



# **User's Manual**

## **DAC M-SERIES**

**M30/M30+/M40/M40+/M60**

**and**

## **DAC H-SERIES**

**H180/H200/H300**

**ohv diagnostic GmbH**



---

# Imprint

## Responsible for the content:

ohv diagnostic GmbH  
Großenhainer Str. 101  
01127 Dresden  
Germany

Tel.: +49 (0) 351 79527300  
Fax: +49 (0) 351 79527301  
E-Mail: [info@ohv-diagnostic.com](mailto:info@ohv-diagnostic.com)  
Web: [www.ohv-diagnostic.com](http://www.ohv-diagnostic.com)

## Legal Information:

Copyrights and other rights in the entire content are reserved for ohv diagnostic GmbH, hereinafter called OHV. The entire content of that manual is copyright protected. Any reproduction, transmission, modification, linking or use for any other purposes, either commercially or publicly are prohibited without written approval of OHV. OHV verifies and reviews the information. In spite of all diligence, data and technology may have changed in the meantime. Liability and guarantee for up-to-dateness, correctness and completeness can therefore not be given. Furthermore, OHV reserves the right to change or up-date any information at any time and without any further notice. OHV and its related companies reserve all rights in this document and in the information contained therein. Without written consent of OHV, no part of this manual is allowed to be photocopied or reproduced, in any form. Changes and modifications of this manual are reserved by OHV without any previous notice. OHV is not liable for any technical or printing errors in this manual. Likewise, OHV does not assume any liability for damages, which have been caused directly or indirectly while delivering or using this material.

# Revision List

Revision	Date	Author(s)	Description
01	2014-07-18	KJ	Initial revision
02	2014-10-02	KJ	Added content in "Theory" and "Performing a Test" and changed software screen shots to latest version
03	2016-09-19	CF	Update Contact Information
04	2017-08-02	CF	Updated documentation with OHV Suite software
05	2017-12-05	CF	Added Remote Support Tool Description
06	2018-03-02	CF	Updated DAC measurement section
07	2018-12-07	JP	Added cable voltage input description
08	2019-03-18	CF/JP	Updated information for M40 and H-Series
09	2019-04-30	HK	Added application settings section, updated images
10	2019-09-27	PS	Added section about updating. Updated some screenshots of the analysis.
11	2019-12-10	CF	Updated software documentation and images
12	2020-06-04	CF	Updated technical data
13	2020-08-04	CF	Added chapter for word reporting. Updated documentation and images.
14	2020-08-18	PS	Updated word reporting section with more detailed information.
15	2021-11-19	JP	Added information about maximum operating altitude.
16	2022-05-02	CF	Added information for handling of accepting and removing of locations in advanced analysis mode.
17	2022-05-30	YW	Added information for filtering DAC shots, updated screen shots.
18	2022-10-14	CF	Added information to H-Series for the H200
19	2023-06-19	JP	Updated formatting for technical data M- and H-Series
20	2023-10-27	CF	Added appendix chapter for capacitance diagrams over target voltage
21	2023-11-29	CF/JP	Added appendix chapter for altitude information and list available languages

# Symbols and Abbreviations

## Used Symbols



This symbol displays a warning message. Warnings are important information which are used to highlight important facts and must not be ignored!



This symbol is used to provide additional information which are an addition to the surrounding text and may be used to prevent ambiguities.

## Abbreviations

<b>DAC</b>	Damped Alternating Current
<b>PD</b>	Partial Discharge
<b>Q</b>	unit for apparent charge $Q$ , quantified in pC (pico Coulomb)
<b>HV</b>	High Voltage
<b>TV</b>	Test Voltage
<b>PRPDA</b>	Phase Resolved Partial Discharge Analysis
$D_f$	Damping Factor (do not confuse with dissipation factor / dielectric loss factor / $\tan \delta$ )
<b>TDR</b>	Time Domain Reflectometry
<b>SNR</b>	Signal-To-Noise Ratio
<b>VT/PT</b>	Voltage Transformer / combined instrument transformer
<b>TO</b>	Test Object



# Contents

<b>1</b>	<b>Safety Considerations</b>	<b>1</b>
1.1	Important Safety Rules	1
1.2	General Safety Rules and Grounding	2
1.3	Safety Precautions when Testing with DAC System	2
1.4	Using the Safety Box	2
1.4.1	During Calibration	3
1.4.2	During HV Test	3
1.5	Error handling after power loss	3
<b>2</b>	<b>Relevant Standards</b>	<b>5</b>
2.1	General on-site testing	5
2.2	Cable testing	5
2.3	Standardized PD detection	5
<b>3</b>	<b>Introduction</b>	<b>6</b>
3.1	Scope of Application	6
3.2	Theory	6
3.2.1	DAC Voltage Testing	6
3.2.2	Dissipation Factor Estimation Using DAC	7
3.2.3	Partial Discharge Detection	9
3.2.4	Partial discharge location	11
<b>4</b>	<b>Hardware and Software Description</b>	<b>14</b>
4.1	Technical Data M-Series	14
4.2	Technical Data H-Series	16
4.3	Parts List M-Series	17
4.3.1	Basic Equipment	17
4.3.2	Supplementary Equipment	19
4.4	Parts List H-Series	20
4.4.1	Basic Equipment	20
4.5	Software requirements	22
<b>5</b>	<b>Performing a Test</b>	<b>23</b>
5.1	Before Testing	23
5.2	Setting-Up the Cable under Test	23
5.3	Setting-Up the Test for the M-Series	24
5.3.1	Hardware Set-Up (M-Series)	24
5.4	Setting-Up the Test for the H-Series	26
5.4.1	Hardware Set-Up (H-Series)	26
5.5	Perform the test	28
5.5.1	Setting-Up test information	28
5.5.2	Setting-Up Calibrator	28
5.5.3	Performing Calibration	28

5.5.4	Performing HV Test	30
5.6	Starting the OHV Suite Software	31
<b>6</b>	<b>DAC Catalog</b>	<b>32</b>
6.1	DAC Catalog configuration	32
6.2	Simple mode	33
6.2.1	Cable voltage input	34
6.3	Advanced mode	35
6.3.1	Test Locations	36
6.3.2	Tester	37
6.3.3	Cable	38
6.3.4	Cable voltage inputs	39
6.3.5	Customer	40
6.3.6	Test Procedure	41
<b>7</b>	<b>DAC measurement</b>	<b>42</b>
7.1	DAC measurement configuration	42
7.1.1	General measurement settings	42
7.1.2	Measurement parameter definitions	42
7.1.3	Simple measurement mode	42
7.1.4	Advanced measurement mode	43
7.2	Apply safety rules	44
7.3	Overview	45
7.3.1	Device information	46
7.3.2	DAC measurement information	46
7.3.3	DAC Measurement Modes	47
7.4	PD Calibration	49
7.5	TDR Calibration	51
7.5.1	TDR input parameter	53
7.5.2	TDR result area	53
7.5.3	TDR control elements	53
7.6	DAC Measurement (Simple mode)	56
7.6.1	UI elements for simple mode	57
7.6.2	Perform a DAC measurement in simple mode	59
7.7	DAC Measurement (Advanced mode)	62
7.7.1	UI elements	62
7.7.2	Perform a DAC measurement in advanced mode	65
7.8	Double side Measurement (Simple mode)	67
7.8.1	UI elements for simple mode	68
7.8.2	Perform a Double side measurement in simple mode	70
7.9	Double side Measurement (Advanced mode)	73
7.9.1	UI elements	73
7.9.2	Perform a Double side measurement in advanced mode	76
7.10	VLF measurement	78
7.10.1	UI elements	78
7.10.2	Perform a VLF measurement	80
7.11	Leakage current measurement (LC measurement)	81
7.11.1	UI elements	81
7.11.2	Performing a LC measurement	83
7.12	Control elements inside different measure modes	85
7.12.1	Add a comment	85
7.12.2	Add new voltage level	85
<b>8</b>	<b>DAC analysis</b>	<b>86</b>
8.1	Analysis Configuration	86
8.1.1	General Settings	86
8.1.2	Reporting Settings	87

8.1.3	Simple Mode	87
8.1.4	Advanced Mode	87
8.2	Test Browser	89
8.2.1	Select a test to analyze	89
8.3	Result Overview after Test	91
8.3.1	Overview	95
8.3.2	Measurements	96
8.3.3	Data Filtering	97
8.3.4	TDR Calibrations	98
8.3.5	Pattern	99
8.3.6	Pulses	100
8.3.7	VLF	101
8.3.8	Reflections	102
8.3.9	Details	105
8.3.10	Report	109
8.4	Import of old measurement	113
8.5	Double Side Analysis	116
<b>9</b>	<b>DAC word report template</b>	<b>118</b>
9.1	Word report template	118
9.2	Word report template syntax	119
9.2.1	Basic placeholder usage	119
9.2.2	Basic statement usage	119
9.2.3	Conditional statement - IF statement	119
9.2.4	Filling template tables - FOR statement	120
9.3	Word report template content	121
9.3.1	Word report template key for all report templates	121
9.3.2	Word report template key for DAC report templates	124
9.3.3	Word report template key for VLF report templates	125
<b>A</b>	<b>General Information</b>	<b>126</b>
A.1	General software structure	126
A.2	Start screen - Main application	127
A.2.1	Settings	128
A.2.2	About	131
<b>B</b>	<b>General Application settings</b>	<b>132</b>
B.1	Diagram Settings	132
<b>C</b>	<b>Software Update</b>	<b>133</b>
C.1	Updating OHV Suite software	133
C.1.1	Checking software update	133
C.1.2	Downloading software update	133
C.1.3	Installing software update	134
C.2	Updating device software	136
<b>D</b>	<b>Connection manager</b>	<b>138</b>
D.1	Connecting to a DAC device	139
<b>E</b>	<b>Remote support</b>	<b>141</b>
E.1	Start remote support tool	141
E.2	Allow remote connection	141
<b>F</b>	<b>Test object capacitance diagrams</b>	<b>142</b>
F.1	DAC M60 maximum available test object capacitance depending on test voltage	142
<b>G</b>	<b>Test object altitude</b>	<b>143</b>

List of Figures	144
List of Tables	147

---

# Safety Considerations

## 1.1 Important Safety Rules

Read the information below **carefully** before using this instrument.



**Following general safety precautions have to be observed during operation of this instrument. Failure to comply with these precautions or with specific warning elsewhere in this manual violates safety standards for design, manufacture, and intended use of the instrument.**

Each user should be aware of the contents of these guidelines before using the instrument. The OHV products should be handled only by skilled workers. Repairing and maintenance are only allowed by well skilled experts. The measuring systems of OHV are developed and tested according to DIN EN 61010-1 *Safety requirements for electronic measuring set*. The delivery of OHV products guarantees safe operation if the general safety guidelines are strictly be followed by the user. The instruments of OHV are designed for application under dry ambient condition, where the operation temperature may range between +5 °C and +40 °C. Since PD diagnosis tests are carried out on test objects subjected to high voltage (HV), the rules for minimum safety working distance have strictly to be followed, in order to prevent any dangerous situation. In this respect also the charging of potential-free devices in the surroundings of HV lines has to be taken into account. Persons which are not directly involved with the PD detection procedure must be kept away from the testing area by means of suitable barriers clearly indicated by warning boards. Even if the testing voltage is switched off, but the test object is not grounded by well visible conductors, nobody is allowed to enter the measuring area. If possible, both, the test object and the HV test supply must be installed within a closed safety testing area. All switching components must be equipped with additional locking mechanism in order to prevent dangerous situations, such as the test voltage being switched on by a non-authorized person. Never insert the main plug of measuring system in socket, which is not grounded. It is not allowed to use mains connection leads without protective conductor. To guarantee effective safety, the power plug should be inserted in the corresponding instrument and should be connected to a socket, before other testing cable and measuring cable will be connected. Before attaching of any measuring cable, a protective conductor should always be connected to earth connection. In case of PD measurements in the standard circuit the protective conductor must be joined with the grounding of the test area, which is provided with the measuring impedance.



**A break-off of protective conductor outside of the instrument and a break-off of protecting earth connection could cause a dangerous situation. Never disconnect the protective conductor.**

Adjustment, repairing and maintenance are not allowed, when the device is opened and connected to the supplying operating voltage. When a blown fuse has to be replaced, it should be guaranteed that the spare fuse has the rated current range and is of the right type. Never use a short circuited fuse. In case of any defect, switch off the device immediately. The internal protection unit of the device becomes ineffective, if e.g. the measuring equipment:

- Is damaged
- Has been stored for long time under abnormal conditions
- Has suffered transport damages.

PD detection is not allowed, if the well known general safety rules for working in the surroundings of HV installations are not strictly followed by the operator. A periodic training of operators on the basis of the above given instructions is recommended urgently. The regulations of the DIN EN 50191:2000 *Installation and Operating of Electrical Test Units* as well as the given safety requirements have to be kept conscientious!

## 1.2 General Safety Rules and Grounding

- 1 Disconnect power cable and discharge all high-voltage capacitors before testing.
- 2 Protect against re-energizing.
- 3 Confirm absence of voltage.
- 4 Ground all phases.
- 5 Cover or shield adjacent energized parts.

The DAC test equipment should be used by qualified personnel only. Make use of the grounding stick for grounding the DAC system.

Good grounding of the high voltage apparatus is mandatory. The safety of the user cannot be guaranteed without proper grounding of the DAC device and the screen of the high voltage test lead. All metallic parts of the switchgear and the phases that are currently not tested should remain grounded.

During testing keep clearance of at least 1.5 m (5 ft) to high voltage parts of the DAC device as well as the cable under test.

## 1.3 Safety Precautions when Testing with DAC System

- Use the DAC test system only as specified in this manual.
- Do not use the DAC device if it is damaged. Before you use it inspect the casing and look for cracks or missing parts.
- Inspect the high voltage test leads for damaged insulation. Replace damaged test leads before you use the DAC system.
- Do not operate the DAC system around explosive gas, vapor, or wet environments.
- Never use the device in wet conditions when there is water on the surface.
- Always consider the maximum operating altitude of 2000m (above sea level).
- Adjustments, repairs or maintenance work on the instrument should be carried out by qualified manufacturer-trained personnel only.

## 1.4 Using the Safety Box

The high voltage can only be switched on with the connected auxiliary safety box. In case of an emergency the red emergency button may be pushed for immediately switching off the high voltage source.



Figure 1.1: DAC remote safety box

#### 1.4.1 During Calibration

Calibration can only be performed with the safety box connected (Figure 1.1) and *READY* key turned to *I*-position.

- 1 Make sure that the safety box is properly connected to the device
- 2 Turn *READY* key to the *I*-position; green *HV ON* button will light up
- 3 Unground the phase under test
- 4 Perform TDR and PD calibration (cf. Section 5.5)

#### 1.4.2 During HV Test

High voltage can only be applied with the connected safety box, *READY* key turned to *I*-position, and *HV ON* switched on.

- 1 Make sure that the safety box is properly connected to the device
- 2 Turn *READY* key to the *I*-position; green *HV ON* button will light up
- 3 Unground the phase under test
- 4 Click on *HV ON* button; red *HV OFF* button will light-up; now the device is ready for HV test
- 5 Perform test (cf. Section 5.5)
- 6 Push *HV OFF* button; high voltage source will be de-energized
- 7 Turn *READY* key to *O*-position
- 8 Ground device

### 1.5 Error handling after power loss

The DAC system is powered through the power supply connector. If the power supply for the DAC system is lost during a high voltage measurement the cable is still charged with DC and there is not discharge performed. In such a case it is required to discharge the cable manually by using a unloading bar and waiting at least 5 minutes before the cable is unloaded.



Direct grounding of the cable can damage the cable and DAC device!



---

## Relevant Standards

### 2.1 General on-site testing

**IEC 60060-3** High Voltage test techniques Part 3: Definitions and requirements for on-site testing

### 2.2 Cable testing

**IEEE 400** Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems Rated 5 kV and Above

**IEEE 400.4** Guide for Field-Testing of Shielded Power Cable Systems Rated 5 kV and Above with Damped Alternating Current Voltage (DAC)

**IEC 60502-2** Power cables with extruded insulation and their accessories for rated voltages from 6 kV ( $U_m = 7,2$  kV) up to 30 kV ( $U_m = 36$  kV)

**VDE Dresden** Recommended practice for the commissioning test of medium voltage cables

### 2.3 Standardized PD detection

**IEEE 400.3** Guide for PD Testing of Shielded Power Cable Systems in a Field Environment

**IEC 60270** Partial discharges measurements

**IEC 60885-3** Test methods for partial discharges measurements on lengths of extruded power cable

---

# Introduction

This chapter gives you a quick theory part, and introduction to all the features and capabilities of the DAC test equipment.

## 3.1 Scope of Application

DAC voltage test and diagnostic measurements (partial discharge and loss factor) provide for reliable detection of

- Poor installation,
- Failures due to inappropriate laying,
- Failures in accessories or
- Deterioration in cable insulation due to aging.

It allows much more than a simple *go or no-go* decision. DAC testing is an advanced maintenance tool which supports asset management and grid operation as well.

- Withstand voltage test method with test voltages representing operational stresses.
- Sensitive PD measurement and location in complete cable systems (insulation and accessories).
- Assessment of cable aging status in comparison with other cables based on dissipation factor ( $\tan \delta$ ) estimation.



On-site DAC voltage test in combination with non-destructive PD and loss factor measurement is unique and fundamental for reliable service of newly installed, repaired or service-aged cable systems. The DAC test voltage as well as the partial discharge measurement complies with national and international standards for on-site testing.

## 3.2 Theory

### 3.2.1 DAC Voltage Testing

#### DAC voltage generation

DAC voltage is generated by energizing the capacitive test object (cable) up to the pre-selected peak test voltage by a high voltage source within a couple of seconds. When the test voltage is reached, the HV switch closes instantly providing LC resonance circuit with the cable capacitance and the system inductance (according to Figure 3.2). This provides a damped sinusoidal AC (DAC) voltage. Depending on the capacitance of the test object the AC frequency  $f_{\text{res}}$  (3.1) typically varies in the range from 40 to a few hundreds of Hz.

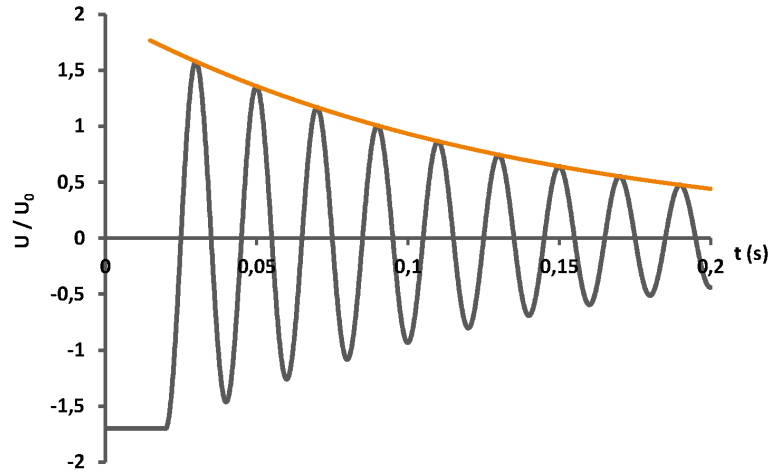


Figure 3.1: DAC voltage shape (50 Hz) with damping curve

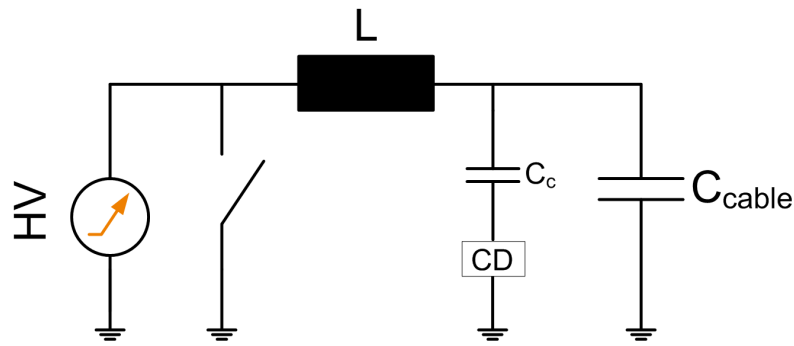


Figure 3.2: DAC testing equipment illustration

$$f_{\text{res}} = \frac{1}{2\pi\sqrt{LC_{\text{cable}}}} \quad (3.1)$$

Since the DAC frequency of the test voltage is close to nominal AC service conditions, all AC voltage stresses and measured PD activities can be effectively evaluated and are comparable with the service conditions under power frequency. In case of harmful insulation defects, a breakdown may occur inside the test object. In addition, the PD inception voltage (PDIV) and PD extinction voltage (PDEV) are measured. The dissipation factor can be estimated due to the decaying amplitude of the test voltage (see also Figure 3.1).

### DAC Test Procedure

Unlike continuous AC stress the DAC test is performed in pre-defined sequences of charging and discharging cycles (Standard *IEEE 400* and Standard *IEC 60060-3*, cf. Section 2). During the DAC voltage test, a designated number of DAC excitations is applied to the test object for each voltage level. See Figure 3.3 for an example test procedure.

#### 3.2.2 Dissipation Factor Estimation Using DAC

One simple model of an insulation system at one specific frequency, voltage and temperature is the equivalent circuit consisting of the cable capacitance and its resistance in parallel according to Figure 3.4.

Based on the series equivalent circuit the **dissipation factor** ( $\tan \delta$ ) is calculated from the relation between active and reactive power (3.2):

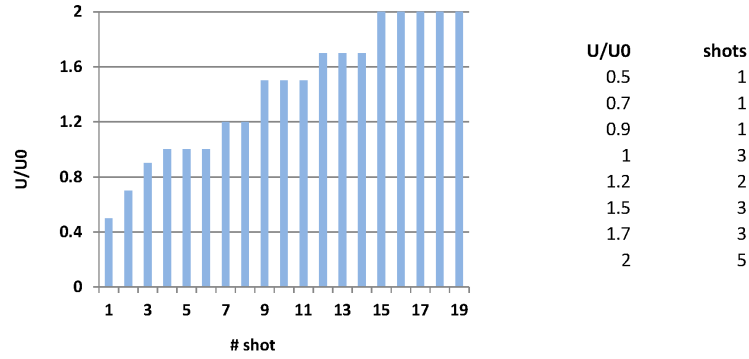


Figure 3.3: Example test procedure for DAC test

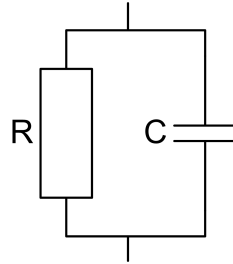


Figure 3.4: basic parallel equivalent circuit of an insulation system

$$\tan \delta = \frac{P}{Q} = \frac{u^2}{R} \frac{1}{u^2 \omega C} = \frac{1}{\omega RC} \quad (3.2)$$

During the high voltage oscillation period the resistance  $R$  results in voltage damping. The enveloping damping curve can be mathematically described with following proportionality (3.3):

$$u(t) \propto e^{-\frac{t}{RC}} \quad (3.3)$$

The higher the overall losses (including the dissipation factor of the cable insulation) are, the more distinct the damping characteristic is. Knowing the exact losses of the test equipment the dissipation factor of the cable insulation under test can be derived.

The **damping factor**  $D_f$  referred to Figure 3.5 and Equation (3.4) can be used to quantify the damping characteristic (Standard IEC 60060-3).

$$D_f = 1 - \frac{a_1}{a_0} \quad (3.4)$$

With the measured damping factor from (3.4) and the test frequency  $f = \frac{\omega}{2\pi}$  the time constant  $RC$  from Formula (3.10) can be determined:

$$RC = -\frac{1}{f \ln [1 - D_f]} \quad (3.5)$$

Note, that  $D_f$  includes the overall losses  $\sum \tan \delta$  (3.6) of the test circuit, including losses inside the DAC equipment, contact resistance, and cable insulation losses.

$$\sum \tan \delta = -\frac{1}{\pi} \ln [1 - D_f] \quad (3.6)$$

Moreover, all quantities strongly depend on temperature ( $T$ ), voltage level ( $u$ ) and frequency ( $\omega$ ). Hence, the absolute dissipation factor of the cable  $\tan \delta_{\text{cable}}$  can only be estimated. However, the voltage tip-up, as well as relations between phases, or between former tests can still be successfully analyzed.

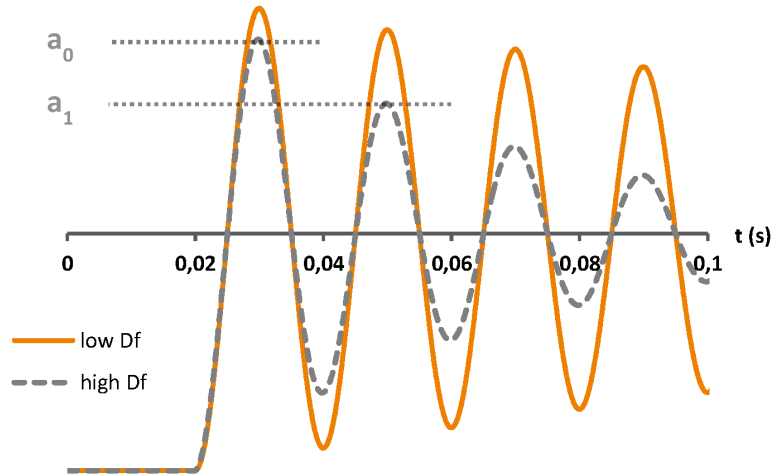


Figure 3.5: Damping factor



According to the *IEC 60060-3* standard the damping factor  $D_f$  can reach up to 40 %.

The simplest liner model for the estimated losses inside the test equipment is a LR series circuit according to Figure 3.6 and Formula (3.7). Note, that the losses inside the resistance  $R_{DAC}$  also depend on temperature ( $T$ ), voltage level ( $u$ ) and frequency ( $\omega$ ).

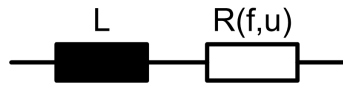


Figure 3.6: Simple model for losses inside DAC test circuit

$$\tan \delta_{DAC} = \frac{P}{Q} = \frac{i^2 R_{DAC}}{i^2 \omega L} = \frac{R_{DAC}}{\omega L} \quad (3.7)$$

Finally, the dielectric losses  $\tan \delta_{cable}$  inside the cable insulation can be estimated to (3.8):

$$\tan \delta_{cable} = \sum \tan \delta - \tan \delta_{DAC} \quad (3.8)$$

### 3.2.3 Partial Discharge Detection

Partial discharges indicate inhomogeneities within high voltage insulation systems. For this reason sensitive detecting as well as exact locating of PD signals are important requirements for condition assessment of high voltage equipment.

The PRPDA pattern analysis is a well-proven method to separate real PD signals from noise and other disturbance signals. Therefore, the first cycle of several DAC excitations (shots) with the same amplitude are superposed in one diagram, according to Illustration 3.7. As a result, typical phase resolved patterns are generated depending on the PD type. If there is no indication for PD activity during testing no further PD analysis such as PD location is needed.

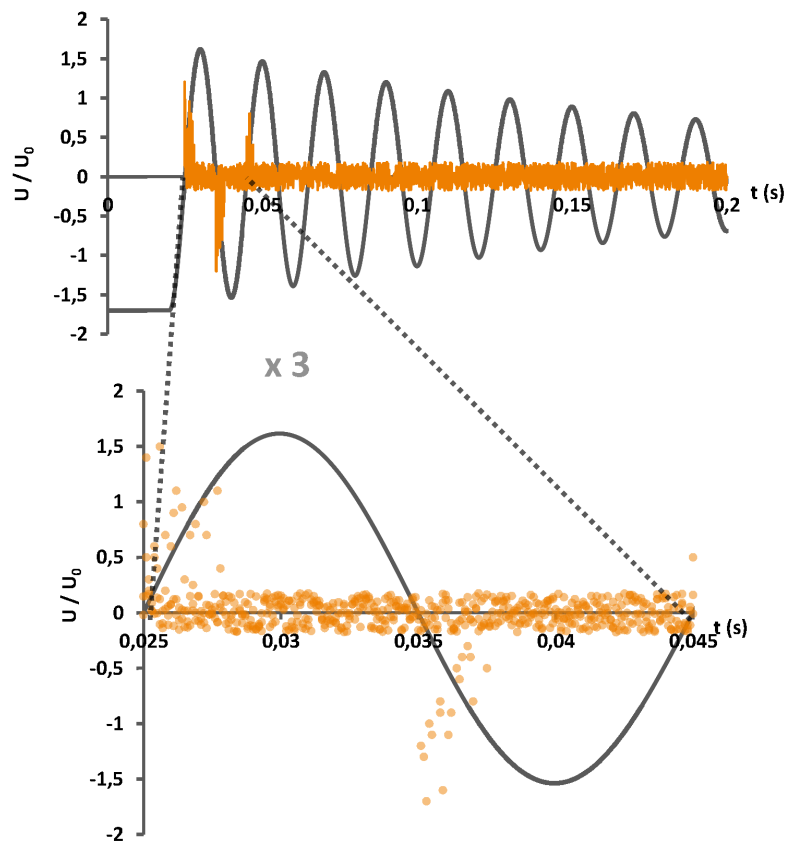


Figure 3.7: PRPDA pattern generation from several shots



The PRPDA pattern generation (as presented in Figure 3.7) provides you the same evaluation possibilities as during continuous AC test. The more shots with the same amplitude are superposed the better the PRPDA result will be. There are typical pattern shapes generated by specific types of PD. Harmful surface discharges as well as inner PD generate phase resolved patterns between 0 to 90, and 180 to 270 degrees. Refer to Section 2 for further information.



The quantization of the PD level in pC (pico coulomb) requires the test circuit to be calibrated according to the *IEC60270* standard. After calibration the test setup must not be changed in any way. Note, that in most cases one calibration is sufficient for all three phases.

### 3.2.4 Partial discharge location

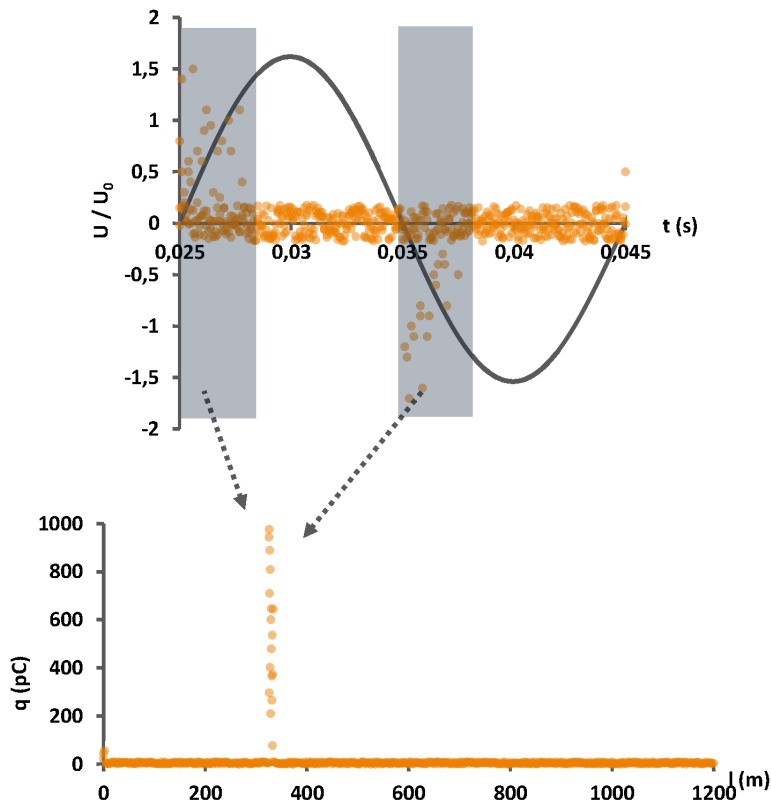


Figure 3.8: PD location mapping from selected PD signals

For locating the PD signals single sided TDR (Time Domain Reflectometry) is performed on the selected areas of the first cycle (see Figure 3.8).



Note, that the distinction of real PD from noise signals still is hand work. The automatic algorithm assumes that every found reflection is a PD signal. After the automatic analysis the test engineer should be able to separate real PD events from noise, and correcting it manually.

#### Principle of Time Domain Reflectometry

In Figure 3.9 the generation of a typical PD signal reflectogram for a PD event starting at time  $t_0$  at a distance  $x = s$  from near end is illustrated:

- At  $t_0$  the ignited PD signal is split in two portions: the direct pulse is propagating directly to the near end, and the indirect pulse is propagating to the far end.
- The direct pulse is reaching the PD detector at  $t_1$ .
- In the meanwhile, the indirect pulse is still propagating towards the opened far end  $L$  where it is being reflected.
- The reflected signal is propagating towards the near end. At  $t_2$  it is being detected as a lower and wider second pulse.

By knowing the overall cable length  $L$ , the group propagation speed  $v_g$  of the PD pulse, and the time distance  $\Delta t = t_2 - t_1$  between the direct and indirect PD pulse the location  $s$  of the PD source can be calculated using Formula (3.9).

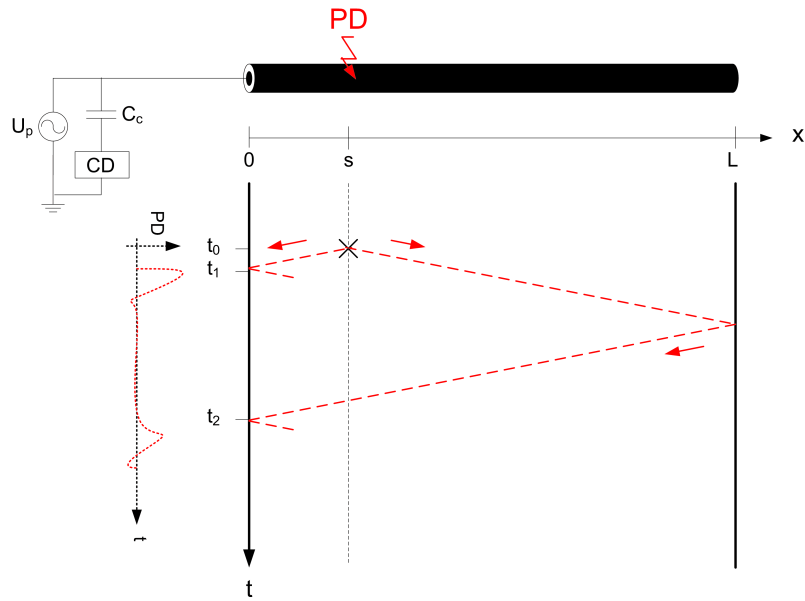


Figure 3.9: Generation of a PD signal reflectogram

$$s = L - \frac{1}{2}v_g\Delta t \quad (3.9)$$

### Finding reflections

The automatic algorithm uses the damping curve which has been calculated during TDR calibration (see Figure 3.10). The damping curve is a mathematical model describing the exponential damping  $\alpha$  of the signal amplitude when propagating along the cable length.

$$q_2 = q_1 \cdot e^{-\alpha 2L} \quad (3.10)$$

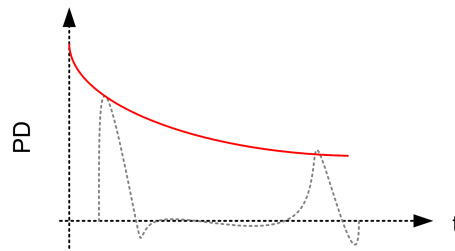


Figure 3.10: Damping curve of PD signal damping

During TDR calibration the amplitude  $q_1$  of the direct calibration pulse is compared to the amplitude  $q_2$  of the indirect pulse after having traveled twice the cable length  $L$ . The exponential approach from (3.10) results in Formula (3.11) for the damping  $\alpha$ .

$$\alpha = \frac{\ln \frac{q_1}{q_2}}{2L} \quad (3.11)$$

The main difficulty during TDR analysis is to finding the correspondent reflection of the direct signal, because of

- high damping inside the insulation (high dielectric losses) that lead to low amplitudes of the direct pulse and reflection,
- high damping due to long cable that lead to low amplitudes of the reflection,



- superposed wide-band noise signals which could lead to misinterpretation,
- dispersion of direct and indirect pulse (different frequency portions of the wide-band PD signal propagate with different velocities) that leads to change of pulse shape (see Figure 3.11),
- joint reflections which attenuate the signal and interfere with far-end reflections,
- and overlapping of different PD events.

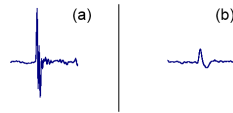


Figure 3.11: PD signal (a) before and (b) after having traveled approx. 800 meters inside XLPE cable

### Displaying TDR results

Every single PD event is automatically analyzed and transferred into a PD map (Figure 3.8).

The PD map in Figure 3.8 is illustrating the location of the PD signals inside the cable. Conspicuous concentrations at particular locations indicate insulation defects.



Note, that most of PD related insulation defects occur inside cable accessories. The joint locations may give you good orientation for finding the exact PD location.

# Hardware and Software Description

## 4.1 Technical Data M-Series

	DAC M30	DAC M60	DAC M30+
<b>Maximum output voltage</b>			
DAC:	30 kV (peak)	60 kV (peak)	40 kV (peak)
VLF:	21,2 kV (RMS)	42,4 kV (RMS)	28,3 kV (RMS)
			33 kV (peak)
			23,3 kV (RMS)
<b>Minimum output voltage</b>	3 kV (peak)	6 kV (peak)	3 kV (peak)
	2,12 kV (RMS)	4,24 kV (RMS)	2,12 kV (RMS)
<b>Rated coil inductance</b>	1,0 H	1,5 H	1,0 H
<b>DAC frequency <sup>1</sup></b>	35 ... 800 Hz	35 ... 800 Hz	35 ... 800 Hz
<b>Test object capacitance <sup>2</sup></b>			
DAC:	0,025 ... 5 $\mu$ F	0,025 ... 8 $\mu$ F	0,025 ... 5 $\mu$ F
VLF:			0,025 ... 3 $\mu$ F
<b>Test object length <sup>1</sup></b>		50 m ... > 10 km	
<b>Power supply</b>		94 ... 250 V, 48 ... 63 Hz, 500 VA	
<b>Data acquisition</b>		105 MS/s, 14 Bit vertical resolution	
<b>PD measuring range</b>		2 pC ... 100 nC	
<b>PD integration</b>		Wide-band integration (acc. to IEC60270)	
		Optimized integrator for higher SNR	
<b>DF, Tan <math>\delta</math> estimation</b>		0,1 % ... 50 % (Resolution 0,01 %)	
<b>Protocol</b>		TCP/IP	
<b>Operating temperature</b>		-5 ... 40 deg.	
<b>Operating altitude</b>		< 2000m (above sea level)	
<b>Dimensions</b>			
(without wheels)	77 cm	107 cm	77 cm

*Continued on next page*

Table 4.1 – Continued from previous page

	DAC M30	DAC M60	DAC M30+
<b>Weight</b> (device only)	approx. 75 kg	approx. 85 kg	approx. 90 kg
	DAC M40		DAC M40+
<b>Maximum output voltage</b>	40 kV (peak) 28,3 kV (RMS)		40 kV (peak) 28,3 kV (RMS)
<b>Minimum output voltage</b>	3 kV (peak) 2,12 kV (RMS)		4 kV (peak) 2,83 kV (RMS)
<b>Rated coil inductance</b>	1,0 H		1,0 H
<b>DAC frequency</b> <sup>1</sup>	35 ... 800 Hz		35 ... 800 Hz
<b>Test object capacitance</b> <sup>2</sup>	0,025 ... 5 $\mu$ F		0,025 ... 5 $\mu$ F
<b>Test object length</b> <sup>1</sup>		50 m ... > 10 km	
<b>Power supply</b>		94 ... 250 V, 48 ... 63 Hz, 500 VA	
<b>Data acquisition</b>		105 MS/s, 14 Bit vertical resolution	
<b>PD measuring range</b>		2 pC ... 100 nC	
<b>PD integration</b>		Wide-band integration (acc. to IEC60270) Optimized integrator for higher SNR	
<b>DF, Tan <math>\delta</math> estimation</b>		0,1 % ... 50 % (Resolution 0,01 %)	
<b>Protocol</b>		TCP/IP	
<b>Operating temperature</b>		-5 ... 40 deg.	
<b>Operating altitude</b> <sup>3</sup>		< 2000m (above sea level)	
<b>Dimensions</b> (without wheels)	77 cm		77 cm
<b>Weight</b> (device only)	approx. 75 kg		approx. 90 kg

<sup>1</sup>Depending on load capacitance<sup>2</sup>Depending on the test voltage (cf. Appendix F)<sup>3</sup>See Appendix G for details

## 4.2 Technical Data H-Series

	DAC H180	DAC H200	DAC H300
Maximum output voltage	180 kV (peak) 127,3 kV (RMS)	200 kV (peak) 141,4 kV (RMS)	300 kV (peak) 212,1 kV (RMS)
Minimum output voltage	10 kV (peak) 7,1 kV (RMS)	10 kV (peak) 7,1 kV (RMS)	10 kV (peak) 7,1 kV (RMS)
Rated coil inductance	approx. 2 H	approx. 2 H	approx. 4 H
DAC frequency <sup>1,2</sup>	35 ... 800 Hz	35 ... 800 Hz	35 ... 800 Hz
Test object capacitance <sup>3,4</sup>	0,025 ... 3 μF	0,025 ... 3 μF	0,025 ... 3 μF
Test object length <sup>1</sup>	50 m ... >10 km		
Power supply	220/380 V ... 250/400 V, 48 ... 63 Hz, 3P5W (3P,N,PE), 4500 VA		
Data acquisition	105 MS/s, 14 Bit vertical resolution		
PD measuring range	2 pC ... 100 nC		
PD integration	Wide-band integration (acc. to IEC60270) Optimized integrator for higher SNR		
DF, Tan δ estimation	0,1 % ... 50 % (Resolution 0,01 %)		
Protocol	TCP/IP		
Operating temperature	-5 ... 40 deg.		
Operating altitude <sup>5</sup>	< 2000m (above sea level)		
Dimensions (W x L x H)			
HV Supply	80 x 80 x 152 cm	80 x 105 x 150 cm	80 x 80 x 152 cm
Coil	80 x 80 x 179 cm		80 x 80 x 179 cm
Coil 2,3	80 x 80 x 123 cm	65 x 65 x 37 cm	80 x 80 x 123 cm
Capacitor	80 x 80 x 179 cm	80 x 80 x 180 cm	80 x 80 x 179 cm
Switch			80 x 80 x 152 cm
Switch / Coil combination		80 x 80 x 180 cm	
Weight (approx.)			
HV Supply	140 kg	160 kg	140 kg
Coil	200 kg		150 kg
Coil 2,3	200 kg	70 kg	200 kg
Capacitor	110 kg	100 kg	110 kg
Switch			240 kg
Switch / Coil combination		185 kg	
Total	650 kg	515 kg	840 kg

<sup>1</sup>Depending on load capacitance

<sup>2</sup>Upon request 20 Hz ... 800 Hz possible

<sup>3</sup>Depending on the test voltage (cf. Appendix F)

<sup>4</sup>Up to 15  $\mu$ F available upon request

<sup>5</sup>See Appendix G for details

## 4.3 Parts List M-Series

### 4.3.1 Basic Equipment

#### B01 - High Voltage Unit

Consisting of:

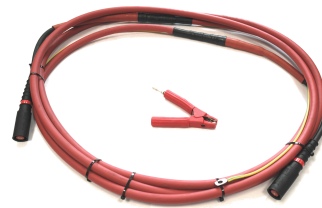
- wide-band power supply input
- high voltage charger
- high voltage solid state switch
- air coil (standard: 1 H)
- DC and AC voltage divider
- coupling capacitor and coupling device for PD measurement
- rolls and carrying bars



#### B02 - High voltage connection cable

Consisting of:

- MC connectors (female)
- including MC connector clamp
- including grounding clamp
- standard length: 7,5 m



#### B03 - Safety Box

Including:

- 1 pair of safety keys
- approx. 5 m of connection cable



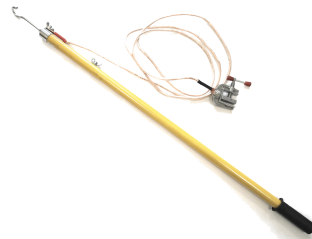
**B04 - Calibrator**

Including:

- BNC to 4mm connection leads, 1 m (black and red)
- Connection clamps
- Test certificate

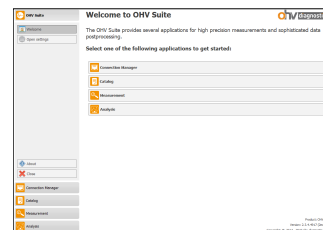
**B05 - Grounding Stick**

Grounding stick

**B06 - OHV Suite**

Consisting of:

- latest measurement software
- latest analyzer software
- including documentation, technical support and software updates



### 4.3.2 Supplementary Equipment

#### S01 - Cable accessory connection box

Consisting of:

- adapter for T-connectors M12 and M14
- adapter for bus bars
- electrodes for PD free assembly



#### S02 - Spare MC connector clamp

Spare MC connector clamp



#### S03 - Base load capacitor

- rated capacitance: 200 nF
- rated voltage: 60 kV
- including high frequency suppression filter
- including connection leads to DAC device



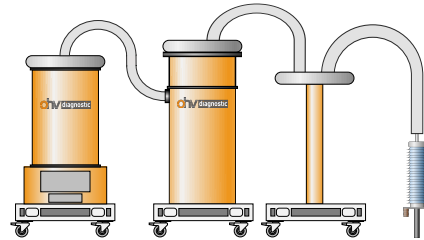
## 4.4 Parts List H-Series

### 4.4.1 Basic Equipment

#### B01.1 - High Voltage Unit H180

Consisting of:

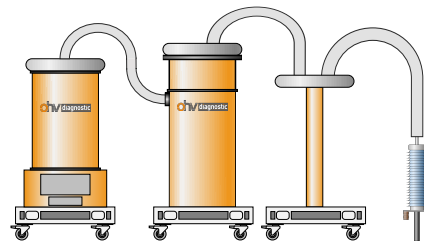
- wide-band power supply input
- high voltage charger
- high voltage solid state switch
- air coil (approx. 2 H)
- DC and AC voltage divider
- coupling capacitor and coupling device for PD measurement
- Base load with 25 nF (optional)
- Double side unit for range extension (optional)
- Intermediate DAC unit for join measurements (optional)



#### B01.2 - High Voltage Unit H200

Consisting of:

- wide-band power supply input
- high voltage charger
- high voltage solid state switch
- air coil (approx. 2 H)
- DC and AC voltage divider
- coupling capacitor and coupling device for PD measurement
- Base load with 25 nF (optional)
- Double side unit for range extension (optional)
- Intermediate DAC unit for join measurements (optional)

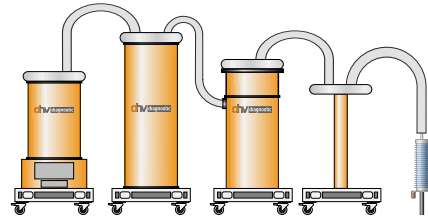




**B01.3 - High Voltage Unit H300**

Consisting of:

- wide-band power supply input
- high voltage charger
- high voltage solid state switch
- air coil (approx. 4 H)
- DC and AC voltage divider
- coupling capacitor and coupling device for PD measurement
- Base load with 25 nF (optional)
- Double side unit for range extension (optional)
- Intermediate DAC unit for join measurements (optional)

**B02 - High voltage connection cable**

Consisting of:

- 2 cables (10 m and 5 m)
- connection adapter
- including grounding clamp

**B03 - Safety Box**

Including:

- 1 pair of safety keys
- approx. 5 m of connection cable



B04 - Calibrator

Including:

- BNC to 4mm connection leads, 1 m (black and red)
- Connection clamps
- Test certificate



B05 - Grounding Stick

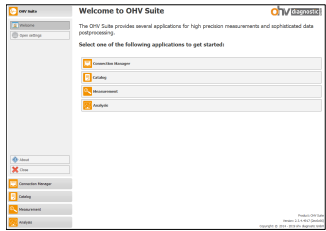
Grounding stick (length: 4 m)



B06 - OHV Suite

Consisting of:

- latest measurement software
- latest analyzer software
- including documentation, technical support and software updates



4.5 Software requirements

This section describes (cf. Table 4.4) the minimum requirements for PC or Laptop hardware on which the OHV Suite should be run.

Description	Minimum requirement
RAM	4 GB
Display resolution	WSXGA (1440 x 900 Pixel)
Free hard drive space	2 GB
Operating System	Windows 10 (64bit) or Windows 11 (64bit)

Table 4.4: Software requirements

---

# Performing a Test

This chapter teaches you how to setting-up up your DAC testing device, and how to perform a test for the first time.

## 5.1 Before Testing

Make sure that the operator of the power cable under test provides you all mandatory information needed for performing the test which at least includes:

- Cable operating voltage ( $U_0$ ),
- Exact cable length,
- Joint positions,
- Type of cable terminations,
- Test procedure / maximum voltage level



Note, that you are able fill-in and save the needed information in the software test set-up in your office without the hardware set-up. Doing this will save you time on site.



In some cases the cable operator does not know the exact cable length. In this case you need to perform a cable length estimation using TDR calibration or with the help of a reflectometer. For the signal propagation velocity  $v_g$ , which depends on the insulation material and thickness, the cable manufacturer may provide the right value.

## 5.2 Setting-Up the Cable under Test



Working on power equipment in substations must be performed by qualified personnel only. Consider local safety relevant rules before starting any modification of the installation

- In the substations all VTs and PTs usually connected to the cable should remain disconnected during calibration and testing, otherwise the DAC device will not be able to charge the cable.
- When calibrating and testing both the cable far end and near end must remain ungrounded.
- Groundings of the cable screens must remain grounded.

- If you test phase-by-phase the two remaining phases must be grounded manually.
- Use the grounding stick for the phase under test for grounding.
- It is recommended that all capacitive voltage indicators of the switchgear fields that remain connected to the high voltage must be grounded while testing.
- For measurements on very short cable runs, the use of the base load capacitor is recommended. This increases the capacitance of the test object and reduces the DAC frequency. The base load capacitor is connected directly to another branch on the DAC device in parallel with the cable under test using the high voltage connection cable included in the scope of delivery.

### 5.3 Setting-Up the Test for the M-Series

Please consider safety notes before setting-up any DAC test. All phases must remain grounded while setting-up the test.

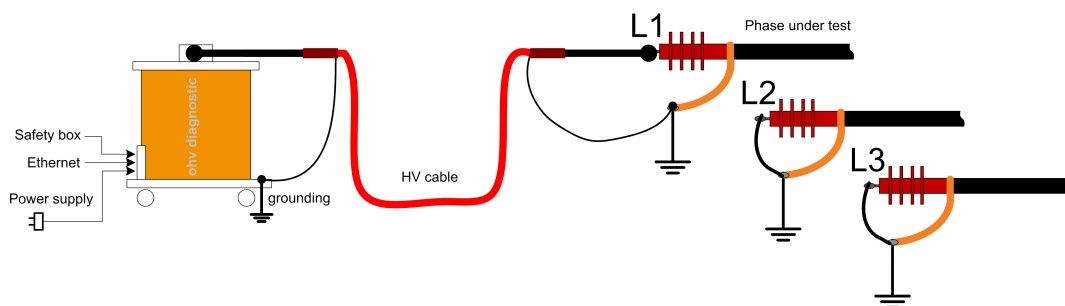


Figure 5.1: Connecting the DAC device (M-Series)

#### 5.3.1 Hardware Set-Up (M-Series)

The basic DAC test device consists of the high voltage source, high voltage connection cable, safety box, calibrator, grounding stick and remote laptop.

- 1 Connect the high voltage cable to the cable termination under test (ref. to Figure 5.1). Use the connection clamp or applicable connection tools from the connection box for cable accessories.
- 2 Ground the high voltage cable screen at substation ground, and as close as possible to the grounding of the cable under test.
- 3 Align the DAC equipment near cable termination. Consider clearance of at least 0.15 meters to all nearby metallic parts.
- 4 Connect the other end of the high voltage cable to the DAC equipment.
- 5 Ground the base plate of the DAC equipment via cable screen of the high voltage cable.
- 6 Connect grounding stick to DAC equipment.
- 7 Connect control unit to power supply (ref. to Figure 5.2).
- 8 Connect remote laptop to control unit via Ethernet cable (ref. to Figure 5.2).
- 9 Connect safety box to control unit (ref. to Figure 5.2).
- 10 Switch-on DAC device and laptop.

In Figure 5.2 all available connectors and labels are marked on the control unit with 1 to 8. Each of them will be described in Table 5.1.



Consider good and short grounding between the DAC test device and the substation grounding. For higher SNR avoid grounding loops in your test set-up (e.g. multiple groundings and long grounding lines).

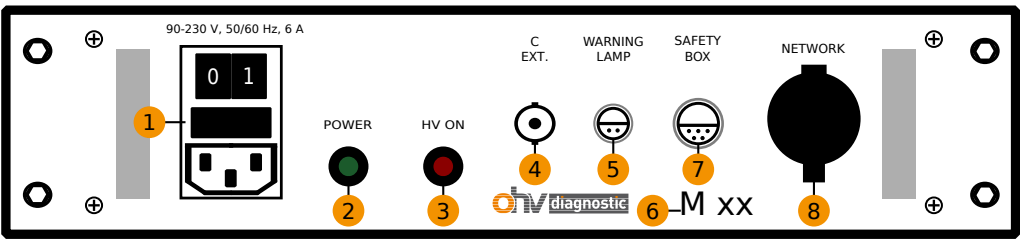


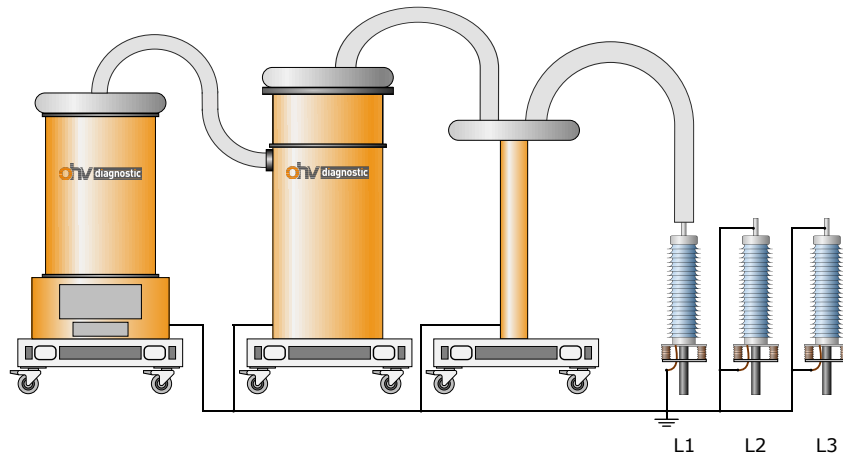
Figure 5.2: Available connections on the control unit (M-Series)

Element	Description
1	Power supply with switch for power on / off and the fuse with 6 A
2	The power LED, which is green when the device is powered on.
3	The high voltage LED. This LED is illuminated red when the high voltage is on.
4	BNC Connector for the external C.
5	Connector used for external warning lamp.
6	This label contains the name of the DAC device (this could be M30, M60 or M30+).
7	Connector for the safety box.
8	The network connection for the Ethernet.

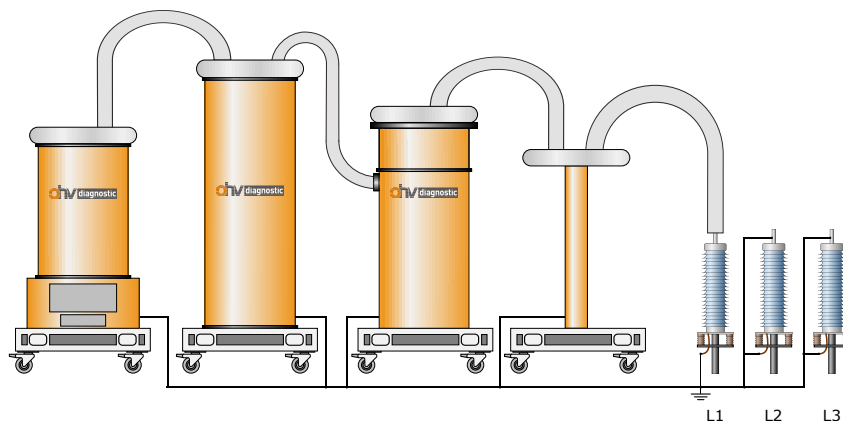
Table 5.1: Available connections on the control unit (M-Series)

## 5.4 Setting-Up the Test for the H-Series

Please consider safety notes before setting-up any DAC test. All phases must remain grounded while setting-up the test.



(a) Connecting the H180 / H200 DAC device



(b) Connecting the H300 DAC device

Figure 5.3: Connecting the H-Series DAC device

### 5.4.1 Hardware Set-Up (H-Series)

The H-Series DAC test device consists of a separate high voltage source, high voltage switch (only H-300), high voltage coils, high voltage connection cable, safety box, calibrator, grounding stick and remote laptop.

- 1 Connect the high voltage cable to the cable termination under test (ref. to Figure 5.3). Use the connection clamp or applicable connection tools from the connection box for cable accessories. Please choose the correct connections based on the specific H-Series model (H180, H200 or H300).
- 2 Ground the high voltage cable screen at substation ground, and as close as possible to the grounding of the cable under test.
- 3 Align the DAC equipment near cable termination. Consider clearance of at least 0.15 meters to all nearby metallic parts.
- 4 Connect the other end of the high voltage cable to the DAC equipment.

- 5 Ground the base plate of the DAC equipment via cable screen of the high voltage cable.
- 6 Connect grounding stick to DAC equipment.
- 7 Connect control unit to power supply (ref. to Figure 5.4).
- 8 Connect remote laptop to control unit via Ethernet cable (ref. to Figure 5.4).
- 9 Connect safety box to control unit (ref. to Figure 5.4).
- 10 Switch-on DAC device and laptop.



Consider good and short grounding between the DAC test device and the substation grounding. For higher SNR avoid grounding loops in your test set-up (e.g. multiple groundings and long grounding lines).

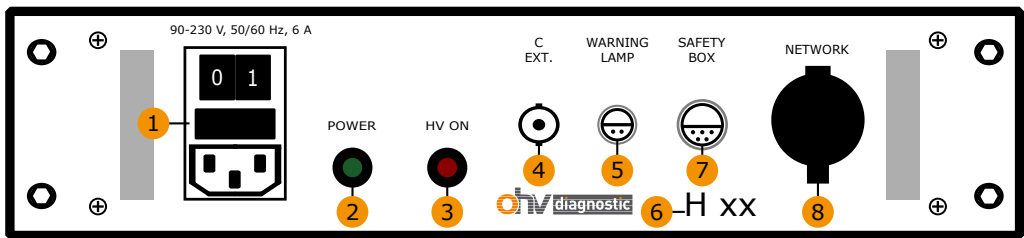


Figure 5.4: Available connections on the control unit (H-Series)

In Figure 5.4 all available connectors and labels are marked on the control unit with 1 to 8. Each of them will be described in Table 5.2.

Element	Description
1	Power supply with switch for power on / off and the fuse with 6 A
2	The power LED, which is green when the device is powered on.
3	The high voltage LED. This LED is illuminated red when the high voltage is on.
4	BNC Connector for the external C.
5	Connector used for external warning lamp.
6	This label contains the name of the DAC device (this could be H180, H200 or H300).
7	Connector for the safety box.
8	The network connection for the Ethernet.

Table 5.2: Available connections on the control unit (H-Series)

## 5.5 Perform the test

This section describes how to perform a complete test. The individual settings in the software are not dealt with directly, but only refer to the corresponding chapters in this manual. The sequence of the subsections in this section describes the normal procedure for a DAC test measurement.

### 5.5.1 Setting-Up test information

In order to carry out a test, some information must be specified for the test. This information can be selected or re-entered via the Test catalog. Detailed information about the UI elements of the Test catalog is explained in Chapter 6. For a quick input of the required information it is recommended to use the simple mode (cf. Figure 6.3) of the Test catalog. All relevant information such as cable information, test environment, testers and test procedures can be entered or selected there.

### 5.5.2 Setting-Up Calibrator

During calibration process important parameters for the PD measurement are set. This includes

- the group velocity  $v_g$  of the PD signals inside the cable (TDR calibration),
- time constant of the damping between first pulse and far-end reflection (TDR calibration),
- check and adjustment of cable length, and check for joint reflections (TDR calibration),
- scaling factor (k-factor) for correct scaling of the pC values (pC calibration)

The calibrator must be connected directly to the cable termination leads (according to Figures 5.5). Check the right calibrator polarity: Connect red wire to conductor, and black wire to cable screen. During calibration the phase under test must remain ungrounded. All other phases must remain grounded.

### 5.5.3 Performing Calibration

Before proceeding to the DAC Measurement make sure that the DAC device is switched on, and the computer is connected to the device via Ethernet link. Additionally it is necessary to establish a connection to the device in the Connection Manager (cf. Chapter D).

The calibration procedure itself consists of two independent parts:

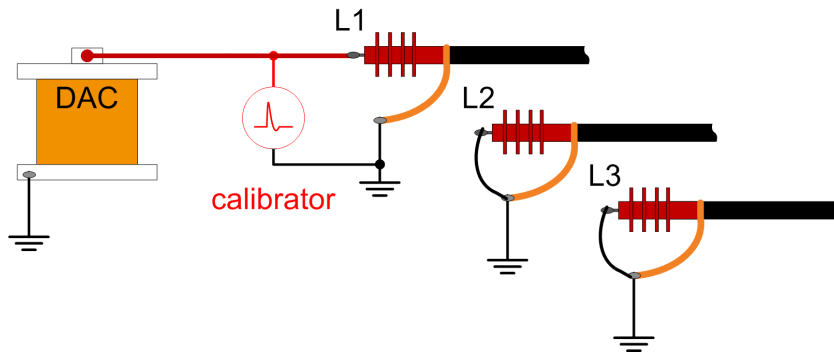
- 1 **Charge calibration:** in the  $Q$  [pC] calibration the scaling factors between the apparent charge of the calibrator and the measured charge are determined.
- 2 **TDR calibration:** the main purpose of the TDR calibration is the determination of relevant signal parameters, such as the signal propagation velocity and the damping curve between direct and reflected pulse. The entire reflectogram will be saved for reference purposes for the analysis software.

#### Charge Calibration

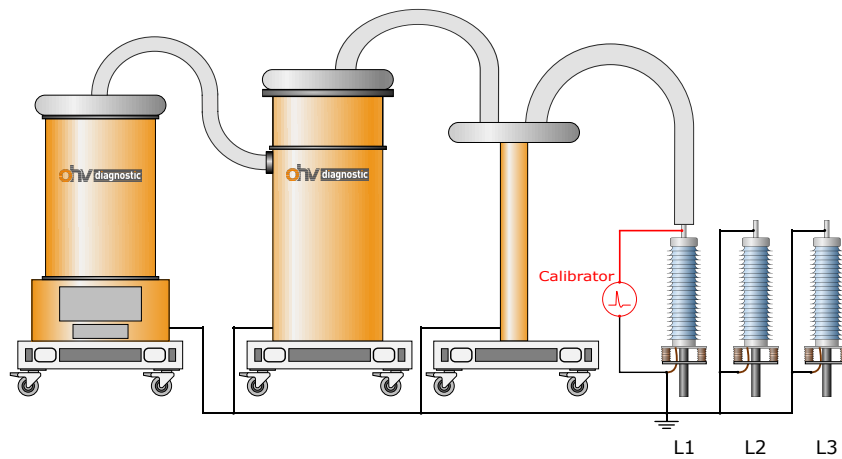
For the charge calibration of the cable is performed in the *Calibration* window of the DAC measurement. The individual UI elements are explained in detail in the Section 7.4. The following steps must be performed to obtain a successful calibration.

- 1 Phase under test must be left ungrounded during calibration.
- 2 Make sure the safety box is connected. Turn safety key so the green LED is illuminated.
- 3 Choose the same pC level as Calibration Input, which you have selected on the calibrator.
- 4 Start the calibration (button *Calibration*) inside the *Calibration* window.

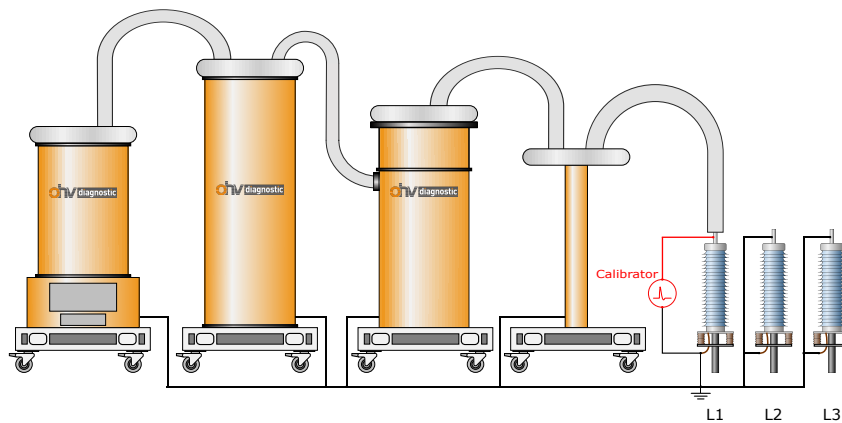




(a) Setting-up calibration for M-Series



(b) Setting-up calibration for H180 / H200 DAC device



(c) Setting-up calibration for H300 DAC device

Figure 5.5: Setting-up calibration

- 5 Check the retrieved data for a valid signal to noise ratio (cf. Figure 7.8c in Section 7.4)
- 6 Adjust *Attenuation*: If the attenuation is too low or too high a visual indicator and a warning will be shown (Figure 7.8a and Figure 7.8b). Increase or decrease the attenuation accordingly until the bar is green.
- 7 If you have a good signal to noise ratio such as in Figure 7.8c click *Save*.



For a three phase cable system the calibration on one phase is enough in most cases. If you feel the phase lengths deviate too much from each other you may also perform a calibration for each phase.



A calibrator of type RC (**Re**Chargeable) can not be loaded at the same time when a TDR or PD calibration is performed!

### TDR Calibration

The TDR calibration is performed to determine the length of the cable or the propagation speed of the cable. To carry out this calibration, one of these values must be known. The detailed overview of the available UI elements and the corresponding function description is described in the Section 7.5. The following steps must be performed to obtain a successful TDR.

- 1 Make sure that the calibrator is connected with the right polarity (red lead to HV, black to ground). Phase under test must be left ungrounded during calibration.
- 2 Inject 10 nC into the test circuit. Switch calibrator to this position
- 3 Make sure the safety box is connected. Turn safety key so the green LED is illuminated.
- 4 Select the estimated cable length. **The selected or entered length must be greater than the real length of the cable!**
- 5 Click on *Data Acquisition* (cf. Figure 7.9 in Section 7.5) which starts the permanent data acquisition for the calibration.
- 6 The signal on the channel is shown on the scope screen (cf. Figure 7.10c).
- 7 Adjust *Attenuation*: Adjust *Attenuation*: If the attenuation is too low or too high a visual indicator and a warning will be shown (Figure 7.10a). Increase or decrease the attenuation accordingly until the bar is green.
- 8 Check cursor positions for the first peak and the second highest peak (reflection).
- 9 Check that the calculated length matches the expected length. If this is not the case, the propagation velocity should be slightly adjusted.
- 10 If you have a good reflectogram such as in Figure 7.10c stop the acquisition and use the *Save* button to save the calibration.



The minimum cable length for performing automatic TDR calibration is 400 m.

#### 5.5.4 Performing HV Test

After PD and TDR calibration has been completed successfully, the high voltage measurement can now be performed. In this section, the sequence of a high-voltage measurement is briefly written. To do this, you have to switch to the *DAC* or *VLf* window in the DAC measurement software. The individual surface elements available for measurement are described in detail in the sections 7.6, 7.7 resp. 7.10 in detail.

To be able to carry out the high-voltage test, the test must be started by click on the button *Begin test*. A message box appears that the calibrator has to be removed (cf. Figure 7.16). Furthermore, the high voltage must be switched on. To do this, press the *HV ON* button on the safety box.



Before a high-voltage measurement can be carried out, the calibrator **must** be removed! The calibrator will be damaged if it is not removed before the high voltage test.

Depending on the selected measurement type, various actions are available to perform the measurement. The exact details can be read separately in the above sections. After having finished the HV test switch off the high voltage by clicking on the red button on the safety box.

## 5.6 Starting the OHV Suite Software

Start the measurement software OHV Suite. The *Welcome*-screen will appear (Figure 5.6). You can select one of the following actions:

- **Connection Manager** for connecting to the DAC Device (cf. Section D).
- **Test Catalog** for setting-up test information (cf. Section 6).
- **Measurement** for performing a predefined test procedure (cf. Section 7).
- **Analysis** for analyzing an already performed test (cf. Section 8).

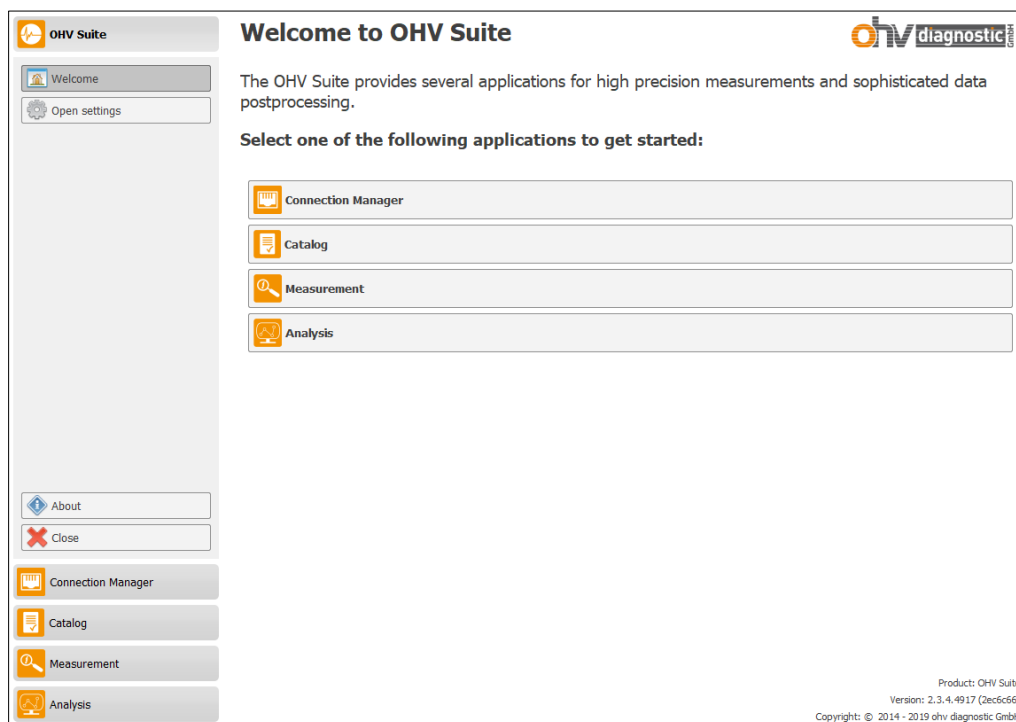


Figure 5.6: DAC system software: Welcome window

# DAC Catalog

This chapter describes the structure of the DAC Catalog, which is available for entering test information. The test information are required to perform a DAC test. The information entered is stored in a database. The Chapter 6.1 describes the different configuration options for the DAC Catalog. The Chapter 6.2 contains the description for the simple input mode of the test information. Chapter 6.3 describes the input options in advanced mode.

## 6.1 DAC Catalog configuration

The configuration for the DAC Catalog consists of three parts (Figure 6.1 shows these parts). In the upper area (A) the current path for the database is shown, where the data of the DAC Catalog are stored. The middle section (B) allows you to switch between the Simple and Advanced mode for entering test information. The lower area (C) displays the current location for the DAC measurements. With the help of the button *Select Data Folder* another directory can be selected for saving the measurement data. If a different folder than the default folder is selected, the button *Reset to Default Folder* (cf. Figure 6.2) can be used to switch back to the default folder.

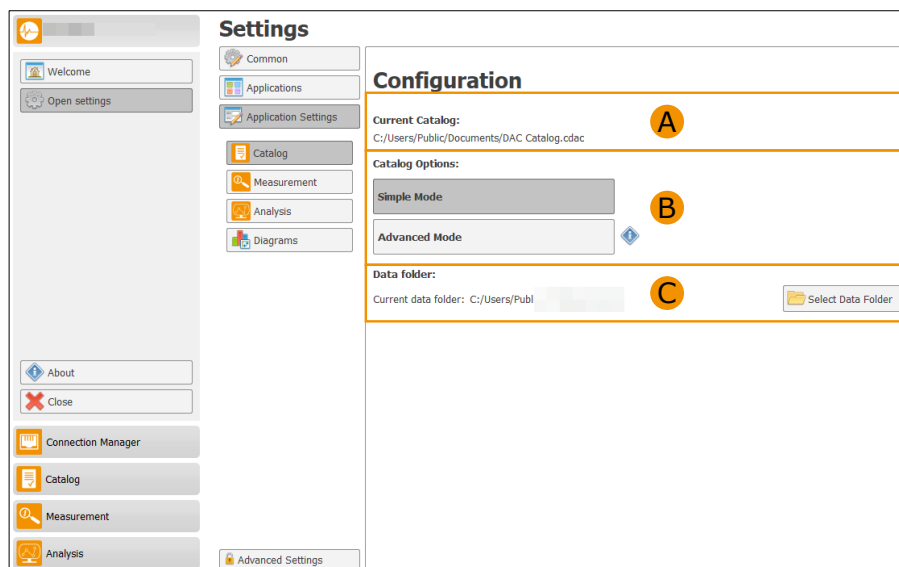


Figure 6.1: General overview for the DAC Catalog



Figure 6.2: Reset to Default Folder

## 6.2 Simple mode

The Simple mode for entering test information can be selected via the *Test information* button in the application area. The left pane now shows the currently selected information for the test (cf. Figure 6.3). The following information are required for a test:

- *Location* indicates the location of the measurement
- *Cable* indicates the structure of the cable
- *Tester* Specifies the tester who carries out the measurement
- *Test procedure* specifies the test sequence of the test

Figure 6.3: Simple Mode view

For all required information a combo box with a list of available Location, Cables, Tester or Test procedures appears. The available data can be selected via these selection fields. For deleting a single element the button can be used. If new information needs to be entered for the test, this can be done directly in the individual input fields. Make sure that all available information is filled in. If there is a change in the input fields, the button *Save* ( in Figure 6.4) appears at the bottom. Clicking this button saves the changes to the DAC Catalog database.

Figure 6.4: Modified test information in Simple Mode

### 6.2.1 Cable voltage input

The cable voltage input is available through a separate dialog. The dialog is automatically opened when the input field (U0) is selected. Figure 6.5 (Selection A) shows the input dialog. The voltage value may be specified as RMS or peak value. Only one value needs to be entered as the other value is automatically calculated. The dialog can be closed through pressing the ESC key or using the available close button. If a valid voltage value was entered the dialog is automatically closed and the voltage value is applied.

**Test information**

Location:

Substation Far:

Substation Near:

Cable:

Tester:

Test procedure:

U0:

U0 (RMS): 6.15 kV

U0 (Peak): 8.70 kV

U0: RMS: 6.15 kV Peak: 8.70 kV

Velocity: 168.0 m/µs

Company:

Name:

Standard DAC Test Procedure for new cable

Steps:

1	0 %	Move Up
2	50 %	Move Down
3	100 %	
4	100 %	Edit
5	100 %	Add
6	110 %	Remove

Type: Relative Voltage Level

Save

Figure 6.5: Cable voltage input in simple mode

## 6.3 Advanced mode

If the Advanced mode for test information input is selected, a separate window is available for each information. Additional buttons are available in the application area to switch to the individual input modes. **A** in Figure 6.6 shows all possible buttons of the input modes.

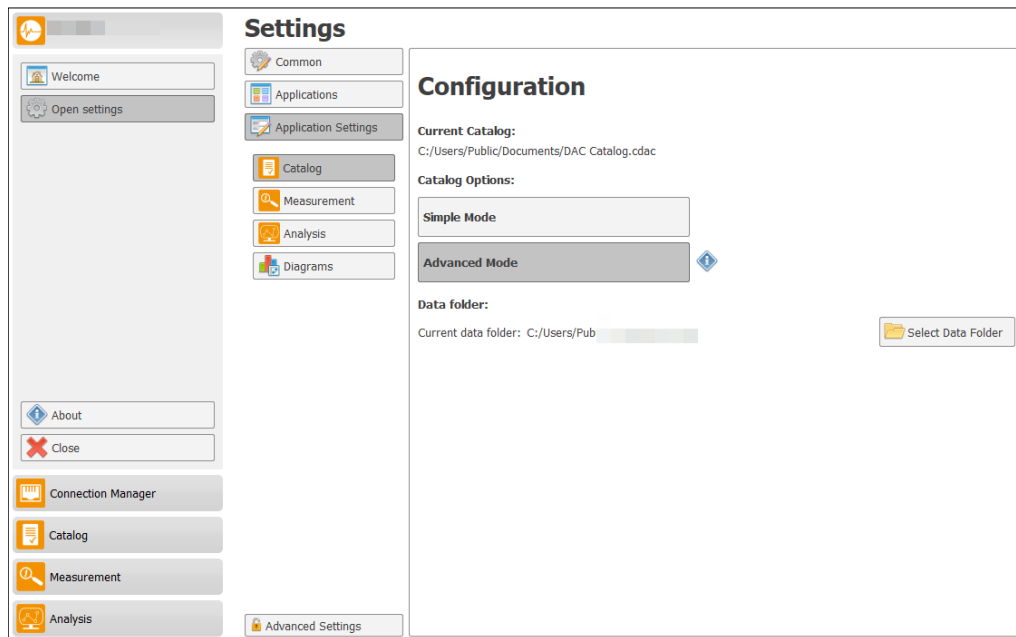


Figure 6.6: Advanced configuration mode

The next sections explain the individual input options in detail.

### 6.3.1 Test Locations

The test environment contains information about the geographical location of the measurement. Optional information can be set to facilitate the subsequent location of examinations. This makes it possible, for example, to search for all examination locations in a country at a later date. These optional properties are displayed by pressing the *Show all Options* button. Table 6.1 and Figure 6.7 show all possible entries for the test location.

ID	Description	Optional
City	The city where the test is conducted.	Yes
Country	The country in which the test is carried out.	Yes
Location	The location where the test is performed.	No
Postal Code	The postal code of the test environment.	Yes
Substation Far	The name of the test station at the far end.	No
Substation Near	The name of the test station at the near end.	No

Table 6.1: Test location options

The button *Save* writes the newly created test environment to the database and automatically sets this environment to all selected test environment.

The screenshot shows the 'Test location' configuration window. On the left is a sidebar with a navigation menu containing 'Connection Manager', 'Catalog', 'Test Locations' (selected), 'Tester', 'Cables', 'Customers', 'Test procedure', 'Measurement', and 'Analysis'. The main area is titled 'Test location' and contains several input fields: 'City:', 'Country:', 'Location:', 'Postal Code:', 'Substation Far:', and 'Substation Near:'. Below these fields is a 'Show all Options' button. In the bottom right corner of the main area is a 'Save' button. At the bottom of the window, a status bar displays the message 'Please configure the following missing categories: Test Location' and a row of buttons: 'Test Location' (highlighted in red), 'Tester', 'Cable', 'Customer', and 'Test Procedure'.

Figure 6.7: New test location



### 6.3.2 Tester

The examiner contains the name and company of the person performing the test. Further information can also be added by pressing *Show all Options*. Table 6.2 and Figure 6.8 show all possible entries for the tester.

ID	Description	Optional
Address	The address of the tester	Yes
Company	The company in which the tester is employed	No
Contact details	Possible contact details of the tester	Yes
Name	The name of the tester	No

Table 6.2: Tester options

The button *Save* writes the newly created tester to the database and automatically sets this as selected tester.

**Tester data**

Address:

Company:

Contact details:

Name:

Please configure the following missing categories: Tester

Figure 6.8: New tester

### 6.3.3 Cable

The cable comprises the physical properties of the cable to be tested. Here too, additional information such as joint configuration can be entered by pressing *Show all Options*. Table 6.3 and Figure 6.9 show all possible entries for the cable.

ID	Description	Optional
Cores	The existing cores in the cable.	Yes
Date of manufacture	The manufacturing date of the cable.	No
Length	The length of the cable.	No
Material	The material of the cable sheath.	Yes
Cable ID	Contains the identification for the cable.	No
Topology	The inner structure of the cable.	No
U	The nominal voltage of the cable.	Yes
U0	The conductor-earth voltage of the cable.	No
Um	The highest permissible operating voltage.	Yes
Velocity	The electromagnetic propagation velocity in the cable.	No

Table 6.3: Cable options

The button *Save* writes the newly created cable to the database and automatically sets it as the selected cable.

**Cable information**

Offset Date of manufacture Material Comment

Move Up Move Down

Edit Add Remove

Cores:

Date of manufacture: Mittwoch, November 27, 2019 [Clear Date](#)

Length: 0 m

Material:

Cable ID:

Topology: Single-phase single-core

U: RMS: 0.00 kV Peak: 0.00 kV

U0: RMS: 0.71 V Peak: 1.00 V

Um: RMS: 0.00 kV Peak: 0.00 kV

Velocity: 0.0 m/μs

Show all Options

Save

Please configure the following missing categories: Cable

Test Location Tester Cable Customer Test Procedure

Figure 6.9: New Cable

#### 6.3.4 Cable voltage inputs

The cable voltage inputs are available through a separate dialog. The dialog is automatically opened when one of the input fields (U, U0, Um) is selected. Figure 6.5 (Selection A) shows the input dialog. The voltage value may be specified as RMS or peak value. Only one value needs to be entered as the other value is automatically calculated. The dialog can be closed through pressing the ESC key or using the available close button. If a valid voltage value was entered the dialog is automatically closed and the voltage value is applied.

### 6.3.5 Customer

The customer contains all customer-specific measurement data. Table 6.4 and Figure 6.10 show all possible entries for the customer.

ID	Description	Optional
Address	The customer's address	No
Company	The company acting as customer	No
Contact details	Additional contact information.	Yes
Contact person	Contact person of the company	No
Description	Additional description.	Yes
References	Further customer contacts.	Yes

Table 6.4: Customer options

The button *Save* writes the newly created customer to the database and automatically sets it as the selected customer.

**Customer information**

Address:

Company:

Contact details:

Contact Person:

Description:

Reference:

Show all Options

Save

Please configure the following missing categories: Customer

Test Location Tester Cable **Customer** Test Procedure

Figure 6.10: New customer

### 6.3.6 Test Procedure

In the *Test Procedure* window (Figure 6.11) the test procedure for the DAC measurement is set (cf. Table 6.5). Either you can load an existing test procedure, or you can create a new one. The *Type* specifies the input method for adding the voltage level. Here you can switch between *Relative Voltage Level* and *Absolute Voltage Level*. For adding a voltage sequence simply fill-in the amount of shots and the voltage step  $U/U_0$ , and click on *Add*. Insert the desired voltage value, and press *Enter*-key. For deleting a sequence click on the corresponding row and press *Remove*. Your custom test procedure will be saved for future tests.

ID	Description	Optional
Name	A descriptive Name for the test procedure.	No
Steps	A list of all voltage level steps which form the procedure.	No
Type	The method for applying the voltage levels.	No

Table 6.5: Test procedure options

The button *Save* writes the newly created test procedure to the database and automatically sets it as the selected test procedure.

Figure 6.11: New test procedure

---

# DAC measurement

This chapter describes how to use the DAC measurement software to perform a test on a cable. The next sections describe the individual UI elements in detail.

The measurement configuration (section 7.1) allows to make settings which are applied during the measurement. The following sections describe the individual UI elements that are available for each connected device. The sequence during a check is adhered to. The general overview (section 7.3) refers to starting a new check and the individual problems that may occur. The section 7.4 describes how to use the software for a charge calibration. Section 7.5 describes the use of TDR calibration. In the sections 7.6, 7.7 and 7.10 the interface elements available for the different high voltage tests are explained. The concluding section 7.12 describes generally used UI elements, which are available at the different points during the measurement.

## 7.1 DAC measurement configuration

The measurement configuration consists of four parts, which can be seen in the Image 7.1. In the upper area (A) you can switch between different measurement modes. The B section shows the general settings. The third section C provides updating measurement parameter definition file. The last section D provides various settings for the individual measurement modes.

### 7.1.1 General measurement settings

The general measurement settings are used for all available measurement modes. The *Voltage axis autorange* check box activates the automatic axis scaling of the high voltage axis during measurement. If this option is not active, the voltage axis is displayed with a fixed scaling. This maximum scaling depends on which DAC device is used.

### 7.1.2 Measurement parameter definitions

The measurement parameter definition contains several parameters which allows to modify some special parameters for the measurement. These parameters definitions are supported through OHV. Each of the file have a current version which is shown inside the brackets. For checking if a new version of the definition is available the button on the right side can be used to check for a new version. If a new version is available it can be downloaded and the OHV Suite must be restarted.

### 7.1.3 Simple measurement mode

The simple measurement mode is activated by pressing the *Simple mode* button in the A area. For this mode, further settings are available in the lower section D. In simple measurement mode, the measurement is performed automatically without interactions for the user.



The tester must be able to guarantee during the complete measuring procedure the safety of installation and environment. This mode does not provide unattended operation, but serves only to facilitate the work.

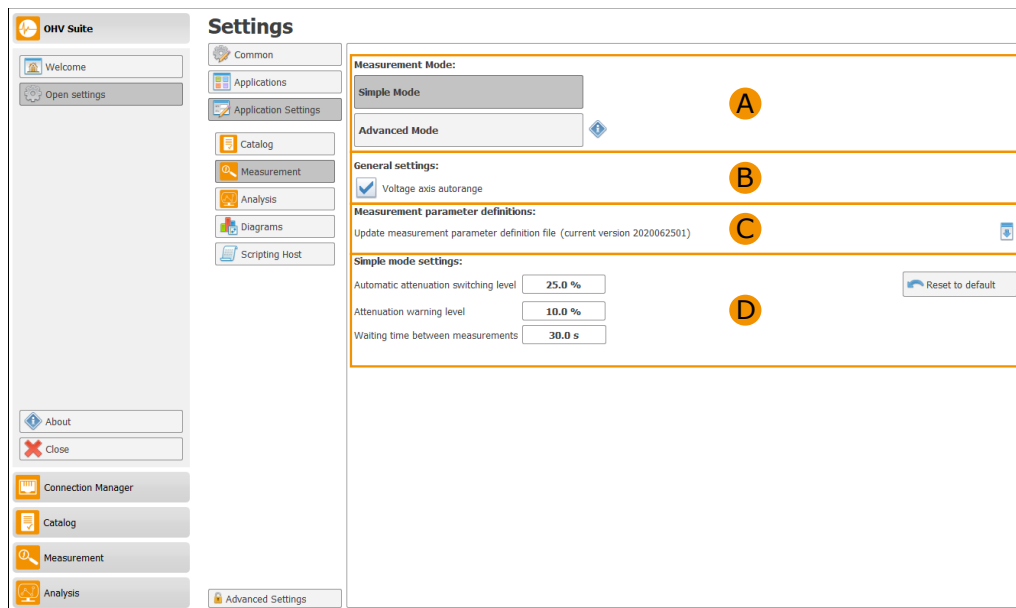


Figure 7.1: Overview simple measurement configuration

The setting *Automatic attenuation switching level* is used to automatically switch the attenuation levels of the DAC device. The attenuation is automatically increased or decreased by one step. The *Automatic attenuation switching level* can be selected between 10 % and 40 %. The *Attenuation warning level* specifies the threshold at which a prompt window appears asking whether the last measurement should be repeated, the next procedure step should be carried out or the check should be aborted. The attenuation is automatically increased or decreased by two steps. The *Attenuation warning level* can be between 5 % and 25 %. Both settings are applied at the upper and lower gain limits. In Figure 7.2 the two limits and their allowed values are shown.

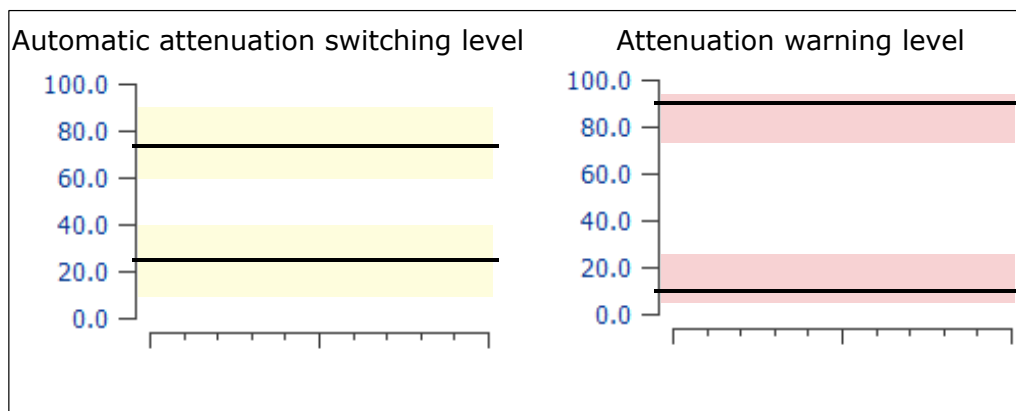


Figure 7.2: Display the switching ranges in simple measurement mode

The setting *Waiting time between two measurements* specifies the period of time to wait between completion of the last measurement and the next measurement.

#### 7.1.4 Advanced measurement mode

The advanced measurement mode is activated by pressing the *Advanced mode* button in the A area. This mode has no advanced settings during measurement. In the advanced measurement mode, the user is responsible for the settings of the DAC device and starting the measurement. The detailed information and settings are explained separately in the respective section.

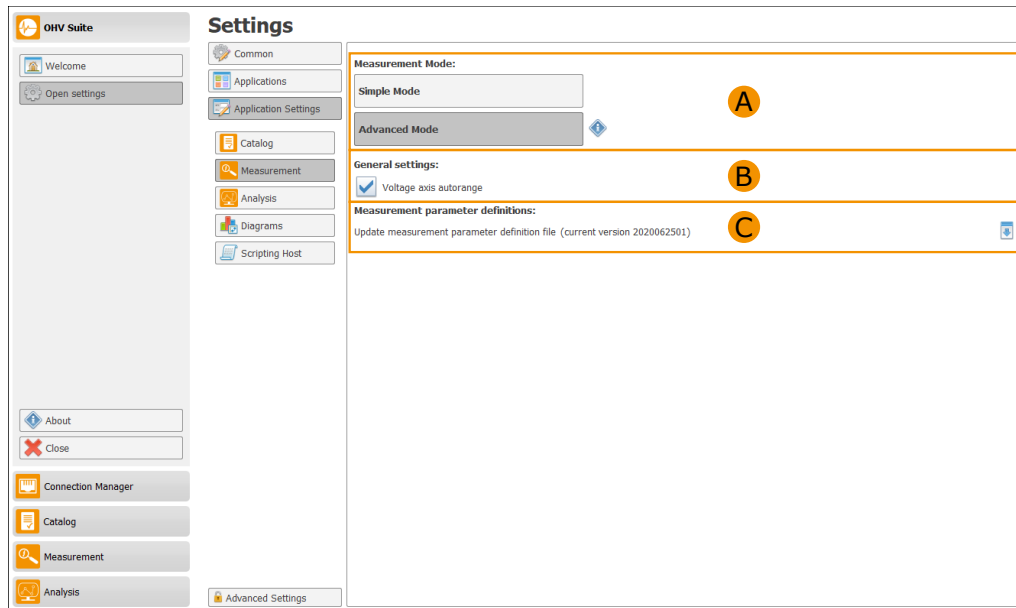


Figure 7.3: Overview advanced measurement configuration

## 7.2 Apply safety rules

The security rules are displayed on every successful connection to the device. This information must be carefully read and the message window then confirmed (cf. Figure 7.4).

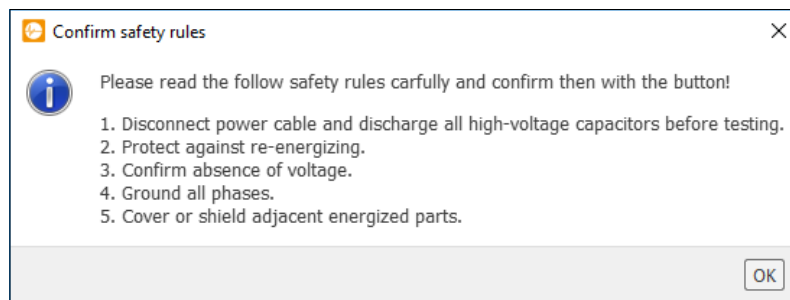


Figure 7.4: Safety rules



### 7.3 Overview

This section describes the general overview for a connected DAC device. Once a new connection to a device has been established (How to establish a new connection is described in Chapter D) the overview (Figure 7.5) is automatically displayed. In the upper Section A (Figure 7.5) all information about the device are displayed. The B area displays all information to start the DAC test measurement.



The availability for certain measure modes and high voltage levels depend on the available hardware model of the device. Please refer to the technical specification section for an overview of the differences.

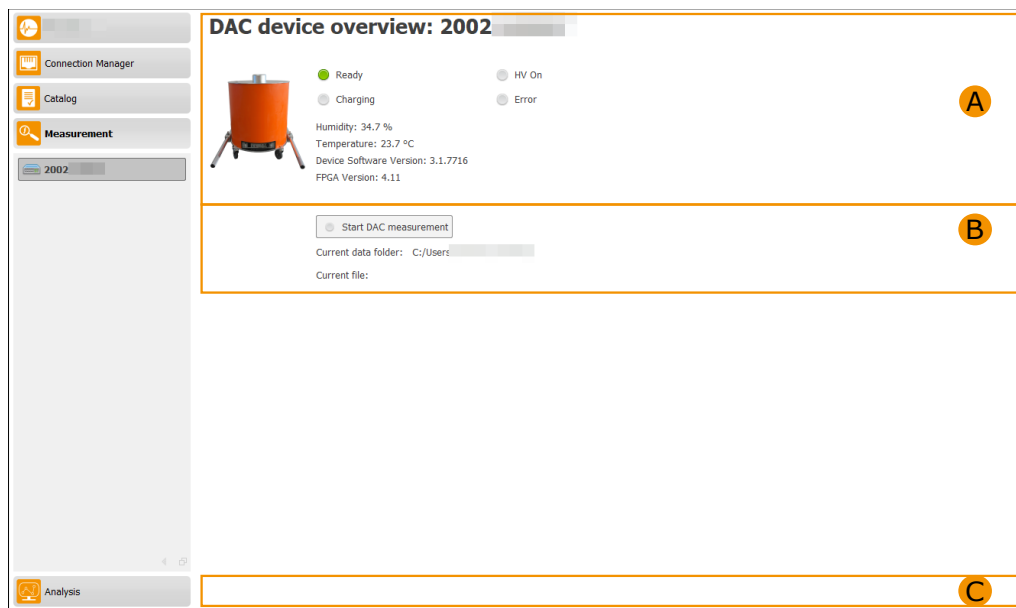


Figure 7.5: Device overview without started measurement


### 7.3.1 Device information

For each device, the following information is displayed in the  area and described in Table 7.1:

Element	Description
<b>Serial number</b>	The serial number of the device can be seen at the top edge.
<b>Device image</b>	A picture of the DAC system is displayed in the left area of the device information.
<b>Status LEDs</b>	<p>The status LEDs show the current status of the device. A colored LED indicates an activity and a gray LED means inactive.</p> <p><i>Ready</i> The device is ready for use, the key switch and the emergency stop button are activated on the safety box.</p> <p><i>HV ON</i> When this LED is red, the high voltage is switched on.</p> <p><i>Charging</i> If this LED is green, the cable is charged with voltage.</p> <p><i>Error</i> If this LED is red, an error has occurred.</p>
<b>Environment values</b>	Below the status LEDs, the humidity and temperature are displayed within the DAC unit.
<b>Program versions</b>	Below the environment values the program versions which are currently running on the device are displayed. This is the device software version and the FPGA version.
<b>Available Updates</b>	If any update for the connected device is available an additionally information about the new version is shown. This also includes a new button for performing the update. More information about the device update are described in Section C.2.

Table 7.1: Device information

### 7.3.2 DAC measurement information

The section  displays the information used for the current DAC measurement. This includes the button *Start DAC measurement*, *Current data folder* and *Current file*. Depending on the selected device, procedure and cable a warning for implausible configuration could be displayed below the button *Start DAC measurement*. The possible warning are depicted in section 7.3.2. Independent of these warning the measurement could be started, but it is possible that not all measurements can be performed with this measurement configuration.

The button *Start DAC measurement* starts a new measurement. A new measurement file is automatically created. The software will store all necessary information which are needed to evaluate the measurement inside this file. The file storage location is determined through the selected measurement directory (cf. Section 6.1), followed by the near end substation. The file name is generated automatically and is composed as follows: CABLEID\_YYYYMMDD\_HHmm.tdac.

The information are replaced as follows:

- **CABLEID** is the identification of the cable
- **YYYY** is the current year
- **MM** is the current month, including leading zeros

- **DD** is the current day, including leading zeros
- **HH** is the current hour, including leading zeros
- **mm** is the current minute, including leading zeros

The current file name is displayed in the field *Current file*. The button *Start DAC measurement* is renamed to *Stop DAC measurement* and in the **C** area all available measurement modes are displayed (cf. Figure 7.6).

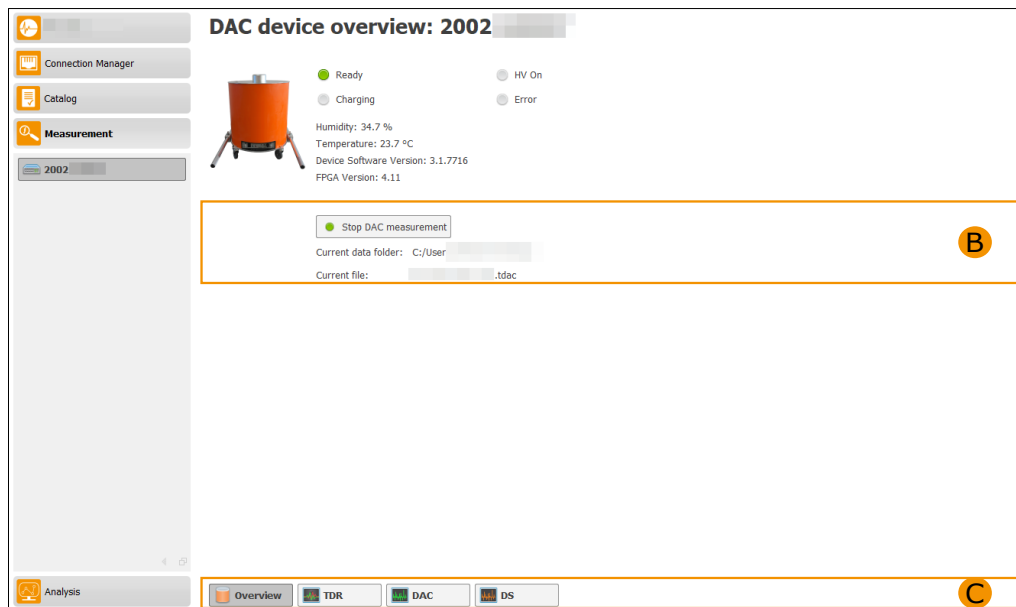


Figure 7.6: Device overview with started measurement

### Implausible configuration warnings

Implausible configurations are detected through the combination of selected procedure, cable and the used DAC device. There are four different misconfigurations possible. The following table ( reftable:DacImplausibleConfigurations) shows the different warning.

### 7.3.3 DAC Measurement Modes

Depending on the available measurement modes, buttons for each type of measurement are displayed in the **C** area. The following list contains all available measurement modes:

- **Overview** display the device and measurement information
- **Calibration** allows calibration of charge for the cable
- **TDR** enables TDR calibration for the cable
- **DAC** enables high-voltage tests on the cable
- **LC** enables leakage current measurements on the cable
- **VLF** enables the execution of VLF high-voltage tests on the cable
- **DS** enables high-voltage tests on the cable for the far end





Warning	Description
 At least one procedure step exceeds the rated voltage for this device (35.00 kV > 30.00 kV)	The procedure has at least one step which is over the maximum voltage of the device. Please check the procedure and the cable for corresponding input to the used device.
 At least one voltage is below the minimum voltage for this cable (1.00 kV < 1.50 kV)	The output voltage is below the expected minimum cable voltage. Please check the cable for valid input.
 Maximum voltage exceeds U0 factor for this cable (4.0 > 3.0)	The procedure is invalid for the used cable. It is not recommended to test a cable with a high factor as 3.0 for the U0 voltage.
 At least one procedure step is below the minimum output voltage for this device (1.00 kV < 1.50 kV)	The procedure contains a step which tries to set the output voltage below the minimum voltage of the device.

Table 7.2: Implausible configurations

## 7.4 PD Calibration

This chapter describes the UI elements available for PD calibration. Calibration is achieved by clicking on the *Calibration* button (C in Figure 7.6).

Figure 7.7 shows the distribution of the calibration window. In the upper section (A) the input fields for the supplied calibration value and the selection of the attenuation stages are available. The middle section (B) displays the results during calibration. The lower section (C) contains the buttons for starting the calibration and saving.

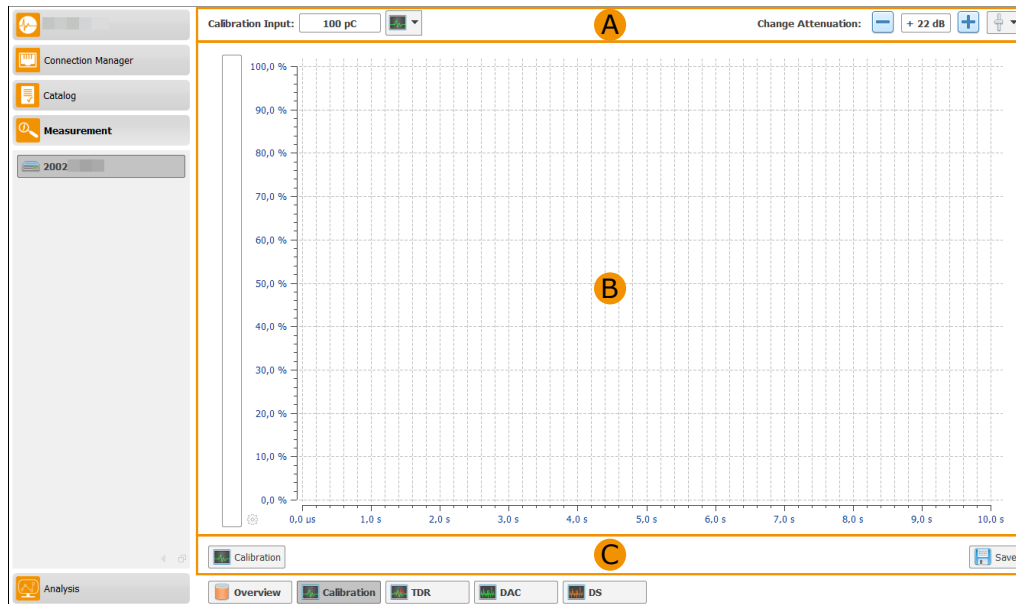
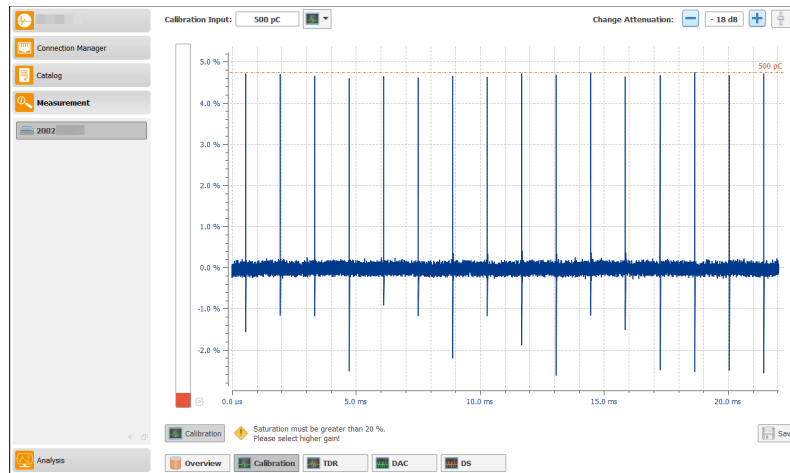
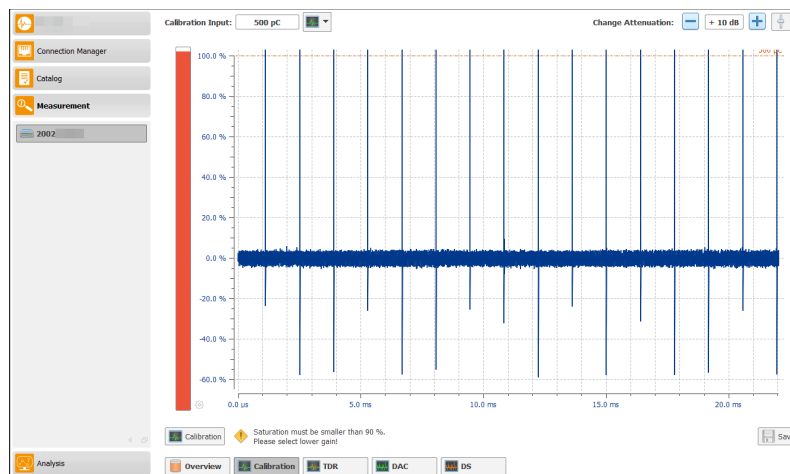


Figure 7.7: PD calibration overview

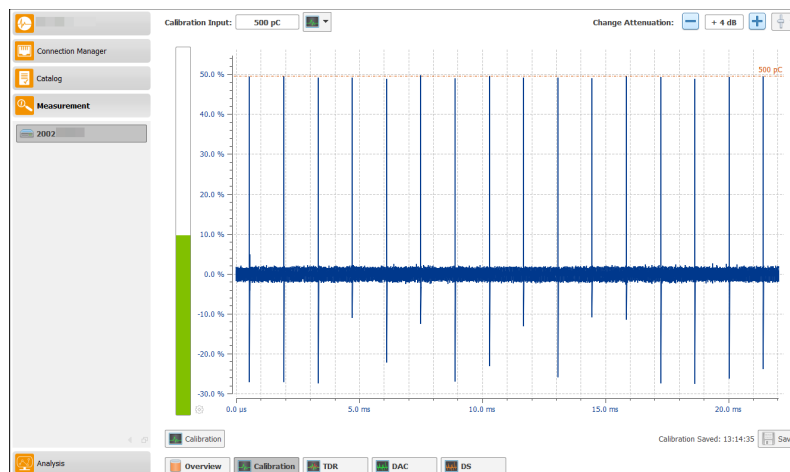
To carry out a calibration, the set value is entered by the calibrator into the *Calibration Input* test field or selected directly via the check box. The *Calibration* button starts a calibration measurement. As soon as the measurement is finished, the result is displayed (B). During calibration, care must be taken to ensure that the signal-to-noise ratio is good. In Figure 7.8c such a relation is represented. In Figure 7.8 there is an image with too little relative magnitude (low signal-to-noise ratio, 7.8a) and an image with excessively high signal (signal-to-noise ratio is good, but the signal value for the selected attenuation is too high, 7.8b). If the result is not in the expected range, the attenuation must be increased with the help of button + or decreased with the button -. Afterwards, the calibration must be carried out again and the result must be waited for. This must be done until a good level is reached (cf. Figure 7.8c). As soon as the calibration was successful, the calibration can be saved with the button *Save*. If the calibration has been successfully stored, the time for saving is displayed before the button *Save* (cf. Figure 7.8c).



(a) PD calibration signal too low



(b) PD calibration signal too high



(c) Good PD calibration signal

Figure 7.8: Calibration saturation

## 7.5 TDR Calibration

This chapter describes the UI elements available for a TDR calibration. TDR Calibration is activated by clicking the *TDR* button (C in Figure 7.6).

Figure 7.9 shows the available areas of the TDR calibration window. The A section is used to enter parameters for TDR calibration and data evaluation. The B section displays the results of the TDR calibration. C contains the control elements for TDR calibration.

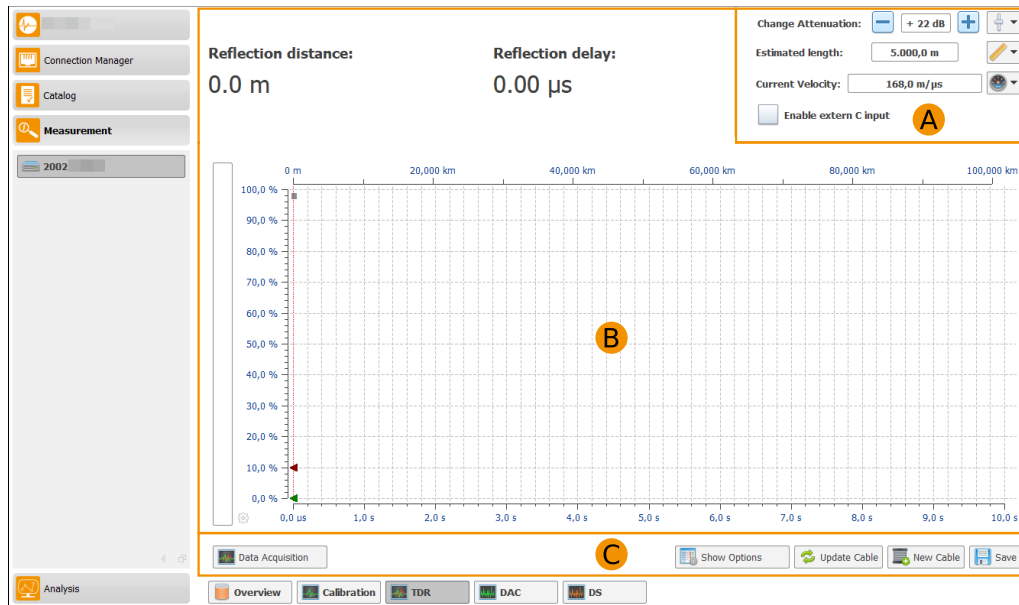
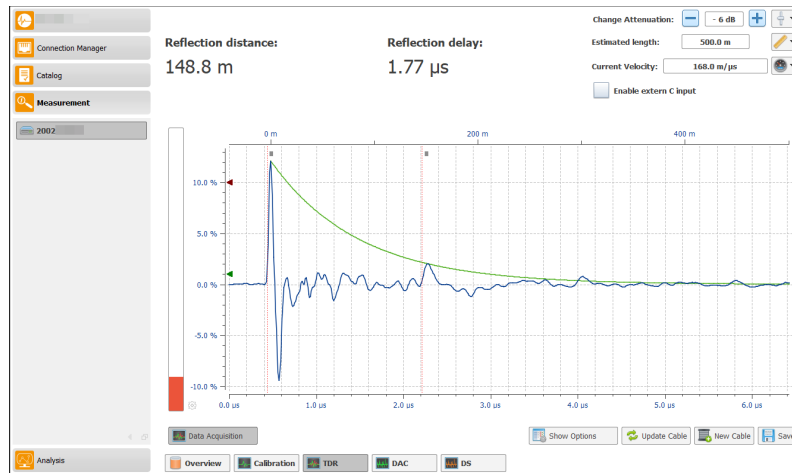
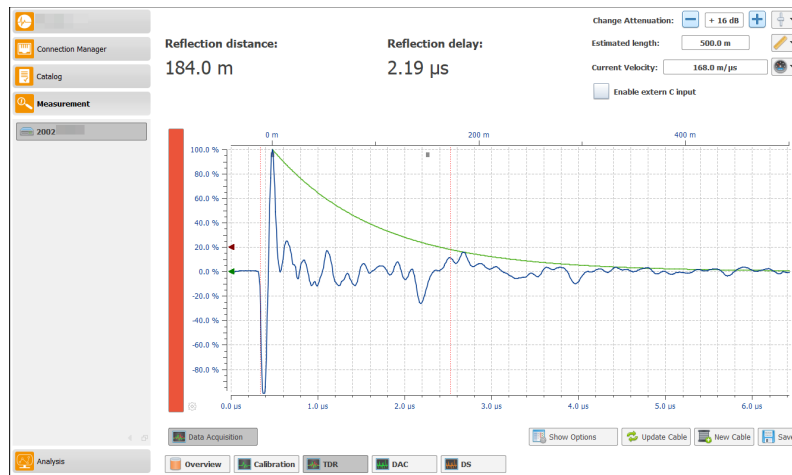


Figure 7.9: TDR calibration overview

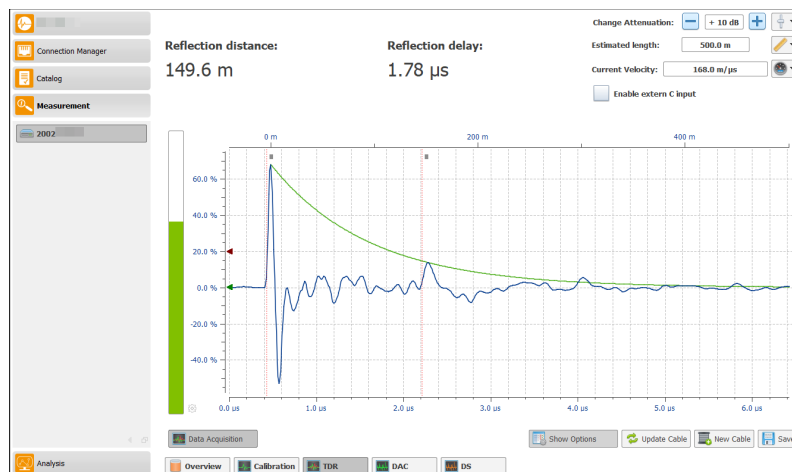
In order to perform a TDR calibration, a calibrator signal must be fed into the test object (details about the TDR calibration can be found in Chapter 5.5.3). The button *Data Acquisition* starts the TDR measurement. In contrast to the PD calibration, TDR calibration is performed permanently. This means that when new measurement results are available, they are evaluated and displayed and the next measurement is carried out automatically. This is done until the *Data Acquisition* button is pressed again. Changes to the settings in the A area are applied directly to the next measurement. As with the PD calibration, care must be taken to ensure that the signals are well controlled. Figure 7.10 shows a poorly controlled TDR measurement in Figure 7.10a and Figure 7.10b. Figure 7.10c shows a well controlled measurement.



(a) TDR calibration signal too low



(b) TDR calibration signal too high




(c) Good TDR calibration signal

Figure 7.10: Bad and good TDR calibration saturation



### 7.5.1 TDR input parameter

For TDR calibration, the following parameters can be specified in the  area in Figure 7.9. Table 7.3 contains the detailed description of the parameters.



Parameter	Description
<b>Change Attenuation</b>	Changes the sensitivity of the device. With the button  the attenuation can be increased and decreased with the button  .
<b>Estimated length</b>	The estimated cable length must be greater than the actual length of the cable. This length determines the number of data recorded by the DAC device.
<b>Current velocity</b>	The propagation velocity is used to calculate the cable length.
<b>Enable extern C input</b>	Switches the external C input of the device on or off.

Table 7.3: TDR input parameter

### 7.5.2 TDR result area

The result area displays the calculated values *Reflection distance* and *Reflection delay*. These are determined from the distance between the first peak and the reflection, whereby the propagation velocity is included in the calculation. The TDR diagram is displayed in the lower part of the result output.

### 7.5.3 TDR control elements

Different buttons are available in the lower part of the TDR calibration window. The button *Data Acquisition* allows to start and stop the TDR measurement. With the buttons *Update cable* and *New cable* it is possible to update the current cable or create a new cable. In Section [Cable manipulation](#) the details for this are explained in more detail. The *Show Options* button displays additional options for TDR measurement to the left of the diagram. Details are explained in the Section [TDR options](#). The button *Save* is available for saving a TDR calibration. When saving, the current TDR measurement is added to the selected cable and is therefore available for evaluation.

#### Cable manipulation





There are two possibilities for manipulating the cable. It is possible to change the propagation velocity and length of an existing cable or to create a new cable.

**Update cable** When updating the propagation speed and length, clicking the *Update cable* button opens a pop-up window (cf. Figure 7.11). In this window you can select the value to be updated. The current value and the new value are displayed for each. Using the button *Apply* the selected is updated inside the current cable. If the update should be aborted, the *Cancel* button is available.

**Create new cable** To create a new cable, click the *New cable* button. A pop-up window opens (cf. Figure 7.12). In this window it is possible to enter all parameters for a cable which are needed. The individual parameters are described in Chapter 6.3.3. After entering all parameters, the cable can be create via the *Create New* button.


	Current value	New value
Velocity	<input type="radio"/> 166.0 m/μs	<input checked="" type="radio"/> 172.0 m/μs
Cable length	<input type="radio"/> 1,980.0 m	<input checked="" type="radio"/> 530.7 m
		<input type="button" value="Apply"/> <input type="button" value="Abort"/>
<input type="button" value="Show Options"/>		<input type="button" value="Update Cable"/>

Figure 7.11: Update current cable



Length: 531 m

Cable ID:

Topology: Single-phase single-core 

U0: 0.00 kV

Velocity: 172.0 m/μs

Figure 7.12: Create new cable

TDR options

The TDR measurement has different options to improve the measurement. In Figure 7.13 the options are shown and are briefly described in Table 7.4.

Average Depth:

-

10

+

Trigger Level [%]:

-

10

+

Reflection Level [%]:

-

0.1

+

☐ Manual Reflection Selection

☐ Invert Signal

Figure 7.13: TDR options

Option	Description
<b>Average Depth</b>	Specifies the number of measurements over which an average value is calculated and then the evaluation is carried out.
<b>Trigger level</b>	Specifies the threshold in %, which must be exceeded for the first peak.
<b>Reflection level</b>	Specifies the threshold in % that must be exceeded for reflection.
<b>Manual Reflection Selection</b>	If this is active, a moveable line is displayed in the diagram, which determines the value for the length calculation manually.
<b>Invert Signal</b>	If this is active, the signal is inverted (multiplied with -1).

Table 7.4: TDR options

## 7.6 DAC Measurement (Simple mode)

This chapter describes the UI elements that are available for a DAC measurement in Simple mode. Figure 7.14 shows the general structure of the measurement surface if now high voltage is switched on. In this case the **B** area displays the information for switching on the high voltage before a test could be started. After switching on the high voltage the user interface changes the **B** area like shown in Figure 7.15. The area **B** contains now three part which are available during the measurement. Now the **B** area contains buttons available for performing the test and showing the current status for high voltage. **C** is used to display current data and the advanced options. In the area **D** the current progress and the status of the measurement is displayed.

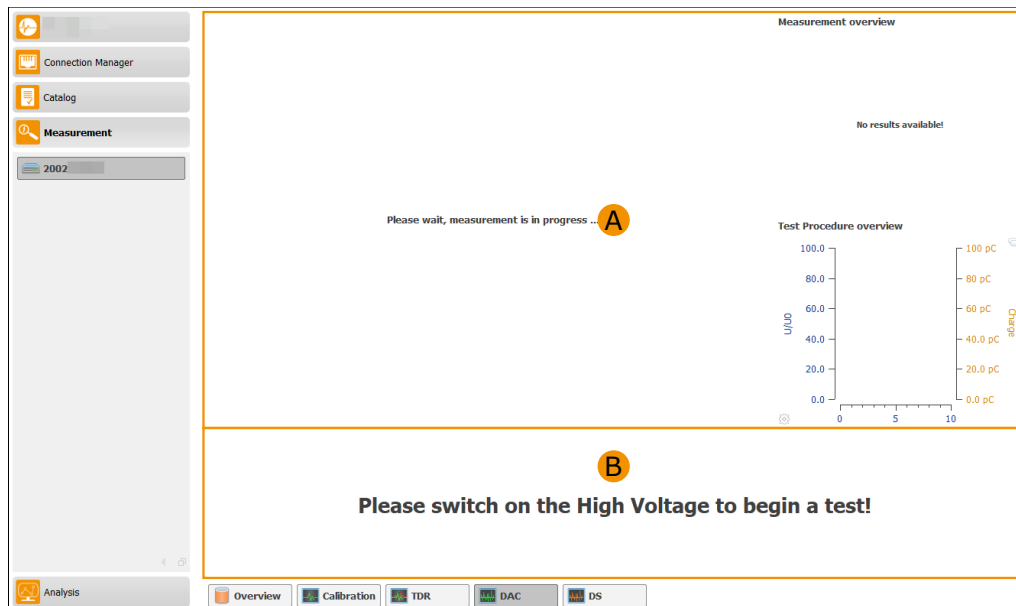


Figure 7.14: DAC measurement overview high voltage off (simple mode)

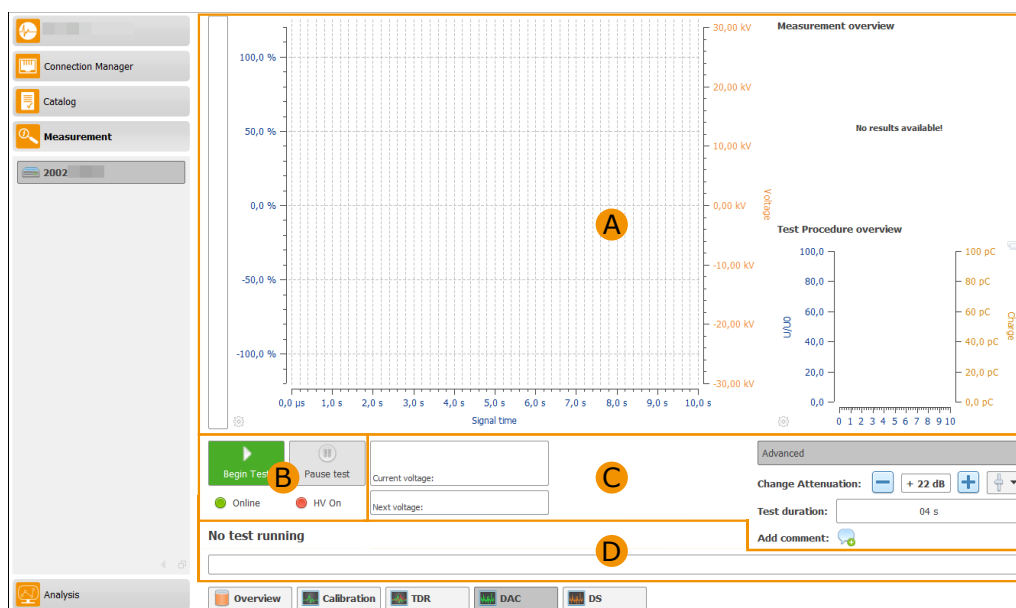


Figure 7.15: DAC measurement overview high voltage on (simple mode)

### 7.6.1 UI elements for simple mode

The following three sections describe the individual UI elements in detail. In Section 7.6.2 only these elements are referred to afterwards.

#### Result view elements

**A** in Figure 7.15 displays the measurement results of the last shot. The following elements (cf. Table 7.5) are available:

Element	Description
<b>Diagram</b>	Displays the last shot data.
<b>Saturation</b>	Shows the level of the last shot. Depending on this level, the attenuation may have to be adjusted.
<b>Measurement overview</b>	Displays the calculated results of the last shot.
<b>Test procedure overview</b>	Shows the test procedure for the current measurement. The individual shots are highlighted in color to indicate whether they have already been completed, are in execution or have yet to be executed. The voltage ratio $U/U_0$ for each single shot is displayed and at the same time the calculated charge.

Table 7.5: Result view elements


#### Navigation elements

**B** in Figure 7.15 shows elements that are needed to perform a DAC measurement. Table 7.6 describes the elements.

Element	Description
<b>Begin/Finish Test</b>	This button can be used to start or end a test.
<b>LED's</b>	<i>Online</i> The device is ready for use, the key switch and the emergency stop button are activated on the safety box. <i>HV ON</i> When this LED is red, the high voltage is switched on.
<b>Pause</b>	The automatic execution of the procedure can be interrupted and continued again.

Table 7.6: DAC measurement elements

Elements for the current values

 in Figure 7.15 contains element for setting the device and displays measurement values. Table 7.7 describes the elements.



Element	Description
Current voltage	Displays the current voltage value, which is approached at the next triggering of a shot.
Next voltage	Displays the next voltage value which is used for the next procedure step.
Advanced	This button can be used to show or hide additional information. The additional elements includes attenuation change elements, the measurement time for the current test and it is possible to specify a comment for the test via the button  (see section 7.12.1 for detailed information).

Table 7.7: Current DAC measurement value elements

Status information elements

 in Figure 7.15 depicted the status elements for the simple measurement mode. The upper line contains the information in which step the software is currently perform. The lower progress bar depicted the current progress of the procedure.

### 7.6.2 Perform a DAC measurement in simple mode

A DAC measurement in simple mode is almost completely automatic. The user has little interaction to perform, but is responsible for ensuring security. In this mode, the specified test procedure is performed. The next steps are automatically taken and the amplifier stages are switched according to the set parameters (cf. Section 7.1.3).

For starting a test, the high voltage on the safety box must first be switched on. When starting a test, a warning message (cf. Figure 7.16) indicates that the calibrator must be removed.



Before a high-voltage measurement can be carried out, the calibrator **must** be removed! The calibrator will be damaged if it is not removed before the high voltage test.

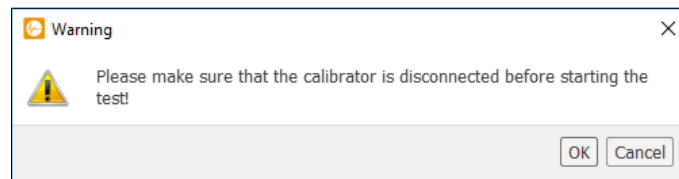


Figure 7.16: Calibrator removal warning

If the cable to be tested is a multi-conductor cable, the phase of the cable to be measured is still queried (cf. Figure 7.17). If the phase has been selected or a single-core cable is involved, the first shot of the procedure is immediately started.

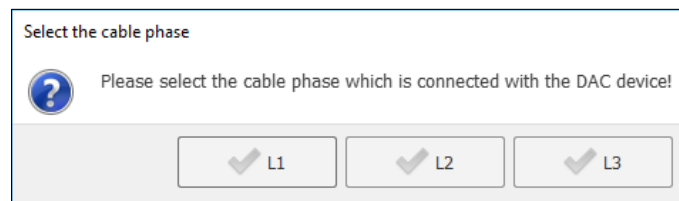


Figure 7.17: Phase selection

After each shot, the measurement results for this shot are displayed. On the basis of these measurement results, the software decides whether the gain of the device must be changed. If this is the case, this is done automatically. If the level is too high, a warning message is displayed on how to proceed with the further measurement. The possibilities are described in Table 7.8:

Element	Description
<b>Repeat measurement</b>	The last shot is repeated with a lower amplification.
<b>Continue with test</b>	The test continues with lower amplification. The next step is automatically taken.
<b>Abort</b>	The test is aborted.

Table 7.8: Possibilities for continuing the DAC measurement

After each shot the time is counted down until the next shot can be taken (cf. Figure 7.18). This time can be set in the Simple Mode measurement settings (cf. Section 7.1.3). In the test procedure overview you can see the currently measured charge value for the individual shots. All completed shots are displayed as green bars. The orange bar marks the next step in the procedure. All blue bars represent the steps that still need to be performed.



Figure 7.18: Waiting for next measurement

After the last shot of the procedure has been done, the test is automatically terminated if it is a single-core cable. If the cable consists of several conductors, the user is asked whether the measurement should be performed with the next phase (cf. Figure 7.19), or whether the test should be terminated.

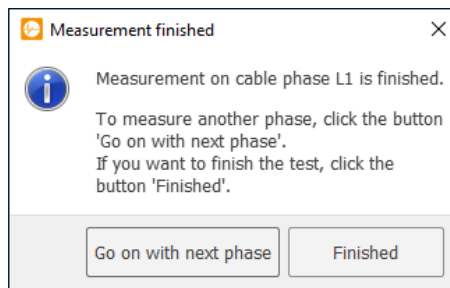


Figure 7.19: Continue with next phase

If the measurement is to be continued with the next phase, the message appears that the high voltage is to be switched off, the grounding stick is used for earthing and then the next phase can be connected (cf. Figure 7.20).

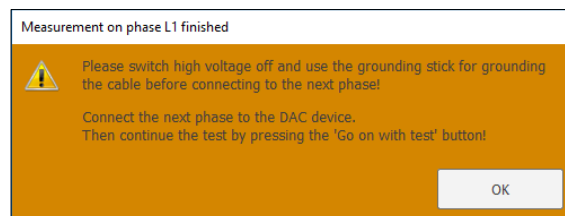


Figure 7.20: Grounding and connecting new phase warning

After the next phase for the measurement has been connected, the software waits for the measurement to continue (cf. Figure 7.21). Press the button *Go on with Test* to start the measurement. When starting the measurement for the new phase, you still have to select which phase is to be used for the measurement. As at the beginning of the measurement, a message box appears which phase should be measured next. In Figure 7.22 you can see that the first phase has already been



measured and only the two other phases are available. After selecting the corresponding phase, the cycle starts over the procedure again and the measurements are carried out for the corresponding phase.

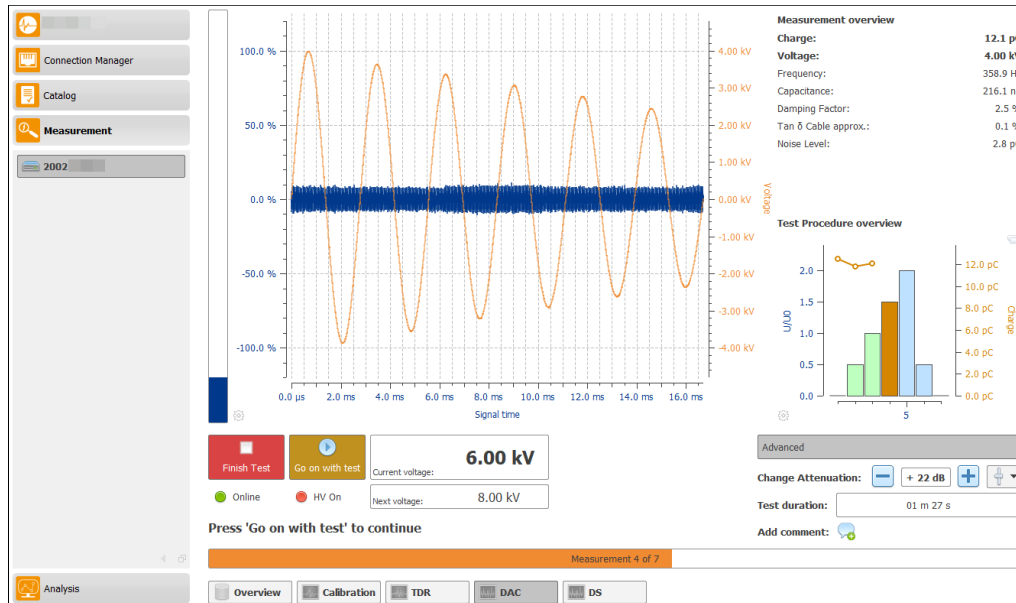


Figure 7.21: Wait for continue the measurement

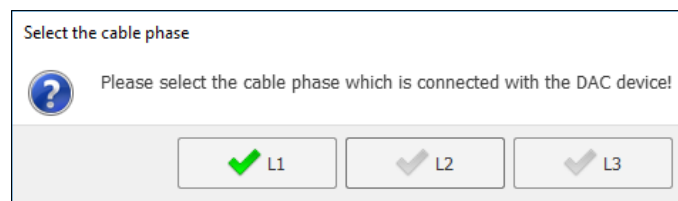


Figure 7.22: Select next phase

## 7.7 DAC Measurement (Advanced mode)

This chapter describes the UI elements which are available for a DAC measurement in Advanced mode. Figure 7.23 shows the general structure of the measurement surface. **A** displays the measurement results after each high-voltage shot. The **B** section contains buttons that can be used to navigate within a procedure, as well as buttons to perform a test or trigger a shot. **C** displays current data and selects measurement settings.

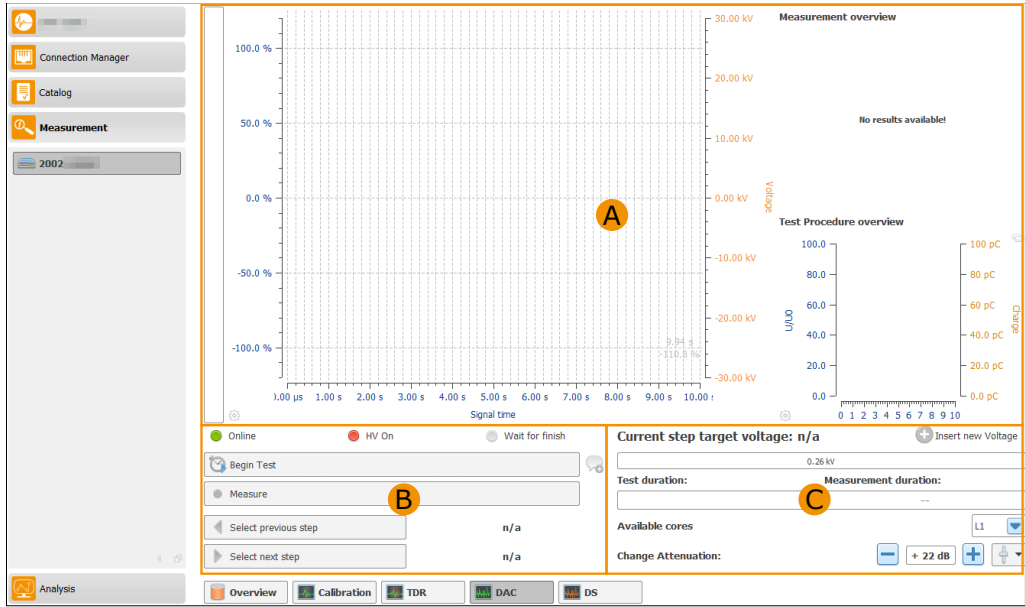


Figure 7.23: DAC measurement overview

### 7.7.1 UI elements

The following three sections describe the individual UI elements in detail. In Section 7.7.2 only these elements are referenced afterwards.

#### Result view elements

**A** in Figure 7.23 displays the measurement results of the last shot. The following elements (cf. Table 7.9) are available:

Element	Description
Diagram	Displays the last shot data.
Saturation	Shows the level of the last shot. Depending on this level, the attenuation may have to be adjusted.
Measurement overview	Displays the calculated results of the last shot.
Test procedure overview	Displays an overview of the completed measurements of the test. The voltage ratio $U/U_0$ for each individual shot is displayed and the calculated charge.

Table 7.9: Result view elements

Navigation elements

**B** in Figure 7.23 shows elements that are needed to perform a DAC measurement. Table 7.10 describes the elements.


Element	Description
LED's	<i>Online</i> The device is ready for use, the key switch and the emergency stop button are activated on the safety box. <i>HV ON</i> When this LED is red, the high voltage is switched on. <i>Wait for finish</i> This LED is green as long as a high-voltage measurement is performed (charging the cable and retrieving data).
Begin/Finish Test	This button can be used to start or end a test.
Measure	Triggers a new high-voltage shot.
Select previous step	Goes to the previous step in the procedure. Next to the button the voltage is displayed, which would correspond to the one before. Once the first step is reached <i>n.a.</i> is displayed.
Select next step	Goes to the next step in the procedure. Next to the button the voltage is displayed, which would correspond to the next one. Once the last step has been reached <i>n.a.</i> is displayed.
Comment 	Allows adding comments to the test (cf. Section 7.12.1 for detailed information).

Table 7.10: DAC measurement elements

Elements for the current values

**C** in Figure 7.23 contains element for setting the device and displays measurement values. Table 7.11 describes the elements.




Element	Description
<b>Current step target voltage</b>	Displays the current voltage value, which is approached at the next triggering of a shot.
<b>Insert new Voltage</b> 	Allows you to add a manual step for the next shot (cf. Section 7.12.2 for detailed information).
<b>Test duration</b>	Displays the time since the start of the test.
<b>Measurement duration</b>	Displays the duration from triggering a shot to evaluation.
<b>Available cores</b>	Contains a list of cores stored in the cable. This makes it possible to assign the individual shots to the selected phase.
<b>Change Attenuation</b>	Allows you to adjust the attenuation. The buttons  and  increase or decrease the attenuation.

Table 7.11: Current DAC measurement value elements

### 7.7.2 Perform a DAC measurement in advanced mode

In order to carry out a DAC measurement, the high voltage must first be switched on at the safety box. Furthermore, it is necessary to start a new test. A test is necessary so that the individual shots can be assigned to this test. When starting a test, a warning message (cf. Figure 7.16) is displayed that the calibrator must be removed. After confirming the warning, the button *Begin test* will be renamed *Finish test*. Now it is possible to start with the measurement. For this the first shot can be released by pressing the button *Measure*. This means that the cable is charged up to the specified voltage and the measurement is then recorded. In the area **A** (Figure 7.23) the measured values and the diagram are hidden (Figure 7.24) until the new measured values are available.



Before a high-voltage measurement can be carried out, the calibrator **must** be removed! The calibrator will be damaged if it is not removed before the high voltage test.

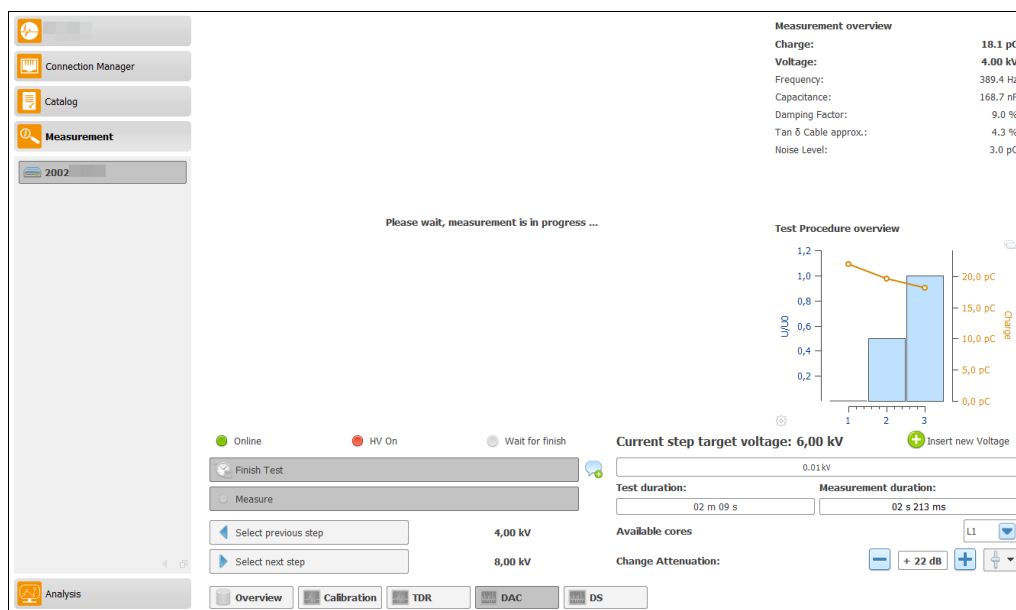


Figure 7.24: Disabled result view during running measurement

After the shot has been carried out and the measurement results are displayed, it is necessary to check whether the measurement settings need to be changed.



In order to ensure good reflection detection, it is necessary that the level of the charge can be clearly recognized. For this purpose, the attenuation can be increased or decreased with the buttons **+** and **-**. However, the control of the charge level must not reach or exceed the 100% mark, as the DAC system would be overloaded and signals are cut off!

If it should be necessary to change the attenuation, the current shot can be restarted after the change by means of the button *Measure*. Otherwise, you can go to the next step of the procedure and perform the next measurement. This procedure is carried out until the end of the test process. A test can be completed using the *Finish Test* button (cf. Figure 7.25).

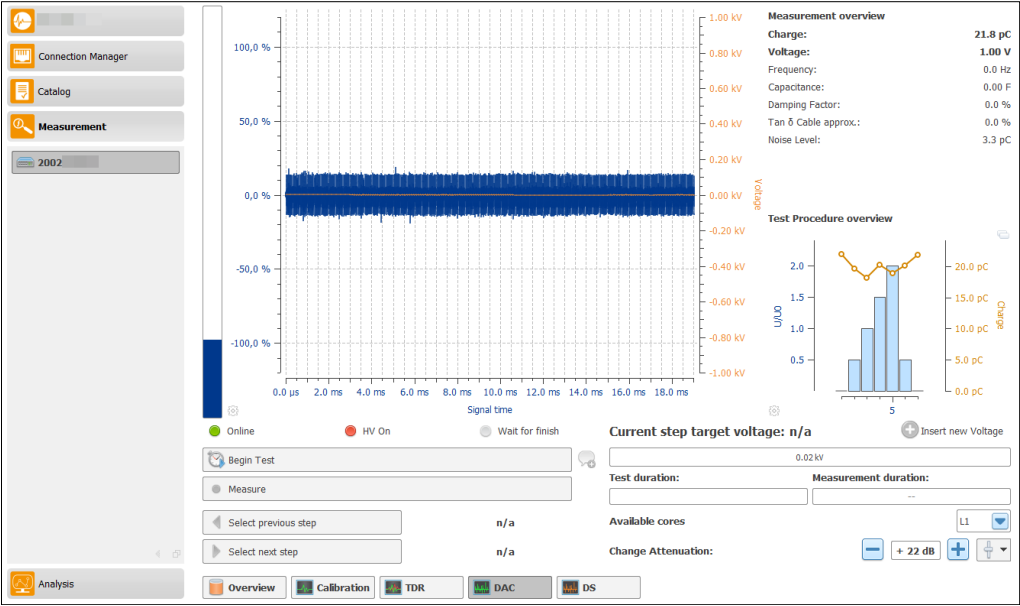


Figure 7.25: Finished test

## 7.8 Double side Measurement (Simple mode)

This chapter describes the UI elements that are available for a Double side measurement in Simple mode. Figure 7.26 shows the general structure of the measurement surface if now high voltage is switched on. In this case the **B** area displays the information for switching on the high voltage before a test could be started. After switching on the high voltage the user interface changes the **B** area like shown in Figure 7.27. The area **B** contains now three part which are available during the measurement. Now the **B** area contains buttons available for performing the test and showing the current status for high voltage. **C** is used to display current data and the advanced options. In the area **D** the current progress and the status of the measurement is displayed.

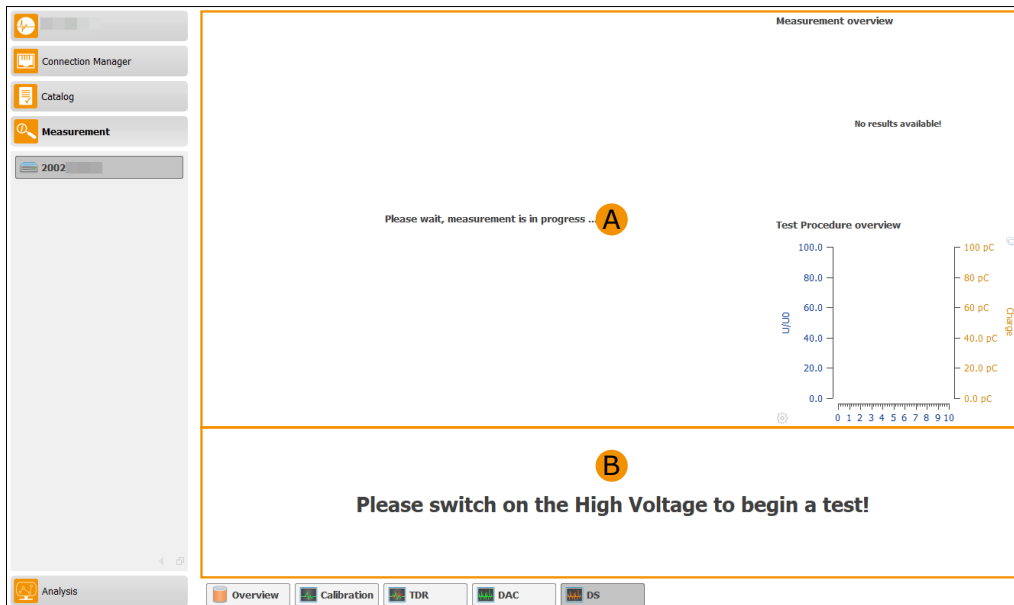


Figure 7.26: Double side measurement overview high voltage off (simple mode)

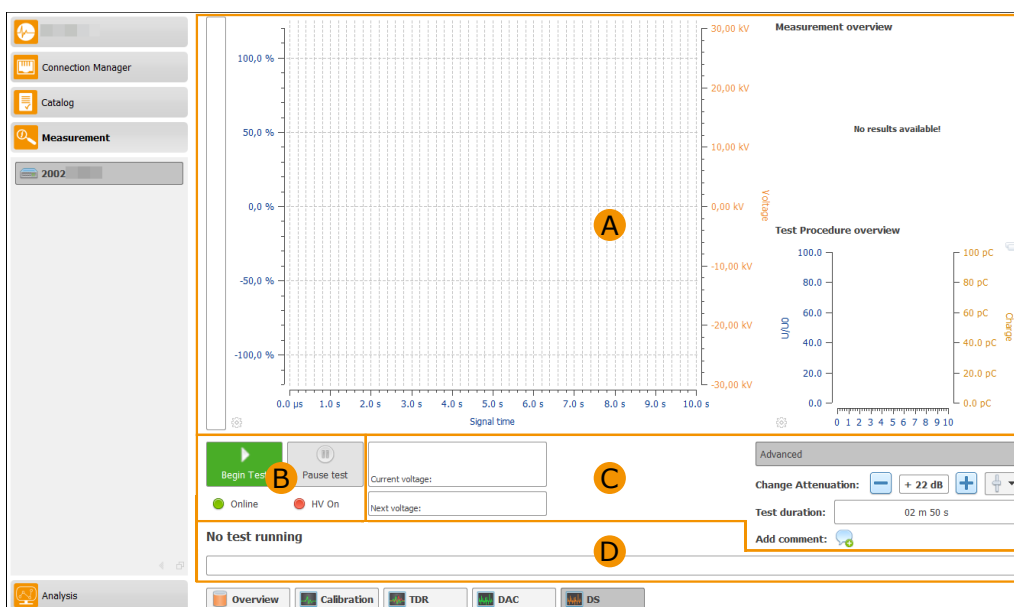


Figure 7.27: Double side measurement overview high voltage on (simple mode)

### 7.8.1 UI elements for simple mode

The following three sections describe the individual UI elements in detail. In Section 7.8.2 only these elements are referred to afterwards.

#### Result view elements

**A** in Figure 7.27 displays the measurement results of the last shot. The following elements (cf. Table 7.12) are available:

Element	Description
<b>Diagram</b>	Displays the last shot data.
<b>Saturation</b>	Shows the level of the last shot. Depending on this level, the attenuation may have to be adjusted.
<b>Measurement overview</b>	Displays the calculated results of the last shot.
<b>Test procedure overview</b>	Shows the test procedure for the current measurement. The individual shots are highlighted in color to indicate whether they have already been completed, are in execution or have yet to be executed. The voltage ratio $U/U_0$ for each single shot is displayed and at the same time the calculated charge.

Table 7.12: Result view elements

#### Navigation elements


**B** in Figure 7.27 shows elements that are needed to perform a Double side measurement. Table 7.13 describes the elements.

Element	Description
<b>Begin/Finish Test</b>	This button can be used to start or end a test.
<b>LED's</b>	<i>Online</i> The device is ready for use, the key switch and the emergency stop button are activated on the safety box. <i>HV ON</i> When this LED is red, the high voltage is switched on.
<b>Pause</b>	The automatic execution of the procedure can be interrupted and continued again.

Table 7.13: Double side measurement elements



Elements for the current values

 in Figure 7.27 contains element for setting the device and displays measurement values. Table 7.14 describes the elements.



Element	Description
Current voltage	Displays the current voltage value, which is approached at the next triggering of a shot.
Next voltage	Displays the next voltage value which is used for the next procedure step.
Advanced	This button can be used to show or hide additional information. The additional elements includes attenuation change elements, the measurement time for the current test and it is possible to specify a comment for the test via the button  (see section 7.12.1 for detailed information).

Table 7.14: Current Double side measurement value elements

Status information elements

 in Figure 7.27 depicted the status elements for the simple measurement mode. The upper line contains the information in which step the software is currently perform. The lower progress bar depicted the current progress of the procedure.

### 7.8.2 Perform a Double side measurement in simple mode

A Double side measurement in simple mode is almost completely automatic. The user has little interaction to perform, but is responsible for ensuring security. In this mode, the specified test procedure is performed. The next steps are automatically taken and the amplifier stages are switched according to the set parameters (cf. Section 7.1.3).



For a double side measurement each zero kV shot will be automatically skipped!

For starting a test, the high voltage on the safety box must first be switched on. When starting a test, a warning message (cf. Figure 7.28) indicates that the calibrator must be removed.



Before a high-voltage measurement can be carried out, the calibrator **must** be removed! The calibrator will be damaged if it is not removed before the high voltage test.

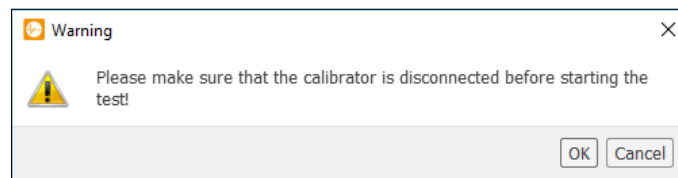


Figure 7.28: Calibrator removal warning

If the cable to be tested is a multi-conductor cable, the phase of the cable to be measured is still queried (cf. Figure 7.29). If the phase has been selected or a single-core cable is involved, the first shot of the procedure is immediately started.

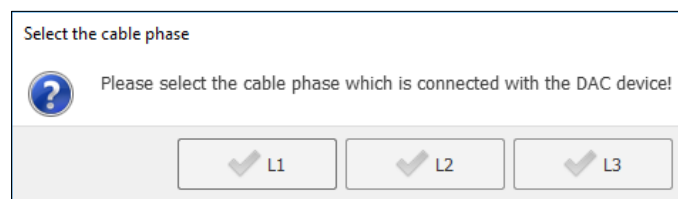


Figure 7.29: Phase selection

After each shot, the measurement results for this shot are displayed. On the basis of these measurement results, the software decides whether the gain of the device must be changed. If this is the case, this is done automatically. If the level is too high, a warning message is displayed on how to proceed with the further measurement. The possibilities are described in Table 7.15:

Element	Description
<b>Repeat measurement</b>	The last shot is repeated with a lower amplification.
<b>Continue with test</b>	The test continues with lower amplification. The next step is automatically taken.
<b>Abort</b>	The test is aborted.

Table 7.15: Possibilities for continuing the Double side measurement

After each shot the time is counted down until the next shot can be taken (cf. Figure 7.30). This time can be set in the Simple Mode measurement settings (cf. Section 7.1.3). In the test procedure overview you can see the currently measured charge value for the individual shots. All completed shots are displayed as green bars. The orange bar marks the next step in the procedure. All blue bars represent the steps that still need to be performed.

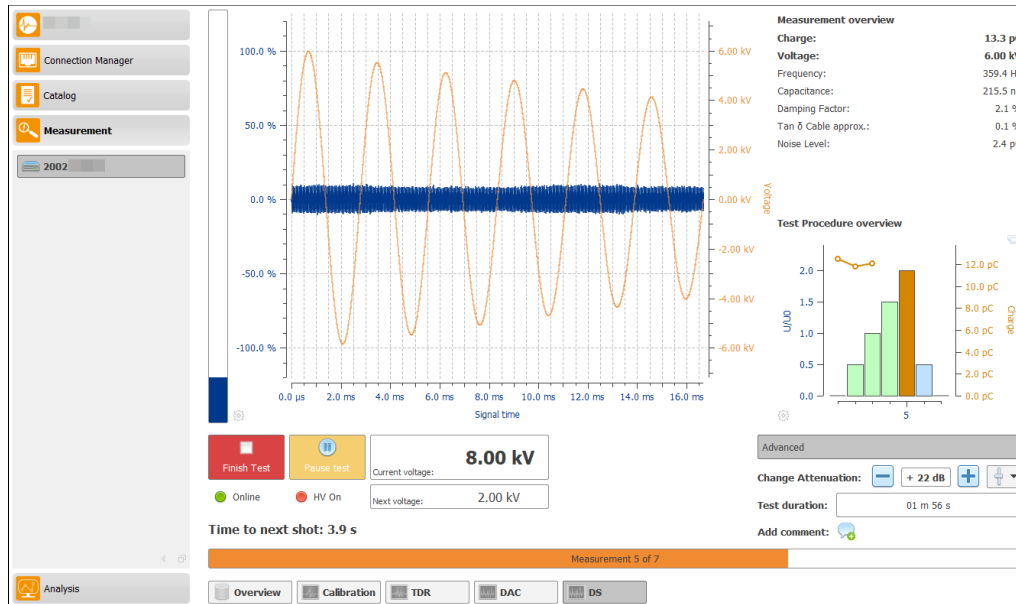


Figure 7.30: Waiting for next measurement

After the last shot of the procedure has been done, the test is automatically terminated if it is a single-core cable. If the cable consists of several conductors, the user is asked whether the measurement should be performed with the next phase (cf. Figure 7.31), or whether the test should be terminated.

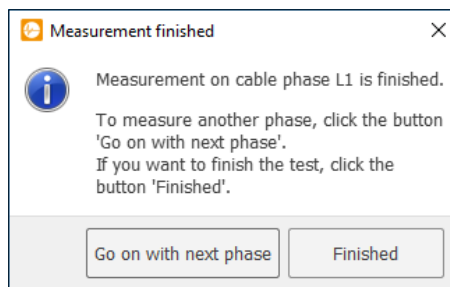


Figure 7.31: Continue with next phase

If the measurement is to be continued with the next phase, the message appears that the high voltage is to be switched off, the grounding stick is used for earthing and then the next phase can be connected (cf. Figure 7.32).

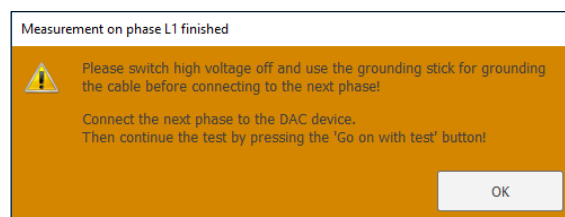


Figure 7.32: Grounding and connecting new phase warning

After the next phase for the measurement has been connected, the software waits for the measurement to continue (cf. Figure 7.33). Press the button *Go on with Test* to start the measurement. When starting the measurement for the new phase, you still have to select which phase is to be used for the measurement. As at the beginning of the measurement, a message box appears which phase should be measured next. In Figure 7.34 you can see that the first phase has already been measured and only the two other phases are available. After selecting the corresponding phase, the cycle starts over the procedure again and the measurements are carried out for the corresponding phase.



Figure 7.33: Wait for continue the measurement

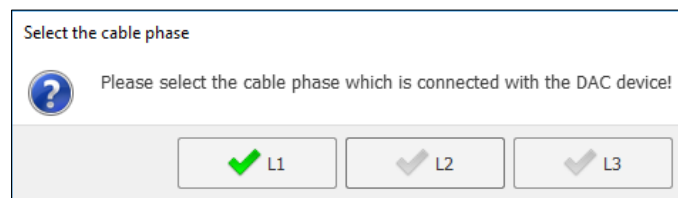


Figure 7.34: Select next phase

## 7.9 Double side Measurement (Advanced mode)

This chapter describes the UI elements which are available for a Double side measurement in Advanced mode. Figure 7.35 shows the general structure of the measurement surface. **A** displays the measurement results after each high-voltage shot. The **B** section contains buttons that can be used to navigate within a procedure, as well as buttons to perform a test or trigger a shot. **C** displays current data and selects measurement settings.

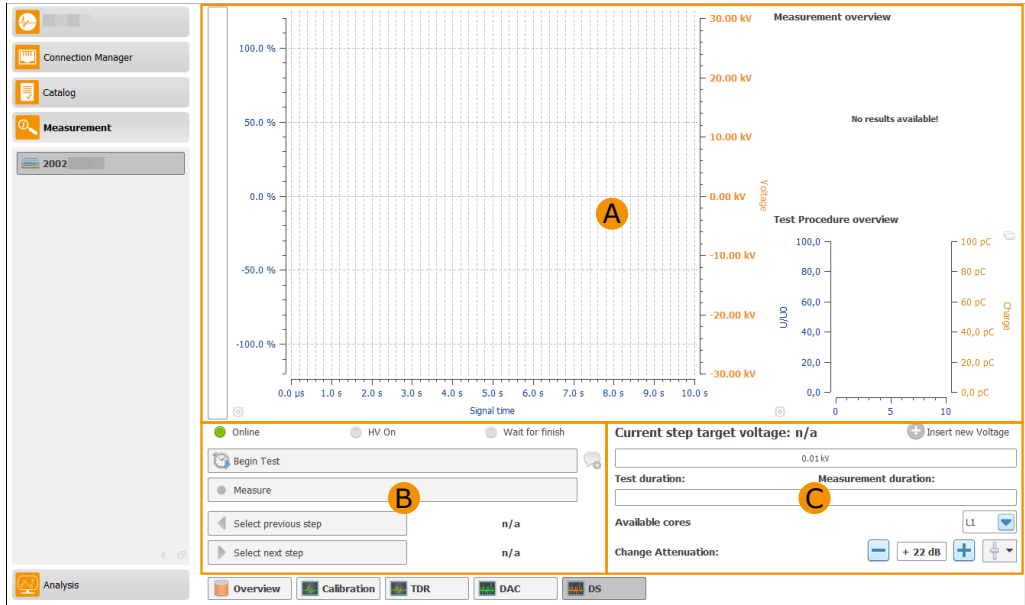


Figure 7.35: Double side measurement overview

### 7.9.1 UI elements

The following three sections describe the individual UI elements in detail. In Section 7.7.2 only these elements are referenced afterwards.

#### Result view elements

**A** in Figure 7.35 displays the measurement results of the last shot. The following elements (cf. Table 7.16) are available:

Element	Description
<b>Diagram</b>	Displays the last shot data.
<b>Saturation</b>	Shows the level of the last shot. Depending on this level, the attenuation may have to be adjusted.
<b>Measurement overview</b>	Displays the calculated results of the last shot.
<b>Test procedure overview</b>	Displays an overview of the completed measurements of the test. The voltage ratio $U/U_0$ for each individual shot is displayed and the calculated charge.

Table 7.16: Result view elements

### Navigation elements

**B** in Figure 7.35 shows elements that are needed to perform a double side measurement. Table 7.17 describes the elements.


Element	Description
<b>LED's</b>	<p><i>Online</i> The device is ready for use, the key switch and the emergency stop button are activated on the safety box.</p> <p><i>HV ON</i> When this LED is red, the high voltage is switched on.</p> <p><i>Wait for finish</i> This LED is green as long as a high-voltage measurement is performed (charging the cable and retrieving data).</p>
<b>Begin/Finish Test</b>	This button can be used to start or end a test.
<b>Measure</b>	Triggers a new high-voltage shot.
<b>Select previous step</b>	Goes to the previous step in the procedure. Next to the button the voltage is displayed, which would correspond to the one before. Once the first step is reached <i>n.a.</i> is displayed.
<b>Select next step</b>	Goes to the next step in the procedure. Next to the button the voltage is displayed, which would correspond to the next one. Once the last step has been reached <i>n.a.</i> is displayed.
<b>Comment</b> 	Allows adding comments to the test (cf. Section 7.12.1 for detailed information).

Table 7.17: Double side measurement elements

### Elements for the current values

**C** in Figure 7.35 contains element for setting the device and displays measurement values. Table 7.18 describes the elements.




Element	Description
<b>Current step target voltage</b>	Displays the current voltage value, which is approached at the next triggering of a shot.
<b>Insert new Voltage</b> 	Allows you to add a manual step for the next shot (cf. Section 7.12.2 for detailed information).
<b>Test duration</b>	Displays the time since the start of the test.
<b>Measurement duration</b>	Displays the duration from triggering a shot to evaluation.
<b>Available cores</b>	Contains a list of cores stored in the cable. This makes it possible to assign the individual shots to the selected phase.
<b>Change Attenuation</b>	Allows you to adjust the attenuation. The buttons  and  increase or decrease the attenuation.

Table 7.18: Current Double side measurement value elements

### 7.9.2 Perform a Double side measurement in advanced mode

In order to carry out a Double side measurement, the high voltage must first be switched on at the safety box. Furthermore, it is necessary to start a new test. A test is necessary so that the individual shots can be assigned to this test. When starting a test, a warning message (cf. Figure 7.28) is displayed that the calibrator must be removed. After confirming the warning, the button *Begin test* will be renamed *Finish test*. Now it is possible to start with the measurement.



For a double side measurement each zero kV shot will be automatically skipped!

For this the first shot can be released by pressing the button *Measure*. This means that the cable is charged up to the specified voltage and the measurement is then recorded. In the area **A** (Figure 7.35) the measured values and the diagram are hidden (Figure 7.36) until the new measured values are available.



Before a high-voltage measurement can be carried out, the calibrator **must** be removed! The calibrator will be damaged if it is not removed before the high voltage test.

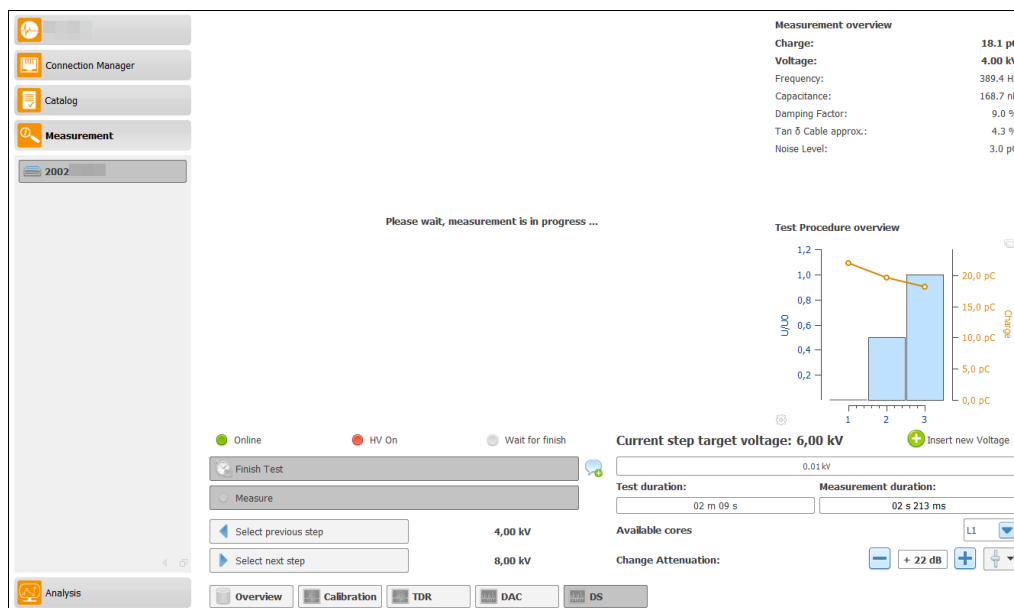




Figure 7.36: Disabled result view during running measurement

After the shot has been carried out and the measurement results are displayed, it is necessary to check whether the measurement settings need to be changed.



In order to ensure good reflection detection, it is necessary that the level of the charge can be clearly recognized. For this purpose, the attenuation can be increased or decreased with the buttons  and . However, the control of the charge level must not reach or exceed the 100% mark, as the DAC system would be overloaded and signals are cut off!

If it should be necessary to change the attenuation, the current shot can be restarted after the change by means of the button *Measure*. Otherwise, you can go to the next step of the procedure and perform the next measurement. This procedure is carried out until the end of the test process. A test can be completed using the *Finish Test* button (cf. Figure 7.37).



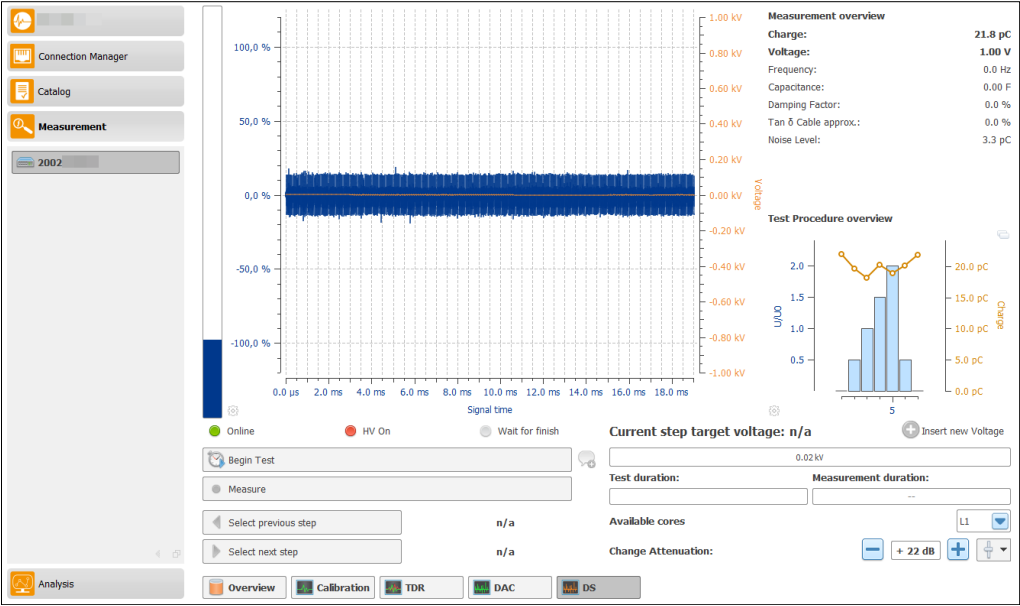


Figure 7.37: Finished test

## 7.10 VLF measurement

This chapter describes the UI elements that are available for a VLF measurement. Figure 7.38 shows the general structure of the measurement surface. **A** represents the time course of the measurement. The **B** area is used to display the current measurement results for the last measurement and the complete test procedure during the test. The **C** area contains buttons that can be used to navigate within a procedure and the button to start the test. The currently selected settings are displayed in the **D** area.

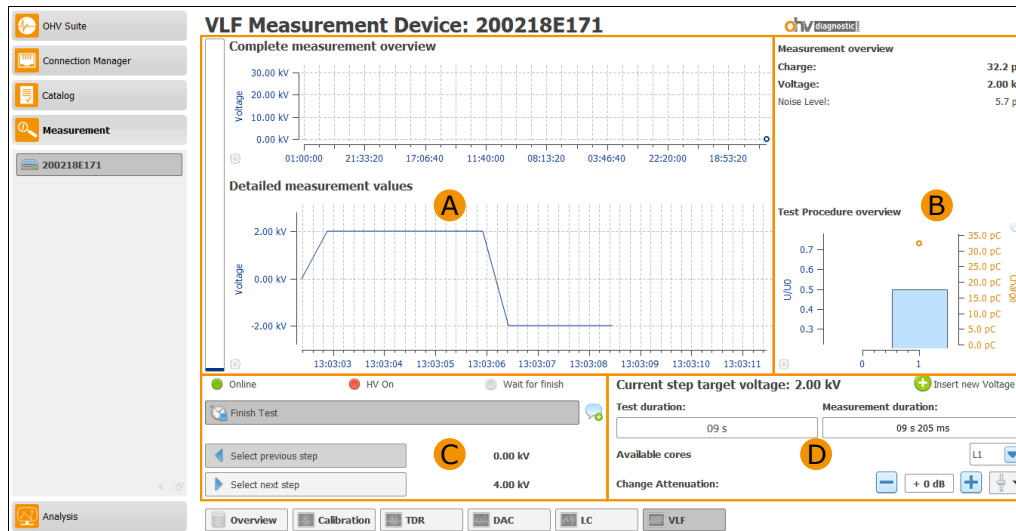


Figure 7.38: VLF measurement overview

### 7.10.1 UI elements

The following four sections describe the individual UI elements in detail. In section 7.10.2 only these elements are referenced afterwards.

#### VLF measurement overview

For the display of the VLF measurement, in the area **A** in Figure 7.38 the time course of the VLF measurement is displayed. The upper diagram shows the complete process and the lower diagram shows the more detailed process. The data for the complete process are updated all 30 s with a new voltage value. The added voltage value is the maximum of the test since the last addition to the diagram. The detailed process diagram contains a new voltage value for all 500 ms, which corresponds to the current voltage value of the measurement. The maximum display time for this diagram is 1 min. The saturation of the last VLF shot is displayed to the left of the diagrams. The attenuation level can be adjusted with the aid of this saturation level.

#### Measurement results

**B** in Figure 7.38 displays the current measurement results of the last shot, as well as the test procedure for the VLF measurement. The current results are displayed in the upper area. The lower area contains an overview of the VLF measurements performed. For each measurement, the used voltage value and the maximum charge are displayed in a diagram.

#### VLF navigation elements

**C** in Figure 7.38 shows elements (cf. Table 7.19) that are needed to perform a VLF measurement.



Element	Description
<b>LED's</b>	<p><i>Online</i> The device is ready for use, the key switch and the emergency stop button are activated on the safety box.</p> <p><i>HV ON</i> When this LED is red, the high voltage is switched on.</p> <p><i>Wait for finish</i> This LED is green as long as measurement data is available.</p>
<b>Begin/Finish Test</b>	This button can be used to start or end a test.
<b>Select previous step</b>	Go to the previous step in the procedure. Behind the button the voltage is displayed, which would correspond to the one before. Once the first step is reached <i>n.a.</i> is displayed.
<b>Select next step</b>	Go to the next step in the procedure. Behind the button the voltage is displayed, which would correspond to the next one. Once the last step has been reached <i>n.a.</i> is displayed.
<b>Comment</b> 	Allows adding comments to the test (cf. Section 7.12.1 for detailed information).

Table 7.19: VLF Measurement overview elements I

#### Elements for the current values

 in Figure 7.38 displays the current values of the VLF measurement. In Table 7.20 the different elements will be described.




Element	Description
<b>Current step target voltage</b>	Displays the current voltage value, which is approached at the next triggering of a shot.
<b>Insert new Voltage</b> 	Allows you to add a manual step for the next shot (cf. Section 7.12.2 for detailed information).
<b>Test duration</b>	Displays the time since the start of the test.
<b>Measurement duration</b>	Displays the measurement duration at the current voltage level. This time is reset when switching to a new voltage level.
<b>Available cores</b>	Contains a list of cores stored in the cable. This makes it possible to assign the individual shots to the selected phase.
<b>Change Attenuation</b>	Allows you to adjust the attenuation. The buttons  and  increase or decrease the attenuation.

Table 7.20: VLF Measurement overview elements II

### 7.10.2 Perform a VLF measurement

In order to carry out a VLF measurement, the high voltage must first be switched on at the safety box. Furthermore, it is necessary to start a new test. A test is necessary so that the individual shots can be assigned to this test during the test. When starting a test, a warning message (cf. Figure 7.16) is displayed that the calibrator must be removed.



Before a high-voltage measurement can be carried out, the calibrator **must** be removed! The calibrator will be damaged if it is not removed before the high voltage test.

After confirming the warning, the button *Begin Test* is renamed to *End Test* and the VLF measurement is started automatically. With VLF measurements, a measurement is carried out for each oscillation process and the data is evaluated. After evaluation, the measurement results are displayed. The saturation level should be observed during the VLF measurement and, if necessary, the attenuation level should be adjusted. As soon as the measurement time at the desired voltage level is reached, the buttons *Select previous step* or *Select previous step* can be used to switch into the new voltage level. This is done until the desired VLF test can be completed. When this has been achieved, the test can be completed with the help of the button *End Test* (see Figure 7.39).

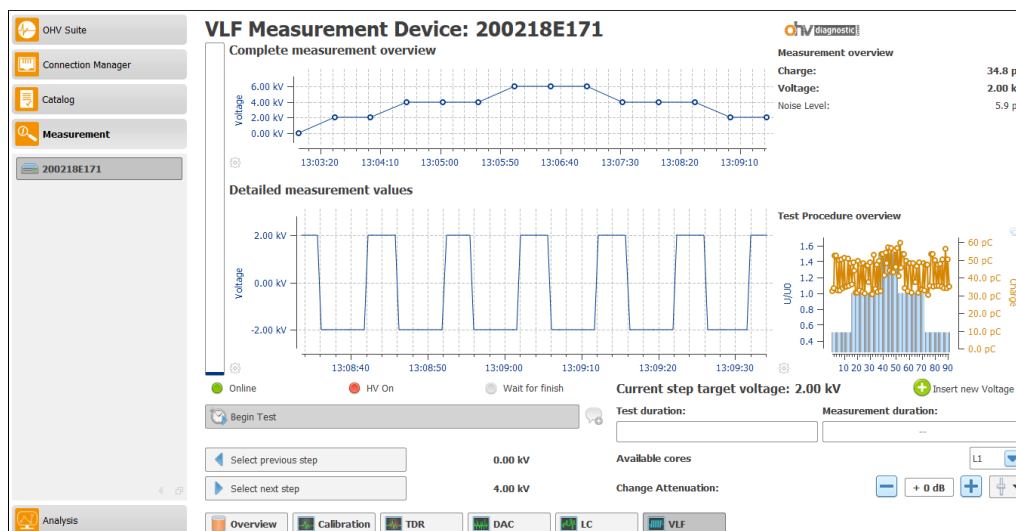


Figure 7.39: VLF measurement finished

## 7.11 Leakage current measurement (LC measurement)

This chapter describes the surface elements that are available for a leakage current measurement (LC). Figure 7.40 shows the general structure of the measurement surface. **A** shows the complete course of the LC measurement. In the area **B** the more detailed course for the leakage current is displayed. The **C** area contains buttons that can be used to navigate within a procedure and the button to start the test. **D** is used to display current data.

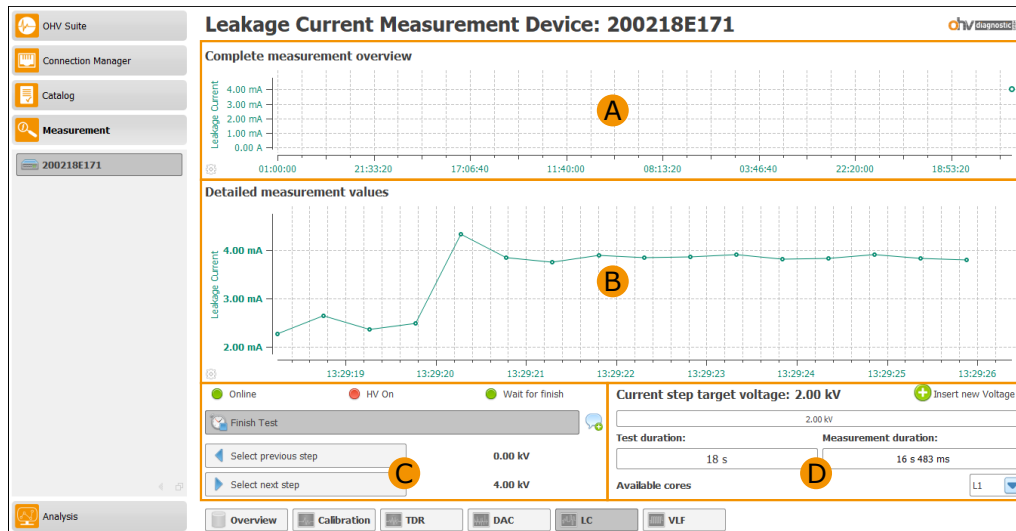


Figure 7.40: Leakage current measurement overview

### 7.11.1 UI elements

The following four sections describe the individual UI elements in detail. In section 7.11.2 only these elements are referenced afterwards.

#### Complete overview of the leakage current measurement

**A** in Figure 7.40 shows the complete course of the leakage current during the test in a diagram. Thus all 30 s a new value is added. The added leakage current value is the maximum of the leakage current since the last addition.

#### Detailed overview of the leakage current measurement

**B** in Figure 7.40 shows the more detailed curve of the leakage current in a diagram. Thus all 500 ms a new value is added. The added value is the current leakage current at that time. The maximum display time for this diagram is 1 min.

#### Navigation elements

**C** in Figure 7.40 shows elements (cf. Table 7.21) that are needed to perform a leakage current measurement.


Element	Description
<b>LED's</b>	<p><i>Online</i> The device is ready for use, the key switch and the emergency stop button are activated on the safety box.</p> <p><i>HV ON</i> When this LED is red, the high voltage is switched on.</p> <p><i>Wait for finish</i> This LED is green as long as measurement data is available.</p>
<b>Begin/Finish Test</b>	This button can be used to start or end a test.
<b>Select previous step</b>	Go to the previous step in the procedure. Behind the button the voltage is displayed, which would correspond to the one before. Once the first step is reached <i>n.a.</i> is displayed.
<b>Select next step</b>	Go to the next step in the procedure. Behind the button the voltage is displayed, which would correspond to the next one. Once the last step has been reached <i>n.a.</i> is displayed.
<b>Comment</b> 	Allows adding comments to the test (cf. Section 7.12.1 for detailed information).

Table 7.21: LC Measurement overview elements I

Current value elements

 in Figure 7.40 displays the current values for the leakage current measurement.


Element	Description
Current step target voltage	Displays the current voltage value, which is approached at the next triggering of a shot.
Insert new Voltage 	Allows you to add a manual step for the next shot (cf. Section 7.12.2 for detailed information).
Test duration	Displays the time since the start of the test.
Measurement duration	Displays the measurement duration at the current voltage level. This time is reset when switching to a new voltage level.
Available cores	Contains a list of cores stored in the cable. This makes it possible to assign the individual shots to the selected phase.

Table 7.22: LC Measurement overview elements II

7.11.2 Performing a LC measurement

For a leakage current measurement to be carried out, the high voltage on the safety box must be switched on first. Furthermore, it is necessary to start a new test. When starting a test, a warning message (see Figure 7.16) indicates that the calibrator must be removed.



Before a high-voltage measurement can be carried out, the calibrator **must** be removed! The calibrator will be damaged if it is not removed before the high voltage test.

After confirming the warning, the button *Begin Test* is renamed to *End Test* and the measurement is started automatically. As soon as the measurement time at the desired voltage level is reached, the buttons *Select previous step* or *Select previous step* can be used to set a new voltage level. This is done until the test can be completed with the help of the button *End Test* (see Figure 7.41).

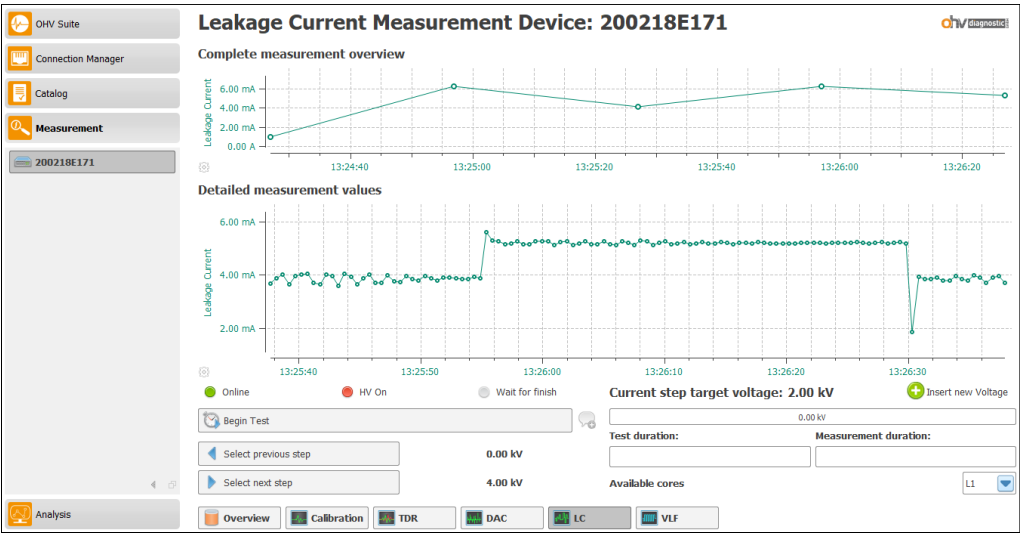



Figure 7.41: LC measurement finished



## 7.12 Control elements inside different measure modes

This section contains information about UI elements contained in the different measurement modes.

### 7.12.1 Add a comment

It is possible to add comments to a test. As long as a test has not been completed, the comment can be added, extended or deleted. For this purpose, there is the symbol  to the right of the *Finish Test* button. Clicking this icon opens a pop-up window (cf. Figure 7.42) where the comment can be entered. After the comment has been entered, you can use the *Save* button to add it to the test.

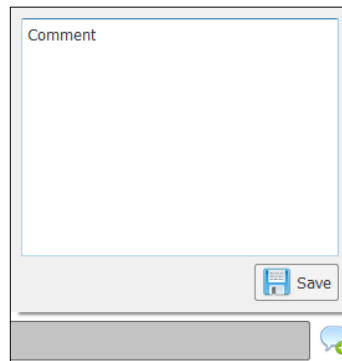



Figure 7.42: Add a comment to the test

### 7.12.2 Add new voltage level

During a test, it may be necessary to deviate from the currently selected procedure and add new steps. This can be done by clicking on the  icon to the right of the current target voltage. This opens a pop-up window (cf. Figure 7.43) with which it is possible to enter a new target voltage for the next shot.



Adding a new target voltage does not change the stored procedure, which was created in the catalog (cf. Section 6.3.6)!



Figure 7.43: Add new high voltage shot

# DAC analysis

This chapter describes the interface elements that are available for evaluating existing measurements and creating reports with the results. The Section 8.1 describes the different settings for the analysis. In Section 8.2 the selection of a test is explained and in which way the test can be open. The different UI elements which are available for analyzing a test are depicted in Section 8.3. The Sections 8.4 and 8.5 describe extended analysis options for importing old tests or providing and displaying tests for a double side analysis.

## 8.1 Analysis Configuration

This section describes the different configuration settings for analyzing tests. Two different modes are available: Simple mode and Advanced mode. In Figure 8.1 the Simple Analysis mode is shown. In area **A** you can switch between the different modes using the *Simple Mode* and *Advanced Mode* buttons. The following sections describe the individual UI elements for the selected modes.

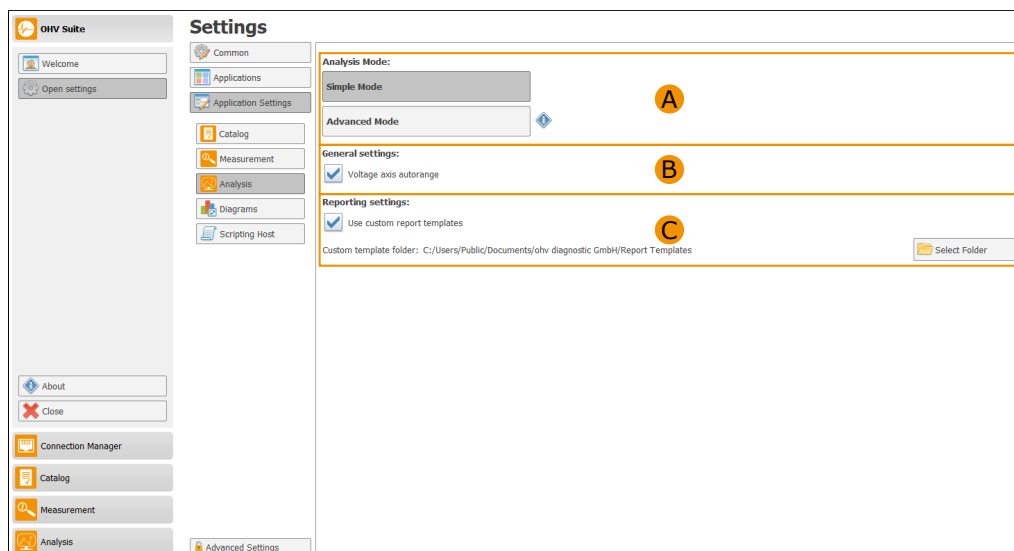



Figure 8.1: Analysis Configuration (Simple Mode)

### 8.1.1 General Settings

The general analysis settings (see **B** in Figure 8.1) are used for all existing analyses. The check box *Voltage axis autorange* activates the automatic axis scaling of the voltage axis for each selected analysis. If this option is not active, the voltage axis is displayed with a fixed scaling. This maximum scaling depends on the DAC device used for the test.


### 8.1.2 Reporting Settings

The reporting settings (see  in Figure 8.1) are used to enable or disable the custom report template support for word reporting. If this option is enabled it is possible to select a folder where to find the custom report templates. How to define a custom word template are detailed described in chapter [refchap:DacWordReportingTemplate](#).

### 8.1.3 Simple Mode

The simple analysis mode has no further settings. All additional UI elements that were activated in extended mode are hidden in simple mode.




### 8.1.4 Advanced Mode

The advanced analysis mode provides additional settings for the analysis. In Figure 8.2 () you can see the options for this mode. In addition to the setting options shown here, further elements are displayed in the analysis views. These are explained separately in the sections where they are displayed.


The check box *Double Side Analysis* enables an additional sub-application with the name *Double Side* which is displayed in the analysis application (left area of the application). The surface available for this application is explained in more detail in Section 8.5.

The *Data Import Support* check box activates another sub-application which allows you to import tests from the old measurement software and perform an analysis with the latest software version. The UI element and how it works is described in section 8.4.

Under the advanced settings you can chose a noise reduction wavelet filtering. This setting will be used for the detection of the reflections during the analysis. Changes to this parameter will be applied when a new reflection detection is performed. Disabling the noise reduction will use the raw data to detect the reflections. Otherwise the selected filter order is used for the reflection detection. The filtering is also applied to the measurements when a new shot is selected. The reflection detection will take longer when a higher filter order is selected.

An other option to adjust the reflection detection is to use the *Signal Noise Ratio* slider to set the distance between the background noise and the signal. The factor shown inside the figure means that the signal must be 5 times as high as the noise level during the measurement. The button  or  allow to increase or decrease the signal noise ratio by 0.1. The  button resets the signal noise ratio to the default value of 2.0.

Additionally the order of reflection data processing can be chosen from the combo box right next to *Select sorting order of reflection*. Choosing *Sort by shot index* will order the detected reflections by the index of the shot by which they were detected. When selected *Sort by location*, the reflections will be sorted by the distance at which they were detected.

The analysis of the data are using default parameters to detect the reflections. For updating these parameters the button  can be used. This will check if a new version is available and will be automatically download the new version. After restarting the application the new parameters can be used for the analysis.

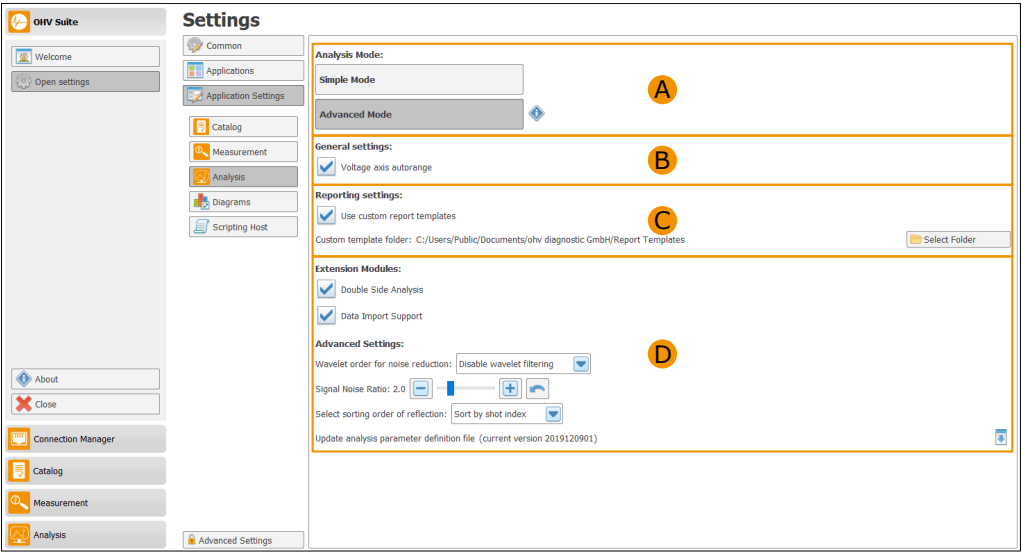


Figure 8.2: Analysis Configuration (Advanced Mode)

## 8.2 Test Browser

After a test is finished, the measurements are saved in the database. In order to inspect a previously recorded test, a test must be selected in the test browser. In Figure 8.3 the initial window of the test browser is displayed.

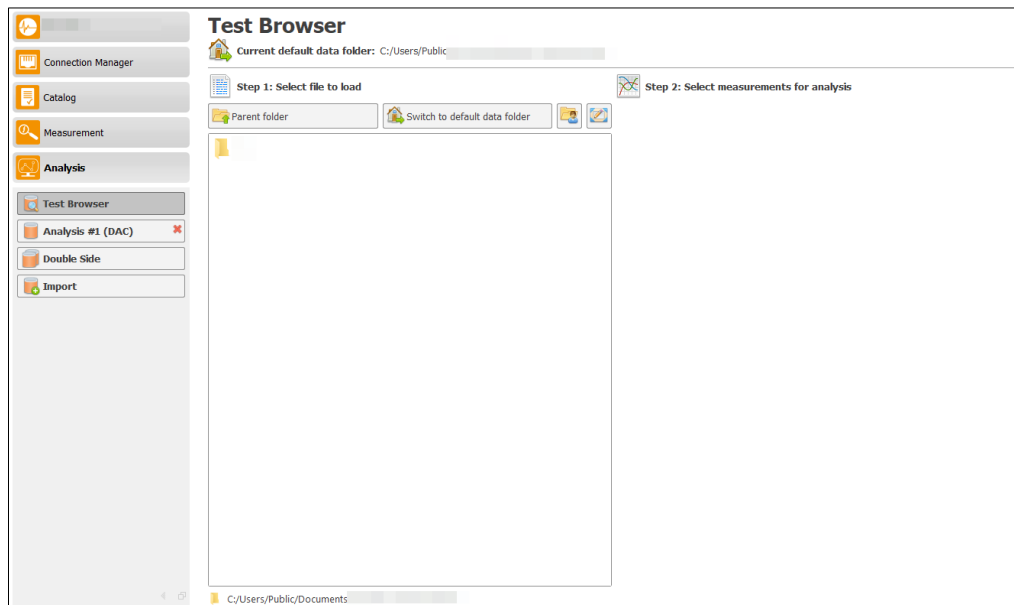


Figure 8.3: DAC analysis test browser

### 8.2.1 Select a test to analyze

This section describes how a test can be selected for the analyzation. Figure 8.4 shows the steps which are required for selecting a test. The left area (A) contains a browser window which displays all available files and folders which can be selected. On the top of this area the button *Parent folder* allows to change in the higher folder level. The button *Switch to default data folder* goes to the default data folder which is selected inside the DAC catalog configuration (cf. Section 6.1). The button goes to the *home directory* and button changes the folder to the *desktop*. For opening a folder a single left mouse click is used. Selecting a single measurement file will show the detailed information on the right upper side (B). The list in B contains all found measurements which are stored inside the file. Each of the measurement is shown with the type of the measurement, the date when the measurement was performed and the number of shot which were done during the measurement. The next step is to select a measurement of the list. This will provide more detailed information of the measurement in C. Additionally the button *Analyze this measurement* is show, which can be used to start the analysis of the selected measurement. When this button is click the analysis is started and selected analysis is automatically shown. The next sections describes the detailed analysis views.

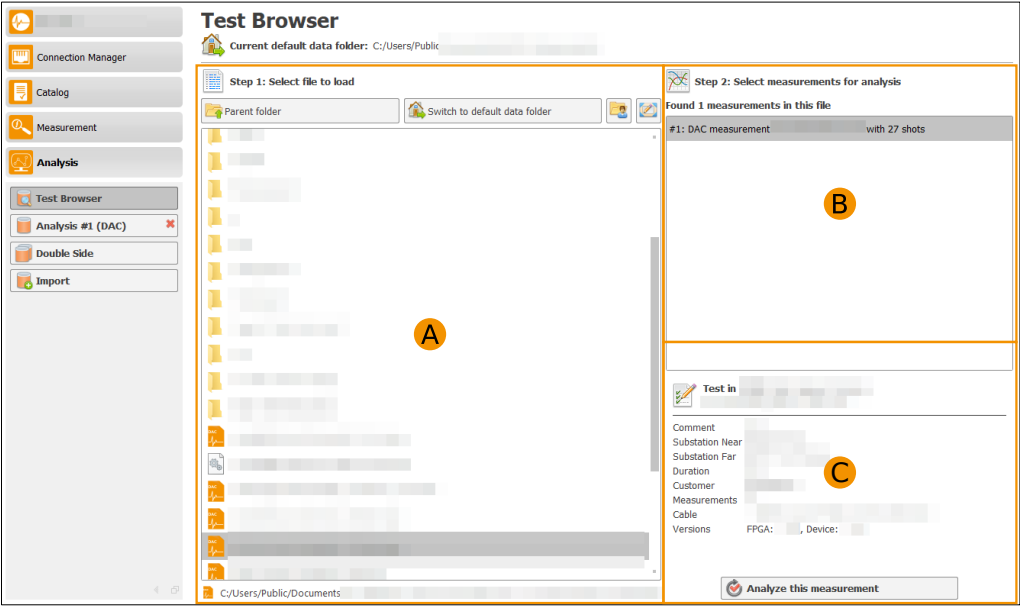
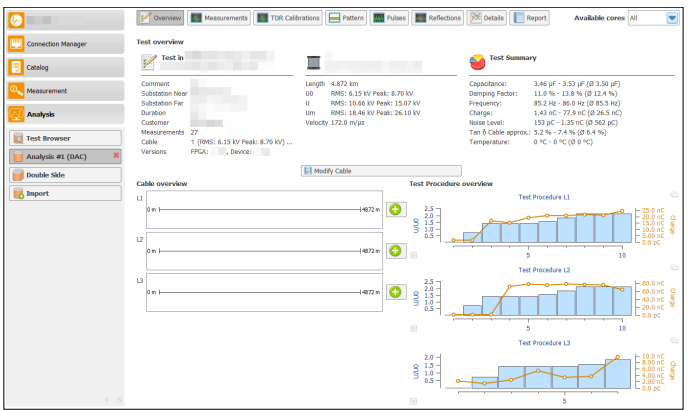


Figure 8.4: Select a test to analyze

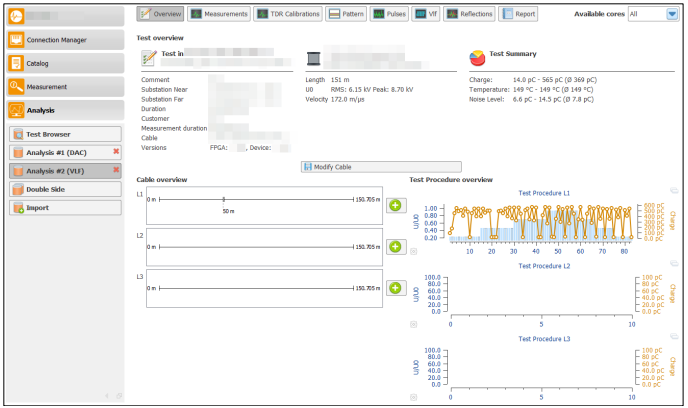
### 8.3 Result Overview after Test

Selecting the open analysis displays an overview of the results. Detailed data views can be viewed in several diagrams. The following table shows an overview of the available possibilities of display according to the type of check.

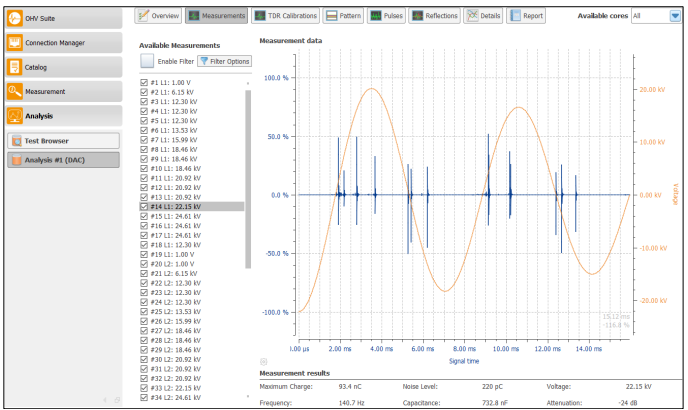
Overview (DAC)



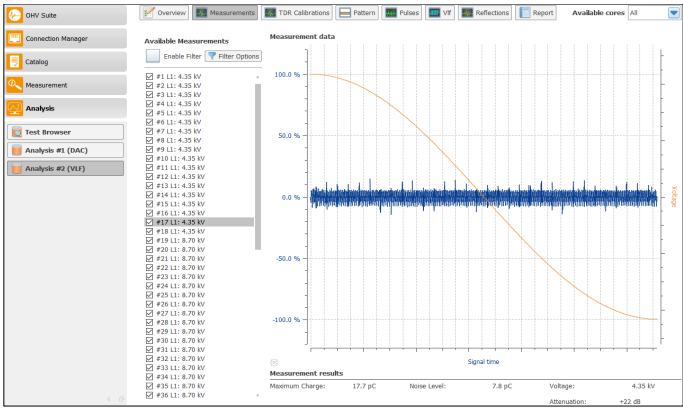
Overview (VLF)



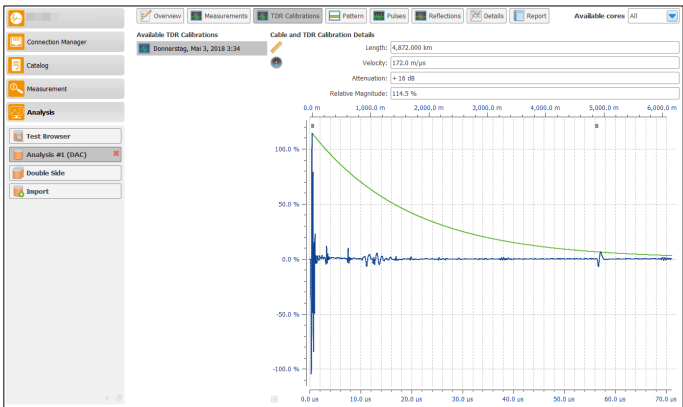
Measurements (DAC)



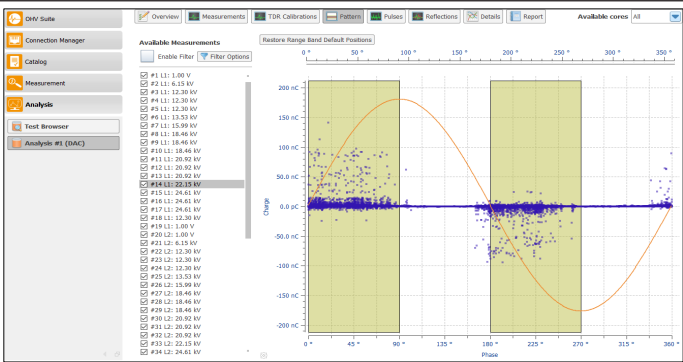
Measurements (VLF)



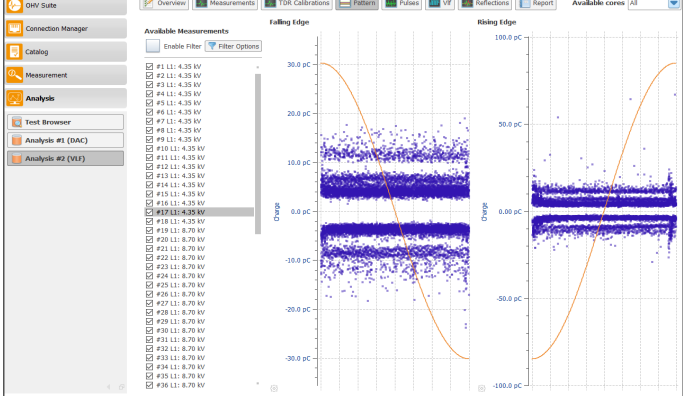
TDR Calibrations



Pattern (DAC)

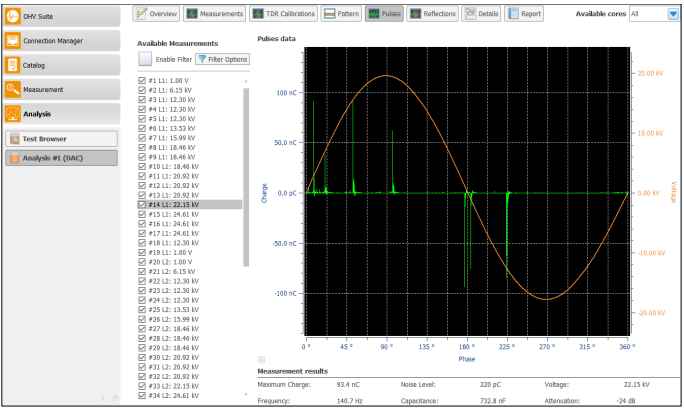


Pattern (VLF)

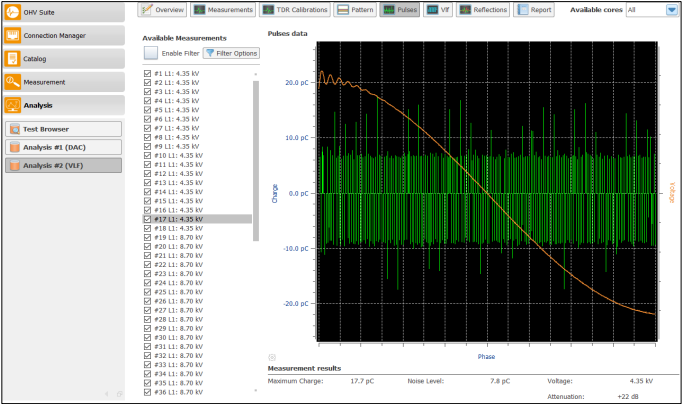




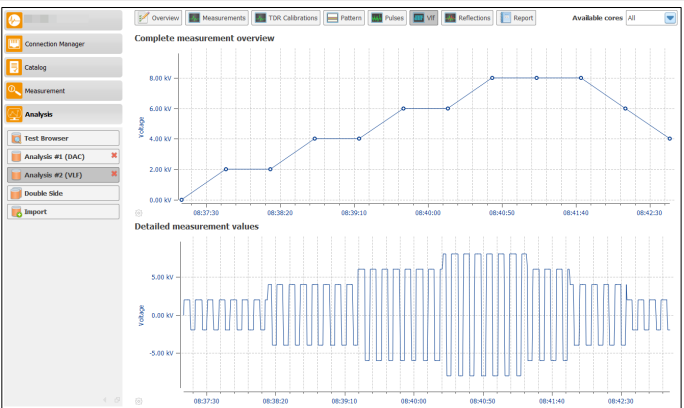
Pulses (DAC)



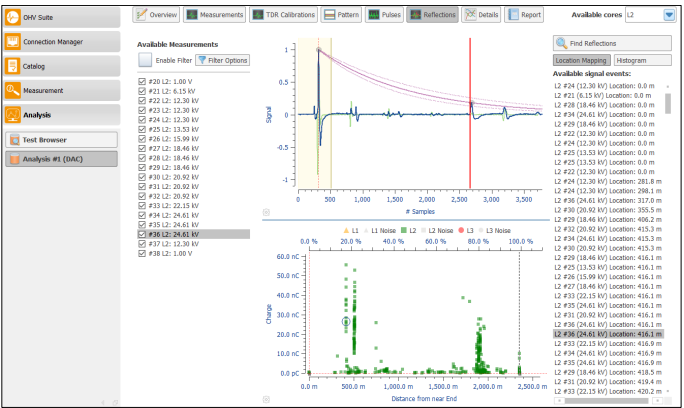
Pulses (VLF)



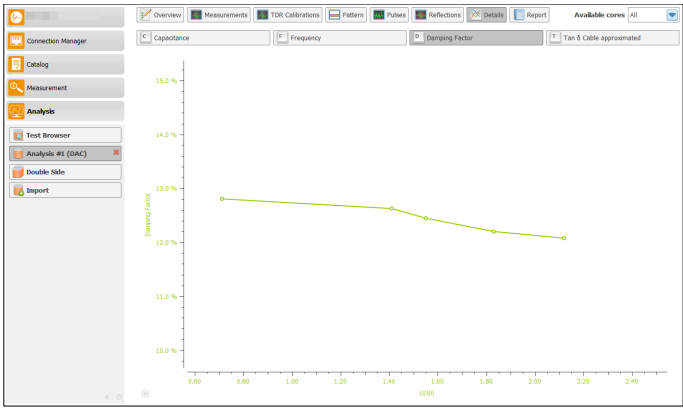
VLF



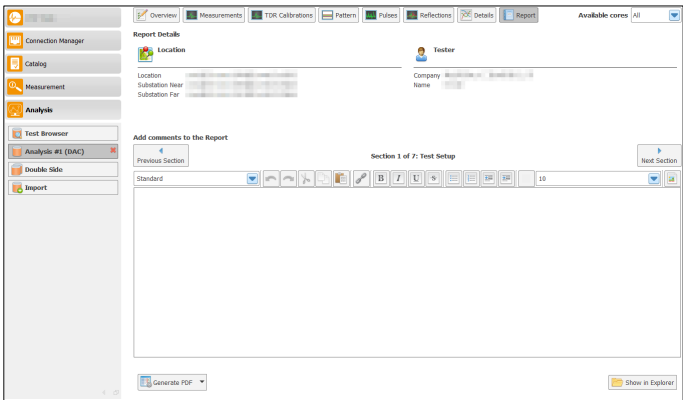
Reflections



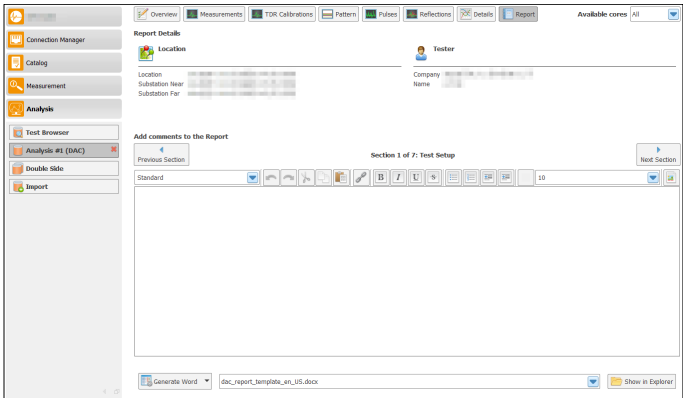
Details (DAC)



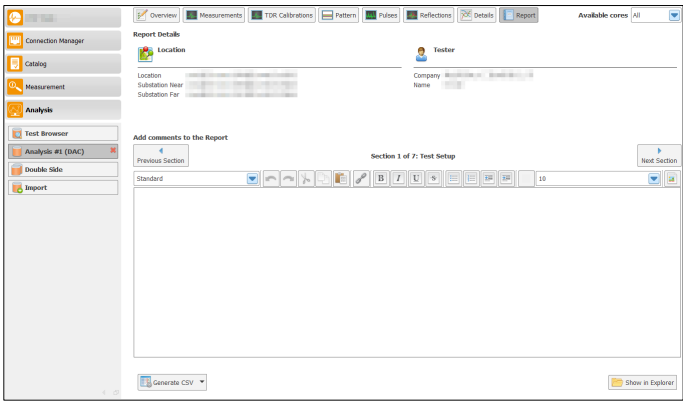
Report (PDF)



Report (Word)



Report (CSV)



### 8.3.1 Overview

The analysis overview (cf. Figure 8.5) displays the general information of the selected test. In Figure 8.6 the analysis interface for a VLF test is displayed. The analysis surface for all testing types is divided into two parts. The upper section (A) contains the buttons for the individual analysis surfaces. The current phase of the cable can also be selected in this area. The selection list on the right side of this area is available for selecting the phase of the cable. The cable determines the number of possible choices. If it is a multi-conductor cable, the individual phases  $L1$  to  $L3$ , as well as the selection for all phases ( $All$ ) are available. The respective phase selection directly influences the display of the individual analysis views. The A area is included in each individual analysis interface. The lower section B displays the correspondingly selected analysis view and is toggled by clicking the buttons.

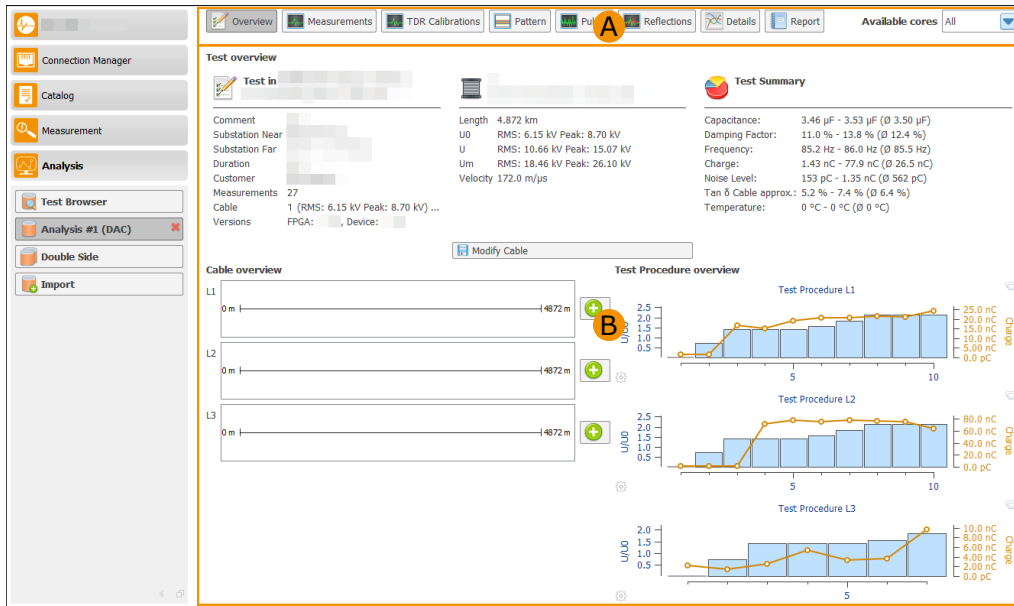


Figure 8.5: Analysis Overview (DAC test)

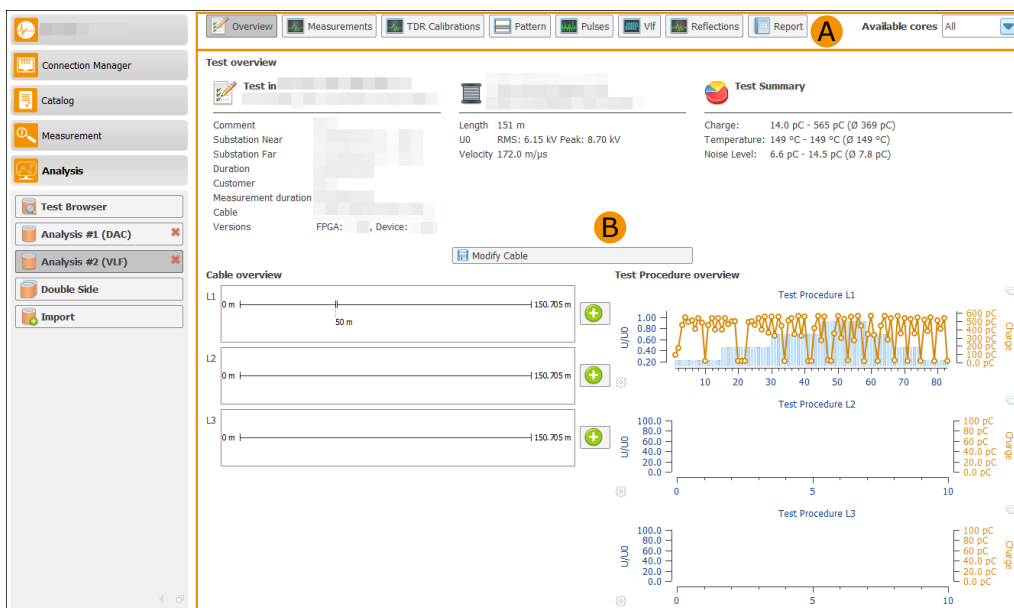


Figure 8.6: Analysis Overview (VLF test)

### 8.3.2 Measurements

The individual shots (A cf. Figure 8.7) can be selected in the measurement overview. In the right pane (B) the measurement data of the selected shot are then displayed. The lower range of B represents the calculated values as well as the used attenuation of the selected shot.

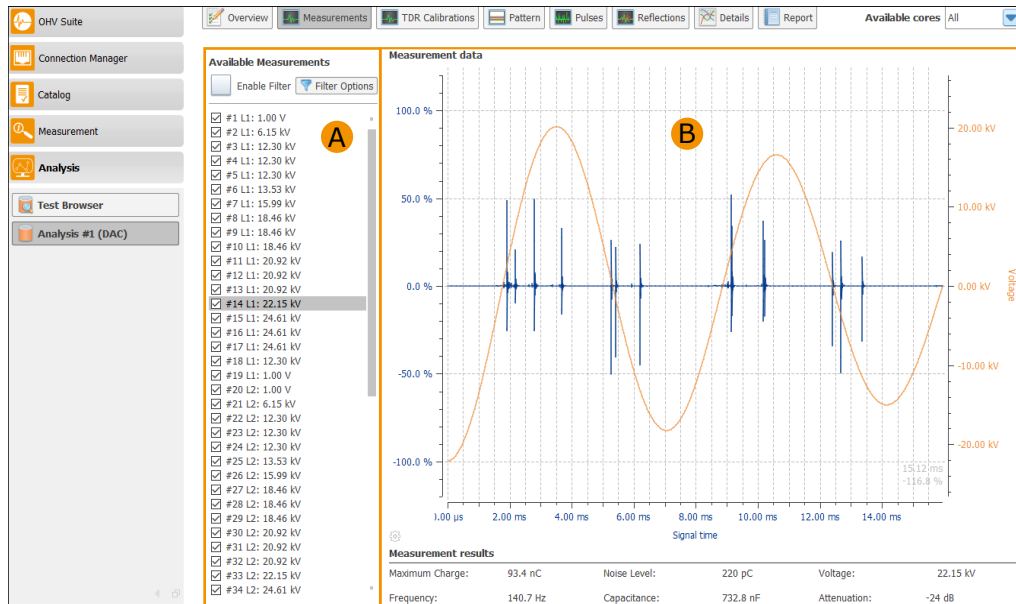


Figure 8.7: DAC Measurement

For a VLF measurement, the area of the A and the lower area of B are identical and contain the same information. The display of the selected shot is displayed at the top of B, but only the overturning process of the VLF measurement is displayed (cf. Figure 8.8).

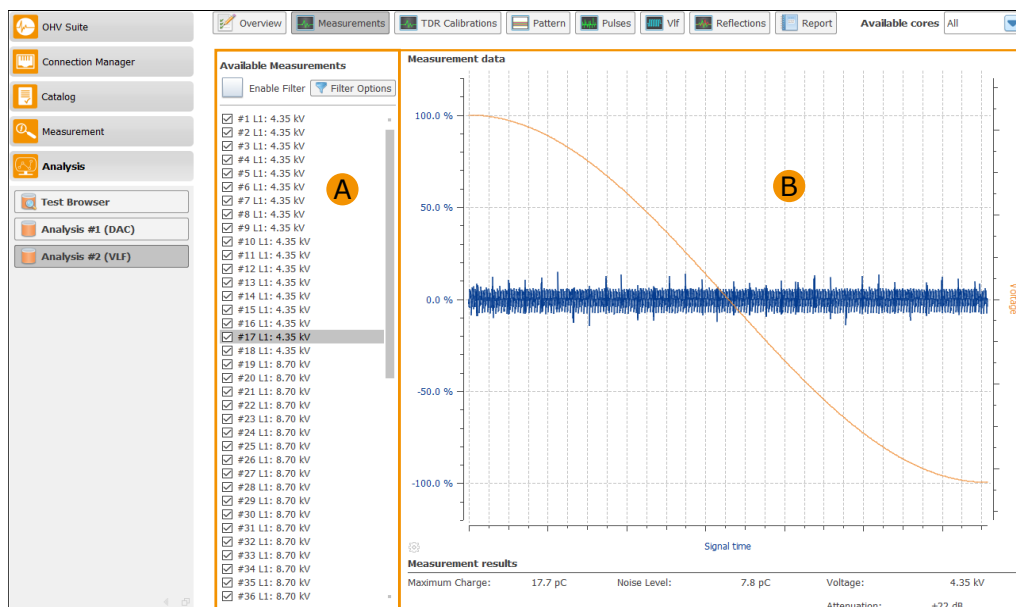


Figure 8.8: VLF Measurement

### 8.3.3 Data Filtering

Data filtering is provided for shot data viewing. This function is available at following overviews: Measurements, Pattern, Pulses and Reflections. Filtering function could be enabled or disabled by ticking the checkbox “Enable Filter”. Filtering option could be accessed by clicking button “Filter Options”. Currently filtering is only based on “Voltage” and following five filtering criteria are available:

- \* *above* Only those data which are greater than the specific value are selected
- \* *below* Only those data which are less than the specific value are selected
- \* *atleast* Only those data which are greater or equal than the specific value are selected
- \* *atmost* Only those data which are less or equal than the specific value are selected
- \* *between* Only those data which are less or equal than the minimum specification and greater or equal than the maximum specification are selected

The specific value namely minimum and maximum specification could be selected from the checkbox of value specification. Those value options would be updated automatically after every test execution. Filter options are updated only when button “Apply” in the filter option window is clicked. Both value specifications are only available under “between” mode. When filtering is enabled, current filtering criterion could also be displayed between filter buttons and shot data list (cf. Figure 8.9).

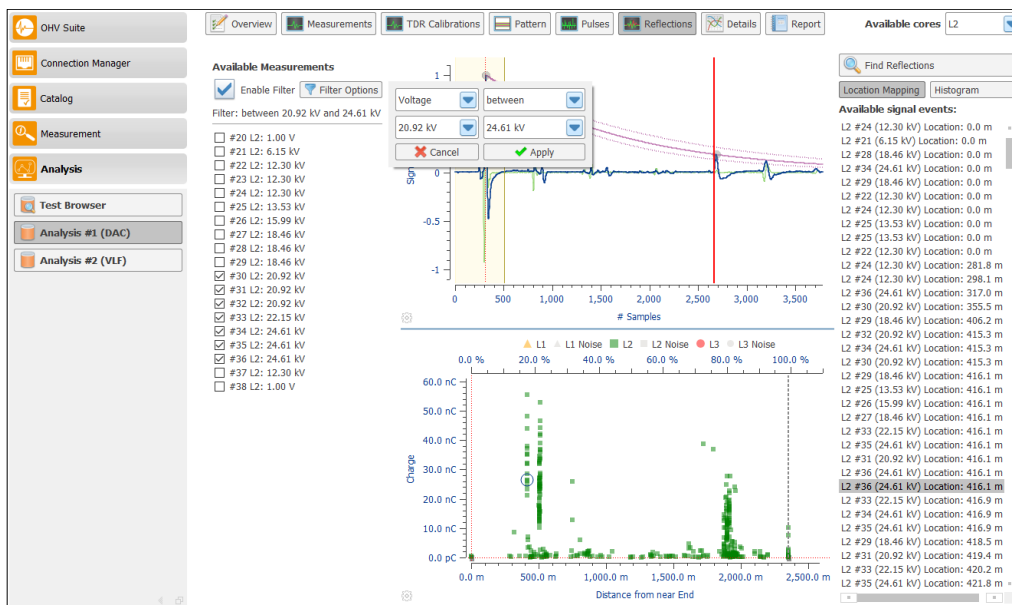


Figure 8.9: Data Filtering

### 8.3.4 TDR Calibrations

The TDR Calibration window displays all stored TDR calibration **A** (cf. Figure 8.10) for the cable that was stored during the test procedure for the cable. For a selected TDR calibration, all relevant information is displayed in the **B** area. The upper part of the **B** displays the propagation speed, length of the cable, the used gain and the relative gain during calibration. The lower area provides the TDR data in a diagram.

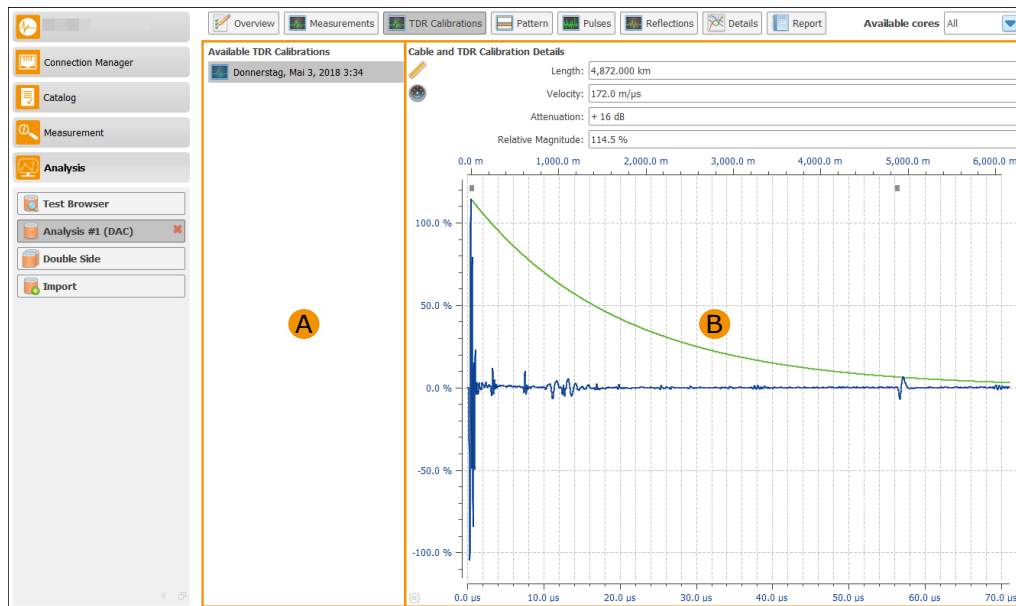


Figure 8.10: TDR Calibrations

### 8.3.5 Pattern

The pattern overview (cf. Figure 8.11) contains the data of all selected shots (A) as phase resolved PD events. In the (B) area, the overflow diagram is displayed where all PD events outside the maximum pattern scaling are sorted. Furthermore, it is possible to reset the selection ranges for reflection search to the default values. The pattern diagram is displayed in the (C) area. Noise can be excluded when selecting the analysis ranges. By moving the edges of the yellow rectangle the analysis ranges can be changed. The newly selected areas are then used within the reflection analysis. After changes to the analysis ranges, it is always necessary to run the reflection analysis again.

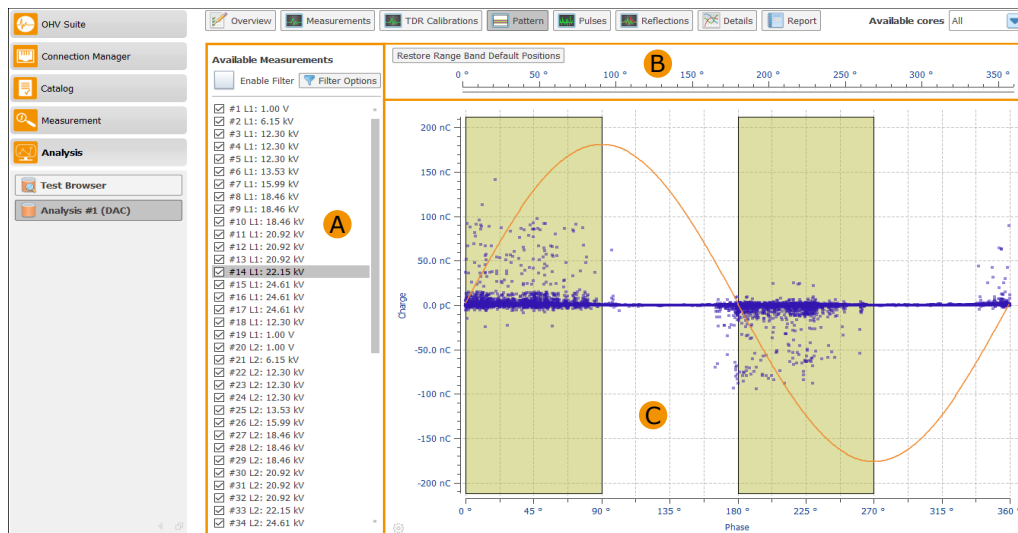


Figure 8.11: Analysis Pattern (DAC test)

Figure 8.12 shows the pattern display for a VLF test. The (A) area also contains the selected shots, which are displayed inside diagrams. On the left side of area (B) the pattern diagram for the falling edge of the VLF measurement is displayed, on the right side of this area the diagram for the rising edge of the VLF measurement is shown. The complete displayed area of the pattern is used for the reflection search and therefore no area selection is necessary.

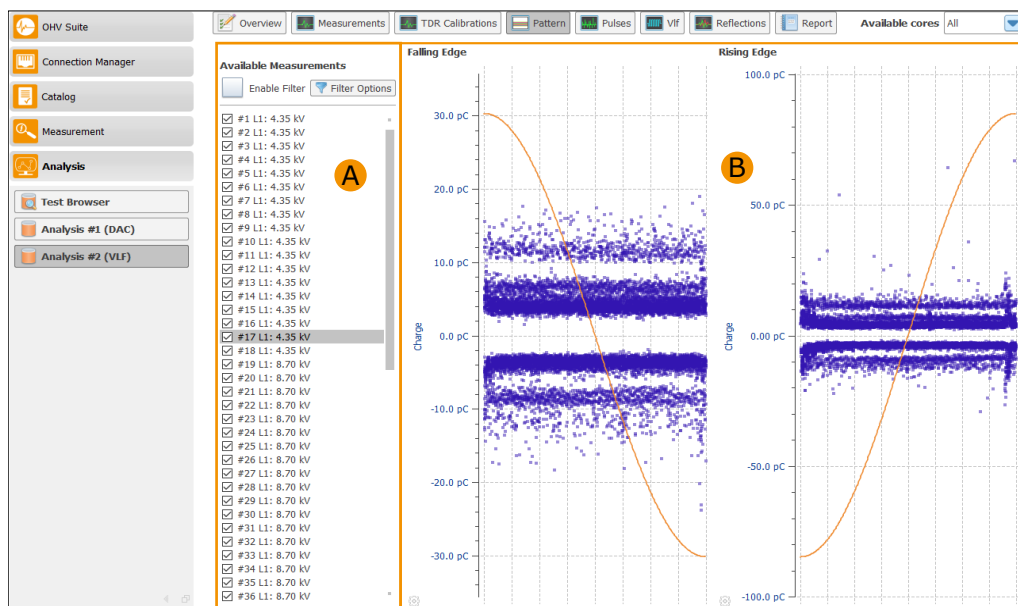


Figure 8.12: Analysis Pattern (VLF test)

### 8.3.6 Pulses

The pulse overview shows for the individual shots (A cf. Figure 8.13) the phase resolved TE events of the first period. In the right area (B) the pulse data of the selected shot are then displayed. The upper portion of B displays the calculated values as well as the used attenuation of the selected shot.

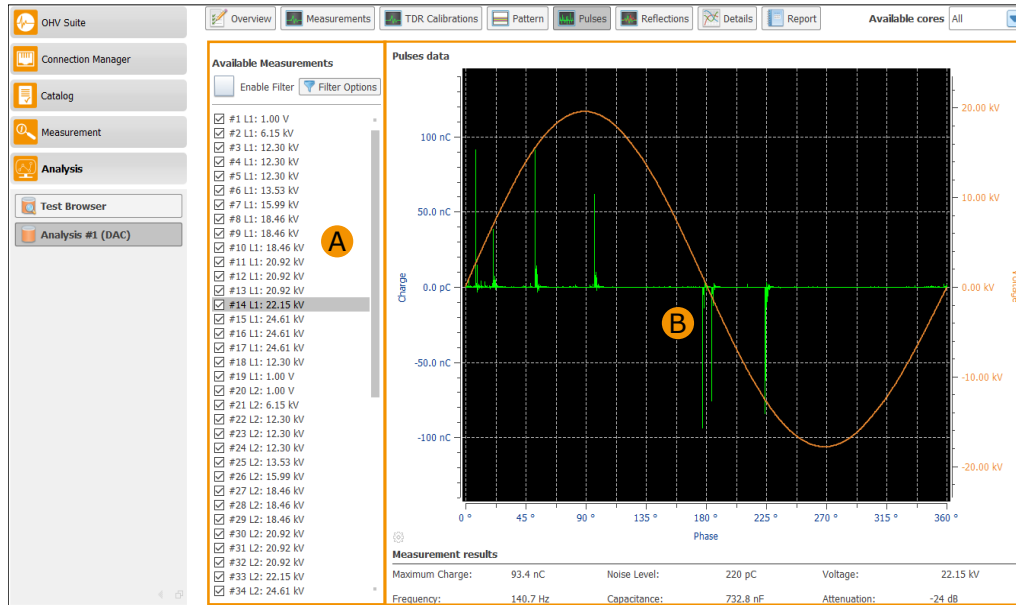


Figure 8.13: Pulses Overview (DAC test)

In a VLF test, the position of the PD events during the overturning process of the selected shot is shown in the pulse diagram. The remaining information are displayed in the same way as in a DAC test.

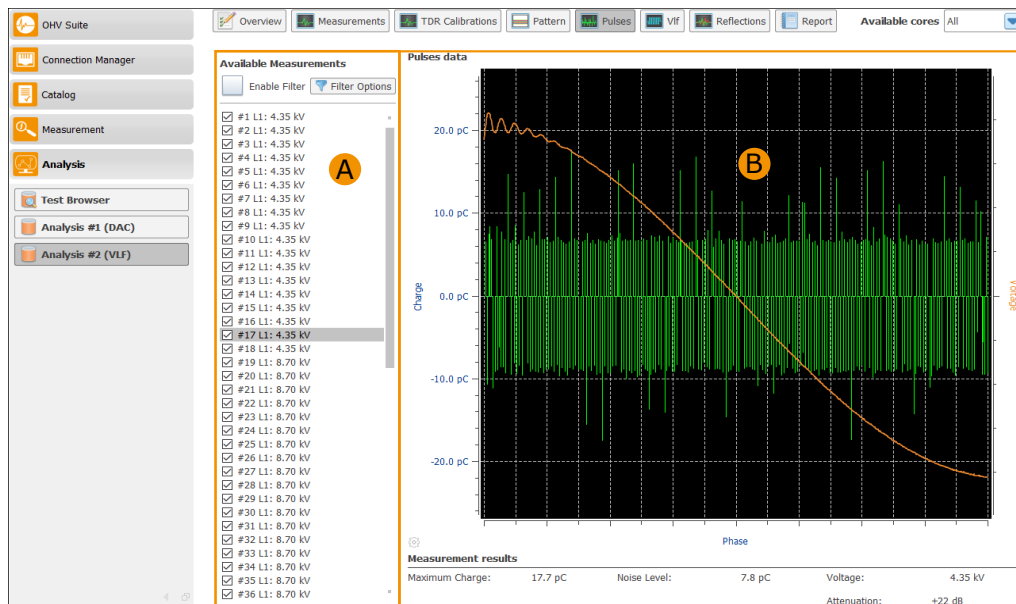


Figure 8.14: Pulses Overview (VLF test)



### 8.3.7 VLF

The VLF overview shows the time curve of the voltage during the test. In the area **A** in Figure 8.15 the complete measurement overview is displayed in the upper area. In the lower area the more detailed measurement results are displayed during the test, whereby the complete overturn processes are recognizable during the test.

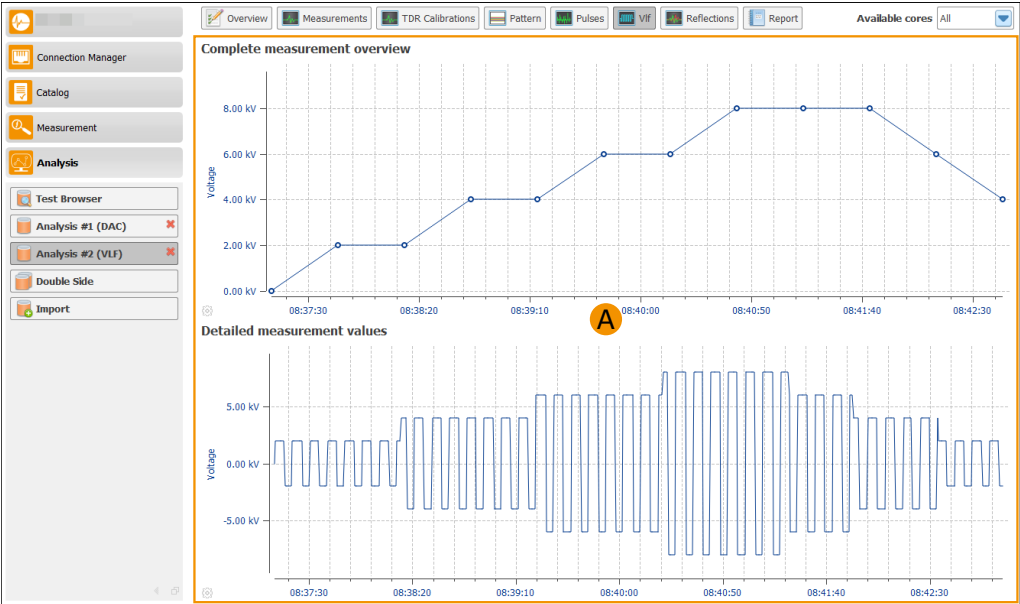


Figure 8.15: VLF Overview



This view is only available for a VLF test.

### 8.3.8 Reflections

The reflection overview (cf. Figure 8.16) shows the detected reflections of the cable. On the left side (A) all available shots are displayed. All selected shots are included in the reflection search. In the middle section (B) the location mapping diagram is displayed in the lower section and a selected reflection in the upper section of the diagram. On the right side (C) all found reflections are listed. The *Find Reflections* button starts the analysis.

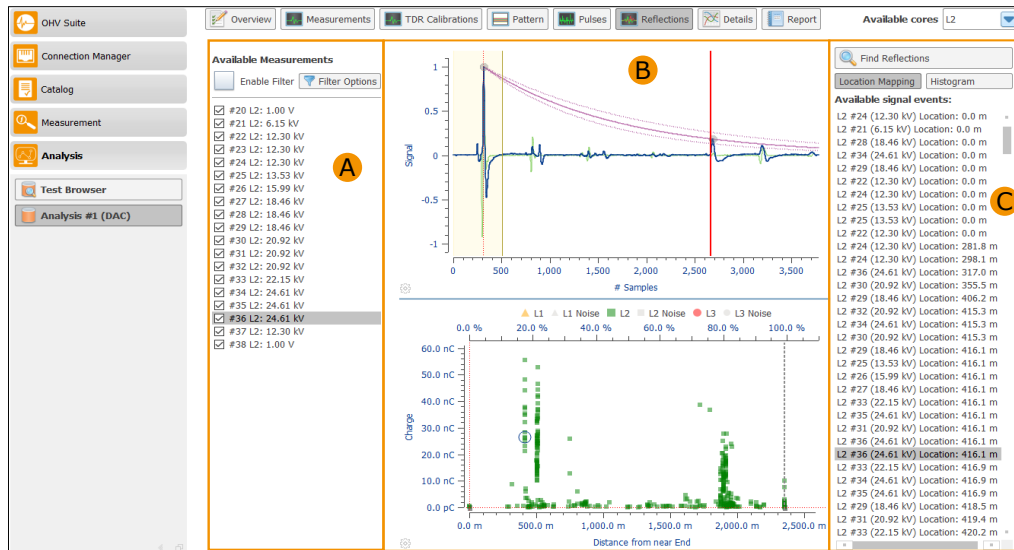


Figure 8.16: Reflections Overview (Simple analysis mode)

All available measurements are displayed in the (A) area and can be selected or deselected individually via the check boxes. All selected measurements are used for the analysis, all unselected measurements are ignored and are not included in the analysis. In the reflection overview, the analysis must always be restarted using the *Find reflections* button if the selection of measurements has changed.




The middle area (B) represents the diagrams (reflection diagram on top and fault location diagram below). In both diagrams it is possible to zoom into the curves to get a more detailed view in the zoomed area. To zoom in, hold the pressed left mouse button and select an area to be enlarged. It is also possible to zoom in several times by selecting an area again while holding down the left mouse button. The right mouse button is used to zoom out to the original view.

The blue line between the two diagrams can be used to adjusted the size of the reflection and fault location diagram. Keeping the left mouse button pressed, the line is moved up or down until the desired size is reached.

Inside the reflection diagram a selected signal is shown. For the selection of a reflection signal there are two ways. On the one hand, in the (C) area you can click directly on a found position. The selected reflection is displayed in the upper diagram and framed with a blue circle in the fault location diagram. Another way to select a reflection is to hold down the *Ctrl* key on the keyboard and use the left mouse button to select the desired position in the fault location diagram.

Within the reflection diagram, the detailed signal used to determine the distance is displayed after selecting a position. The distance was calculated from the starting point of the first peak signal to the starting point of the reflection. In the diagram, these points are marked with two red vertical lines. The second vertical line can be moved with the help of the left mouse button to change the start position of the reflection. This automatically results in a recalculation of the position for the origin of the signal. This recalculation triggers a movement of the position in the fault location diagram and in the length of the defect is adjusted in the list (C) automatically. This adjustment can lead to a better localization of the defect.


If the advanced mode has been selected inside analysis configuration (see Section 8.1.4), additional options for the reflection search are available, which are depicted in Figure 8.17 (A). Use the *Peak tolerance* slider to set the sensitivity for the reflection search. A higher value will find more

reflections, but it can also produce more results, which is no real reflection. The sensitivity can also be adjusted using the buttons  or . Using the button  the sensitivity is reset to the default value.

The TDR calibration curve can be shown if the option *Show calibration curve information* is checked. This will display a green curve with the TDR calibration data.

If the option *Show damping curve information* is enable a new violet curve is displayed with the damped information between the first and second peak of the reflection.

The option *Invert location mapping* can be used if the reflection positions from the other end of the cable should to be displayed. The check box *Synchronize to Double Side* is only available if the configuration option *Double Side analysis* has been activated. With the help of this option, the found reflections will be available for the double side analysis.

Option *Custom reflection dead time* allows to enable the modification of the dead time for the reflection detection. The reflection dead time is the time where no reflection could be found after the first peak was detected. Changing the reflection dead time can be done by using the orange slider inside the reflection diagram. With button  the reflection dead time can be reset to the default value for the reflection detection, which is currently 5 % of distance between the first and second peak of the TDR calibration. To apply the changed reflection dead time for the analysis, the button *Find Reflections* must be used to restart the reflection detection.

With the buttons *Location Mapping* and *Histogram* one can toggle between these two diagrams. In image 8.17 the histogram can be seen. Furthermore the result of choosing *Sort by location* in the configuration can be seen.

If the advanced option *Double Side Analysis* is enabled inside the configuration (cf. Section 8.1.4) the reflections can be added to the double side analysis mapping by enabling the option *Synchronize to Double Side*. This will add each of the available signal events to the mapping of the double side.

In Figure 8.17 several buttons are depicted with  can be used to navigate through the list of available signal event and noise events.

The buttons *Add to noise [F3]* and *Next signal [F4]* allows to navigate through the list of available signal events. The button *Add to noise [F3]* or short cut *F3* will remove the selected reflection candidate to the list of noise events and the next reflection candidate is automatically selected. The button *Next signal [F4]* or short cut *F4* can be used to go to the next event inside the available signal event list without removing from the list (the event will be accept as real location).

The buttons *Restore [F5]* and *Next noise [F6]* allows to navigate through the list of available noise signals. With button *Restore [F5]* or short cut *F5* the selected noise event will be moved back to the list of available signal events and selects the next noise event. The button *Next noise [F6]* or short cut *F6* will go to the next noise event inside the list. Per default the noise events are not visible inside the location mapping. With the option *Show noise events* all the data within the noise event list will be displayed inside the location mapping. The noise events are with the same symbol like defines for each phase in gray color.



All changed settings for the reflection search are only applied when a new search is started using the *Find Reflections* button.

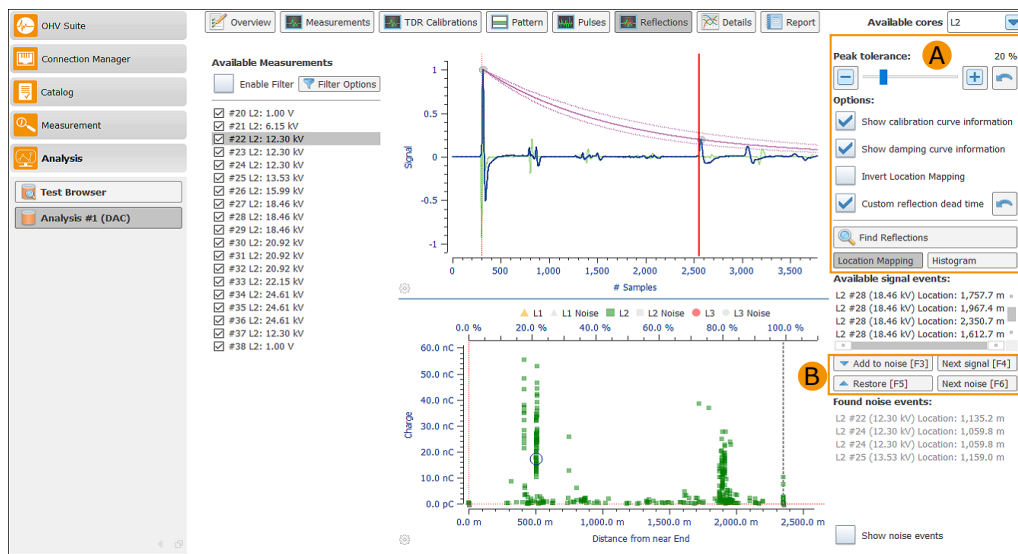


Figure 8.17: Reflections Overview (Advanced analysis mode)

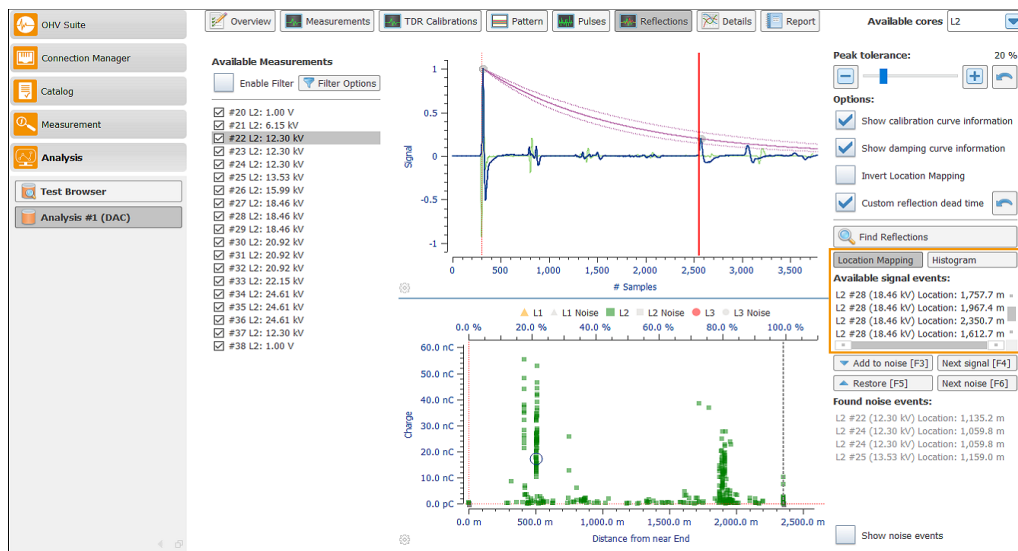


Figure 8.18: Reflections Overview (Advanced analysis mode with histogram and sorted by location)

8.3.9 Details

The detail view contains various diagrams of measured values of all shots. Figure 8.19 shows the general structure of the detail overview. The upper section **A** contains the buttons to switch between the individual diagrams. The corresponding diagrams are then displayed in the **B** area.

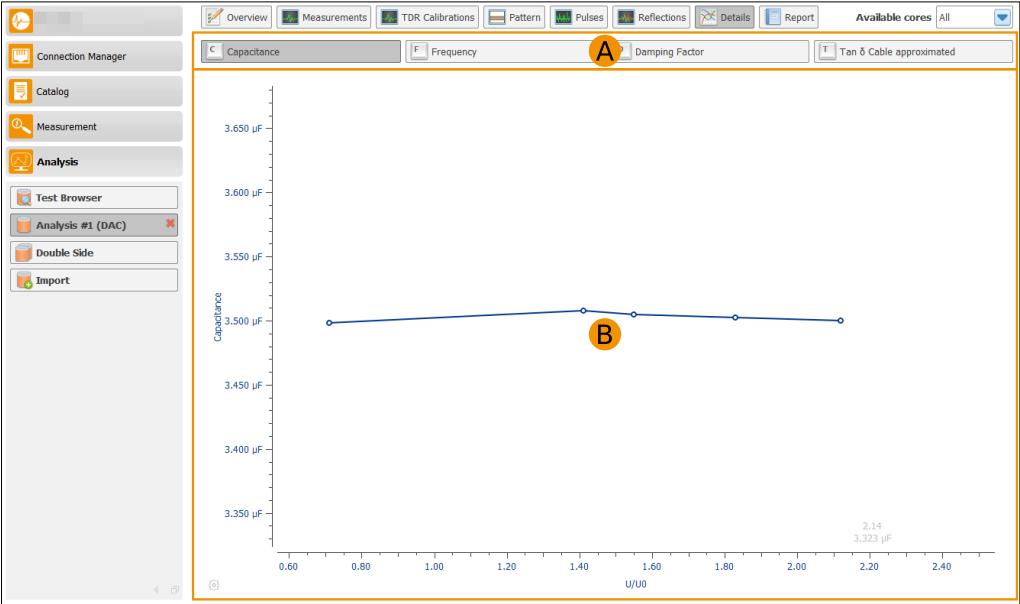


Figure 8.19: The DAC Analysis Details



This view is only available for DAC tests.

Capacitance

In Figure 8.20 the capacity of individual shots is represented. All values of the individual shots for one voltage level ( $U/U_0$ ) are averaged and then displayed in the diagram.

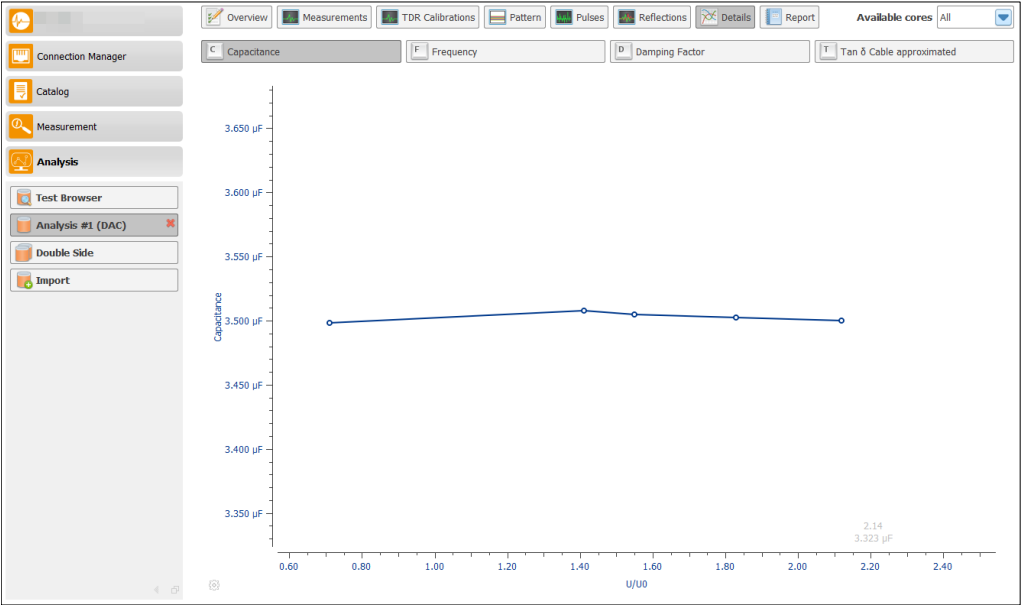


Figure 8.20: Capacitance

## Frequency

In Figure 8.21 the frequency of individual shots is represented. All values of the individual shots for one voltage level ( $U/U_0$ ) are averaged and then displayed in the diagram.

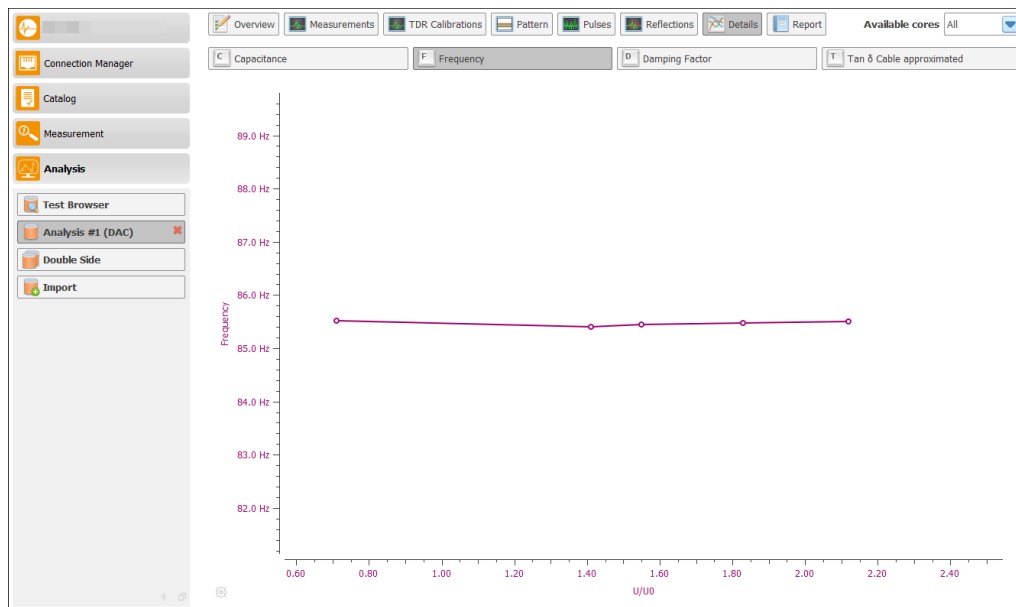


Figure 8.21: Frequency

## Damping factor

Figure 8.22 shows the damping factor of the individual shots. All values of the individual shots for one voltage level ( $U/U_0$ ) are averaged and then displayed in the diagram.

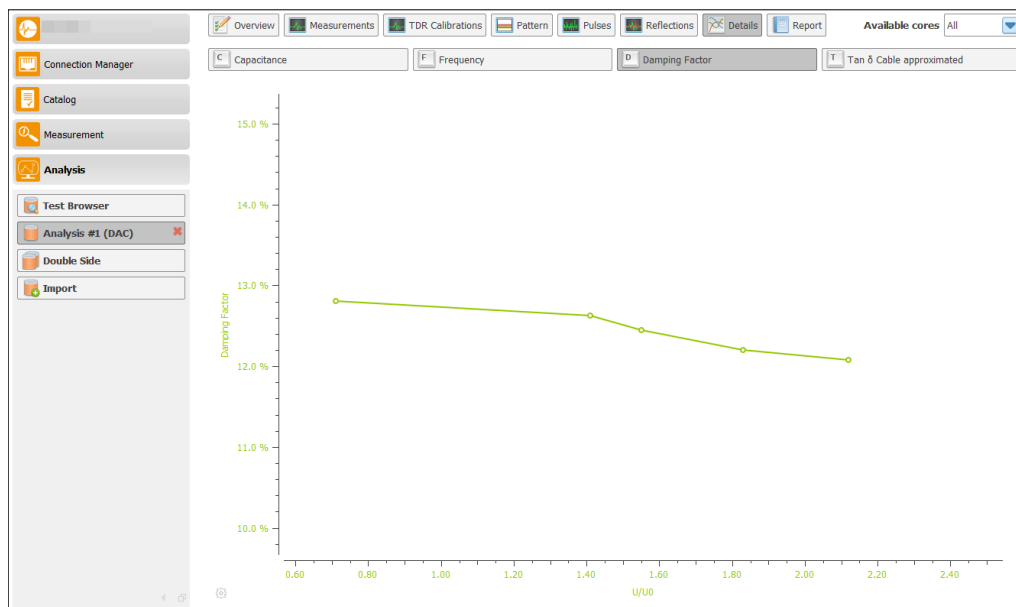


Figure 8.22: Damping factor

### Approx. $\tan \delta$ Cable

In Figure 8.23 the approx.  $\tan \delta$  of the cable of individual shots presented. All values of the individual shots for one voltage level ( $U/U_0$ ) are averaged and then displayed in the diagram.

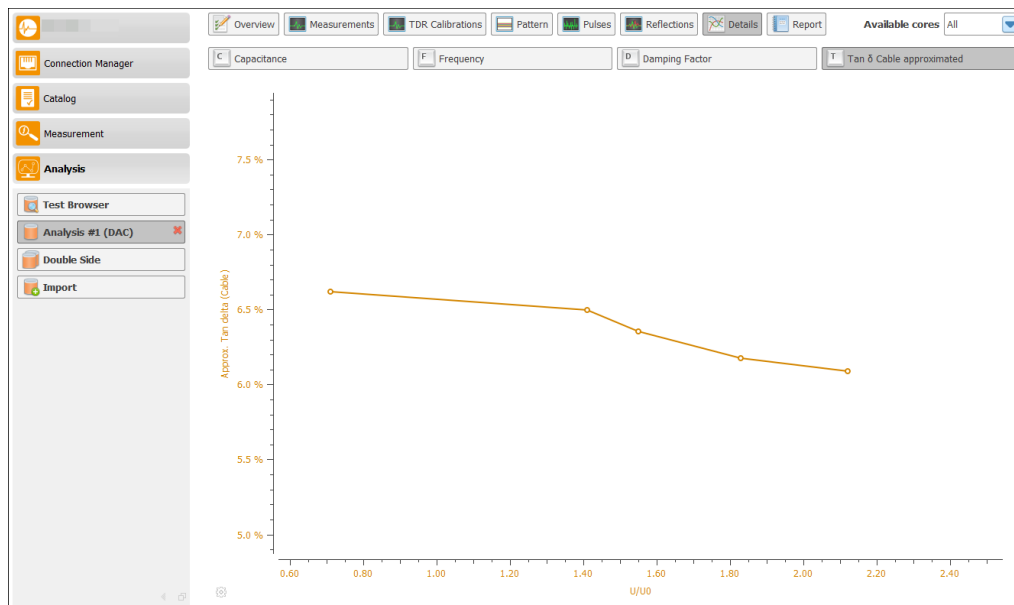


Figure 8.23: Approx.  $\tan \delta$  Cable



### 8.3.10 Report

After all test have been finished, the measurement analysis can be composed into a report. The report can be created as Word (cf. Section [Generate Word report](#)) or PDF file (cf. Section [Generate PDF report](#)). Figure 8.24 shows the report view. The report view is separated into three parts. In (A) the report details of the measurement are depicted. The center area (B) allows to add notes which should be contained inside the report. To add the notes a simple text editor is available. With the buttons *Previous Section* and *Next Section* it is possible to switch between the different parts inside the report. In Table 8.2 all available sections of the report are described. The bottom area (C) can be used to select the report type and opening the finished reports.

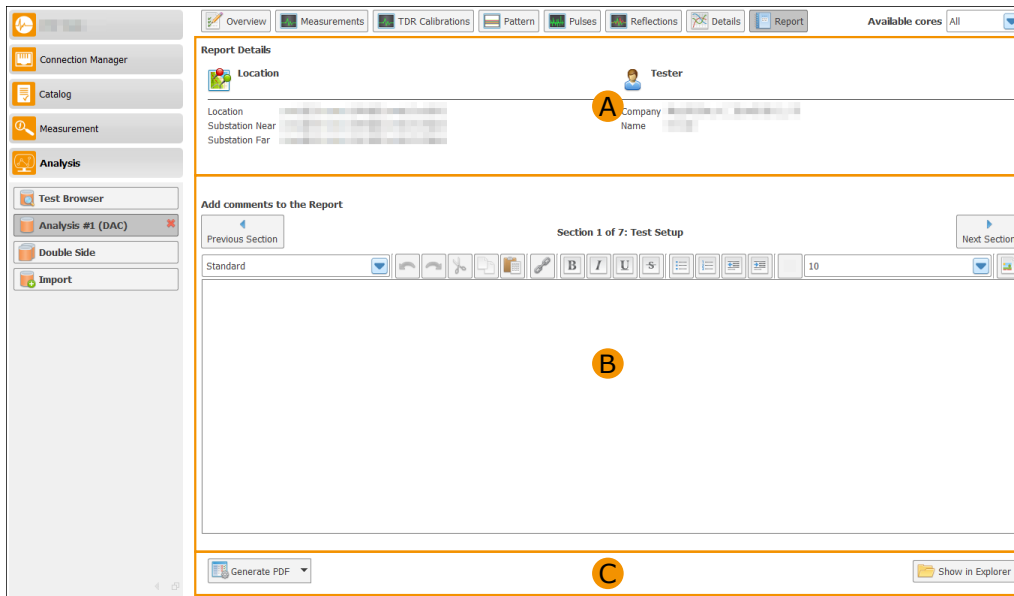


Figure 8.24: The automatic report generation

Section	Description
<b>Test Setup</b>	Additional information about the test setup can be entered.
<b>TDR calibration result</b>	Information for the TDR calibration can be entered.
<b>VLF Test Results: Voltage over Time Diagram</b>	Information for the diagrams complete measurement overview and detailed measurement value can be added. <i>This input is only available during a VLF test.</i>
<b>PD Test Results: PRPDA/PD Detection</b> <b>VLF Test Results: PRPDA/PD Detection</b>	Information for the PRPDA pattern can be entered.
<b>PD Test Results: PD Location Mapping</b>	Information to the fault location mapping data can be entered.
<b>Detailed Analysis</b>	Allows to append notes for the detailed diagrams (Capacitance, Frequency, Damping factor and Approx. $\tan \delta$ ). <i>This input is only available during a DAC test.</i>
<b>Conclusion</b>	Allows to enter a conclusion for the test.

Table 8.2: Report sections

### Generate PDF report

The tool button is used to selected *Generate PDF*. The user interface displays the option for the generation of the PDF report. The report will be created by a click onto the *Generate PDF* button (C). After a successful generated report (cf. Figure 8.25) the name of the report and two additional buttons are shown. With button *Open Report* it is possible to open the PDF file inside a PDF viewer and *Show in Explorer* opens the Windows Explorer where the PDF file is located.

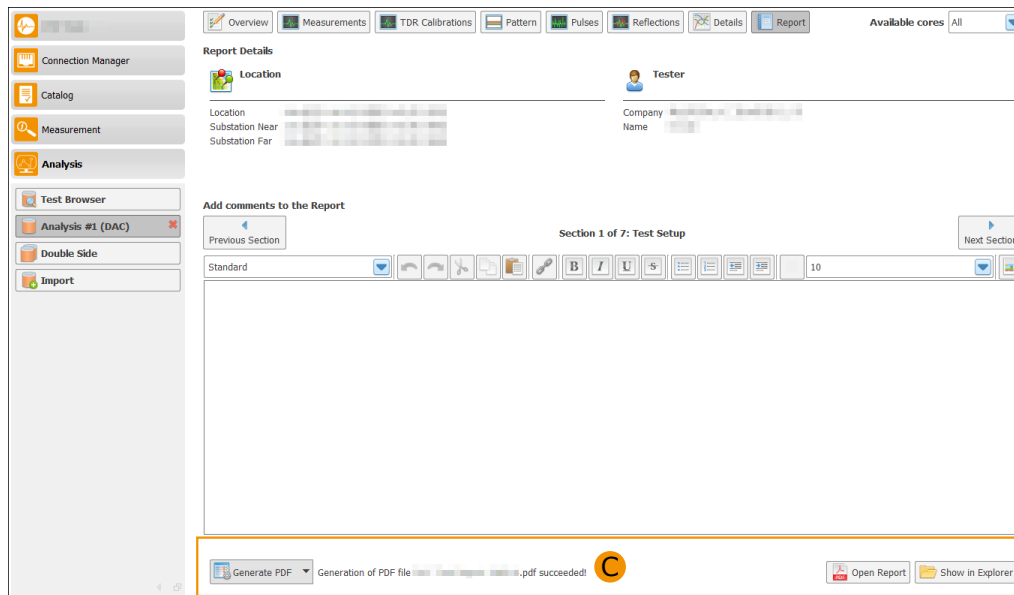


Figure 8.25: Successful generated PDF Report

### Generate CSV report

The procedure for generating a CSV report is similar to generating a PDF. Instead of *Generate PDF* the tool button has to be set to *Generate CSV*. By clicking the button *Generate CSV*, the CSV report will be generated. When the report was successfully generated, the name of the file will be displayed together with a success message, similar to a successful PDF report generation (cf. Figure 8.25). The resulting CSV file will be formatted in UTF-8 text file. Values are separated by a single colon character ','. Character string are contained in ". The file contains the meta data of the measurement in the first two lines, followed by an empty line. Line 4 and 5 contain the average values for the capacitance, frequency and temperature, which are again followed by an blank line. After this blank line, a line containing the header information of the measurement is added. The following lines contain the exact measured data of each shot. The line of the last shot is followed by a blank line. The last line in the file contains the location information for all point found during the analysis.

### Generate Word report

For the generation of a Word report the tool button is used to select *Generate Word*. The user interface displays the option for the generation of the Word report. In the middle of section C in Figure 8.26 the template for the word report can be selected from the selection box. The selection box contains all found template which are contained inside the provided report template folder. The selected template is automatically saved. When using the Word report type the first time the last template is automatically selected.

Word report will be created by click onto the *Generate Word* button. After a successful generated report (cf. Figure 8.27) the name of the report and two additional buttons are shown. The button *Open Report* open the Word file inside a office program which allows to open Word documents. With the button *Show in Explorer* the Windows Explorer is open where the generated Word file is located. The button allows to go back to the Word template selection.

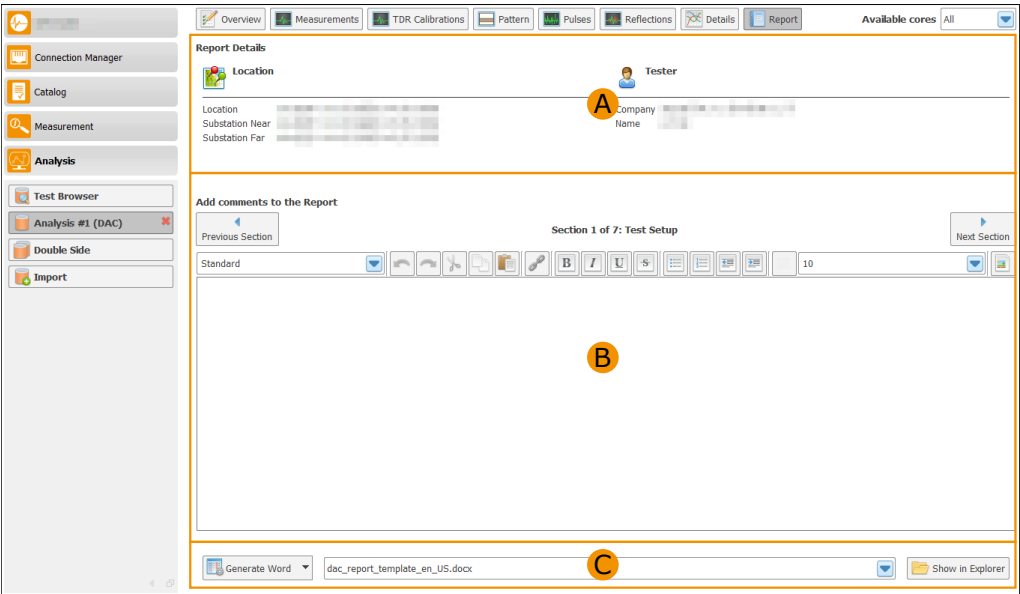


Figure 8.26: Word report template selection

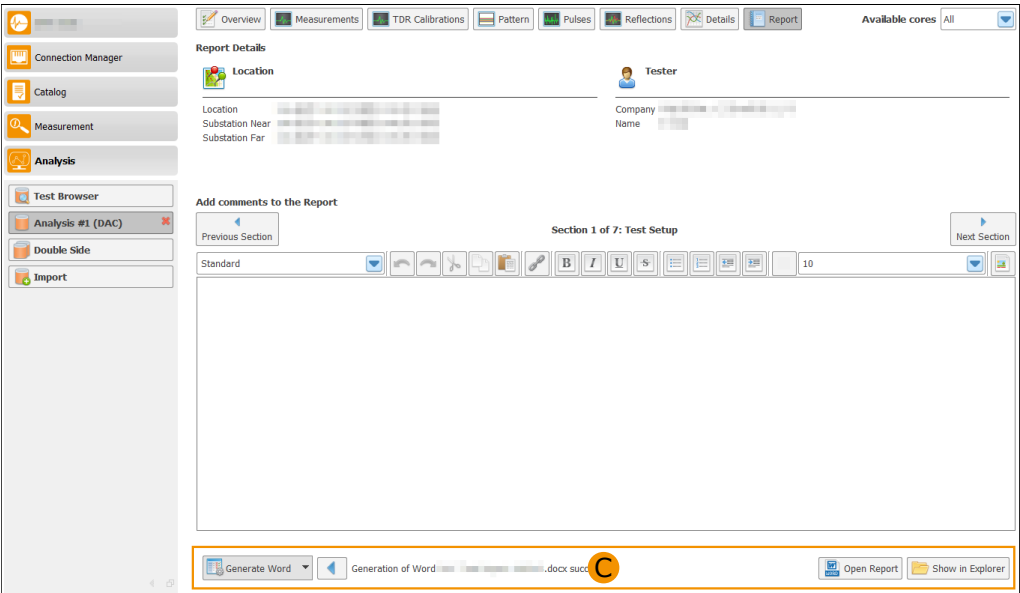


Figure 8.27: Successful generated Word Report

## 8.4 Import of old measurement

This section describes how to import measurement data from the old DAC software (DAC measurement software version 1.x).



The import of old measurement data is only possible if the Advanced Analysis Mode is selected and the option *Data Import Support* is activated.

For importing data, select the sub application *Import*. The import is divided into two areas (see Figure 8.28). The left pane (A) contains a selection window that displays all available folders. In the upper area, the *Parent folder* button allows you to move to a higher folder level. The button *Switch to default data folder* changes to the default data folder selected within the DAC catalog configuration (see Section 6.1). A simple left mouse click is used to open a folder. If there is an old measurement file in the selected folder which can be imported, this is displayed in the B area. (see Figure 8.29). By selecting the found file, the *Import Selected* button is activated and can be used to start the data import. As soon as the data import has been started, a progress bar (see Figure 8.30) appears next to the button *Import Selected*, which shows the current progress of the data import. All buttons are deactivated during the import. After the import is finished, the complete path with the file name at the bottom is displayed in the B area (cf. Figure 8.31). If the mouse pointer is moved over the path, the complete path appears as a tool tip. In order to be able to open and analyze the imported file afterwards, you have to into the *Test Browser* and select the imported file. The selection of measurement files is described in Section 8.2.1.

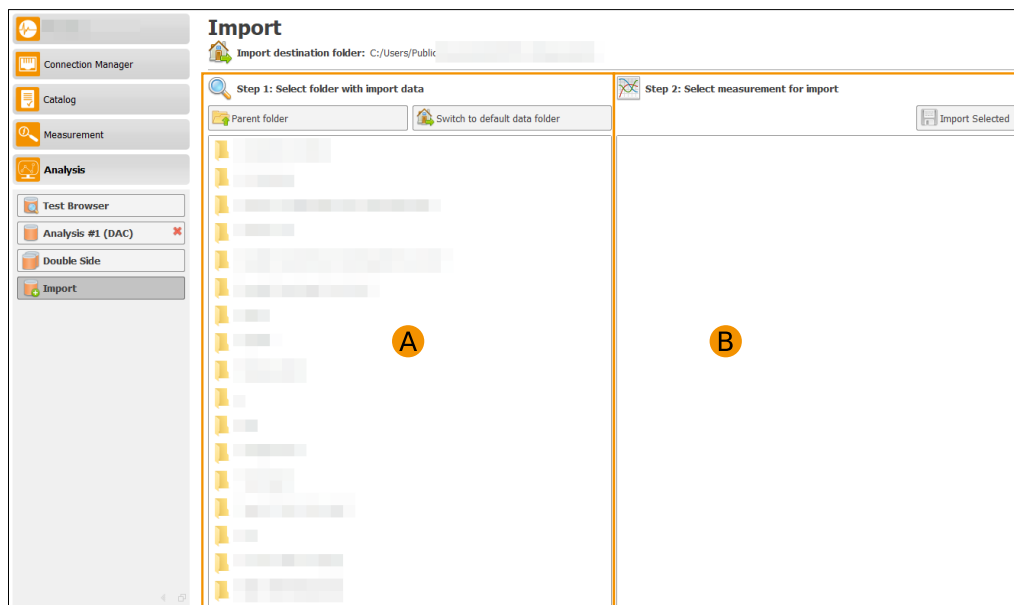


Figure 8.28: Selection for import folder

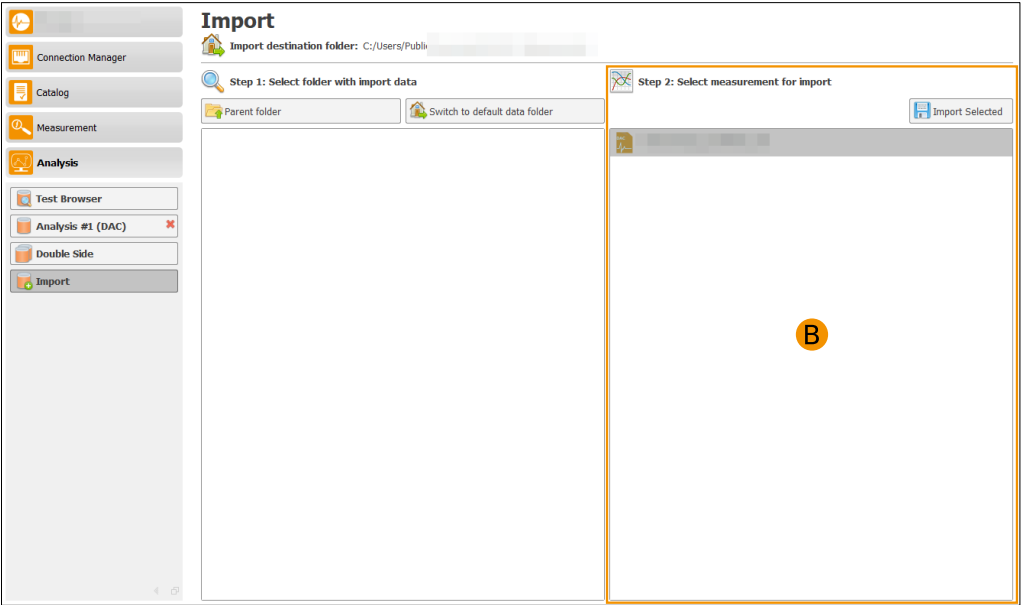


Figure 8.29: File selection for the import

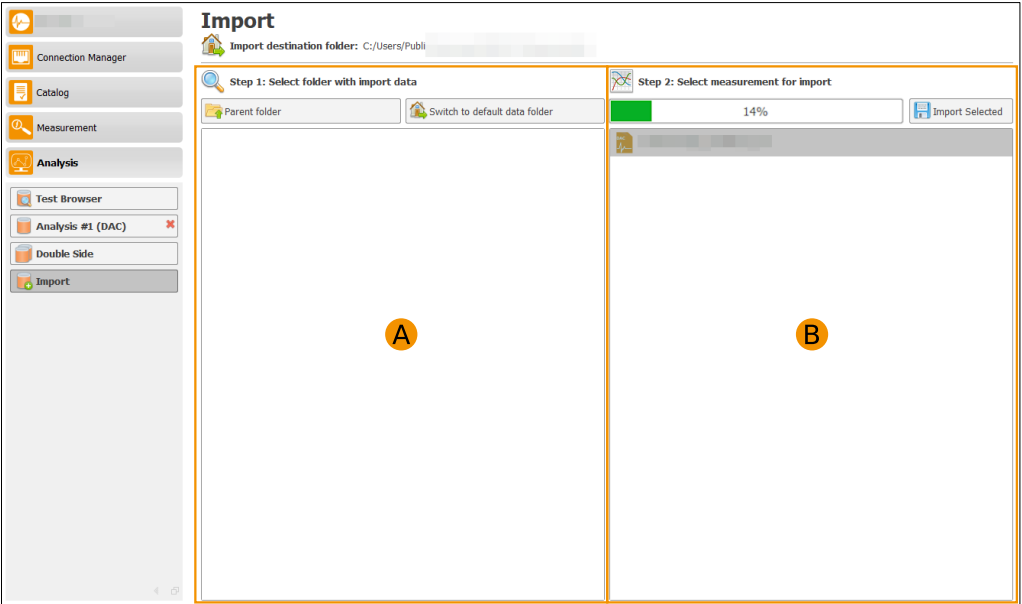


Figure 8.30: Progress of the import

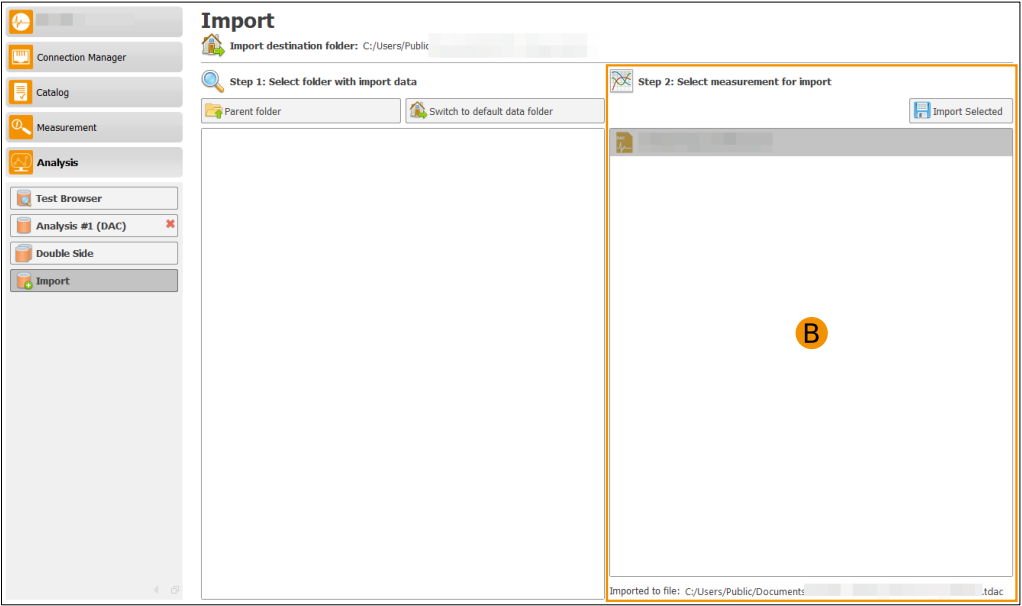


Figure 8.31: Data import finished

## 8.5 Double Side Analysis

This section describes how different measurements can be displayed and thus compared as double side analysis. In the following explanation, a DAC measurement and a double side measurement are compared, but it is also possible to compare different DAC measurements with each other. However, this comparison only makes sense if the cable is the same.



Double side analysis is only possible if Advanced Analysis Mode is selected and the *Double Side Analysis* option is enabled.

For the double side analysis it is necessary to evaluate individual measurements and the option *Synchronize to Double Side* must be selected. In Figures 8.32 and 8.33 a DAC measurement and the corresponding double side measurement are displayed within the reflection view. In both figures the fault location diagram can be seen in the **B** area. Both measurements were selected for the double side analysis (cf. **A** in Figure 8.32 and Figure 8.33).

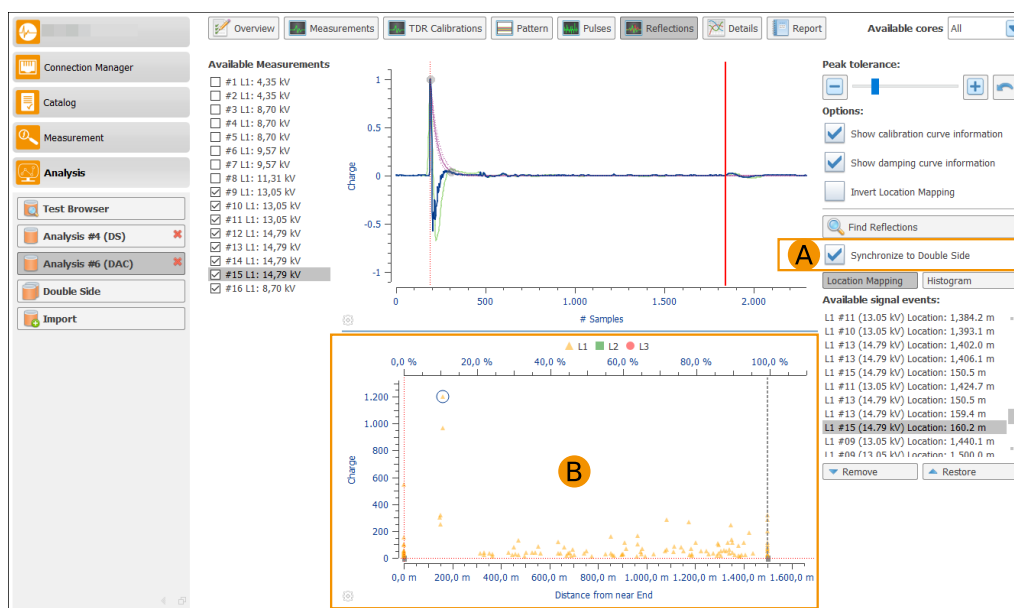


Figure 8.32: Fault location DAC measurement

The double side analysis can be open when the sub application *Double Side*. In Figure 8.34 the double side analysis is displayed. In area **A**, a selection box is available containing all cable lengths available for this analysis. Identical cable lengths are displayed only once.

With the button *Clear Double Side Mapping* it is possible to remove the data from the locating diagram. The option *Synchronize to Double Side* is deactivated in all selected analyzes.

The area **B** is used for displaying double side fault location diagram. All fault location data from a DAC measurement are displayed in orange and all fault location data from a double side measurement are displayed in green.



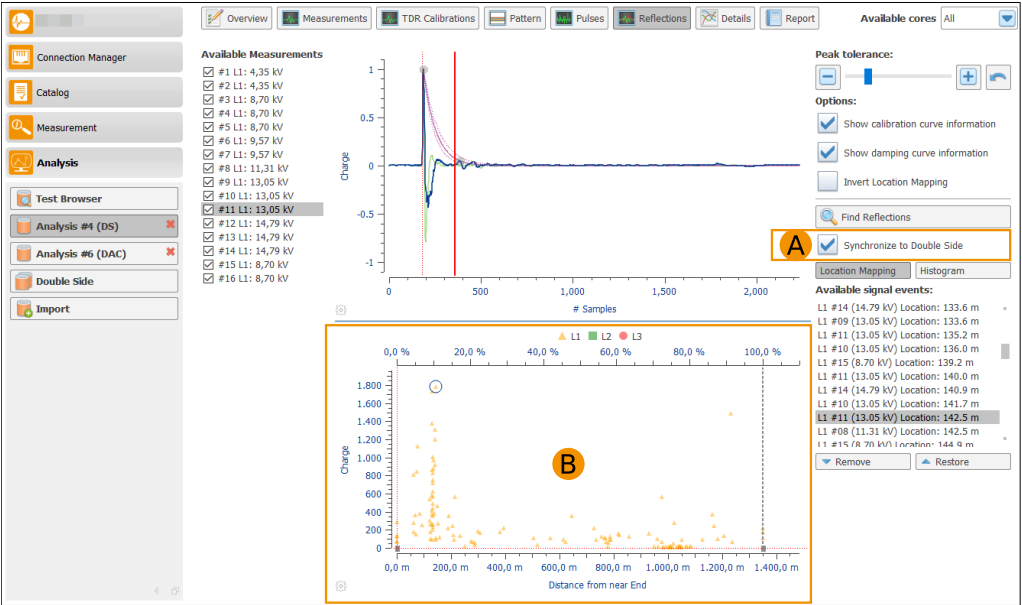


Figure 8.33: Fault location Double Side measurement

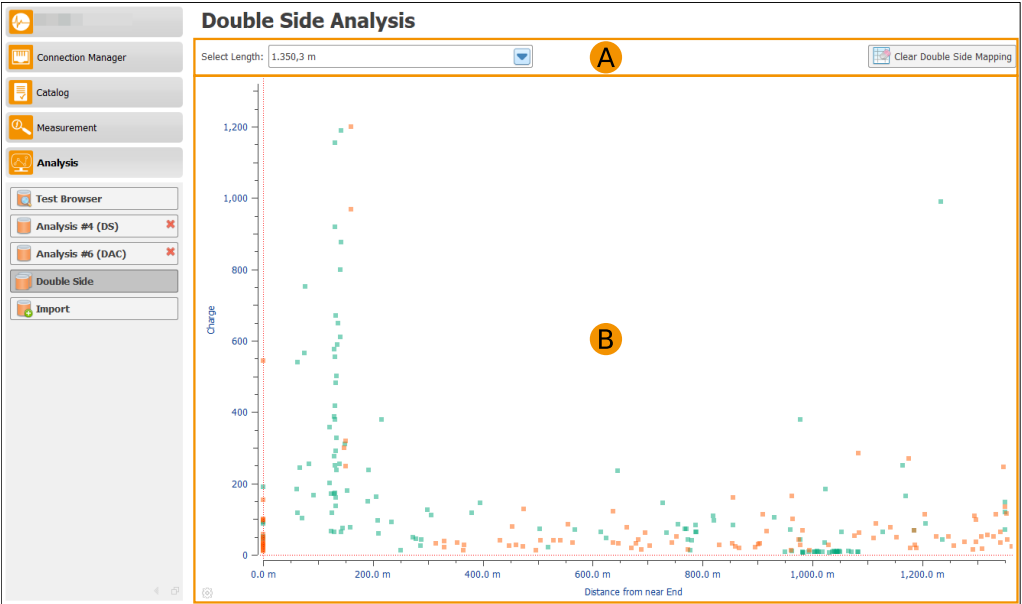


Figure 8.34: Fault location double side analysis

---

## DAC word report template

This section describes the creation of customized Word report templates. Section 9.1 contains the description where to find the existing templates and how to create a new one. The section 9.3 contains all available key words which can be used to fill the report with data. Using the word reporting requires the python scripting functionality, which is contained inside the OHV Suite and will be installed automatically. The word template can contain plausibility checks for the data which are inserted into the report. A syntax description for defining custom templates with small examples can be found in section 9.2.



The translations of the report content must be done by the user. The values of the report will never contain any translations.

### 9.1 Word report template

The OHV Suite provide it's own default Word templates which can be used for the report generation. These templates will be copied into the public documents folder with sub folders: 'ohv diagnostic GmbH/Report Templates'. Template file names have the following structure: `TYPE_report_template_LANGUAGE.docx`.

- **TYPE** is the type of the report template. The supported types are *dac* (for normal DAC reports) and *dacvlf* (for VLF reports).
- **LANGUAGE** is the language code which is supported through the OHV Suite.

If you want to create your own report templates, it is highly recommended to copy an existing template and save it under a different file name in the same location as the default templates. The default templates may be changed or extended in future OHV Suite versions, which can lead to conflicts with changed templates saved under the name of a default template, ultimately bringing the risk that your changes will be overwritten when the application updates it's default templates.

## 9.2 Word report template syntax

Report templates are ordinary word documents with the exception, that they contain placeholders for the report data. In this section the usage of these placeholder is briefly explained, so users will be able to create their own templates.

### 9.2.1 Basic placeholder usage

Placeholders start with two curly brackets and end with two closing curly brackets. Enclosed by the two pairs of curly brackets, the identifier or name of the placeholder is given. An example with the resulting replacement can be seen below (cf. Figure 9.1). As it can be seen, the identifier and the surrounding brackets should be separated by spaces. Also notice, that the formatting of the placeholder was inherited by the result. In general, if the placeholder text is formatted in a special way, the text replacing it will inherit the formatting. If the placeholder is to be replaced by a picture, the picture will at least inherit the layout formatting, e.g. when the placeholder is centered, the picture will be too. In the example, the placeholder `MyTextPlaceholder` is replaced by text and `MyImagePlaceholder` with an picture.

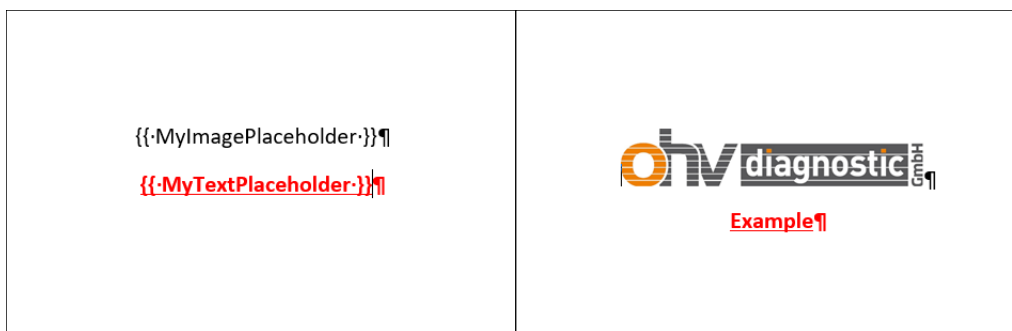


Figure 9.1: Basic Placeholder example

### 9.2.2 Basic statement usage

Placeholders of the form `{% Statement %}` are so called statements. Technically they aren't placeholders but used to control the output when processing a template. For example, statements can be used to replace placeholders only under certain conditions or to generate tables with dynamic row count. Statements will be executed and not replaced. Lines with statements will not be part of the resulting output.



Placeholders of the form `{{ Placeholder }}` will be replaced with content. Statements of the form `{% Statement %}` will not be part of the output but will be executed while processing the template.

### 9.2.3 Conditional statement - IF statement

This subsection describes how to use conditional statements and how to check if placeholders contain plausible data. Listing 9.1 shows an example of conditional placeholder usage. The first example starts on line number 1. The example show how to check if a placeholder was defined. This is done by using the `if` statement follow by the placeholder name. Only if the condition is fulfilled, the resulting document will contain the text in line 3, e.g. when the placeholder in the example is defined. Only if the condition is not fulfilled, the text after the `else` will be part of the resulting document. Each `if` has to be ended with an `endif` statement, as shown. Only text enclosed by the `if` and `endif` statements will be affected by the condition checking. The `else` path is optional as can be seen in the example starting in line number 9. This example shows how to check a placeholder for a special value, in this case it is compared to an empty character

```
1 This is an example.
2 {% if condition %}
3 Condition is fulfilled!
4 {% else %}
5 Condition is not fulfilled!
6 {% endif %}
7 This text will not be affected by the condition.
8
9 This is an example with nested placeholders and comparison.
10 {% if condition != "" %}
11 Condition is not empty and contains {{ condition }}
12 {% endif %}
```

Listing 9.1: Example of conditional placeholders

string and the condition is only fulfilled, if the placeholder contains some text. As seen in line 11 placeholders can be nested. The example only adds the text in line 11 and the text, that the placeholder condition contains, only if the placeholder contains text.

9.2.4 Filling template tables - FOR statement

This subsection will explain how to create templates for tables and how they are filled with data. Figure 9.2 shows an example table definition and the result. Let’s assume we have a list of data we want to process and display in table form. The list contains cities and each city has a name and a postcode. In the example we process a list containing two entries [Dresden, 01127] and [Dresden, 01069]. For each list element there is a placeholder name and code defined. A third placeholder `city_list` is defined which refers to our list of cities. The template now defines a header row, which will not be affected. The next row uses statement consisting of `tr` to create a new table row and the `for` statement, which will be used to iterate through the elements of the list `city_list` refers to. In this case `city` is no placeholder and is simply used to refer to the current element of the list. In the next row `city.name` and `city.code` are placeholders used to access data behind name and code of the current city. To end the row, the statement `{% tr endfor %}` is used. Please note that this will only work with lists of elements.

Template:	
City-Name	Postcode
{% tr for city in city_list %}	
{{city.name}}	{{city.code}}
{% tr endfor %}	
Result:	
City-Name	Postcode
Dresden	01127
Dresden	01069

Figure 9.2: Template table example

### 9.3 Word report template content

This section describes the existing keys which can be used inside the word report templates. These keys can be used as placeholder inside the template document and will be replaced with the content from the reporting. In Section 9.3.1 contains all available keys which can be used inside DAC and VLF report template. In sub section 9.3.2 all keys are listed, which can be used in DAC report templates only. The Section 9.3.3 lists all keys which can be used for VLF report templates. Besides a brief description, the tables also list the type of the data which the placeholders refer to.

#### 9.3.1 Word report template key for all report templates

The table 9.1 contains all available keys which can be used inside DAC and VLF report template.

Key	Type	Description
dac_report_id	String	Contains the unique report ID containing of the first 3 letters of the cable name and an increased report counter with 3 digits.
dac_cable_name	String	The name of the cable on which the test was performed.
dac_location	String	The location where the test was performed.
dac_measurement_date	String	The date when the test was performed.
dac_tester_name	String	The name of the tester who performs the test.
dac_tester_address	String	The address of the tester.
dac_tester_contact_details	String	The contact details of the tester.
dac_cable_near_end	String	The name of substation on the near end of cable.
dac_cable_far_end	String	The name of the substation on the far end of cable
dac_cable_owner	String	The cable owner.
dac_test_comment	String	The comment which was added during the test.
dac_current_date	String	The current date.
dac_software_name	String	The software name which was used to perform the report.
dac_software_version	String	The software version which was used to perform the report.
dac_capacitance_minimum	String	The minimum value of the capacitance as formatted string with unit.
dac_capacitance_maximum	String	The maximum value of the capacitance as formatted string with unit.
dac_capacitance_average	String	The average value over all measurements for the capacitance as formatted string with unit.
dac_temperature_minimum	String	The minimum value of the temperature as formatted string with unit.
dac_temperature_maximum	String	The maximum value of the temperature as formatted string with unit.
dac_temperature_average	String	The average value over all measurements for the temperature as formatted string with unit.
dac_damping_factor_minimum	String	The minimum value of the damping factor as formatted string with unit.

*Continued on next page*

Table 9.1 – Continued from previous page

Key	Return	Description
dac_damping_factor_maximum	String	The maximum value of the damping factor as formatted string with unit.
dac_damping_factor_average	String	The average value over all measurements for the damping factor as formatted string with unit.
dac_estimated_tandelta_cable_minimum	String	The minimum value of the estimated cable tan delta as formatted string with unit.
dac_estimated_tandelta_cable_maximum	String	The maximum value of the estimated cable tan delta as formatted string with unit.
dac_estimated_tandelta_cable_average	String	The average value over all measurements for the estimated cable tan delta as formatted string with unit.
dac_cable_length	String	The length of the cable as formatted string with unit.
dac_cable_topology	String	The cable topology.
dac_cable_rms_value	String	The cable voltage U0 as rms value formatted as string with unit.
dac_cable_peak_value	String	The cable voltage U0 as peak value formatted as string with unit.
dac_cable_comment	String	The comment which was added into the report text editor for the cable.
dac_tdr_gain	String	The used gain factor during TDR calibration.
dac_tdr_relative_magnitude	String	The relative magnitude of the TDR calibration.
dac_tdr_velocity	String	The velocity of the cable.
dac_tdr_comment	String	The comment which was added into the report text editor for the TDR calibration.
dac_pattern_comment	String	The comment which was added into the report text editor for the pattern.
dac_location_comment	String	The comment which was added into the report text editor for the location.
dac_conclusion_comment	String	The comment which was added into the report text editor for the conclusion.
cable_structure_pics	List of Elements	Is the mapping of the cable structure as image with the phase name as description. For accessing the data the key 'image' is for the cable structure image and 'desc' to access the description of the cable (phase name).
dac_tdr_data	Image	Contains the TDR diagram as an image.
dac_analyze_area_list	List of Elements	Contains the list of all available analysis regions which were used during the reflection detection. Each entry have the following parameter which can be accessed in a loop: 'index' is the current number of the analysis area, 'startPhase' is the phase where the area starts, 'endPhase' is the phase where the area ends, 'minSignal' is the minimum signal where the area starts and 'maxSignal' is the maximum signal where the area ends
dac_analyze_phase_ranges	Integer	Is the number of used analysis areas.

*Continued on next page*

Table 9.1 – Continued from previous page

Key	Return	Description
dac_location_mapping_list	List of Elements	Contains the image of the location mapping with corresponding phase name. For accessing the data the key 'image' is for the location mapping image and 'desc' to access the description of the cable (phase name).
dac_location_histogram_data	Image	Contains the image of the location histogram diagram.

Table 9.1: Word report template keys for all report templates

### 9.3.2 Word report template key for DAC report templates

This section contains all keys which are only available if a DAC report should be created. In table 9.2 all keys are contained which can be used in DAC report templates only.



The key *dac\_number\_of\_shots* is used to detect a report template for the DAC report.

Key	Type	Description
dac_number_of_shots	Integer	The number of shots during the test.
dac_frequency_minimum	String	The minimum value of the frequency as formatted string with unit.
dac_frequency_maximum	String	The maximum value of the frequency as formatted string with unit.
dac_frequency_average	String	The average value over all measurements for the frequency as formatted string with unit.
dac_analysis_comment	String	The comment which was added into the report text editor for the analysis.
dac_pattern_data	Image	Contains the pattern diagram as an image.
dac_damping_analysis_list	List of Elements	Contains the images for detail diagrams with corresponding cable phase name. Each entry can be accessed in a loop with following parameters: 'desc' is the cable phase name, 'image_frequency' is the image of the frequency diagram, 'image_capacitance' is the image of the capacitance diagram, 'image_damping_factor' is the image of the damping factor diagram and 'image_tan_delta' is the image of the approx. tan delta diagram.

Table 9.2: Word report template keys for DAC report templates



### 9.3.3 Word report template key for VLF report templates

This section contains all keys which are only available if a VLF report should be created. The table 9.3 contains all keys which can be used for VLF report templates.



The key *dacvlf\_measure\_duration* is used to detect a report template for the VLF report.

Key	Type	Description
dacvlf_measure_duration	String	Contains the duration of the VLF test.
dacvlf_overview_comment	String	The comment which was added into the report text editor for the overview.
dacvlf_rising_pattern_data	Image	Contains the pattern diagram for the rising edge as image.
dacvlf_falling_pattern_data	Image	Contains the pattern diagram for the falling edge as image.
dacvlf_complete_measurement_data	Image	Contains the image for the complete VLF overview diagram.
dacvlf_detailed_measurement_data	Image	Contains the image for the detailed VLF overview diagram.

Table 9.3: Word report template keys for VLF report templates

# General Information

This chapter describes the general overview of the OHV Suite software. The software has a modular structure so that different modules can be loaded during run time. This chapter does not deal with the different modules, but describes the general handling of the application. The main focus here is to obtain important information such as the software version, contact information and main settings.

## A.1 General software structure

The general structure of the software is split into two main parts. In Figure A.1 the structure of OHV Suite can be seen.

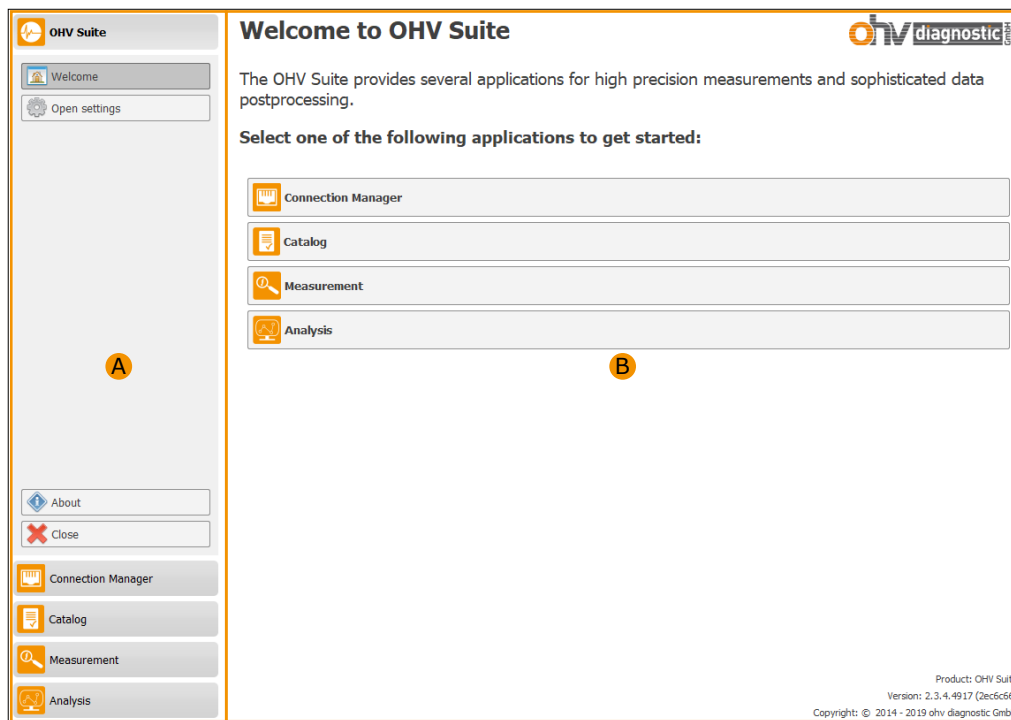


Figure A.1: Logical software structure

On left side of the software, marked with **A**, all available applications are shown and can be selected. The right part of the software, marked with **B**, is used for displaying the screen for the selected application.

## A.2 Start screen - Main application

After starting of OHV Suite software the start screen with the main application ① is shown (cf. Figure A.2).

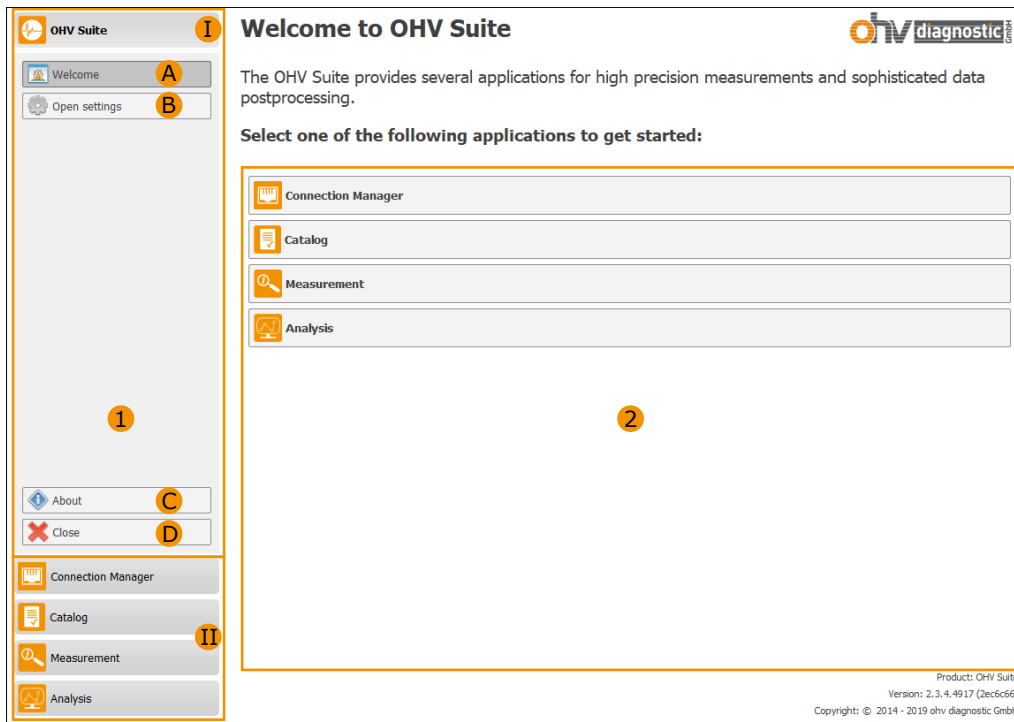


Figure A.2: Start screen (marked important information)

The left side of the contains the different applications which are marked with ① and ②. Here ① represents the selected application and ② all other non-selected applications. ① contains all available sub application options which are available for the main application. The right side ② displays the first sub application page (A). On this page all available applications are listed. The start screen can be reached by clicking on the button ① and than on button A. The main application contains the following sub applications:

- ① Welcome page, which displays the start screen
- ② Settings page, which allows to change application settings
- ③ About page, which displays the general information
- ④ Close button, allows closing of the application

### A.2.1 Settings

The settings could be reached by using the **B** (cf. Figure A.2) button. The selected sub settings page is shown on the right side.

#### General settings

The OHV Suite software is written as a multilingual application that allows switching between different languages. The available languages are listed in the selection list in the general settings. Selecting a new language automatically displays the application in the selected language without restarting. Currently the following languages are available within the software:

- English
- German
- Chinese (simplified)
- Vietnamese

Additionally the OHV Suite software allows to check for new updates. Details about the software update can be read in Section C.1.

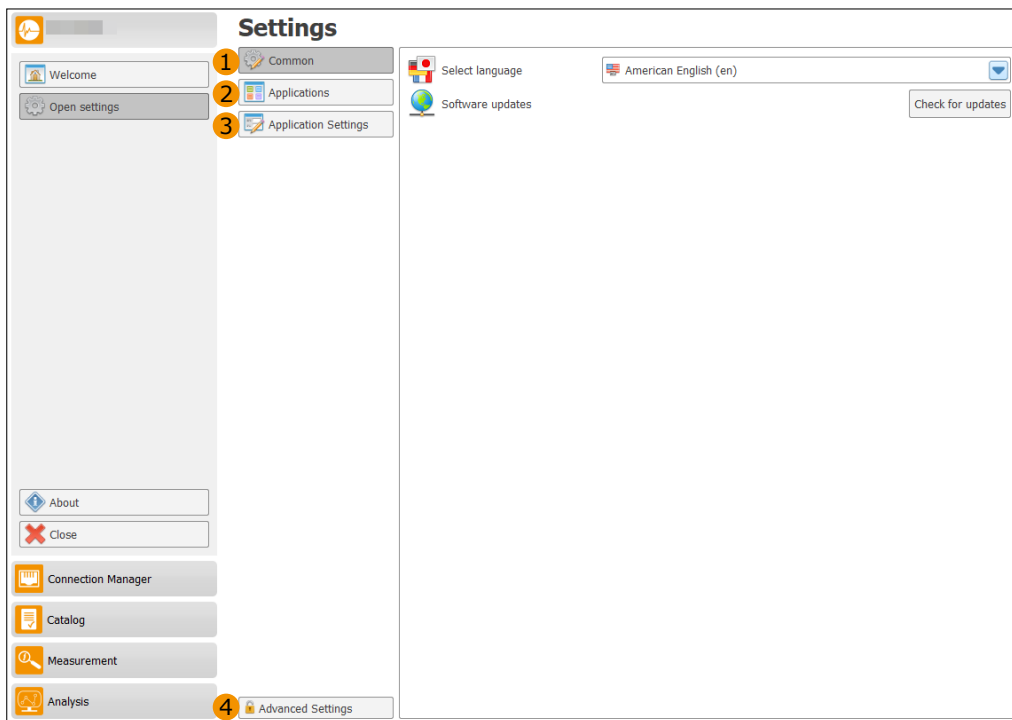


Figure A.3: General settings

## Applications

This setting can be reached by a click on the button marked with ② inside the settings page. On the top of the applications (cf. A on Figure A.4) all available applications are listed. These applications can be enabled or disabled inside the OHV Suite software.



Disabled applications could not be used and are not shown inside the application list.

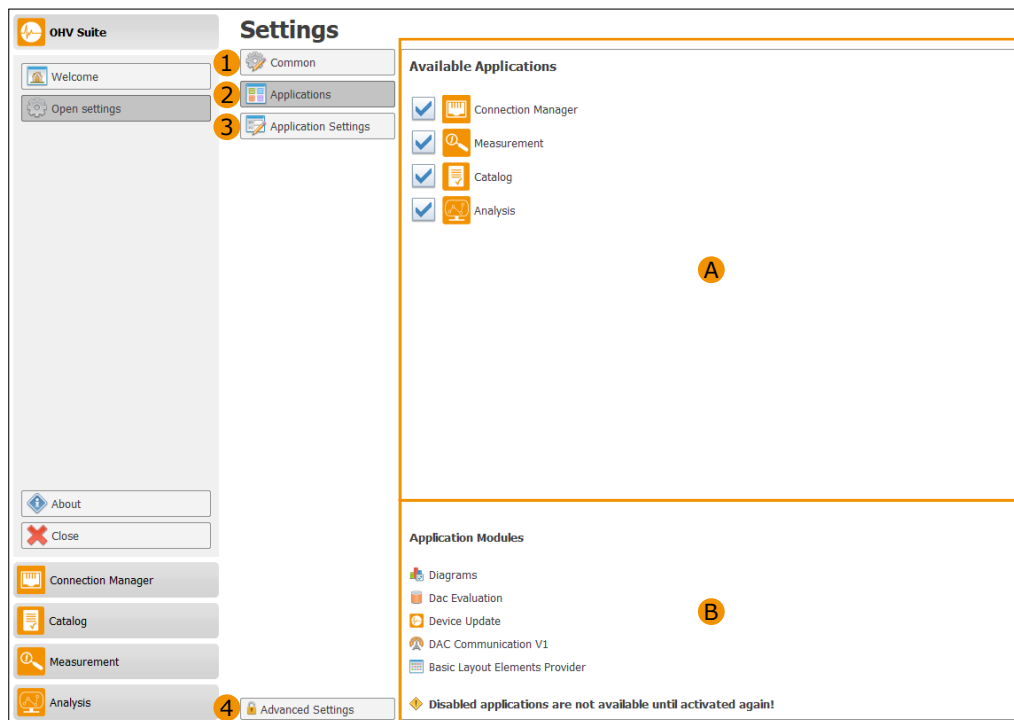


Figure A.4: Applications

On the bottom of the applications (cf. B on Figure A.4) all modules are listed which are required to provide different functionality used inside the OHV Suite software. These modules could not be disabled like the applications above.

Each of these parts have its own program version. The different version information can be shown by using the mouse and hover over the module or application. After a short time a tool-tip is shown with all information of the module or application.

## General Application Settings

The general application settings can be selected with button ③ in Figure A.5. Within this section all the available application settings can be found. These settings depends on the application that was detected during the loading of different libraries when starting the OHV Suite. When an application setting is selected on the the left side (cf. ① on Figure A.5) the setting can be modified.

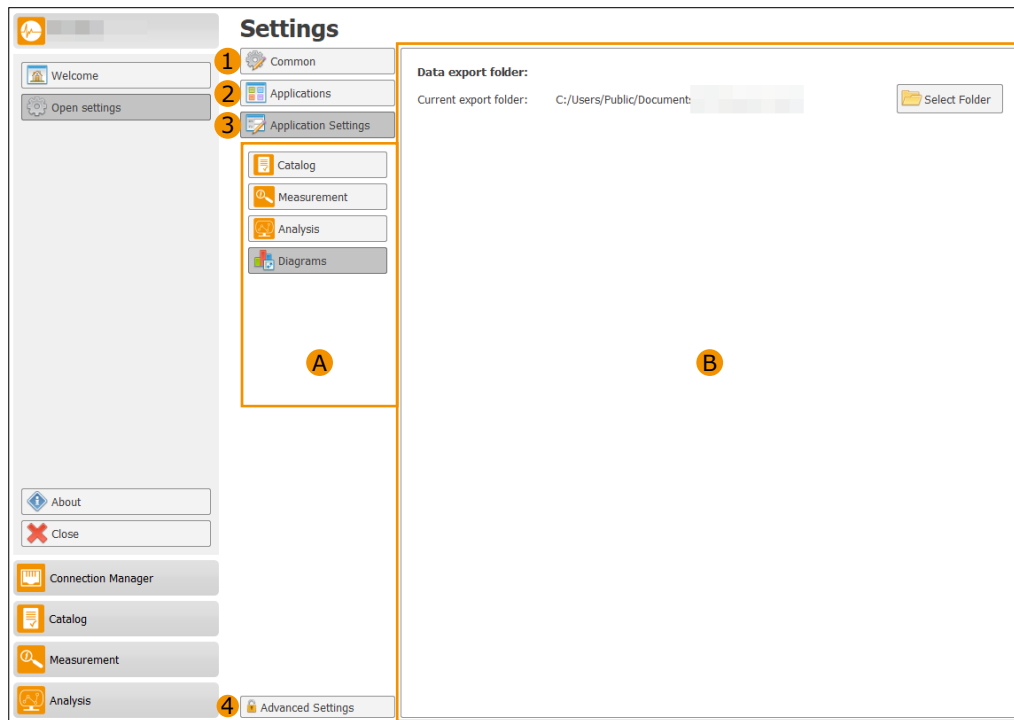


Figure A.5: General Application settings

**Diagram** The diagram settings are described in section B.1.

**Catalog** The DAC Catalog settings are described inside section 6.1.

**Measurement** The DAC measurement settings are described inside section 7.1.

**Analysis** The Analysis settings are described inside section 8.1.

## Advanced settings

The button ④ in Figure A.4 shows a window for inserting a password which enables advanced settings. These extended settings are only available for the developers and service technicians of ohv diagnostic GmbH.

### A.2.2 About

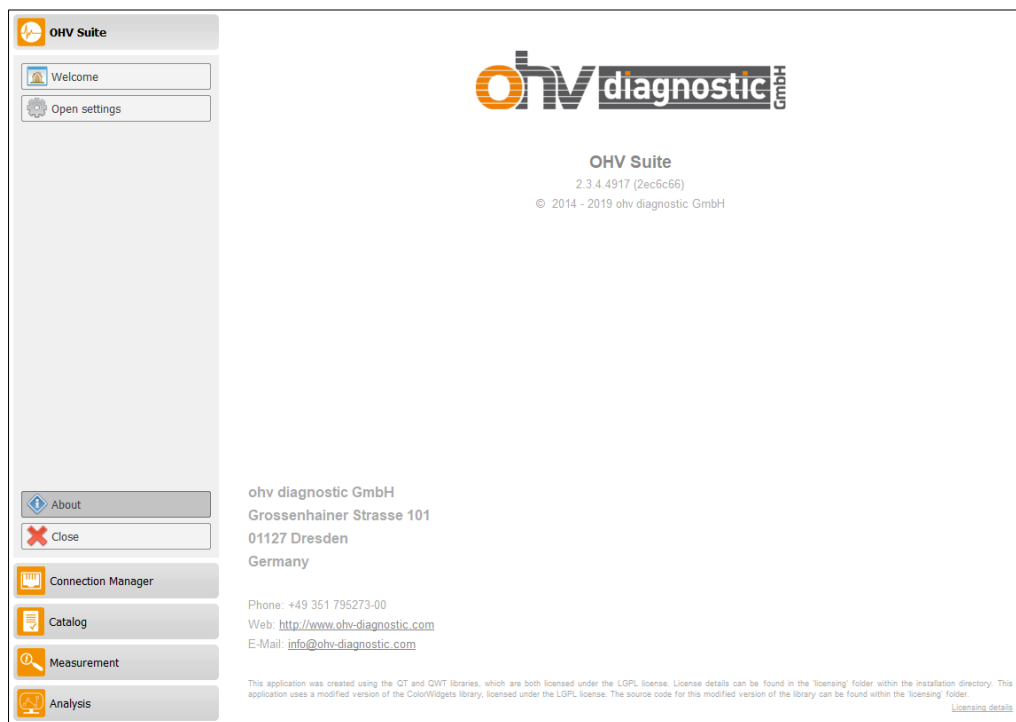


Figure A.6: About information

This page contains all information about the OHV Suite software and the contact information.

## General Application settings

This chapter describes the general application settings available in the OHV Suite software. Inside the application settings, available will be the basic settings (cf. **A** on Figure B.1) for all the selected applications like the PD Analysis, Measurement, Analysis, catalog. The settings for all the other applications varies with the type of the application.

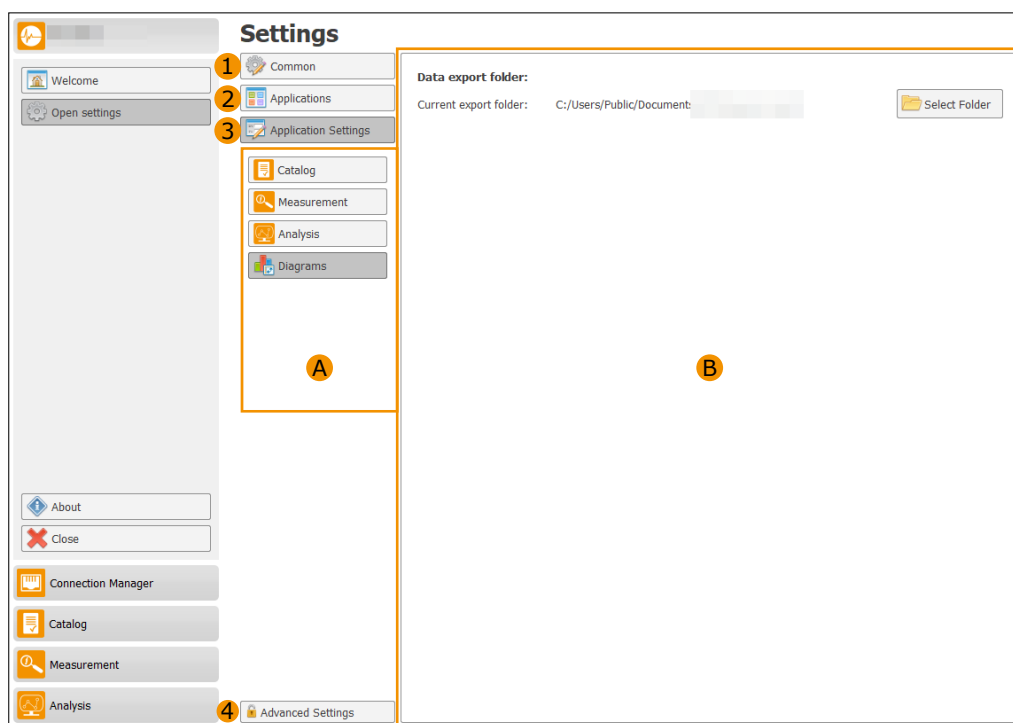


Figure B.1: Application settings

### B.1 Diagram Settings

Along with these settings, an option for selecting the Diagrams export folder is available (cf. **B** on Figure B.1). The export folder is used to store the diagram data exports and diagram images.



## Software Update

This chapter describes how to update the OHV Suite software and the device software.

### C.1 Updating OHV Suite software

The next sections containing the information how the OHV Suite software can be updated.

#### C.1.1 Checking software update

This section describes how the checking for a software update can be done. The software update check can be found if the main application will be opened, then navigate over *Open settings* and *Common* to the common settings overview. How to navigate inside the OHV Suite software is described in Chapter A.

The button *Check for updates* (cf. Figure C.1, A) can be used if a new update for the OHV Suite software is available. When a new version was found a message box is shown (cf. Figure C.2). If there is no update available this information is depicted inside the status information like in Figure C.1.

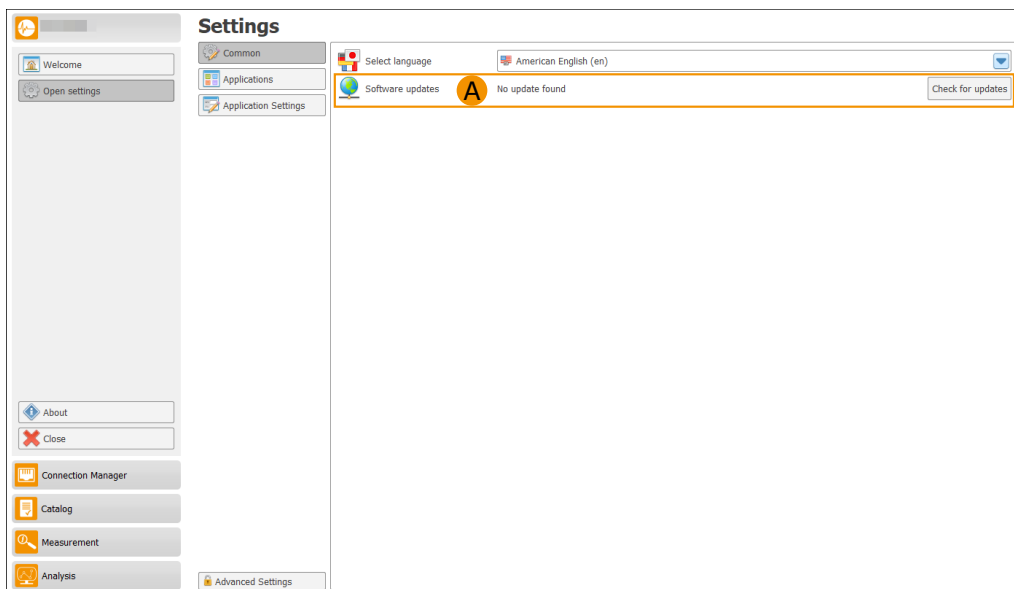


Figure C.1: Checking for update

#### C.1.2 Downloading software update

Downloading the software can be done in two ways. The first option is to perform the download automatically with the software or manually over the homepage.

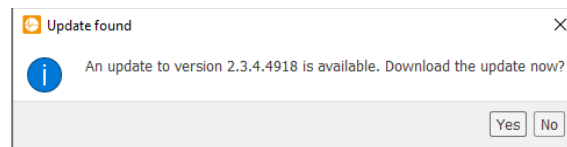


Figure C.2: Update available

For downloading the latest version through the software the *Yes* button of the message box C.2 must be clicked. This will start the download immediately. The user interface will be changed for displaying the current status of the download progress like shown in Figure C.3.

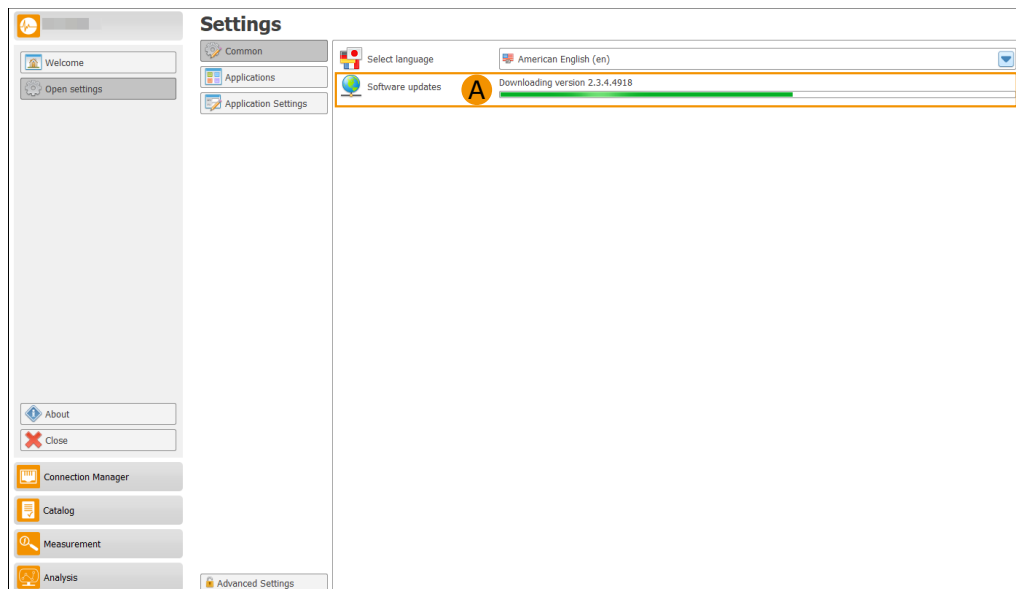


Figure C.3: Downloading update

If the download should be performed manually the *No* button of the message box C.2 must be clicked. The user interface depicted now a button *Download update manually* (cf. Figure C.4). By clicking this button the web browser is opened with the web site where the download could be select manually.

### C.1.3 Installing software update

Installing the update can also be done in two ways. The first way is to start the installation from the software directly by pressing the button *Install* (cf. Figure C.5). If the downloaded file is not available the message box C.6 is appeared that the downloaded file is missing. Otherwise the download is started automatically and the software is closed directly.

The second way to install the new software is to start the setup manually from the download folder or where the browser is storing the downloaded files.

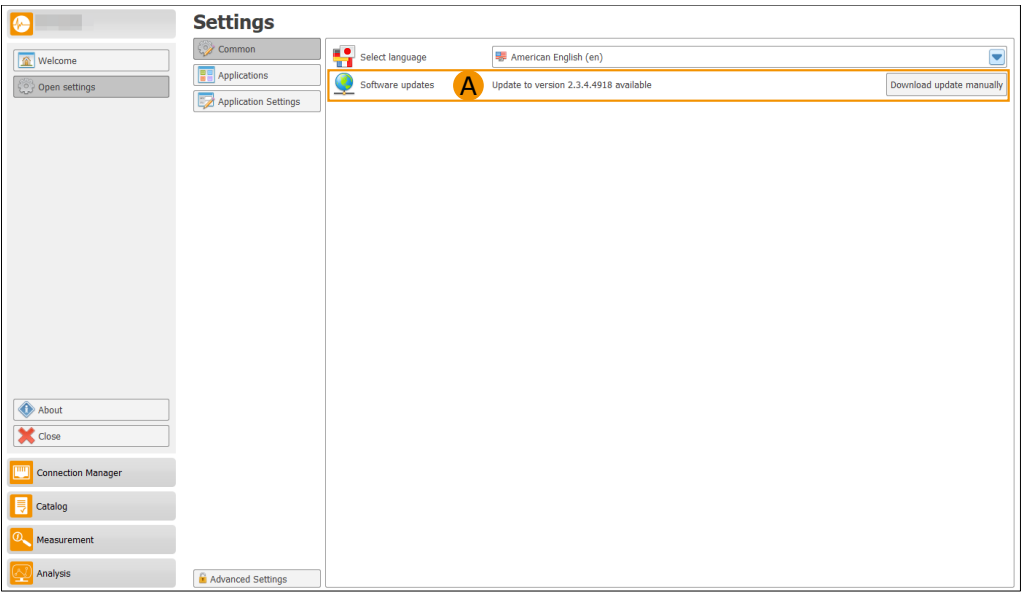


Figure C.4: Manual download

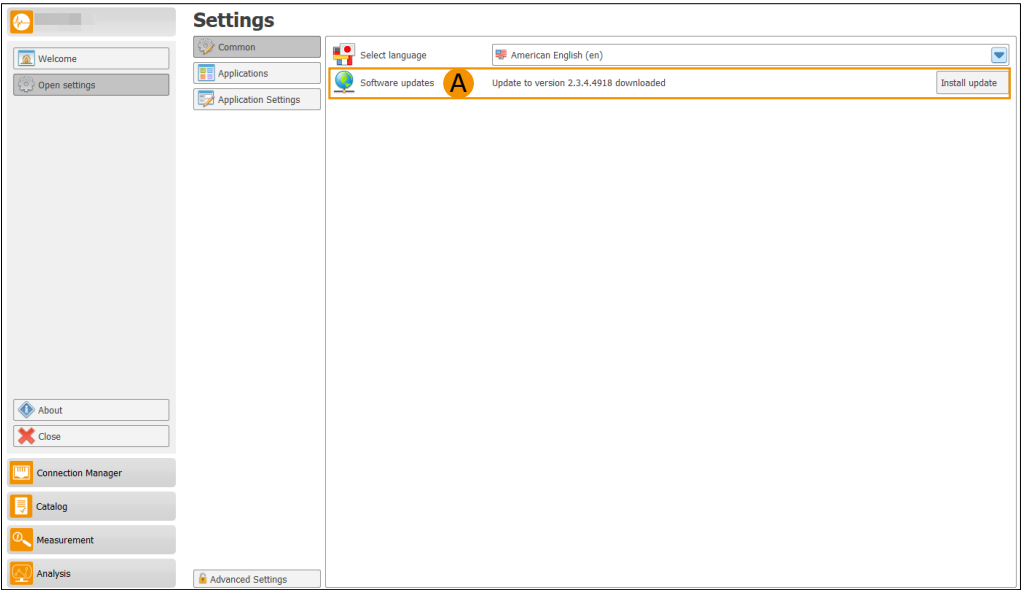


Figure C.5: Download finished

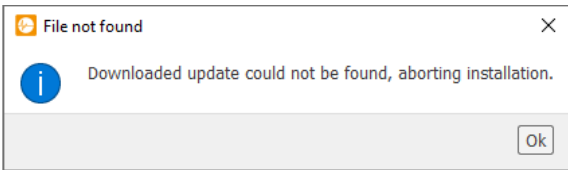


Figure C.6: Download file missing

## C.2 Updating device software

The software suite supports upgrading the device software. This section will explain how this can be done.

After to connection to the device was established successfully, the device overview will be shown, as can be seen in Image C.7. Next to the device status and software version information the *Update* button can be found at the bottom right of the area marked with **A**.

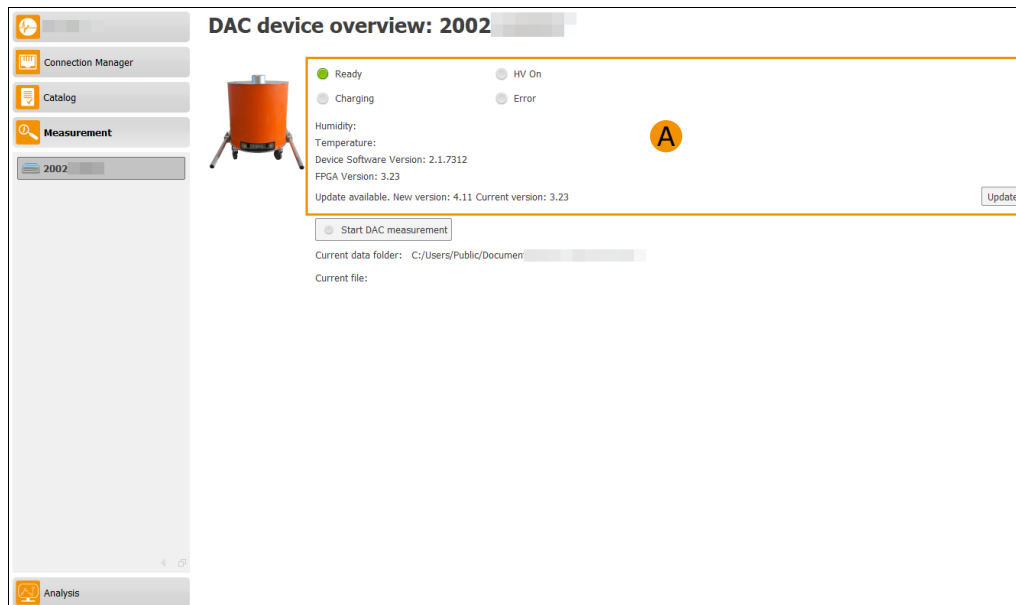


Figure C.7: Information about the chosen device

When the button is clicked, the update will start. The button now will be replaced by a progress bar which indicates the progress of the update (image C.8). Next to the progress bar on the left side information will be displayed what version of the device software is installing.



Don't interrupt the update by shutting off the device or in any other way!

When the upgrade is finished, the software will inform about this event by showing a message similar as in Image C.9. The application will now be closed and has to be restarted. After this, the upgrade is done.

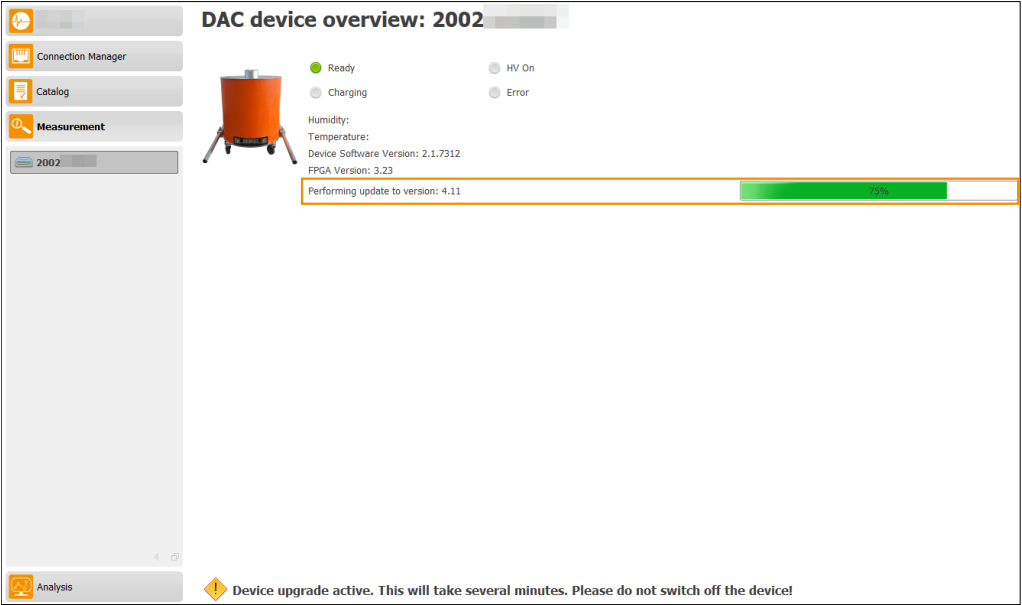


Figure C.8: Updating in process

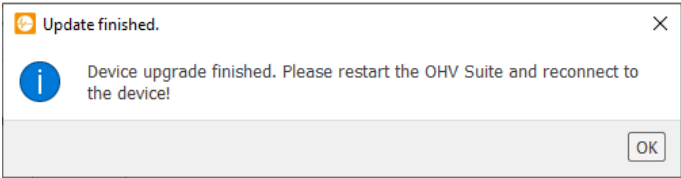


Figure C.9: Information about finished upgrade

## Connection manager

This chapter describes how to establish a connection to a device. To be able to connect to a device, the connection management must be opened. The general structure of the connection management is shown in Figure D.1.

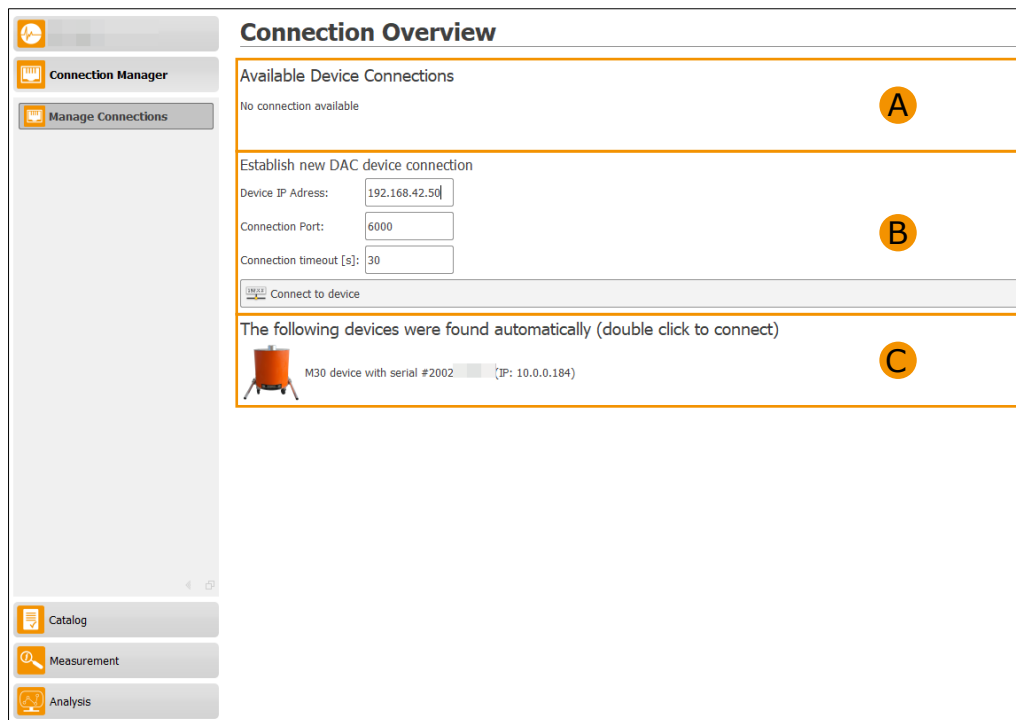


Figure D.1: Connection manager

In the upper section **A** you will find the list with all connections and their status information. The **B** section contains the information required for a connection and a *Connect to device* button to start a connection attempt. The lower section **C** contains a list of devices found in the network.

## D.1 Connecting to a DAC device

To connect to a DAC device, the following fields (cf. Table D.1) must be filled in. By a single left-click on a device in the device list, the input fields are filled with the required data to connect to this specific device. If double clicked, the connection manager will automatically connect to the selected device.

Element	Description
<b>Device IP Address</b>	The static IPv4 address of the device must be entered in this field. This is normally attached to the device. The concrete procedure for network configuration is described in the corresponding manual of the device.
<b>Connection Port</b>	Here you can specify an alternative port for the connection.
<b>Connection timeout</b>	This field specifies timeout after which a connection is interrupted.

Table D.1: Connection input elements for a DAC device

After all settings have been made, a connection to the device can be established by clicking the *Connect to device* button. To finish the connection, it is required to confirm that the shown safety rules where read as can be seen in D.2. The device is now displayed in the connection overview. Depending on the connection status, the information is also displayed in the device overview. The following status messages are described in Table D.2:

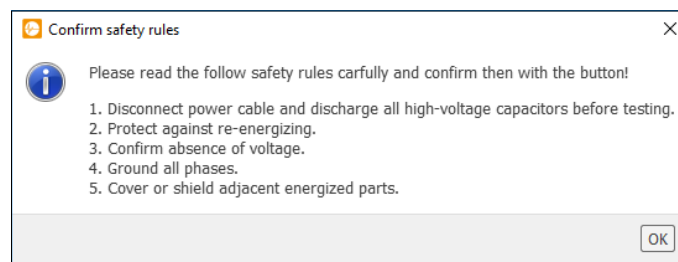


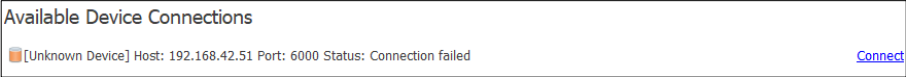
Figure D.2: Confirm safety rules.

Element	Description
<b>Establishing connection</b>	An attempt is made to connect to the device with the specified IP address and port (cf. Figure D.3a).
<b>Connection established</b>	The connection to the device was successfully established (cf. Figure D.3c). The text <i>Disconnect</i> is displayed on the right. Clicking on this label disconnects the connection to the device.
<b>Connection failed</b>	No connection to the device could be established (cf. Figure D.3b). The text <i>Connect</i> is displayed on the right. Clicking this label will attempt to reconnect to the device.

Table D.2: Connection status



(a) Establishing connection



(b) Connection failed



(c) Connection established

Figure D.3: Connection status



---

## Remote support

This chapter describes how to use the remote support tool. When installing OHV Suite, you can also install the additional program for remote support. This makes it possible to connect the ohv diagnostic GmbH to the customer's computer in order to clarify problems directly with the customer and to see the work steps. An active Internet connection is required for remote support. The *TeamViewer* service is used as a remote support tool, via which the connection is established. When starting remote support, the ohv diagnostic GmbH automatically receives a notification that a new request exists.

### E.1 Start remote support tool

The remote support tool can be searched directly via the Windows input mask. Click on the Windows icon and then type *OHV Suite Remote-Support* in the *Search Programs/Files* text box. If the program has been installed, the name of the program (cf. Figure E.1) will appear in the upper area. Click on the program with the left mouse button to start the program.

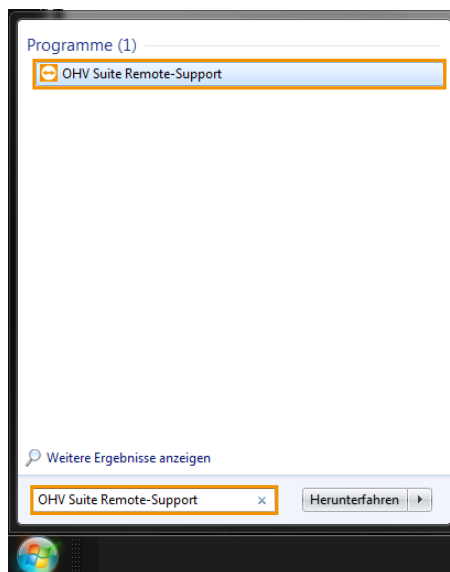


Figure E.1: Start the remote support tool

### E.2 Allow remote connection

The ohv diagnostic GmbH tries to establish a connection with the remote support tool, where the customer must allow the connection. As a result, ohv diagnostic GmbH gets access to the client's computer.

---

## Test object capacitance diagrams

### F.1 DAC M60 maximum available test object capacitance depending on test voltage

The following diagram shows the maximum available capacitance which can be loaded depending on the test voltage for a DAC M60 device.

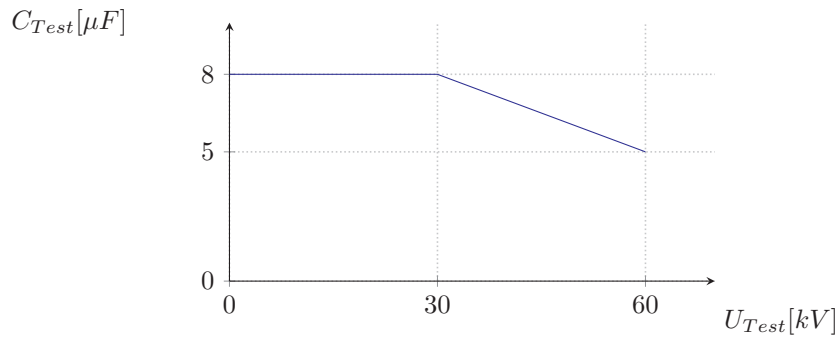


Figure F.1: DAC M60 test object capacitance depending on test voltage

---

## Test object altitude

The maximum available test voltage depends on the altitude above sea level and the ambient temperature.

The specified maximum test voltage levels are provided for 0 m above sea level and a temperature of 20°.

# List of Figures

1.1	DAC remote safety box . . . . .	3
3.1	DAC voltage shape (50 Hz) with damping curve . . . . .	7
3.2	DAC testing equipment illustration . . . . .	7
3.3	Example test procedure for DAC test . . . . .	8
3.4	basic parallel equivalent circuit of an insulation system . . . . .	8
3.5	Damping factor . . . . .	9
3.6	Simple model for losses inside DAC test circuit . . . . .	9
3.7	PRPDA pattern generation from several shots . . . . .	10
3.8	PD location mapping from selected PD signals . . . . .	11
3.9	Generation of a PD signal reflectogram . . . . .	12
3.10	Damping curve of PD signal damping . . . . .	12
3.11	PD signal (a) before and (b) after having traveled approx. 800 meters inside XLPE cable . . . . .	13
5.1	Connecting the DAC device (M-Series) . . . . .	24
5.2	Available connections on the control unit (M-Series) . . . . .	25
5.3	Connecting the H-Series DAC device . . . . .	26
5.4	Available connections on the control unit (H-Series) . . . . .	27
5.5	Setting-up calibration . . . . .	29
5.6	DAC system software: Welcome window . . . . .	31
6.1	General overview for the DAC Catalog . . . . .	32
6.2	Reset to Default Folder . . . . .	32
6.3	Simple Mode view . . . . .	33
6.4	Modified test information in Simple Mode . . . . .	33
6.5	Cable voltage input in simple mode . . . . .	34
6.6	Advanced configuration mode . . . . .	35
6.7	New test location . . . . .	36
6.8	New tester . . . . .	37
6.9	New Cable . . . . .	38
6.10	New customer . . . . .	40
6.11	New test procedure . . . . .	41
7.1	Overview simple measurement configuration . . . . .	43
7.2	Display the switching ranges in simple measurement mode . . . . .	43
7.3	Overview advanced measurement configuration . . . . .	44
7.4	Safety rules . . . . .	44
7.5	Device overview without started measurement . . . . .	45
7.6	Device overview with started measurement . . . . .	47
7.7	PD calibration overview . . . . .	49
7.8	Calibration saturation . . . . .	50
7.9	TDR calibration overview . . . . .	51
7.10	Bad and good TDR calibration saturation . . . . .	52
7.11	Update current cable . . . . .	54

7.12	Create new cable	54
7.13	TDR options	54
7.14	DAC measurement overview high voltage off (simple mode)	56
7.15	DAC measurement overview high voltage on (simple mode)	56
7.16	Calibrator removal warning	59
7.17	Phase selection	59
7.18	Waiting for next measurement	60
7.19	Continue with next phase	60
7.20	Grounding and connecting new phase warning	60
7.21	Wait for continue the measurement	61
7.22	Select next phase	61
7.23	DAC measurement overview	62
7.24	Disabled result view during running measurement	65
7.25	Finished test	66
7.26	Double side measurement overview high voltage off (simple mode)	67
7.27	Double side measurement overview high voltage on (simple mode)	67
7.28	Calibrator removal warning	70
7.29	Phase selection	70
7.30	Waiting for next measurement	71
7.31	Continue with next phase	71
7.32	Grounding and connecting new phase warning	71
7.33	Wait for continue the measurement	72
7.34	Select next phase	72
7.35	Double side measurement overview	73
7.36	Disabled result view during running measurement	76
7.37	Finished test	77
7.38	VLF measurement overview	78
7.39	VLF measurement finished	80
7.40	Leakage current measurement overview	81
7.41	LC measurement finished	84
7.42	Add a comment to the test	85
7.43	Add new high voltage shot	85
8.1	Analysis Configuration (Simple Mode)	86
8.2	Analysis Configuration (Advanced Mode)	88
8.3	DAC analysis test browser	89
8.4	Select a test to analyze	90
8.5	Analysis Overview (DAC test)	95
8.6	Analysis Overview (VLF test)	95
8.7	DAC Measurement	96
8.8	VLF Measurement	96
8.9	Data Filtering	97
8.10	TDR Calibrations	98
8.11	Analysis Pattern (DAC test)	99
8.12	Analysis Pattern (VLF test)	99
8.13	Pulses Overview (DAC test)	100
8.14	Pulses Overview (VLF test)	100
8.15	VLF Overview	101
8.16	Reflections Overview (Simple analysis mode)	102
8.17	Reflections Overview (Advanced analysis mode)	104
8.18	Reflections Overview (Advanced analysis mode with histogram and sorted by location)	104
8.19	The DAC Analysis Details	105
8.20	Capacitance	106
8.21	Frequency	107
8.22	Damping factor	107
8.23	Approx. $\tan \delta$ Cable	108
8.24	The automatic report generation	109

8.25	Successful generated PDF Report . . . . .	111
8.26	Word report template selection . . . . .	112
8.27	Successful generated Word Report . . . . .	112
8.28	Selection for import folder . . . . .	113
8.29	File selection for the import . . . . .	114
8.30	Progress of the import . . . . .	114
8.31	Data import finished . . . . .	115
8.32	Fault location DAC measurement . . . . .	116
8.33	Fault location Double Side measurement . . . . .	117
8.34	Fault location double side analysis . . . . .	117
9.1	Basic Placeholder example . . . . .	119
9.2	Template table example . . . . .	120
A.1	Logical software structure . . . . .	126
A.2	Start screen (marked important information) . . . . .	127
A.3	General settings . . . . .	128
A.4	Applications . . . . .	129
A.5	General Application settings . . . . .	130
A.6	About information . . . . .	131
B.1	Application settings . . . . .	132
C.1	Checking for update . . . . .	133
C.2	Update available . . . . .	134
C.3	Downloading update . . . . .	134
C.4	Manual download . . . . .	135
C.5	Download finished . . . . .	135
C.6	Download file missing . . . . .	135
C.7	Information about the chosen device . . . . .	136
C.8	Updating in process . . . . .	137
C.9	Information about finished upgrade . . . . .	137
D.1	Connection manager . . . . .	138
D.2	Confirm safety rules. . . . .	139
D.3	Connection status . . . . .	140
E.1	Start the remote support tool . . . . .	141
F.1	DAC M60 test object capacitance depending on test voltage . . . . .	142



---

# List of Tables

4.4	Software requirements . . . . .	22
5.1	Available connections on the control unit (M-Series) . . . . .	25
5.2	Available connections on the control unit (H-Series) . . . . .	27
6.1	Test location options . . . . .	36
6.2	Tester options . . . . .	37
6.3	Cable options . . . . .	38
6.4	Customer options . . . . .	40
6.5	Test procedure options . . . . .	41
7.1	Device information . . . . .	46
7.2	Implausible configurations . . . . .	48
7.3	TDR input parameter . . . . .	53
7.4	TDR options . . . . .	55
7.5	Result view elements . . . . .	57
7.6	DAC measurement elements . . . . .	57
7.7	Current DAC measurement value elements . . . . .	58
7.8	Possibilities for continuing the DAC measurement . . . . .	59
7.9	Result view elements . . . . .	62
7.10	DAC measurement elements . . . . .	63
7.11	Current DAC measurement value elements . . . . .	64
7.12	Result view elements . . . . .	68
7.13	Double side measurement elements . . . . .	68
7.14	Current Double side measurement value elements . . . . .	69
7.15	Possibilities for continuing the Double side measurement . . . . .	70
7.16	Result view elements . . . . .	73
7.17	Double side measurement elements . . . . .	74
7.18	Current Double side measurement value elements . . . . .	75
7.19	VLF Measurement overview elements I . . . . .	79
7.20	VLF Measurement overview elements II . . . . .	79
7.21	LC Measurement overview elements I . . . . .	82
7.22	LC Measurement overview elements II . . . . .	83
8.2	Report sections . . . . .	110
9.1	Word report template keys for all report templates . . . . .	123
9.2	Word report template keys for DAC report templates . . . . .	124
9.3	Word report template keys for VLF report templates . . . . .	125
D.1	Connection input elements for a DAC device . . . . .	139
D.2	Connection status . . . . .	139