" activates that the graphs are also saved as image files (upper option is for "Record diagram", lower option is for "Summary diagram").

At the bottom, the folders for storing the XML files and PNG images can be specified.

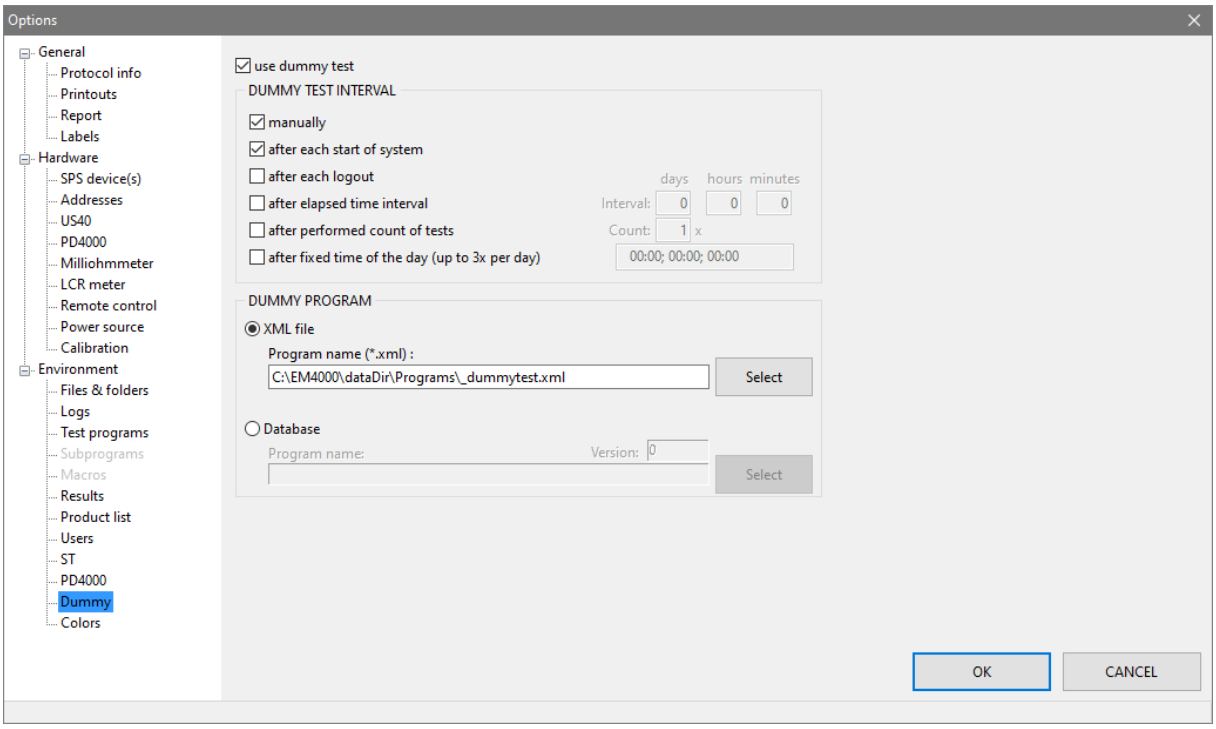


Fig. 27: Tab "Dummy"

Tab "Dummy":

With the options of this tab, the execution of a regular dummy test can be forced, e.g. to ensure that the system is functioning correctly.
In the field *DUMMY TEST INTERVAL* the execution interval of the dummy test can be chosen.
In the field *DUMMY PROGRAM* the test program to use for this test can be specified.

If a dummy test is pending since the time interval crterium is met, then the software will automatically force the dummy test to be executed. Regular test operation is possible again only after this dummy test has been passed successfully.

(Note: Users with the right *"Skip Dummy Test"* are authorized to skip a pending dummy test.)

Tab "Colors":

In the multi-tab "Colors", you can change the colors used for the result protocols, as well as for the print and screen display of the graphics module:

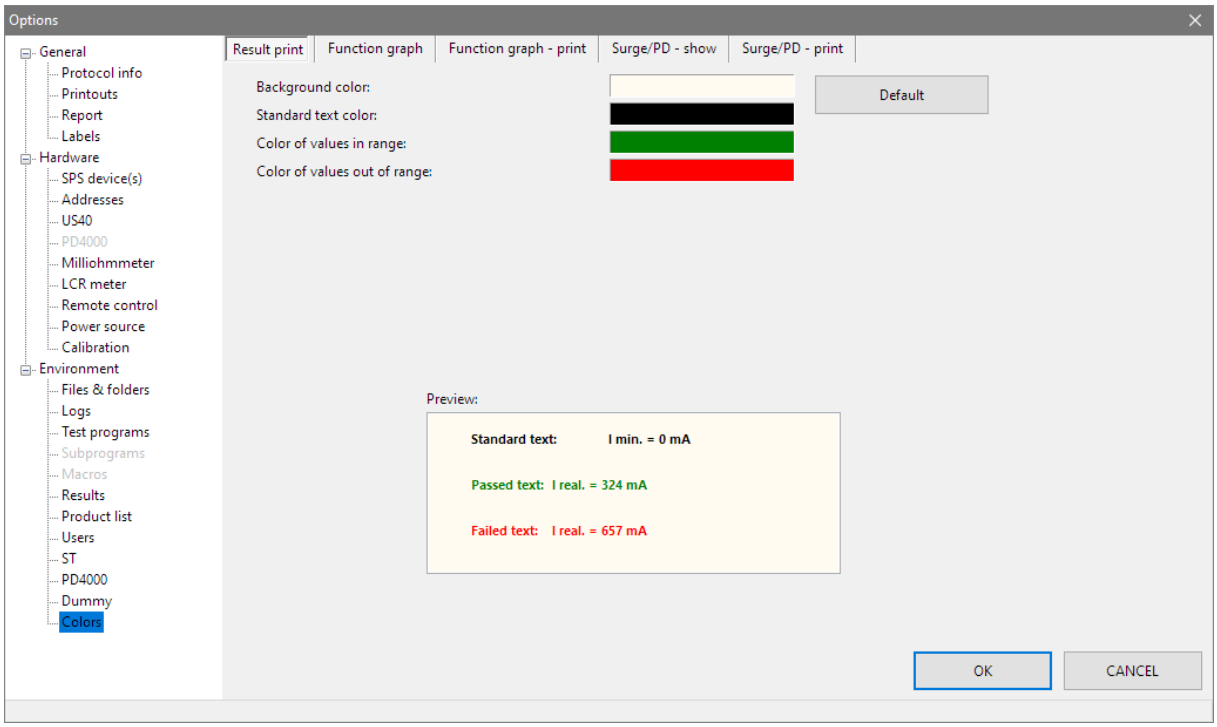


Fig. 28: Tab „Colors / Protocol print“

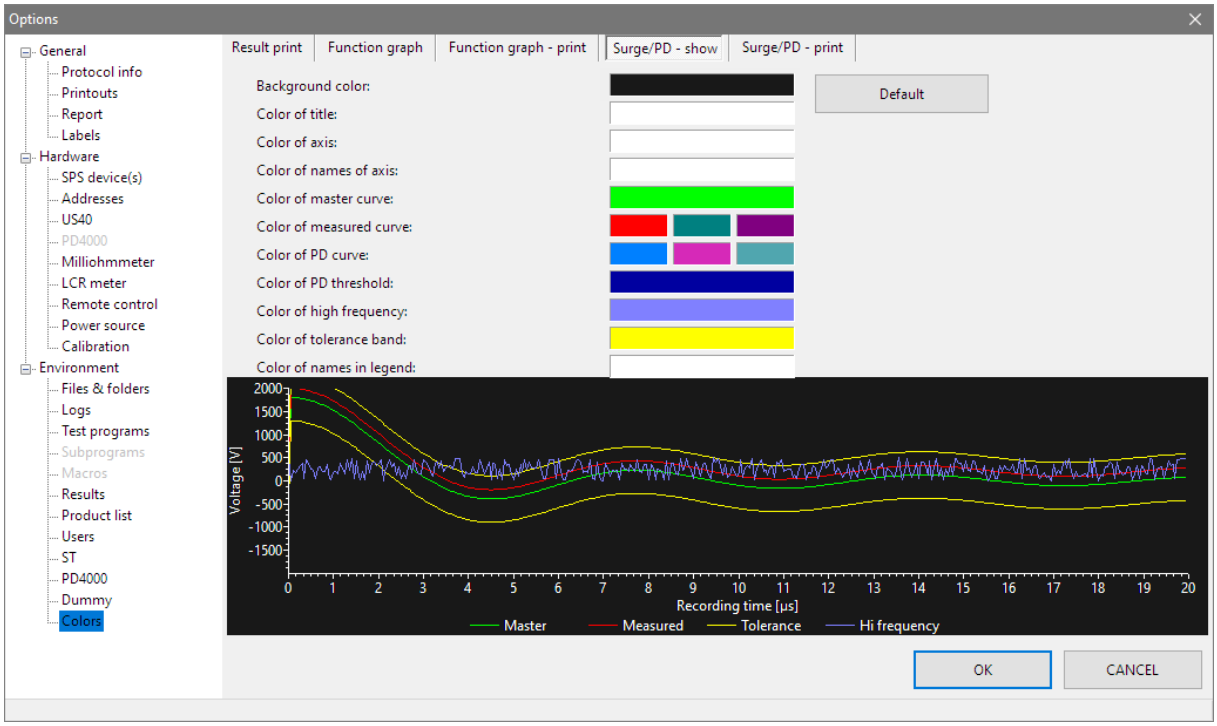


Fig. 29: Tab „Colors / Show Surge/PD“

4.2.5 User Administration

The software has a built-in *User administration*. Here all users of the software must be registered. To get into the program for the first time, you have to enter "SPS" as user and password both. After this, you can enter new users with their depending passwords and rights (see Fig. 30).

After having given the users and rights confirming your needs, we recommend to delete the user "*SPS*" in order to avoid abuse of the software.

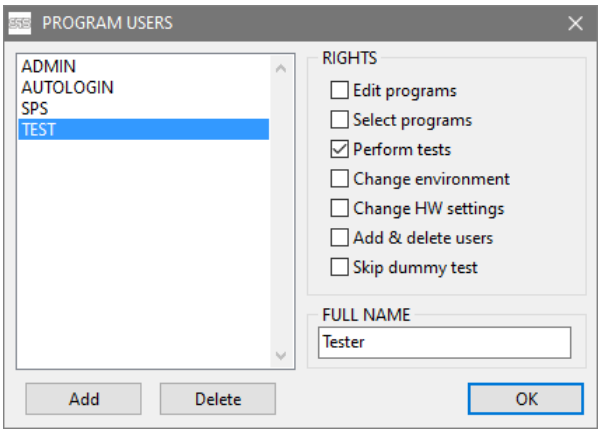


Fig. 30: User administration

Explanation of the rights:

Edit programs	enables editing of test programs
Select programs	enables loading of test programs
Perform tests	enables to switch to the module »testing«
Change environment	enables changes of program environment
Change HW settings	enables changes of hardware settings
Add & delete users	Enables to make changes in *Options / User administration*
Skip dummy tests	Allows to skip the daily dummy test (if dummy test is activated)
Full name	Here the full name of each user is specified. This full name is used in the test protocols.

4.3 The Product List

The product list contains the assignments between devices/article numbers and the test program to use for each kind of device. Hereby it is possible to automatically load the correct test program for each DUT by scanning its barcode.

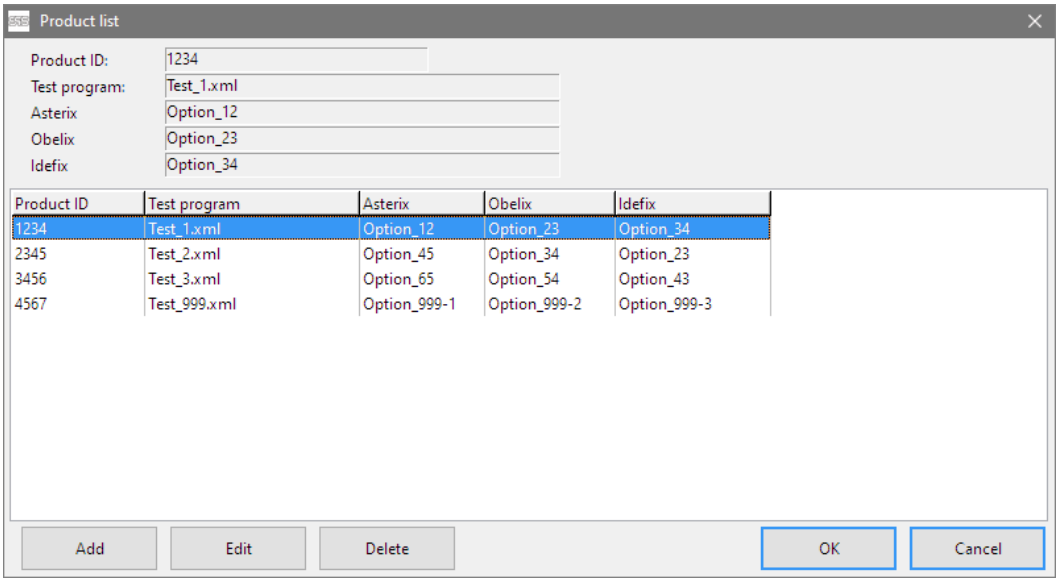


Fig. 31: the Product List

The values for *Product ID* and *Test program* are of particular importance:

- For *Product ID* one must enter exactly that character sequence that will be read from the DUT during testing.
- For *Test program* the exact name of the test program to use for the given type of DUT must be entered.
- The entry for *Device* may be of free form – it deals only for information of the tester, and for logging purposes in the test protocol.
- The same goes for the entry *Remark*.

Note: The entries "Device" and "Remark" are present only if in the menu *Options/General* it was defined to **not** read these values from the barcode.

To enter a new kind of device into the product list, or to edit the properties of an existing one, the buttons "Add" resp. "Edit" will open a new dialog window, in which the needed data can be entered:

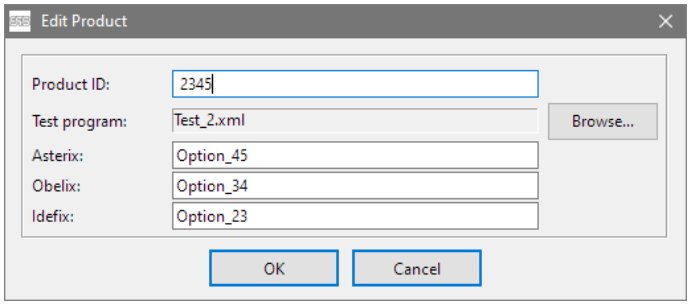


Fig. 32: dialog window "new product"

4.4 Module "Editor"

4.4.1 General

With the editor module you arrange the test, parametrize the single test steps and archivate the test programs.

All test programs created with the editor are stored in the built-in hard disk and are available for later testing. Each test program has a definite name (plus extension *.prg). The name should be product-related for programs to be easy to identify.

Each test program has the following structure:

- general information: name of DUT, author, etc.
- protocol information: Whether a protocol will be created, and how should it look like.
- sequence of test run
- an internal statistic module (numeric), embedded in the program file.

The sequence of the test run is displayed in the middle of the window and can be changed with the editor's tools.
The single test steps can be:

- inserted: a new test step is inserted by double-clicking a step from the list on the left side.
- deleted: the test to be deleted has to be highlighted, then it can be deleted by keyboard's "del" key.
- edited: double-clicking a test step in the program listing will open the parameter window.
- moved to a differnt location in the program: this is done by "dragging" a test step with the mouse.
- copied: duplicating a test step can be done by additionally holding the "strg" key while moving the test step.

By means of the menu item *"File / Print"* the actual program inclusive all test parameters can be printed to a connected printer.

Each test step can be changed by either marking it and selecting "edit" from the right-click context menu, or by simply double-clicking it.

By doing so, a new window will open in which all parameters of the test step can be adjusted. (See chapter 4.5: "Description of test parameters".)

Each test step by default receives a name characterizing the test step. In the parameter window this name can be edited to confirm with the DUT the program is written for (like e.g. *"Surge Test U–W"*).

4.4.2 Editor: Testinfo

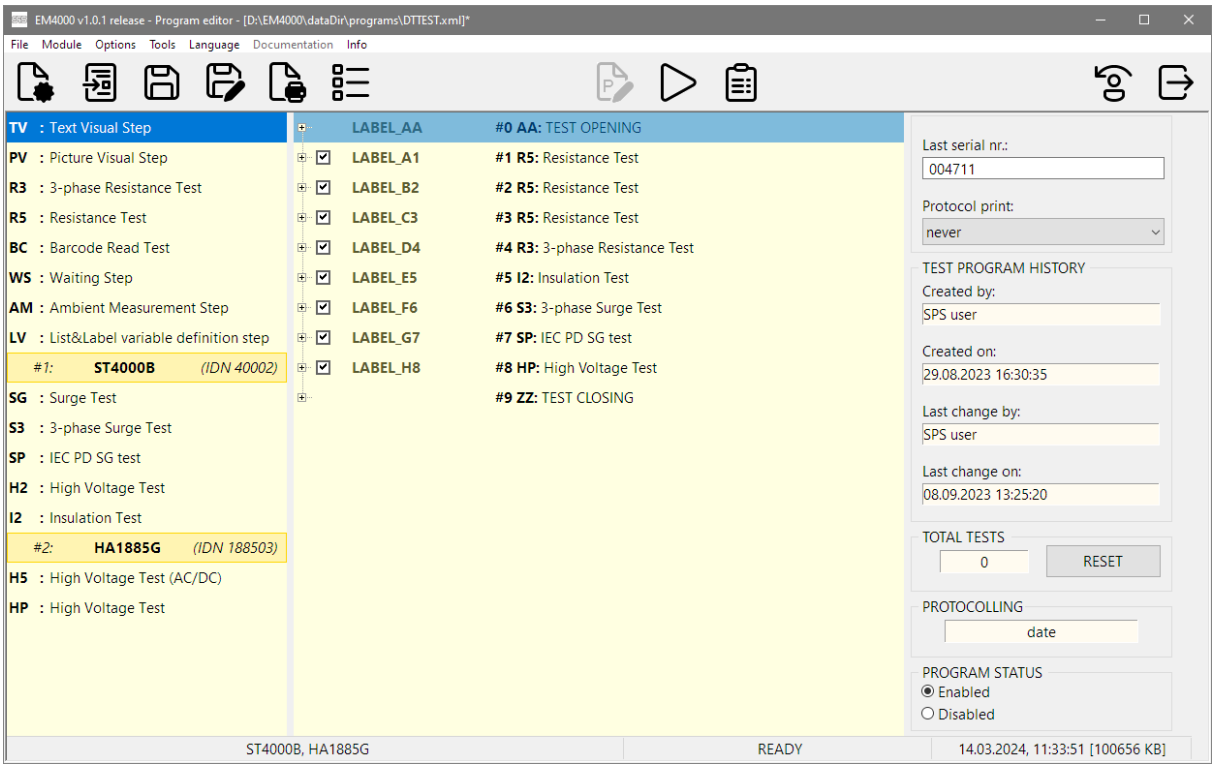


Fig. 33: Program editor

- In the title bar you see the path and name of the actual test program.
- Below there is the menu bar (see paragraph 4.2, p.17).
- The list window to the left shows all test steps that are available to be used.
- The list window to the right shows the actual test program.

In the right part of the window, general data on the actual test program is shown. This information does not effect the test run; it will, however, be shown for information in different windows and be included in the test protocols:

- The input fields "device" and "remark" can be used for aribtrary entries, e.g. for identification of the type of DUT for which the test program has been designed.
- With "Next serial number", one can set the serial number to start with after loading the next test program. (This option is not available when in *Options/General* it has been chosen to read the serial number from the DUT's barcode.)

In the middle field "Test Program History", there is the creation and modification date of the program, along with the creator / user who modified the program. This information is generated directly by the software and cannot be changed by the user.

4.4.2.1 Protocolling to a Printer :

The program allows the output of the test results on the printer. Same happens after each test run. Via the drop-down list "Protocol print" this procedure can be controlled.

Below print possibilities are available to the user:

List element	*Function*
never	No protocol will be printed
always	print protocol after each test
if failed	print protocol only if test result was "Fail"
if passed	print protocol only if test result was "Passed"
failed steps	Protocol only the test step that caused the error

The chosen settings are specific to the actually loaded test program, and are saved together with it..

4.4.2.2 Statistics ("Total tests")

In this test program there is a tabular statistics for each program. The passed, failed and invalid tests are counted and the results of each single test step are recorded. The info field *"Total testsy"* shows the number of all the tests done so far with the current test program.
The statistics can be deleted (reset to zero) via the button "RESET". Deletion of the statistics has to be acknowledged via a safety inquiry (see Fig. 34).

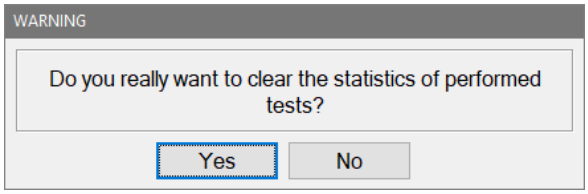


Fig. 34: Safety inquiry

4.4.2.3 Program Status:

By means of the field *"Program status"*, the possibility to run the actual test program can be *disabled* or *enabled*.
This setting applies to each test program independently, and is saved together with same.
Only users wich have the right *"Change test programs"* are able to change this setting!
This option is intended for *not* releasing a test program if, for example, it is still "in development".

Attention:

In order to perform tests with the remote software EM4000, this setting has to be enabled. As long as *"Program Status"* is set to *"disabled"*, no test operation can be done with that test program!

4.4.2.4 Protocol settings :

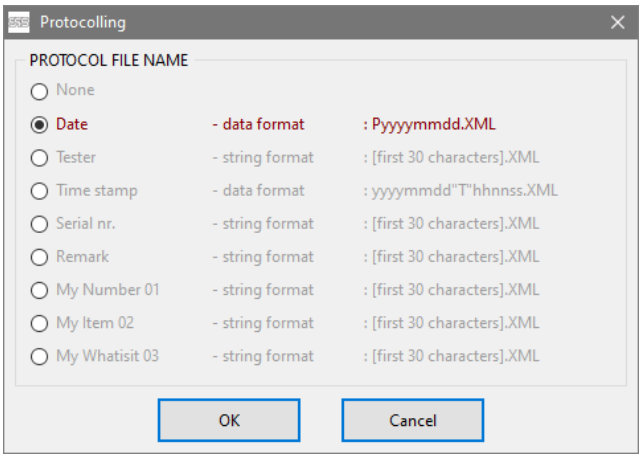


Fig. 35: Dialog window "Protocolling"

After each test the test and measuring results are stored in a protocol file. By pressing the button "CHANGE" beneath the "PROTOCOLLING" field, the user can determine the naming scheme of the protocol. Fig. 35 shows the dialog window for defining the name.

Option	***Function***
Date	File name is made up from the date of day. The date format is Pyyyymmdd. E.g. a protocol file created on May 07, 2023 would be filed as P20230507.xml . This setting has the advantage all tests of a day are saved in one single file.
Tester	File name is created from the first 30 letters of the operator name.
Time stamp	Similar to "date" above, but due to the "resolution" down to the seconds range, no dayly files with all-tests-of-the-day are created, but each test individually according to the time stamp.
Serial nr.	File name is created from the first 30 letters of the serial number.
Device *)	*These designations or file names are*
Article Nr.. *)	*user-defined, i.e. they correspond to*
Asterix *)	*what has been defined*
Obelix … *)	*under "Settings/General/Protocol info".*

** These items can be renamed individually, see p. 20,"Protocol Info".*

Notice:

The name definition for the result files described here is only used if the token SPS is specified for the file name under *Settings/Environment/Results*. If other name tokens are specified in the settings there, the protocol settings described on this page will not be applied!

4.4.3 Editor: Test steps

The organisation of the test steps and the definition of the test run is managed directly in the main window of the program editor:

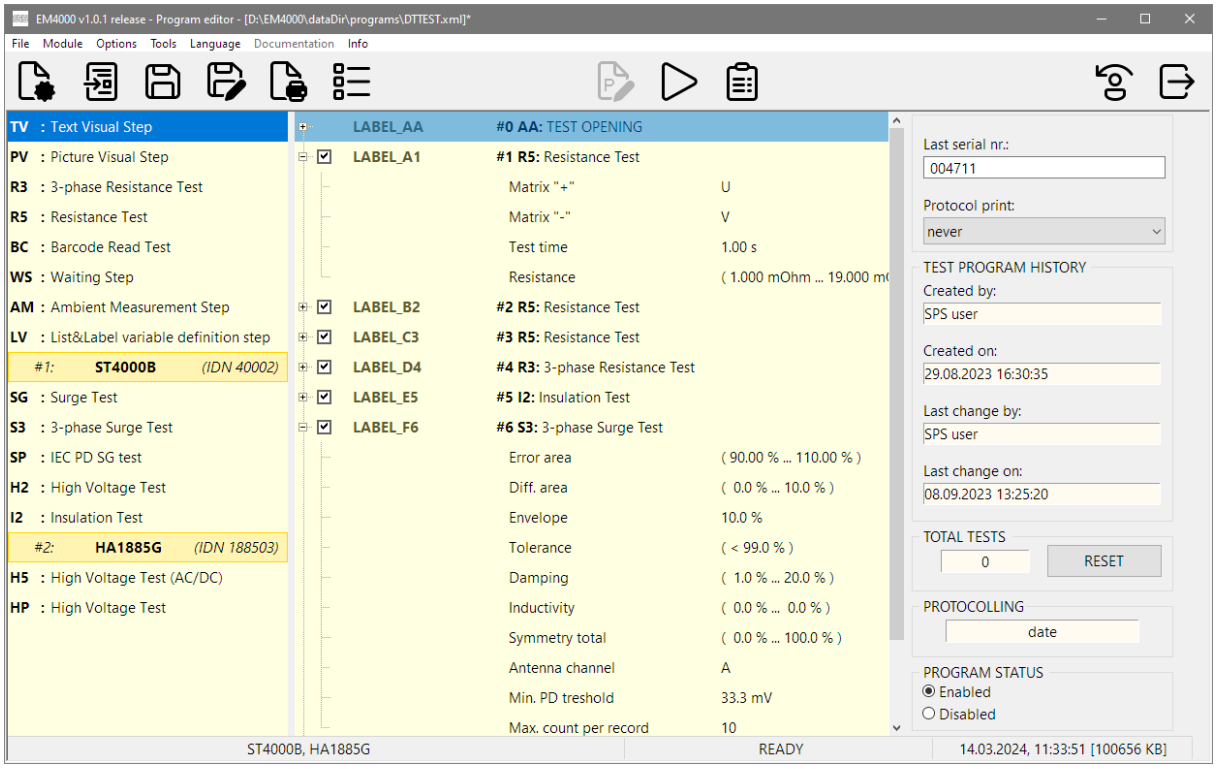


Fig. 36: Editing of a test program

The list window on the left shows all the test steps available in the program. By double-clicking one of these test steps same is included in the test run list. Before inserting a new test step the step after which this new step is to be inserted should be marked in the test run list. With this double click the respective parameter window of the new test step opens automatically, and after editing the parameter and closing the parameter window the new test step will appear at the desired position in the test run list.

The list window on the right shows the current test program.The test steps are shown one by one with step number, grammalogue and definition of each step

Before and after each test run the test steps "TEST OPENING" and "TEST CLOSING" are arranged automatically. This way certain operations can be defined at the beginning and at the end of a test run.
By means of the [+] symbol, each test step can be switched between "brief" and "detailed" display mode. In "brief" mode, only the step number, step type and step name are displayed. When switching a step to "detailed", it is shown with all of its parameters and settings.

To change the order of test steps, each test step can be "dragged" with the mouse to another position in the test program. (Except for the steps "AA" and "ZZ", which cannot be moved.)

Moreover, test steps can be handled in the Windows-typical manner of "cut", "copy" and "paste". To do so, a test step must be marked by the mouse, then one can perform the appropriate action by right-clicking the step, and using the context menu that will pop up.

To save the current test program to the harddisk, choose the menu item "File / Save" or "File / Save as…".
"Save" will just save the file with the current name.
"Save as…" allows to choose another file name.

4.5 Description of Test Parameters

4.5.1 General Information

The test steps have all common dialog elements or test parameters. With the following example, the make up of the dialog windows for the common test parameters is explained:

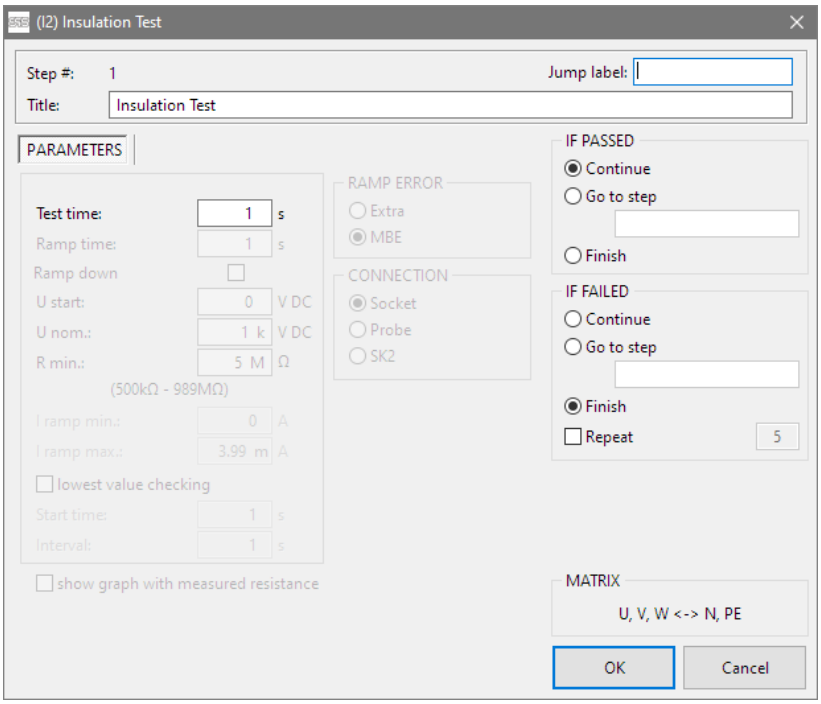


Fig. 37: Dialog window with test parameters (example)

Common paramters:

Dialog element	*Function*
Step #	The number of the actual test step in the test program.
Title	Labelling of test step. Display on test run window and during test run. You can also give instructions in the title for the testing person, e.g. »protective wire test at fan/ventilated motor«
Test time	Duration of the test step. (Not available for TV & PV.)
IF PASSED / IF FAILED	It is possible to make "jumps" in the order of the test program, depending on whether the result of a test step was "Passed" or "Failed". The possibilities of branching are:
- Continue	The test run is continued with the next step in the list
- Go to step	A jump is done to the test step with the LABEL entered here.
- Finish	A jump to the test step "ZZ" is performed.
- Repeat possibility	If the test step result was "Failed", the tester is asked whether the step shall be repeated. If there's no error during the repeated step, the test result is "Passed."
Invert Result	This option is only available for the test program that is defined as "dummy test program". When the dummy simulates a "fail" situation, and the tester does reckognize "fail", then this is "good" in the sense of a dummy-test, hence the inversion is used solely in the dummy-test to make a fail-test "good".

4.5.2 AA: Start of Test

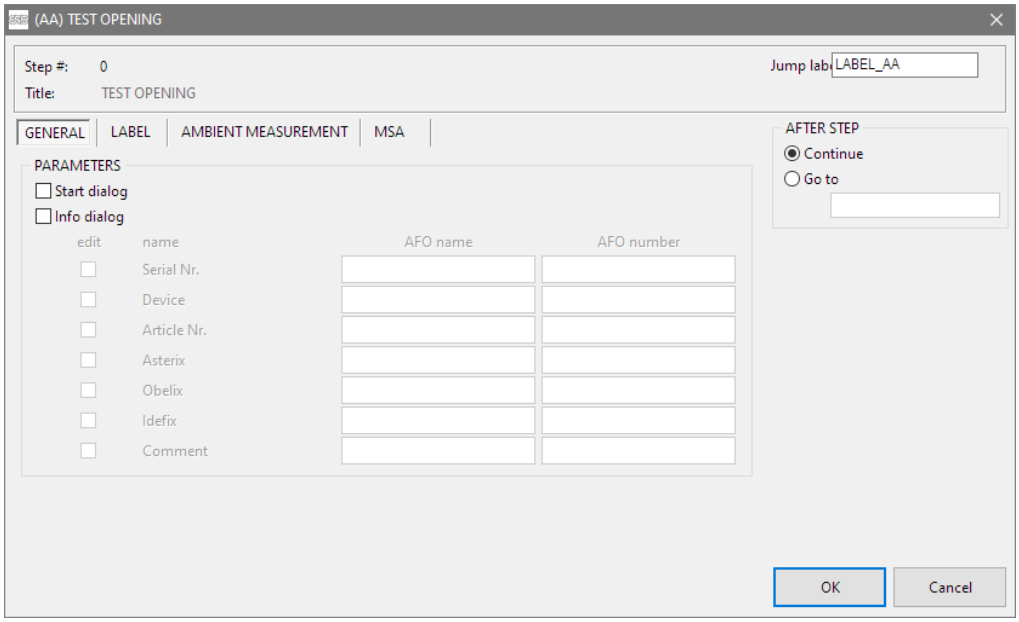


Fig. 38: Test parameters "Start of Test"

When "Info Dialog" is checked, a window with information about the DUT will be shown at the start of each test. If the user shall be able to edit certain DUT data when a test starts, the wished positions have to be checked here.
When "Start dialog" is checked, then at every start of a test run the testing person will be requested to contact the DUT.

Tab "Label"

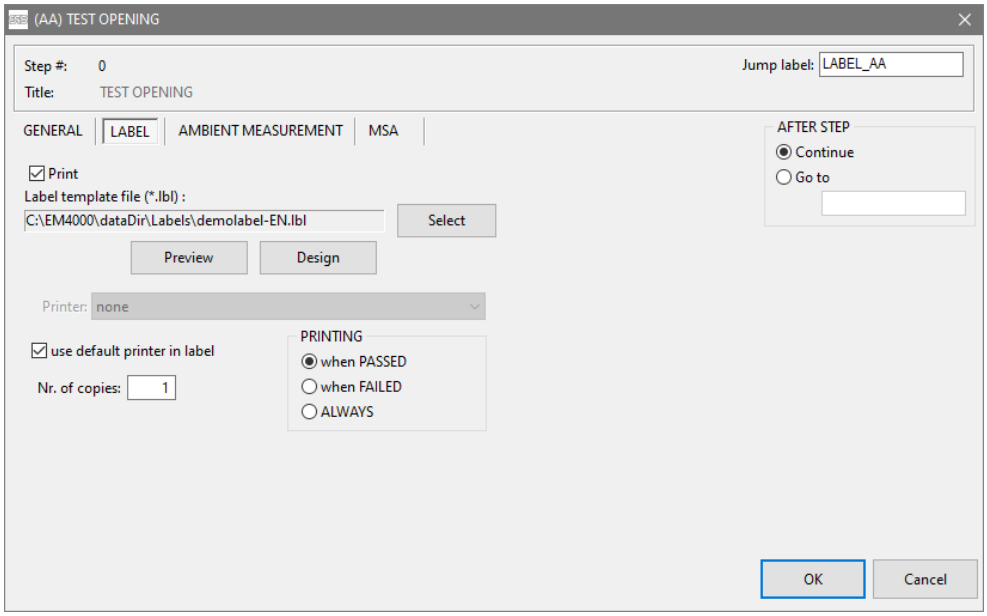


Fig. 39: Test parameters "Label print"

Here the parameters for the label printing of the Pass/Fail/ tests are set.
The "Preview" button provides a quick preview of the selected label template.
The "Design" button opens the List + Label module, which can be used to create and edit label templates.

Tab "Ambient Measurement"

In the "Ambient Measurement" tab you can specify which measured values of the environmental sensor should be recorded right at the beginning of the test program. These measured values are stored in the XML results files listed in the introductory header.

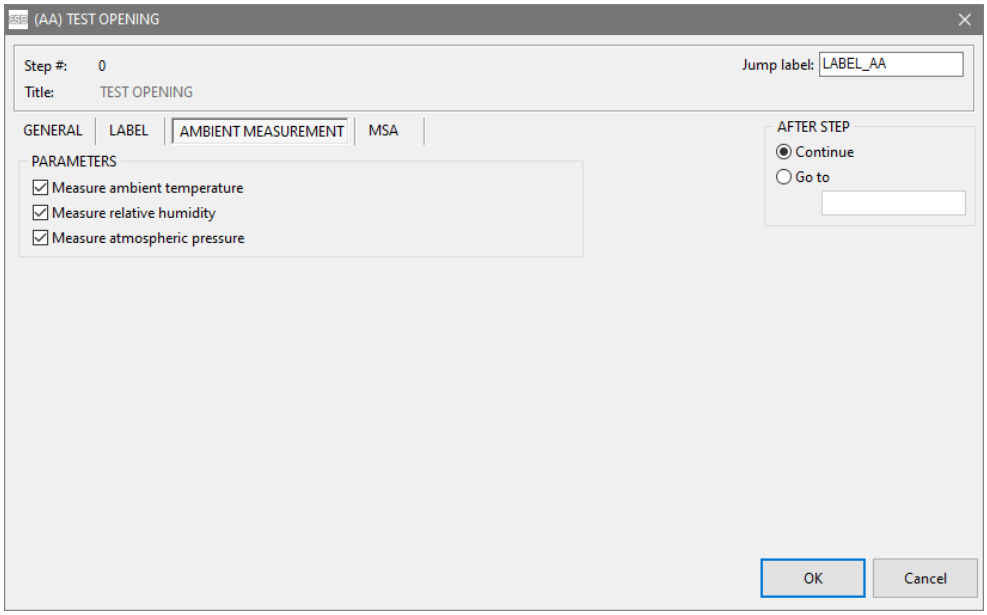


Fig. 40: Tab "Ambient measurement"

In the last tab, the "MSA" mode can be activated for the actual test program. The whole test program will be repeated as many times as specified.

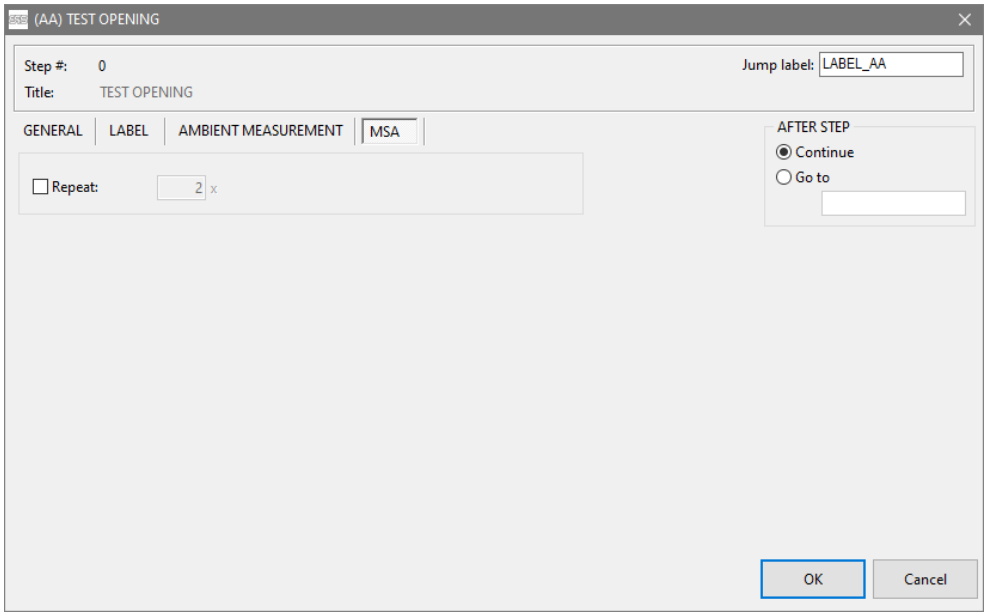


Fig. 41: Tab "MSA"

4.5.3 TV: Text Visual Step

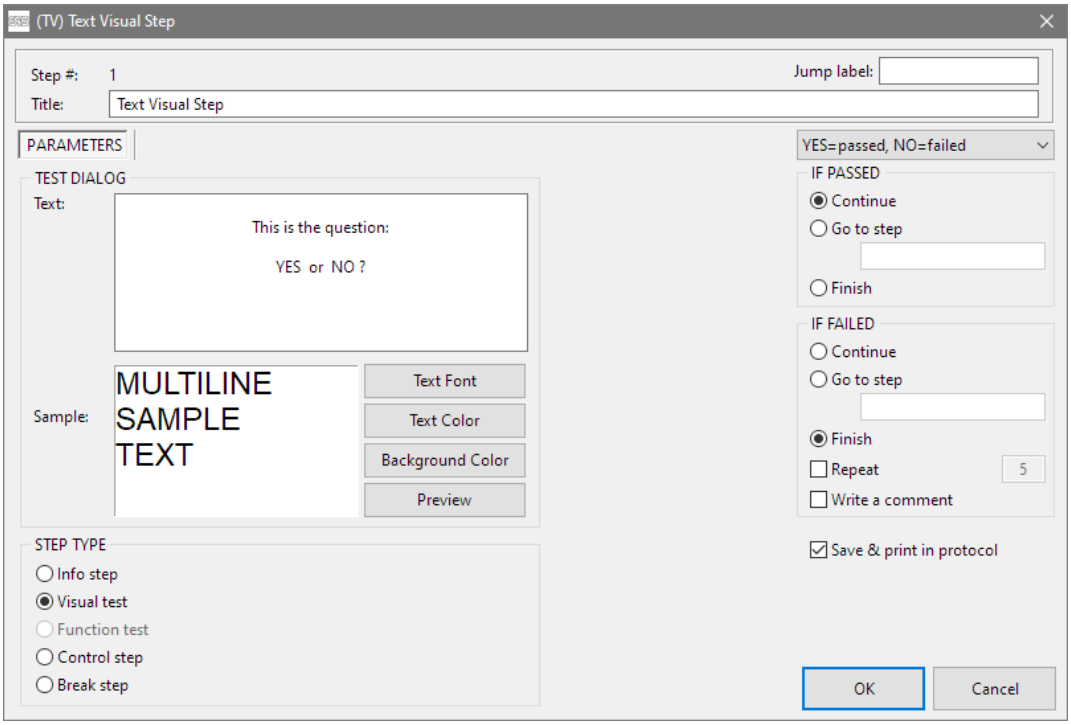


Fig. 42: Test parameters "Text visual step"

In the test step *Text visual step* the dialog elements have below functions:

Dialog element	***Function***
Text	Contents of this field is displayed when step is executed. The message has to consist of a minimum of five characters.
Text font	Choose the desired font for the message text
Background color	Choose the color of background on which the message will be displayed
Preview	Have a look on how your message will appear
Write a comment	If the test is confirmed with NO, one can enter a comment to the test
Save&print in protocol	If not checked, the test will not appear in the results, nor will it be printed
YES=passed, NO=failed	By switching this parameter, it is possible to revert answer logic for certain questions (*"Is there smoke coming out of the DUT?" → "NO" → result PASS*)
Step type	
Info step	Choose this to give any information to the tester. There will only be an OK button to acknowledge the message.
Visual test	Choosing this option forces a dialog to appear which can be quitted with YES or NO. In case of NO, the DUT has **failed** the test
Function test	*Not available for the ST4000 device*
Control step	This test type is for information only. No test result PASSED or FAILED.
Break step	Similar as "Info step", but after confirmation the program will be stopped.

4.5.4 PV: Picture Visual Step

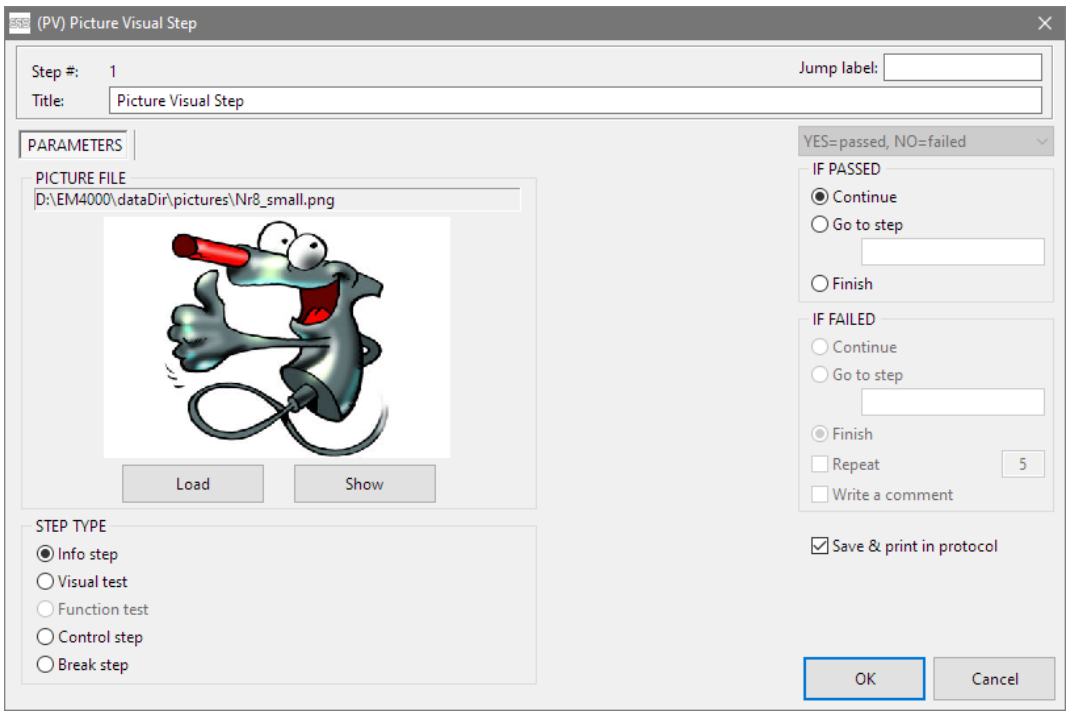


Fig. 43: Test parameters "Picture visual step"

In the test step *Text visual step* the dialog elements have below functions:

Dialog element	***Function***
Load	Opens standard »open file« dialogue to choose an image
Show	Have a look on how things will look on paper
Write a comment	If the test is confirmed with NO, one can enter a comment to the test.
Save&print in protocol	If not checked, the test will not appear in the results, nor will it be printed
YES=passed, NO=failed	reverts answer logic (see *Text visual step*)
Step type	
Info step	Choose this to give any information to the tester. There will only be an OK button to acknowledge the message.
Visual test	Choosing this option forces a dialog to appear which can be quitted with YES or NO. In case of NO, the DUT has **failed** the test
Function test	*Not available for the ST4000 device*
Control step	This test type is for information only. No test result PASSED or FAILED.
Break step	Similar as "Info step", but after confirmation the program will be stopped.

4.5.5 R5: Resistance Test 1-phase

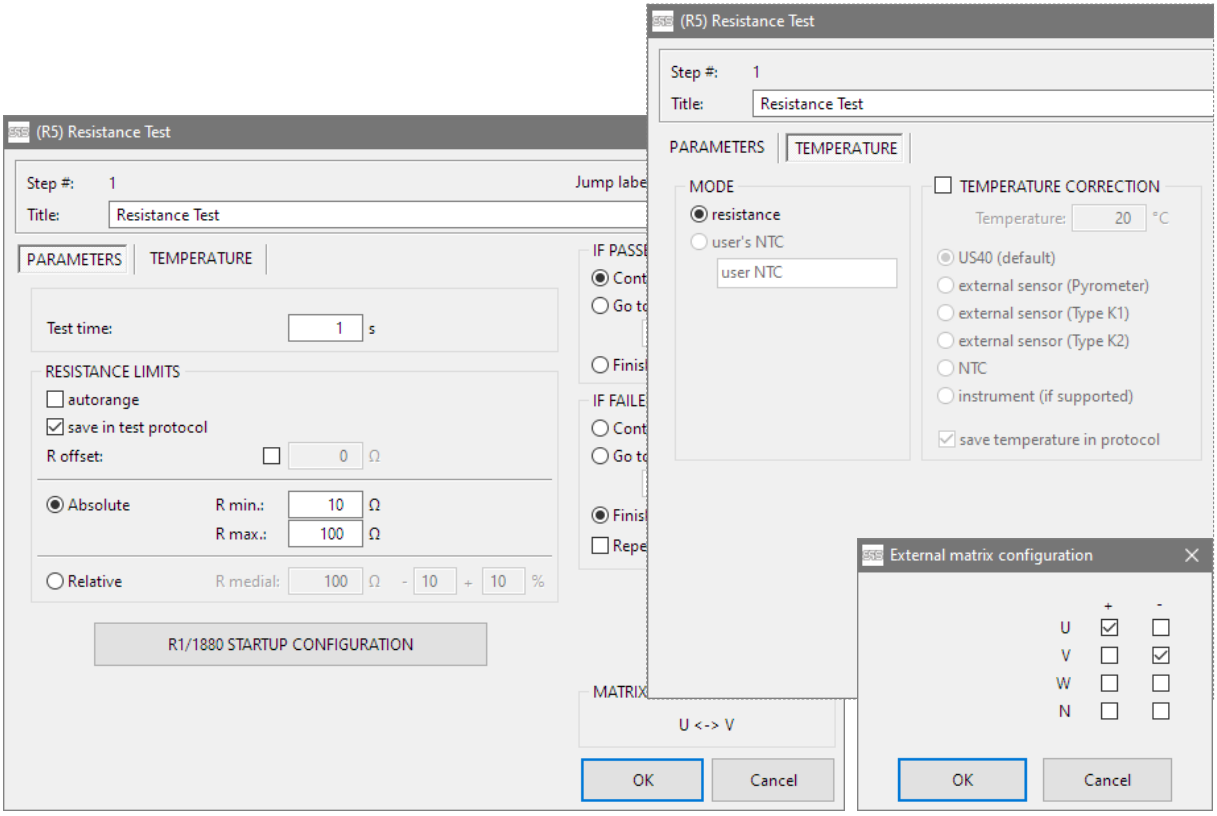


Fig. 44+45: Test parameters "Resistance Test" (R5)

This is the dialog for the "R5" one-phase Resistance Test:

Dialog element	***Function***
Absolute	*Uses absolute thresholds for resistance:*
R min	Minimum allowed resistance
R max	Maximum allowed resistance
Relative	*Uses relative thresholds for resistance:*
R medial	Sets the average expected resistance
–	max.allowed percentual deviation, negative
+	max. allowed percentual deviation, positive
temperature correction	When chosen, the obtained resistance is normalized to a standard temperature (usually 20°C).
External Matrix	Specifies the contact points at which the measurement will be done.

4.5.6 R3: 3-phase Resistance Test

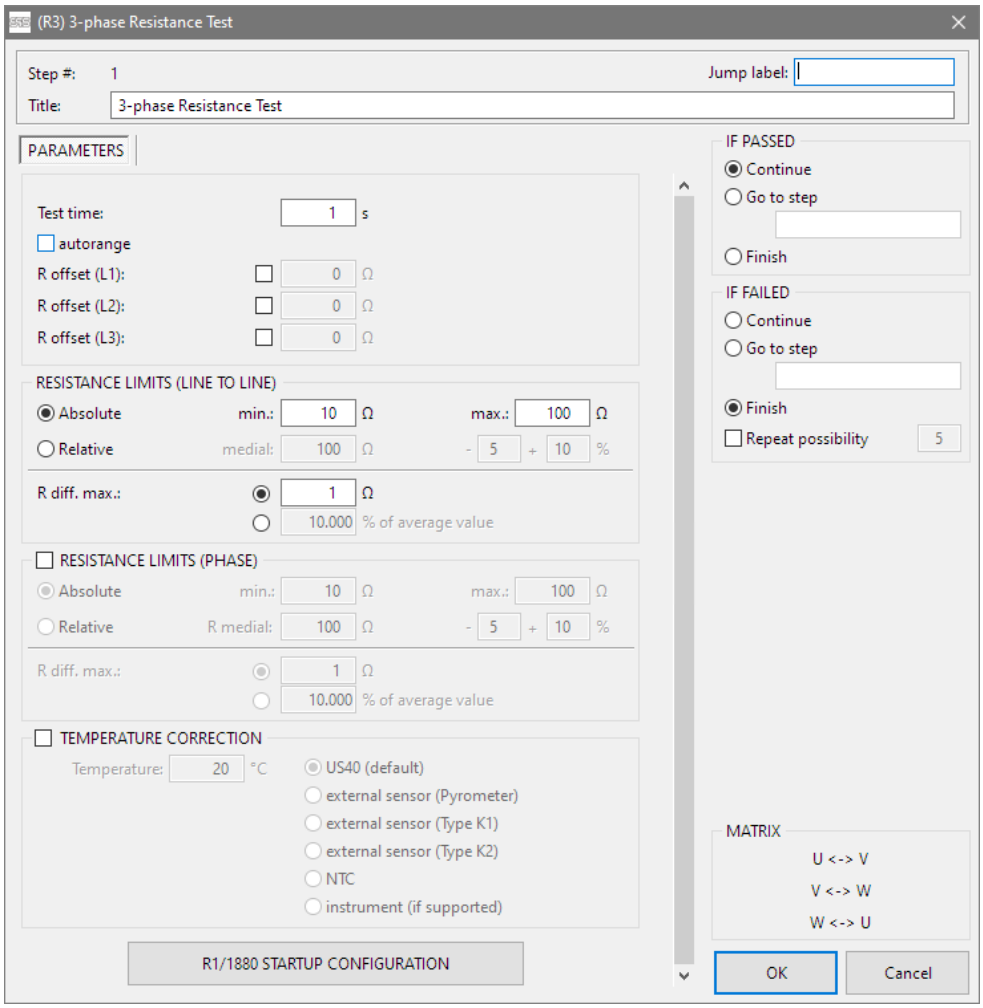


Fig. 46: Test parameters "3-phase resistance test" (R3)

The 3-phase resistance test measures the resistance at three current pathes, e.g. U–V, U-W, V-W.

Each of these must fulfill the thresholds given in "resistance limits".

Additionally, the maximally allowed *difference* between any of these three is checked acc. to "R diff max".

(Note that you need to call the matrix window three times to complete the configuration.)

4.5.7 I2: Insulation Test

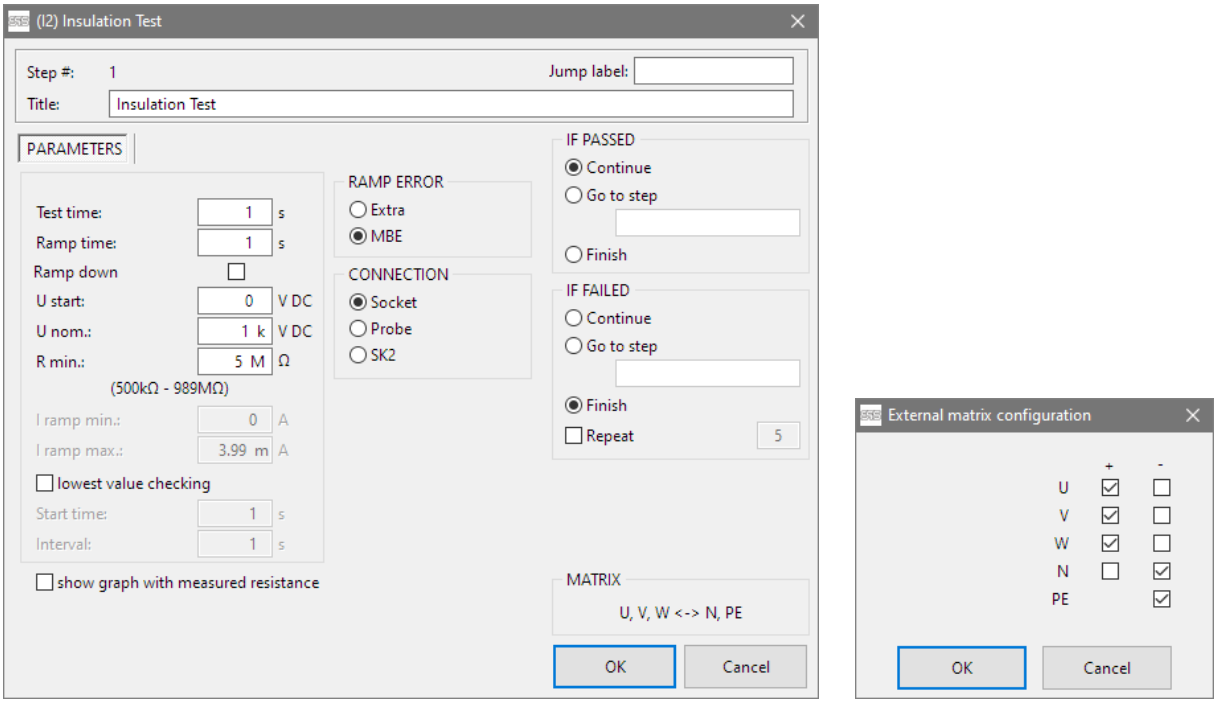
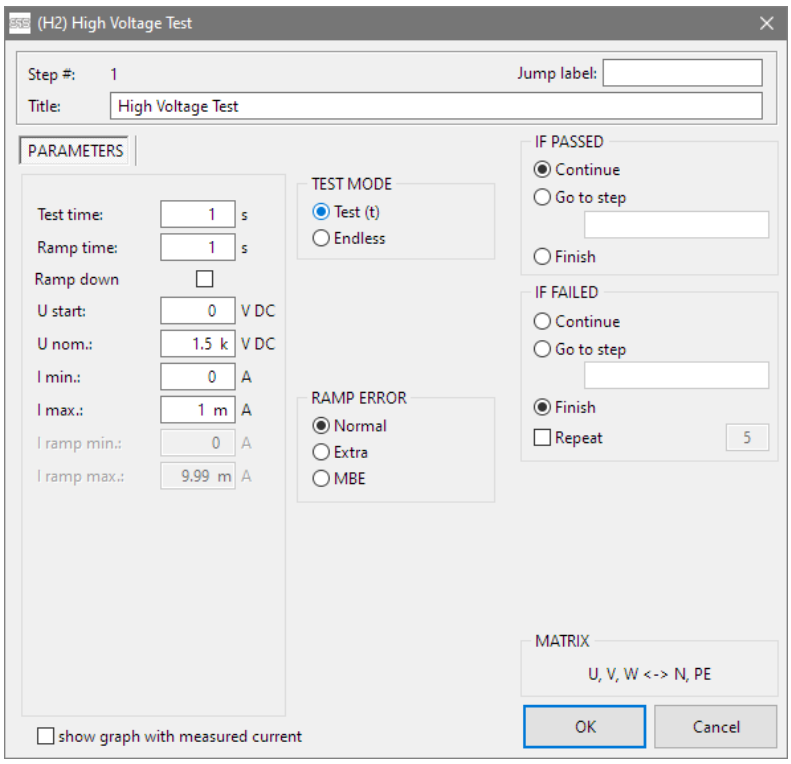


Fig. 47 + 48: Test parameters "Insulation Test" (I2)

This is the dialog for the "I2" insulation test:

Dialog element	*Function*
Ramp time	Time for voltage to be increased to maximum (when »0«, no ramp is used)
Ramp down	If checked, at the test's end the voltage will be decreased instead of just switched off (same time as for "ramp up")
U start	Starting value of test voltage when voltage ramp is used
U nom	Nominal value of test voltage
R min	Minimum of required resistance. The available range depends on the voltage chosen for Unom. The actually available resistance range is shown below the Rmin field.
I ramp min / max	Minimum/maximum of allowed current during voltage ramp (only available when option "ramp error" is set to "Extra")
Matrix	Specifies the contact points at which the measurement will be done.

4.5.8 H2: High Voltage Test DC



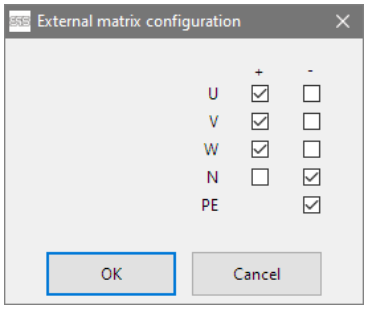


Fig. 49 + 50: Test parameters "High Voltage Test" (H2)

This is the dialog for the "H2" high voltage test:

Dialog element	*Function*
Ramp time	Time for voltage to be increased to maximum (when »0«, no ramp is used)
Ramp down	If checked, at the test's end the voltage will be decreased instead of just switched off (same time as for "ramp up")
U start	Starting value of test voltage when voltage ramp is used
U nom	Nominal value of test voltage
I min	Minimum of allowed current during actual test
I max	Maximum of allowed current during actual test
IR min / max	Minimum/maximum of allowed current during voltage ramp (only available when option "ramp error" is set to "Extra")
external matrix	In this window it has to be defined to which contact points the test voltage will be applied.

4.5.9 SG: Surge Test

Choosing the test step »Surge Test«, the following window appears:

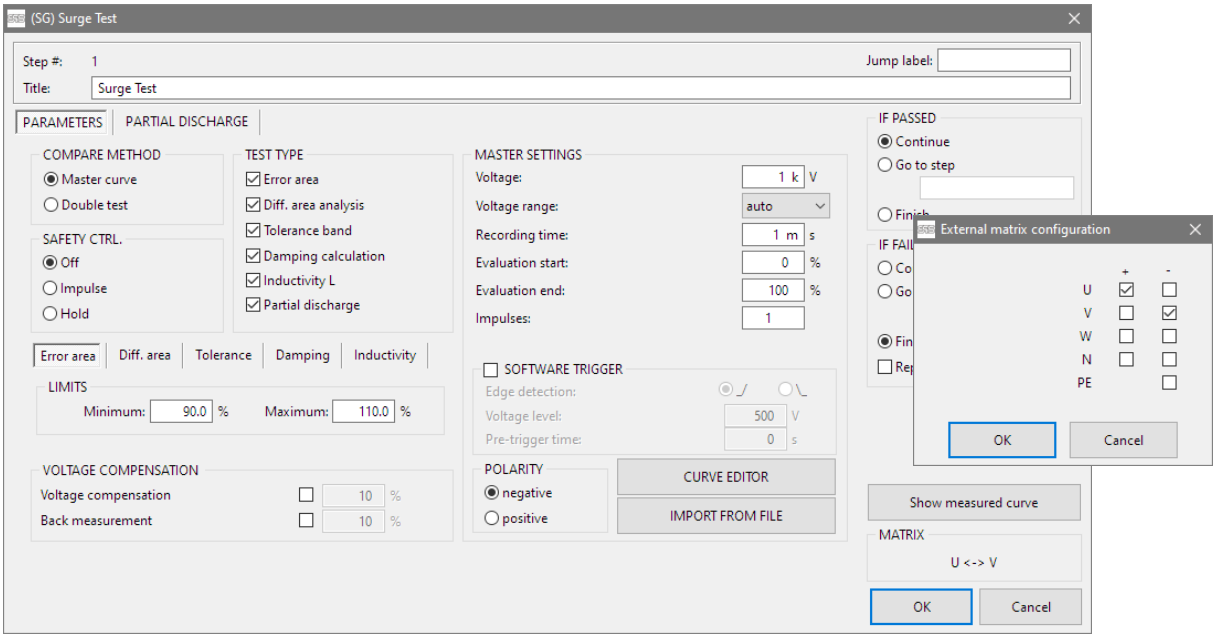


Fig. 51+52: Test parameters "Surge test"

Dialog element	*Function*
COMPARE METHOD	Chooses which comparison method to use: *(See: "A-1 - Methods of evaluation", p.74ff.)*
- Master curve	The curve obtained from the DUT is compared with a reference curve
- Double test	The curves of two different surge impulses are taken from the same DUT, one after another, and are compared with each other
MASTER CURVE	Shows the name of the actually chosen master curve.
- Master settings	Opens the mastercurve editor, with which one can edit existing curves, or record new ones. Please see chapter A-2, page 77ff.
TEST TYPE	Chooses the method of curve evaluation. See page *74ff.*

Partial discharge evaluation: *(See screenshot of S3-teststep)*

Min. PD threshold:
This value determines from which strength a single peak is counted as a partial discharge.

Max. PDs per record:
This value defines the maximum number of partial discharges within a measuring interval, so that the test step is still considered "good".

Antenna channel:
Usually, channel A is used for the microwave antenna MW40, channel B is for the line coupler HW40.

Parameters for method "Master curve":

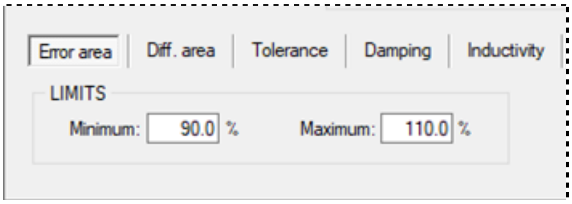


Fig. 53: Tab "Error area"

Fig. 54: Tab "Diff. area"

Fig. 55: Tab „Tolerance“

Fig. 56: Tab „Damping“

Fig. 57: Tab „Inductivity“

Dialog element	*Function*
TEST TYPE	Chooses the method of curve evaluation:
- Error area	The values "minimum" and "maximum" define how big the area (i.e. the integral) of the measured curve is allowed to be, in percentual relation to the master curve.
- Diff. area analysis	The values "minimum" and "maximum" define, how big the difference area between master curve and measured curve may be, in percentual relation to the master curve.
- Tolerance band	With "Envelope", the distance between master curve and tolerance band is defined. "Tolerance" then defines how much of all measured samples are allowed to be located outside of the tolerance band.
- Damping	This measures the damping factor of the surge curve, also commonly referred to as the "Quality Factor Q".
- Inductivity	This measures the inductive capacitance of the winding material being tested.

4.5.10 S3: Three-phase Surge Test

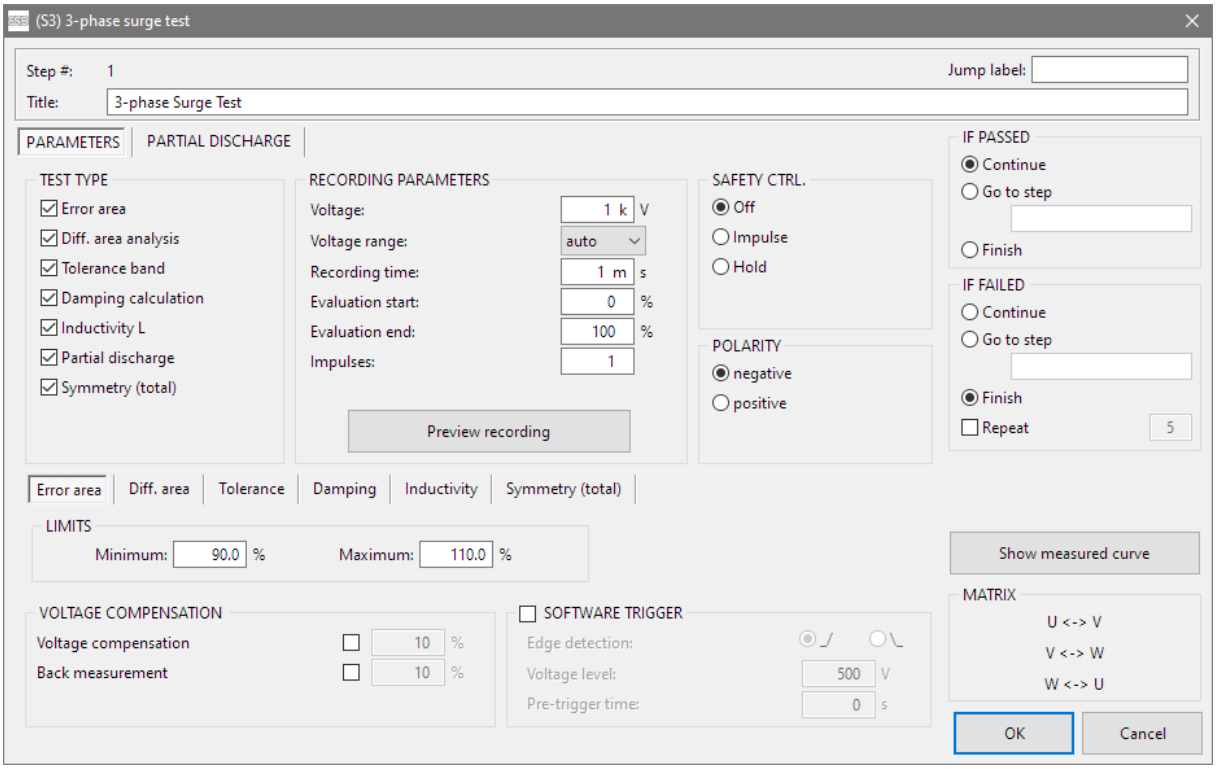


Fig. 58: Test parameters "3-phase surge test" (S3)

The three-phase surge test is very similar to the one-phase surge test previously described. However, work is done here without a "master curve". Rather, three surge curves are recorded between the phases U-V, V-W and V-W, and these three curves are compared against each other with the known evaluation methods.

Partial discharge evaluation:

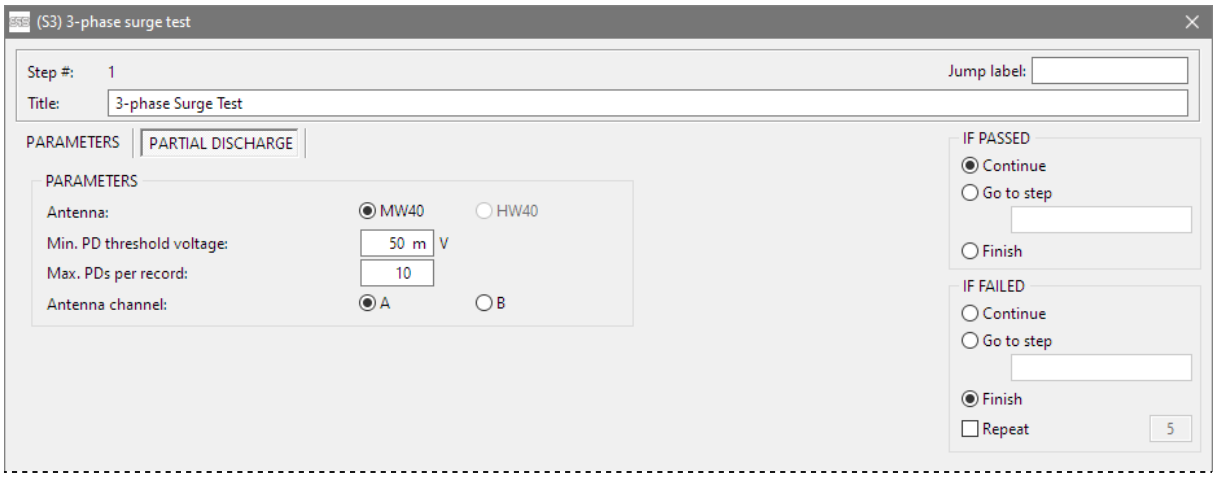


Fig. 59: Test parameters for partial discharge evaluation)

This is configured in the same way as in the SG surge test.

4.5.11 SP: IEC PD Surge Test

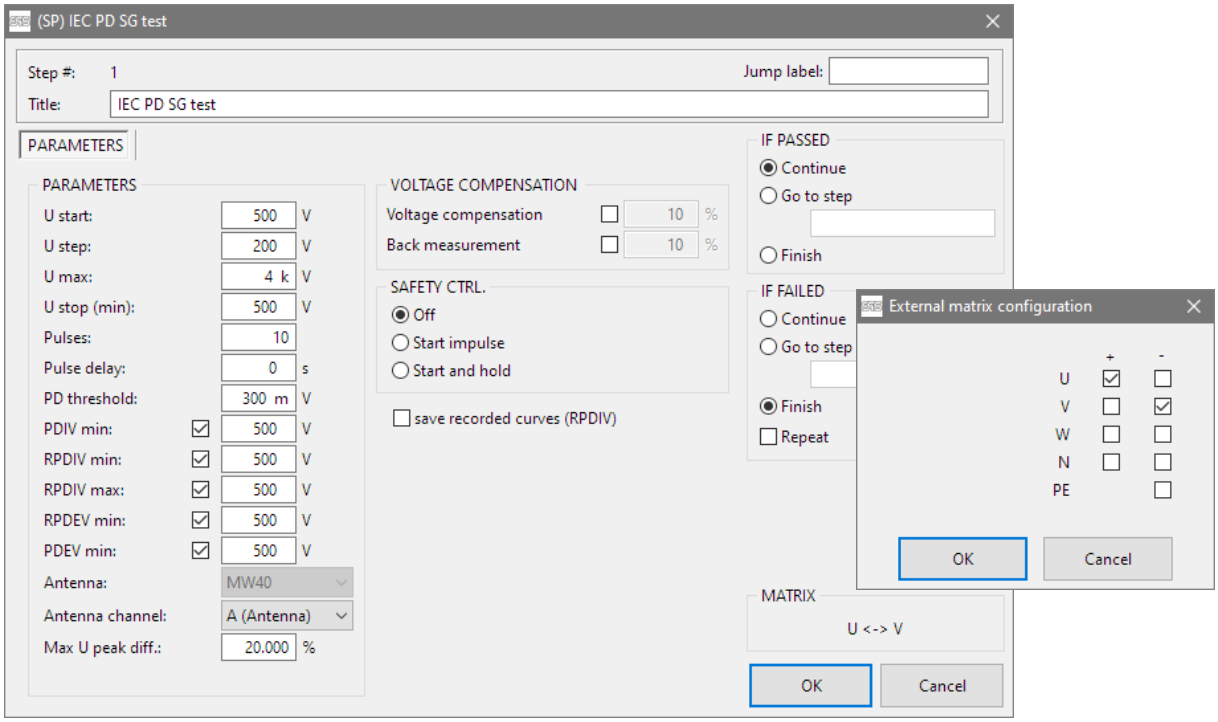


Fig. 60+61: Test parameters "IEC PD surge test" (SP)

In this test step, surge impulses are carried out with successively increasing test voltage, whereby the evaluation is oriented to resulting partial discharges:

PDIV min: the smallest surge voltage at which a partial discharge may occur for the first time

RPDIV min: the smallest voltage at which "repeatable" partial discharges may occur (repeatable = at least 50% of all surges)

RPDEV / PDEV: during the subsequent lowering of the test voltage, at which the repeatability or the single occurrence of partial discharges should disappear again.

((R)PDIV = (repetitive) partial discharge inception voltage
(R)PDEV = (repetitive) partial discharge extinction voltage)

4.5.12 AM: Ambient measurement step

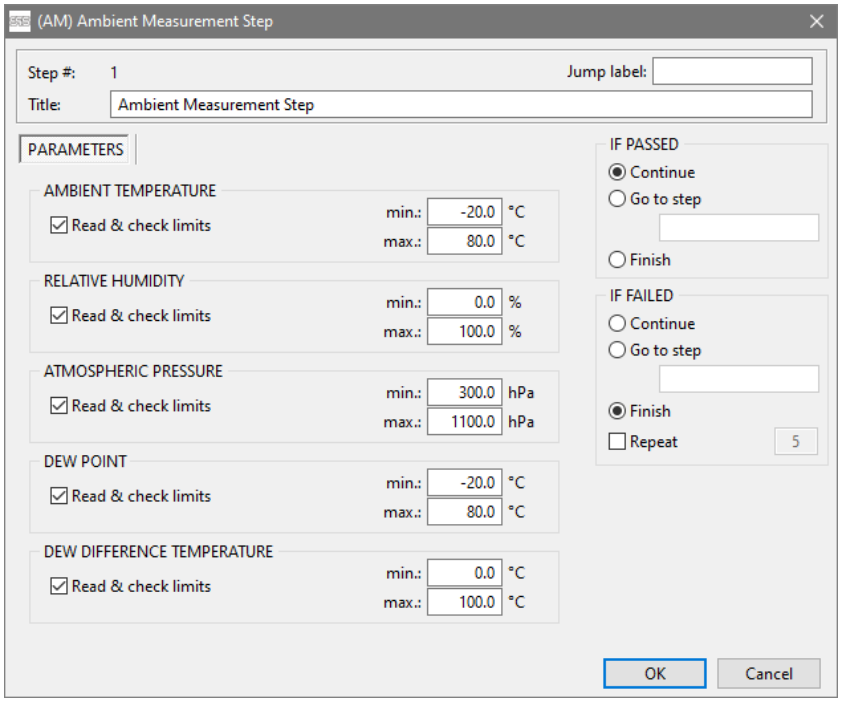


Fig. 62: Test parameters "Ambient measurement" (AM)

With this step, all available data from the “weather station” US40 can be read in.

The measured values are thereby explicitely included in the test protocols.

4.5.13 LV: List&Label Variable Definition

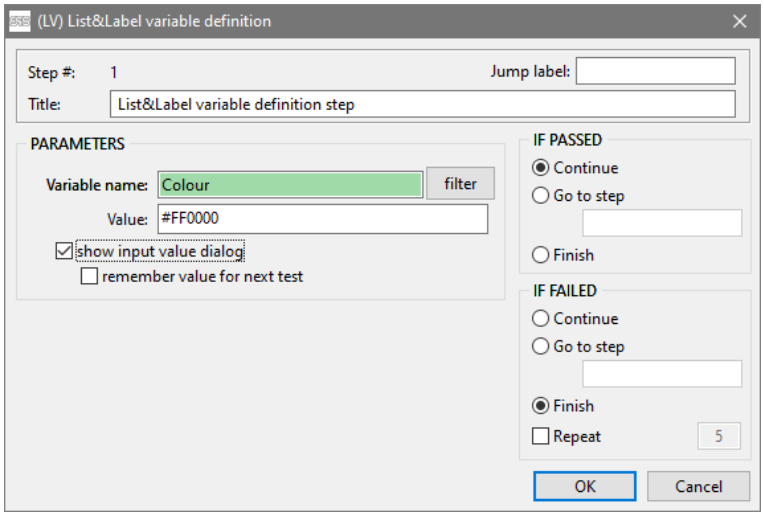


Fig. 63: Test parameters "List&Label variable definition" (LV)

By means of this step, it is possible to create additional variables that can be handed over to the List & Label module and can be used there.

These additional variables can have a fixed value assigned, or an initial value that can be edited by the user during the test run.

4.5.14 BC: Barcode Read Test

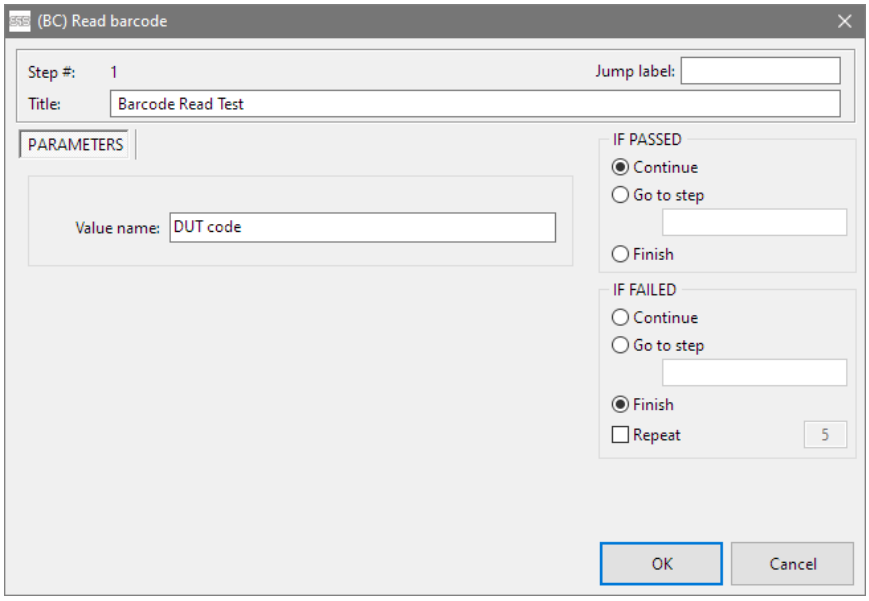


Fig. 64: Test parameters "Barcode Read Test" (BC)

By means of this test step, a barcode can be read during a test run. The read barcode then is included in the test protocol.

4.5.15 ZZ: End of Test

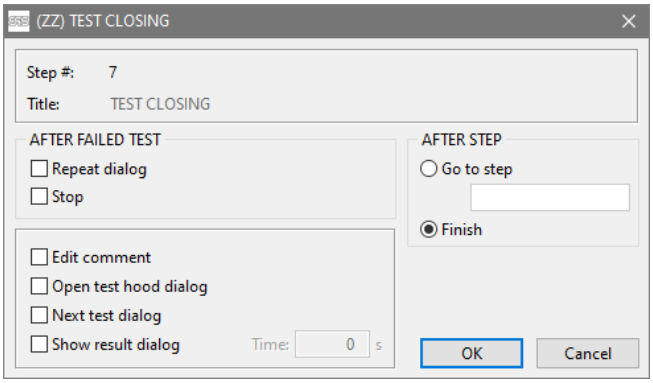


Fig. 65: Test parameters "Test Closing" (ZZ)

With this test step, several options can be changed about what will happen when a test run has finished:

Dialog element	*Function*
Repeat dialog	Repetition of the test, serial number remains the same
Stop	If the whole test failed, testing is stopped
Edit comment	The comment can be edited/added
Next test Dialog	After the test run a message box is displayed asking if there is another test to perform.
Show result dialog	Waiting time in seconds in which the result of the test is displayed

4.6 Program Module "Testing"

When programing of the test programs has be done, testing can begin. With the button "Test" one gets to the menu *Testing*. Now it is possible to work with either the actual program (as shown in the window's title bar), or to load a different program by means of the button "Load".

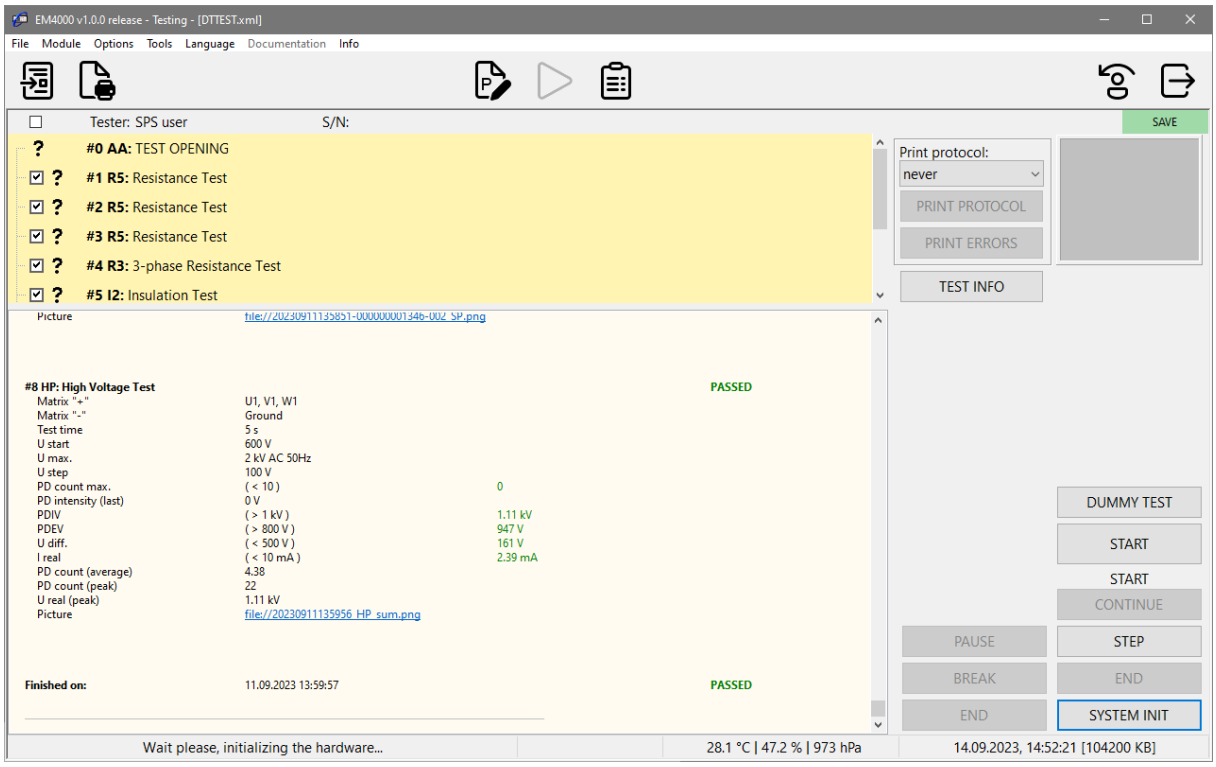


Fig. 66: Program Module "Testing"

In the upper part, the test program with its single test steps is shown.
To the upper right, the symbolized "Signal lamp" show the actual testing status.

On the right side, there are the functional buttons to control the test runs:

Start – This will start the automatic test run. All test steps of the program are executed sequentially.

Step – With this button, a "single step" test can be performed. When this button is used, only the test step that's next in order will be executed. After that step has finished, the test run is paused, until the next step is called by using the "Step" button once more.

Continue – If a test had been begun in "Step" mode, it is possible to switch to automatic mode again by using the "Continue" button.

System init – this will initialize all connected hardware devices. If the Initialization returns an error, the test program can not be started.

4.6.1 Start of Test

When pushing the "Test info" button, or when "Info dialog" has been set in test step AA, the below window will open. Which of the individual fields are open to be edited, or are non-changeable shown in grey, is dependent on the chosen settings in the AA-step.

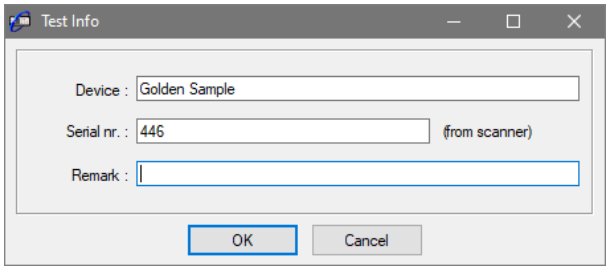


Fig. 67: Dialog window at the start of a test

With the "*Start*" button the automated test run is started. All active test steps of the test program will be executed sequentially.

If "scanned product ID" is selected, then at the start of the test, first the dialogue for scanning the DUT's barcode is carried out. After scanning the barcode, the required test program is determined from the product list, loaded and started:

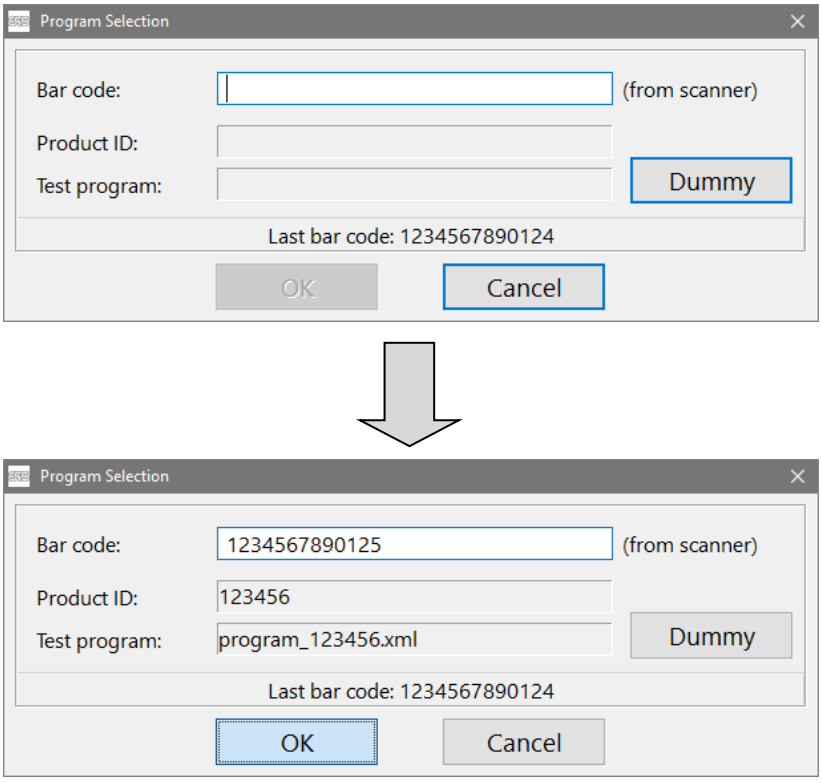


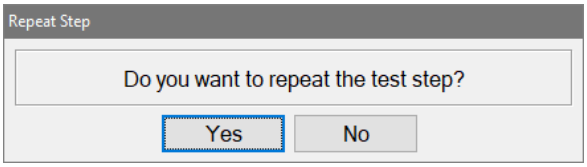
Fig. 68+69: Barcode dialog at the test start

4.6.2 Testing mode "Step"

The step by step test run guarantees that the DUT can e.g. be connected somewhere else or that changes can be made between the test steps. When starting the test, the Start Window will appear first in which - if it was activated in the editor - you can make changes. Then you are asked to connect the DUT. Each test step has to be started with the key "Step". (A similar effect can be achieved by means of "info steps").

4.6.3 Faulty DUT

A faulty DUT is shown on the monitor by the message "FAILED". At the tester the red lamp "fail" lights up (via ext. I/O of device, too) as long as the test is re-started or until the device is initialized again.



If the option "repeat possibility" was chosen in the "If Fail" – field of the respective test step (see chpt 4.5.1), this dialog appears:

4.6.4 Error-free DUT

If there is no error during the test then the message "PASSED" appears on the monitor and the green lamp "pass" lights up (via ext. I/O of device, too) as long as the test is re-started or the device is initialized again.

4.6.5 Interrupting a running test

A running test can be interrupted by means of the buttons "Pause" and "Break". Test steps that open a new window (i.e. Text or Picture steps) do have their own Pause/Break buttons. Tests that are displayed directly in the main window of the Testing module, these buttons are located at the right side of the main window.
"**PAUSE**" interrupts the test run **after** the current test step has been ended.
"**BREAK**" will abort a running test **immediately**.
A stopped test can either be cancelled with "End" or picked up with "Continue".
The status of the test is displayed in the upper text field. Here is displayed whether the test result was pass or fail or if the test was stopped.

4.6.6 Failed Test Run

A faulty test run is indicated by a "FAILED" message on the monitor. In the power panel N5 and in the connection panel A1 the red "fail" lamp lights up until the test is restarted or until the device is reinitialized.

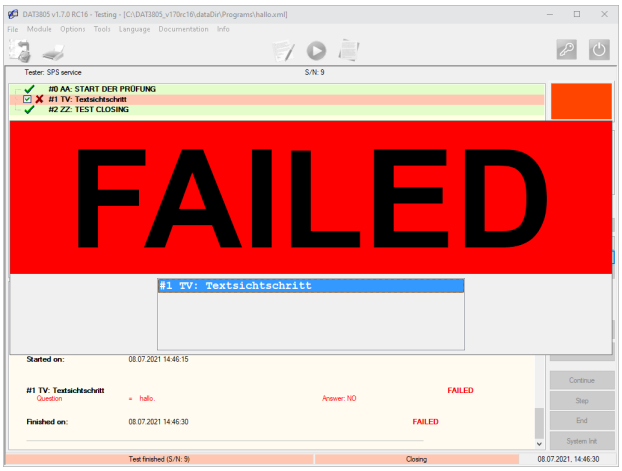
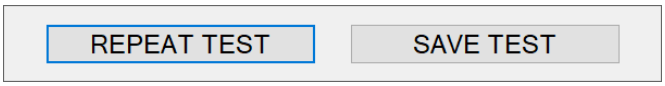


Fig. 70: Fail message

If the option "repeat dialog" was selected in step "ZZ", you will then be asked whether the test should be repeated:



If the repetition is selected, the entire test program (keeping the serial number) is executed again. The previous failed run will not be recorded in the results log.
With "Save test", no repetition is carried out and the failed test is recorded in the result log.

4.6.7 Passed Test Run

If no error occurs during the test, the message "PASSED" appears on the monitor. In the power panel N5 and in connection box A1, the green "pass" lamp lights up until the test is restarted or until the device is reinitialized.

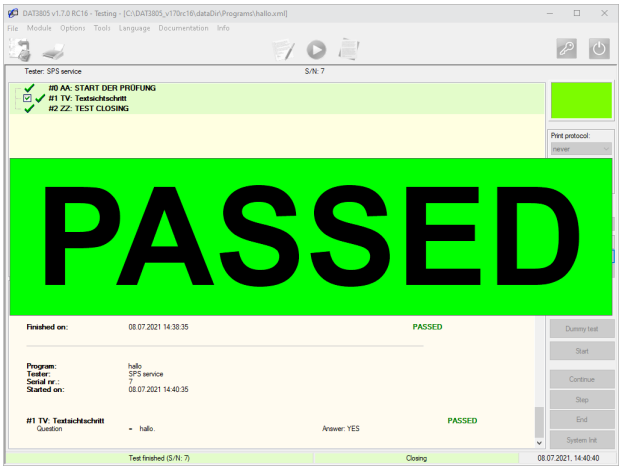


Fig. 71: Pass message

4.7 Test Runs

4.7.1 Text / Picture Visual Step

When one of these test steps is executed, a new dialog window is opened, showing the text or the picture as well as the "Yes"/"No" buttons, which the user must use to confirm the dialog:

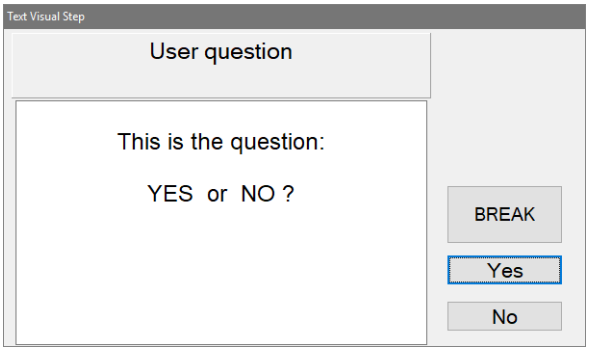


Fig. 72: Test dialog "Text visual step"

Fig. 73: Test dialog "Picture visual step"

For all other test steps, the progress is shown directly in the main window, without opening a new window.

4.7.2 Surge Test

The surge test is so short that nothing is displayed "during" a test, there is just the measured values in the test protocol when the ST-step has finished.
If the software is configured to show the test curve (see page 34), then the following window will come up after a surge test was done:

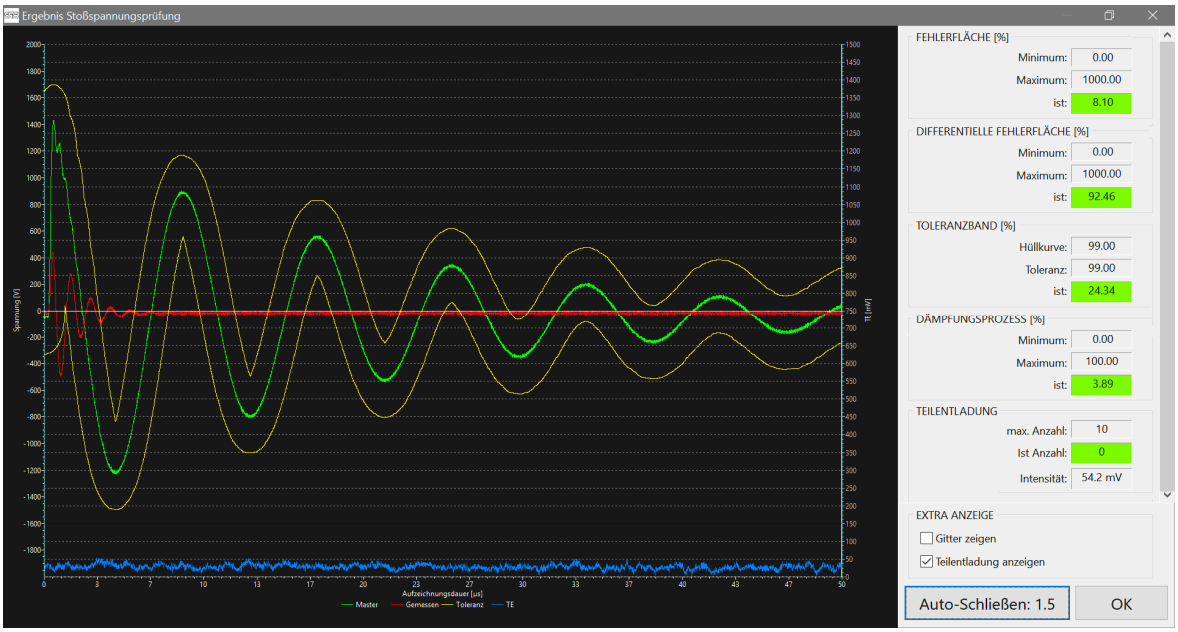


Fig. 74: Window "Result of surge test"

When this window is shown, then the execution of the test program is paused, and will continue when the window is closed with "OK".

4.7.3 IEC Surge- / Partial Discharge Test

During this test, a graph is drawn showing the various voltages and measurements: e.g. surge voltage level (red, 10 pulses each), green/yellow (vertical) partial discharges below/above the limit value, blue (vertical) number of PDs during a surge pulse, and the various limit values (horizontal) for PDIV/RPDIV/PDEV/RPDEV.

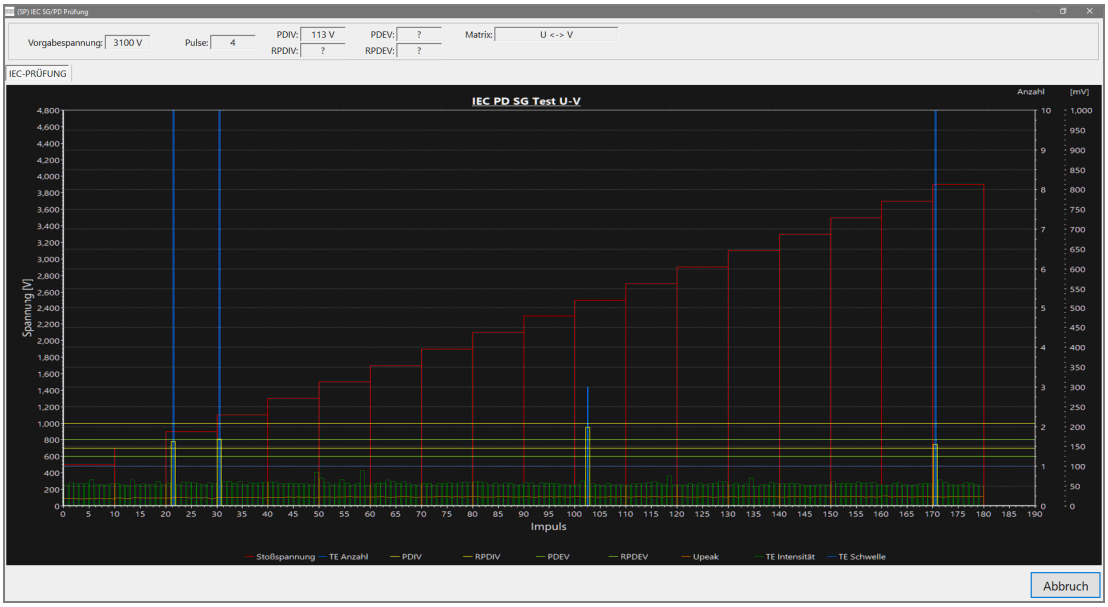


Fig. 75: Display during "IEC PD-SP Test"

4.7.4 Insulation and High Voltage Test I2 / H2

For these two test steps, a time diagram of the current and voltage values can be displayed during the test. This option can be switched on or off in the editor in the respective test step.

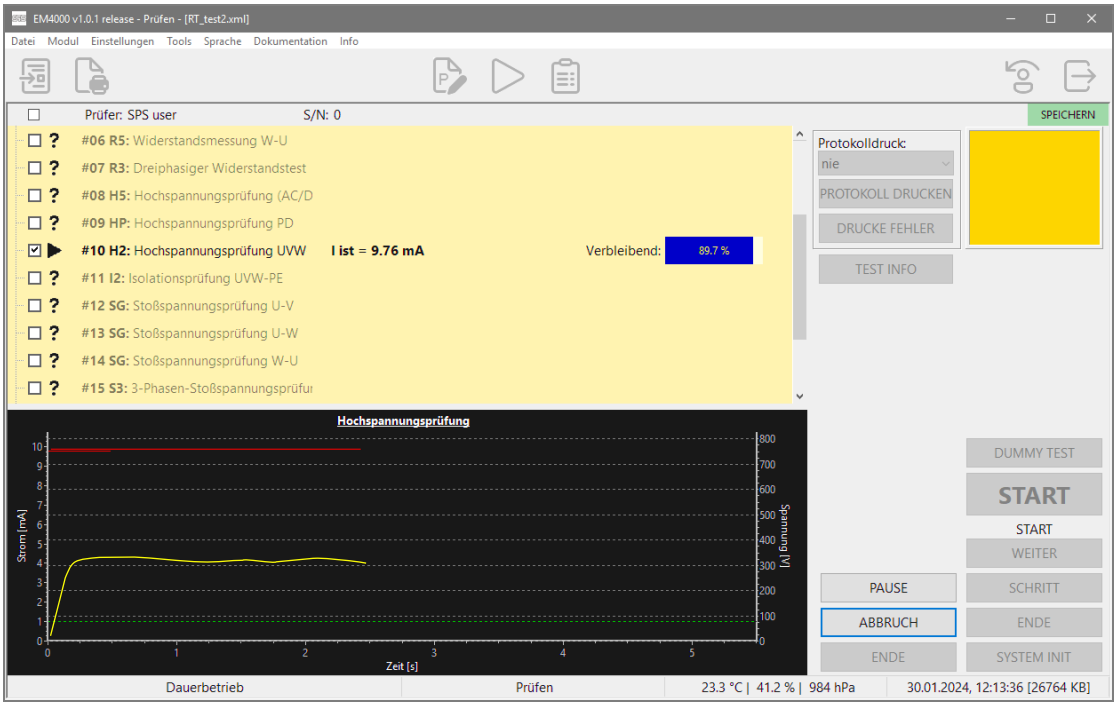


Fig. 76: Display during "H2 Test"

4.7.5 Other test steps

For other test steps, only the momentary reading and the remaining test time are shown beside the test step's name.

Exemplary, the resistance measuring R5 during execution:

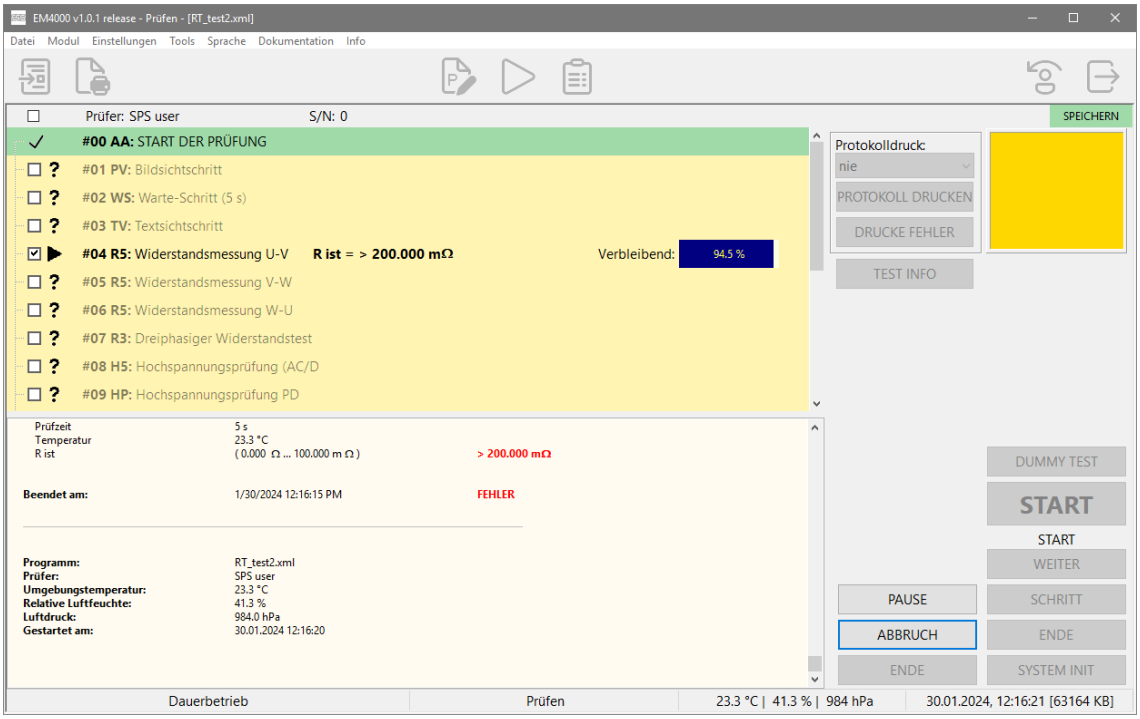


Fig. 77: View during e.g. "Resistance test R5"

4.8 Program Module "Results"

After starting the "Results" module, an "empty" program window appears first. The "Load results" function button (top left) opens a dialog with which the previously saved results can be searched and filtered according to various criteria:

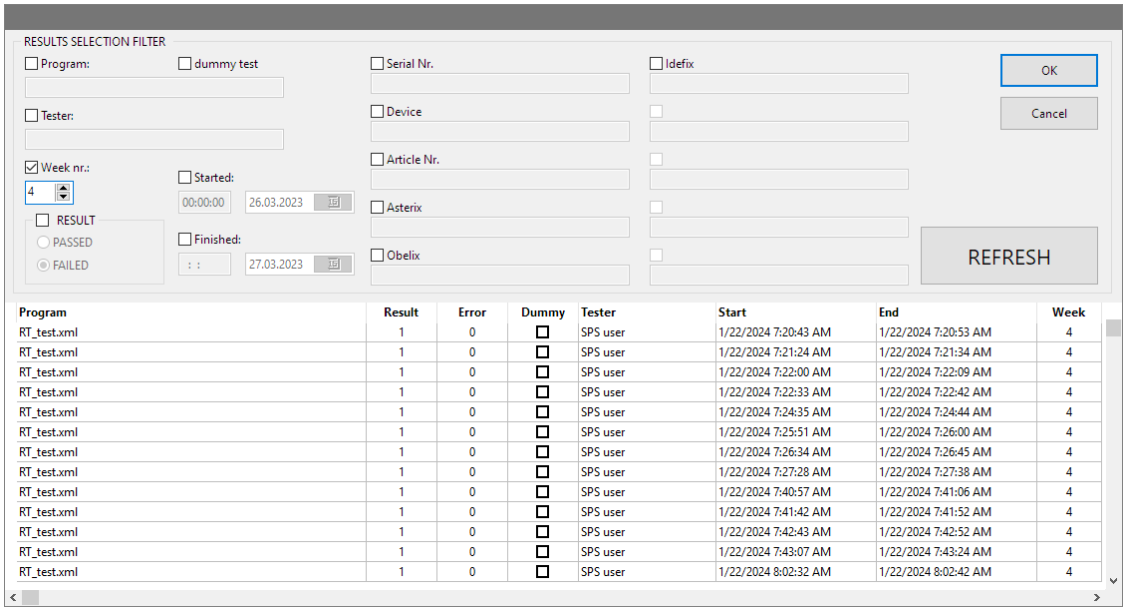


Fig. 78: Filter dialog „results“

The list below then shows all tests that meet the selected criteria.

A double-click on the desired test will load that result protocol into the main window:

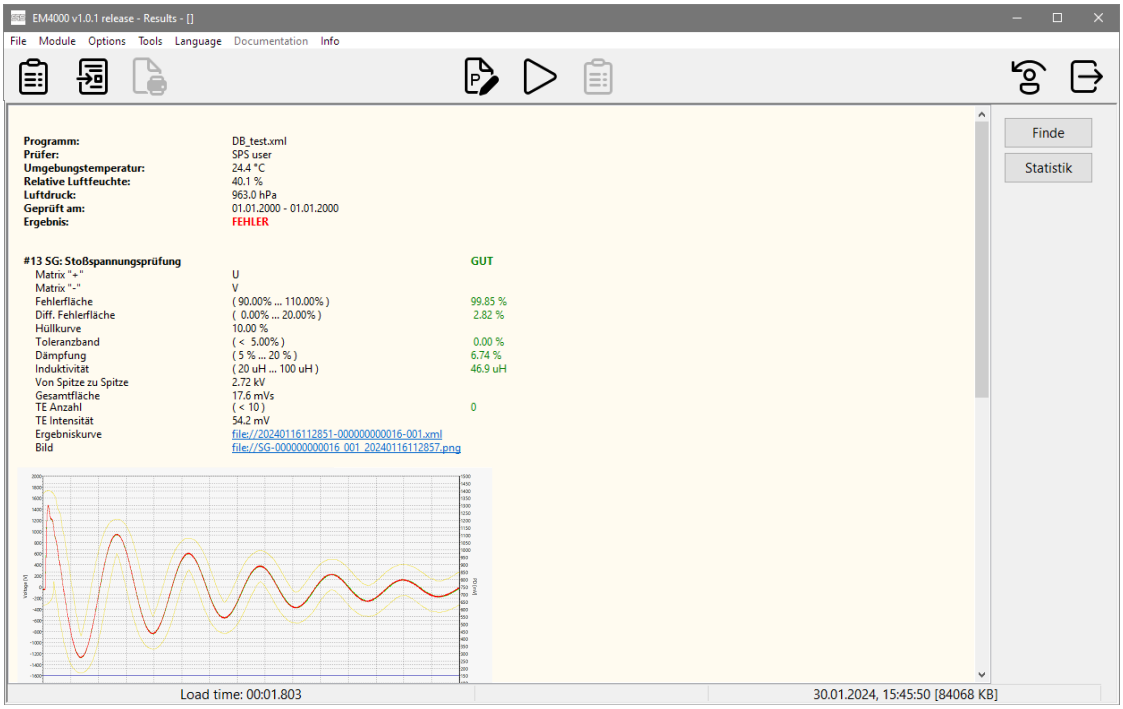


Fig. 79: Presentation of a result protocol

Annex

A About the Surge Test

The most significant difference between the surge test and all other EST tests (high voltage tests, insulation tests, etc.) is that there are no fixed thresholds to judge the test results as GOOD or FAIL. Instead, an electric oscillation gets excited within the DUT by a line surge. Then, the task is to judge the *characteristics* of the resulting oscillation!

Therefore, prior to performing any real testing, it must be evaluated how the oscillation of the DUT should look at all. For that purpose, several test runs with DUTs confirmed to be error free are performed. By averaging their oscillation curves, the so-called **master curve** is obtained. Later, when doing real world test runs, the measurement of the DUTs is compared to that master curve to decide if the result is GOOD or FAIL. The software evaluates the percental deviation of the measured curve to the master curve. The percentage of the maximally allowed deviation can be specified by the user.

A-1 Methods of evaluation

The Surge Tester ST 4000 offers several methods of curve evaluation. In the following, the currently implemented evaluation methods are described.

A-1-1 Error area

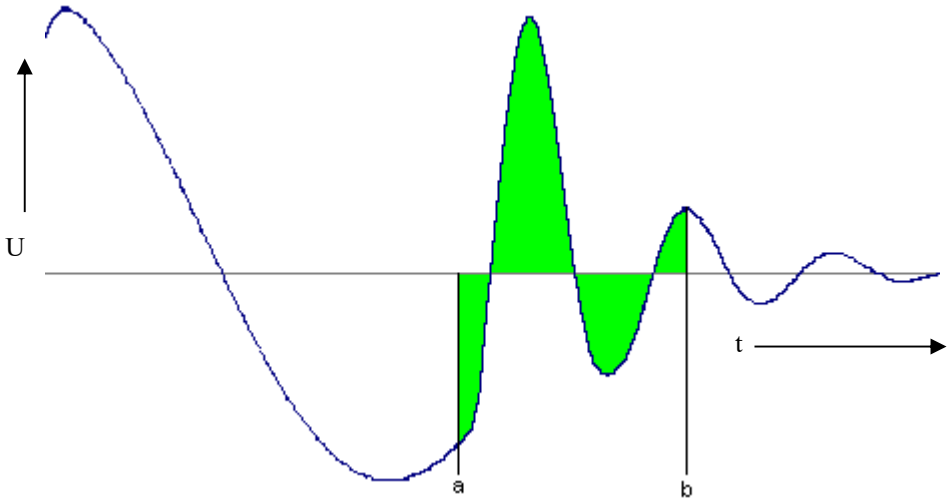


Fig. 80: Curve with evaluation of error area

Relevant for this method is the area included between a curve and the time axis. The area derived from the actually measured curve is compared to the area of the reference curve, and the percentual deviation is calculated.
Fig. 3 shows an example with fixed integral boundaries, between which the evaluation is done.
Mathematically, the used formula is this:

$$\frac{\int_a^b |U(t)\{DUT\}|dt}{\int_a^b |U(t)\{Master\}|dt} = A_{error} \text{ in \%}$$

The areas of the reference curve and of the test specimen are computed. Subsequently, the deviation is calculated by division of the two areas, and indicated in per cent.
The cruical point for error detection is the size of the curve area. Phasing is not considered. Thus, the testing is sensitive to short-circuited coil, since the change of area size is proportional to the energy loss after the surge, and energy loss increases vastly due to short-circuit current.

The optimal result of this test is 100% (area of measured curve == area of reference curve).
The more the result becomes smaller or bigger than 100%, the more different the DUT is to the master.

A-1-2 Differential error area

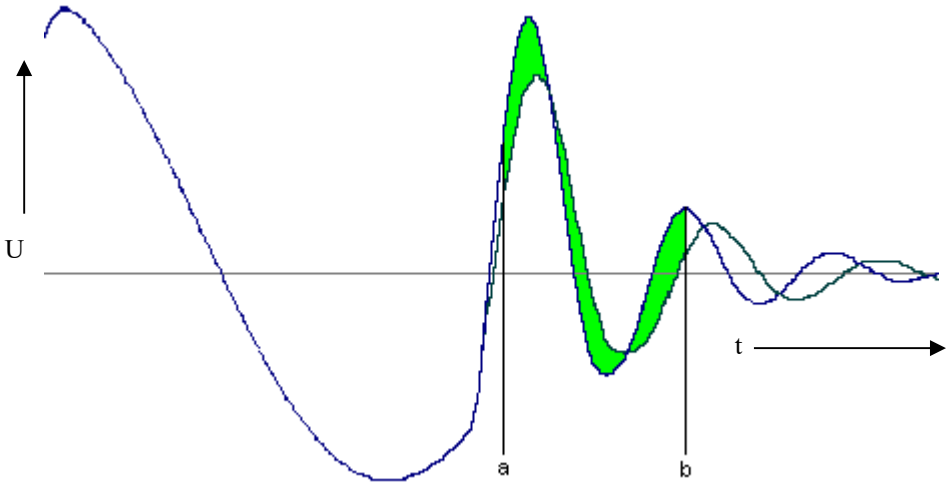


Fig. 81: Curves with differential error area

This method determines the difference area of master curve and specimen curve, then calculates the ratio of that difference and the area of the master curve. This method is more stringent than the error area method, in that it also evaluates phase shifts caused by winding tolerances. Therefore this method is used when uniformity of coil windings and inductive reactance is of major concern (e.g. exploring coils).
The evaluation of master curve's area is the same as used in the error area method, however instead of using the area of the measured curve, the difference between measured curve and master curve is calculated, and the area of this difference is used:.

$$\frac{\int_a^b \left(\left|U(t)\{Master\} - U(t)\{DUT\}\right|\right)dt}{\int_a^b \left|U(t)\{\text{Master}\}\right|dt} = A_{error} \text{ in \%}$$

The optimal result of this test method is 0% (measured curve shows no difference to the master curve).
The bigger the result's percentual value gets, the more different the DUT is to the master.

The relative size of the result is highly dependent on the amplitude of the master curve: if the amplitude of the master curve is rather small, then even relatively small deviations of the DUT may lead to "big numbers": results in range of 1000% are absolutely common..

Therefore, for this test method it is necessary ...
- to choose the voltage range as small as possible, so that the master curve has a sufficiently big extension in "y"-direction
- to place the evaluation period so that only the very first oscillations (after the swing-in transient) are measured, and not the swing-out transient.

A-1-3 Tolerance band method

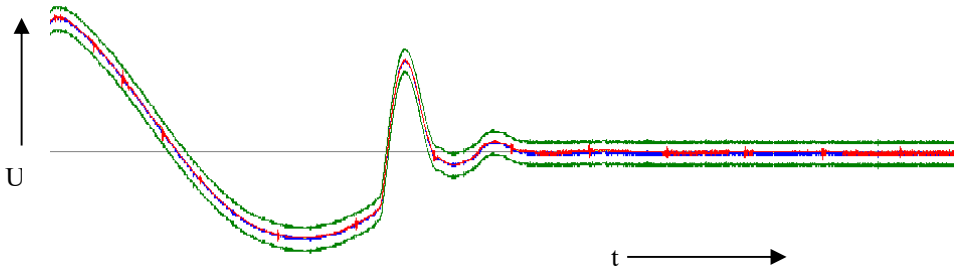


Fig. 82: Tolerance band method

With this evaluation method – also called "envelope method" – the surge curve has to be located inside of a programmable tolerance band. The tolerance band is given as a percentual value. By adding and subtracting this percentage from each sample of the master curve, two curves are derived: these are the envelope curves.

In reference to Fig. 82:
the green curves are the envelope, the area between the green curves is the tolerance band.
The blue curve is the master curve, from which the envelope has been derived.
The red curve is made of the samples measured from the DUT.

This test method evaluates the number of test samples that are located outside of the tolerance band, then builds the ratio of this number to the number of all measured samples.

The example in Fig. 82 has a result of 0%, i.e. there are no samples outside of the tolerance band.

A-2 The Mastercurve Editor

For the test step "surge test", the configuration dialog consists of two different windows.
In the 1st window, the general evaluation parameters for the test are set. These parameters correspond to the actually chosen master curve, the name of which is shown in the Field MASTER CURVE:

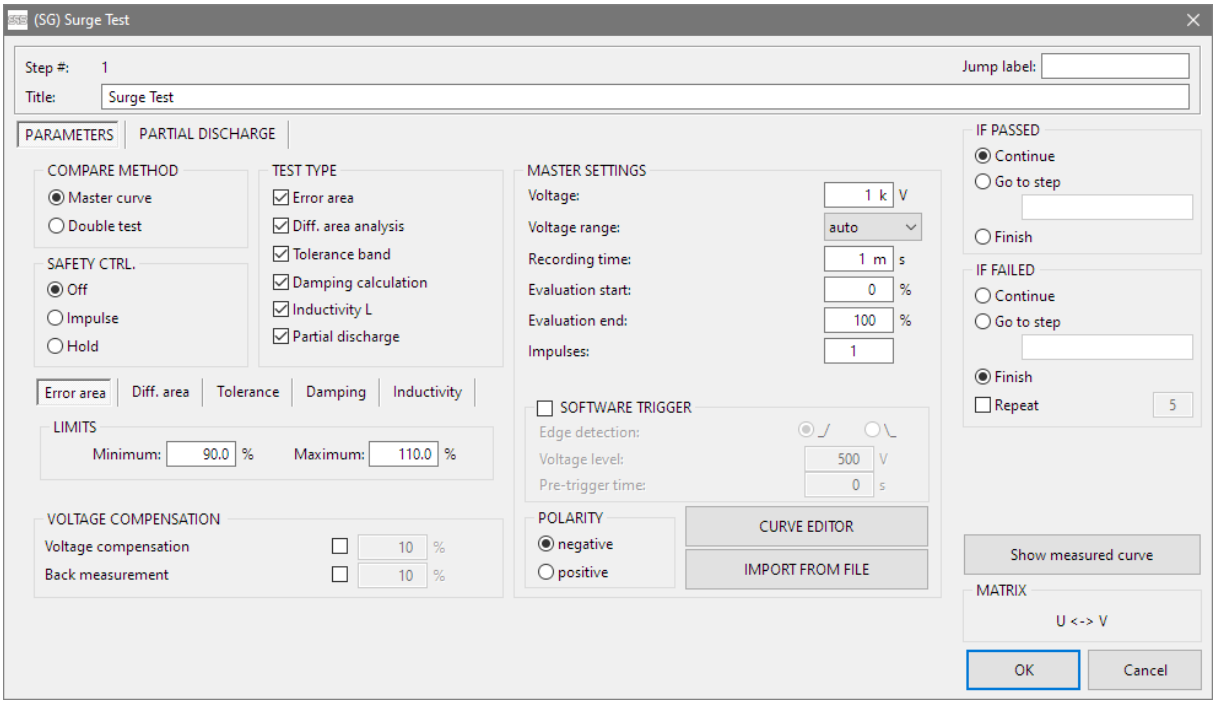


Fig. 83: Test parameters of surge test

In order to choose another master curve to use for the test (or to edit an existing master curve, or to record an all-new master curve), the button *Curve Editor* has to be used. This will open the main window of the master curve editor, with which all these actions can be carried out.
This is described on the follwing pages.

A-2-1 The Main Window of the Master Curve Editor:

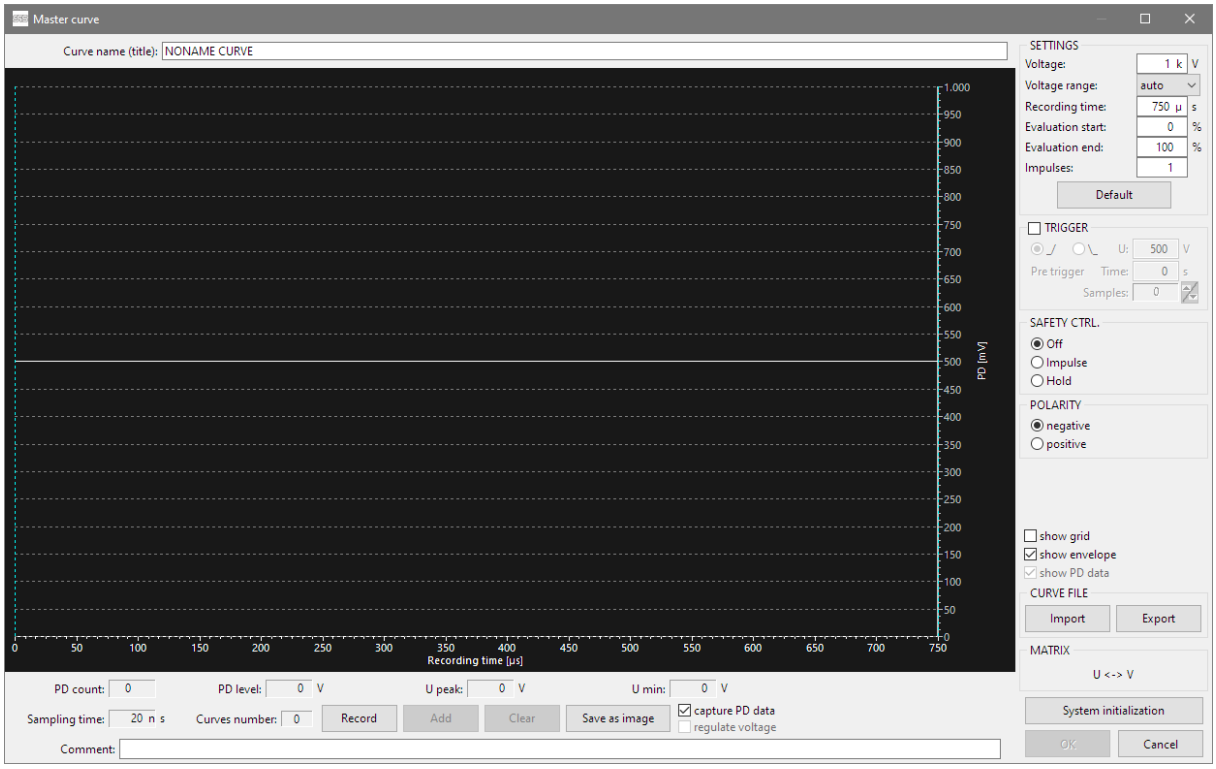


Fig. 84: Master curve editor

At the top of the screen, the name of the actual mastercurve is shown, as well as the file in which the master curve is saved.
At the bottom pf the screen, a comment to the actual mastercurve can be entered.

On the right-side, the values and settings to use for recording a curve are set:

Voltage	Defines the test voltage for the surge test. Possible values are 500 V up to 6000 V.
Voltage range	Defines the voltage range (y axis) manually.
Auto range	Sets the voltage range automatically, according to the test voltage.
Recording time	Defines the range for the x axis.
Evaluation start	In case that the evaluation range should not cover the entire recording time, it can be restricted. The start of evaluation can be entered in %, and is shown in the diagram by a dashed line.
Evaluation end	In accordance to the previous field, the end of evaluation can be defined (in %). This is also shown in the diagram by a broken line.
Impulses	This defines the number of surge impulses. Only the last impulse will force a visible recording. For certain DUTs it is advantageous to perform several impulses prior to the recording, in order to get more stable results.
Trigger	If selected, the recording of the curve is started by the selected trigger settings, i.e. when the selected voltage is first reached on either the rising or the falling edge.

A-2-2 Recording a new master curve

Once that curve name and recording parameters are set, the recording of a new master curve may begin. First of all, via “matrix” it must be defined between which phases the surge curve will be measured:

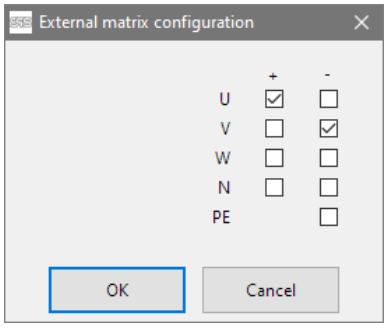


Fig. 85: Matrix contact points

If the matrix is set as desired, confirm with "OK" and return to the main window of the master curve editor. Now you can start recording with the controls directly below the black display field:

Record	Starts the recording of a new curve with the shown parameters. **Attention: High voltage is applied to the DUT !** The recorded curve will be displayed in red.
Add	This adds the actually recorded curve (red) to the storage. By doing so, the curve’s color will change to green.
Clear	Clears curve memory for further recordings.
Save as image	Saves the displayed curve as bitmap graphic.
Curves number	The number of recorded curves that have been put into the curve memory.

After recording a curve, one will get a display similar like this:

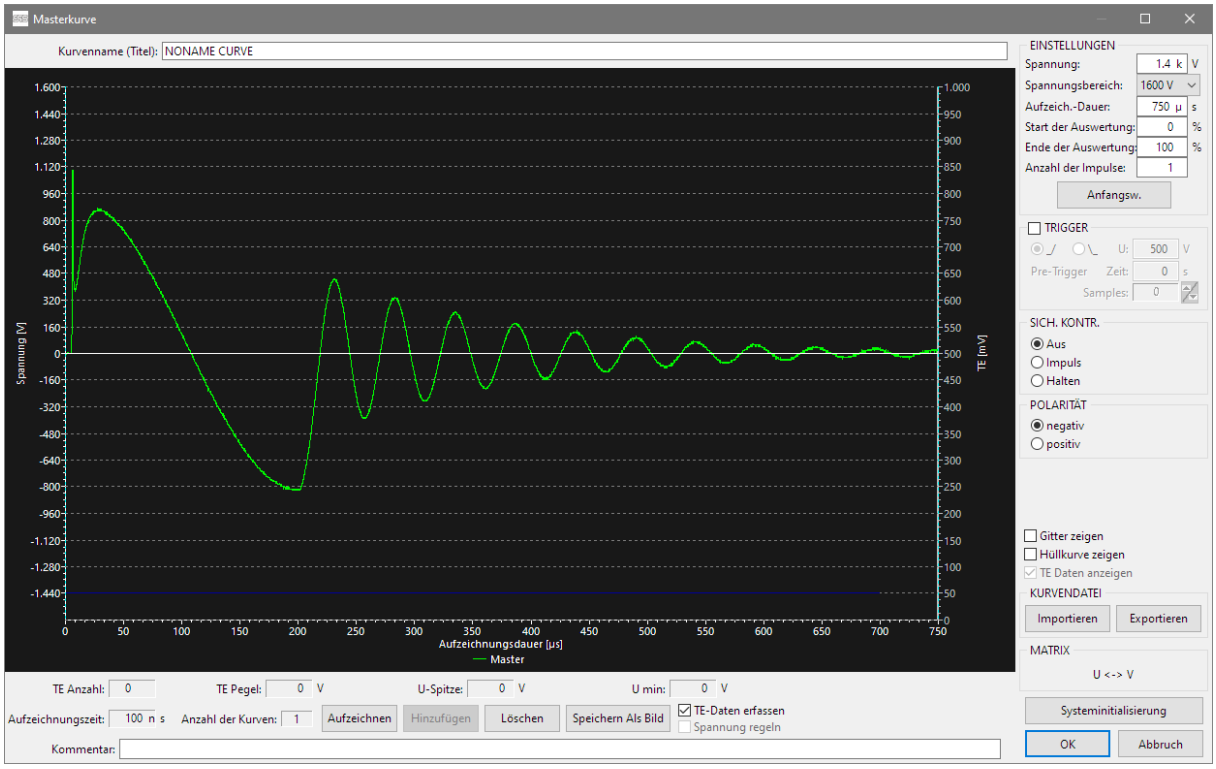


Fig. 86: Recorded curve

Typically, one will build up a master curve by doing several recordings of different DUTs. Since the software will calculate the avarage of all recordings, the resulting mastercurve will be the representative mean of all DUTs that were used to build the master curve.
Immediately after a recording, the recorded curve is shown in red. If the curve seems to be reasonable, it can be added to the internal curve memory by the button "Add". This will compute the new recording into the existing average of all recordings. The counter "curves number" is increased by 1, and the panel shows the resulting master curve in green.

A-2-3 Saving a Master Curve

In contrast to previous software versions (DAT3805), the master curves are no longer saved as separate XML files in the EM4000 software. Instead, as soon as you press the OK button in the curve editor, the master curve is embedded directly in the test program in the current SG step, i.e. the master curve(s) is/are saved together with the test program.

However, the master curves can still be handled as XML files using the "Import/Export" buttons, for example to use a master curve in different test steps or different test programs.