



Automotive
Energy & Power Analysis
Aerospace & Defense
Transportation
General Test & Measurement

Power Tutorial

User Manual



Test & Measurement Solutions



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1 Introduction

Welcome to the DEWETRON Power Manual / Tutorial.

In this paper you will learn all about "**Measurements in Electrical Power Engineering**" with Dewetron Measurement Systems

This paper is meant to be a supportive tool for understanding the DEWETRON power measurement instrument and a supplement to the existing manuals.

The tutorial is subdivided in the following topics:

Power User Manual

Here you will learn how to connect voltage, currents and any other sensor to the system and configure them in the software. As next step you will learn how to calculate the power for different system configurations in the so called "Power module" as well as a description for all parameters which can be calculated. The different storing types for data storing and some additional measurements (efficiency, energy, recuperation, etc) closes this chapter.

Application Notes / Examples

In this chapter you will find tutorials for the measurement on different machines (motor, converter, emobility), how to make Power Quality reports (EN50160, 61000-3-2, etc.), how to set up the device as Fault recorder. The configuration for long-term measurement at wind mills and HVDC lines completes this chapter.

Technical Reference

In the Technical Reference you will find all formulas for the different parameters the software calculates respective the reference to the corresponding standard.

2 Power User Manual

This chapter informs you about measuring:

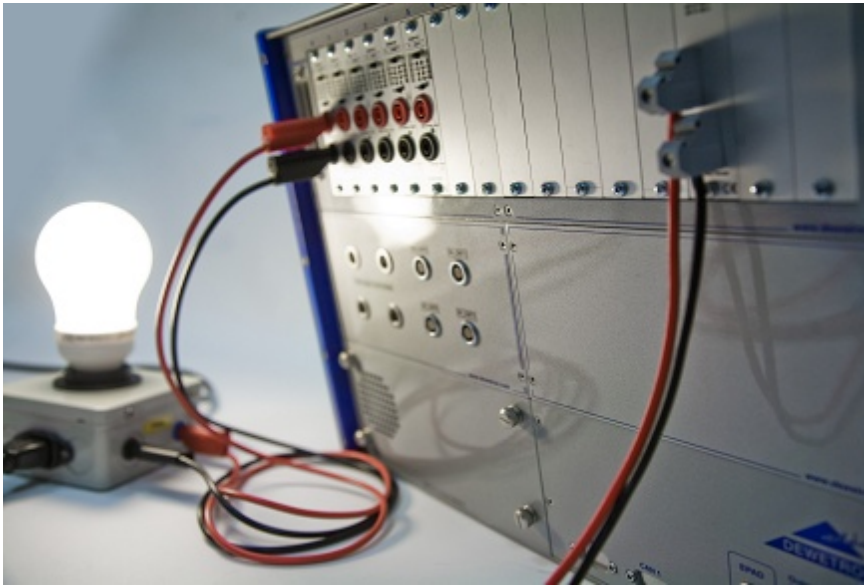
Voltage

Current

Power

[Power Module](#)

Storing data



2.1 Voltage measurement

Objective: This chapter intends to inform you about how to measure voltage.

Required:

a measuring instrument with a rack (e.g. DEWE-2600)

a module type DAQP-HV (or DAQP-DMM)

software DEWESoft

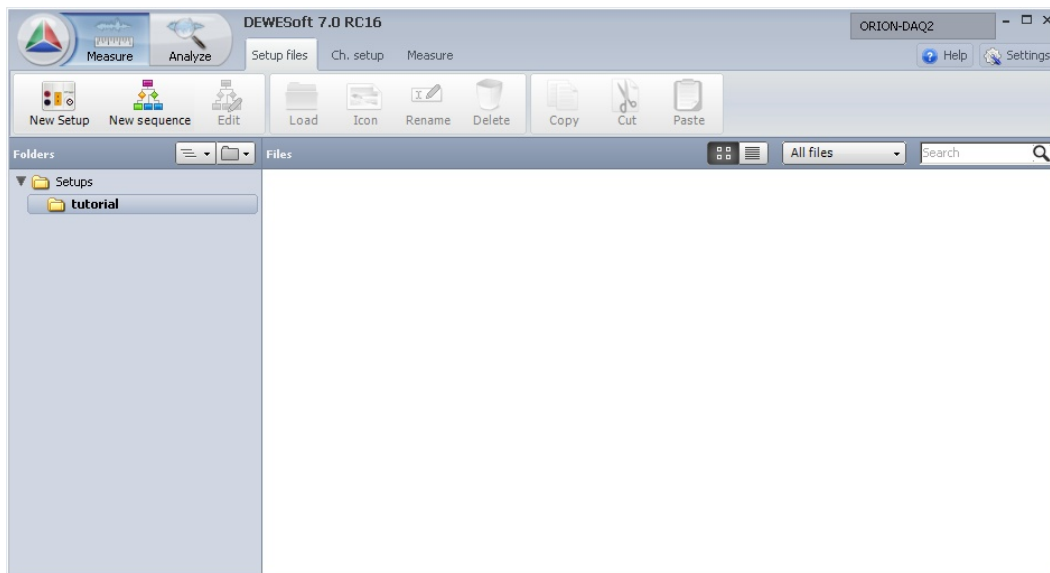
option DEWESoft Power

Procedure:

1. Start DEWESoft.



2. Create a new setup.

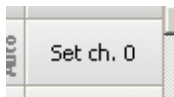
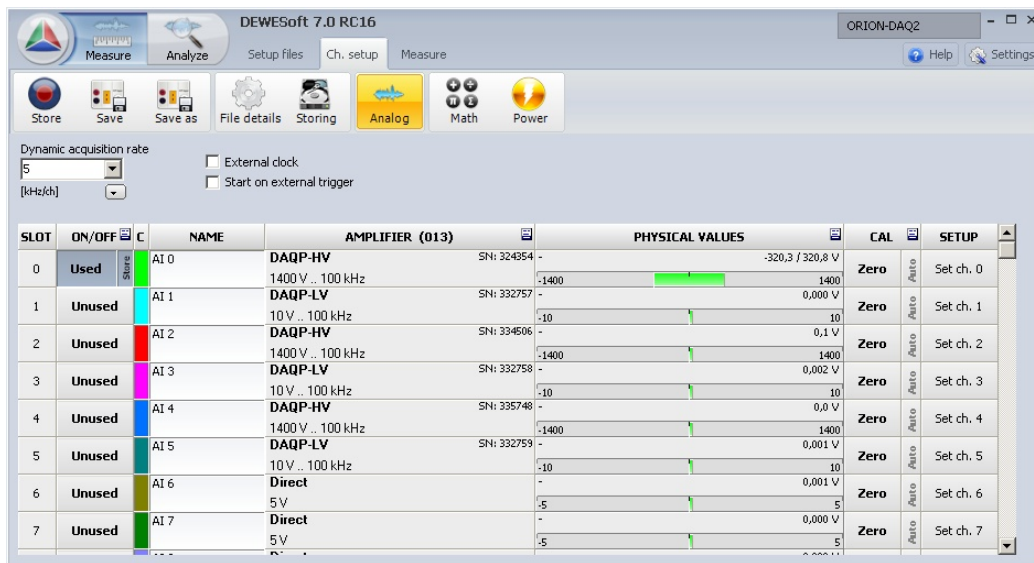


3. Connect voltage and the module.

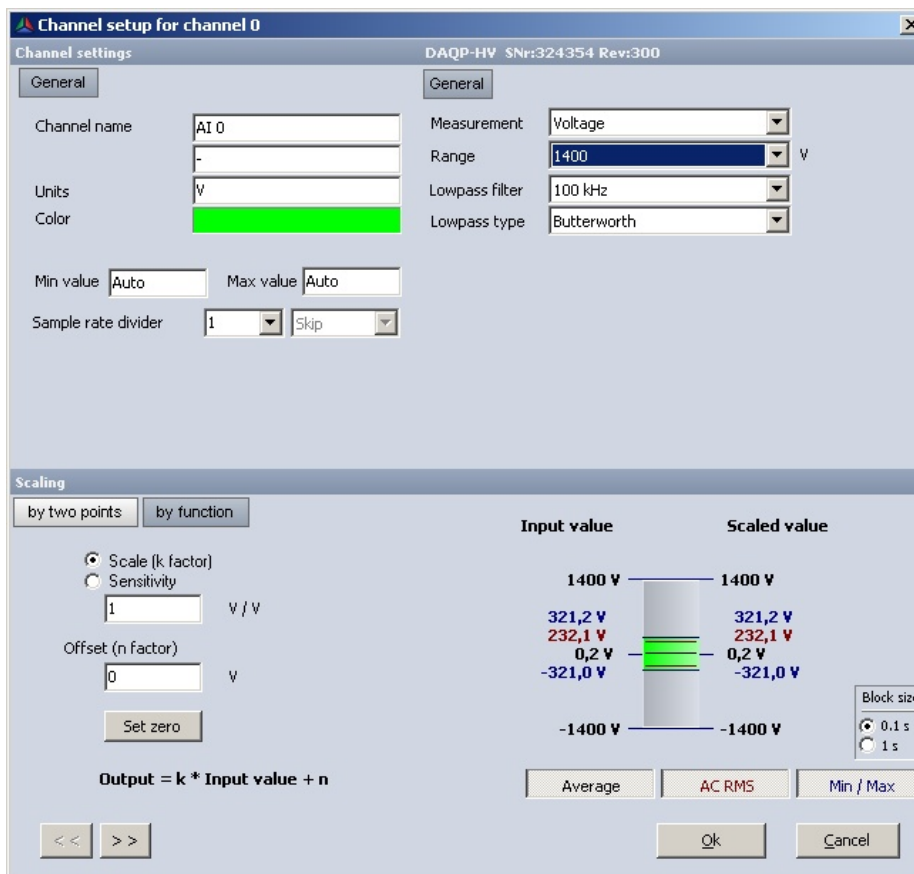
Possible modules to be used: DAQP-HV, DAQP-DMM, MDAQ-PQL-SUB-HV



4. Set the channel.



5. Choose the measurement range and the filter.

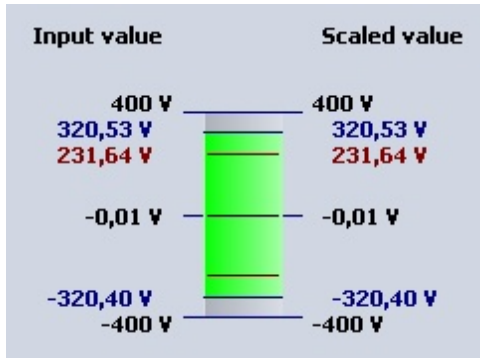


Measurement / range:

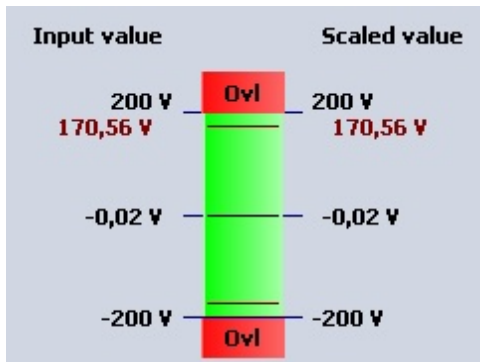
Measurement	Voltage
Range	1400 V

refers to the maximum measurement range of the input channel. This one should lie above the expected peak value of the voltage. Typical setting: measurement voltage 230V / peak value 325V / measurement range 400V

In the level indicator the individual values are already visible (green).



When the measurement range is too small, the indicator turns red and shows the message "overload".



Filter / low-pass filter:

The filter serves as a suppression of the Aliasing effect and should be adjusted to about 40 % of the sample rate.

Lowpass filter	100 kHz
Lowpass type	Butterworth

The value can differ depending on the individual application.

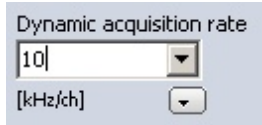
Typical settings:

application	sample rate	filter
measurement of the network, PQ	10 kHz	3 kHz
enhanced measurement of harmonics	20 kHz	10 kHz

measurements on the frequency 1 MSamples
converter

700 kHz (300 kHz)

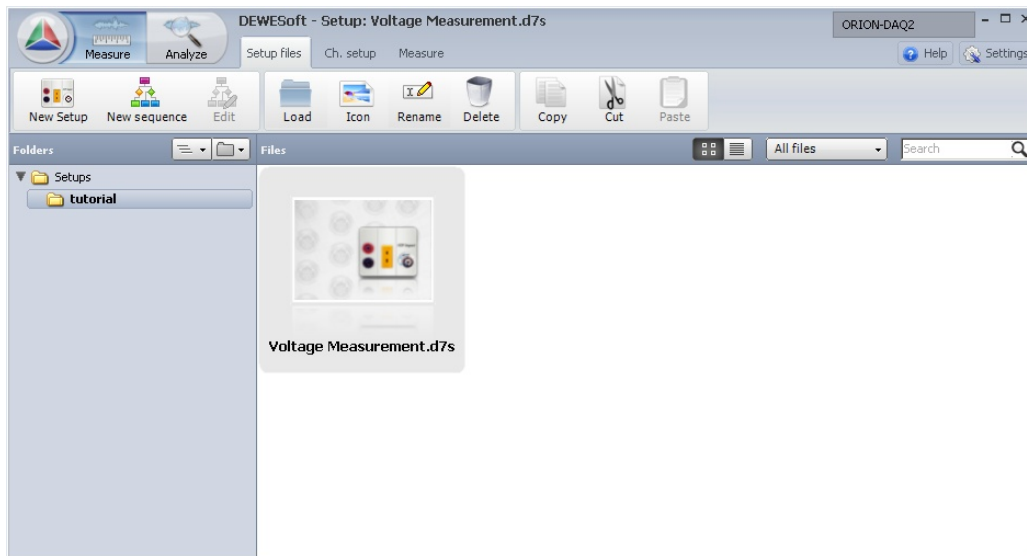
The sample rate is adjusted on the analogue setup screen.



Finally, you insert a name for the measuring - in our example it is "voltage".



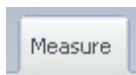
With "save as" you save the setup which then appears on the start screen of DEWESoft (here: voltage measurement).



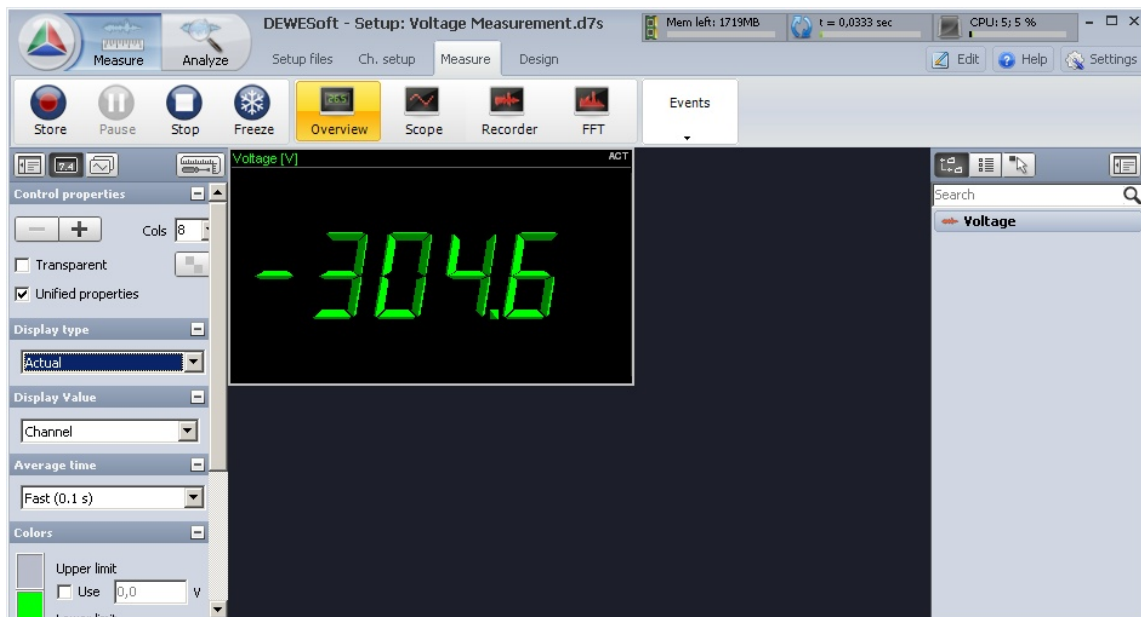
Please, go to chapter "Displaying measured values"

2.1.1 Displaying measured values

Activate the measurement mode of the measuring instrument. In order to do so you have to click



in the menu bar.

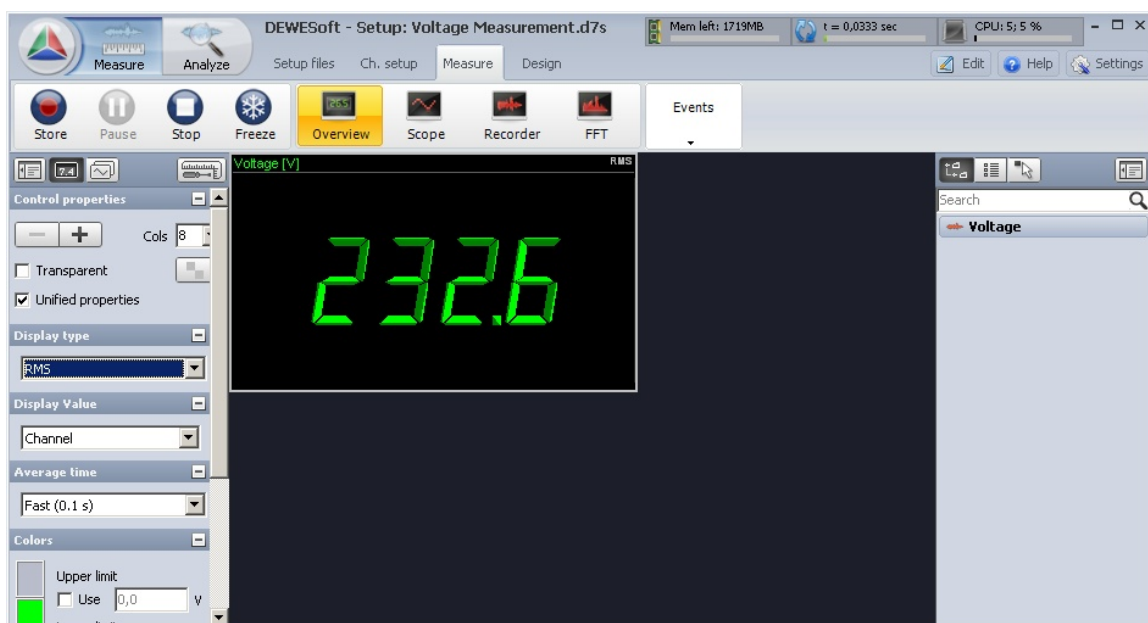


In the beginning, the recent sampling values are displayed. These are constantly changing according to the sinus.

In order to display the RMS value you have to change the "display type" in the drop down menu and choose RMS instead of "actual" (see field of properties on the left).

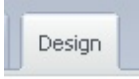


The voltage is displayed as RMS value.



Other screen elements:

Scope and recorder can be added by clicking on the design link.



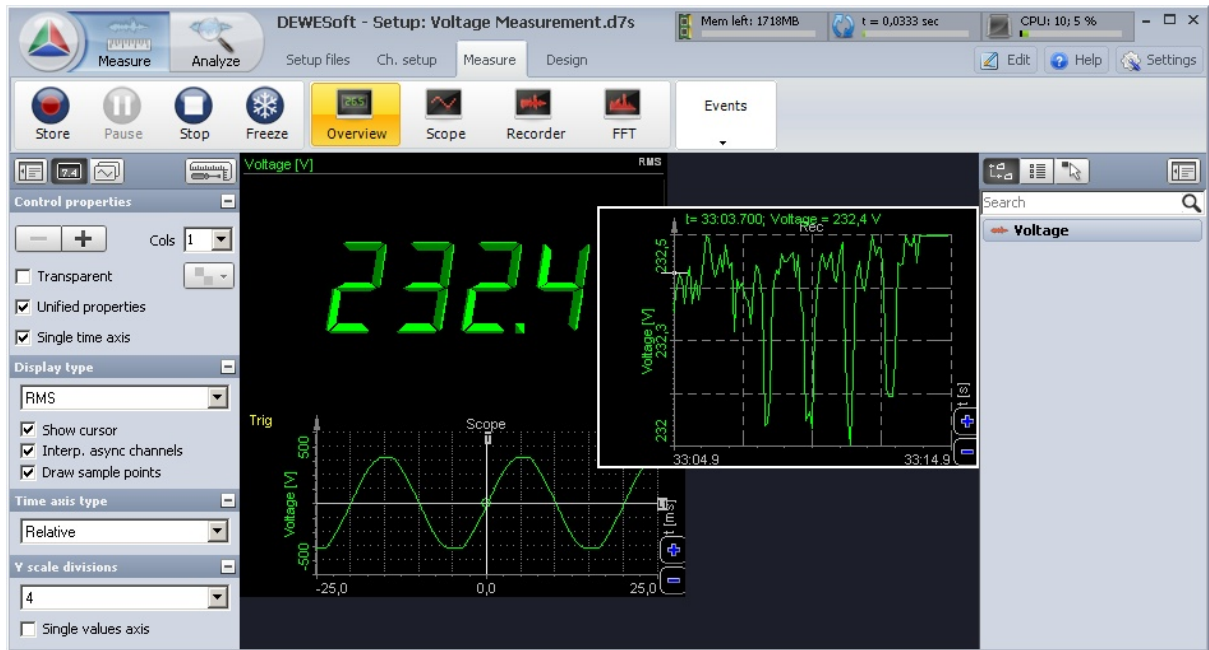
Choose scope



and the recorder respectively.



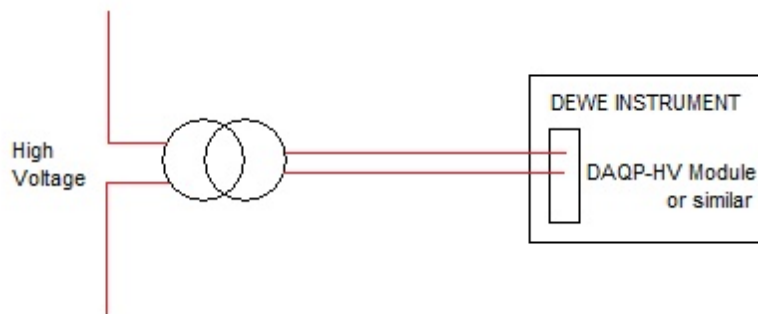
You then receive new screen instruments. These can be changed as regards location and size by applying familiar "Windows methods" such as drag&drop. The properties can again be changed with the help of the menu on the left part of the screen ("control properties").



2.1.2 Measuring on a voltage transducer

Measuring voltage transducers you additionally have to take the transmission ratio into consideration.
Application: medium-voltage power grid, high-voltage power grid

Measurement setup:



The transmission ratio has to be listed in the channel setup: It can either be listed as a function or as a two-point scaling.

Example: medium-voltage transducer 10kV / 100V
two-point scaling

Scaling

First point	Second point
0 equals 0	100 V equals 10000 V
Calibrate from average from RMS	Calibrate from average from RMS

Function:

Scaling

☒ Scale (k factor)
☐ Sensitivity

V / V

Offset (n factor)
 V

Output = k * Input value + n

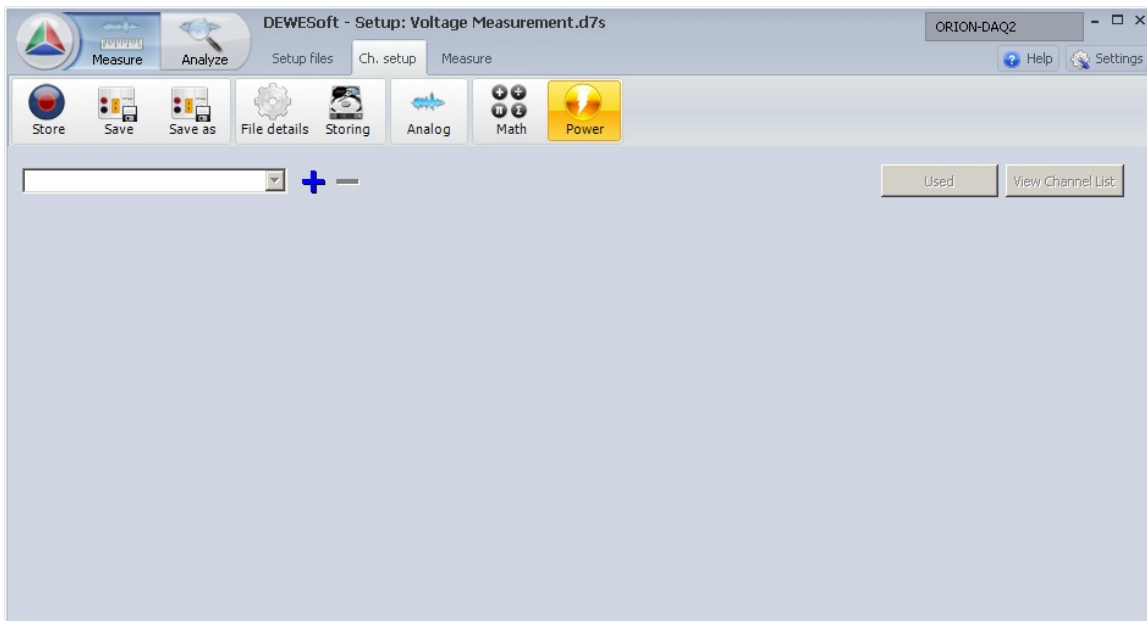
After entering the transmission ration you receive the scaled value.

2.1.3 Measuring voltage with the power module

The power module is a mathematical library for the calculation of alternating current (AC), two-phase and three-phase systems.

It is also useful to identify voltage values according to the exact standard.

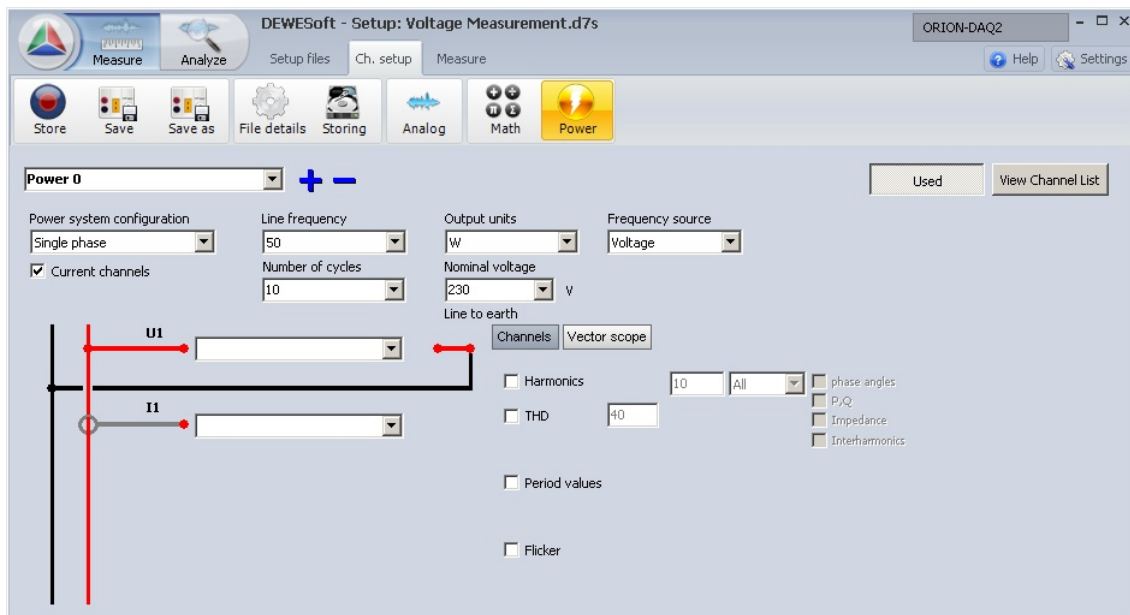
Please, click on the "power" icon first.



Add a new power module by choosing the "+".

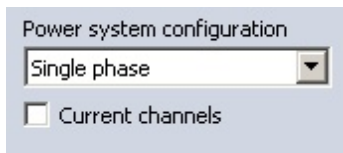


The following screen appears:

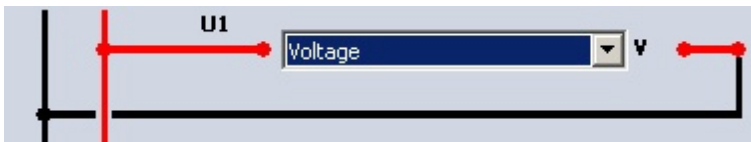


Please, keep in mind:

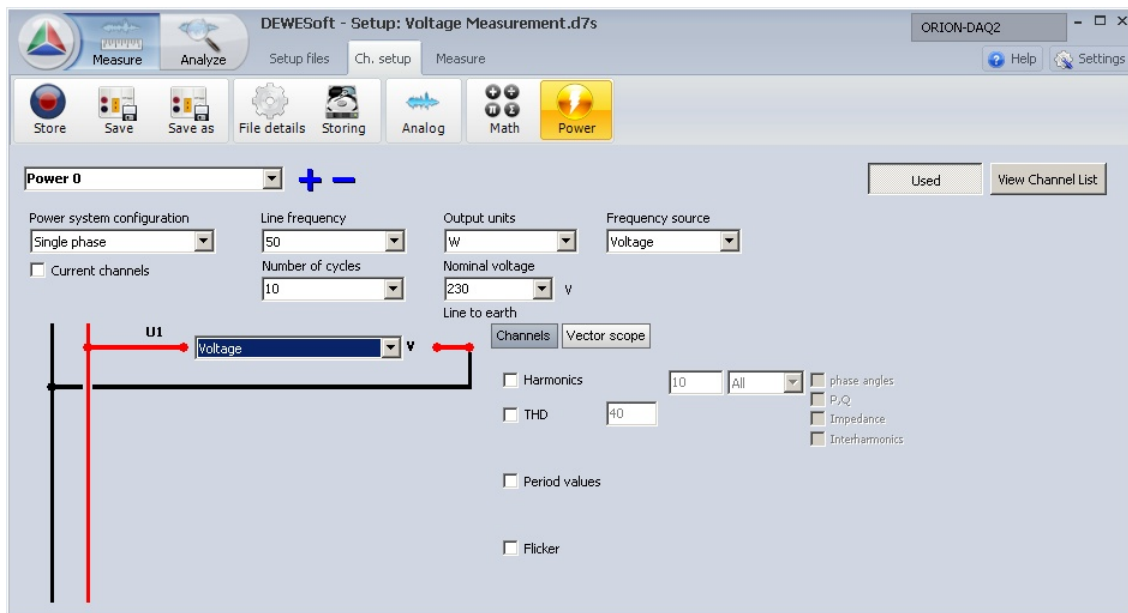
If you want to measure voltage only, it is sufficient to create a "single phase module". In order to measure voltage only you have to deactivate "current channels".



Assign the actual hardware channel "voltage" to the voltage U1.



The setup should look like the following screen shot:



The following values can still be adjusted:

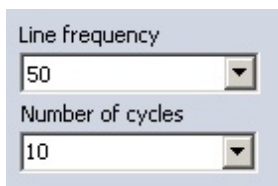
Line frequency: the frequency (example: Europe 50 Hz, USA 60 Hz, Asia and rest of world: 50 or 60 Hz,...).

If the frequency is unknown then enter "variable".

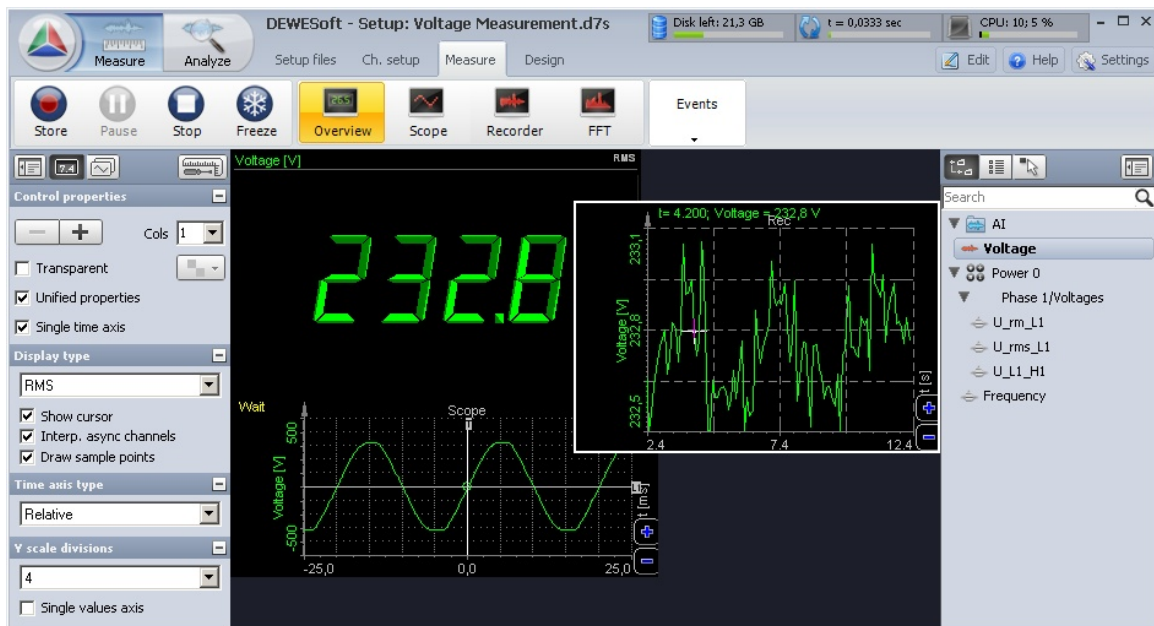
The value is only an index value. The calculation is done on the basis of the actual frequency of the measurement.

Number of cycles:

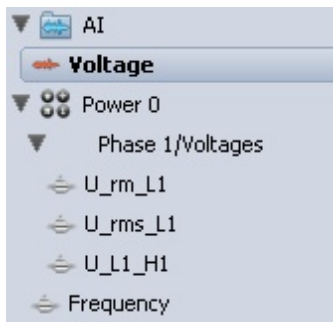
This indicates the number of periods for the calculation of the RMS values. Typically: 10 periods. Some standards need 12 (60 Hz grids); but you can list any arbitrary number (starting from 5).



Changing back to the measurement you now have a number of measuring channels on the right side:



The following channels are available:



Group A: (analogue inputs)

Voltage...the original input channel

Group Power:

Power 0...the power module with its name "Power 0"

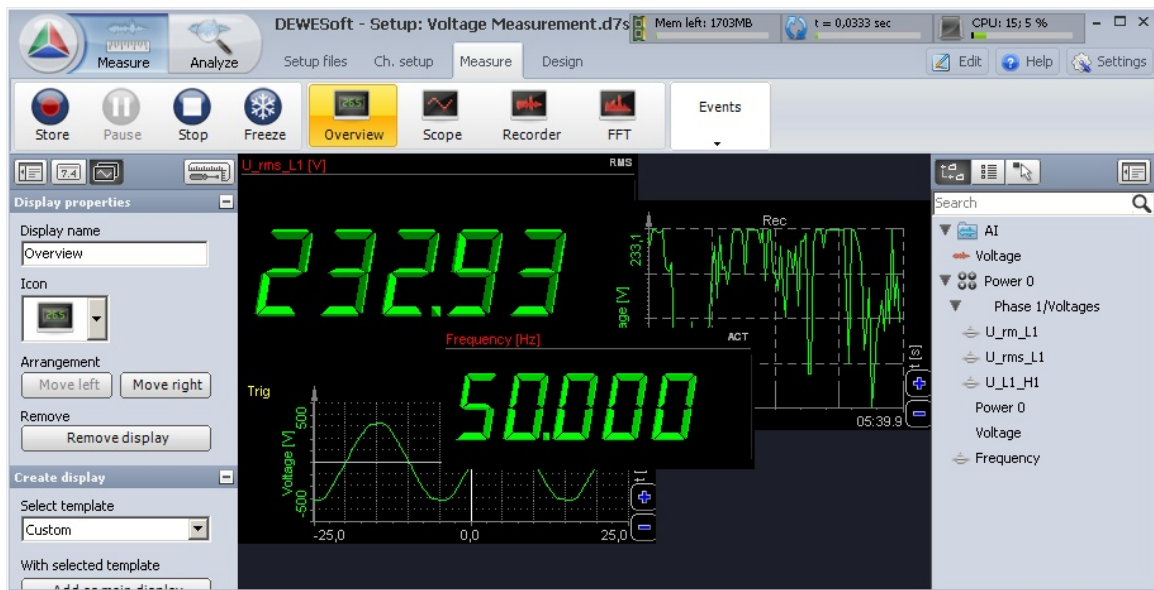
Frequency...the actual grid frequency

U_rms_L1...the 10-period RMS value of voltage

U_L1_H1...the fundamental oscillation value of voltage

U_rm...the rectified mean value of voltage

Display the measuring values by selecting an instrument in the middle part of the screen and choosing the channel on the right which you would like to present. In our example it is U_rms_L1 on top left and frequency in the centre.



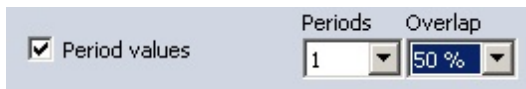
Further measuring channels:

Period RMS values of voltage

2.1.3.1 RMS values of voltage

Period values are RMS values (and average values of power respectively) that are generated periodically.

In the power module you have to tick the checkbox "period values".



Periods: number of periods on the basis of which the value should be calculated

Overlap: the overlap in percent

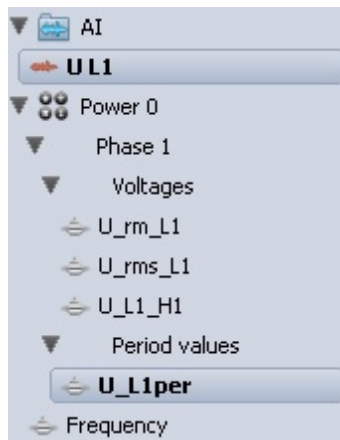
If it is necessary, for example, to do a full-period calculation.

If it is required to e.g. do a full-period calculation every half period (as is required by the PQ standard IEC 61000-4-30 e.g.) you have to enter the following:



The period / accumulated value is available as measured value in DEWESoft as is any other value:

Name: U_L1per



The following chart shows 3 arrays:

first one - green graph: the analogically read sine wave

red graph: the RMS value from the power module created over 10 periods

yellow graph: the NEW period RMS value, created periodically



2.2 Current measurement

Objective: In this chapter you learn how to measure current.

Premises:

a measuring instrument with a rack (e.g. DEWE-2600) or a dedicated one (e.g. DEWE571)
a module type DAQP-HV (or DAQP-DMM)
a module type DAQP-LV
eventually a module type DAQP-LA
shunt, current clamp, transformer if necessary
software DEWESoft
option DEWESoft Power

Measuring current can be done in different ways.

shunt (instrument shunt)
direct current modules
measuring current with a current clamp with voltage output
current clamp with a current clamp with current output
Rogowsky coil with voltage output
zero flux transducer

Using the current channels is then always done in the same way.

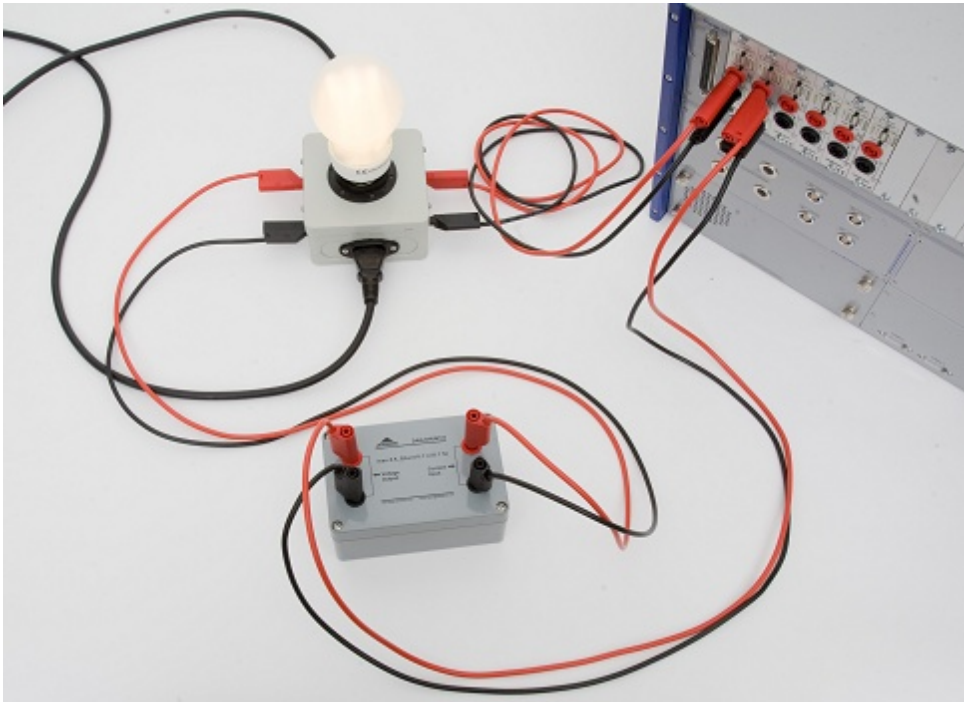
Advice: The methods for displaying measurement values of the current measurement are similar to those of the current measurement. This topic is thus not further described.

Note: Please always use in analogue setup DC coupling and input type bipolar for all types of current measurement. If you select AC-coupling a highpass filter will be activated which can lead to deviation in phase measurement (e.g. at 50 Hz). The option AC coupling is used just for special applications.

Measurement	Current	▼
Range	5	▼ A
Lowpass filter	3 kHz	▼
Lowpass type	Bessel	▼
Coupling	DC	▼
Input type	Bipolar	▼

2.2.1 Current measurement with a shunt (instrument shunt)

Measurement setup:



The current path of the tested object is lead via a shunt (instrument shunt). This one is connected to a module of the instrument in order to measure small voltage.

module types: DAQP-LV, DAQP-V

settings in the channel setup:

When using a 0,1 Ohm shunt:

Channel setup for channel 1 DAQP-LV SNr:332757 Rev:100

Channel settings

General

Channel name: Current
Units: A
Color:
Min value: Auto Max value: Auto
Sample rate divider: 1 Skip

Sensors

Measurement: Current
Range: 5 A
Lowpass filter: 100 kHz
Lowpass type: Bessel
Coupling: DC
Input type: Bipolar
External shunt: Shunt 2 Imax = 5 A
Resistor [ohm]: 0,1 Pmax [watt]: 2,5

Scaling

by two points by function

☒ Scale (k factor)
☐ Sensitivity

1 A / A

Offset (n factor)
0 A

Set zero

Output = k * Input value + n

Input value

5 A
0,0093 A
-0,0003 A
-0,0105 A
-5 A

Scaled value

5 A
0,0093 A
-0,0003 A
-0,0105 A
-5 A

Block size
☒ 0.1 s
☐ 1 s

Average AC RMS Min / Max

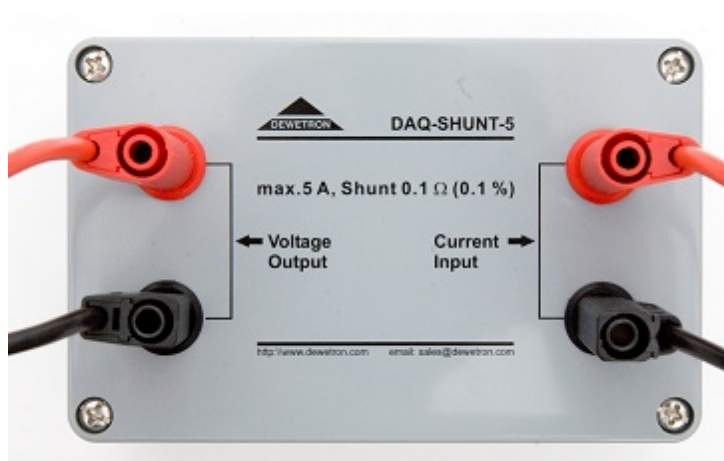
Ok Cancel

First, choose current in the field measurement.

Measurement: Current
Range: 5 A

Then choose the shunt . Usually, a 0,1 Ohm shunt is used (=shunt 2).

External shunt: Shunt 2 Imax = 5 A
Resistor [ohm]: 0,1 Pmax [watt]: 2,5



When using an arbitrary shunt:

Please, choose "custom" in the field "external shunt" and enter the resistance value (resistor) and the maximum power (Pmax).

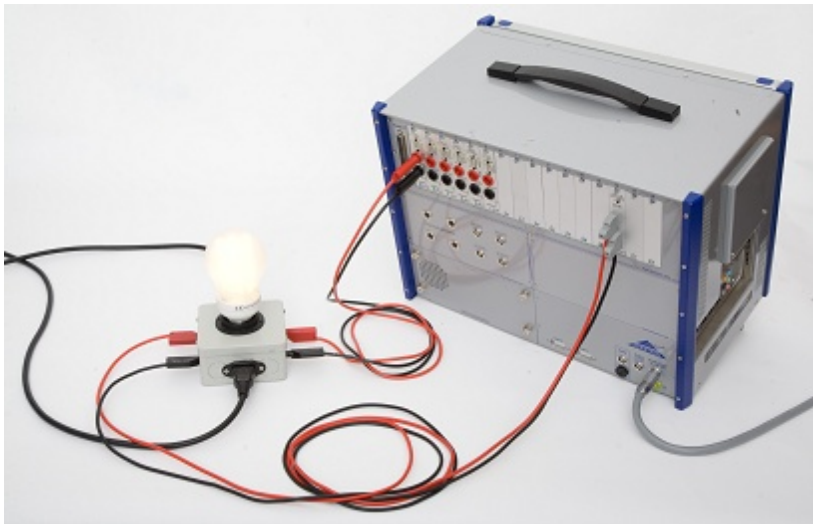
External shunt	Custom	Imax = 2 A	
Resistor [ohm]	0,5	Pmax [watt]	2

2.2.2 Current measurement with current modules

The current modules are primarily meant to measure small current (<5A) and to measure current on the secondary side of current transducers.

Measurement setup:

Current is directly connected to the module.



Module type: DAQP-LA-SC



Settings in the channel setup:

Channel setup for channel 9

Channel settings: Channel name: AI 9, Units: A, Color: [Pink bar], Measurement: Current, Range: 3 A, Lowpass filter: 100 kHz, Lowpass type: Bessel, Min value: Auto, Max value: Auto, Sample rate divider: 1.

Scaling: by two points, by function. Scale (k factor) selected, 1 A / A, Offset (n factor) 0 A, Set zero, Output = k * Input value + n.

Graph: Input value vs Scaled value. Points: 3 A, 0.0005 A, 0.0002 A, 0.0000 A. Block size: 0.1 s. Buttons: Average, AC RMS, Min / Max, Ok, Cancel.

Primarily, you only have to adjust the measurement range.

General

Measurement: Current, Range: 3 A, Lowpass filter: 100 kHz, Lowpass type: Bessel.

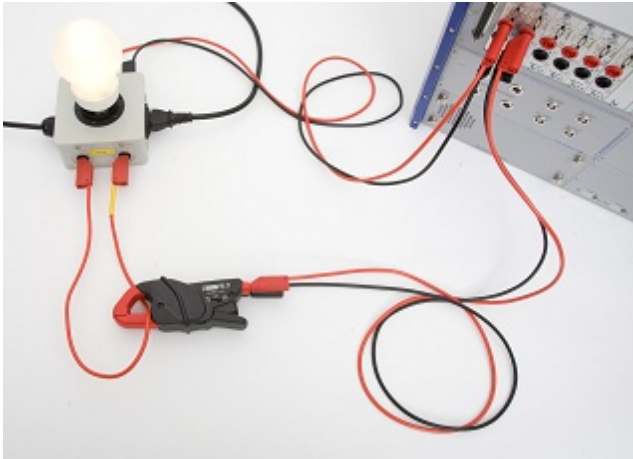
When measuring on the secondary side of a current transducer, then the transducer settings can be selected via the scaling function as is done in the voltage transducer.

2.2.3 Current measurement with current clamp with voltage output

Measurement setup:

The current path is closed with a conductor loop.

The current clamp is clicked onto this conductor loop and furthermore connected to a module for small voltages (DAQP-LV).



current clamp:

Current clamps with voltage outputs have a special identification plate. The transducer ratio is scaled in amps to volt.

In our example: 20 A / 2 V (respectively 200 A / 2 V)



Settings on the module:

module types: DAQP-LV

You first have to select the unit A (amps).

Units	A
-------	---

The scale value can be entered: 2 V are 20 A

Second point	
2	V
equals	
20	A

The scaled value is listed in amps.

Channel setup for channel 1

Channel settings: DAQP-LV SNr:332757 Rev:100

General

Channel name: Current
Units: A
Color: Cyan
Min value: Auto
Max value: Auto
Sample rate divider: 1

General

Measurement: Voltage
Range: 0,5 V
Lowpass filter: 3 kHz
Lowpass type: Bessel
Coupling: DC
Input type: Bipolar

Scaling

by two points

First point	Second point
0 V	2 V
0 A	20 A

Calibrate: from average, from RMS

Input value

0,5 V
0,00017 V
-0,00004 V
-0,00023 V
-0,5 V

Scaled value

5 A
0,0017 A
-0,0004 A
-0,0023 A
-5 A

Block size: 0.1 s, 1 s

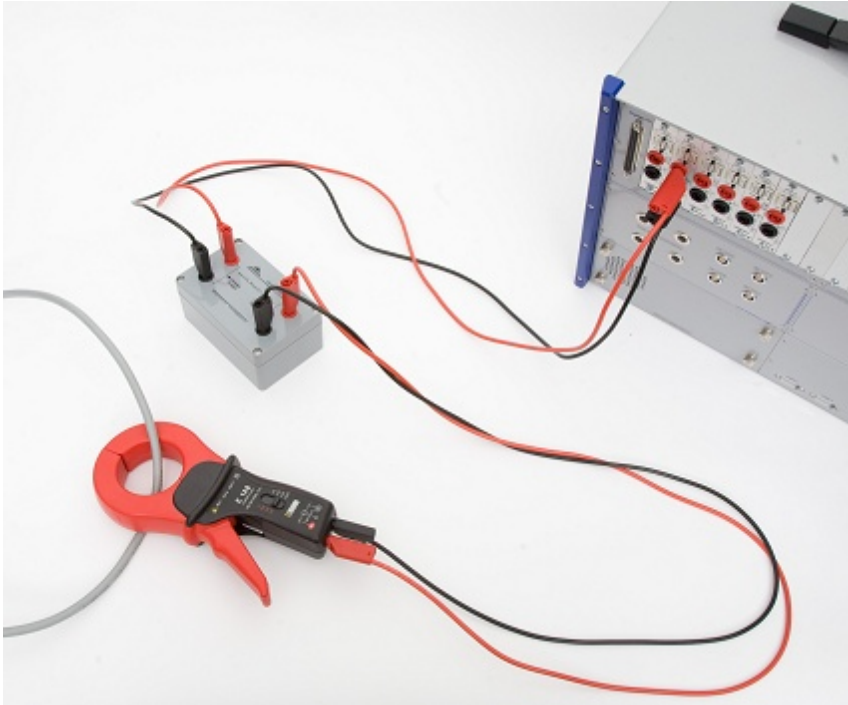
Average, AC RMS, Min / Max

Ok, Cancel

2.2.4 Current measurement with current clamp with current output

Measurement setup:

The current path is closed with a conductor loop. The current clamp is clicked onto this conductor loop and furthermore connected to a shunt. The latter one is connected to a module for small voltages (DAQP-LV).



Current clamp:

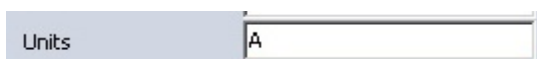
Current clamps and converters can be identified by their identification plates. The transducer ratio is scaled in amps to amps.

In our example: 500 A / 5 A (250 A / 5 A; 1000 A / 5 A)

Settings on the module:

Module types: DAQP-L

First of all you choose amps (A) as the unit.



Then you choose current as type of the measured value.

Measurement	Current
Range	5 A

Now you have to set up the shunt (typically "shunt 2").

External shunt	Shunt 2	$I_{\max} = 5 \text{ A}$
Resistor [ohm]	0,1	Pmax [watt] 2,5

The scale value of the current clamp can be entered directly: 5 A are 500 A

Second point	
5 A	
equals	
500 A	

The scaled value is listed in amps.

Channel setup for channel 1 DAQP-LV SNr:332757 Rev:100

Channel settings

General **Sensors** **General**

Channel name:

Units: Color:

Min value: Max value:

Sample rate divider:

Measurement: Range: A

Lowpass filter: Lowpass type:

Coupling: Input type:

External shunt:

Resistor [ohm]: Pmax [watt]:

Scaling

by two points **by function**

First point	Second point
0 equals 0	5 A equals 500 A
0 equals 0	500 A equals 500 A

Calibrate **Calibrate**

Block size:

Advice: If you want to measure smaller currents with a current clamp with a large measuring range, you can influence the transducer ratio by leading the conductor through the clamp several times.

In our example the conductor was lead through the clamp 5 times. The transducer ratio is 1:5.

The scaling is now 5A / 100 A instead of 5 A / 500 A.

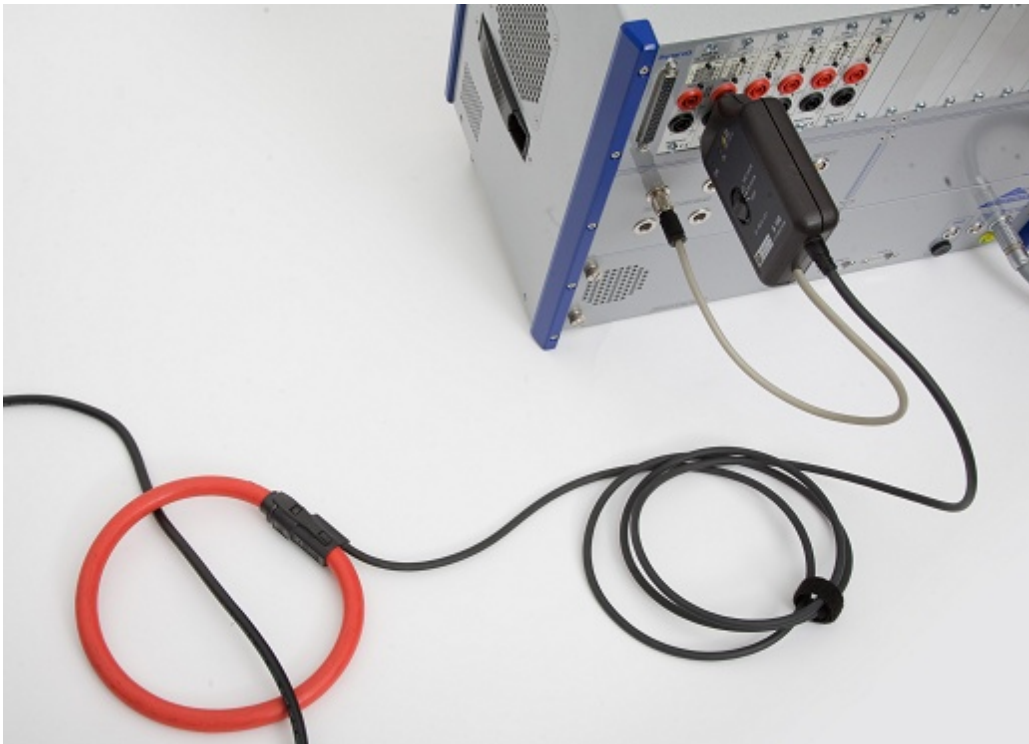


2.2.5 Current measurement with Rogowsky coil

Measurement setup:

The current path is closed with a conductor loop.

The Rogowsky coil is clicked onto this conductor loop and furthermore connected to a module for measuring small voltages (DAQP-LV).



Rogowsky coil:

The Rogowski coil mostly has an amplifier on which you can see the plate efficiency. As the coil has a voltage output channel the plate efficiency is listed in amps to volt.

In our example: 200 A / 2 V (or 20 A / 2 V)



Settings on the module:

Module types: DAQP-LV

First of all you choose A (amps) as the unit.

Units	A
-------	---

The scale value can now be inserted: 2 V is 200 A

Second point	
2	V
equals	
200	A

The scaled value is listed in amps.

Channel setup for channel 1 DAQP-LV SNr:332757 Rev:100

Channel settings

General **Sensors** **General**

Channel name:

Units:

Color:

Min value: Max value:

Sample rate divider:

Measurement:

Range:

Lowpass filter:

Lowpass type:

Coupling:

Input type:

Scaling

by two points **by function**

First point	Second point
0 equals 0	2 V equals 200 A
Calibrate from average from RMS	Calibrate from average from RMS

Input value **Scaled value**

1 V — 100 A

0,00018 V — 0,018 A

-0,00002 V — -0,002 A

-0,00021 V — -0,021 A

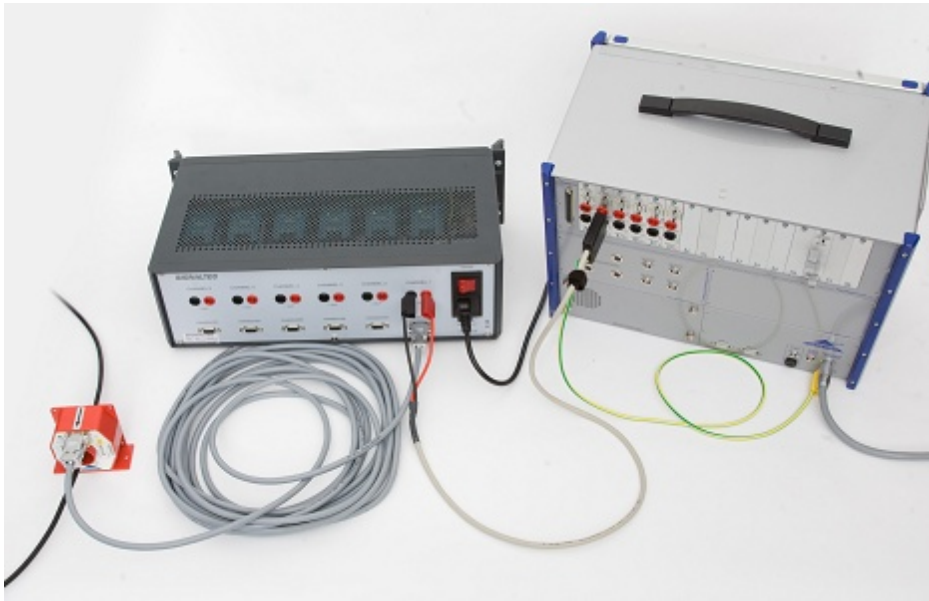
-1 V — -100 A

Block size: ☐ 0.1 s ☐ 1 s

2.2.6 Current measurement with zero flux transducer

Measurement setup:

Zero flux transducers are mostly used in test control units of electrical motors and transducers. In contrast to current clamps they do not have a core to open. The current-carrying conductor must be led through this transducer. Then you have to connect the transducer and the source. The supply source has a current output channel which is connected to the measurement instrument via a shunt.



Zero flux transducer:

These transducers have a current output channel. The nominal current of the transducer is listed on the identification plate (in this case: 200A). The transmission ratio is indicated: In our example 1:1000



The shunt is specially adapted to this transducer. The value is:
5 Ohm (BR5)
1 Ohm (BR1)

Please, notice that the shield has to be connected to the grounding of the measurement instrument via

the green-yellow circuit.



Settings on the module:

Module types: DAQP-L

First of all you choose A (amps) as the unit.

Units	A
-------	--------------------------------

Then you choose current as the type of measured value.

Measurement	Current
Range	200 mA

Now select the shunt (typically it is "custom").

External shunt	Custom	$I_{max} = 400 \text{ mA}$
Resistor [ohm]	5	$P_{max} [\text{watt}]$ 0,8

The scale value of the transducer can now be indicated: 1:1000 is also 1 mA equalling 1 A

Second point	
1 mA	
equals	
1 A	

The scaled value is listed in A (amps).

Channel setup for channel 1

Channel settings DAQP-LV SNr:332757 Rev:100

General

Channel name: Current
Units: A
Color:
Min value: Auto Max value: Auto
Sample rate divider: 1 Skip

Measurement: Current
Range: 200 mA
Lowpass filter: 300 kHz
Bandwidth: Bessel
Coupling: DC
Input type: Bipolar
External shunt: Custom Imax = 400 mA
Resistor [ohm]: 5 Pmax [watt]: 0,8

Scaling

by two points by function

First point	Second point
0	1 mA
0	1 A

Calibrate: from average from RMS

Input value Scaled value

200 mA	200 A
0,07 mA	0,07 A
-0,01 mA	-0,01 A
-0,07 mA	-0,07 A
-200 mA	-200 A

Block size: 0.1 s 1 s

Average AC RMS Min / Max

Ok Cancel

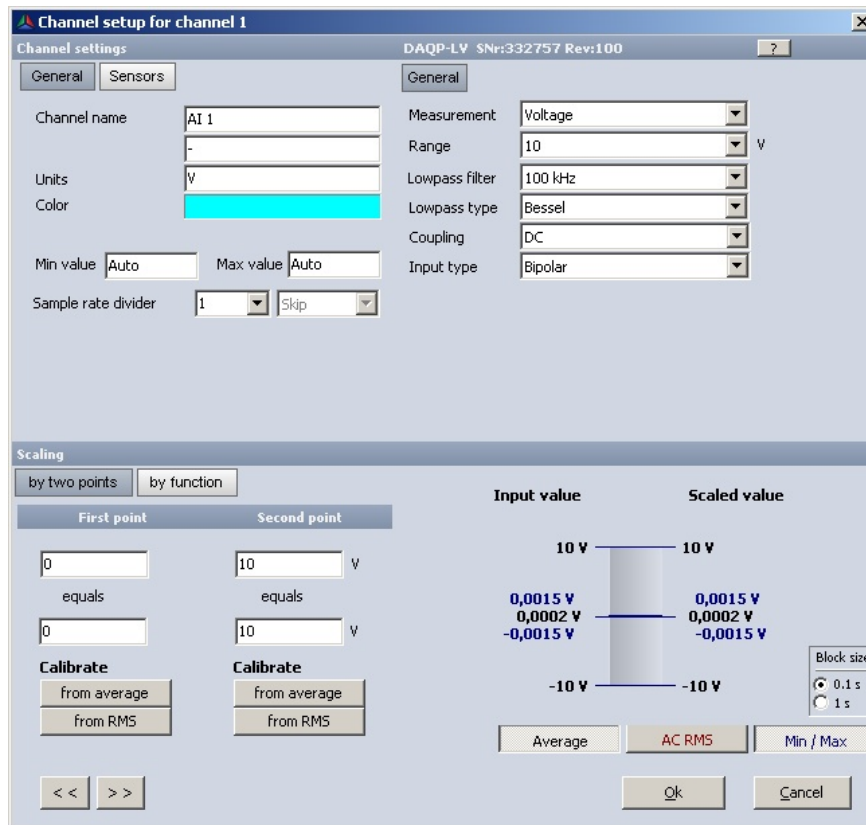
2.2.7 Using a measuring adapter from the sensor database

In the sensor database various current clamps and adapters are pre-defined.

In our example we use a current clamp type "MN 38" (PNA clamp 20) and connect this onto a DAQP-LV module.



First of all, open the window for the channel settings of the module:



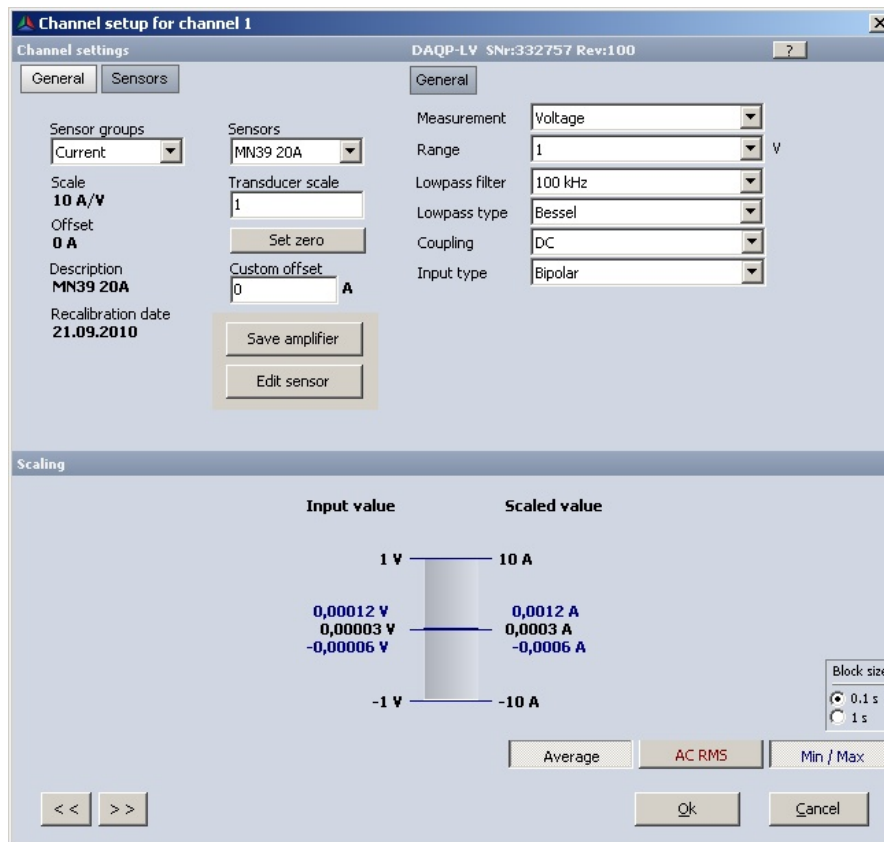
Then go to "sensors" on the upper left corner.



Now select the sensor group and choose a sensor - in our case it is MN39 20A.



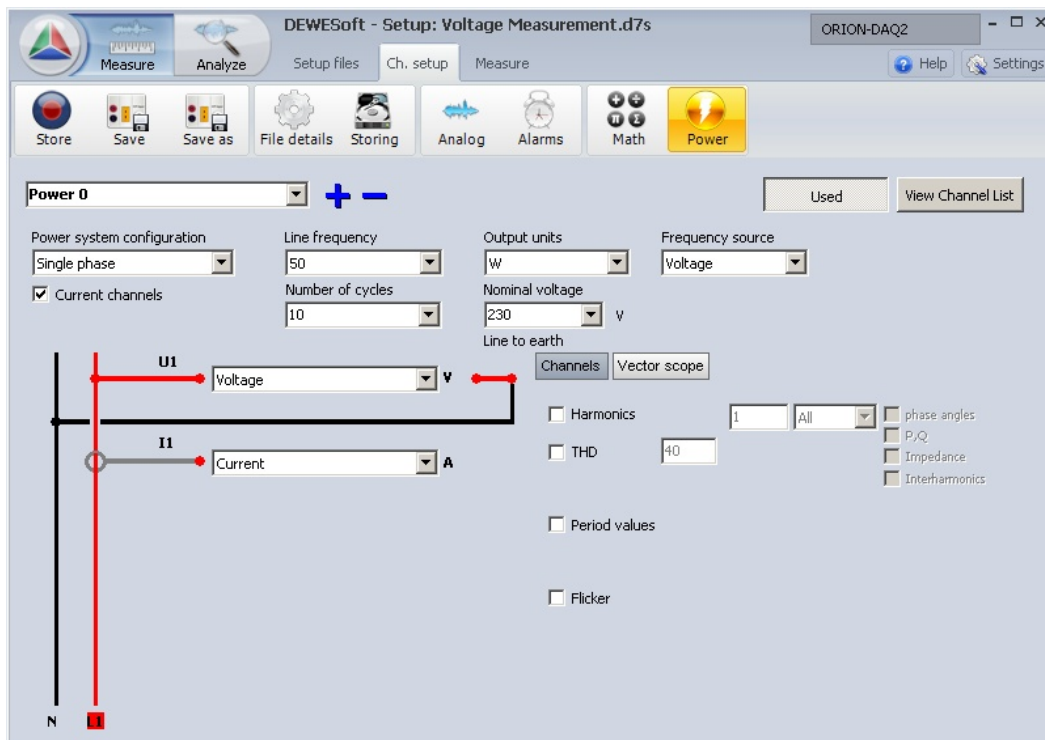
All settings such as scaling factor etc. have been adopted automatically. The values are already listed in amps.



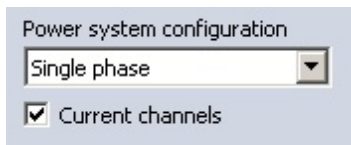
If the frequency response (damping and phase response as a function of frequency) is also defined in this sensor, this will be kept in mind in the power module and this will also guarantee the high precision of the measuring instruments.

2.2.8 Using the power module

If the power module is used for measuring current then the following settings have to be kept in mind:

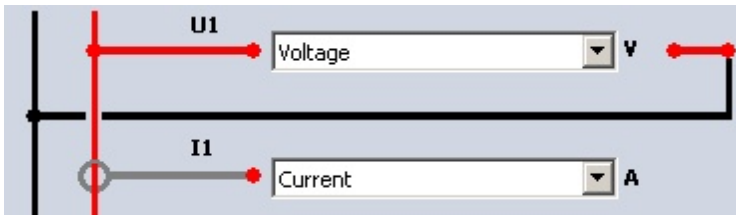


"Current channels" must be activated.

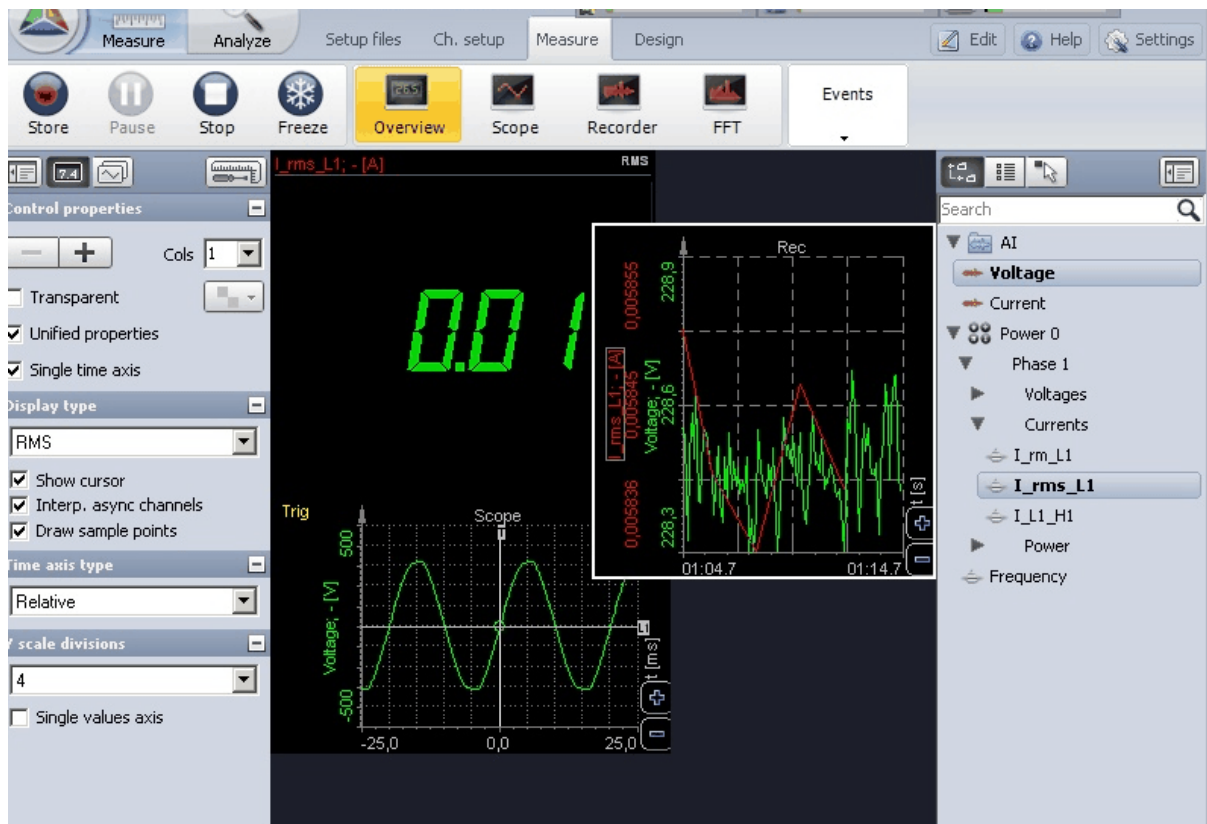


The current channel must be assigned to the module - in our case the analogue channel "current".

If current is measured with the help of the power module then voltage always has to be recorded.



In the measurement mode you can now also choose between the relevant current channels which is similar when measuring voltage.



2.3 Power measurement

Objective: Measuring power is the main objective of this chapter.

Premises:

a measuring instrument with a rack (z.B DEWE-2600)
 one (or 3 respectively) module(s) type DAQP-HV (or DAQP-DMM)
 one (or 3 respectively) module(s) type DAQP-LV (oder DAQP-LA)
 shunts, current clamps, current converters on demand
 software DEWESoft
 option DEWESoft Power

You should have profound knowledge in:

measuring voltage and current

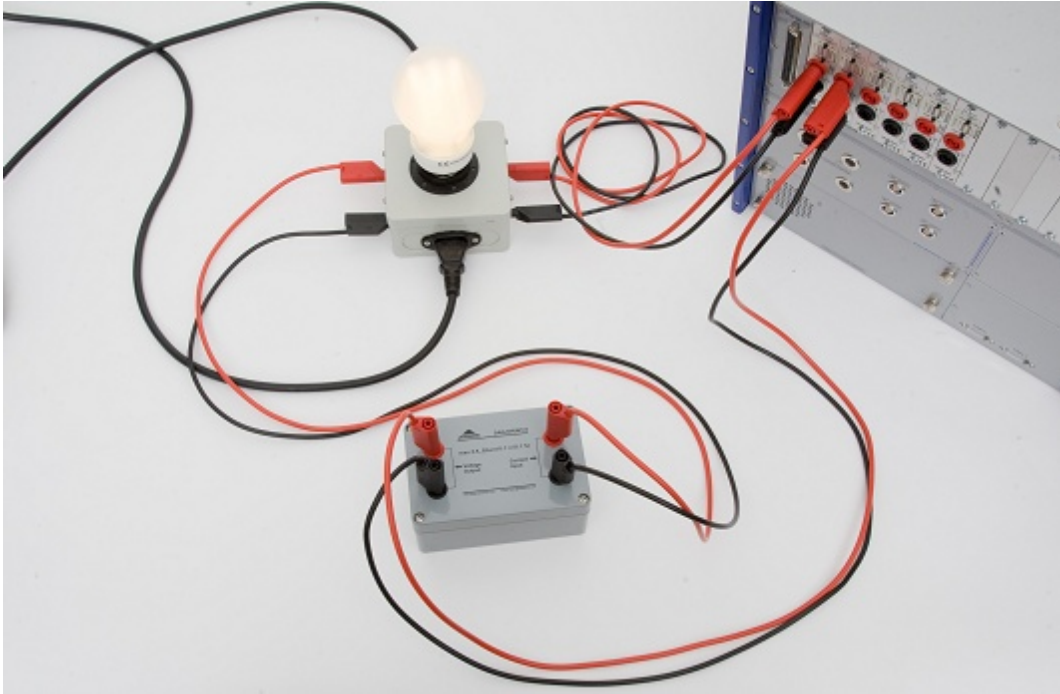
This chapter focuses on the measurement of power in various current systems:

single-phase power measurement
 multi-phase power measurement

You furthermore get to know how to use the special instruments for power measurement.

2.3.1 Single-phase power measurement

First of all connect voltage and current to your measuring instrument.



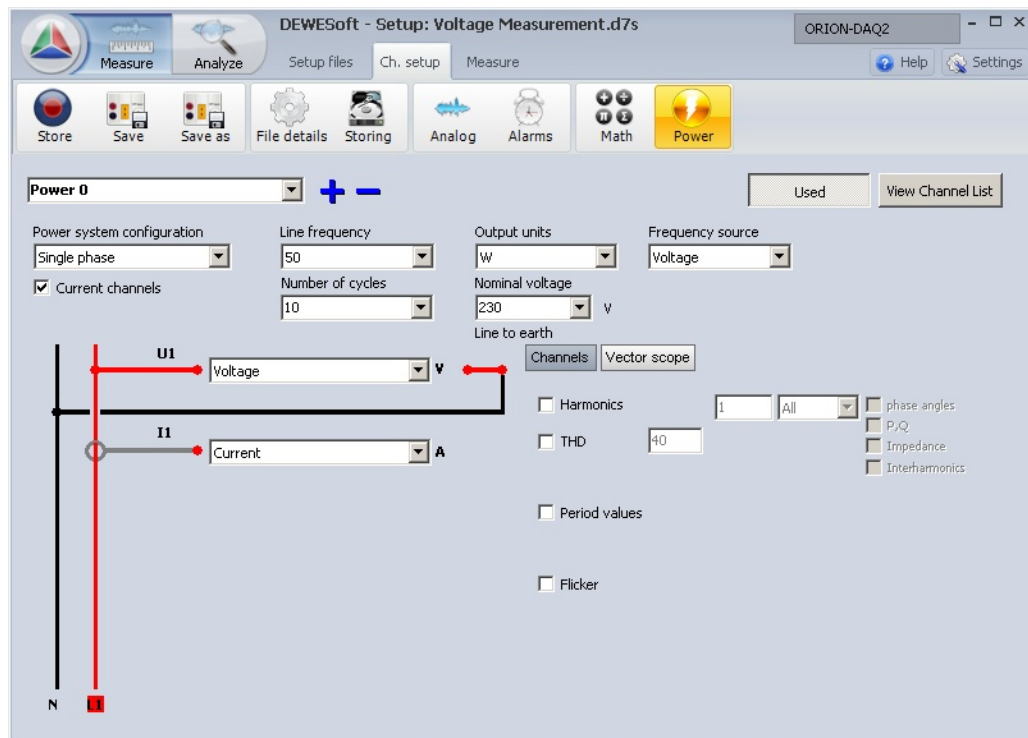
For the power measurement it is, first of all, necessary to set up a power module.



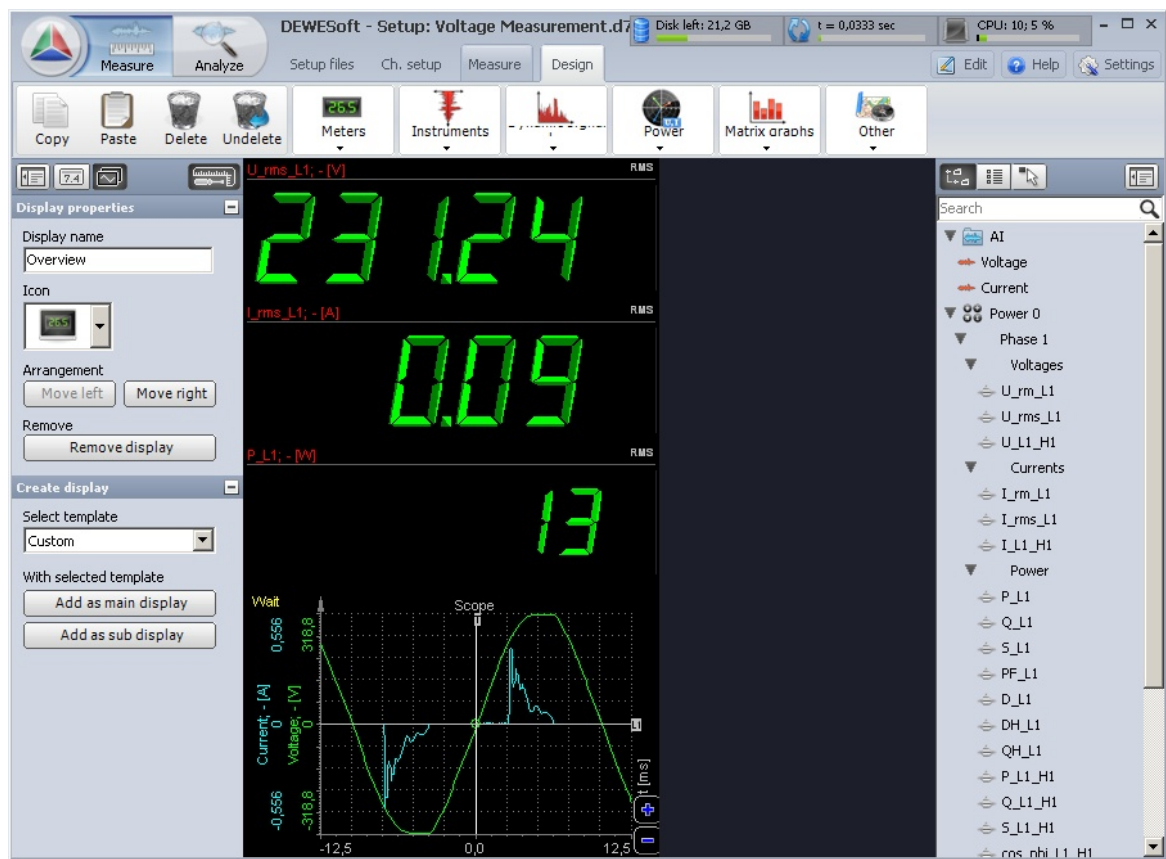
Select "single-phase" for the "power system configuration".

"Current channels" must be activated.

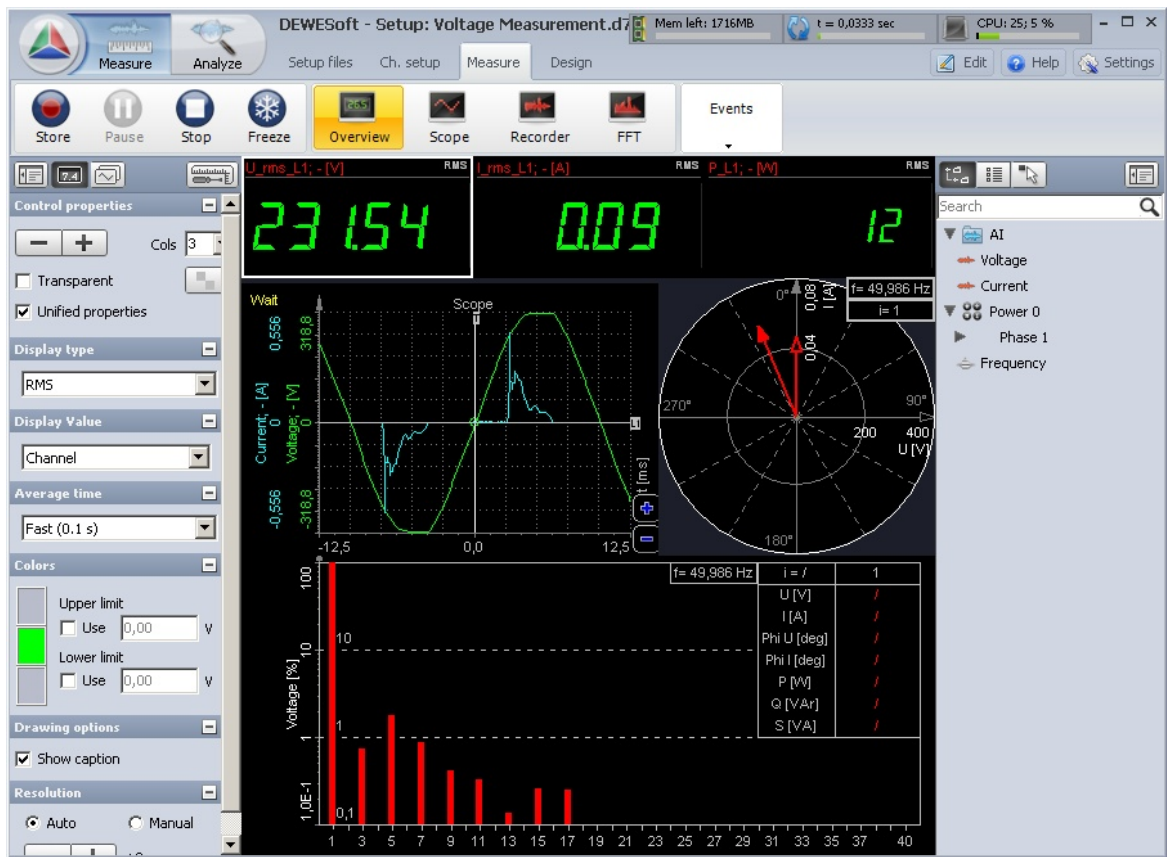
Voltage and current must be assigned.



After changing to the measuring mode all relevant power values are available as measuring channels for the instruments such as displays and recorders.



Additionally to the usual indicating instruments, a vectorscope and an FFT module are available as well.



2.3.2 Multi-phase power measurement

Measuring power in multi-phase systems is similar to measuring power in single-phase systems. Thus only the various circuits are described in detail.

ADVICE: Before you go through this chapter you should have done the chapter of single phase power measurements.

possible connection diagrams of multiphase systems are:

- Star (most used 3 phase system)
- Delta (Motors)
- Aron (3 phase systems without a neutral, star)
- V connection (3 phase systems without a neutral, delta)
- 2 phase systems (e.g. railway)

The formulas for multi phase measurements you can find in the appendix.

2.3.2.1 3ph Star connection

Application:

This connection is the most used in 3 phase systems.

It is used there, where a star point (neutral line) is available (normal low voltage grid) or can be made artificial (direct via the amplifier).

Connection:

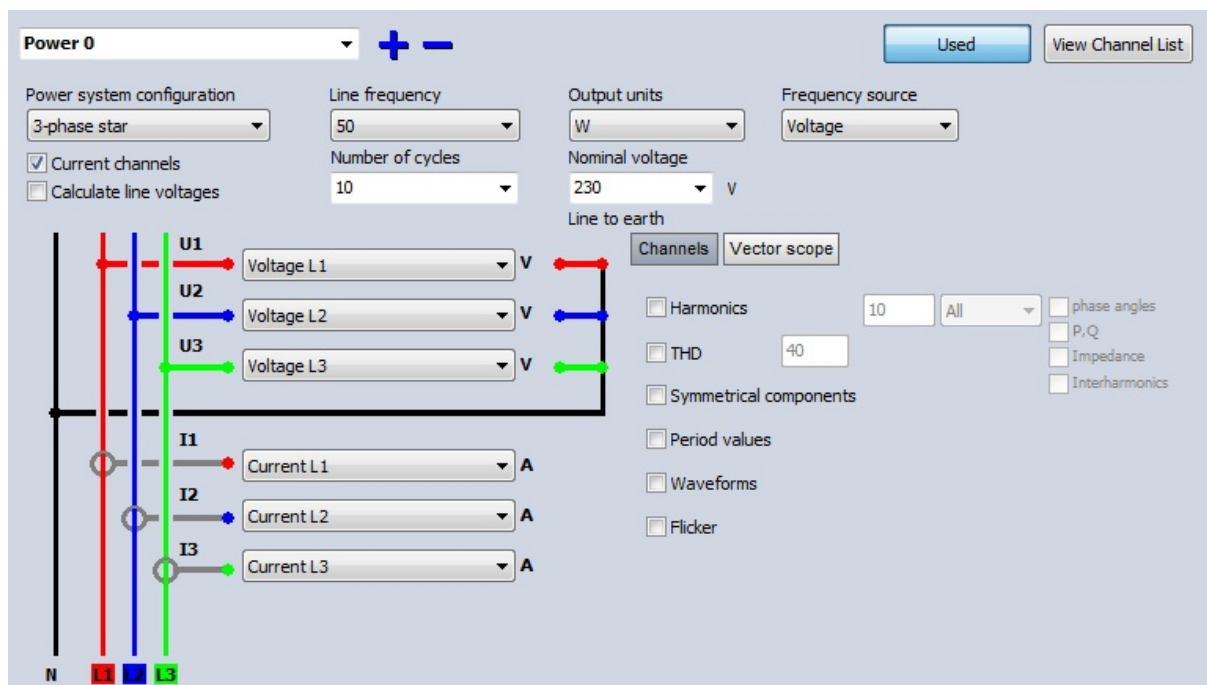
connect the following signals to your instrument and give them the names as shown here:

Phase voltages U L1, U L2 and U L3

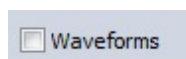
Currents I L1, I L2 and I L3

Select on the "Power Setup" page in the drop down menu "power system configuration" the line "3-phase star".

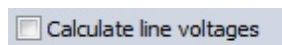
Afterwards assign the the analogue channels to the fields U1, U2 etc. as shown below.



special parameters:



If "waveform" is checked also the line voltages U12, U23 and U31 are available in the scope and for the flicker calculation.



If "calculate line voltages" is checked, also the line voltages are available as RMS values and as Harmonics.

2.3.2.2 3ph Delta connection

Application:

This connection is the most used for measurements on motors.

It is used there, where no star point (neutral line) is available.

Connection:

connect the following signals to your instrument and give them the names as shown here:

line voltages U L12, U L23 and U L31

Currents I L1, I L2 and I L3

Select on the "Power Setup" page in the drop down menu "power system configuration" the line "3-phase delta".

Afterwards assign the the analogue channels to the fields U12, U23 etc. as shown below.

The screenshot shows the "Power Setup" interface for a 3-phase delta connection. The "Power system configuration" is set to "3-phase delta". The "Line frequency" is 50, "Output units" are W, and "Frequency source" is Voltage. The "Nominal voltage" is 398,372 V. The "Current channels" checkbox is checked. The diagram shows three lines (L1, L2, L3) and three voltage measurement points (U12, U23, U31) and three current measurement points (I1, I2, I3). The voltage measurement points are connected to the instrument channels U12, U23, and U31, and the current measurement points are connected to the instrument channels I1, I2, and I3. The interface includes checkboxes for Harmonics, THD, Symmetrical components, Period values, Waveforms, and Flicker. The Waveforms checkbox is checked.

If "waveform" is checked also the phase voltages U1, U2 and U3 are available in the scope.

2.3.2.3 3ph Aron connection

Application:

This connection is the most used in 3 phase systems.

It is used there, where no real star point is available, but for the measurement an artificial one. Only two phases are connected to the current adapters.

Connection:

connect the following signals to your instrument and give them the names as shown here:

Phase voltages U L1, U L2 and U L3

Currents I L1 and I L2

Select on the "Power Setup" page in the drop down menu "power system configuration" the line "3-phase Aron".

Afterwards assign the the analogue channels to the fields U1, U2 etc. as shown below.

special parameters:

☐ Waveforms

If "waveform" is checked also the line voltages U12, U23 and U31 are available in the scope and for the flicker calculation. In addition the missing current I3 is calculated.

☐ Calculate line voltages

If "calculate line voltages" is checked, also the line voltages are available as RMS values and as Harmonics.

2.3.2.4 3ph V connection

Application:

This connection is used there, where no star point (neutral line) is available and only two currents can be measured.

Connection:

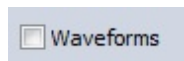
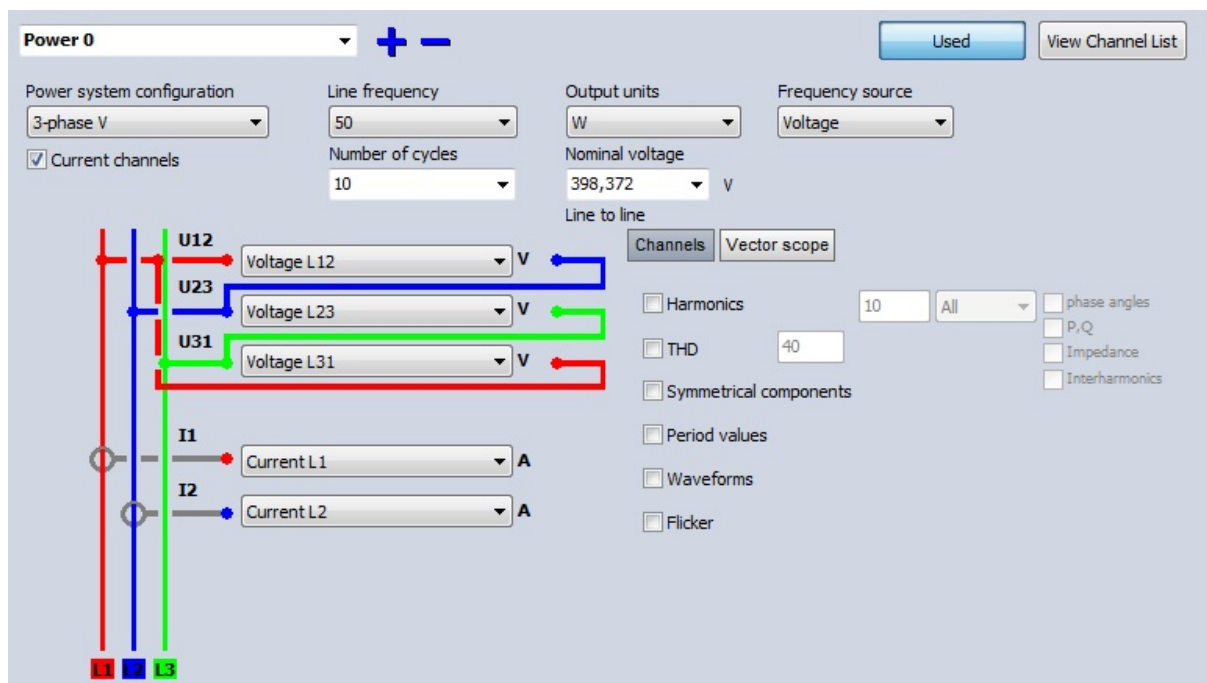
connect the following signals to your instrument and give them the names as shown here:

line voltages U L12, U L23 and U L31

Currents I L1 and I L2

Select on the "Power Setup" page in the drop down menu "power system configuration" the line "3-phase V".

Afterwards assign the the analogue channels to the fields U12, U23 etc. as shown below.



If "waveform" is checked also the phase voltages U1, U2 and U3 are available in the scope. In addition the missing current I3 is calculated.

2.3.2.5 2ph connection

Application:

This connection is used there, where 2 phases are used for the transport of energy. This can be for example a railway supply systems.

Connection:

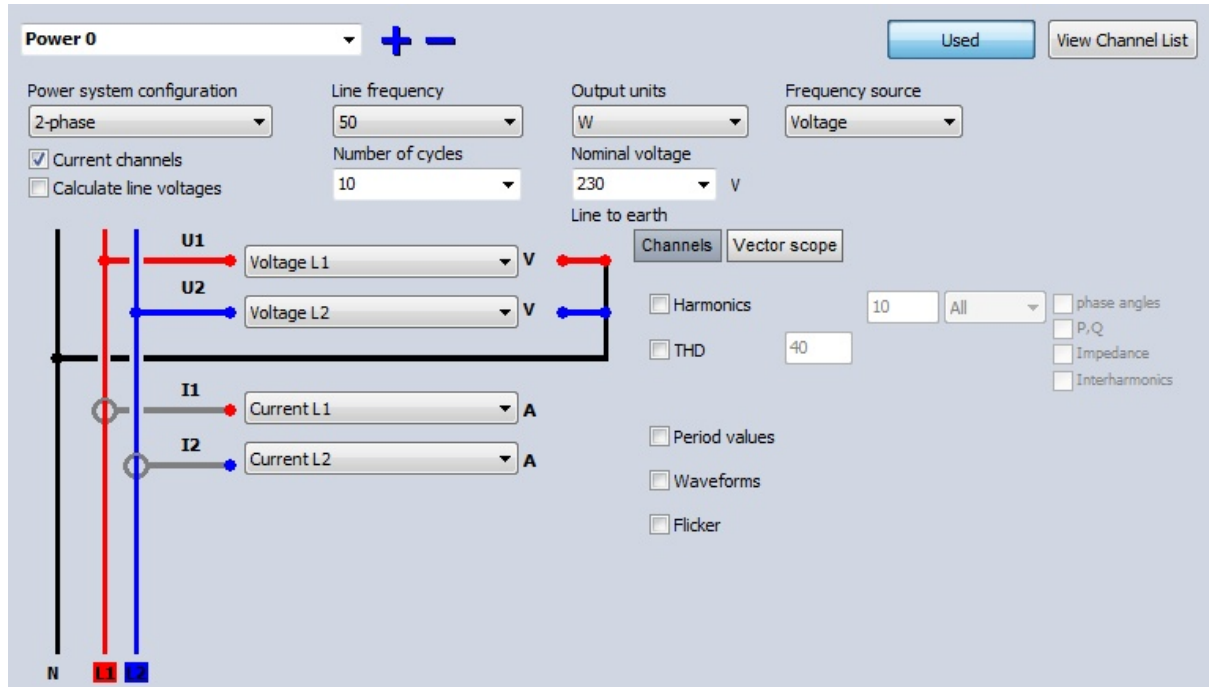
connect the following signals to your instrument and give them the names as shown here:

Phase voltages U L1 and U L2

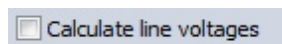
Currents I L1 and I L2

Select on the "Power Setup" page in the drop down menu "power system configuration" the line "2-phase".

Afterwards assign the the analogue channels to the fields U1, U2 etc. as shown below.



If "waveform" is checked also the line voltages U12 is available in the scope.

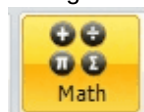


If "calculate line voltages" is checked, also the line voltage U12 is available as RMS value and as Harmonics.

2.3.3 Direct current power measurement

The DC-Power will be calculated with a simple math operation.

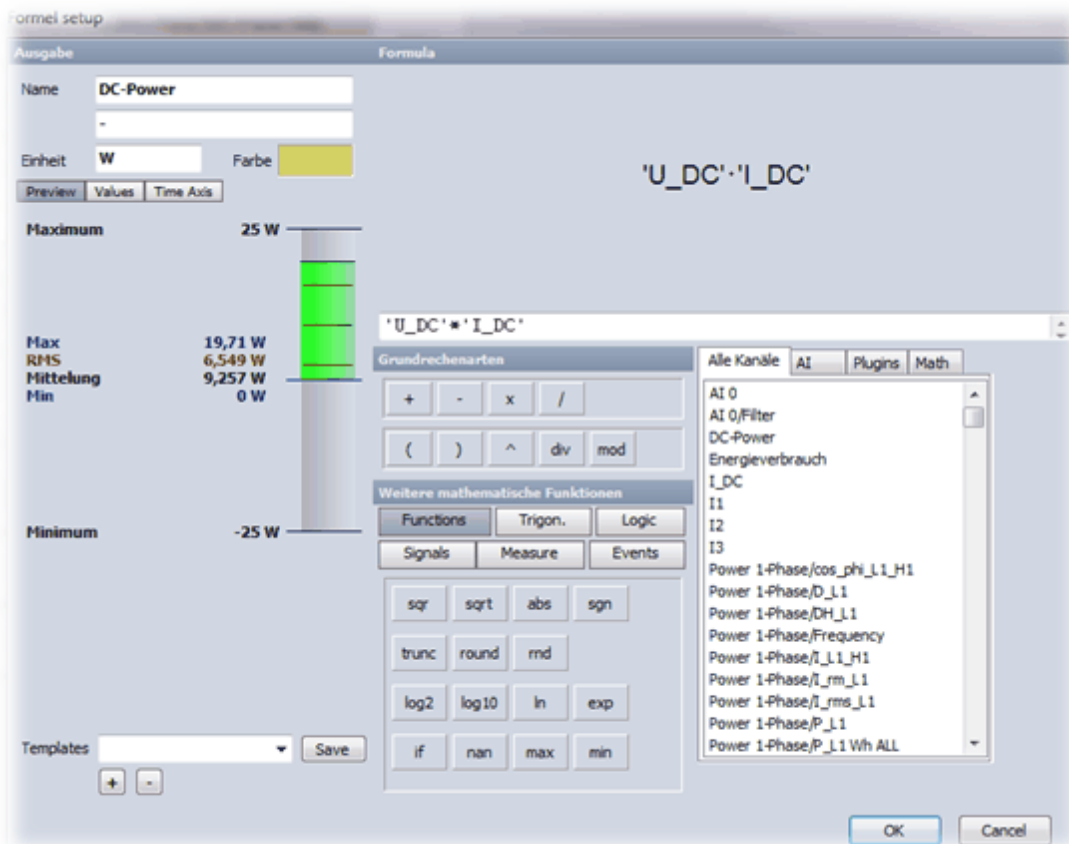
Change in the math-mode in the DEWESoft Setup.



Create a formula to calculate the DC-Power:

$$\sqrt{a^2+b^2}$$

Name the formula: "P_DC" with the Unit "W" and type in the formula:
 $P_{DC}=U_{DC} \cdot I_{DC}$



IMPORTANT:

Don't use the power module for the calculation of the DC power!!!

2.4 Power module

This chapter covers all settings for the Dewetron Power Module.
 All channels which are calculated are described as well as how to select them in measure mode.

All calculations are done according to following standards:

- IEC 61000-4-30 PQ Calculation
- IEC 61000-4-7 Harmonics
- IEC 61000-4-15 Flicker

All formulars for the different parameters you will find in the Technical Reference at the end of this document.

2.4.1 Power Calculation

With the sign "+" and "-" you can add or delete as many power modules as you need. The name of each power module can do be chosen arbitrary.

After the power system configuration (see chapter Power measurement) the basic settings for the power module have to be done.

Line frequency:

50 Hz ... nominal frequency in most countries (Europe, Africa, Asia, etc.)

60 Hz ... nominal frequency in North America, parts of Japan, etc.

16,7 Hz ... nominal frequency in some railway systems (Austria, Germany, Norway, etc.)

400 Hz ... special motors, transformers

800 Hz ... special motors, transformers

Variable ... for variable frequencies (converters) or if the frequency is unknown

Output Units:

W ... watt

kW... kilowatt

MW ... megawatt

Note: If you change the output unit and you use database storing, ensure that all units in the Dewesoft, db-plugin and PMT are the same.

Frequency source:

Voltage measurements at the grid

Current measurements of inverters (voltage signal is pulsed)

External ... every analog or math channel can be used as frequency source

Number of cycles:

This defines for which time period all power parameters (RMS-values) are calculated.

As standard 10 cycles (200ms) for measurements at 50 Hz is selected (required in 61000-4-30).

For 60 Hz applications it would be 12 cycles.

Nominal voltage:

230V line to earth voltage for e.g. star configuration

400V ... line to line voltage for e.g. delta configuration

every other voltage possible

Calculation sample rate:

This defines the sample rate for the calculation of the power module. Please consider that the sample

rate affects strongly the CPU power of the device. So just select the calculation rate you need for your measurement.

For the online-calculation of the parameters calculation rates up to 200 kHz can be reached (modern device). Offline you can reach the full-sampling rate (up to 10 MHz).

The height of the calculation rate depends on the one side on the device itself (CPU power) and on the other site on the number of power modules and the number and type of Math formulas you use.

Advice: If the computing power of your device is not sufficiently you have following options:

- lower acquisition rate: the power isn't less accurate, only the RMS values of the voltage is inaccurate.
- lower calculation rate of the power module: like above but the data points of the analog signal are still available at full acquisition rate (set "Calculation Sampling Rate" in the power setup). If you store the data "fast" you can calculate afterwards the power module with the full sampling rate.
- Calculation in the post processing, the power module is already preset (Offlinemode) or recording raw data, power modules are subsequently added and calculated (Analyzemode).
- Reduce number of Math formulas, Power modules or options in power module (e.g. Flicker, period values etc.). Especially the options: Harmonic Smoothing Filter, Flicker and Period Values in the power module needs a lot of CPU power.

In Math especially Filters, Statistics, Formulas with cosinus, sinus calculation needs a lot of CPU power.

Channel list:

Following channels are automatically calculated in the Power module.

P_L1...active power
Q_L1...reactive power
S_L1...apparent power
PF_L1...power factor

P_L1_H1...active power of the fundamental
Q_L1_H1...reactive power of the fundamental
S_L1_H1...apparent power of the fundamental
cos_Phi_L1_H1...cos Phi of the fundamental and power factor of the fundamental respectively
Phi_L1_H1...angle between voltage and current of the fundamental

D_L1...distortion power (remaining Q excluding the power of the fundamental oscillation Q_H1)
DH_L1...distortion power (remaining Q excluding the reactive power component of the harmonics QH)
QH_L1...reactive power of all harmonics

Values of the Channel List

U_rm_Lx ... rectified mean value (voltage)
U_rms_Lx ... 10 period RMS value (voltage)
U_Lx_H1 ... RMS of fundamental mode (voltage)
U_Lxper ... period-wise mean value (voltage).

If Option "calculate line voltage" is activated, there are additional Channels:

U_rms_L12 ... line voltage U1 and U2.
U_rms_L23... line voltage U2 and U3.
U_rms_L31 ... line voltage U3 and U1.

If Waveform is activated as well, the following Channels are added:

U_12 ... line voltage U1 and U2.

U_23 ... line voltage U2 and U3.

U_31 ... line voltage U3 and U1.

“total” - Values

P ... overall active power.

Q ... overall reactive power.

S ... overall apparent power.

PF ... power factor.

D ... distortion power.

DH ... distortion reactive power.

QH ... sum of harmonic reactive power parts.

P_H1 ... active power of fundamental component; mechanical power conversion.

Q_H1 ... reactive power of fundamental comp.

S_H1 ... apparent power of fundamental comp.

You will find this values in the channel list in the measurement mode:



2.4.2 Harmonics

All calculations are done according to the IEC 61000-4-7.

To measure harmonics with the power module you have several possibilities:

The screenshot shows the following settings:

- ☒ Harmonics: 100, All (dropdown)
- ☒ Number of sidebands: 3
- ☒ Number of halfbands: 1
- ☒ Full FFT
- ☒ Group FFT lines (2 - 40 KHz)
- ☒ Harmonics smoothing filter
- ☒ phase angles
- ☒ P,Q
- ☒ Impedance
- ☒ Interharmonics

Harmonics

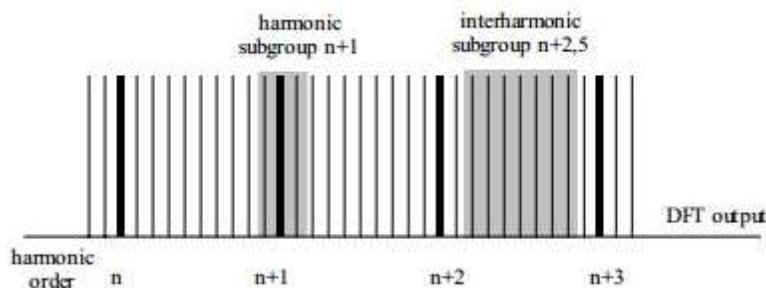
You can select the number of Harmonics you want to calculate. The upper limit is 500.

As next choice you can select if you want to calculate "all" Harmonics or just the "even" or "odd" ones. Furthermore you can select if you also want to calculate the "phase angles", "P,Q", and the "Impedance" (for this options you also need the current channels)

Number of Sidebands:

This is the number of full sidebands which should be considered for the calculation of the Harmonics.

Example: You measure at a frequency of 50 Hz over 10 cycles and you select 1 sideband, the 5Hz line above and below the 50 Hz (45 - 55 Hz) will be considered for the first Harmonic (it's the same for all other harmonics). If you select 2 sidebands the first Harmonic will reach from 40 to 60 Hz.

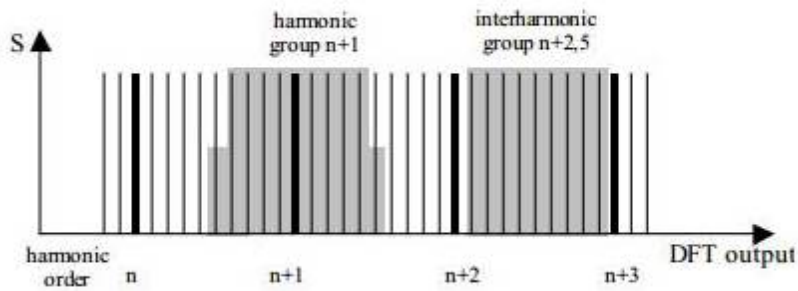


Number of halfbands:

The IEC 61000-4-7 requires for the grouping of the Harmonics also sidebands where only the square root of the quadratic half $\sqrt{(Y_k^2/2)}$ of them should be added (see page 22 of the IEC 61000-4-7). In the Power module it is called "halfbands". This is required for the lowest and highest line.

Example 1: You measure at a frequency of 50 Hz over 10 cycles and you select 1 sideband and 1 halfband: So the first harmonic will cover everything between 45 and 55 Hz and the square root of the quadratic half of the 40 and 60 Hz lines.

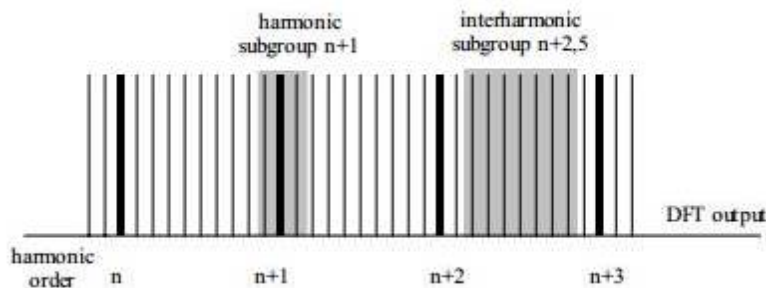
Example 2: If you select for example 2 sidebands and one halfband, you will get the lines from 40 to 60 Hz with the full amplitude and the 35 Hz and the 65 Hz line with the square root of the quadratic half.



Interharmonics:

The interharmonics covers all lines which are not covered by the Harmonics (see page 26 of the IEC 61000-4-7).

Example: You select one sideband at a signal with a frequency of 50 Hz over 10 cycles, you will get for the first interharmonic everything between 0 and 45 Hz. The second interharmonic will cover everything between 55 and 95 Hz and so on.



Group FFT lines

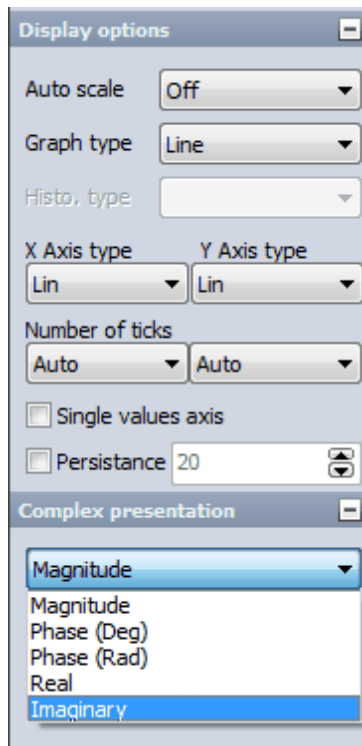
This option groups the FFT lines above 2 kHz in 200 Hz bands, (-95Hz to +100 Hz of the middle frequency, see page 29 of the IEC 61000-4-7). The upper limit can be chosen up to 80 kHz. e.g. for 2,1 kHz it would consider the lines from 2005 to 2200 Hz.

Harmonics Smoothing filter

This options enables the low-pass filter which is required in the IEC 61000-4-7, see page 23.

Full FFT

This options also calculates the Full FFT which afterwards also can be exported to the database. In Dewesoft you can show it via a 2D-graph. There you also can select whether you want to see "Magnitude", "Phase", the "Real" or the "Imaginary" part.



Channel list: (phase one)

U_L1_H voltage harmonics

U_L1_IH voltage interharmonics

U_HF_L1 voltage higher frequencies (the number shows the middle of the grouped lines in kHz).

I_L1_H current harmonics

I_L1_IH current interharmonics

I_HF_L1 current higher frequencies (the number shows the middle of the grouped lines in kHz).

P_L1_H ... power harmonics

Q_L1_H ... reactive power harmonics

phi_I1_H ... current angle harmonics

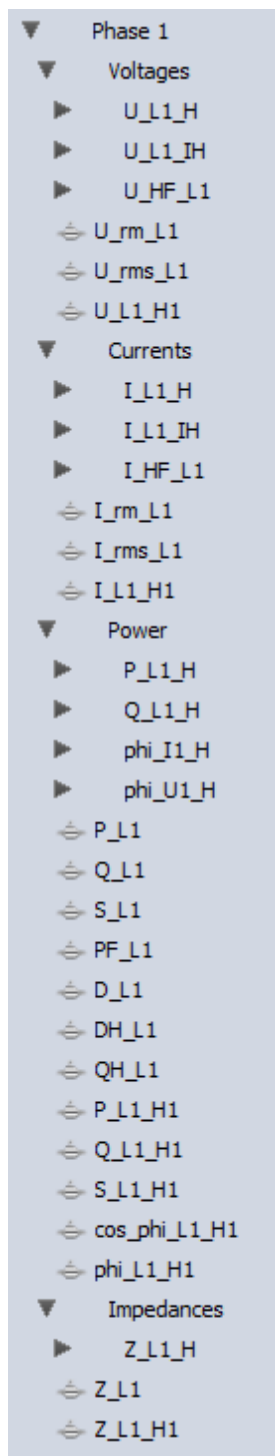
phi_U1_H ... voltage angle harmonics

Z_L1_H ... impedance harmonics

Visualisation:

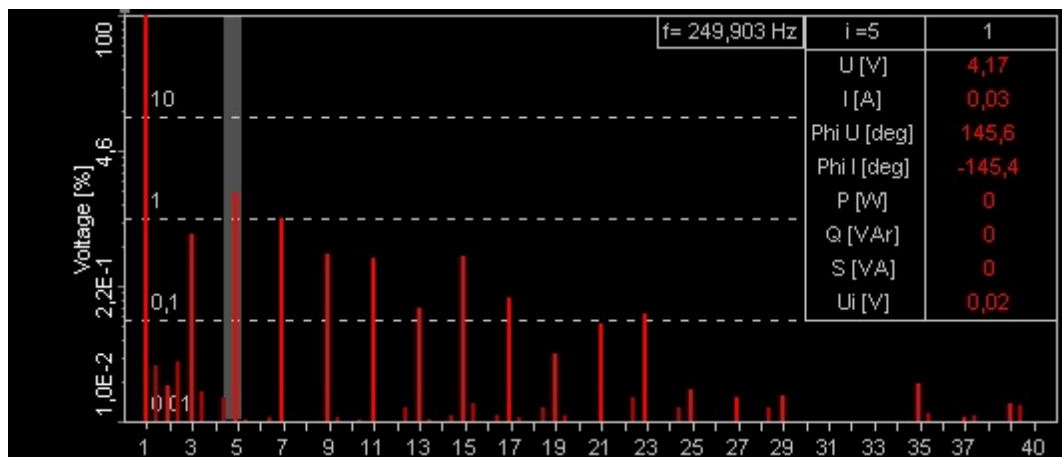
When measuring several ways of representation are available:

- 1) Each value can be used as a display, in the recorder or similar.

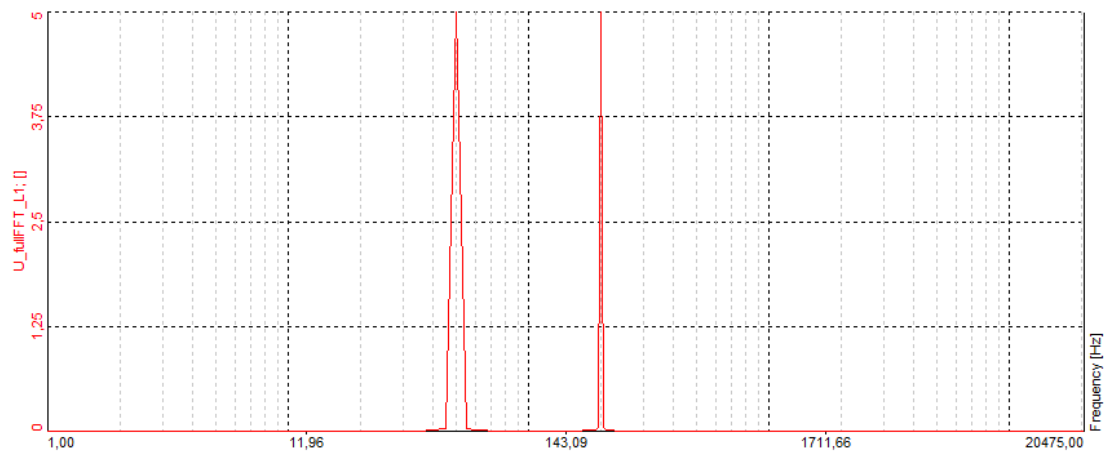


2) FFT representation

FFT representation with the interharmonics:



3) 2D-Graph
Full-FFT



Special measurements:
Full FFT
Backgroundharmonics

2.4.2.1 Background harmonics

Background harmonics (background noise) applies when an existing harmonic pattern in the magnitude and phase recorded and then subtracted from the measured values.

Typical application: commissioning of a powerful power converter.
(To know the additional proportion of this converter)

Procedure:

After the definition of a power module and the assignment of all channels please select the item "Background harmonics" on setup page.

Channels Vector scope Background harmonics

☐ Use background harmonics for voltage

☐ Use background harmonics for current

You can use this function for voltage and/or current.

Channels Vector scope Background harmonics

☒ Use background harmonics for voltage

☐ Use background harmonics for current

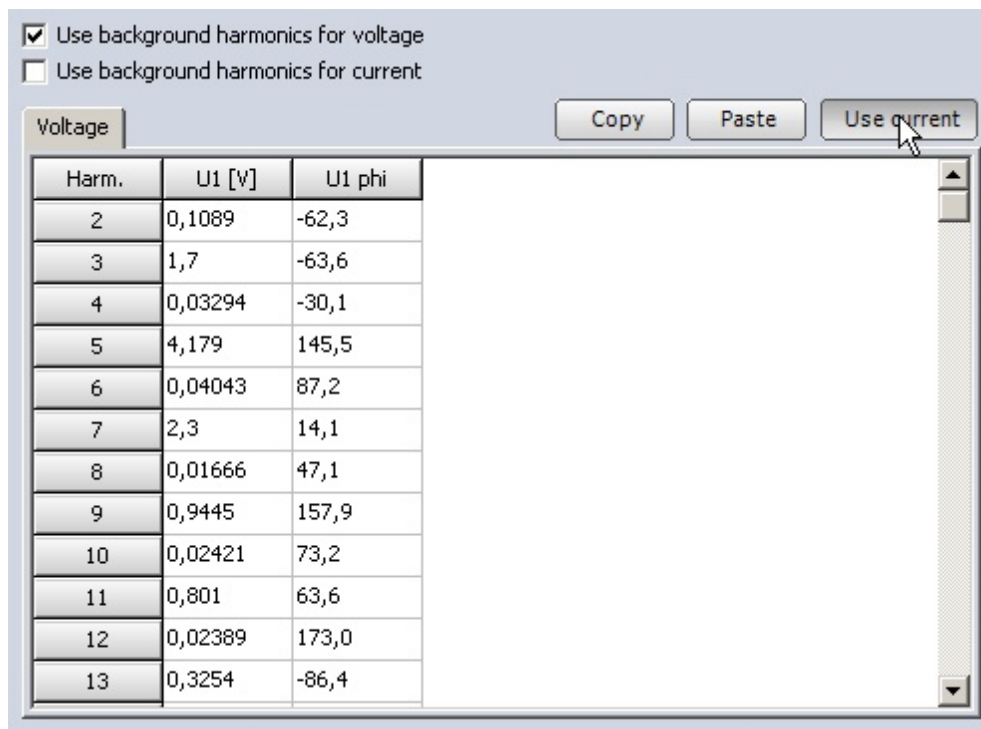
Voltage Copy Paste Use current

Harm.	U1 [V]	U1 phi
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
10	0	0
11	0	0
12	0	0
13	0	0

If you click on "use current" the table instantaneous filled with values.

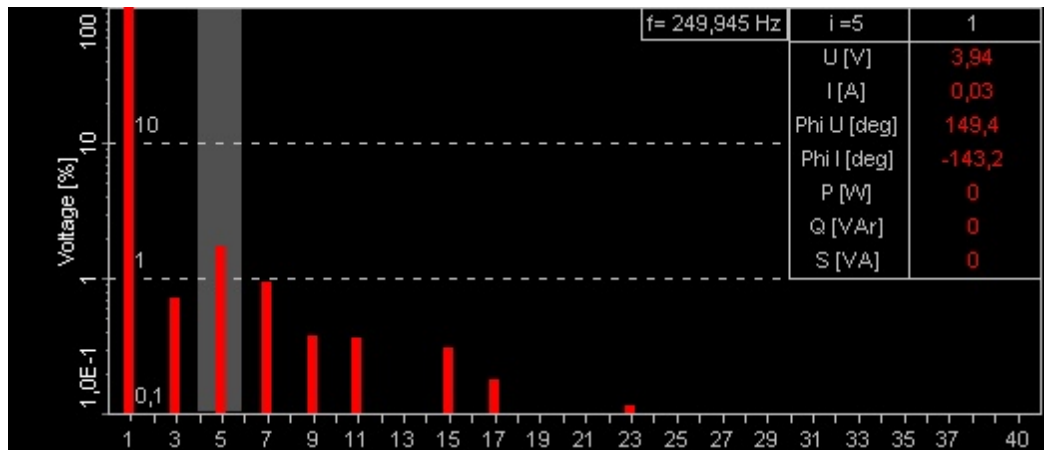
Copy: copies the values of the table to the clipboard

Paste: copies any existing table from the clipboard



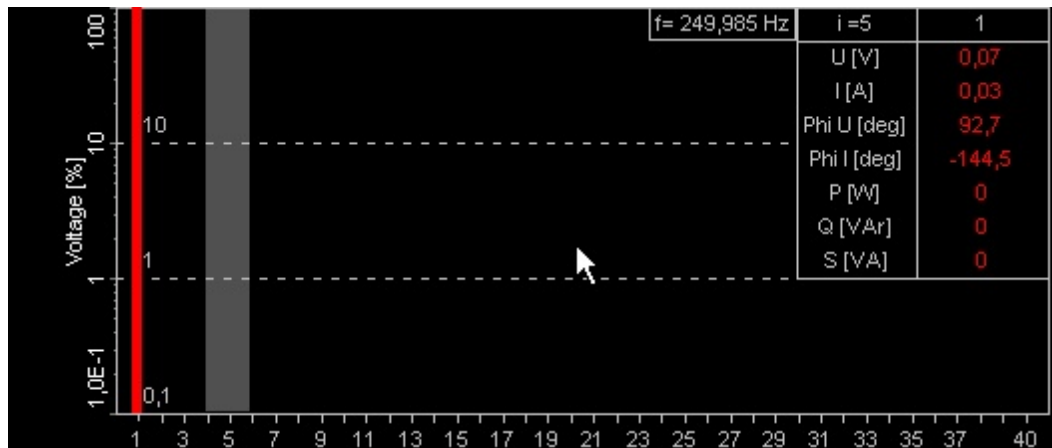
The following screen shows a harmonic spectrum before using this function:

BEFORE



If the "Background harmonics" were applied the spectrum looks like this:

AFTER

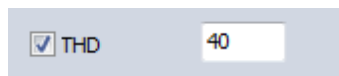


The harmonics "wiped out". Now only newly appearing harmonics are displayed.

2.4.3 THD

THD (Total Harmonic Distortion) is defined as sum of power P_H (all harmonics) to fundamental power P_{H1} ratio (see Technical Reference).

To calculate the THD select the option in the power module. In the selection field you can set the number of the Harmonic to which the THD should be calculated. The upper limit is limited just by the sampling rate



Channel list: (phase one)

THD_U_L1 ... Total harmonic distortion of the voltage

THDOdd_U_L1 ... Total harmonic distortion of the voltage for odd harmonics

THDEven_U_L1 ... Total harmonic distortion of the voltage for even harmonics

THD_I_L1 ... Total harmonic distortion of the current

THDOdd_I_L1 ... Total harmonic distortion of the current for odd harmonics

THDEven_I_L1 ... Total harmonic distortion of the current for even harmonics

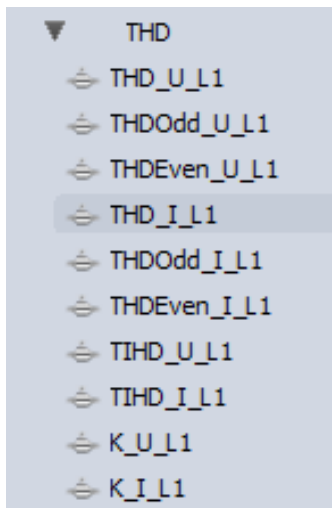
TIHD_U_L1 ... Total interharmonic distortion of the voltage for odd harmonics

TIHD_I_L1 ... Total interharmonic distortion of the current for odd harmonics

K_U_L1 ... k-Factor for voltage ... In comparison to the THD the k-Factor refers to the full-spectrum (the THD just to the fundamental voltage)

K_I_L1 ... k-Factor for current

Visualization:



2.4.4 Symmetrical components

For the calculation of the "Symmetrical components" enable the option in the power module.

☒ Symmetrical components

Channel list:

U_0 zero component of voltage

U_1 ... positive component of voltage

U_2 ... negative component of voltage

I_0 zero component of current

I_1 ... positive component of current

I_2 ... negative component of current

u2 ... negative sequence component of voltage

u0 ... zero sequence component of voltage

u2_1 ... negative sequence component of the fundamental voltage in percent (=Unbalance factor for EN50160 report)

u0_1 ... zero sequence component of the fundamental voltage in percent

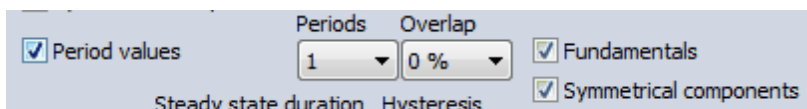
i2 ... negative sequence component of current

i0 ... zero sequence component of current

i2_1 ... negative sequence component of the fundamental current in percent

i0_1 ... zero sequence component of the fundamental current in percent

Additionally to this option, following symmetrical components can also be calculated with the period values.



Period values

P_1p_per ... active power positive sequence

Q_1p_per ... reactive power positive sequence

S_1p_per ... apparent power positive sequence

P_1n_per ... active power negative sequence

Q_1n_per ... reactive power negative sequence

S_1n_per ... apparent power negative sequence
 P_1z_per ... active power zero sequence
 Q_1z_per ... reactive power zero sequence
 S_1z_per ... apparent power zero sequence
 cos_phi_1p_per ..cosinus phi of positive sequence component

U_1p_per ... phase-to-phase voltage of the fundamental positive sequence
 U_1n_per ... phase-to-phase voltage of the fundamental negative sequence
 U_1z_per ... phase-to-phase voltage of the fundamental zero sequence
 I_1p_per ... current of the fundamental positive sequence
 I_1n_per ... current of the fundamental negative sequence
 I_1z_per ... current of the fundamental zero sequence

I_p1p_per ... active current of positive sequence component
 I_q1p_per ... reactive current of positive sequence component

Special calculations

The following values were implemented in the software due to special customer requirements and cover cosinus and sinus calculations for the symmetrical components (see Technical Reference)

U_ap_per
 U_ap_cos_per
 U_ap_sin_per
 I_ap_cos_per
 I_ap_sin_per
 U_an_cos_per
 U_an_sin_per
 I_an_cos_per
 I_an_sin_per
 U_az_cos_per ...
 U_az_sin_per
 I_az_cos_per
 I_az_sin_per

Visualization:

Now the the following measurement channels are available. The channels can be displayed in displays and recorders.

▼ Symmetrical components

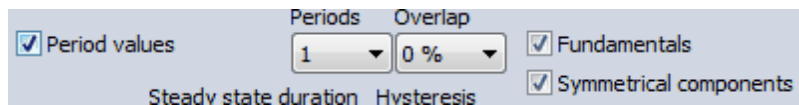
⚙ u2
 ⚙ u0
 ⚙ u2_1
 ⚙ u0_1
 ⚙ U_0
 ⚙ U_1
 ⚙ U_2
 ⚙ i2
 ⚙ i0
 ⚙ i2_1
 ⚙ i0_1
 ⚙ I_0
 ⚙ I_1
 ⚙ I_2
 ⚙ U_ap_per
 ⚙ U_ap_cos_per
 ⚙ U_ap_sin_per
 ⚙ I_ap_cos_per
 ⚙ I_ap_sin_per
 ⚙ P_1p_per
 ⚙ Q_1p_per
 ⚙ U_1p_per
 ⚙ I_1p_per
 ⚙ I_p1p_per
 ⚙ I_q1p_per
 ⚙ cos_phi_1p_per
 ⚙ U_an_cos_per
 ⚙ U_an_sin_per
 ⚙ I_an_cos_per
 ⚙ I_an_sin_per
 ⚙ S_1p_per
 ⚙ P_1n_per
 ⚙ Q_1n_per
 ⚙ S_1n_per
 ⚙ U_1n_per
 ⚙ U_az_cos_per
 ⚙ U_az_sin_per
 ⚙ I_az_cos_per
 ⚙ I_az_sin_per
 ⚙ P_1z_per
 ⚙ Q_1z_per
 ⚙ S_1z_per
 ⚙ U_1z_per
 ⚙ I_1z_per
 ⚙ I_1n_per

2.4.5 Period values

Period values are necessary if you need the calculation of power, voltage, current, etc. more often than you define at "Number of cycles".

In the power module you also can calculate period values for the total and the fundamental values as well as for the symmetrical components (see chapter symmetrical components).

Furthermore you can define if you want to calculate the values for half, full, two or four periods and an defineable overlap between 0% and 95%.



Periods 1/2, 1, 2, 4

Overlap 0%, 25%, 50%, 75%, 90%, 95%

Example: If you select "1" period values with an overlap of 95% you get all period values with an update rate of 1ms.

Channel list period Values:

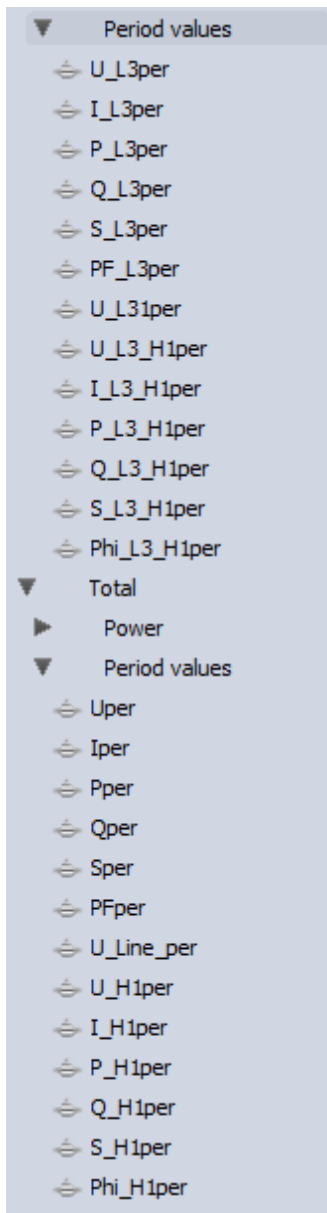
Phase:

U_L1per ... phase-to-earth voltage
 U_L12per ... phase-to-phase voltage
 U_L1_H1per ... fundamental phase-to-earth voltage
 I_L1per ... phase current
 I_L1_H1per ... fundamental phase current
 P_L1per ... active power of phase
 P_L1_H1per ... active power of the fundamental of the phase
 Q_L1per ... reactive power of phase
 Q_L1_H1per ... reactive power of the fundamental of the phase
 S_L1per ... apparent power of phase
 S_L1_H1per ... apparent power of the fundamental of the phase
 PF_L1per ... power factor of the phase
 phi_L1_H1per ... period value of phi

Total:

Uper ... average voltage of all phases
 U_H1per ... average voltage of all phases for the fundamental
 Iper ... cummlate current of all phases
 I_H1per ... cummlate current of all phases for the fundamental
 Pper ...active power
 P_H1per ...active power of the fundamental
 Qper ...reactive power
 Q_H1per ...reactive power of the fundamental
 Sper ... apparent power
 S_H1per ...apparent power of the fundamental
 PFper ... Powerfactor
 phi_H1_per ... average phi of the fundamental

Visualization:



2.4.6 Flicker

NOTE: For the correct calculation of Flicker the sampling rate of the input channels and the calculation rate of the power module have to be the same.

Flicker represents the fluctuation of the voltage.

The brightness of light sources such as light bulbs follows these voltage fluctuations. These are perceived by humans.

The results are lack of concentration and headaches.

The flicker-algorithm IEC 61000-4-15 classified these changes. There are 3 levels available:

Pst...short-term flicker; usually calculates every 10 minutes.

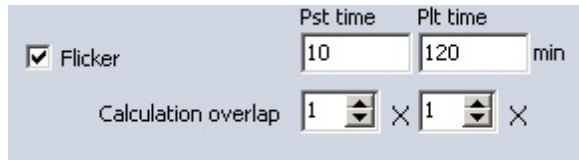
Plt...long-term flicker; usually the average of 12 cubic Pst values, calculated every 2 hours.

Pf5...an internal value of flicker, which shows the changes of input voltage, similar to a derivative of the

input voltage.

Setup:

Please enable "Flicker" in the Power Setup.



Pst time...interval of the short-term flicker calculation

Plt time...interval of the long-term flicker calculation

Calculation Overlap...degree of overlap of the flicker calculation (Example: if 2 is selected here within the "Pst time" the calculation occurs 2 times)

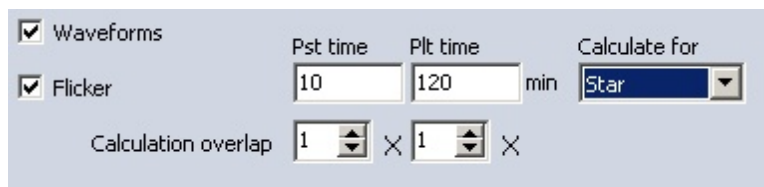
For a period of 10 minutes, that would mean that every 5 minutes a new 10 minute Pst-value is calculated.

Special case:

For 3 phase star connection it is possible to output either the flicker of phase voltages (star) and/ or phase values (delta).

Enable "Waveforms"

Now in the field "Calculate for" you can choose between Star, Delta or both.



Measurement:

Now the measurement channels are available and can be displayed in different displays or recorder.



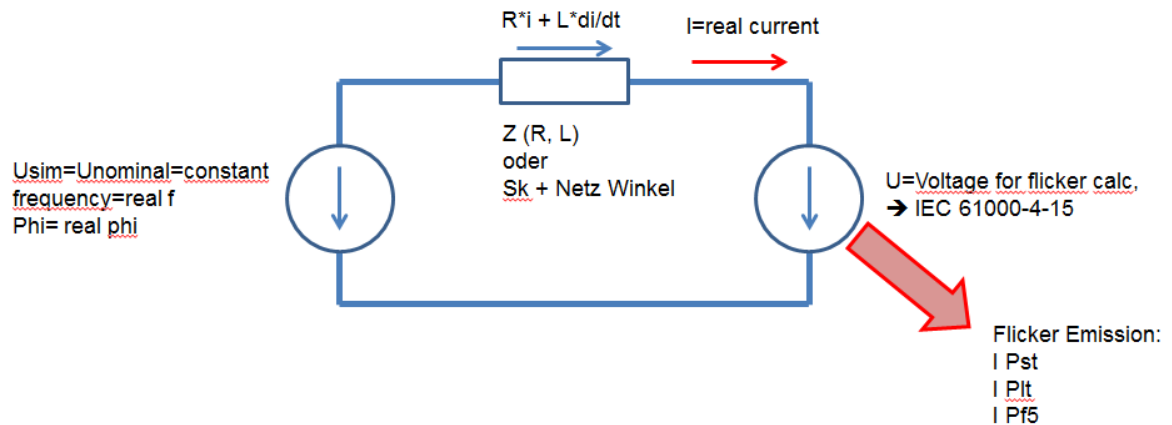
2.4.6.1 Flickeremission

The flickeremission (also called current flicker) calculates the proportion of the flicker, which is added to the grid by a producer or a consumer.

In addition the internal voltage drop is calculated by the grid impedance of the current flow.

The voltage drop is added to an idealized voltage source vectorial.

Using the flicker algorithm and the new voltage the current flicker values are calculated.



Setup:

Enable "Flicker" and "Current Flicker" and input the grid parameters.

You whether can type in the short circuit power or the Impedance of the grid.

Phase: the impedance angle of the grid. You also can type in a number of different phase angles (e.g. 30;50;70;85).

☒ Flicker

Pst time: 10 min
 Plt time: 120 min

Calculate for: Star

Calculation overlap: 1

Lp filter: Auto

☒ Current flicker

Short circuit power: 1 VA

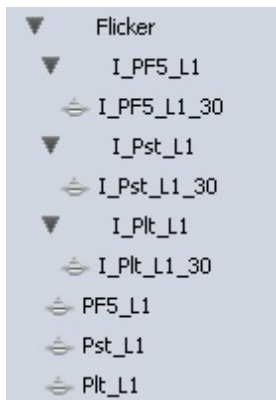
Phase (deg): 0

In the power module the nominal voltage must be set. This value is also the value for the idealized voltage source!

Nominal voltage: 230 V

Mesurement:

Now the measurement channels are available and can be displayed in different displays or recorder.



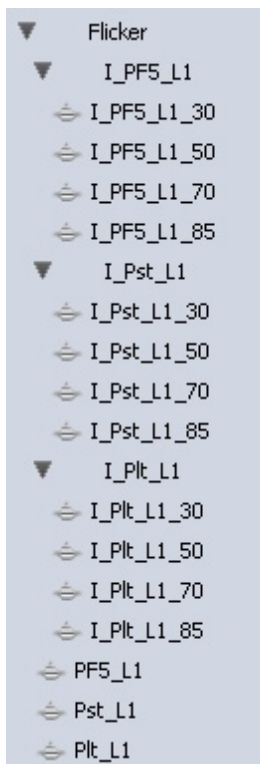
Special Case:

Some standards require a calculation of the flickeremission at several angles of impedance simultaneously!

Enter them separated by ";" (semicolon).



Now the channel-list shows the flickeremission values with the extension of the phase angles.



2.4.6.2 Rapid Voltage Changes (RVC)

The Rapid Voltage Changes (RVC) are a special calculation in Dewesoft which allows to calculate the maximal voltage drop ($d_{\max}$), the stationary deviation after the voltage drop (d_c) and the time where the voltage drop is below 3,3% of U_n .

All values are calculated according to the IEC 61000-4-15. Analysis can be done for example for IEC 61000-3-3 and IEC 61000-3-11.

The following picture shows the calculated parameters (IEC 61000-4-15 page 35).

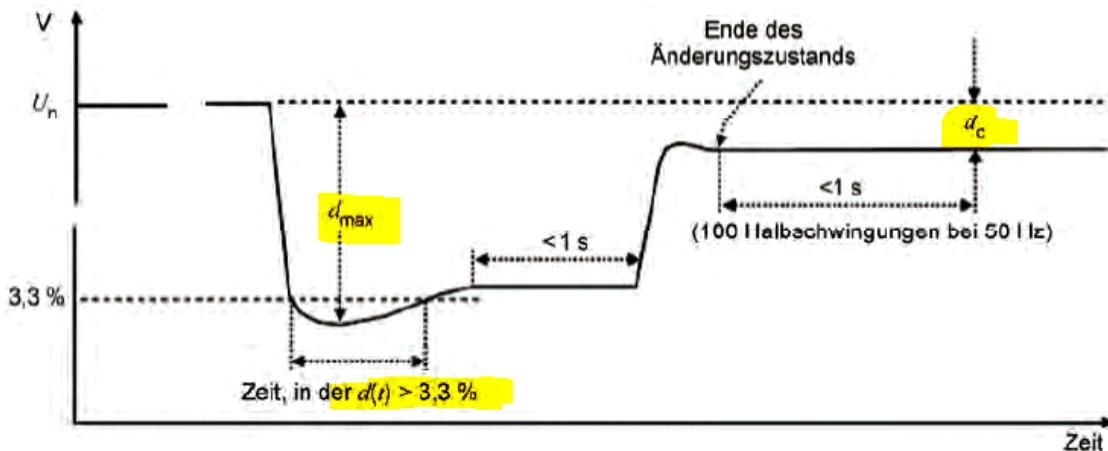
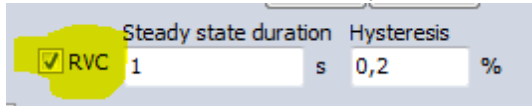


Bild B.2a – Bild zur Erläuterung der d -Parameter-Definitionen

For the calculation in Dewesoft please select RVC in the Power module.



Furthermore you can define a Steady state duration and a Hysteresis.

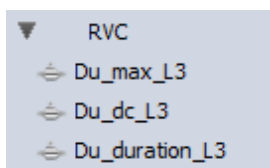
Hysteresis: definable Hysteresis which is the condition for the stationary deviation (du_{dc})... see IEC 61000-4-15 page 8.

Steady state duration: This defines the duration of the steady state.

Example:

If you define a hysteresis of 0,2% and a steady state duration of 1s, the stationary condition is reached if the voltage doesn't leave $\pm 0,2\%$ for 1 second.

In measurement mode the following channels will appear:



Du_max maximal voltage drop

du_dc stationary deviation after the voltage drop

du_duration.... time where the voltage drop is below 3,3%

2.4.7 Vector scope



The vector scope shows the voltage vector (hollow arrow) and the current vector (full arrow).



Additional Settings:

Measured values	
☐	Show measured values
Harmonic	
Shown harmonic	1
Axis settings	
☒	Automatic
U max	5
I max	5
Tick count	3

"Show measured Values"...switch on or off the values

"Shown Harmonic"...select which harmonic shall be shown

Axis Settings...Settings of axis

Automatic...auto scaling

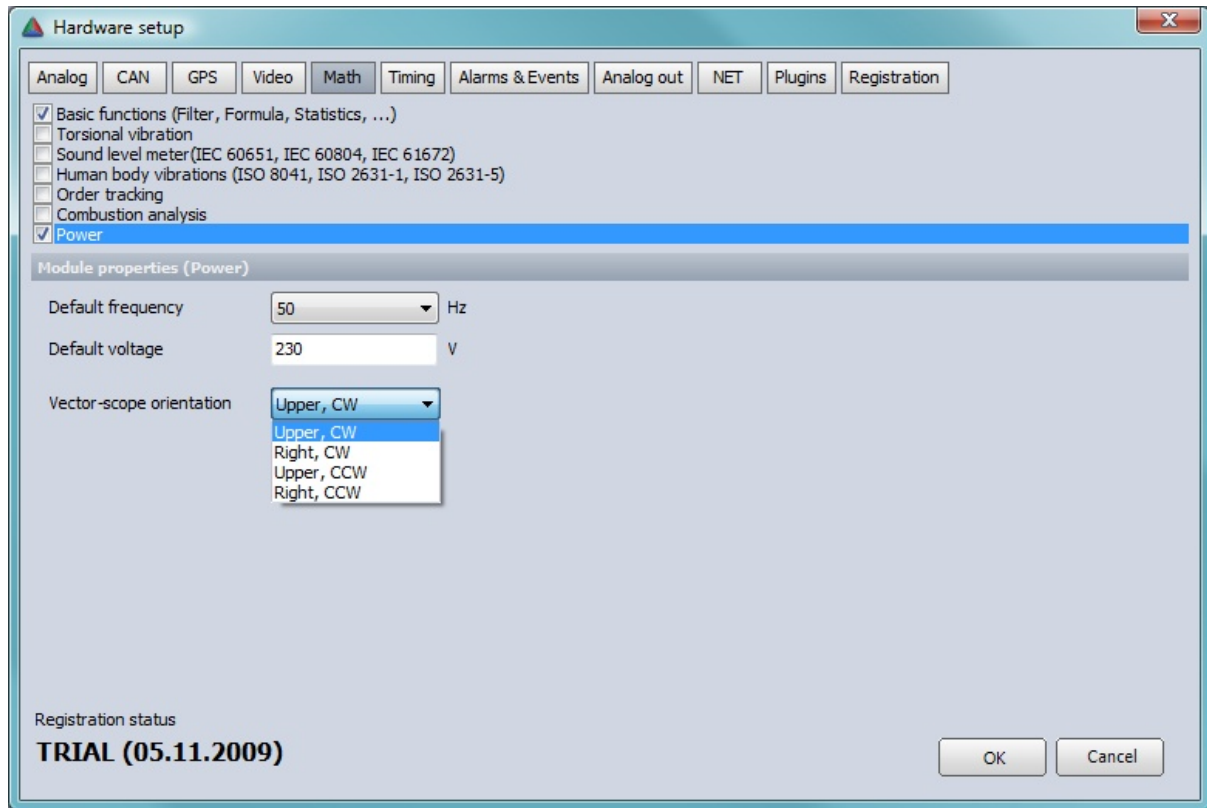
U max...maximum voltage value for manual settings

I max...maximum current value for manual settings

Tick Count...number of circles to be shown

Further Settings which can be done in DEWESoft:

(Settings -> Hardware Settings -> Math -> Power)



Vector Scope Orientation...define where the zero axis is and the rotation direction of the arrows.

Upper, CW...zero is top, the positive phase angle is right (inductive load, CW...clockwise).

Right, CW...zero is right, the positive phase angle is right (inductive load, CW...clockwise).

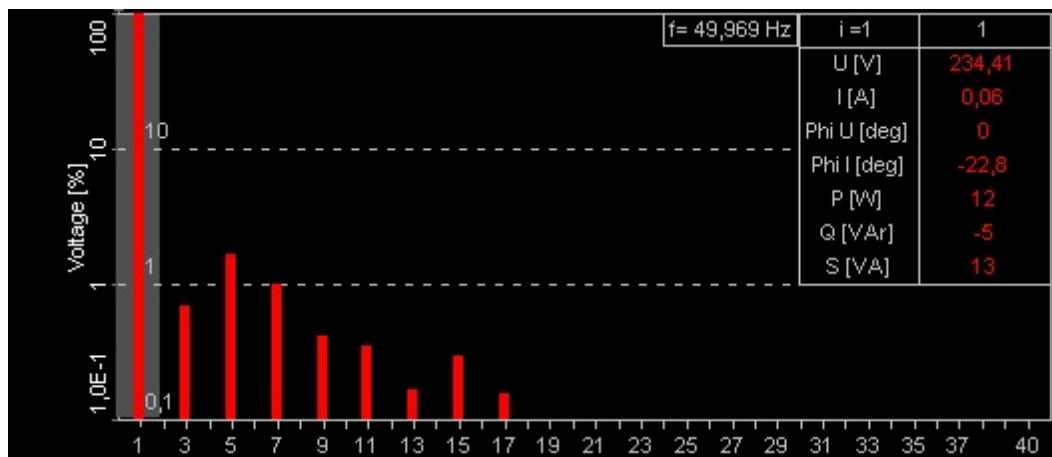
Upper, CCW...zero is top, the positive phase angle is left (inductive load, CCW...counterclockwise)

Right, CCW...zero is right, the positive phase angle is left (inductive load, CCW...counterclockwise)

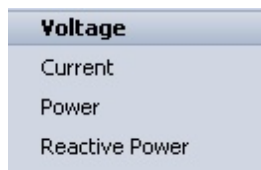
2.4.8 FFT



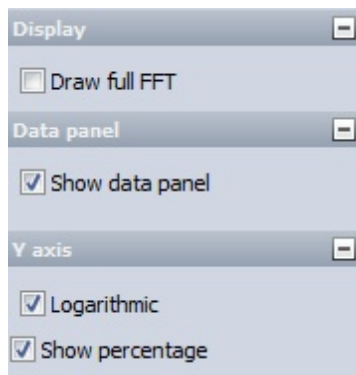
FFT shows the harmonics of voltage, current, active and reactive power



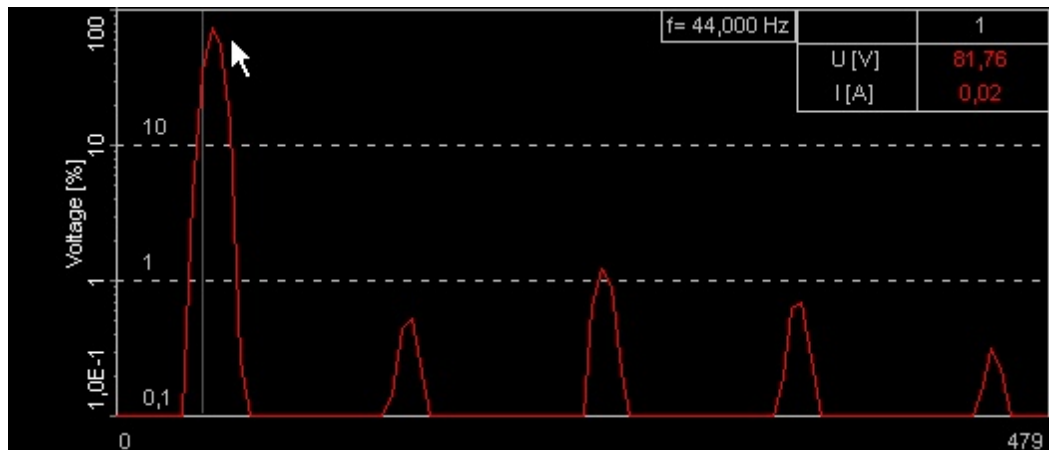
The selector for the data to be shown is on the right side of the screen.



further settings:



"Draw Full FFT"...shows all frequencies, not only the multiples of the fundamental (see also "Harmonics")



Show Data Panel...switch on and off the data on the top right

f = 49,969 Hz	i = 1	1
U [V]		234,41
I [A]		0,06
Phi U [deg]		0
Phi I [deg]		-22,8
P [W]		12
Q [VAr]		-5
S [VA]		13

The values are:

i...the selected harmonic

f...the real frequency of the harmonic

U[V]...voltage of the harmonic

I[A]...current of the harmonic

Phi U [deg]...Angle between zero and the voltage vector (Zero is the Zero crossing of the fundamental of phase 1)

Phi I [deg]...Angle between zero and the current vector

P [W]...active power of the harmonic

Q [VA]...reactive power of the harmonic

S [VA]...total power of the harmonic

Logarithmic...switch between logarithmic and linear scale

Show percentage...switch between absolute (V,A,W,VA) or relative scaling. 100% is the fundamental.

2.5 Storing of data

Target: In this chapter you will learn how to store the data from power measurements.

Files (DEWESoft Files)

Database (PMT and SQL Server)

When is which method used?:

Storing directly in **Dewesoft** is always used if you want to store the data with a **high sampling rate** (e.g. 300 kS/s) and if you want to do calculations or special analysis also via **post-processing**.

Database storing is always used for **long-term measurements** with a storing interval of minutes, hours etc. The database further provides methods for **automatic evaluation and report generation** (e.g. EN50160, 61400-21 etc.) and the possibility to store data of a couple of measurement devices in a **singular database** (e.g. monitoring systems).

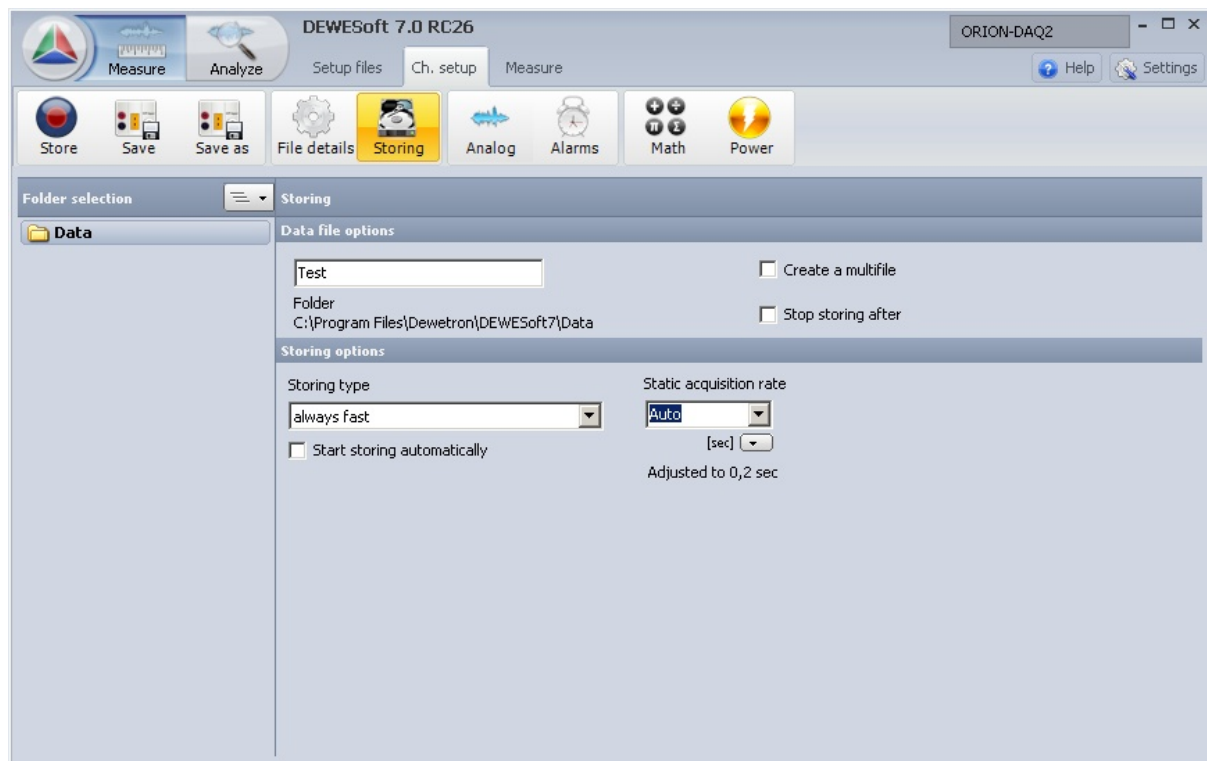
Notice: Please don't use both storing possibilities at the same time with different storing times!

2.5.1 Storing of data in files (DEWESoft)

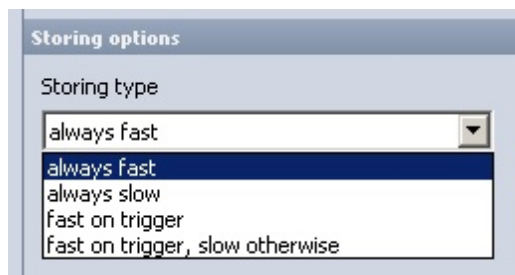
Activate the measurement mode and click first "Channel Setup" and then "Storing"



On the input screen for the storage are the following options available:



Storing Type: In general data can be stored in 4 different ways in DEWESoft.



fast (always fast)	Data always stored by full acquisition rate.
slow (always slow)	Data stored by reduced acquisition rate - e.g. by seconds (Static Acquisition rate). Here average (AVG), RMS, maximum (MAX) and minimum (MIN) will be stored.
fast_on_trigger	Data stored by full acquisition rate when trigger condition is true.
fast_on_trigger_slow_otherwise	Similar to "fast on trigger", but the data will stored by reduced acquisition rate when trigger condition is wrong.

Static acquisition rate: Data build with reduced acquisition rate - e.g. by seconds. The average (AVG), RMS, maximum (MAX) and minimum (MIN) calculated.

Data File Options: Filename and path.

Multifile Option: Enable the multi file option and conditions.

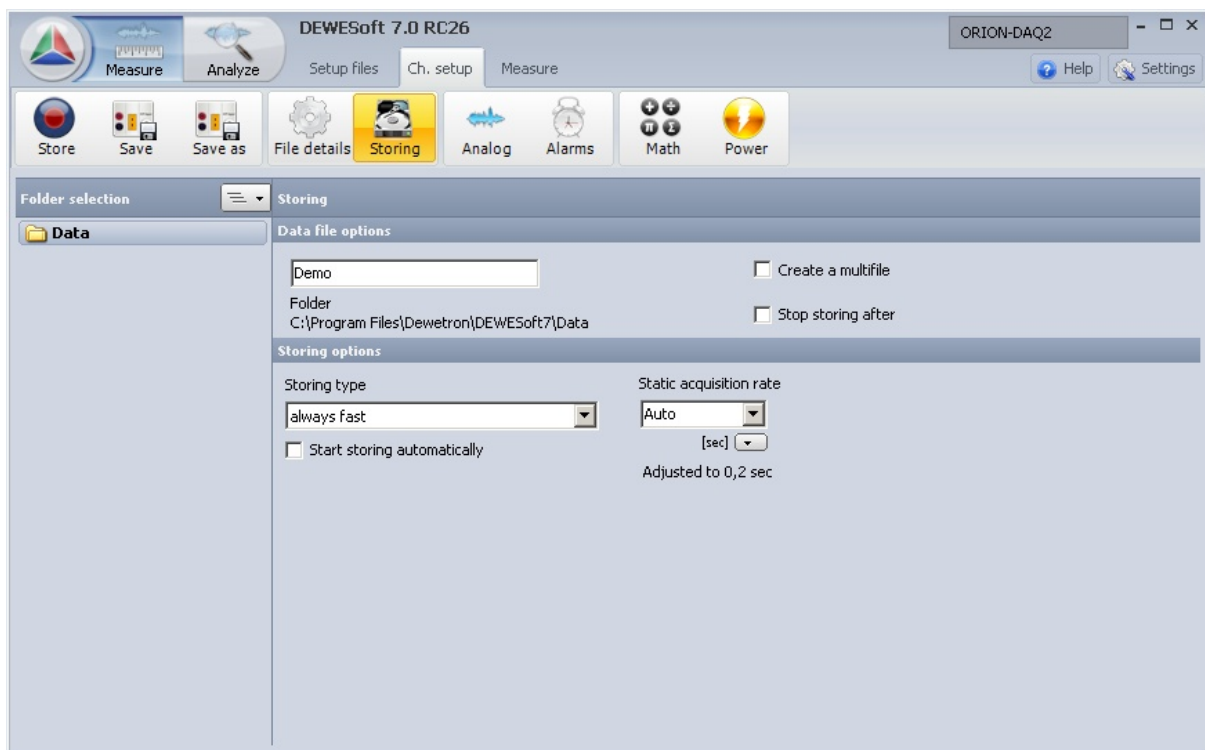
Make new file after: Set the conditions when DEWESoft create a new file (only multi file mode).

Setup: Set how to build the filename in multi file mode:

Stop Storing after: Determine storing automatically after reaching the maximum filesize (not available in multi file mode).

2.5.1.1 Fast storing

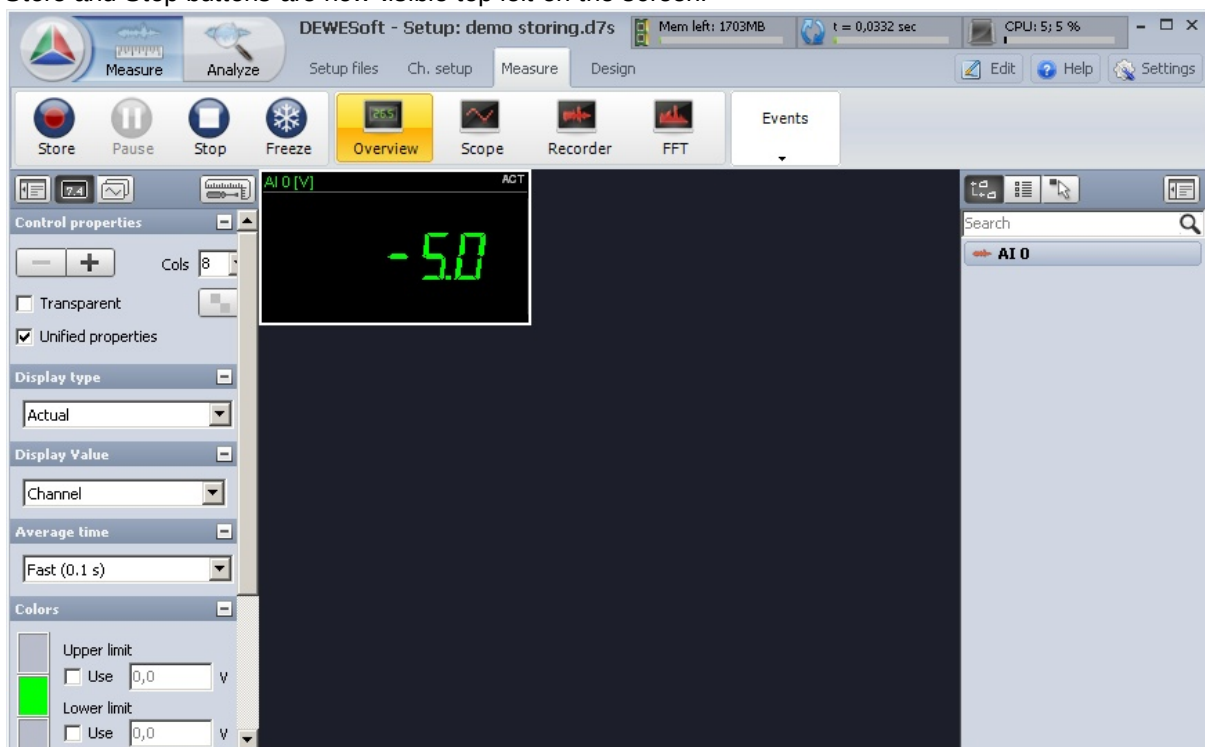
"always fast" selected in storing setup.

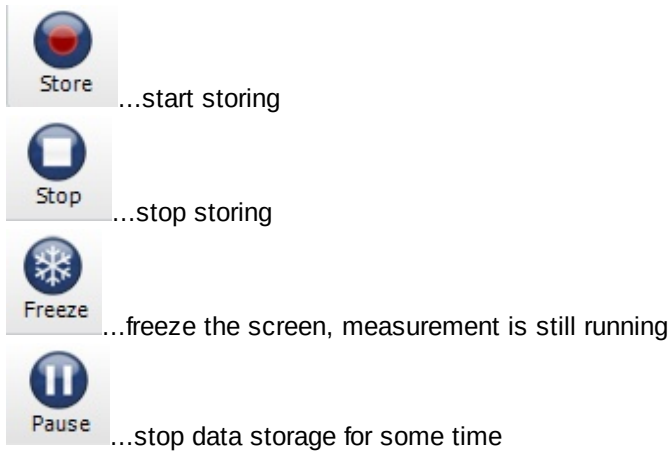


Change to the measurement mode "Measure"

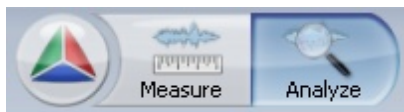


Store and Stop buttons are now visible top left on the screen:

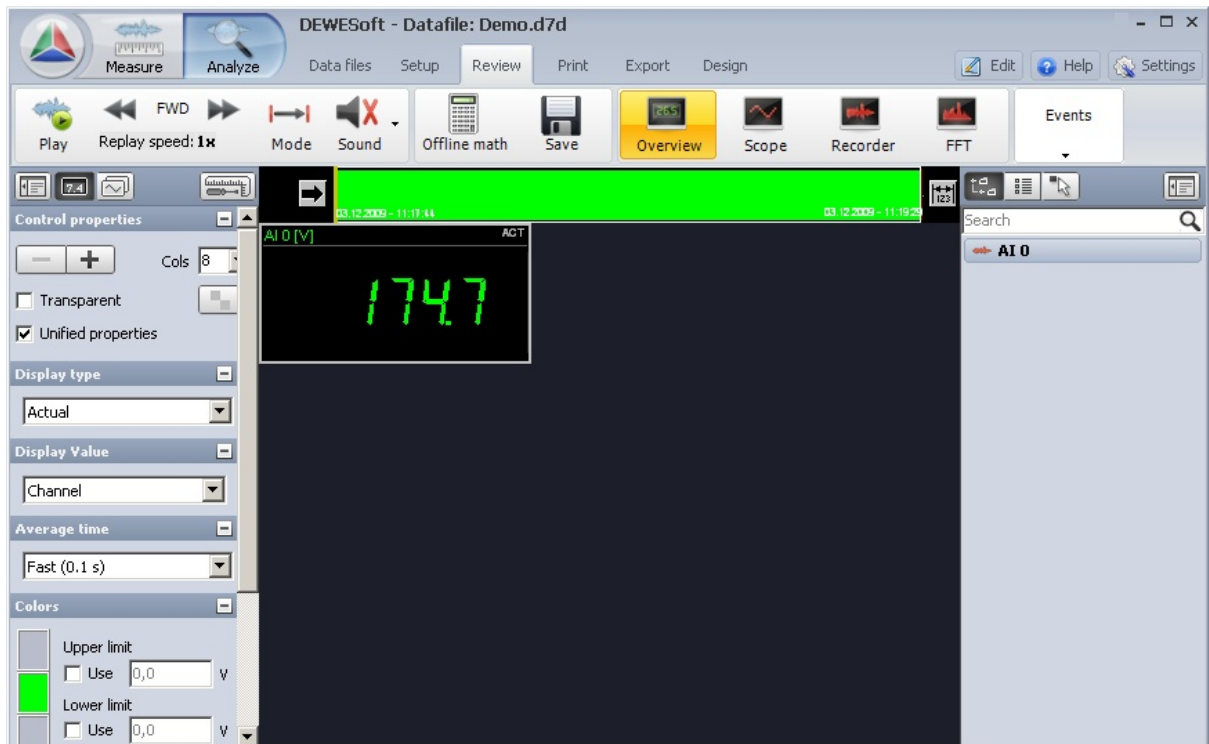




After storing your data you can change to the analyze mode to view your data.



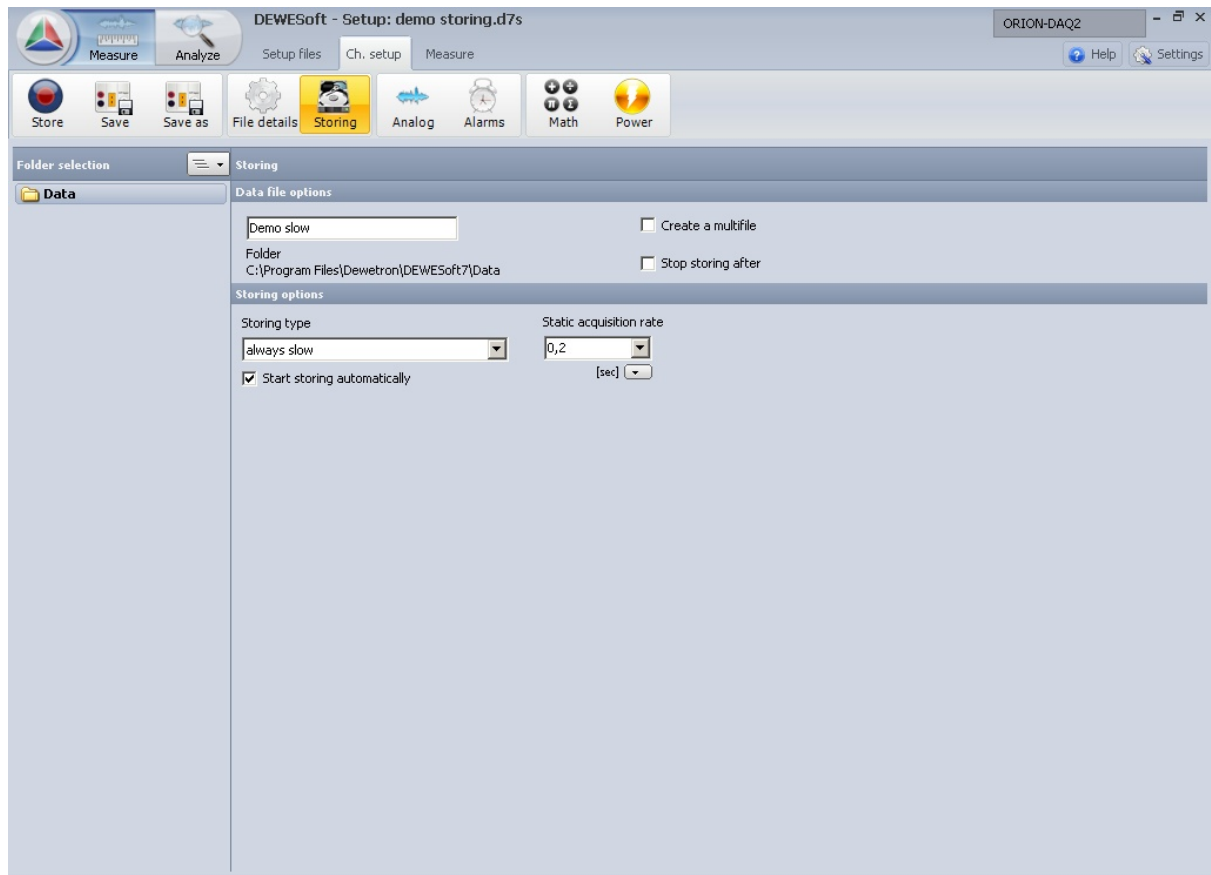
No you can use DEWESoft tools like Replay, customize the screen and so on.



To view an older measurement choose the analyze mode and select your stored file which is shown in the file dialog.

2.5.1.2 Slow storing

Before reading this chapter you should refer to "Fast storing".



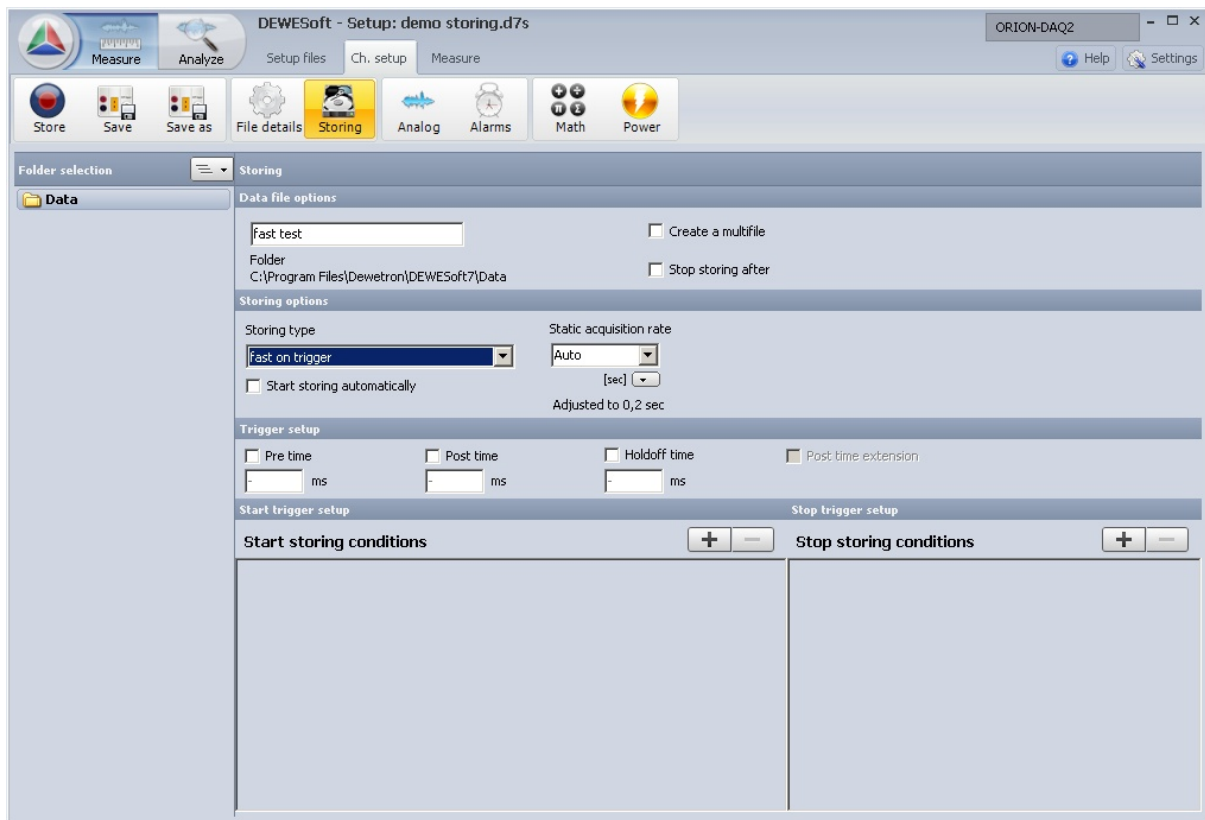
The main difference to "fast storing" is the reduced acquisition rate by storing data - e.g. 0,2 seconds (Static Acquisition rate). Only average (AVG), RMS, maximum (MAX) and minimum (MIN) stored.



To start the recording and analyze it is similar to fast storing.

2.5.1.3 Fast storing on trigger

This chapter intends to inform you about how to record data on trigger ("**fast on trigger**"). Before reading this chapter you should refer to "fast storing".



Our example shows the settings in case of leaving the range of voltage.

Assumption:

nominal voltage 230 V

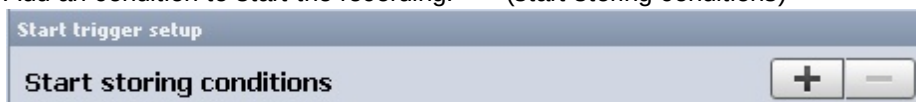
Case 1: If the voltage is less then 200V or greater then 250V the recording should start for 5 seconds.

Case 2: Like Case 1; but the recording should stop if the voltage is in the range of 200-250V.

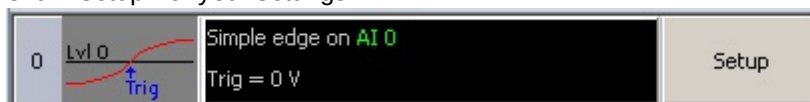
Case 3: Like Case 2; if the current is below 0,1 A the recording should never start.

2.5.1.3.1 Case 1

Add an condition to start the recording: "+" (start storing conditions)



Click "setup" for your settings.



Following settings must be made:

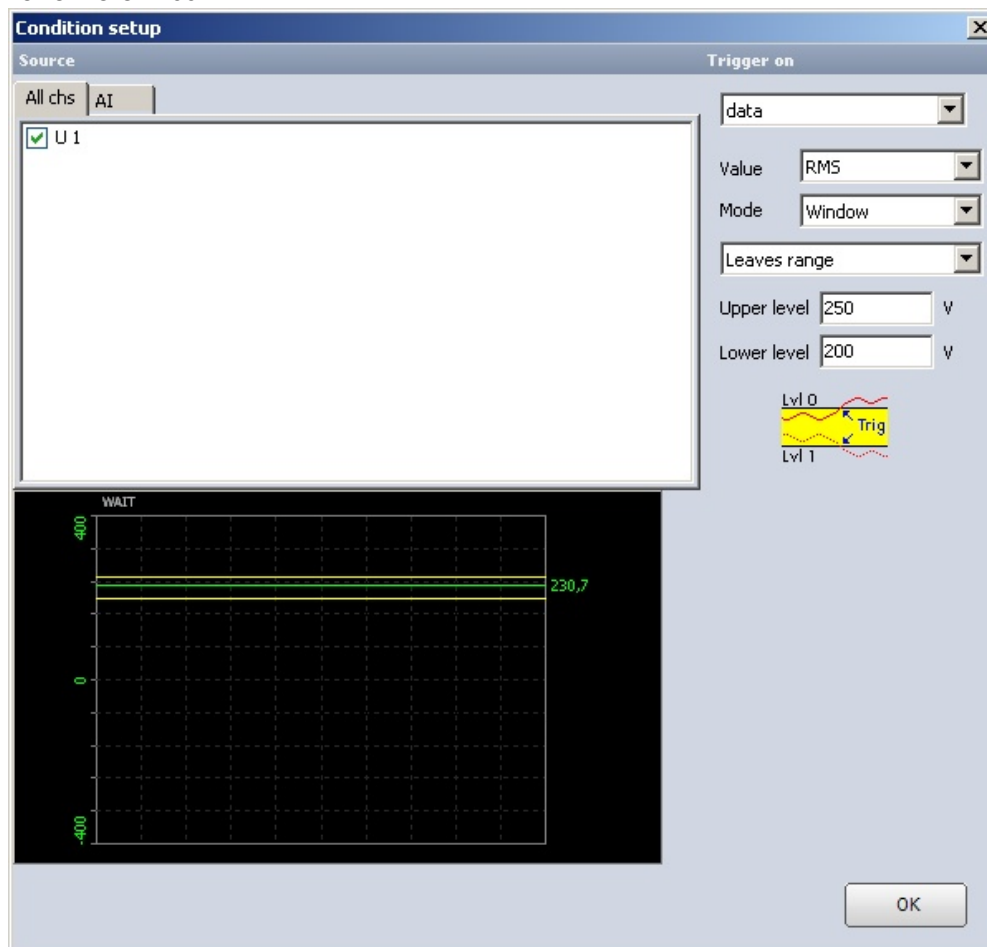
The channel witch starts the recording: U1 (press Ctrl to select multiple)

Value: RMS

Mode: Window

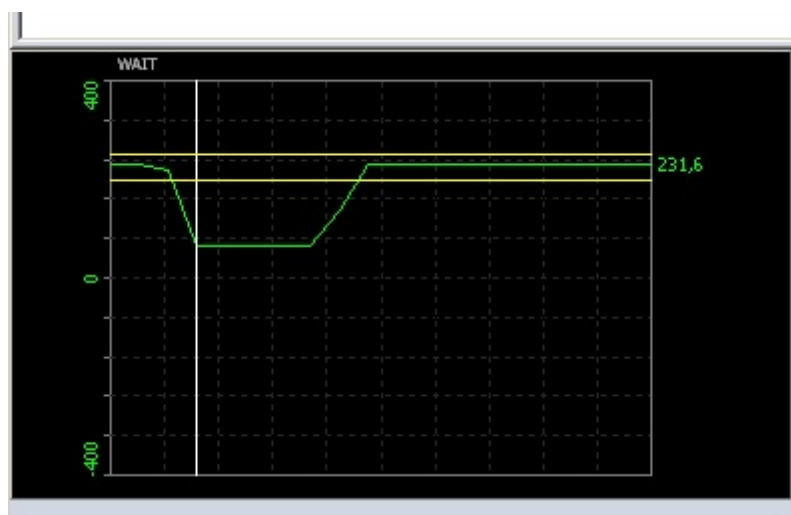
Leve Range

Upper Level: 250V
Lower Level: 200V



In the bottom of Window you will see the trigger level (yellow) and the current measured value (green).

Now you can test your settings by producing a trigger. You should see a white bar: the settings work.



Furthermore the pre and the post time can be set:

The recording starts 1 second before the trigger event and stops 4 seconds after the event.



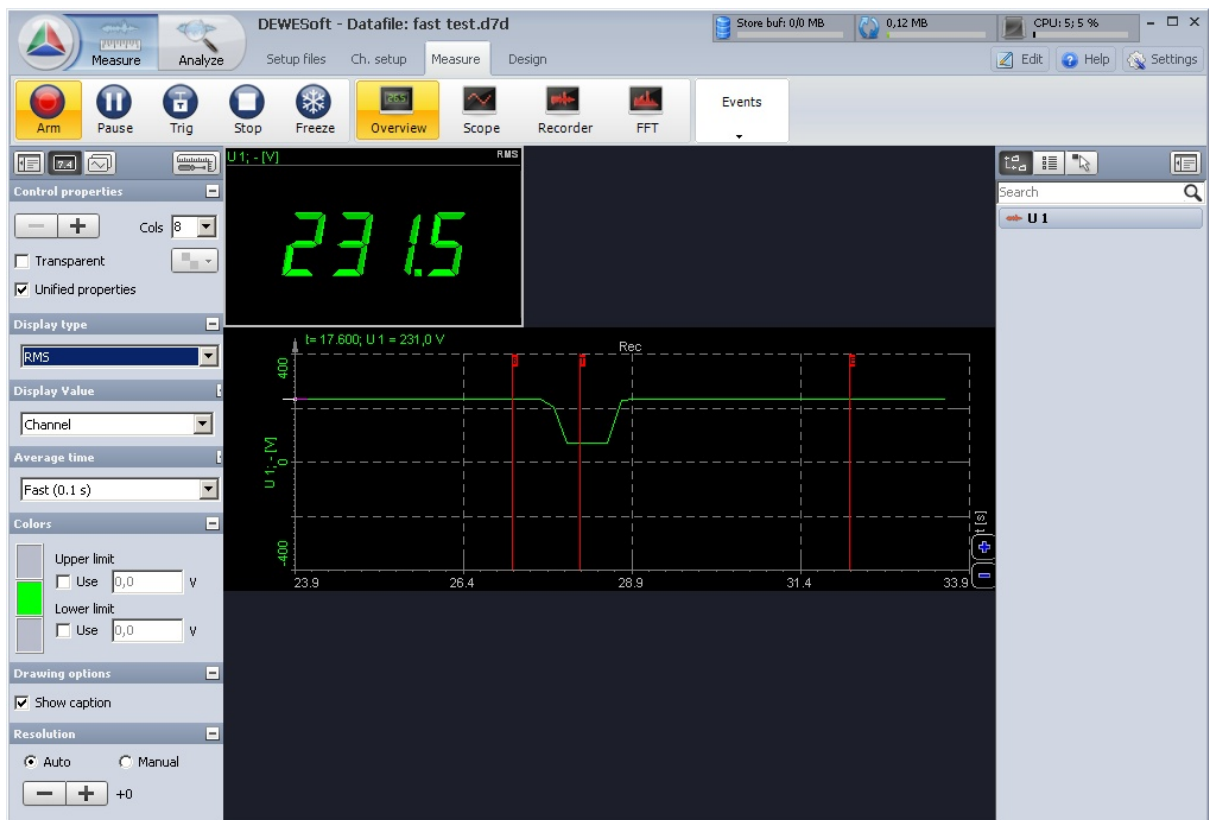
Now the setup is complete.

Change to the measurement mode.

Note that the Store button changed the name to Arm and there is an additional Trig button. Click "Arm"



In case of a trigger the recording will start automatically and you will see the red bars.

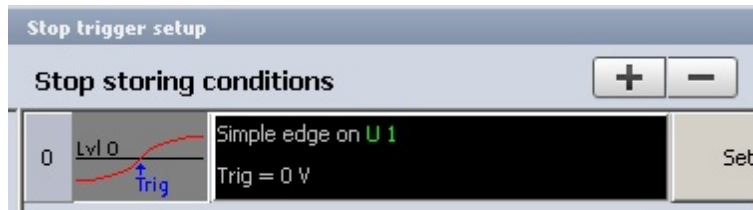


You can edit your data in the "Analyze" mode.

2.5.1.3.2 Case 2

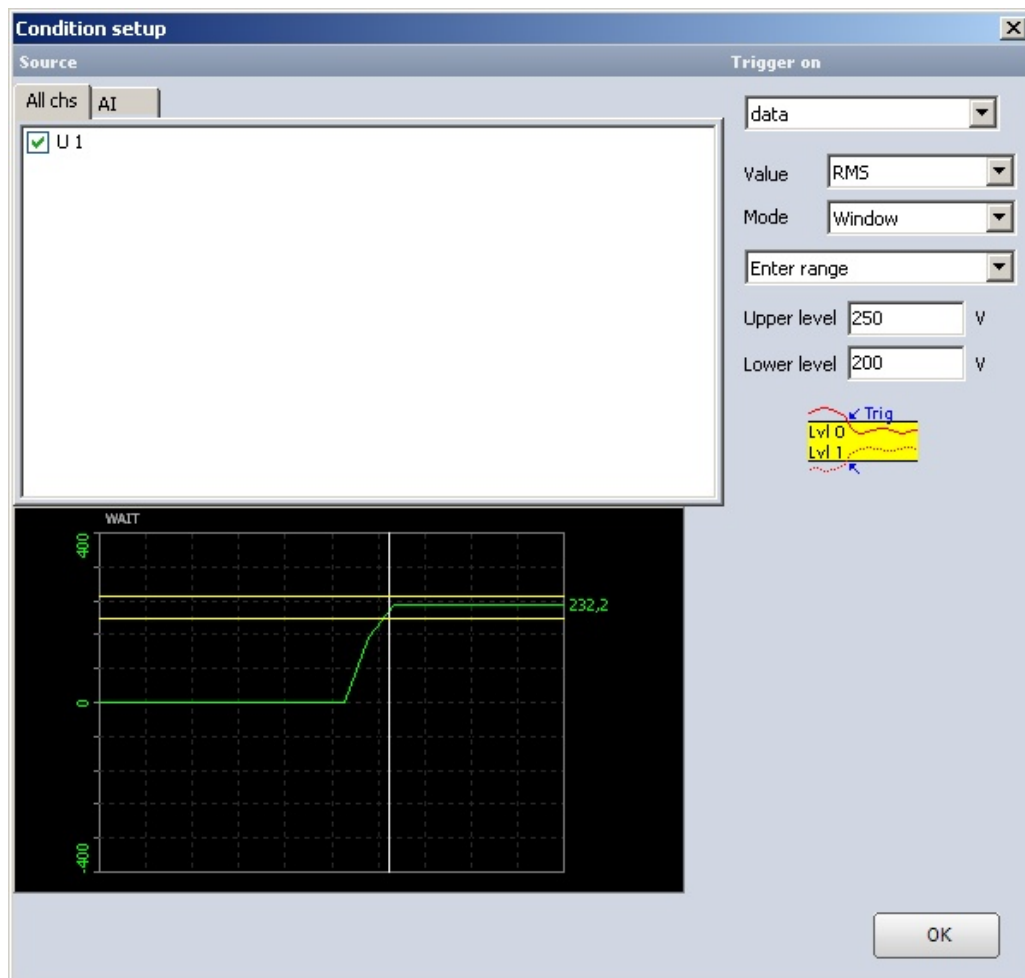
Required: You have worked through Case 1

Now add an stop condition: "+ Stop storing condition"



The settings are similar to start conditions.

Difference: now the achievement of a trigger level is important:
"Enter Range"



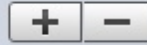
Test your settings.

2.5.1.3.3 Case 3

Additionally to Case 1 or Case 2 a further "Don't store" condition can be defined.

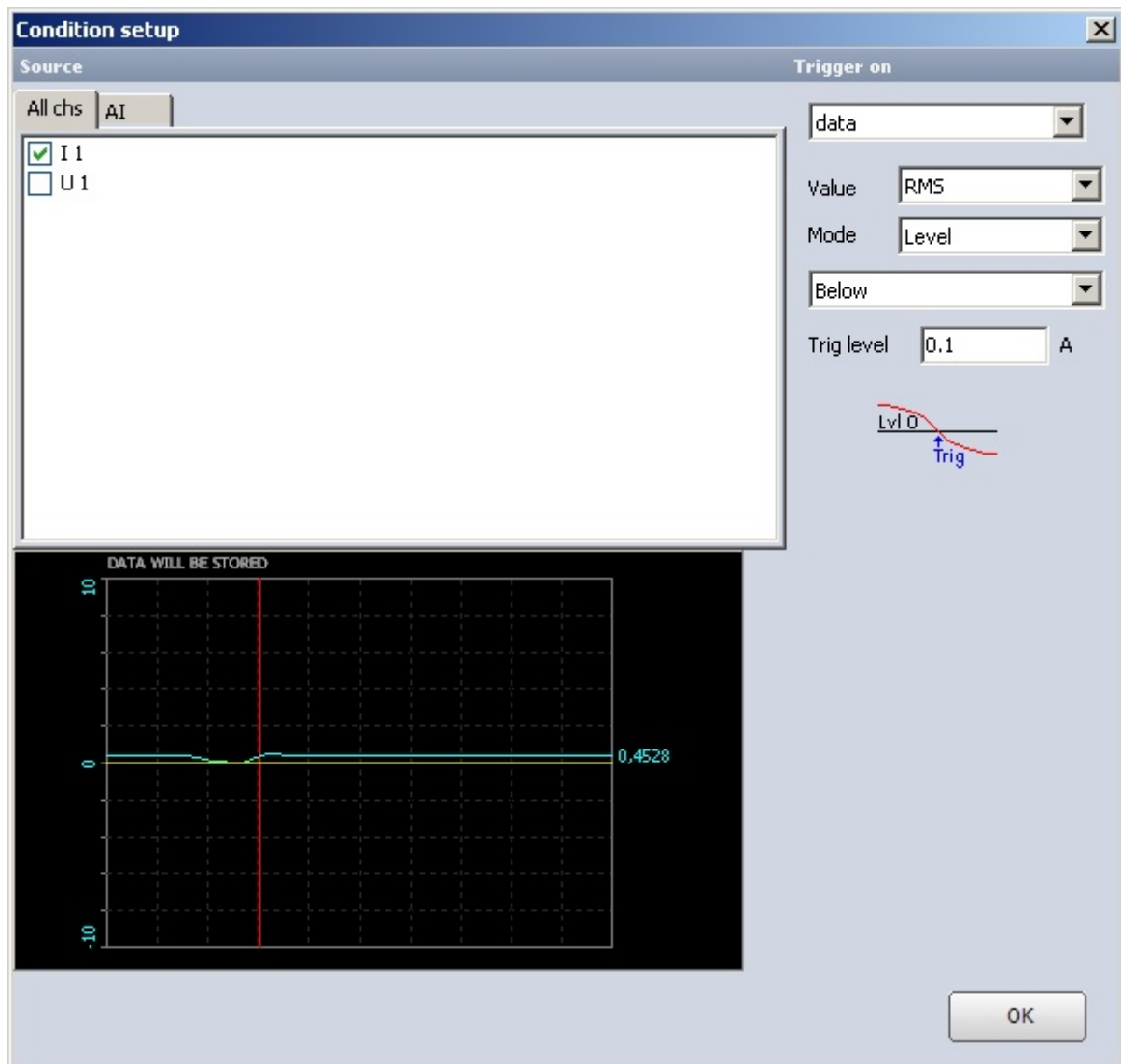
+ "don't store conditions"

"Don't store" conditions



If the current is less than 0,1A the recording should not start.

The settings are similar. Here we set a level for the current I1.

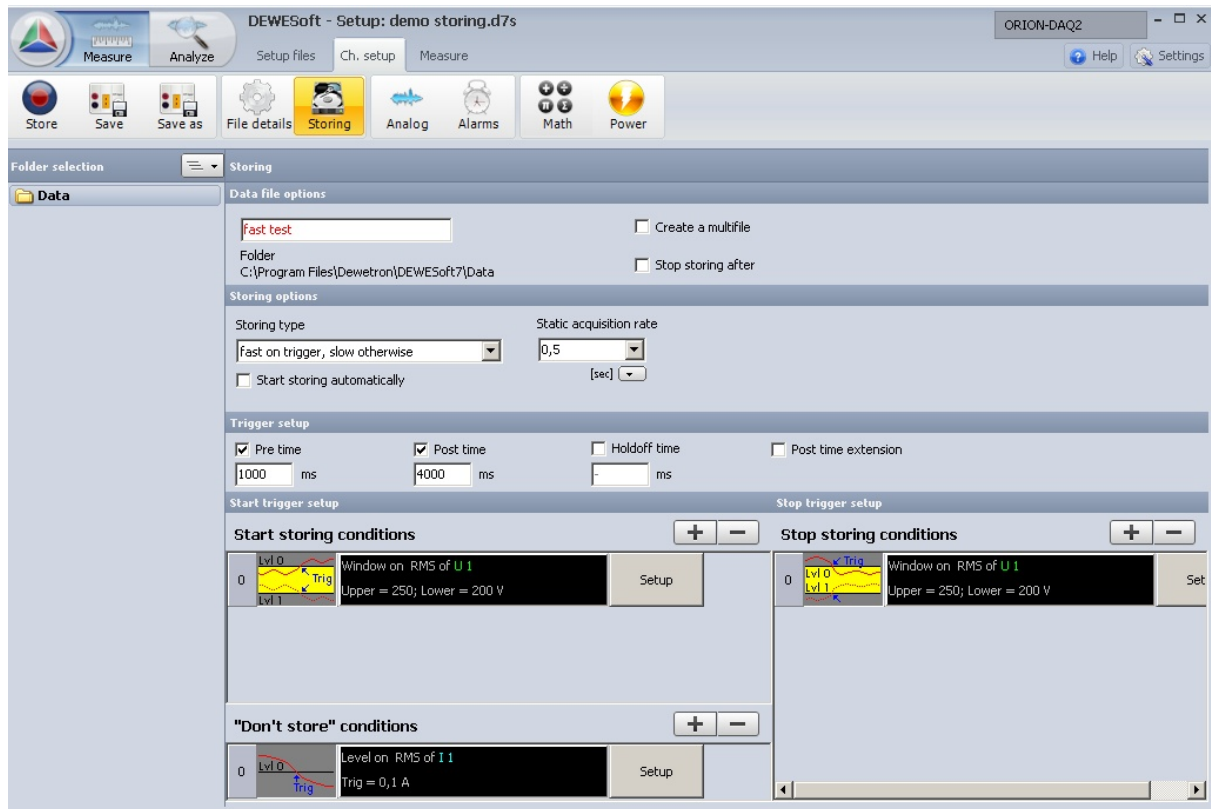


Storing is similar to Case 1.

2.5.1.4 Fast storing on trigger, slow otherwise

The storing is similar to "fast storing on trigger". In addition the data stored "slow" normally.

The operation is similar to the examples above.



2.5.2 Storing of data in database (PMT)

In this chapter you will learn how to save DEWESoft data in a PMT database.

Required:

Knowledge of Power functions in DEWESoft.
Installing PMT4 and database plugin.

Following steps are treated:

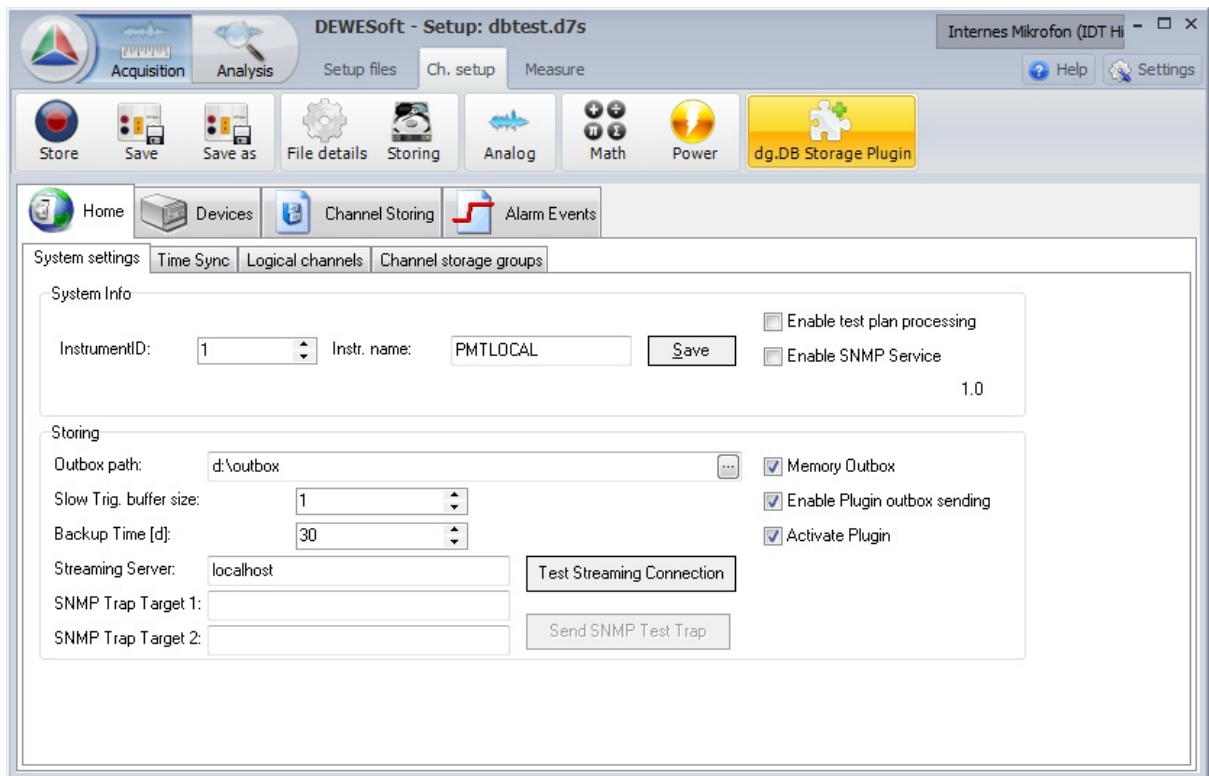
Save a value with a certain interval in database.
Save a power module
Save on trigger (fault records)

2.5.2.1 Store a value in database

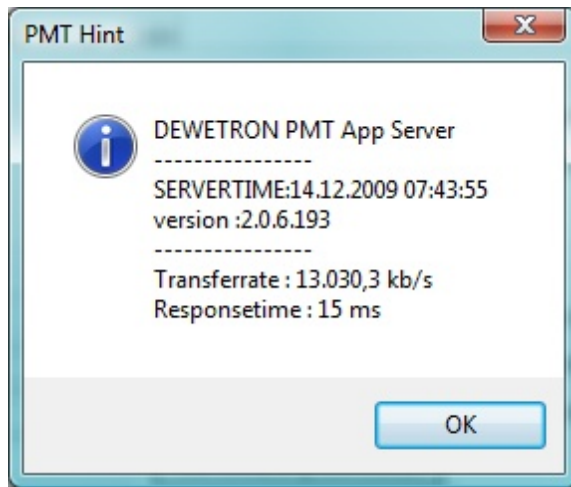
In this example a voltage U_{L1} should be measured and be stored in database every minute.

First of all connect the voltage and denote the channel "U_L1".

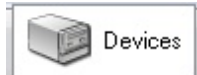
Now open the "Storage Plugin" in DEWESoft:



With the "Test Streaming Connection" you can check the connection to database - otherwise install the database.



Next, define the device (module). With this device you will find your value later in PMT.

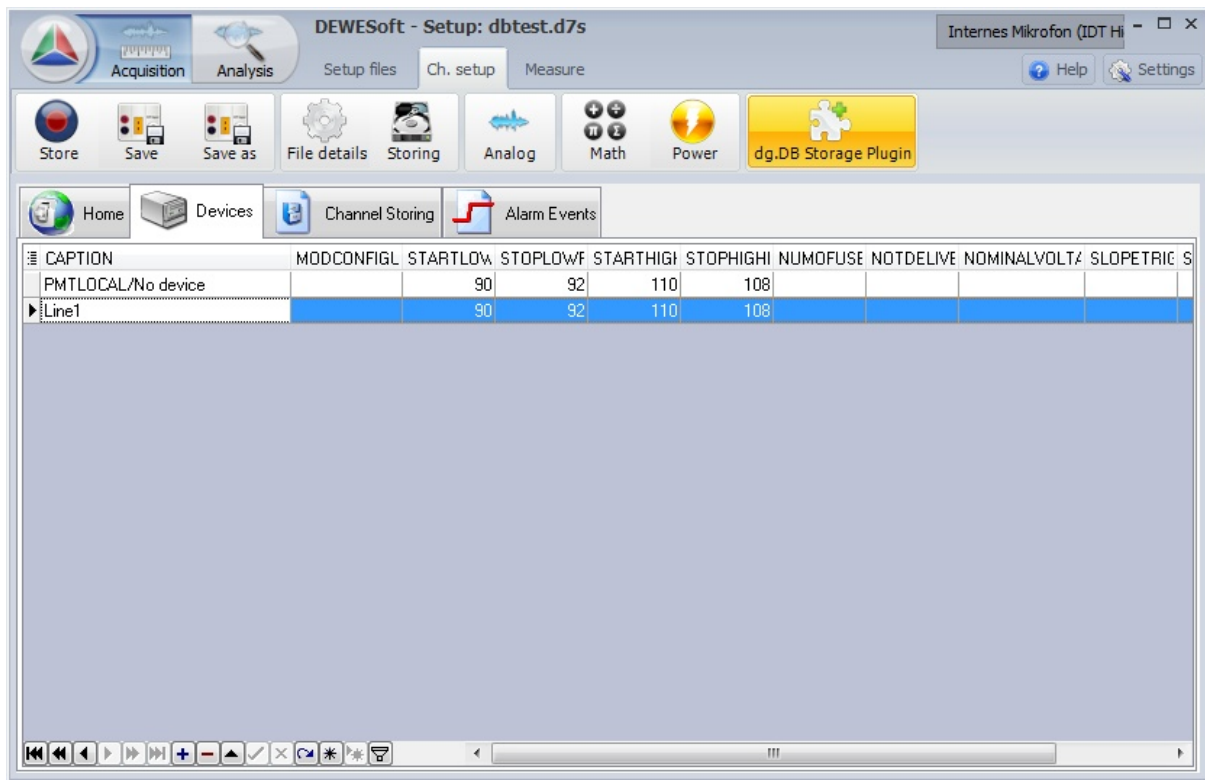


In PMT the data are distinguished not only after measuring channel, but also after modules (virtual device).

Several virtual devices can be thereby defined in the measuring instrument or also several measuring instruments in a database be united. You only see modules (virtual devices) - it makes no difference whether all these modules on one measuring instrument or on several.

Example: In a transformer station 2 lines are measured, in another one. So you will see 3 lines you can analyze.

First of all click  at the bottom of the window, after that you can denote the new module (Line1 in the picture), finally verify your settings .



The next step is to assign the channel:



Module index: select your virtual device (module): Line1

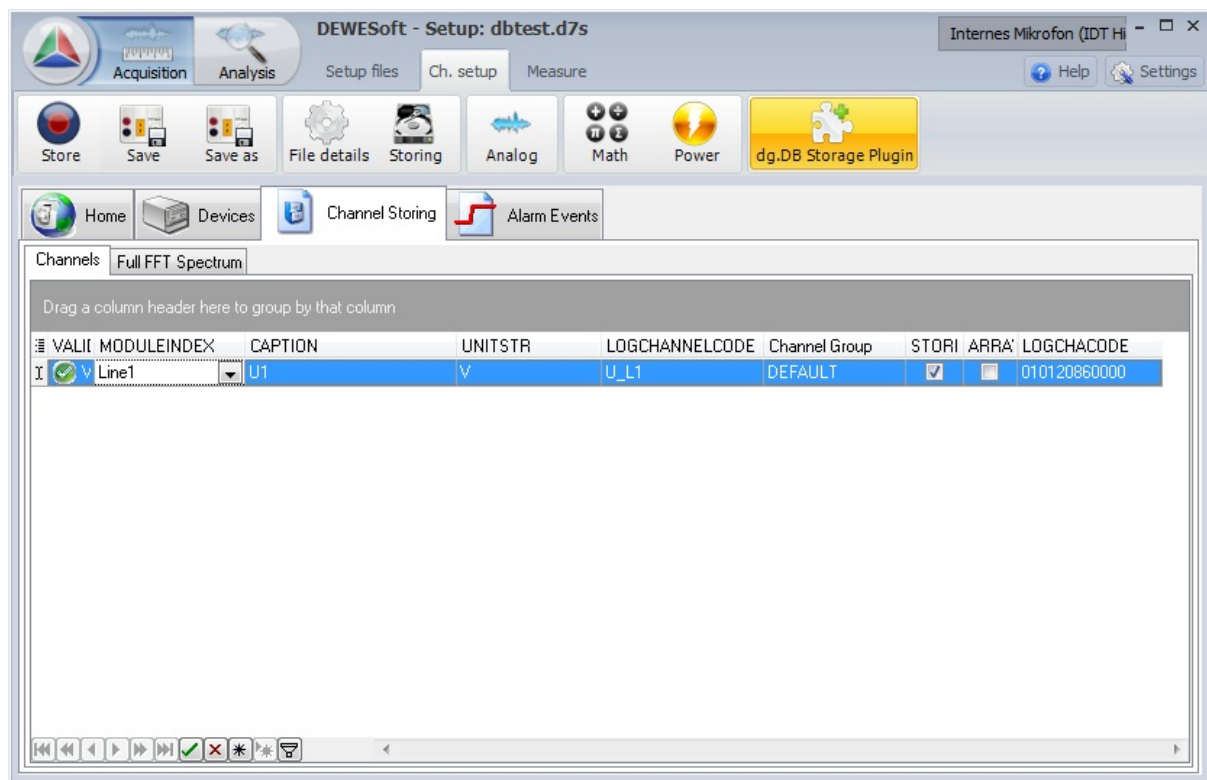
"CAPTION" and "UNITSTR" should be available (voltage channel).

LOGCHANNELCODE: select here the name of the channel which the measuring value should have in database later (LOGCHACODE indicates the internal CODE of the value).

Channel Group: choose the allocation to the memory group - here the the recording interval is set.

STORING must be set to store the channel.

VALID (first column) becomes green if all your settings are OK.



As soon as you change to the measure mode the data will be recorded and you can take a look to the value in PMT.

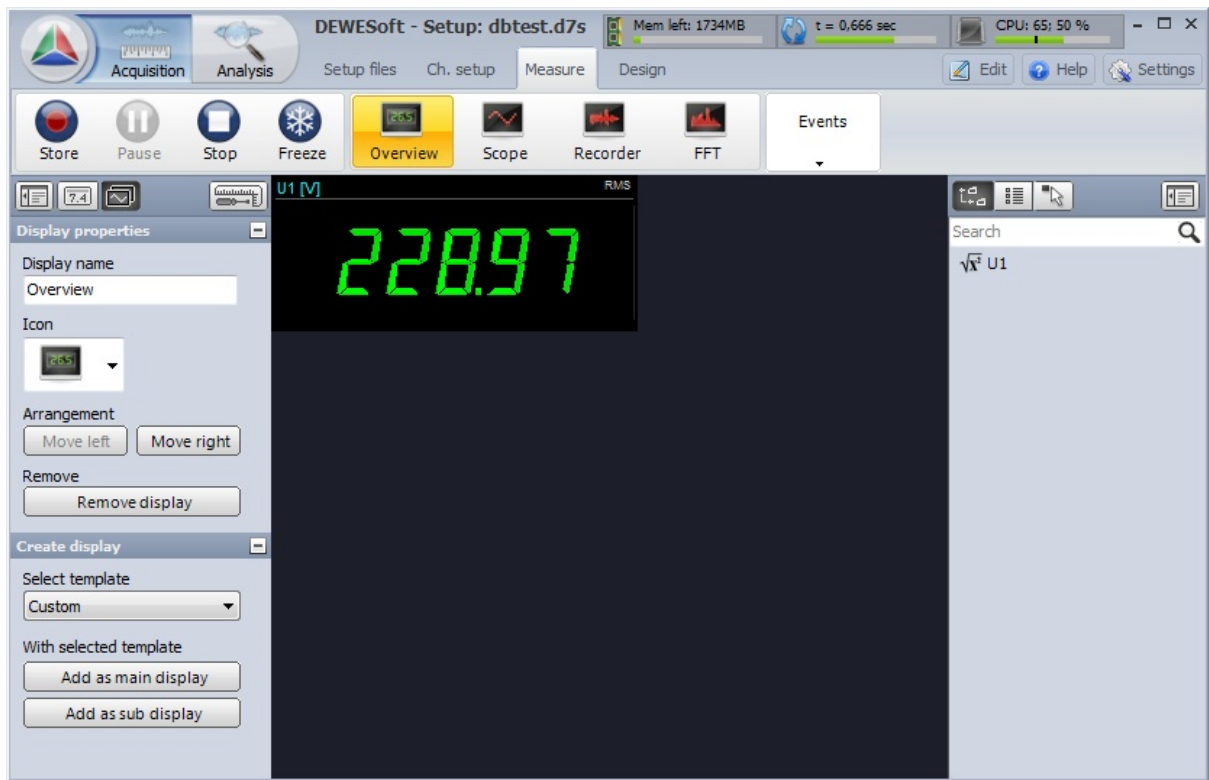
Saved values:

RMS

AVG (average)

MAX (biggest measuring value in the storing interval)

MIN (smallest measuring value in the storing interval)



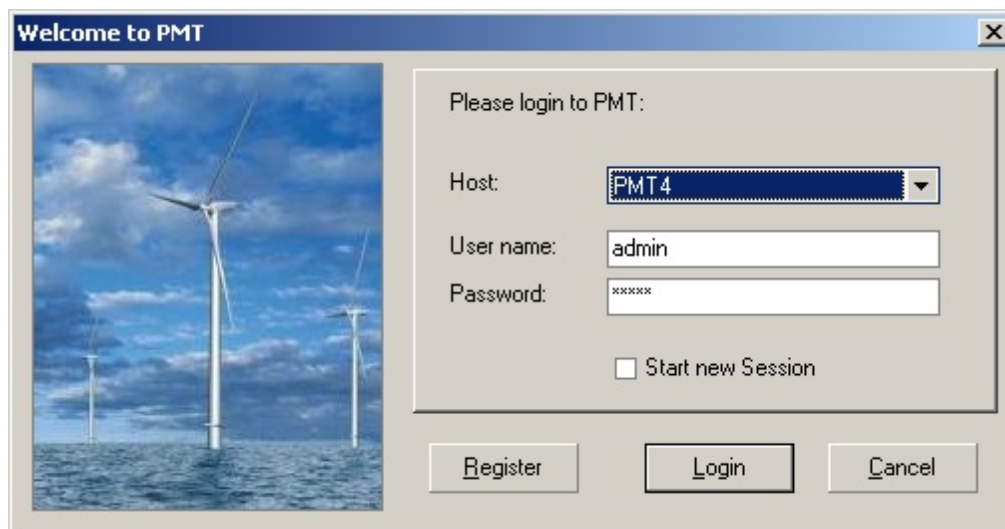
TIP: You **DON'T NEED** the DEWESoft storing functions. Saving in database starts as soon as you change to measure mode.



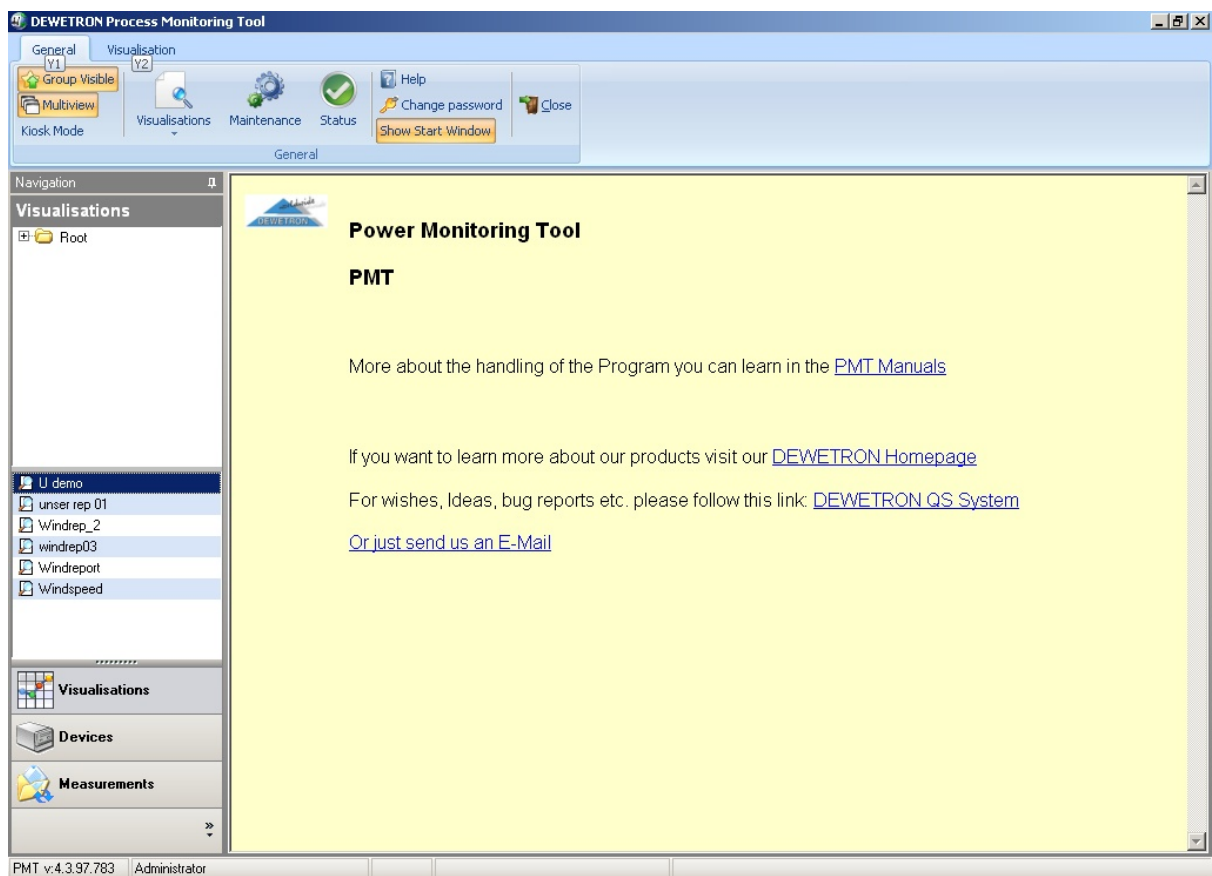
It's up to you, to use the storage in files but it's independent of the storage in the database.

View a value with PMT:

Start the PMT and sign in:



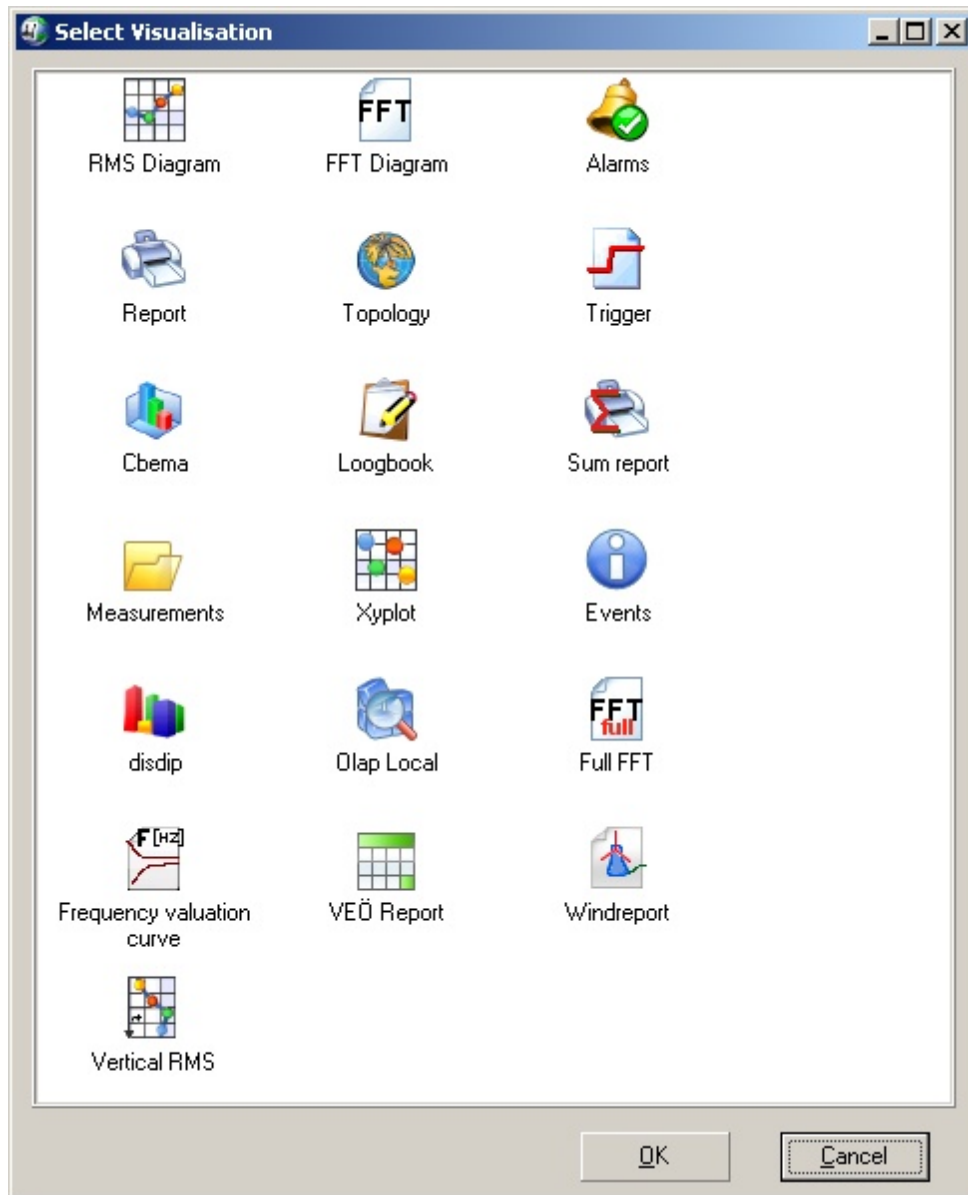
Next Click "Visualisations" and "add visualisations"



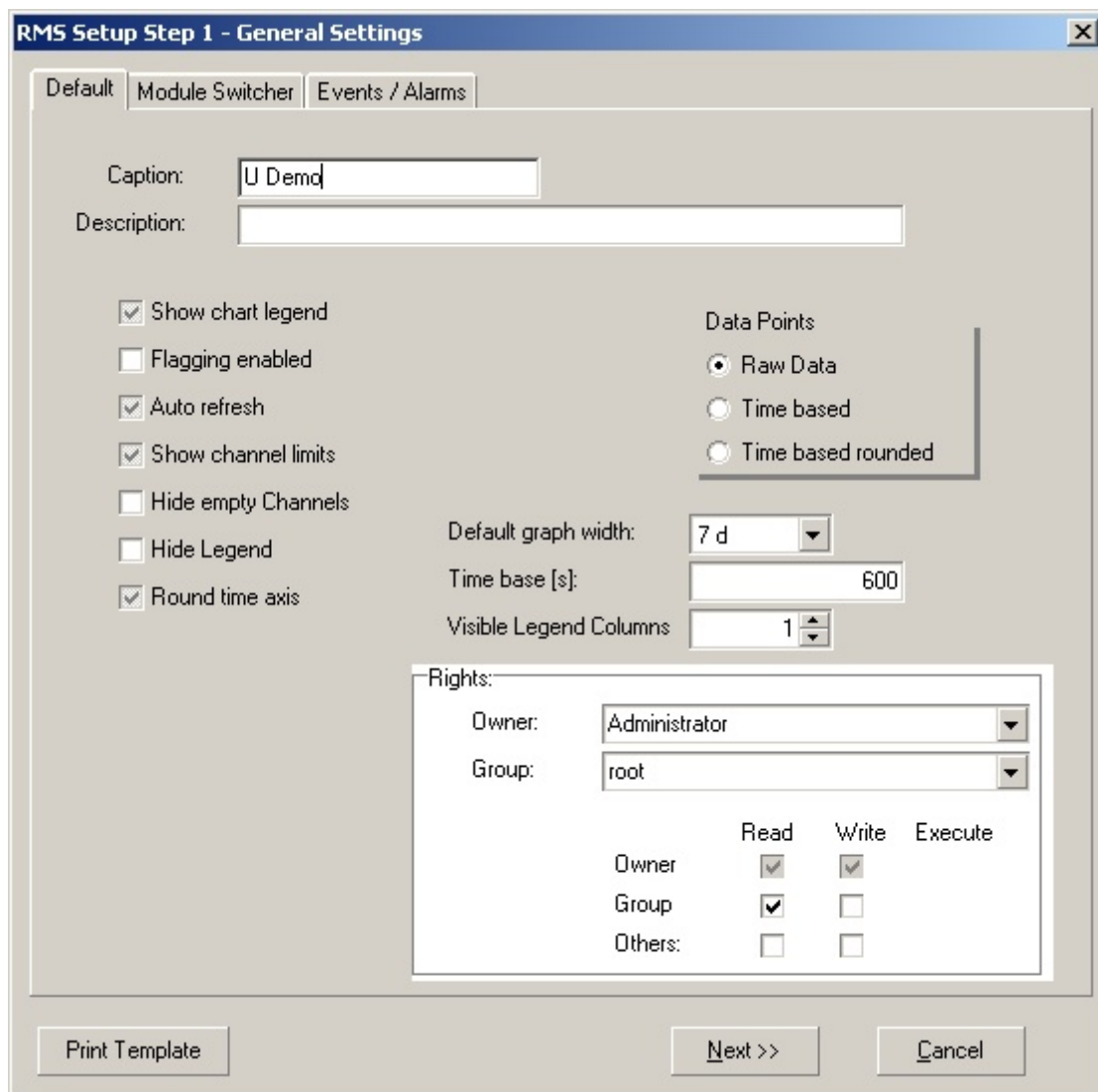
Next choose "RMS Diagram":



RMS Diagram



Enter a name for the report - "U Demo" and click "NEXT".



The dialog box is titled "RMS Setup Step 1 - General Settings" and has three tabs: "Default", "Module Switcher", and "Events / Alarms". The "Default" tab is selected.

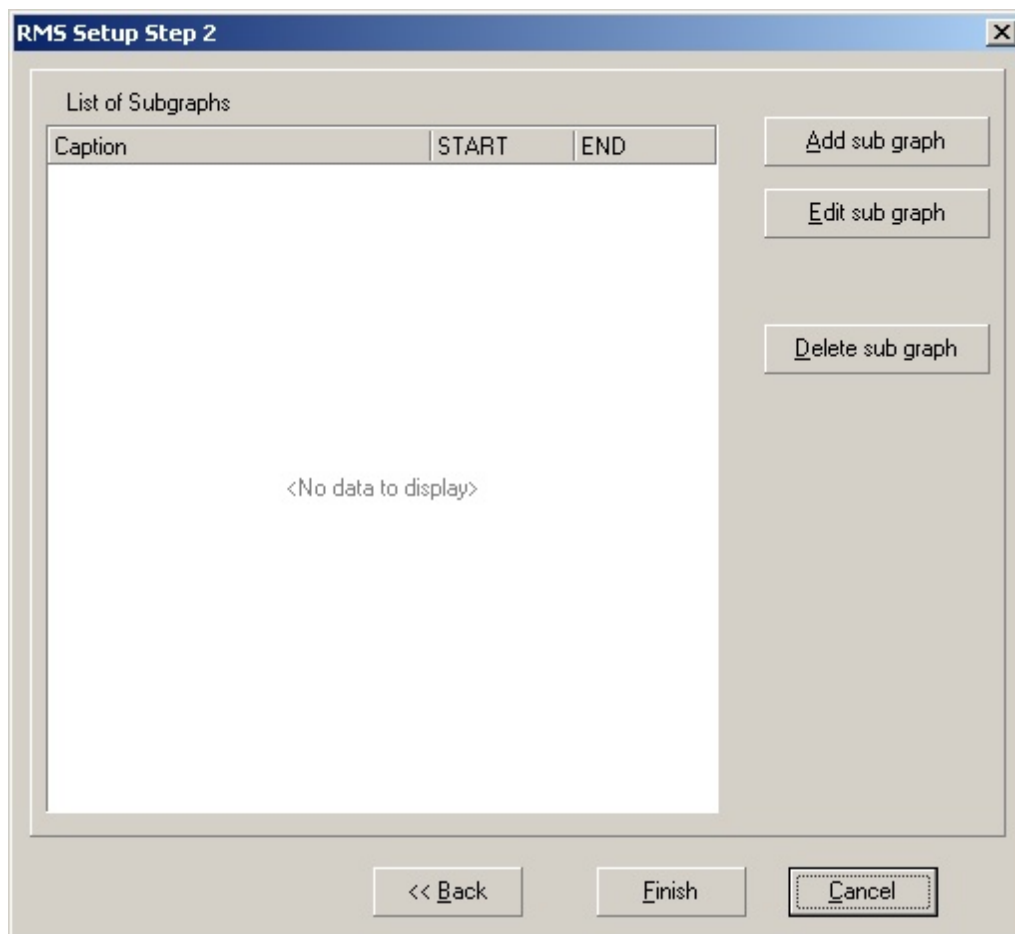
Fields and options include:

- Caption:
- Description:
- Checkboxes:
 - ☒ Show chart legend
 - ☐ Flagging enabled
 - ☒ Auto refresh
 - ☒ Show channel limits
 - ☐ Hide empty Channels
 - ☐ Hide Legend
 - ☒ Round time axis
- Data Points:
 - ☒ Raw Data
 - ☐ Time based
 - ☐ Time based rounded
- Default graph width:
- Time base [s]:
- Visible Legend Columns:
- Rights:

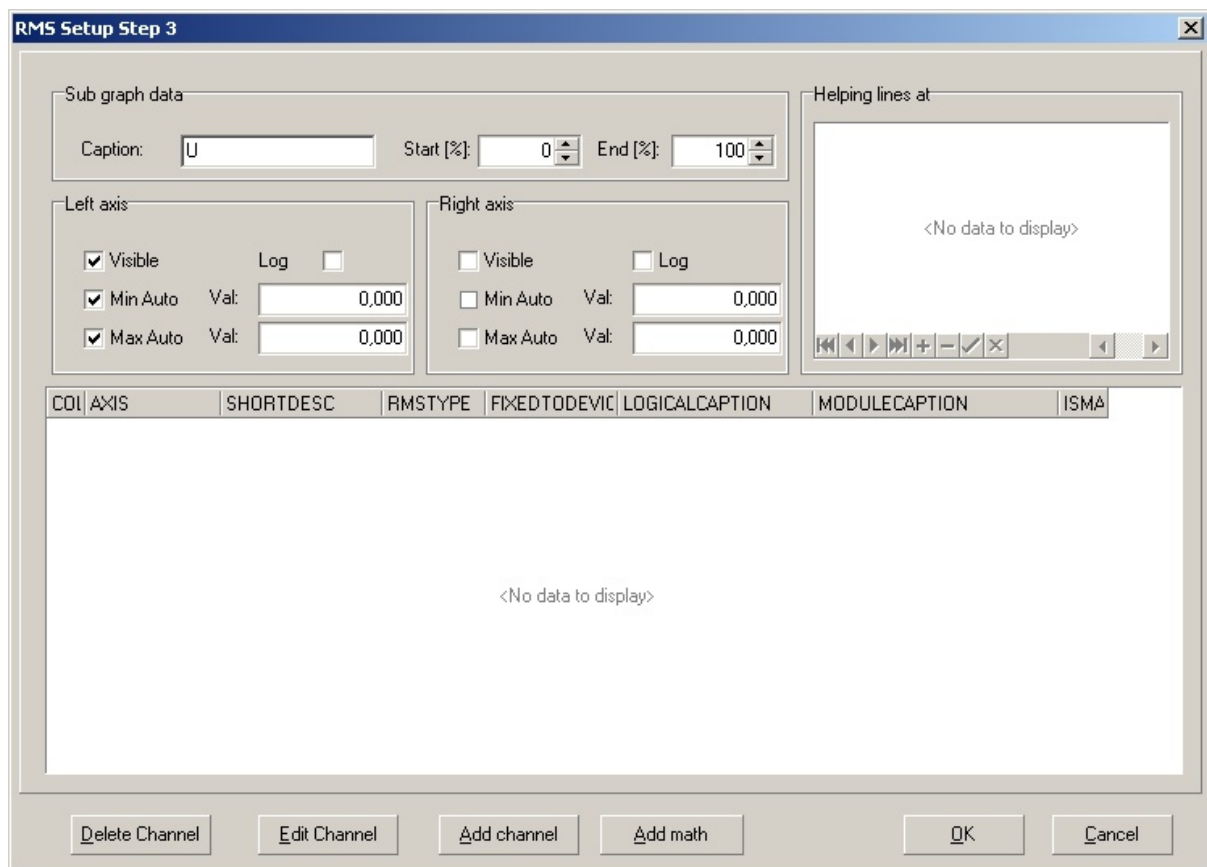
Owner:	Administrator		
Group:	root		
	Read	Write	Execute
Owner	☒	☒	
Group	☒	☐	
Others:	☐	☐	

Buttons at the bottom: "Print Template", "Next >>", and "Cancel".

Now you can define the diagram - in addition you must click on "Add sub graph".



Now you can define the sub graph (Add sub graph).



Next add a channel (Add channel).
Confirm the following request with "yes".

Choose the channel U_L1 in the channel list:

Add Channel to Subgraph

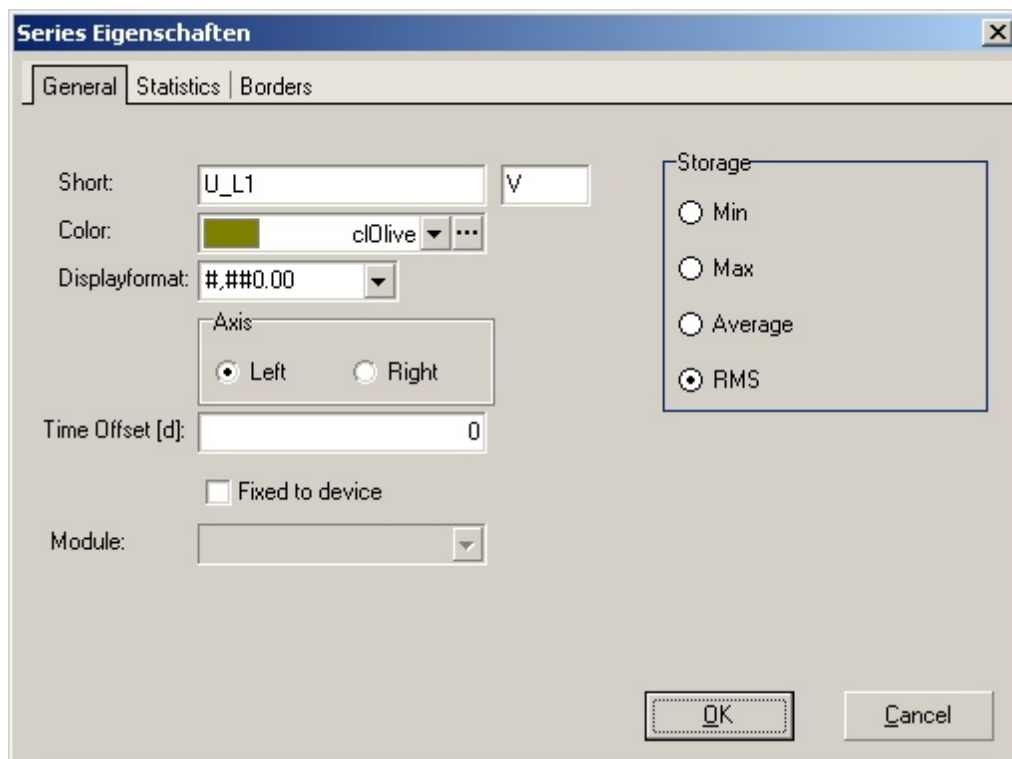
Drag a column header here to group by that column

DEFAL	LOGCHACODE	LOGICALCAPTION	UNITSTR	DESCRIPTION
	0101B1800000	THDEven_U_L23	%	
	0101AB800000	THDEven_U_L3	%	
	0101B4800000	THDEven_U_L31	%	
	0101B8800000	THDOdd_I_L1	%	
	0101B8800000	THDOdd_I_L2	%	
	0101BE800000	THDOdd_I_L3	%	
	0101A6800000	THDOdd_U_L1	%	
	0101AF800000	THDOdd_U_L12	%	
	0101A9800000	THDOdd_U_L2	%	
	0101B2800000	THDOdd_U_L23	%	
	0101AC800000	THDOdd_U_L3	%	
	0101B5800000	THDOdd_U_L31	%	
	01019E800000	U_0	V	
	01019F800000	U_1	V	
	010189860000	U_12	V	
	0101A0800000	U_2	V	
	01018A860000	U_23	V	
	01018B860000	U_31	V	
	0101CD860000	U_EN	V	
	010120860000	U_L1	V	
	010189820000	U_L12per	V	
	010120820000	U_L1per	V	
	010134860000	U_L2	V	
	01018A820000	U_L23per	V	
	010134820000	U_L2per	V	
	010148860000	U_L3	V	
	01018B820000	U_L31per	V	
	010148820000	U_L3per	V	
	010100000000	U_L12per	V	

Reset View ☐ Show Harmonics OK Cancel

In case of AC you have to choose RMS (In future Setups usually calculated values used in the power module - then the setting must remain on Average).

Verify with "OK".



Now the channel should appear in the sub graph.

RMS Setup Step 3

Sub graph data

Caption: Start [%]: End [%]:

Left axis

☒ Visible Log ☐

☒ Min Auto Val:

☒ Max Auto Val:

Right axis

☐ Visible Log ☐

☐ Min Auto Val:

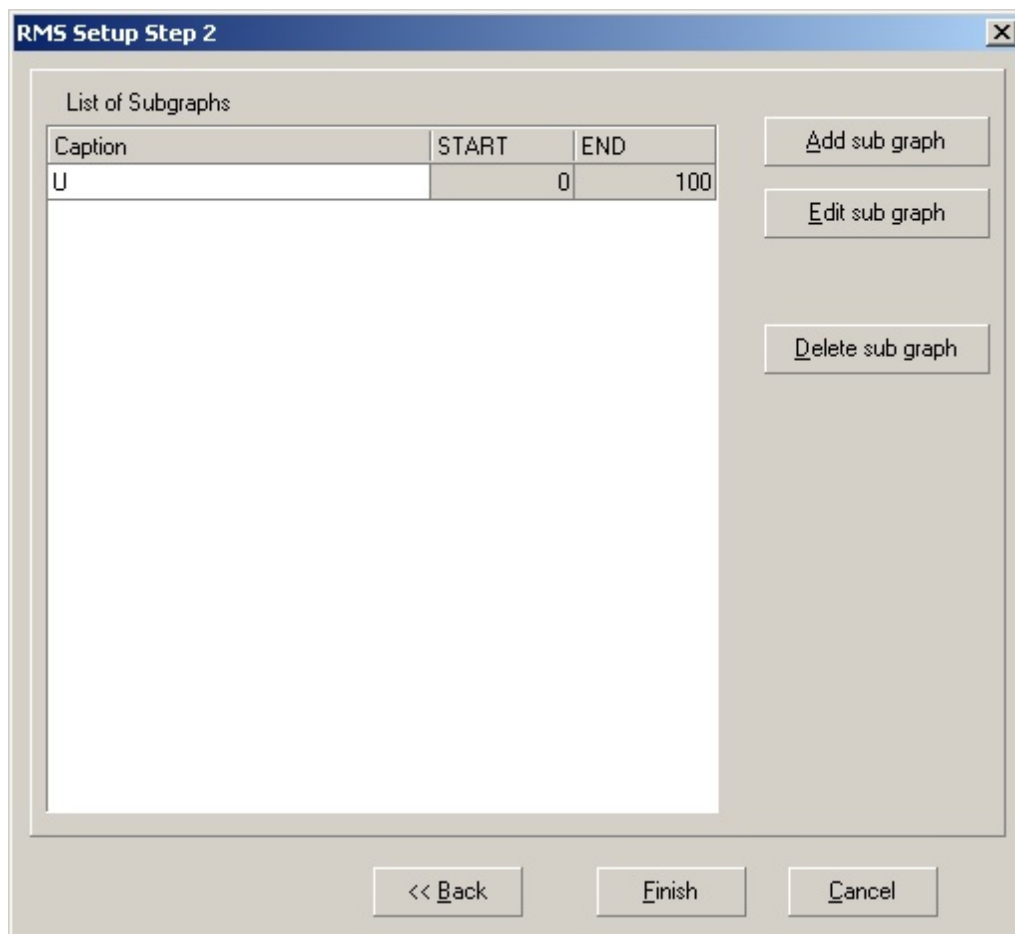
☐ Max Auto Val:

Helping lines at

<No data to display>

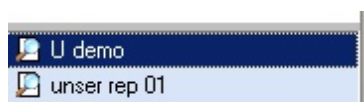
COL	AXIS	SHORTDESC	RMSTYPE	FIXEDTODEVIC	LOGICALCAPTION	MODULECAPTION	ISMA
	Left	U_L1	AVG	☐	U_L1		☐

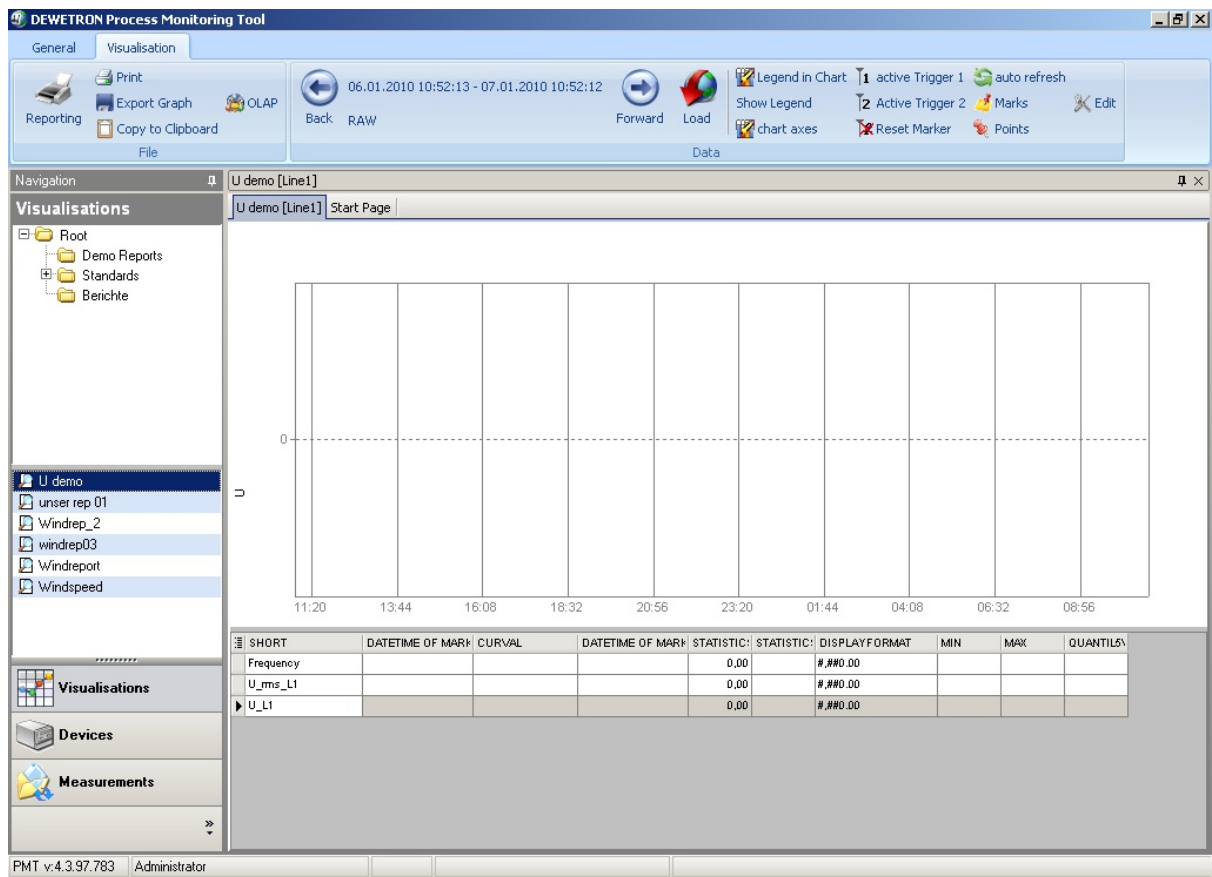
After confirmation with "OK" the sub graph should be displayed in the setup window.



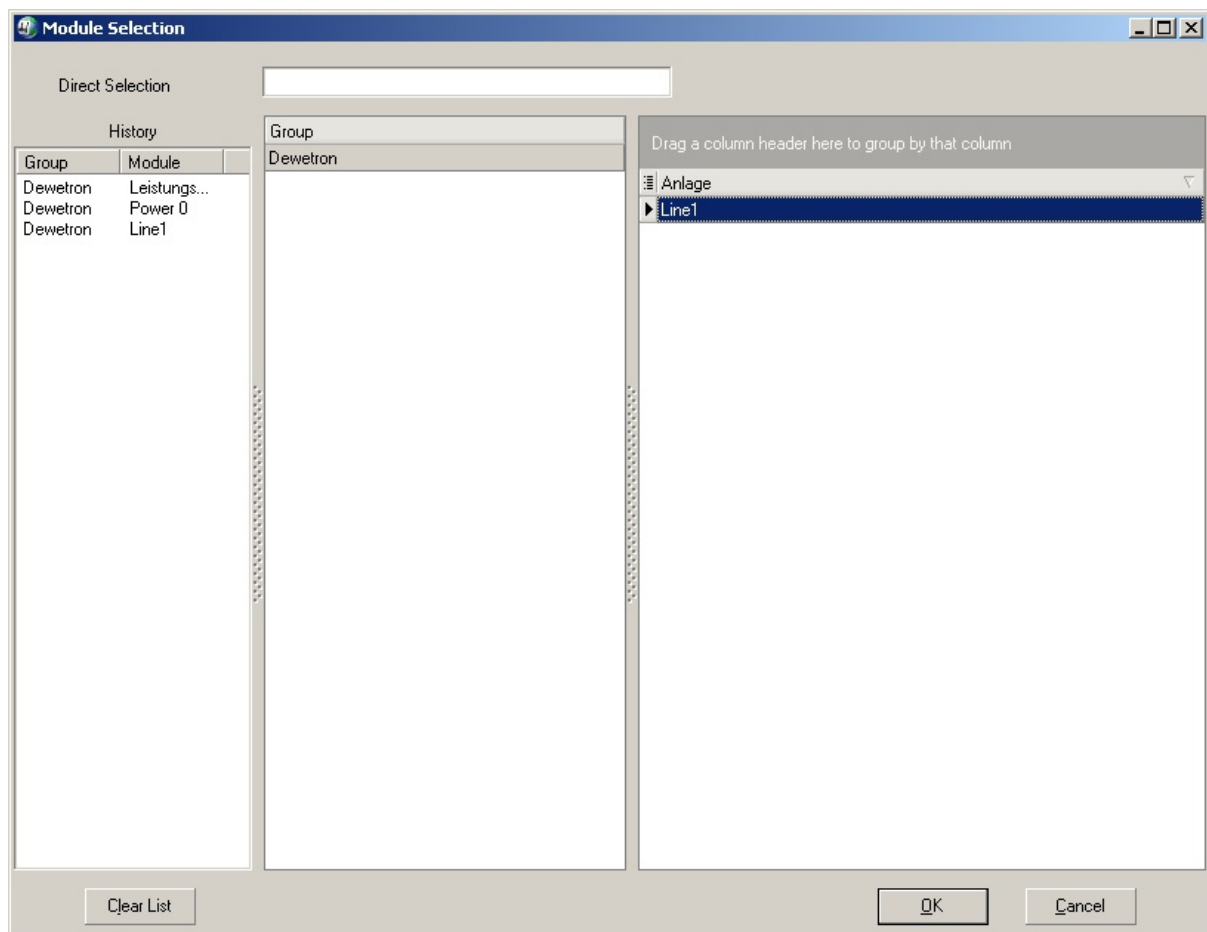
Click "Finish" to store your settings.

Now the report should be displayed on the bottom left in the "Visualisations Navigator" of PMT.

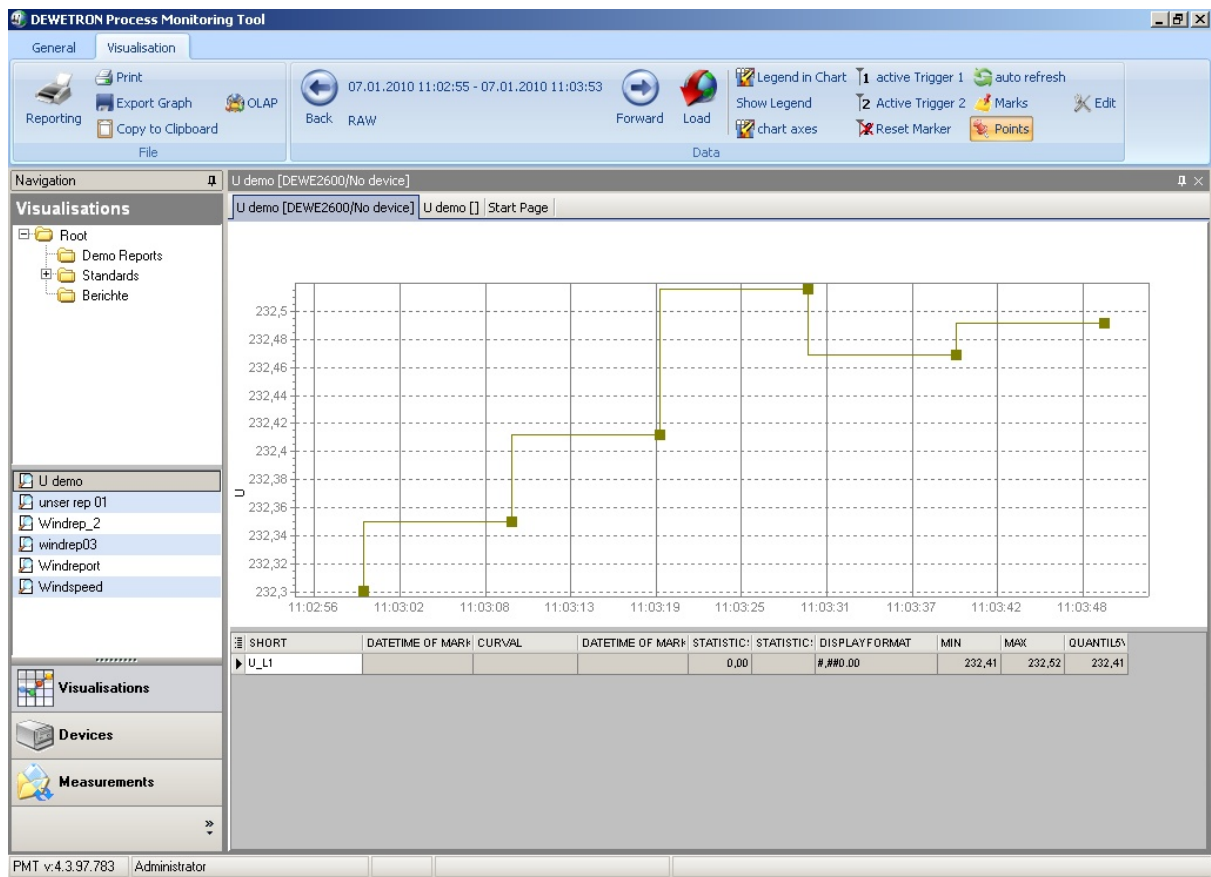




Double click to open and to chose the module.
Choose the module "Line1" and click "OK":



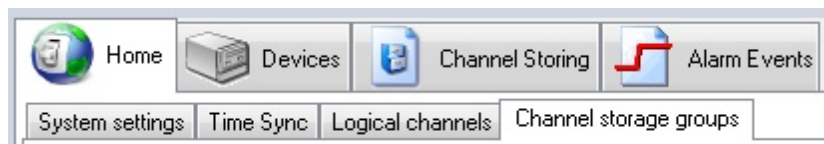
Now you see the diagram with the displayed values on the right.



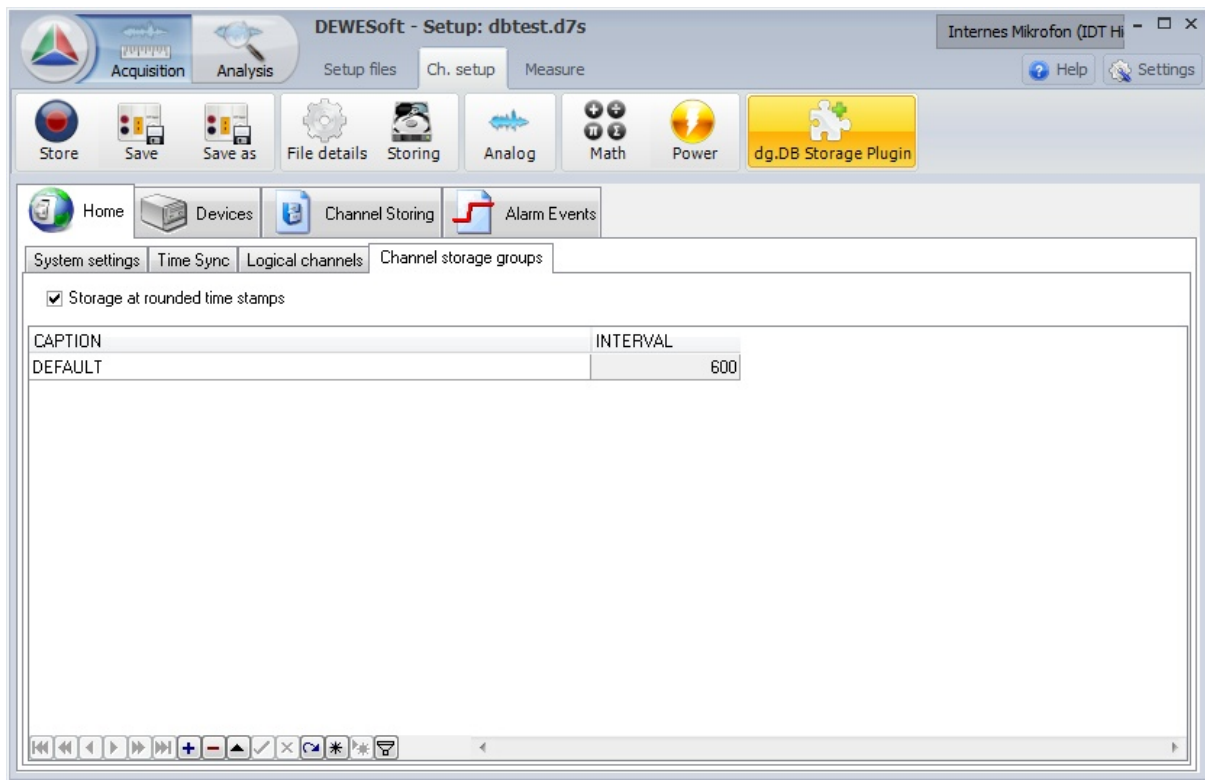
More information to create a diagram and reports you will get in PMT manual.

2.5.2.1.1 Channel Group

In the menu "Channel storage groups" you can set the recording interval.



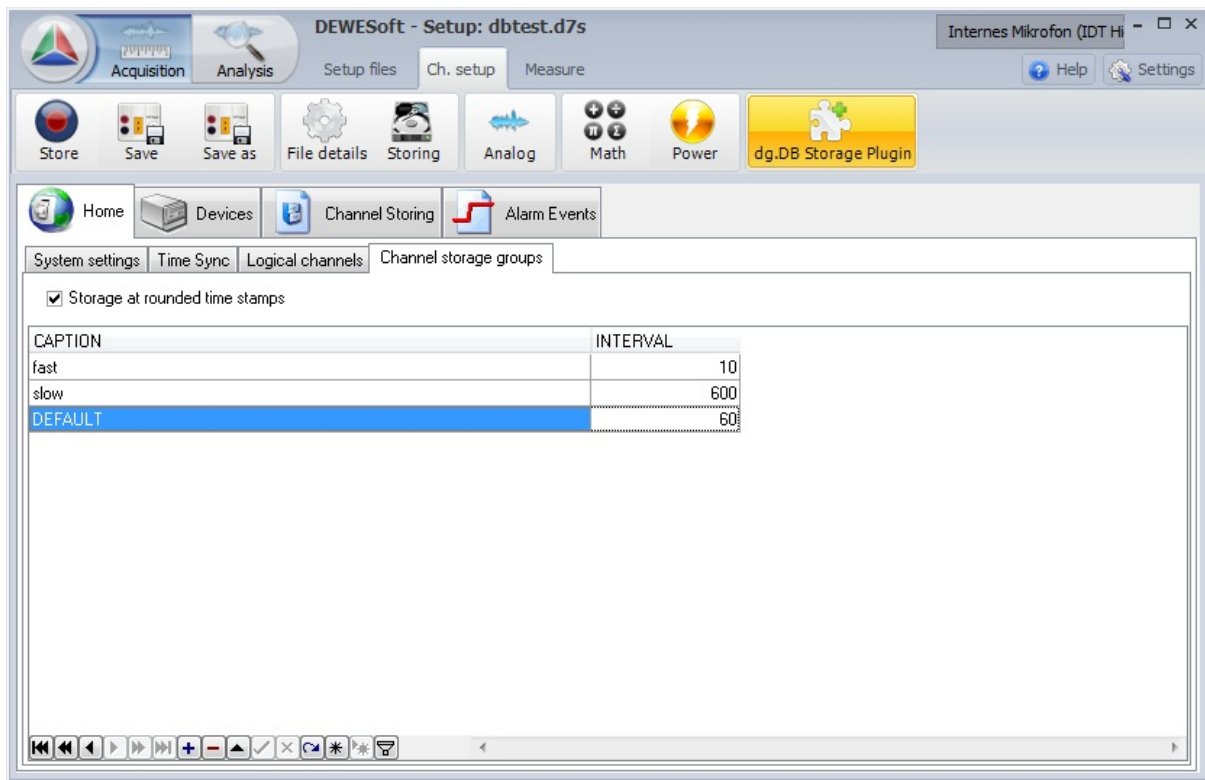
The following example shows a group DEFAULT with an recording interval of 10 minutes.



Of course you can change the interval: For example 60 seconds.

You can also add different groups .

Examples: Group "fast" 10 seconds and group "slow" 600 seconds.



Verify your settings with .

☒ Storage at rounded time stamps

With this option you can specify that the storage always takes place to multiples from 00:00+recording interval. Then a 10 minute value always recorded at 00:10, 00:20 and not between.

2.5.2.2 Store a power module in database - Quick Steps

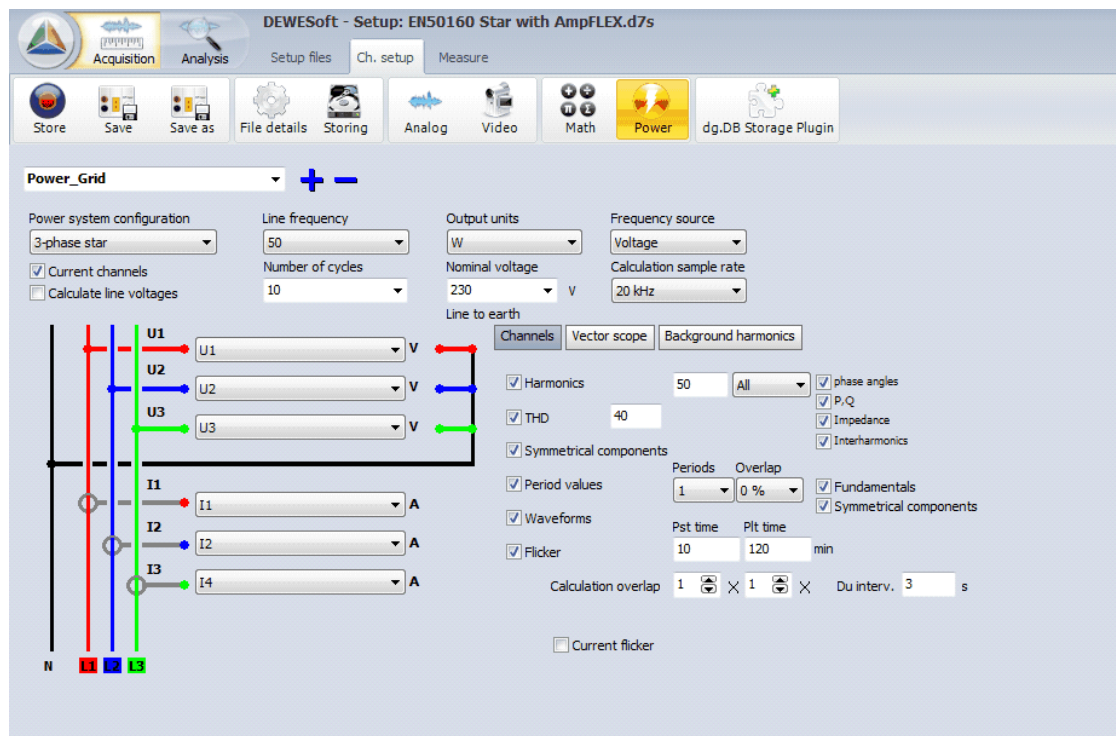
Before you go through this chapter you should have done the chapters below:

- Measuring Power

The configuration of the analog setup and the power module in Dewesoft is required before using the db-plugin (this steps are not described in this tutorial).

1) Power Module configuration - Example

Please consider that all calculations/parameters which should be stored in the database have to be selected in the power module. For example if you want to do reports according to the EN50160 a typical configuration of the power module looks like this:



Other and special configurations are described in the “Power Tutorial”.

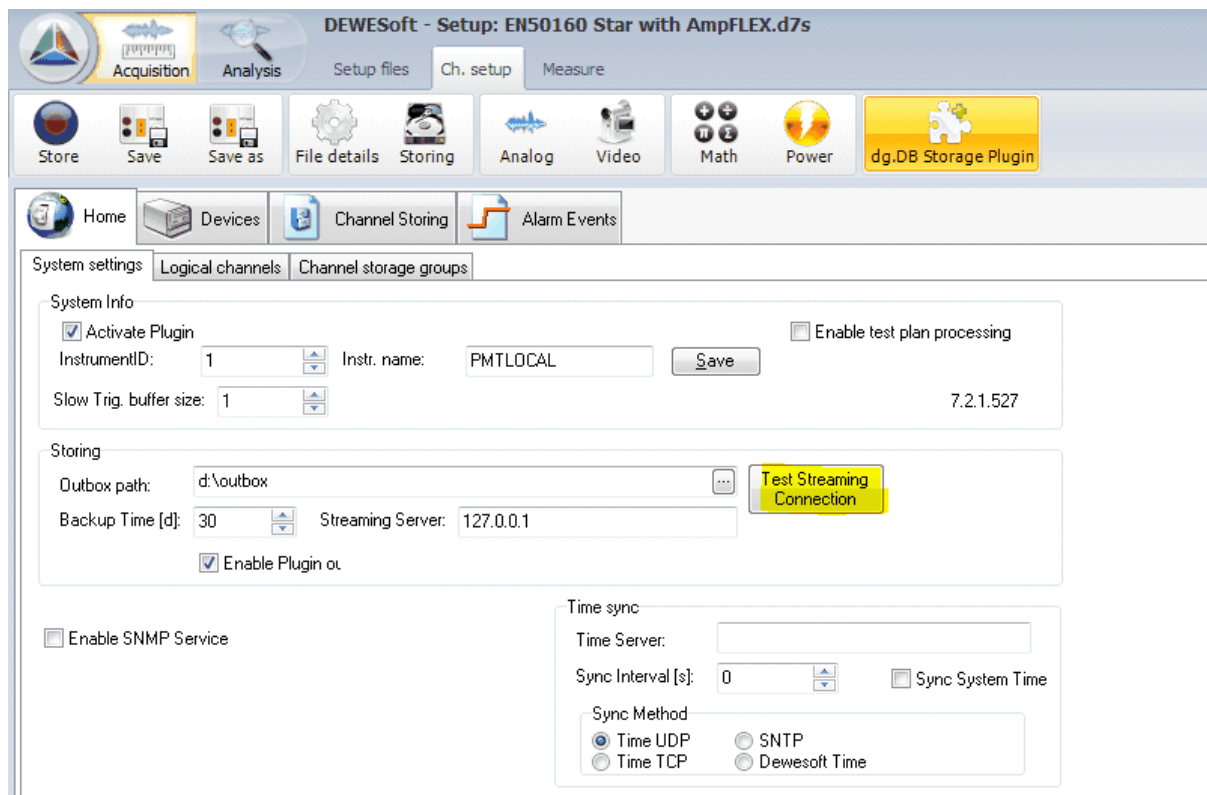
2) dg.DB Storage Plugin

As next step please switch to “dg.DB Storage Plugin”.

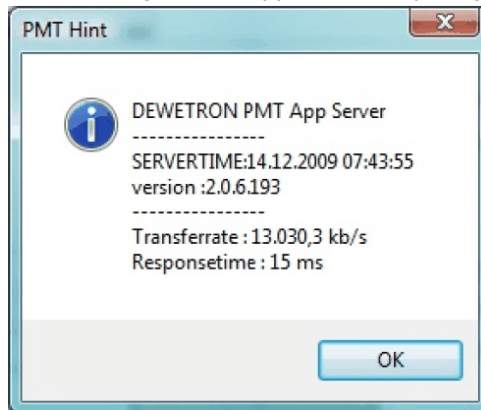
Most settings and selections which can be done in this plugin are just for the installation and configuration of the different software (database, AppServer, PMT etc.) which is necessary to store the data in the database and analyse it in PMT. So they have not to be changed.

Following are the most important settings described you need for basic analyses. The plugin is divided in four tabs (Home, Devices, Channel Storing and Alarm Events).

At tab “Home” and “System Settings” there is a button “Test Streaming Connection”. Her you can check if the connection to the database is OK.

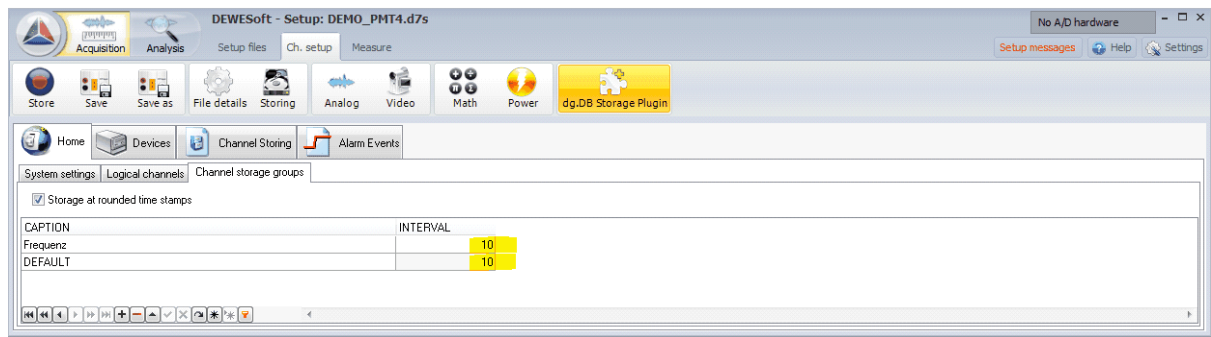


The following screen appears if everything is OK.



At tab "Channel storage group" you can define the storage interval for the channels. If you want to store channels at different time intervals you just have to add an additional storage group and allocate the channels at tab "Channel Storing".

Typical storage intervals are 10 minutes (600 seconds). The interval has to be typed in seconds.



If you change the settings they have to be confirmed with  at the bottom of the window.

Note: Storage intervals below 10 seconds are not supported!

At tab “Channel Storing” you can assign the different channels to the different storage interval. At column “Storing” you can select either the channels should be stored or not.

DEWESoft - Setup: DEMO_PMT4.d7s

Acquisition Analysis Setup files Ch. setup Measure

Store Save Save as File details Storing Analog Video Math Power dg.DB Storage Plugin

Home Devices Channel Storing Alarm Events

Channels Full FFT Spectrum

Drag a column header here to group by that column

VALU	MODULEINDEX	CAPTION	UNITSTR	LOGCHANNELCODE	Channel Group	STORING	ARRA	LOGCHACODE	MODULEINDEX
▶	1	N. PMTLOCAL/No devi	Input	-	DEFAULT	☒	☐	VARIABLE1	4294967296
▶	1	N. PMTLOCAL/No devi	Channel 0	-	DEFAULT	☒	☐	VARIABLE0	4294967296
▶	1	N. PMTLOCAL/No devi	AI 5	A	DEFAULT	☒	☐	010147860000	4294967296
▶	1	N. Power 0	PFper	-	DEFAULT	☒	☐	01010D820000	4688183296
▶	1	N. Power 0	Sper	VA	DEFAULT	☒	☐	010109820000	4688183296
▶	1	N. Power 0	Qper	VAr	DEFAULT	☒	☐	010103820000	4688183296
▶	1	N. Power 0	Pper	W	DEFAULT	☒	☐	01010F820000	4688183296
▶	1	N. Power 0	Iper	A	DEFAULT	☒	☐	01010B820000	4688183296
▶	1	N. Power 0	Uper	V	DEFAULT	☒	☐	01010C820000	4688183296
▶	1	N. Power 0	QH	VAr	DEFAULT	☒	☐	01010380FF00	4688183296
▶	1	N. Power 0	DH	VAr	DEFAULT	☒	☐	010183800100	4688183296
▶	1	N. Power 0	D	VAr	DEFAULT	☒	☐	010183800000	4688183296
▶	1	N. Power 0	PF	-	DEFAULT	☒	☐	01010D800000	4688183296
▶	1	N. Power 0	S	VA	DEFAULT	☒	☐	010109800000	4688183296
▶	1	N. Power 0	Q	VAr	DEFAULT	☒	☐	010103800000	4688183296
▶	1	N. Power 0	P	W	DEFAULT	☒	☐	01010F800000	4688183296
▶	1	N. Power 0	PF_L3per	-	DEFAULT	☒	☐	010149820000	4688183296
▶	1	N. Power 0	S_L3per	VA	DEFAULT	☒	☐	010145820000	4688183296
▶	1	N. Power 0	Q_L3per	VAr	DEFAULT	☒	☐	01013F820000	4688183296
▶	1	N. Power 0	P_L3per	W	DEFAULT	☒	☐	01014B820000	4688183296
▶	1	N. Power 0	I_L3per	A	DEFAULT	☒	☐	010147820000	4688183296
▶	1	N. Power 0	U_L3per	V	DEFAULT	☒	☐	010148820000	4688183296
▶	1	N. Power 0	QH_L3	VAr	DEFAULT	☒	☐	01013F800100	4688183296
▶	1	N. Power 0	DH_L3	VAr	DEFAULT	☒	☐	010186800100	4688183296
▶	1	N. Power 0	D_L3	VAr	DEFAULT	☒	☐	010186800000	4688183296
▶	1	N. Power 0	I_rms_L3	A	DEFAULT	☒	☐	010147810000	4688183296
▶	1	N. Power 0	U_rms_L3	V	DEFAULT	☒	☐	010148810000	4688183296
▶	1	N. Power 0	PF_L3	-	DEFAULT	☒	☐	010149800000	4688183296
▶	1	N. Power 0	S_L3	VA	DEFAULT	☒	☐	010145800000	4688183296
▶	1	N. Power 0	Q_L3	VAr	DEFAULT	☒	☐	01013F800000	4688183296
▶	1	N. Power 0	P_L3	W	DEFAULT	☒	☐	01014B800000	4688183296
▶	1	N. Power 0	I_rm_L3	A	DEFAULT	☒	☐	010200000074	4688183296
▶	1	N. Power 0	U_rm_L3	V	DEFAULT	☒	☐	010200000073	4688183296
▶	1	N. Power 0	PF_L2per	-	DEFAULT	☒	☐	010135820000	4688183296
▶	1	N. Power 0	S_L2per	VA	DEFAULT	☒	☐	010131820000	4688183296
▶	1	N. Power 0	Q_L2per	VAr	DEFAULT	☒	☐	01012B820000	4688183296
▶	1	N. Power 0	P_L2per	W	DEFAULT	☒	☐	010137820000	4688183296
▶	1	N. Power 0	I_L2per	A	DEFAULT	☒	☐	010133820000	4688183296
▶	1	N. Power 0	U_L2per	V	DEFAULT	☒	☐	010134820000	4688183296
▶	1	N. Power 0	QH_L2	VAr	DEFAULT	☒	☐	01012B800100	4688183296
▶	1	N. Power 0	DH_L2	VAr	DEFAULT	☒	☐	010185800100	4688183296
▶	1	N. Power 0	D_L2	VAr	DEFAULT	☒	☐	010185800000	4688183296
▶	1	N. Power 0	I_rms_L2	A	DEFAULT	☒	☐	010133810000	4688183296
▶	1	N. Power 0	U_rms_L2	V	DEFAULT	☒	☐	010134810000	4688183296
▶	1	N. Power 0	PF_L2	-	DEFAULT	☒	☐	010135800000	4688183296
▶	1	N. Power 0	S_L2	VA	DEFAULT	☒	☐	010131800000	4688183296
▶	1	N. Power 0	Q_L2	VAr	DEFAULT	☒	☐	01012B800000	4688183296

If you want to store transients with the analog signal as well, the analog channels have to be assigned at

column “LogChannelCode”. For example the analog channels Voltage 1, Voltage 2 and Voltage 3 have to be assigned to the logchannelcode U_L1, U_L2 and U_L3.

☒	V	Power 0	Voltage 3	V	U_L3	DEFAULT	☒	☐	010148860000	4688183296
☒	V	Power 0	Voltage 2	V	U_L2	DEFAULT	☒	☐	010134860000	4688183296
☒	V	Power 0	Voltage 1	V	U_L1	DEFAULT	☒	☐	010120860000	4688183296

If you want to store other channels than power module channels in the database, please use the Power Tutorial.

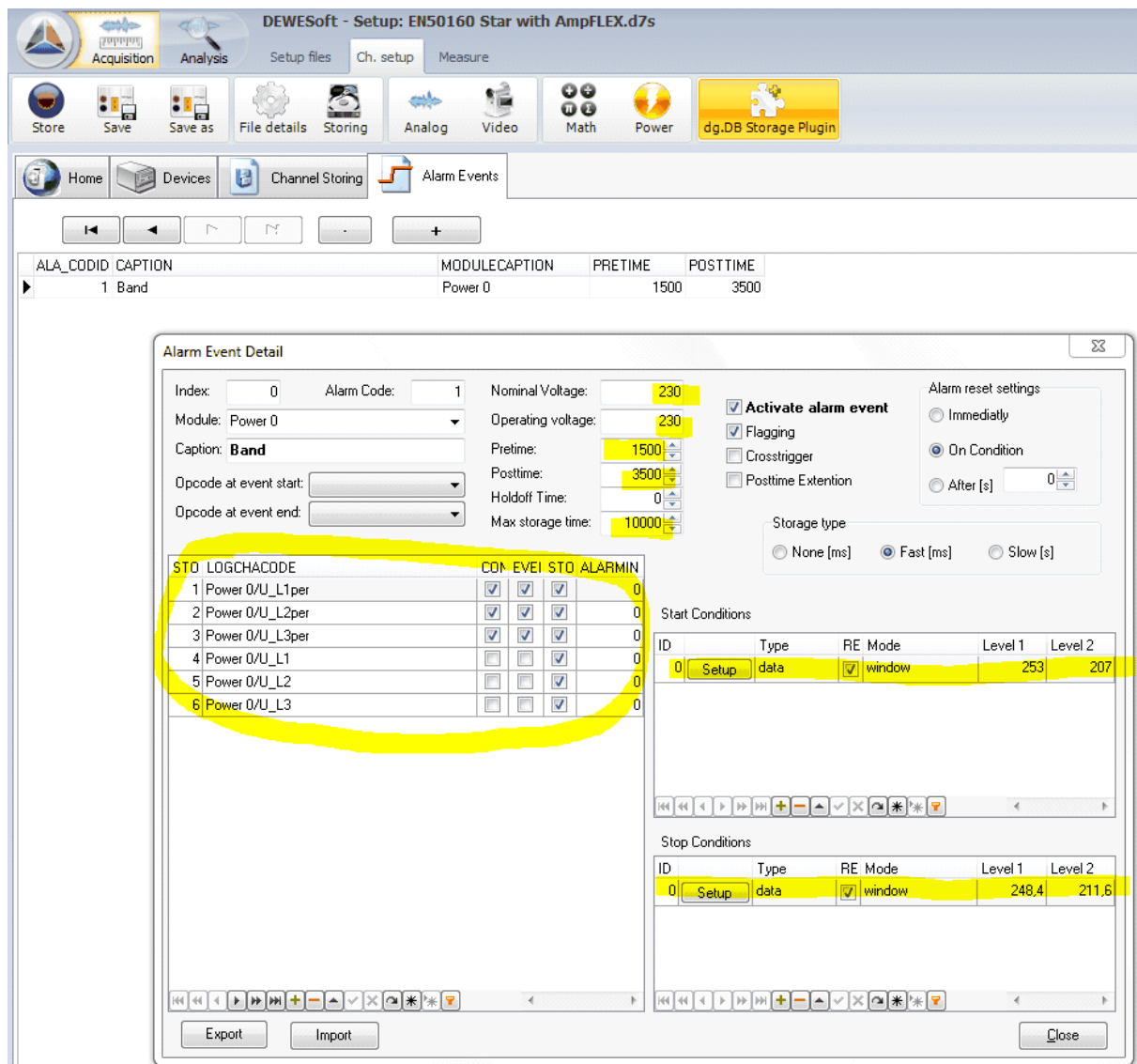
At tab “Full FFT Spectrum” you can select if you want to store the Full FFT for voltages, current, power and reactive power for the different power modules.

CAPTION	Storage Group	Nominal Voltage	Voltages	Current	Power	Reactive Power	Line Voltage
PMTLOCAL/No device		-1	☐	☐	☐	☐	☐
Power 0		230	☒	☒	☒	☒	☒

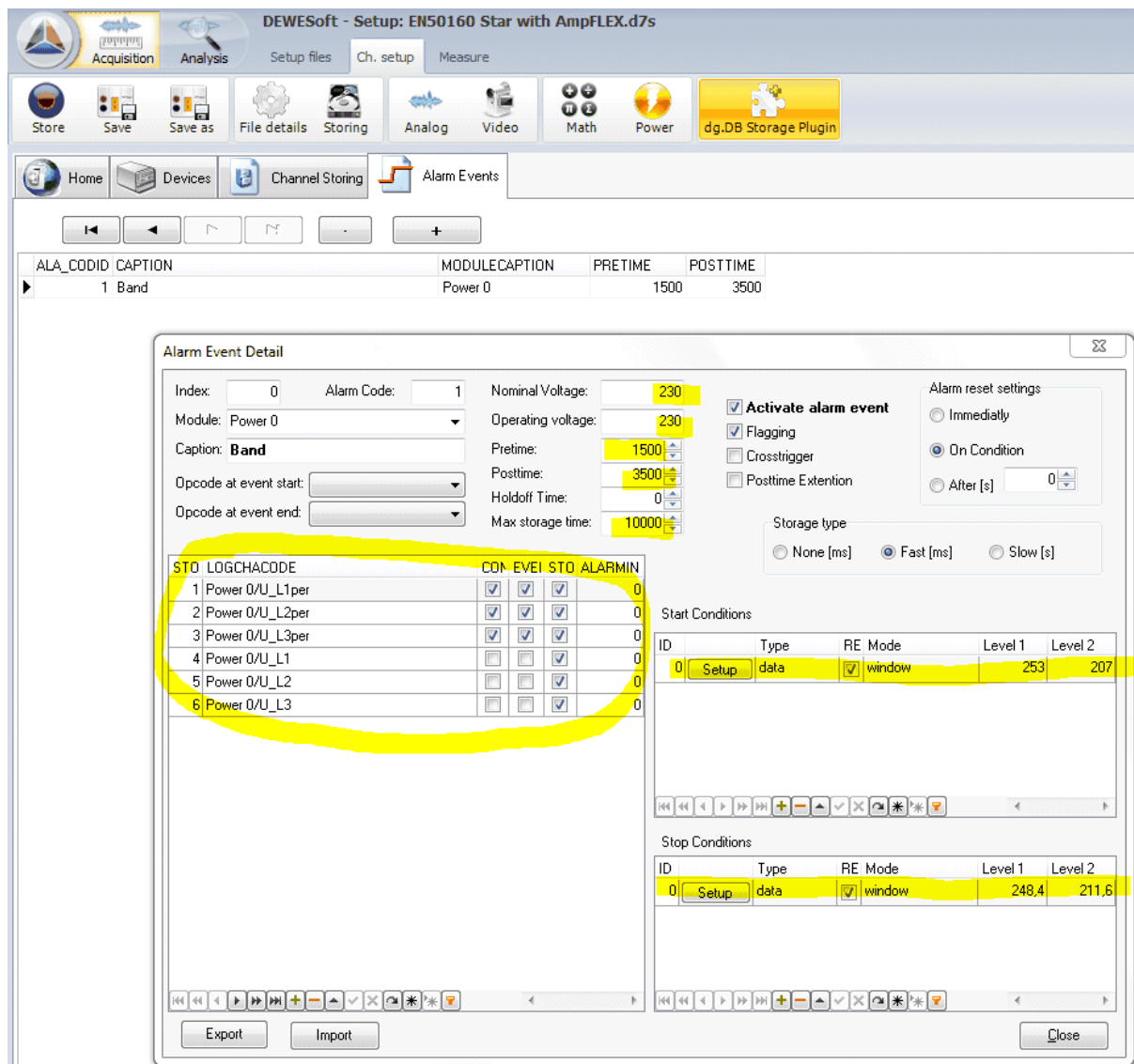
At tab “devices” you can rename the different power modules if you have more than one.

CAPTION	NOMINALV	OPERATINGV	STARTLOW	STOPLOW	STARTRHIGH	STOPHIGH	SLOPETRIC	SLOPETIME
DEWE2600/No device	-1							
Power 0	230	230	90	92	110	108	5	40
Power 1								

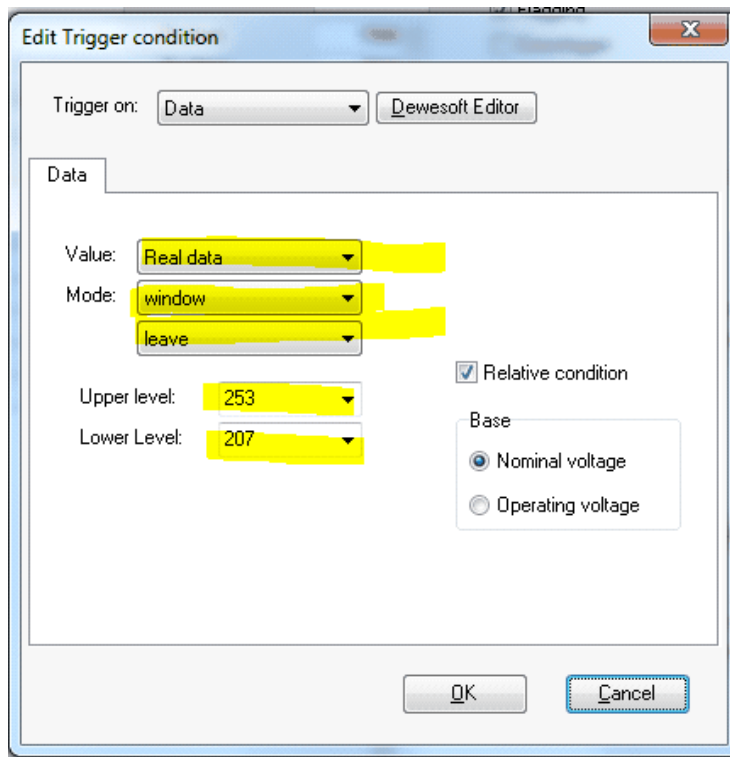
The last tab is “Alarm Events”. Alarms are important if you want to store transients. It's for example important for the DisDip Statistics at the EN50160 report. At first a new Alarm has to be created. At first basic settings like nominal voltage, operating voltage, the pre-, post-, holdoff- and max. storage time has to be selected. The maximum for the storage time which is supported is 10 seconds. The values have to be entered in milliseconds.



As next steps the channels which should be stored and on which the alarm settings should affect have to be added in the left tab. In this case the alarm settings are defined for the period values (U_L1per, U_L2per, U_L3per) via the selection at "Condition" and "Event". The analog signal just should be stored so here is the selection at "Store".



The last step is the setting of the alarm conditions for Start and Stop. After adding a new alarm you can select type (data, RMS values, ...) the mode (window, slope,...) and the limits.



If all settings are done, you just have to switch to the “Measure” in Dewesoft and the data starts to get stored in the database.

TIP: You **DON'T NEED** the DEWESoft storing functions. Saving in database starts as soon as you change to measure mode.

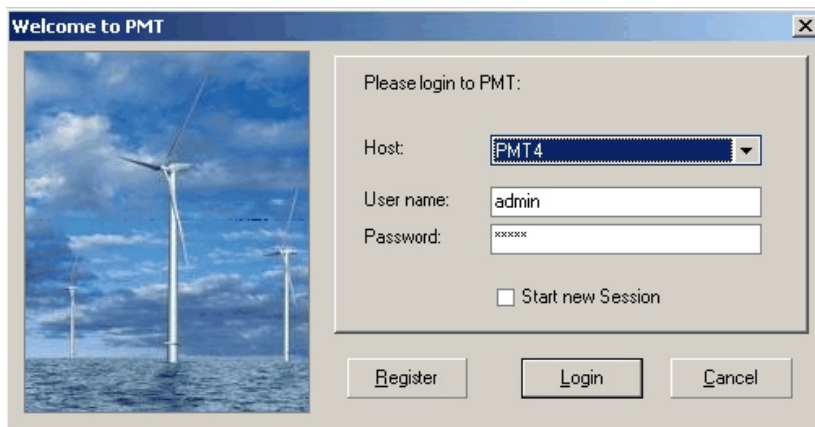


It's up to you, to use the storage in files but it's independent of the storage in the database.

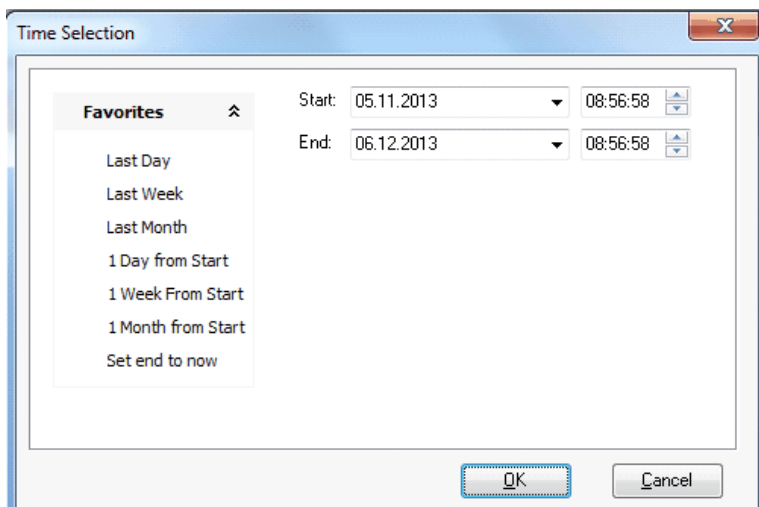
Note: Storing in database is a slow process. So you won't see the first value exactly after the selected storage interval in the database.

3) PMT

To analyse the data in the database please open PMT (username and password: admin).

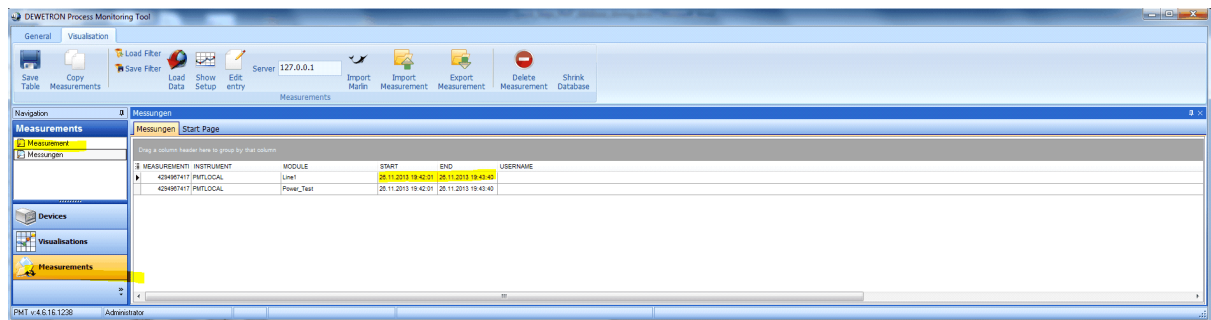


Then switch to the tab Measurements (on the left). On the left side appears again "Measurements". Via double click on "Measurements" a window appears where you can select the time frame of the data you want to analyse.





The measurements for the certain time interval appear on the main tab.



Then switch to visualisations and you will find all visualisations which are in PMT implemented as standard. There are a couple of folders with different visualisations. Just select the visualisation and open it via double click on the measurement.



Page 1 of 13

Power Quality Report EN50160

Report generated: 06.12.2013 09:20:16

User:

Administrator



Location: DEWE571

Feeder: Power 0

Report Start: 12.07.2013 12:37:30

Report End: 23.07.2013 22:10:00

Signature:

Overview

Value	Unit	Quantil (%)	value	max
U _{rms_L1}	V	95	234,51	235,47
U _{rms_L2}	V	95	235,33	236,42
U _{rms_L3}	V	95	236,61	237,90
THD _{U_L1}	%	95	2,12	2,45
THD _{U_L2}	%	95	1,97	2,30
THD _{U_L3}	%	95	2,07	2,34
P _{lit_L1}	-	95	0,67	0,70
P _{lit_L2}	-	95	0,74	0,78
P _{lit_L3}	-	95	0,72	0,76
u2_1	%	95		
Frequency	Hz	99	50,04	50,07

How to save for specific standards can be found in PQ Standards.

Hints to set the fault recorder can be found in chapter fault recorder

2.5.2.3 Installation notes DB Plugin and PMT

How to recognize whether the DB Plugin is installed?

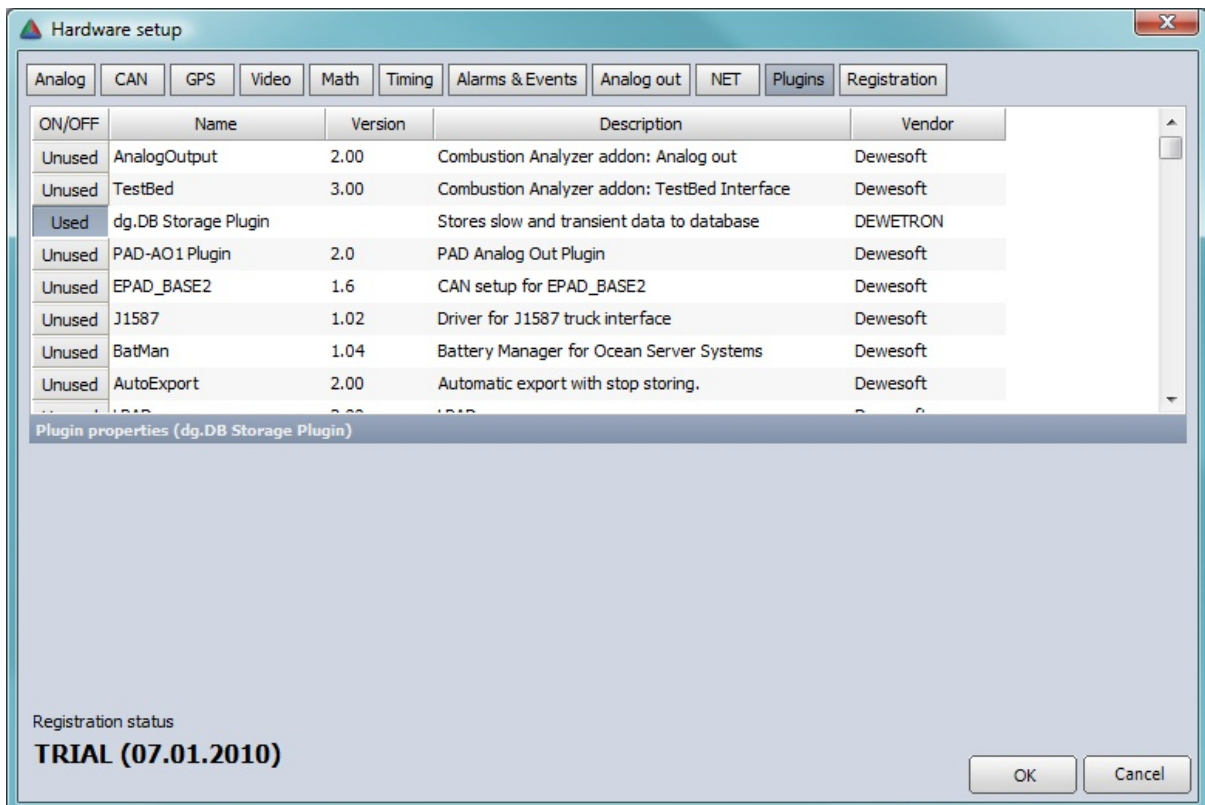
Your DEWESoft menu bar should look like:



This icon indicates the DB Plugin.



If the icon is missing than check that the DB Plugin is enabled in the hardware setup and if it is registered in the registration: "dg.DB storage Plugin".



If the DB Pugin isn't available there, install it first.

For more information, see the PMT4 Manual.

2.6 Additional measurements

Other related tasks may include:

- Energy Calculation
- RPM measurement
- Torque measurement
- Efficiency measurement

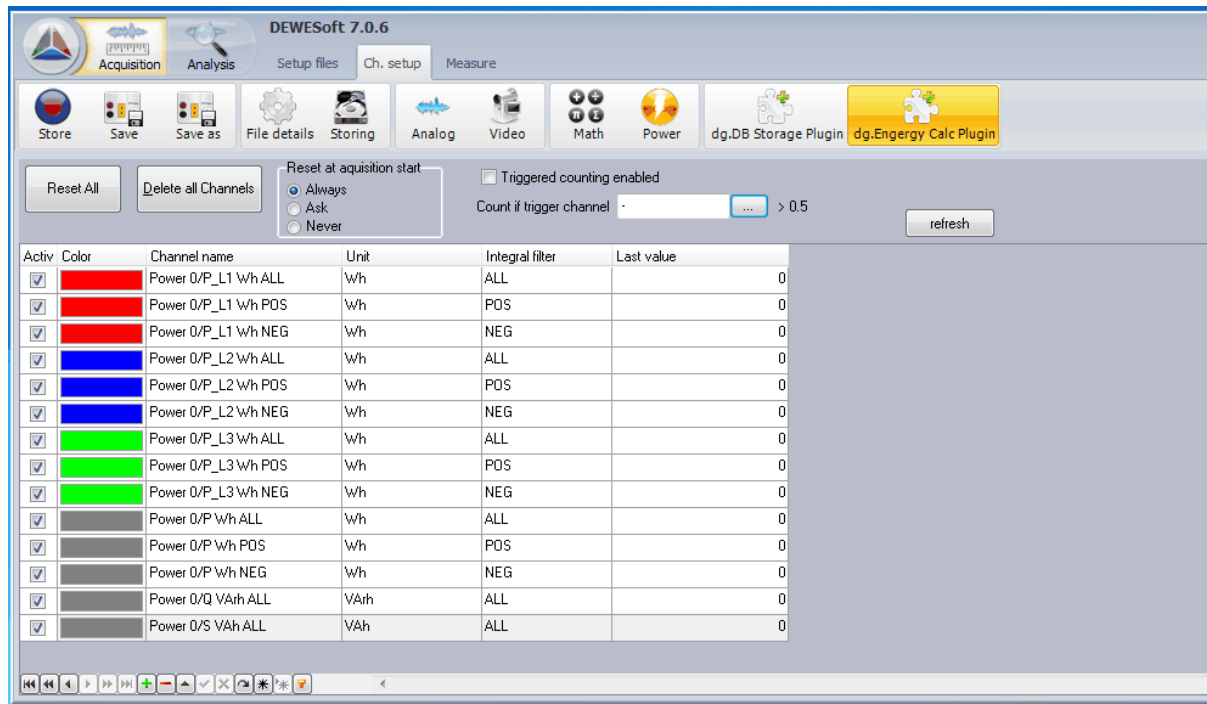
2.6.1 Energy calculation

For the measurement of the Energy you can whether use the energy plugin or calculate it via the Math.

- Energy Plugin

If you use the Energy plugin the energy will be automatically calculated out of the active, reactive and apparent power. An additional benefit is the automatically calculation for positive and negative energy (e.g. recuperation at E-Cars, feed-in of renewables etc.)

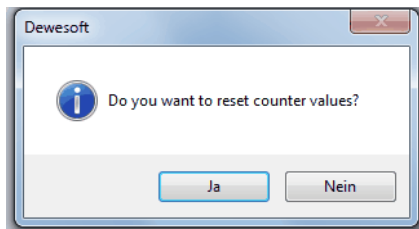
You can also add additional channels, for example if you also want to calculate the energy of DC power. Therefore click at the "+" at the bottom of the screen and select the channel and confirm it with the "OK" sign.



In this plugin you also can set the start time for the calculation at "Reset at acquisition start" with the options "Always", "Ask" or "Never".

Always The energy counter will be reseted every time you start the acquisition.

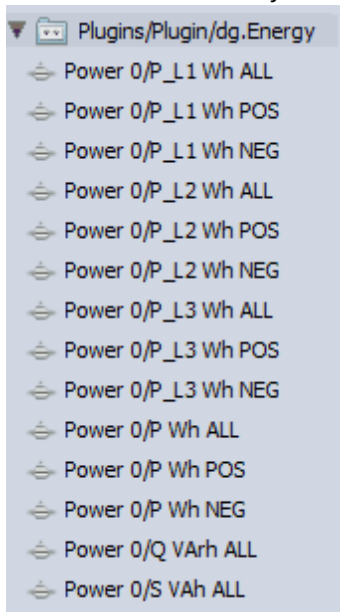
Ask a window will pop up and ask if the values should be reseted



Never ... The counter will never be reseted and will continue at the last value

Furthermore you can start calculating on triggering on a channel. You just have to set the trigger channel and trigger level.

In measurement mode you following will find the additional channels:



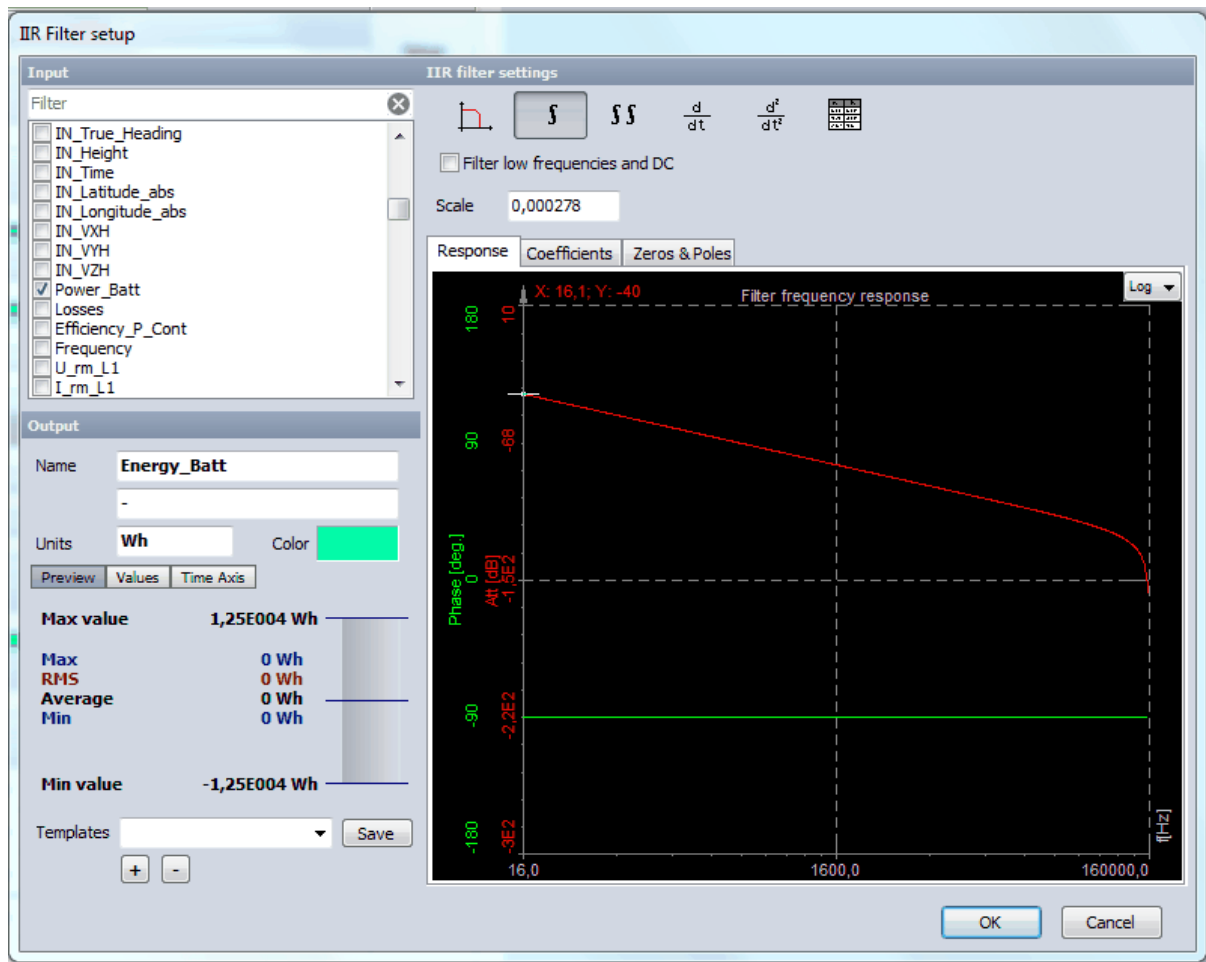
- Math

To calculate the energy via the Math create an "IIR Filter" and select the channel you want to calculate (e.g. P) at Input.

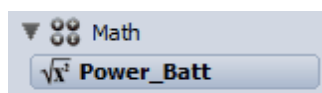
Then switch from "filter" to "Integral" at IIR filter settings and disable "Filter low frequencies and DC" and set the Scale to "0,000278" (= 1/3600) to get the output in Watt hours (Wh).

At output just type in the channel name you want for the calculation and set the right unit (in this case Wh).

Note: As soon as you switch in the Measurement mode, the calculation of the energy starts (not at the point at pressing "Store").



In measurement mode you will find the new channel:



- Recuperation via Math:

If you want to calculate the recuperation in Math you at first need to split the power values in positive and negative ones with the following formula:

Calcul...	Store	$\sqrt{a^2+b^2}$	Formula	if('P_Batt'>0,abs('P_Batt'),0)	- [W]	5E4	Setup
			P_verbr				
Calcul...	Store	$\sqrt{a^2+b^2}$	Formula	if('P_Batt'<0,abs('P_Batt'),0)	- [W]	5E4	Setup
			P_rekup				

In this case P_verbr is the positive power (power consumption) and P_reku is the negative power (recuperation).

P_verbr=if('P_Batt'>0,abs('P_Batt'),0)

P_reku=if('P_Batt'<0,abs('P_Batt'),0)

After splitting the power you again have to make an IIR integral with the same settings as mentioned before.

2.6.2 Efficiency measurement

The efficiency measurement is made with the math-library of DEWESoft.

In this example, the calculation is made for an electric drive.

The measurement of electrical power is done with the Power module.

The mechanical power is measured with rpm and torque.

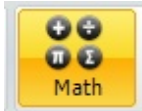
1) Electrical Power

Set a Powermodule at the input of the drive set:

2) Mechanical Power

Run a rpm measurement and a torque measurement.

Change in the math-mode in the DEWESoft Setup.



Create a formula to calculate the mechanical power:

$$P_{\text{mech}} = M \cdot 2 \cdot \pi \cdot n / 60$$



Name the formula "P mech" with the unit "W".

Formula setup

Output	Formula
Name: P mech	$\frac{'M' \cdot 2 \cdot 3,142 \cdot 'n'}{60}$
Units: W Color: 	
SR div: Auto 1	
Max value: 1038 W	
Max 63,08 W RMS 0,04064 W Average 62,96 W Min 62,83 W	$'M' * 2 * 3,142 * 'n' / 60$
Min value: -1038 W	Basic operators + - x / () ^ div mod Other math functions Functions Trigon. Logic Signals Measure Events sqr sqrt abs sgn trunc round rnd log2 log10 ln exp if nan max min

All chs

AI

Math

cos_phi_L1_H1
cos_phi_L2_H1
cos_phi_L3_H1
D
D_L1
D_L2
D_L3
DH
DH_L1
DH_L2
DH_L3
Efficiency
Frequency
I_L1_H1
I_L2_H1
I_L3_H1
I_rm_L1

3) Calculate the efficiency

Create another formula to calculate the efficiency (unit "%")



Efficiency = P mech / P * 100%

Formula setup

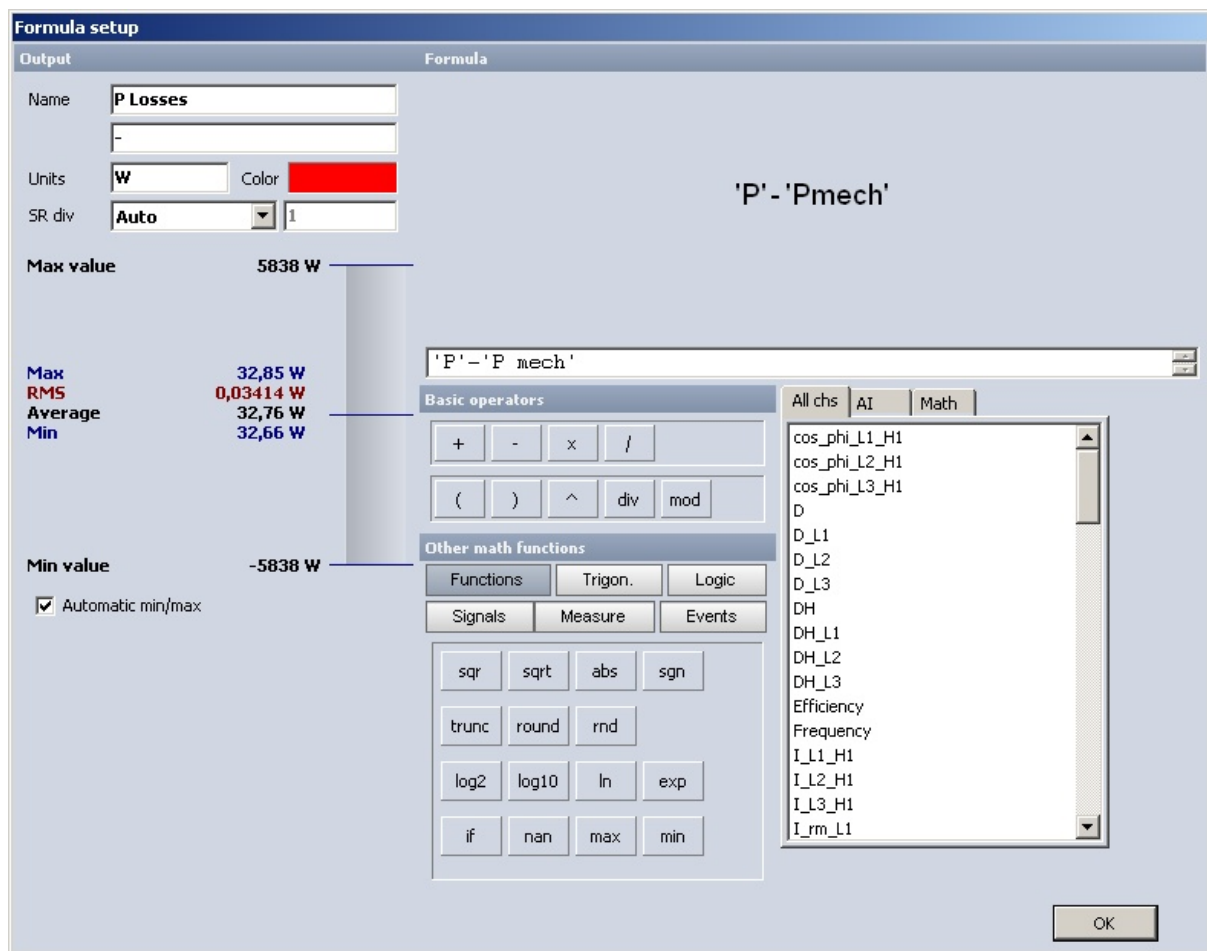
Output	Formula	
Name: Efficiency	$\frac{'P_{mech}'}{'P'} \cdot 100$	
Units: % Color:		
SR div: Auto 1		
Max value: 2,163E004 %		
Max: 65,77 % RMS: 0,03427 % Average: 65,68 % Min: 65,58 %	'P_mech'/'P'*100 Basic operators + - x / () ^ div mod Other math functions Functions Trigon. Logic Signals Measure Events sqr sqrt abs sgn trunc round rnd log2 log10 ln exp if nan max min	All chs AI Math cos_phi_L1_H1 cos_phi_L2_H1 cos_phi_L3_H1 D D_L1 D_L2 D_L3 DH DH_L1 DH_L2 DH_L3 Efficiency Frequency I_L1_H1 I_L2_H1 I_L3_H1 I_rm_L1
Min value: -2,163E004 %		
☒ Automatic min/max		
OK		

4) Calculate the power losses

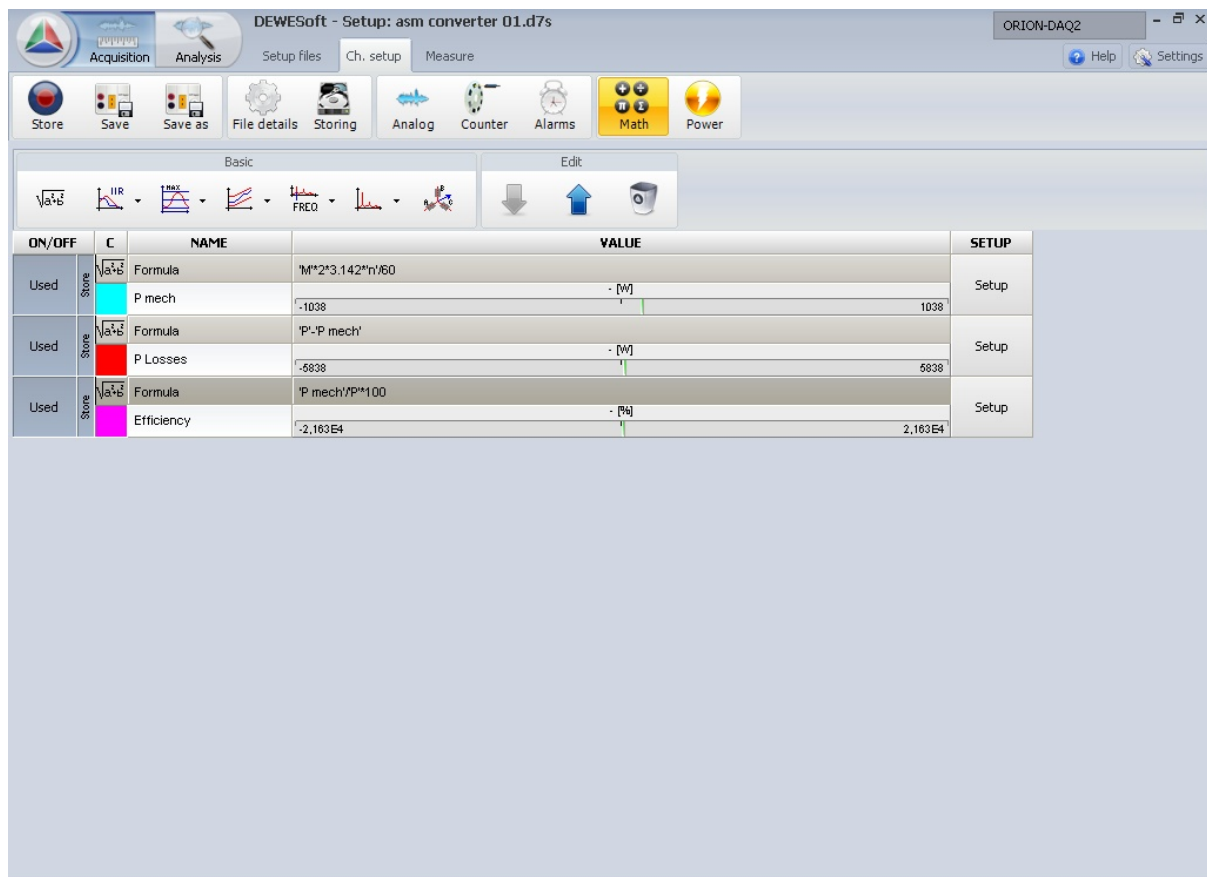
Create another formula to calculate the power losses



$P_{Losses} = P - P_{mech}$

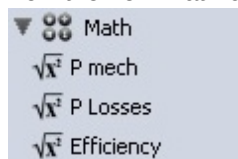


The complete setup of the measurement channels looks like the following:



5) Measurement

Now the new math-channels are available in DEWESoft and can be used for measurement.



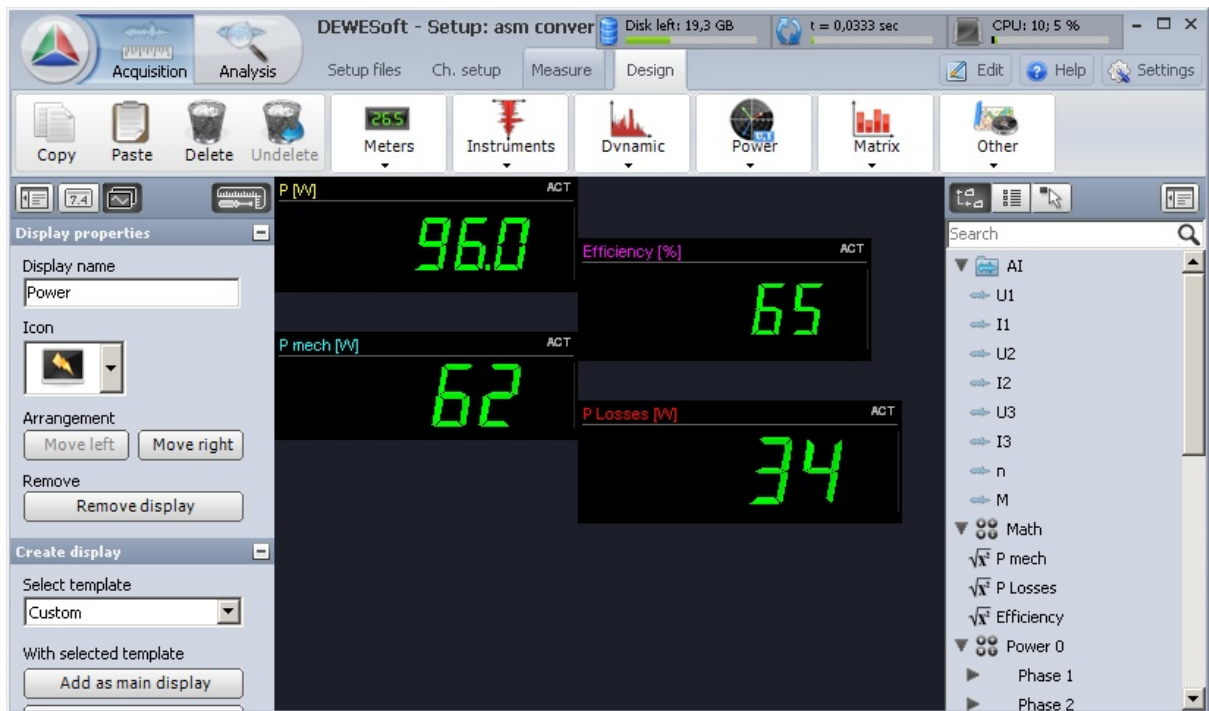
Examples: numeric display of:

P electrical = 96 W

P mech = 62 W

Efficiency = 65 %

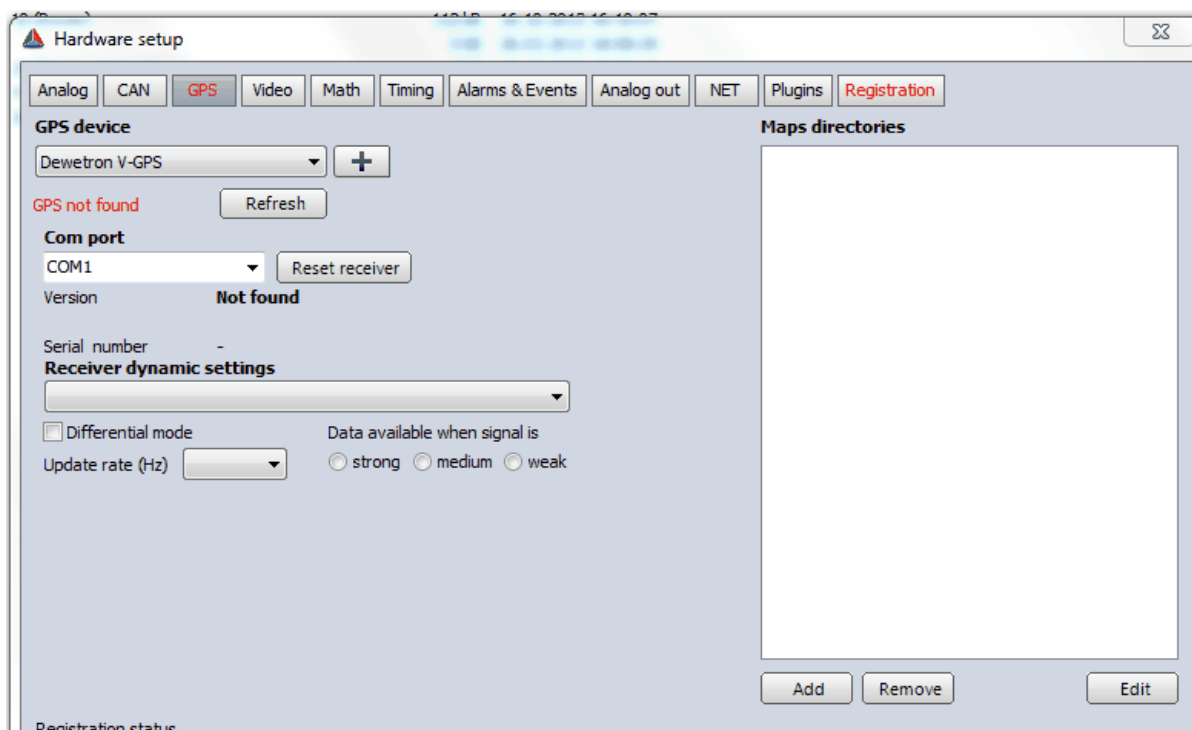
P Losses = 34 W



2.6.3 Connection of GPS

The installation of the GPS depends on the used sensor and how it is connected (COM, USB). Please follow the installation notes.

To activate the GPS sensor in Dewesoft open the "Hardware Settings", switch to "GPS" and select "Dewetron V-GPS".



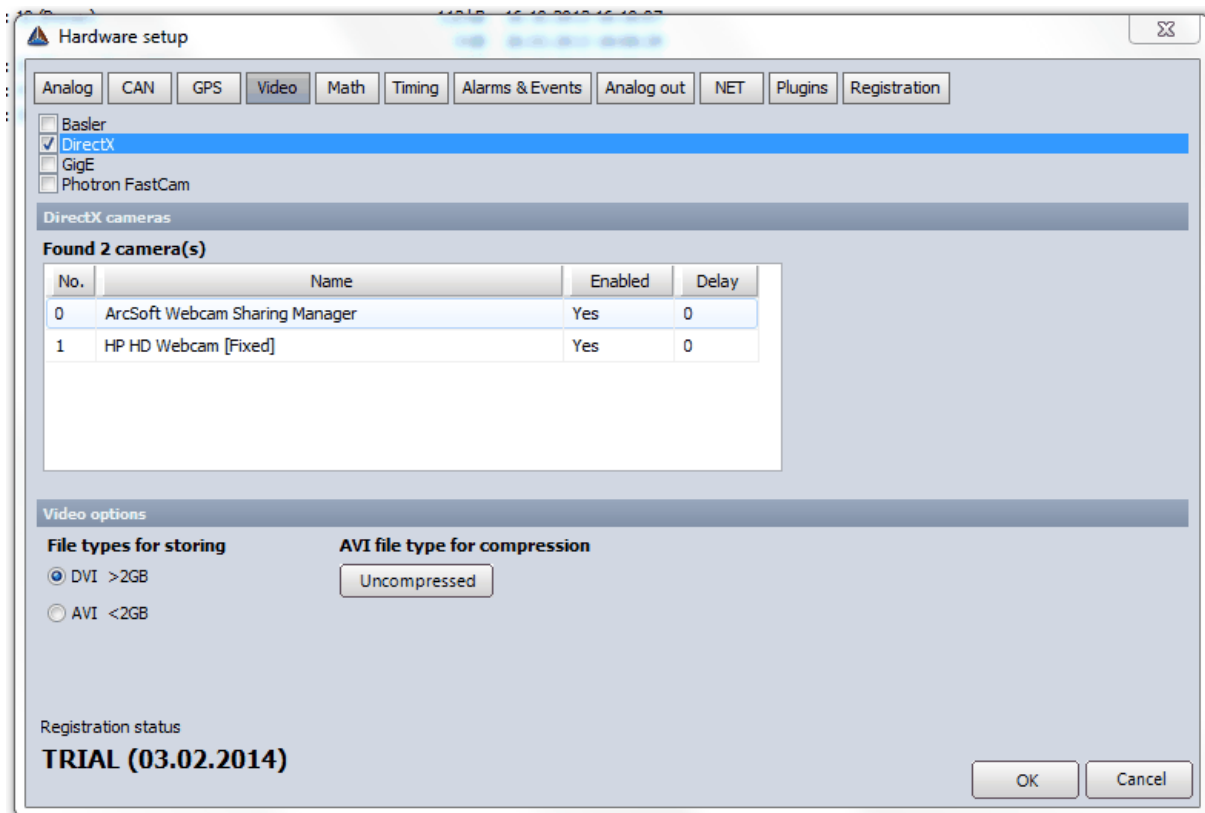
If the GPS can not be found select the port where the GPS is connected from the COM port dropdown menu and hit the Refresh button. If the DEWE-GPS-CLOCK is connected to the DAQ-System via RS232 interface, select the onboard COM port (usually COM1 or COM2). If it is not connected via USB interface, select the COM port which is listed next to the entry "USB Serial port" in the Windows device manager.

For further information use the installation notes (Technical reference).

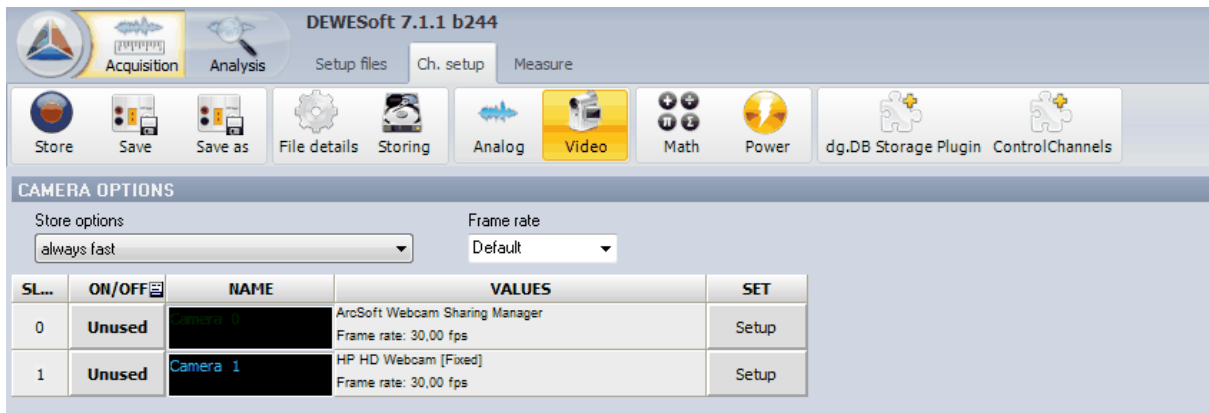
2.6.4 Connection of a Camera

It's possible to connect a camera to the device. After the installation of the camera go to "Settings" - "Hardware Setup".

Switch to "Video" and enable "DirectX". Then all connected cameras appear. Select your camera and confirm with "OK".



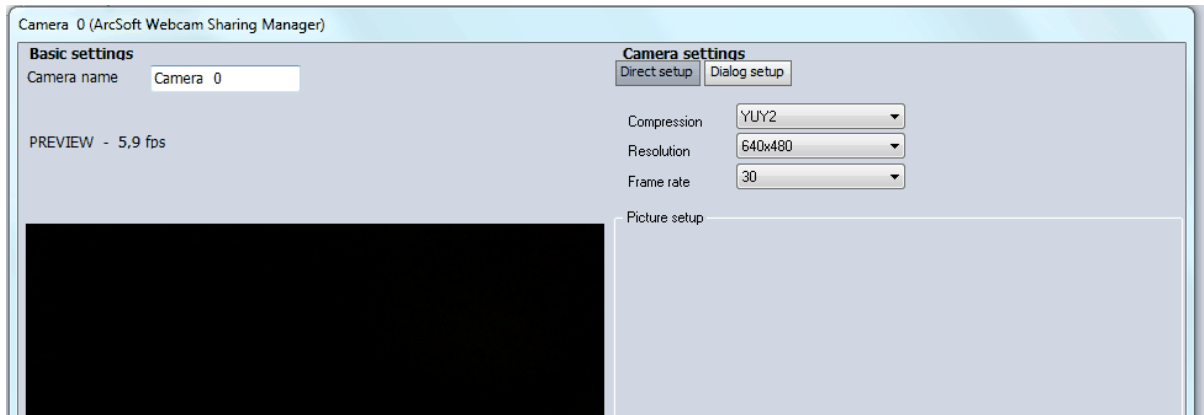
In the Dewesoft main menu you will find now "Video"



Please enable the camera you want in the channel list.

At store options you can select the storing interval.

If you click to "Setup" you can set additional settings for the camera like "Compression", "Resolution" or the "Frame Rate".



In Measurement mode you can display the camera using the Video button:



2.6.5 rpm measurement

The rpm measurement can take place in different ways depending on the sensor:

- rpm encoder with voltage output.
- pulse output (encoder) - (higher accuracy, depending on the number of teeth).

2.6.5.1 rpm sensors with voltage output

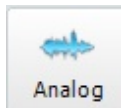
The rpm measurement using sensors with voltage output is performed as follows:

1) Connect the output of the sensor to a module for measuring small voltages (DAQP-LV, MDAQ-V etc...).



Note: To ensure that the parameters correctly you need to know the scale of the sensor (example: 1 V = 1000 rpm).

2) Set-up the module accordingly.



Channel setup for channel 11 DAQP-LV SNr:325569 Rev:100

Channel settings

General **Sensors** **General** **Info**

Channel name:

 Units:
 Color:

Min value: Max value:
 Sample rate divider:

Measurement:
 Range: V
 Lowpass filter:
 Lowpass type:
 Coupling:
 Input type:

Scaling

by two points **by function**

First point	Second point
0 equals 0	1 V equals 1000 rpm
Calibrate from average from RMS	Calibrate from average from RMS

Input value **Scaled value**

10 V	10000 rpm
1,2869 V	1286,9 rpm
1,2458 V	1245,8 rpm
1,2170 V	1217,0 rpm
-10 V	-10000 rpm

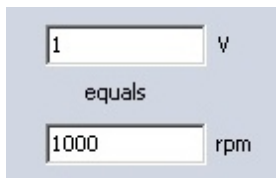
Block size: ☐ 0.1 s ☒ 1 s

Name the channel e.g. "n" with the unit rpm.

By reason that the signal changes slowly enough, a filter with 100 Hz would be sufficient.

Lowpass filter:

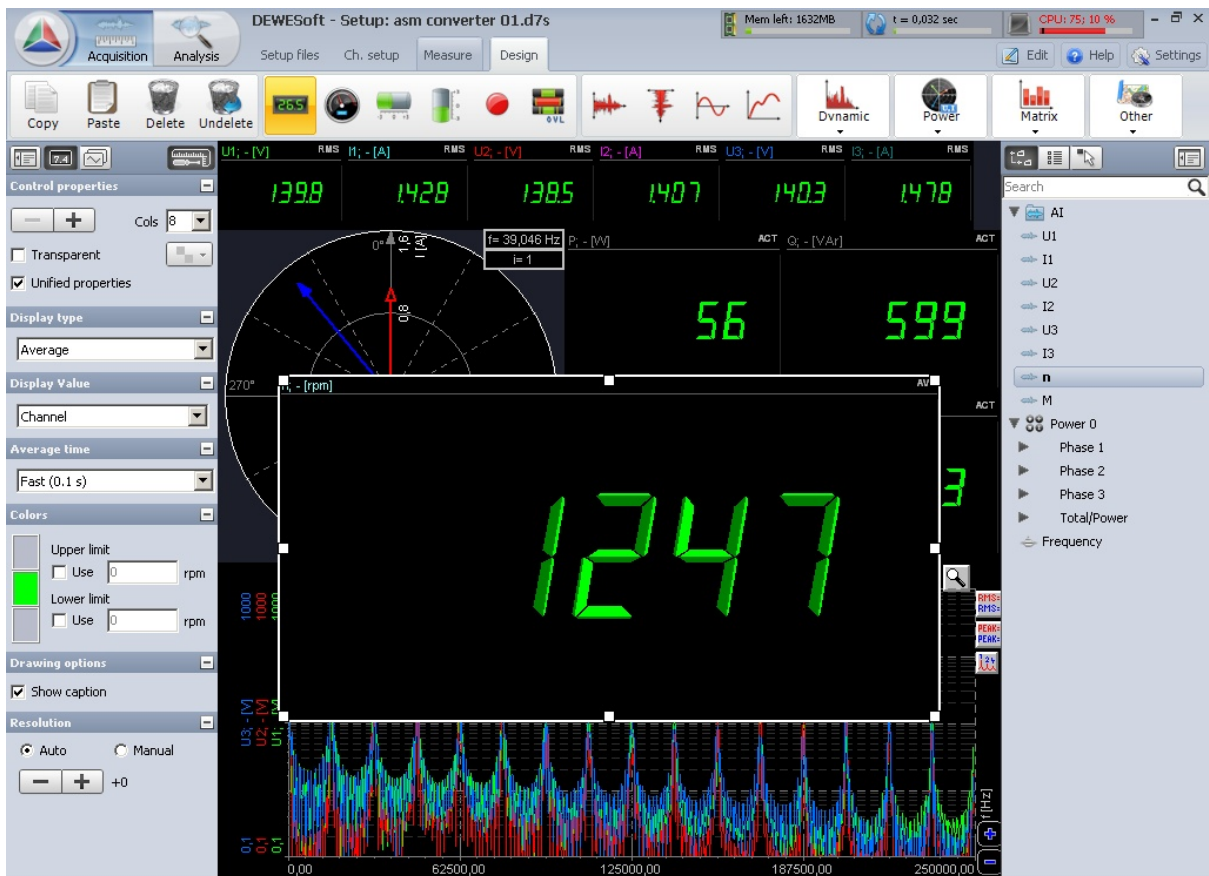
Set the scale correctly. Example: 1 V = 1000 rpm



3) Measurement

Change to the measurement mode and use the new channel "n".

Example: $n = 1247$ rpm



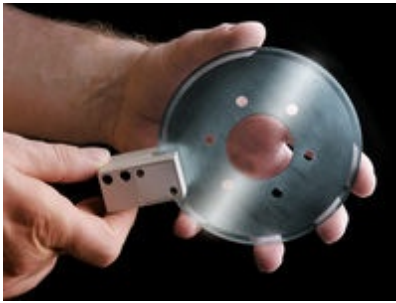
2.6.5.2 Encoder

The rpm measurement with sensors with pulse output (encoder) is performed as follows:

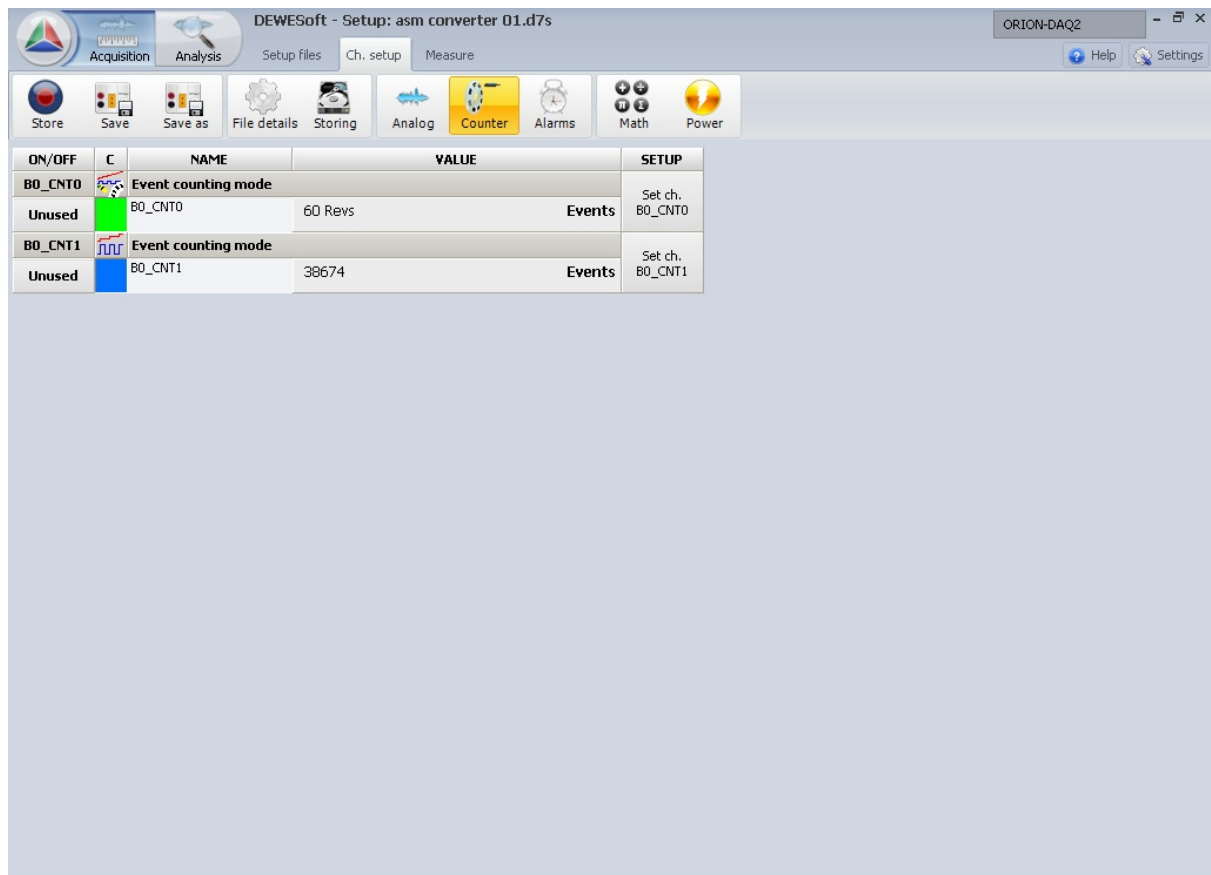
- 1) Connect the output of the sensors with a counter input.



Here a "Dewetron RIE 360" encoder will be used.
This encoder has 360 teeth per rotation and z-pulse.

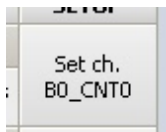


The connection is made at the channel B0_CNT0.



2) Setup

Set the channel B0_CNT0.



"Basic Application" must be set to "Sensor (encoder, CDM, tachometer,...)":

Channel setup for channel B0_CNT0

Basic settings **Hardware settings** **Sensor settings**

Basic application: Input filter:

Counting mode: Count direction: ☒ Enable signal zero

☐ Advanced counter mode

Signal input: ☐ inv

Signal zero: ☐ inv

Output channels:

ON/OFF	C	NAME	MEASUREMENT	RAW VALUE	* SCALE	OFFSET	MIN	SCALED VALUE	UNIT	MAX
Unused		B0_CNT0	-	293	1	0	0	293	Revs	10000

Basic application

Sensor type in our example: CDM360.

Channel setup for channel B0_CNT0

Basic settings **Hardware settings** **Sensor settings**

Basic application: Pulses:

Sensor type: Count direction: ☒ Enable signal zero

Measured pulses: 360

Signal input: ☐ inv

Signal zero: ☐ inv

Output channels:

ON/OFF	C	NAME	MEASUREMENT	RAW VALUE	* SCALE	OFFSET	MIN	SCALED VALUE	UNIT	MAX
Unused		B0_CNT0/Angle	-	0,40971	revs	1	0	0,40971	Revs	10000
Unused		B0_CNT0/Frequency	-	1497,45	RPM	1	0	1497,45	RPM	10000
Unused		B0_CNT0/Raw_Count	-	149		1	0	149	-	10000
Unused		B0_CNT0/Raw_EdgeSep	-	4504		1	0	4504	-	10000

Basic application
Sensor (encoder, CDM, tacho ...) ▼

Sensor type
CDM-360 ▼ ...

If use your own encoder, you can add an sensor or modify an existing sensor with the symbols right to the field "sensor type".

The screenshot shows the 'Counter sensors editor' dialog box. It has a title bar with standard window controls. Below the title bar is a toolbar with four icons: a plus sign with a sensor symbol, a minus sign with a sensor symbol, a floppy disk with a document symbol, and a green 'EXIT' button. Below the toolbar are four main sections: 'Current sensor' with a dropdown menu showing 'CDM-360'; 'Sensor type' with a dropdown menu showing 'Geartooth with zero, CDM + TRG'; 'Geartooth setup' with a text field for '#Teeth' containing '360'; and 'Signal level' with three dropdown menus: 'Signal type' showing 'Digital (TTL level)', 'Signal edge' showing 'Negative', and 'Zero pulse edge' showing 'Positive'. There is also a 'Signal filter' dropdown menu showing '100 ns'.

Counter sensors editor

Current sensor
CDM-360 ▼

Sensor type
Geartooth with zero, CDM + TRG ▼

Geartooth setup
#Teeth
360

Signal level
Signal type
Digital (TTL level) ▼

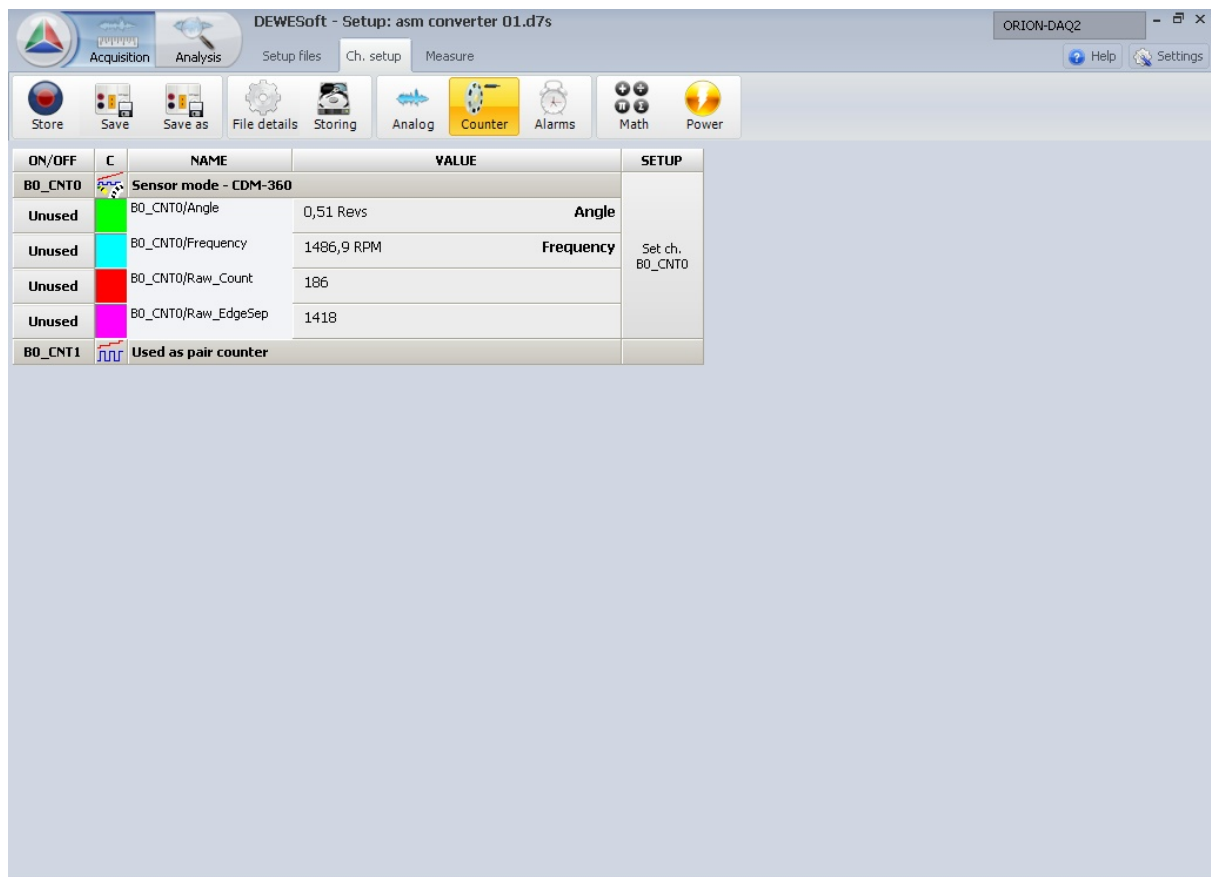
Signal edge
Negative ▼

Zero pulse edge
Positive ▼

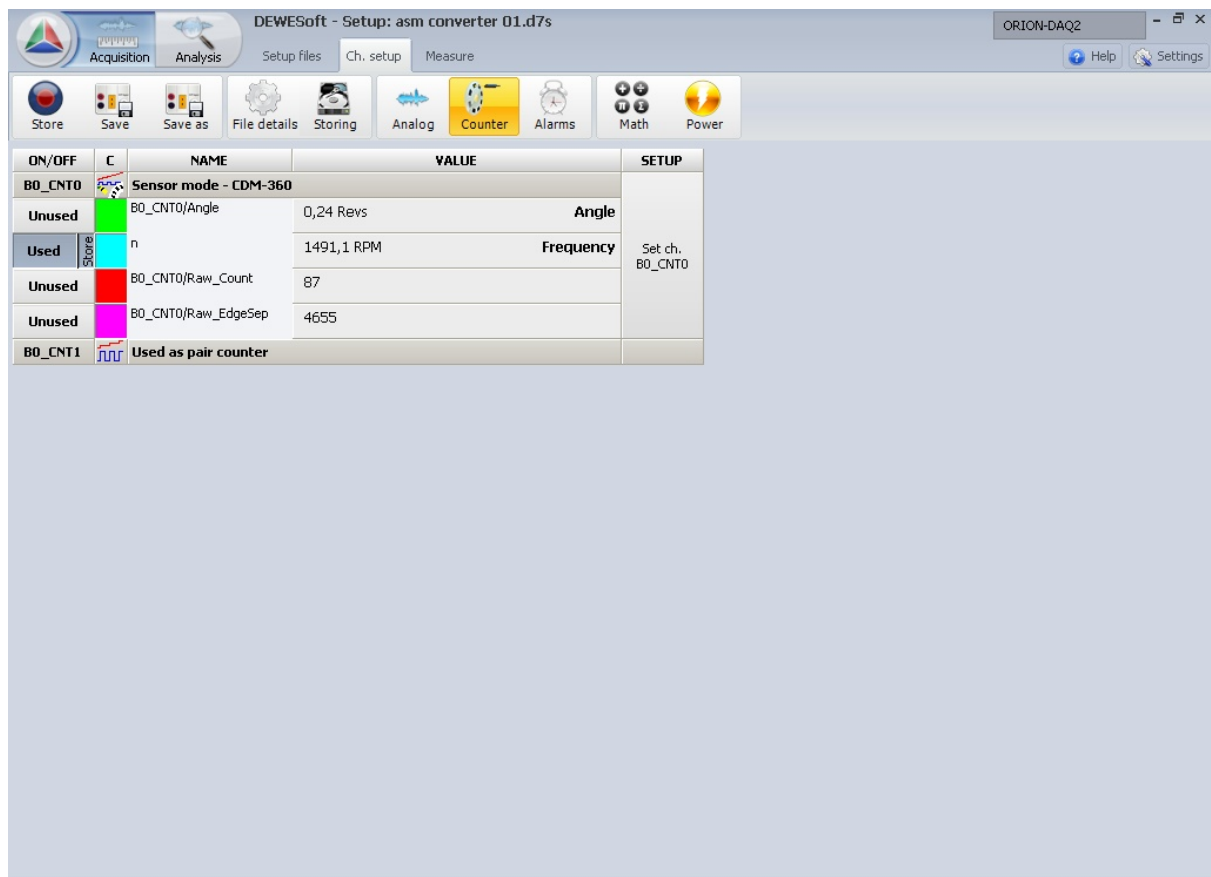
Signal filter
100 ns ▼

Buttons: Add sensor, Remove sensor, Save & Exit, EXIT, Cancel

Confirm your settings and you will get the following channel list in the counter setup.



Set B0_CNT0/Frequency to "used" and name it e.g. "n"



3) Measurement:

"n" is available as measuring channel and can be used in DEWESoft.



In our example: $n = 1492,34 \text{ rpm}$



2.6.6 torque measurement

The torque measurement can take place in different ways depending on the sensor:

- Sensor with voltage output.
- X-Sens torque measurement
For torque measurement with X-Sens sensors please use the X-Sens plugin manual.
- pulse output.

2.6.6.1 Sensors with voltage output

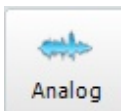
The torque measurement using sensors with voltage output is performed as follows:

- 1) Connect the output of the sensor to a module for measuring small voltages (DAQP-LV, MDAQ-V etc...).



Note: To ensure that the parameters correctly you need to know the scale of the sensor (example: 1 V = 1 Nm).

2) Set-up the module accordingly.



Channel setup for channel 13

Channel settings: **General** | Sensors | DAQP-LV SNr:335716 Rev:100

General | Info

Channel name: M
Units: Nm
Color:

Measurement: Voltage
Range: 10 V
Lowpass filter: 100 Hz
Lowpass type: Bessel
Coupling: DC
Input type: Bipolar

Min value: Auto | Max value: Auto
Sample rate divider: 1 | Skip

Scaling

by two points | by function

First point	Second point
0 equals	1 V equals
0	1 Nm

Calibrate: from average | from RMS

Input value | Scaled value

10 V	10 Nm
0,2338 V	0,2338 Nm
0,2236 V	0,2236 Nm
0,2048 V	0,2048 Nm
-10 V	-10 Nm

Block size: ☐ 0.1 s ☒ 1 s

Average | **AC RMS** | Min / Max

<< >> | Ok | Cancel

Name the channel e.g. "m" with the unit Nm.

M

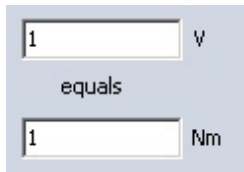
-

Nm

By reason that the signal changes slowly enough, a filter with 100 Hz would be sufficient.

Lowpass filter: 100 Hz

Set the scale correctly. Example: 1 V = 1 Nm



3) Measurement

Change to the measurement mode and use the new channel "m".

Example: $M = 5,903 \text{ Nm}$

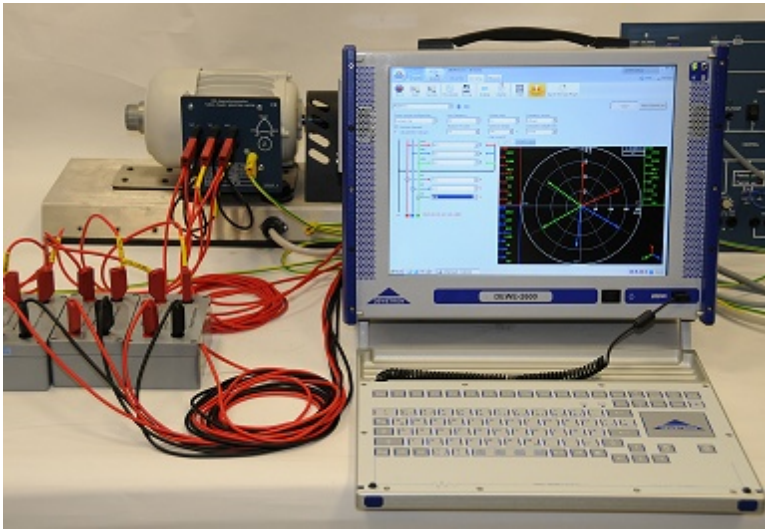


3 Application Notes / Examples

3.1 Electrical Machines

To measure electrical machines you can use Dewetron instruments with the power module. Depending on the task there a few things to mention.

Required: Knowledge in "Measuring power".



Typical Examples:

- ASM (asynchronous machine) on the three-phase-system Star connection (with neutral)
- ASM (asynchronous machine) on the three-phase-system Delta connection
- ASM (asynchronous machine) on a converter
- E-Mobility Measurement

3.1.1 ASM on the three-phase-system

The following two examples show two different ways to connect a asynchronous machine to the three-phase system.

Depending on the configuration we distinguish between:

- Star connection (with neutral)
- Delta connection (without neutral, industrial grid)



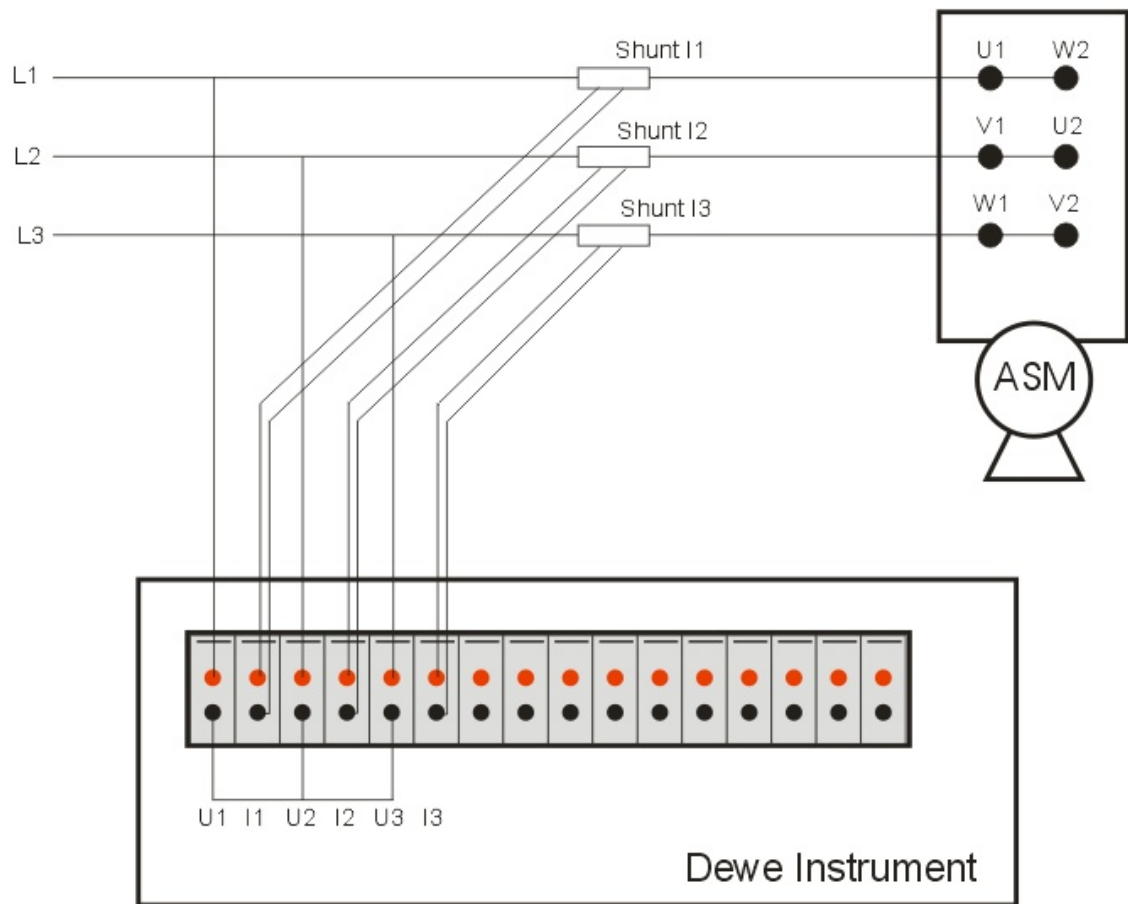
3.1.1.1 ASM on the three-phase-system Star connection

The asynchronous machine which is used in this chapter has a nominal current $<5A$, and a nominal voltage of 400V. Die Asynchronmaschine welche in diesem Kapitel verwendet wird hat einen Nennstrom $<5A$ und eine Nennspannung von 400V.

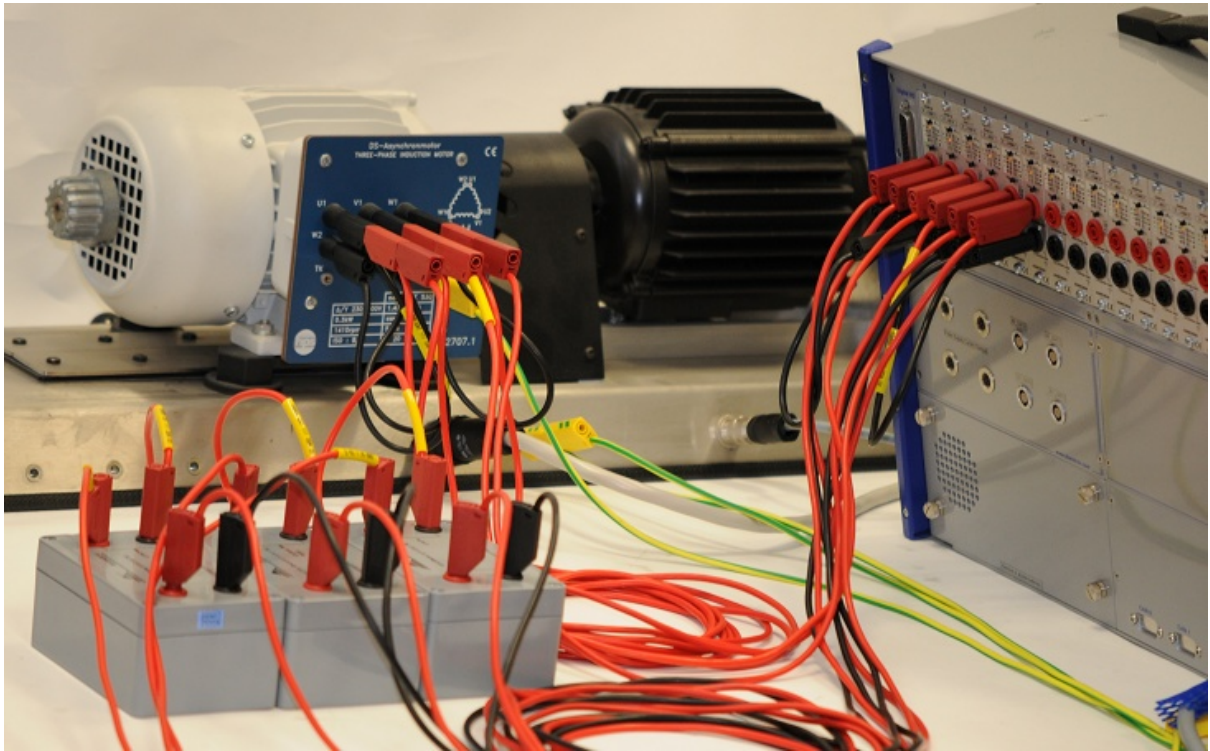


The measurement of voltage is done with 3 DAQP-HV modules.

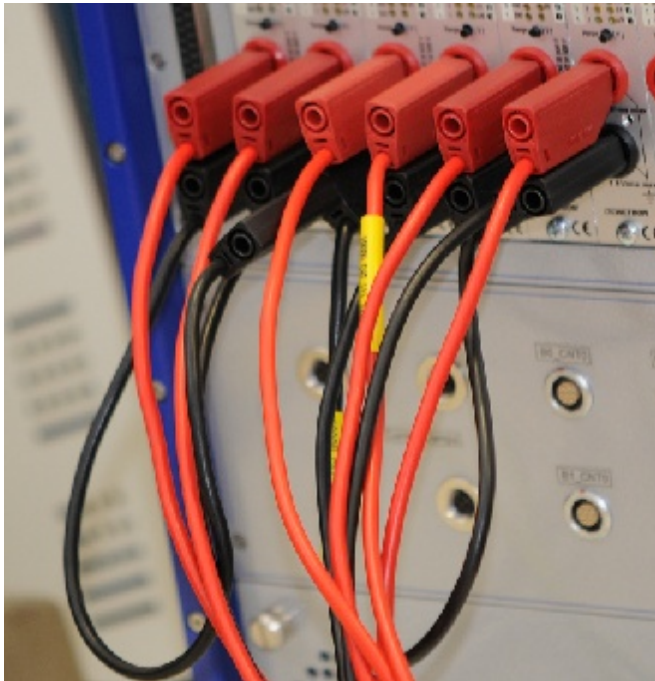
The current is measured via shunts and DAQP-LV modules. The current measurement could also be performed with current clamps, transducers and so on (more on this in the chapter "current measurement").



Measurement setup:



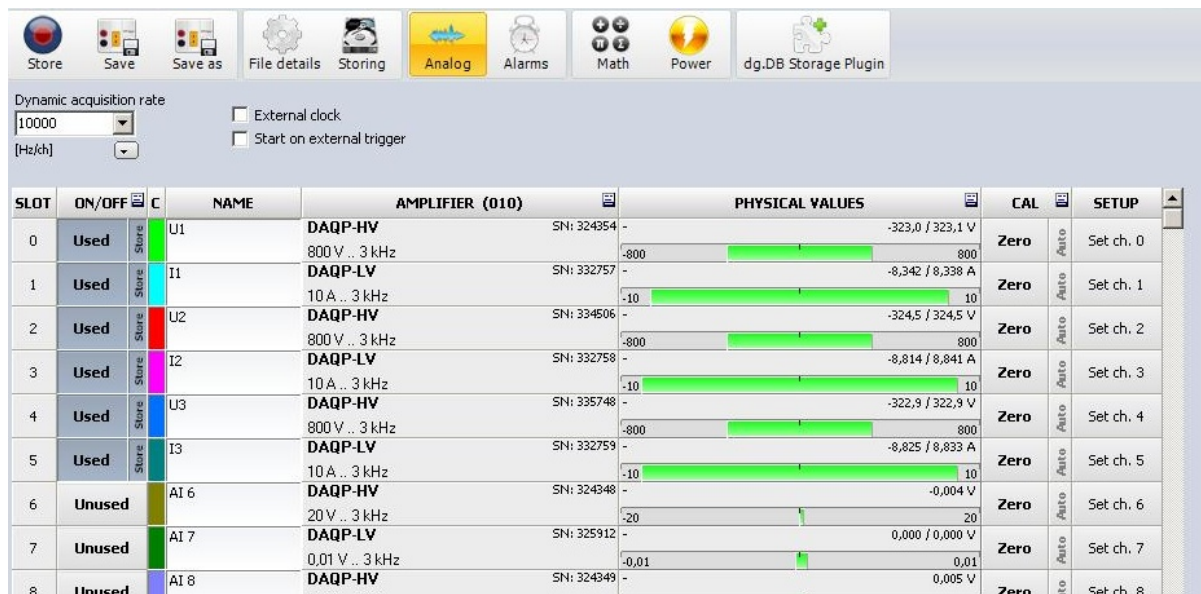
The star point could be made directly at the modules (if no star point is available).
U1-, U2- and U3- (the black one) are connected with cables.
Due to the very high input impedance of the modules the star point could be build directly at the modules. Therefore no external star point is required.



Set-up DEWESoft as follows:

1) Channel setup:

3 voltages and 3 currents are connected (U1, I1, U2, I2, U3 and I3):



The 3 currents are measured by "Shunt 2" (0,1Ohm).

Channel setup for channel 1 DAQP-LV SNr:332757 Rev:100

Channel settings

General **Sensors** **General** **Info**

Channel name: I1
Units: A
Color:
Min value: Auto Max value: Auto
Sample rate divider: 1 Skip

Measurement: Current
Range: 10 A
Lowpass filter: 3 kHz
Lowpass type: Bessel
Coupling: DC
Input type: Bipolar
External shunt: Shunt 2 Imax = 5 A
Resistor [ohm]: 0,1 Pmax [watt]: 2,5

Scaling

by two points by function

☒ Scale (k factor)
☐ Sensitivity

1 A / A
Offset (n factor): 0 A
Set zero

Output = k * Input value + n

Input value Scaled value

10 A 10 A
0,0006 A 0,0006 A
0,0000 A 0,0000 A
-0,0006 A -0,0006 A
-10 A -10 A

Block size: 0.1 s 1 s

Average AC RMS Min / Max

Ok Cancel

For a easier selection of measurement ranges and filters you can use the AUTORANGE function.

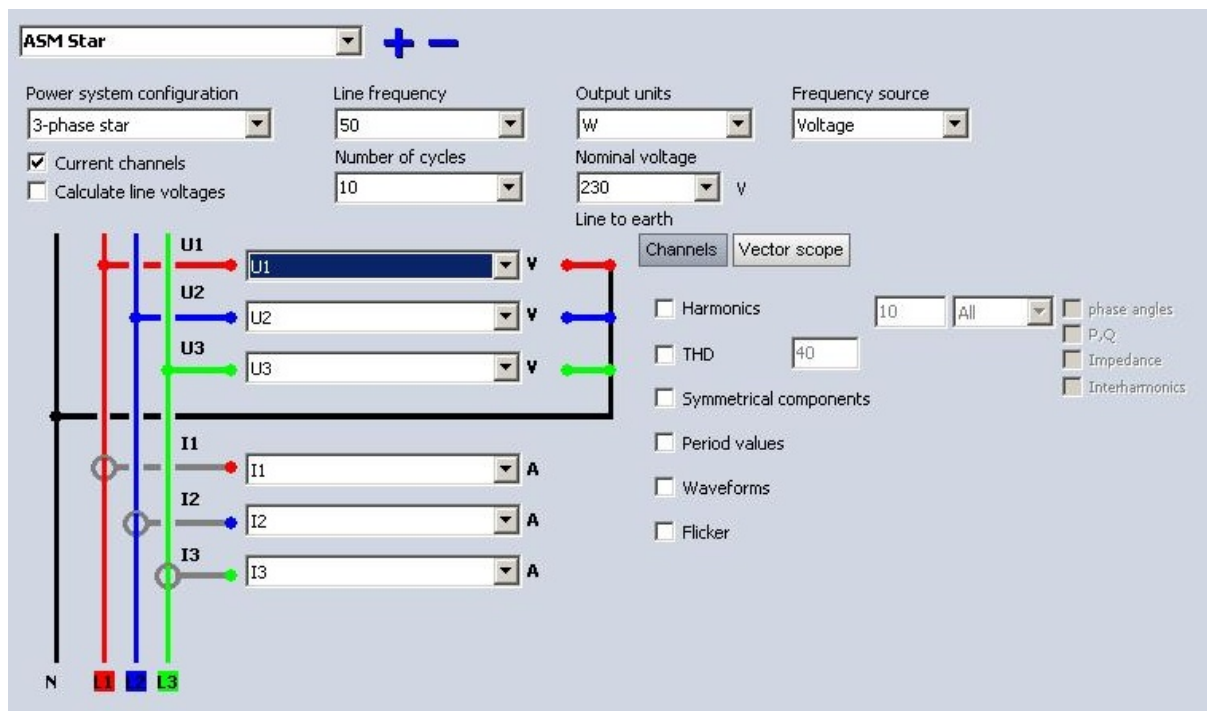
Typical sampling rates for network measurements: 10 kHz at normal harmonic loading.

Appropriate filter settings: at 10 kHz sampling rate you should use 3 kHz filter.

If faster processes analyzed (e.g. transient phenomena) choose a correspondingly higher sampling rate and filter.

2) Power module

Power module setup:



3-phase measurement in star connection with current measurement



In this example, the asynchronous machine operates directly on the grid. Therefore the nominal frequency is the main frequency (line frequency 50 Hz).

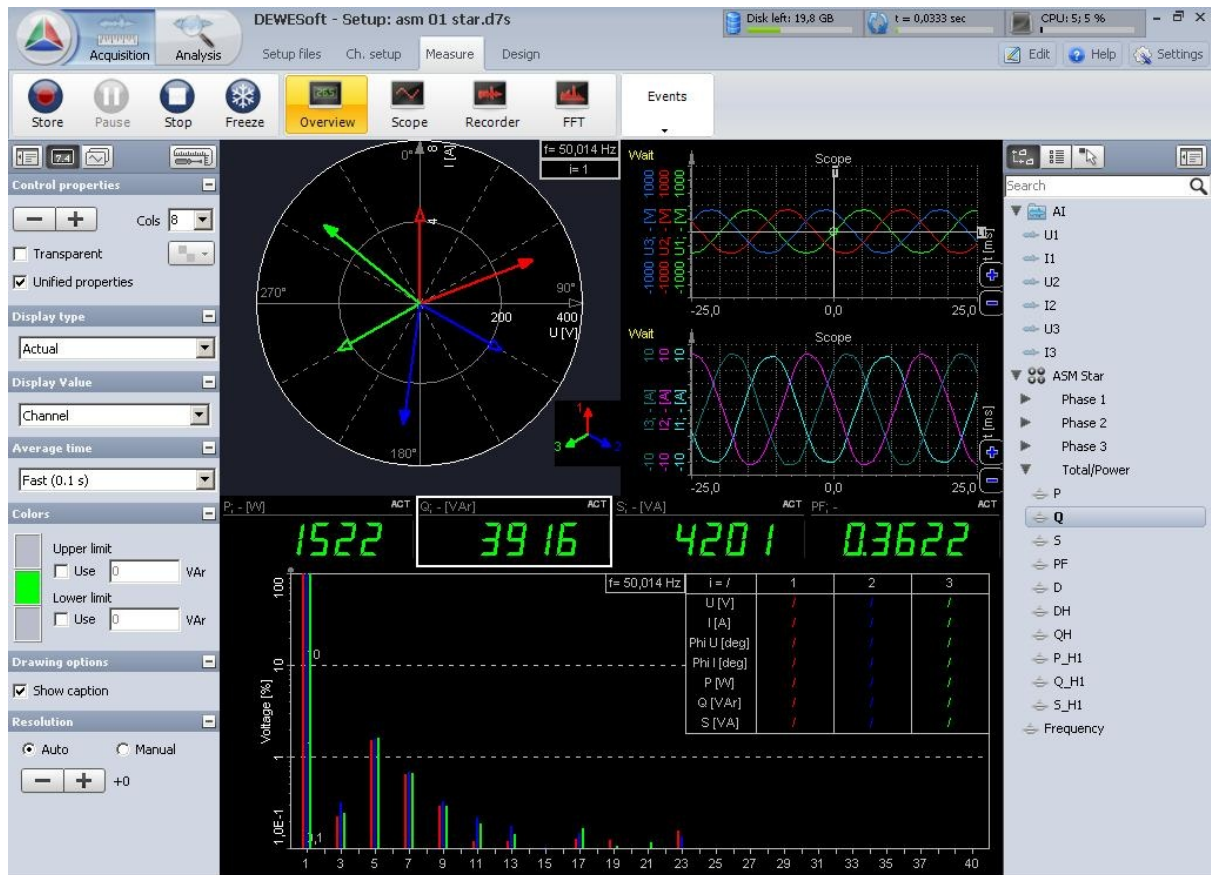
If the machine is operated at a variable frequency, then select "variable".



The main points are already set.

3) Measuring

If you switch now to the measurement mode, you will see the power levels. The screen shows a structure with Vector Scope, oscilloscope, harmonics display and in the middle of the numerical representation of P, Q, S and the power factor PF.



Two specific features of DEWESoft be mentioned at this point:

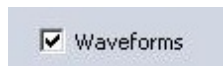
Measuring Star and calculate the phase voltages (waveforms)

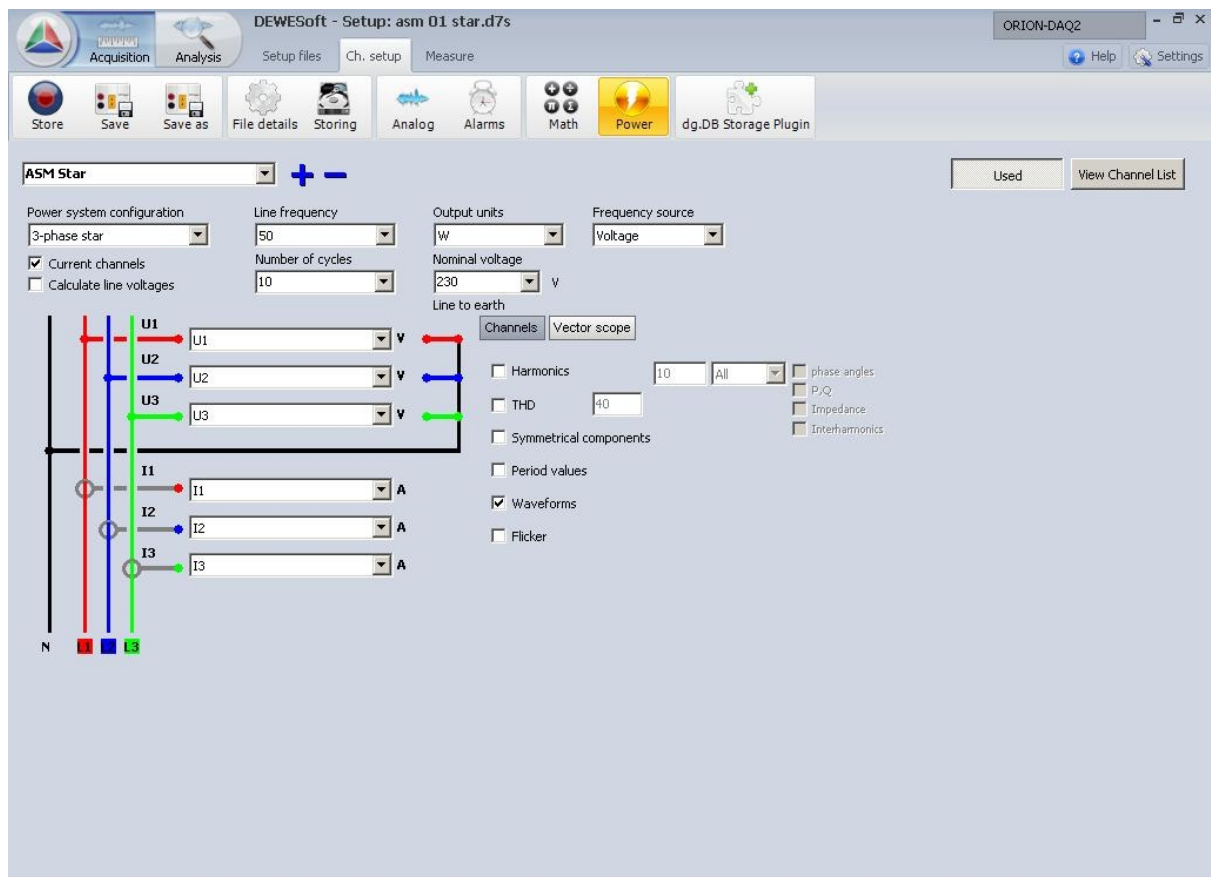
Measuring Star and calculate the harmonics of Star and Delta

3.1.1.1.1 Represent line voltages

If you select "Waveforms" than the phase values U12, U23 and U31 be calculated with the Star values U1, U2 and U3.

The calculation is done directly from the waveform.

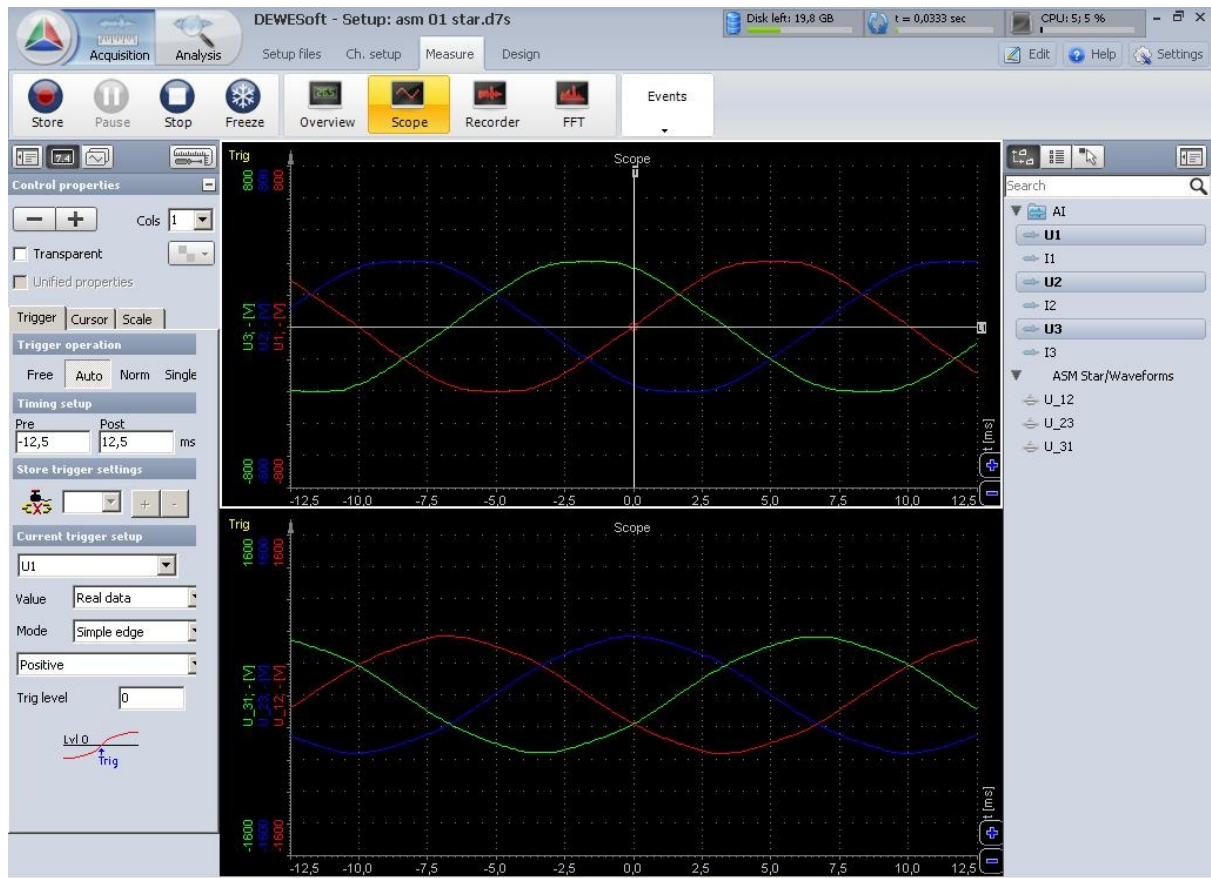




In the measurement mode now the line voltages in addition to the analog inputs are available in the oscilloscope.

The following figure shows the phase voltages (upper graph) and the line voltages (lower graph).

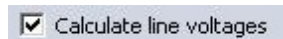
Typical is the flattening of the sine wave of phase voltages (upper graph) and the pointed sine wave of the line voltages (lower graph).

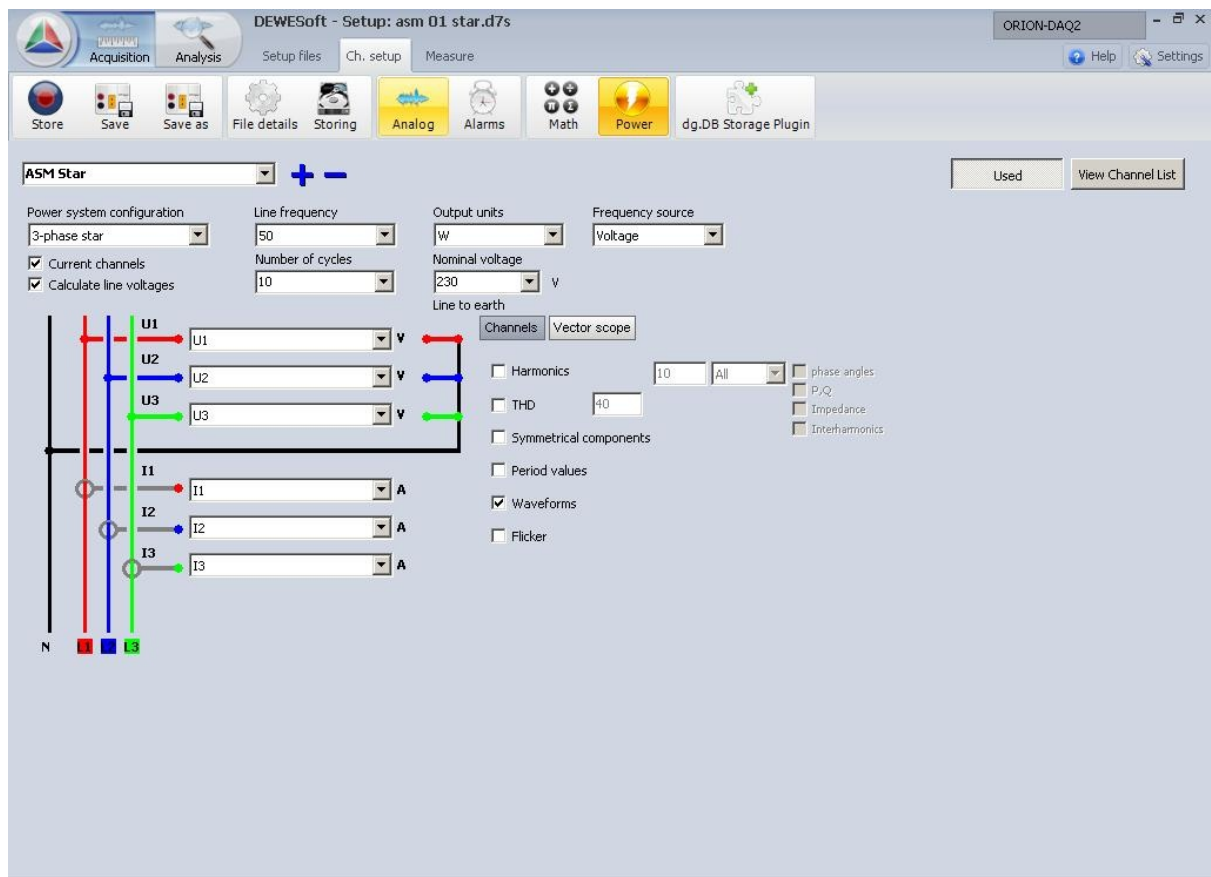


The line voltages U12, U23 and U31 can now be used in other DEWESoft functions e.g. trigger, math, alarm and so on.

3.1.1.1.2 Calculate line harmonics

If the option "calculate line voltages" is selected the harmonics and RMS calculation is also made for the line voltages. The calculation is carried out using the corrected frequency response harmonics (very accurate).



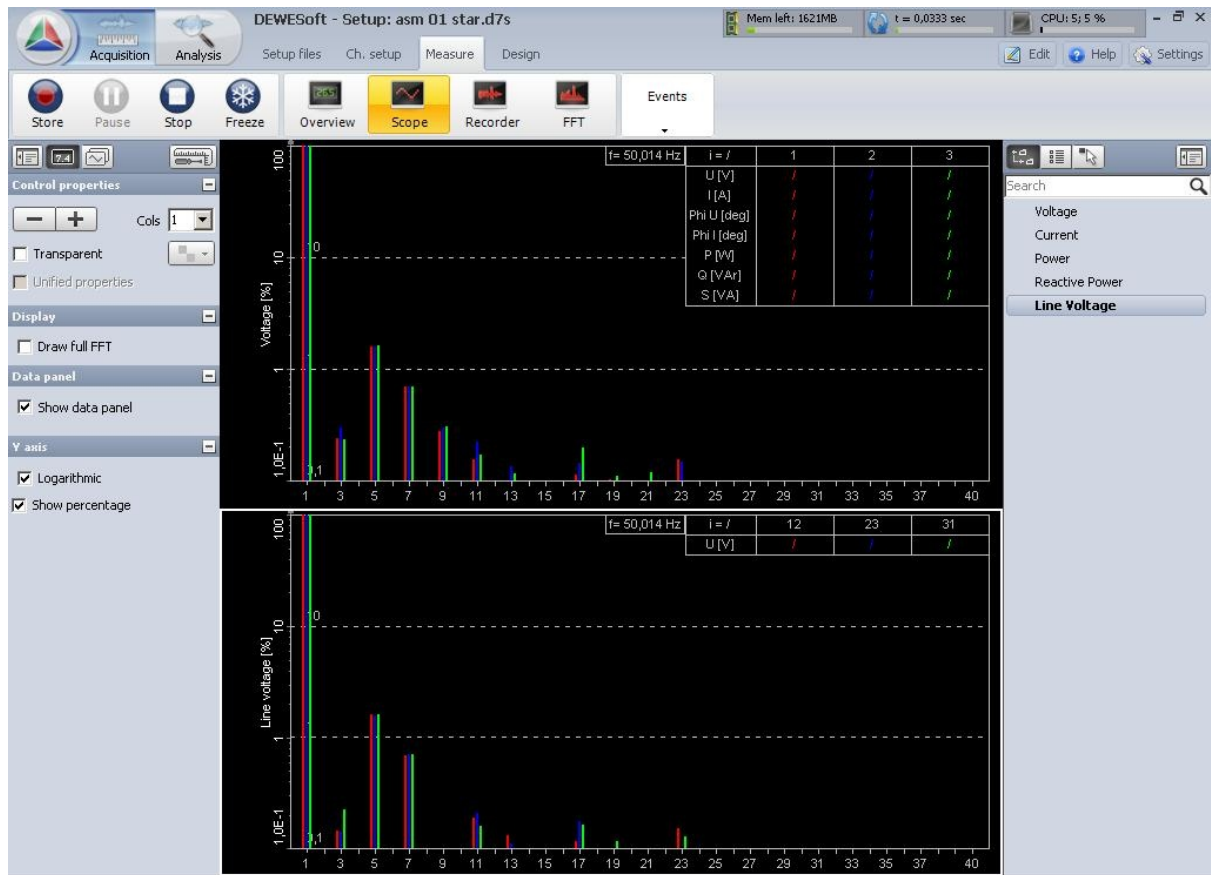


Now the harmonics related to the line voltages are available in the FFT-window.

The picture below shows the phase harmonics (upper graph) and the line harmonics (lower graph).

Typically, the almost extinction of the zero-phase-sequence-system harmonics (3, 9, 15 and so on) in the line view.

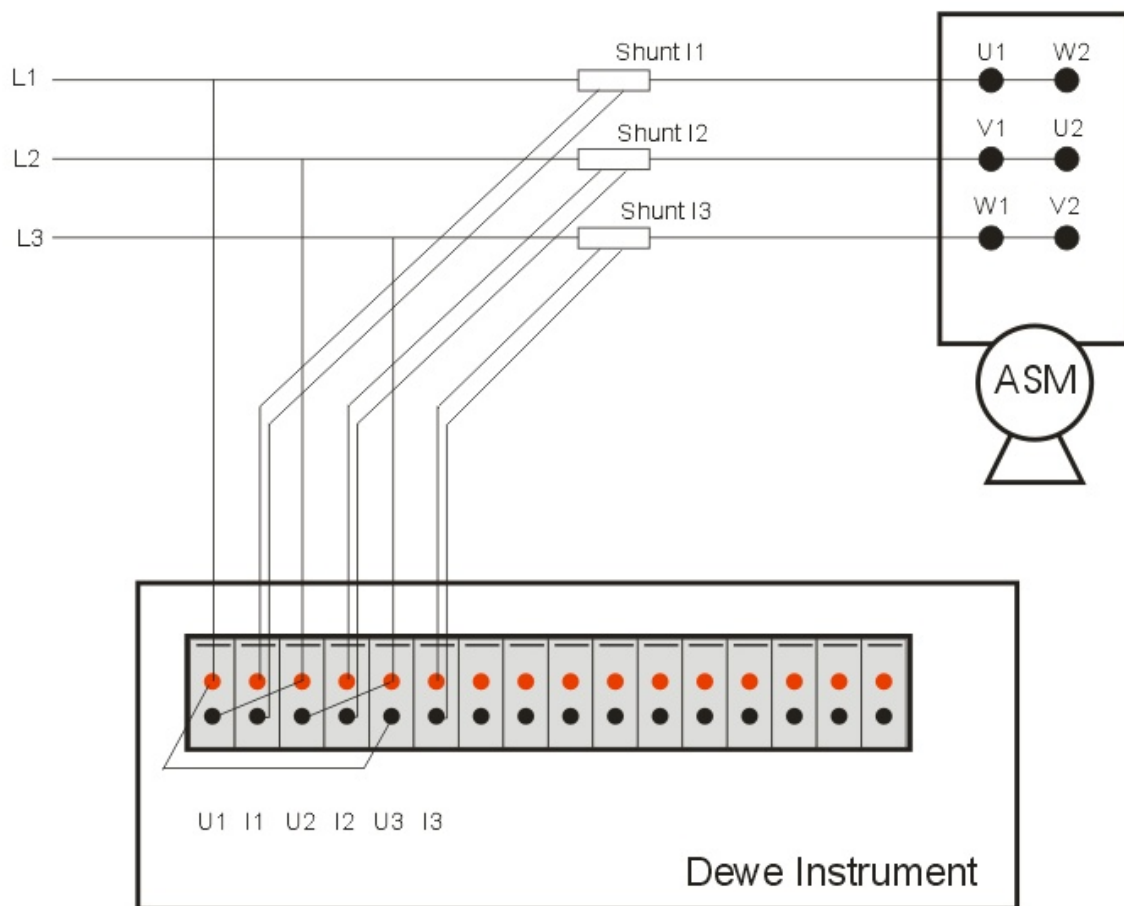
(zero-phase-sequence-system can not formed in Delta-system, no neutral existing)



Each harmonic and RMS value of the line voltages are available in DEWESoft at all modules and can be used in recorders, math or as numeric values.

3.1.1.2 ASM on the three-phase-system in Delta connection

Before reading this chapter please read trough ASM in Star connection.



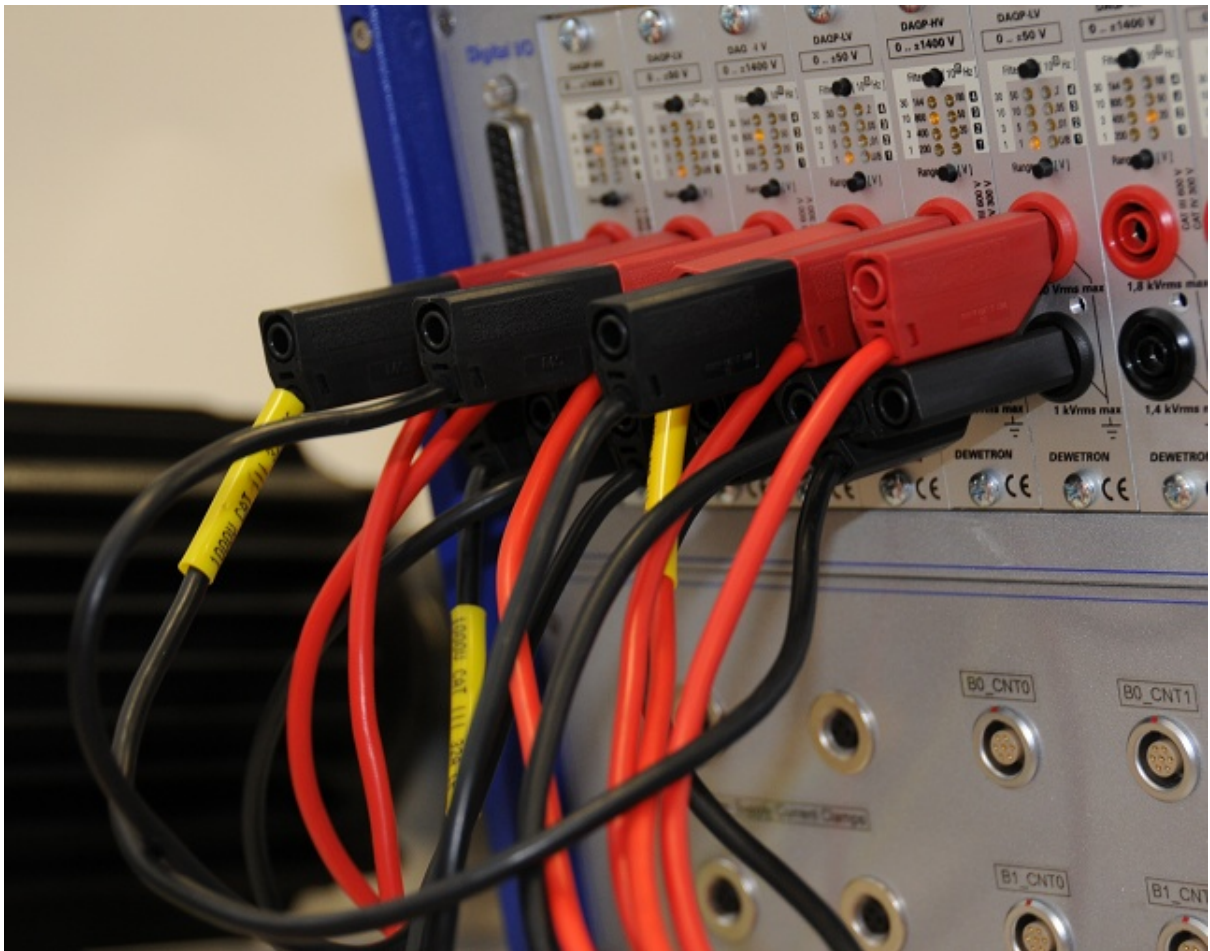
First of all connect the line voltages to the DEWE instrument:

1) Channel setup

The screenshot shows the Dewe Instrument software interface. The top menu bar includes options like Store, Save, Save as, File details, Storing, Analog, Alarms, Math, Power, and dg.DB Storage Plugin. Below the menu bar, there are settings for Dynamic acquisition rate (10000 Hz/ch) and checkboxes for External clock and Start on external trigger. The main part of the interface is a table with columns: SLOT, ON/OFF, C, NAME, AMPLIFIER (004), PHYSICAL VALUES, CAL, and SETUP. The table lists 7 channels, with slots 0 through 6. Slot 0 is used for U12 (DAQP-HV, 800 V ... 3 kHz). Slot 1 is used for I1 (DAQP-LV, 10 A ... 3 kHz). Slot 2 is used for U23 (DAQP-HV, 800 V ... 3 kHz). Slot 3 is used for I2 (DAQP-LV, 10 A ... 3 kHz). Slot 4 is used for U31 (DAQP-HV, 800 V ... 3 kHz). Slot 5 is used for I3 (DAQP-LV, 10 A ... 3 kHz). Slot 6 is unused for AI 6 (DAQP-HV, 20 V ... 3 kHz).

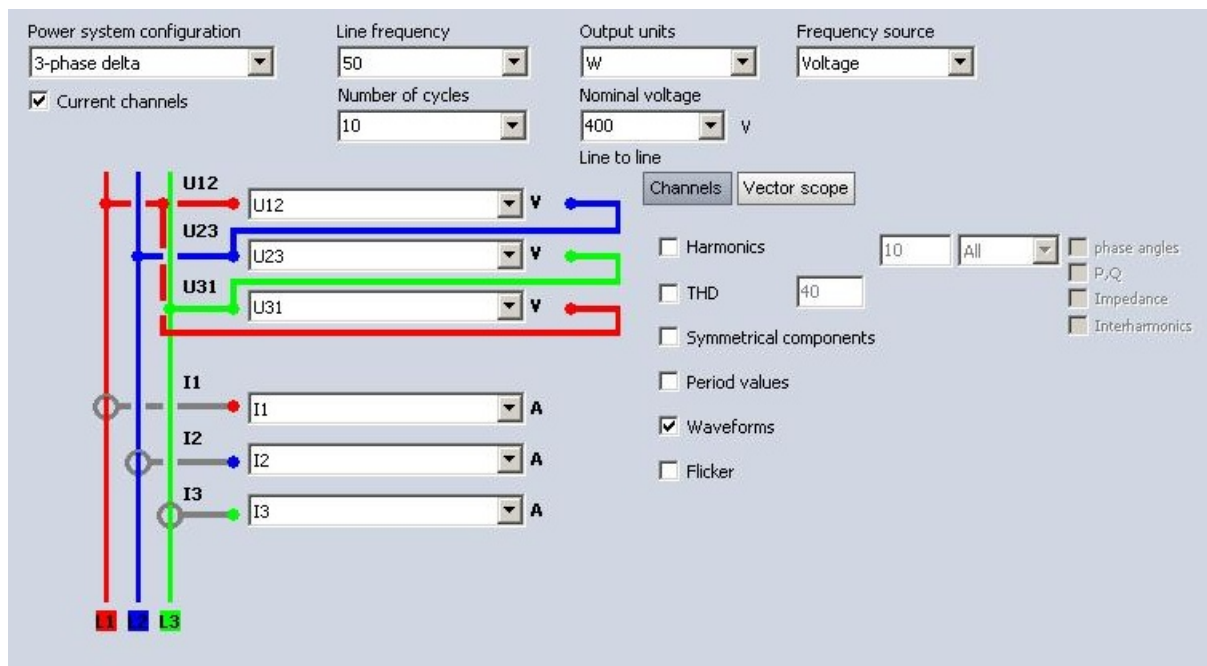
SLOT	ON/OFF	C	NAME	AMPLIFIER (004)	PHYSICAL VALUES	CAL	SETUP
0	Used	Store	U12	DAQP-HV 800 V ... 3 kHz SN: 324354	-582,1 / 581,9 V	Zero	Set ch. 0
1	Used	Store	I1	DAQP-LV 10 A ... 3 kHz SN: 332757	-7,350 / 7,357 A	Zero	Set ch. 1
2	Used	Store	U23	DAQP-HV 800 V ... 3 kHz SN: 334506	-582,3 / 582,0 V	Zero	Set ch. 2
3	Used	Store	I2	DAQP-LV 10 A ... 3 kHz SN: 332758	-8,524 / 8,535 A	Zero	Set ch. 3
4	Used	Store	U31	DAQP-HV 800 V ... 3 kHz SN: 335748	-580,9 / 581,3 V	Zero	Set ch. 4
5	Used	Store	I3	DAQP-LV 10 A ... 3 kHz SN: 332759	-7,875 / 7,865 A	Zero	Set ch. 5
6	Unused	Store	AI 6	DAQP-HV 20 V ... 3 kHz SN: 324348	-0,005 V	Zero	Set ch. 6

The "linkage" of the voltages can be made directly at the instrument.



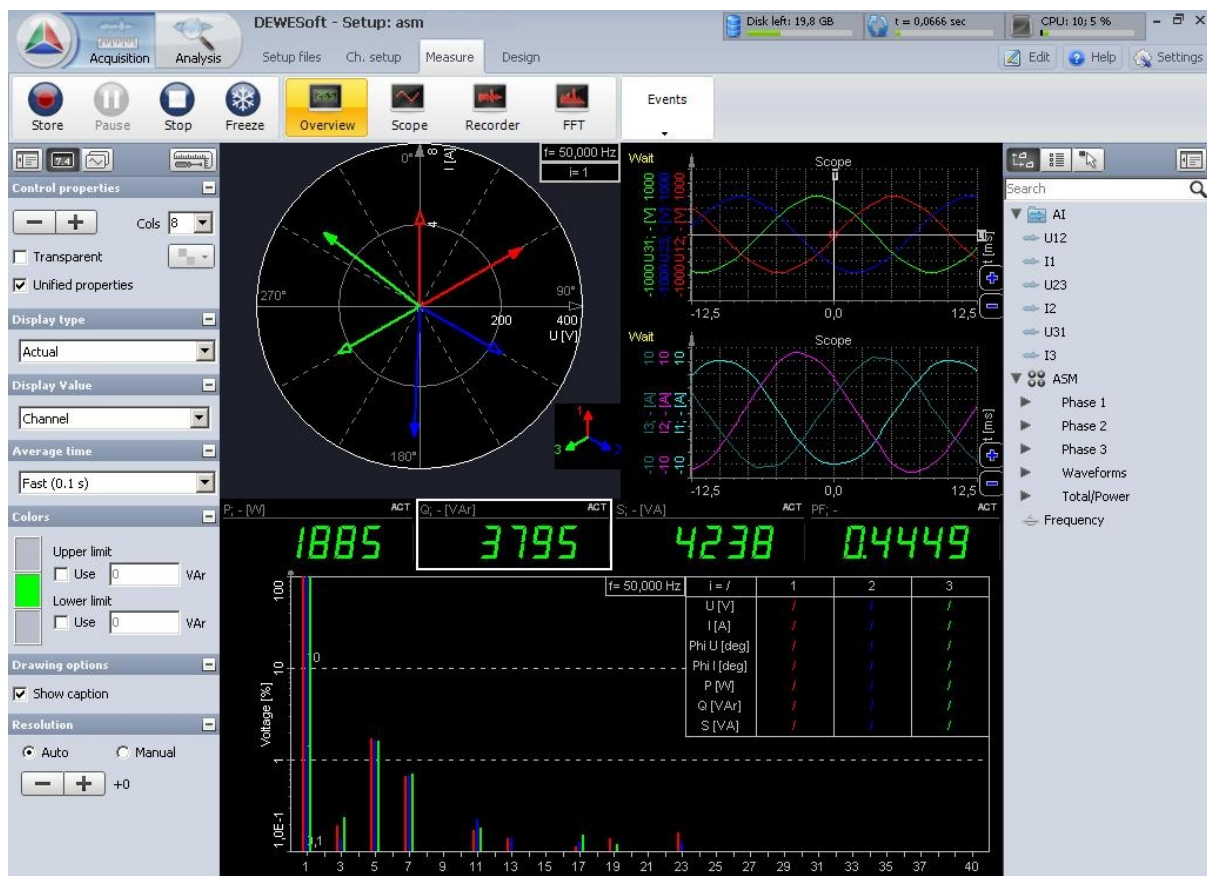
2) Power module

Now please select delta in the power module.



3) Measuring

If you change to the measuring mode, you will see the power levels.



3.1.2 ASM on a converter

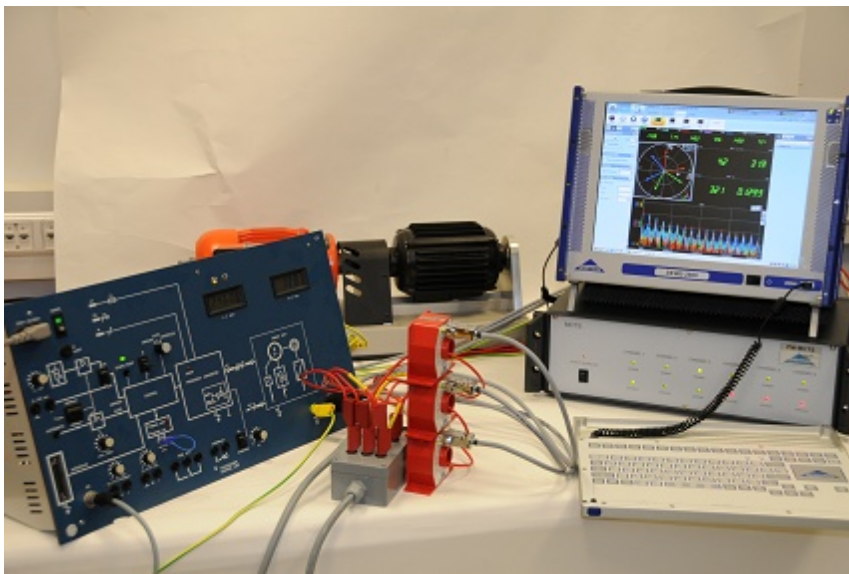
Prerequisite: Chapter ASM on the three-phase-system

DEWE instruments are also suitable for the measurement of pulsed signals, thus also for measurements on motors fed by converters.

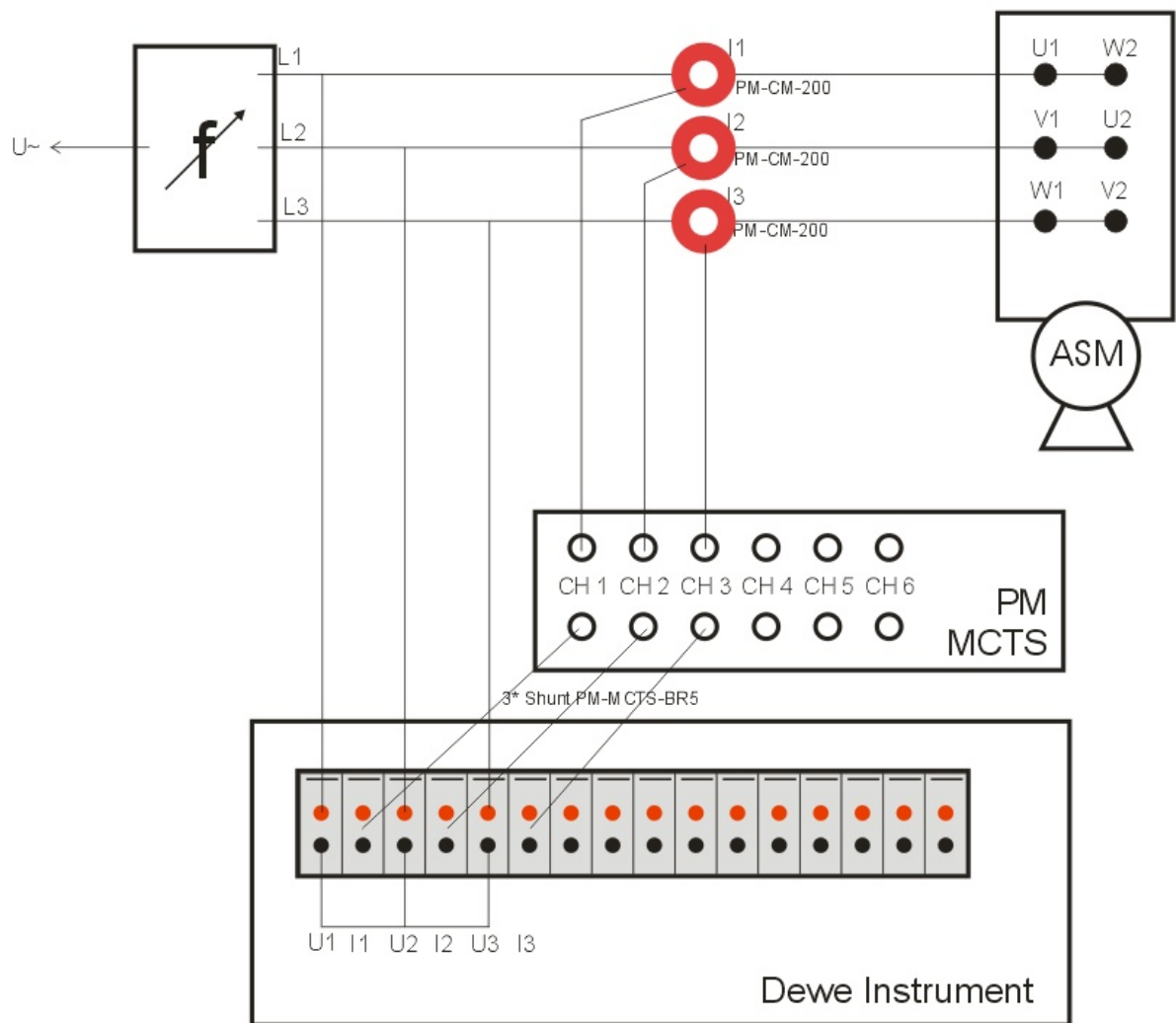
On the one hand a high electrical bandwidth of the input modules is required on the other hand a high sample rate.

Advice: bandwidth $> 20 \cdot \text{frequency of the converter}$

Our example: $f_{\text{converter}} = 25 \text{ kHz} \rightarrow \text{min bandwidth } 500 \text{ kHz} \rightarrow \text{modules with } 2000 \text{ kHz applied.}$



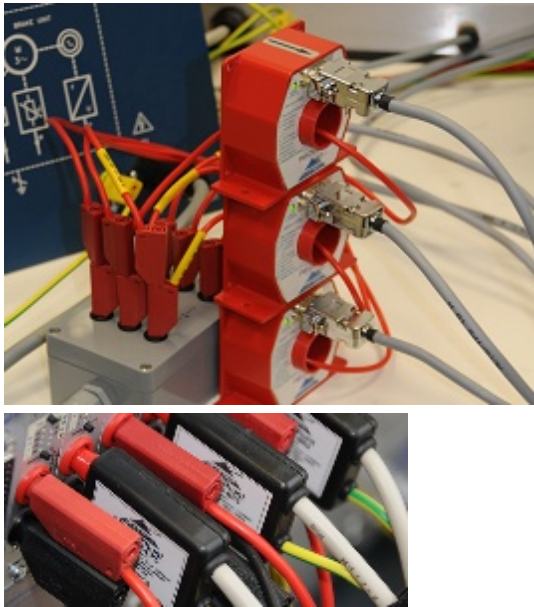
Wiring:



Important: Please connect always in star-connection! The Aron- and V-Connection are not suitable to measure on Converters!

measuring voltage: DAQP-HSI-HV modules (2000 kHz bandwidth, +-1400V input voltage); building star point directly at the modules

current measurement: zero flux transducer, 200A, with shunt

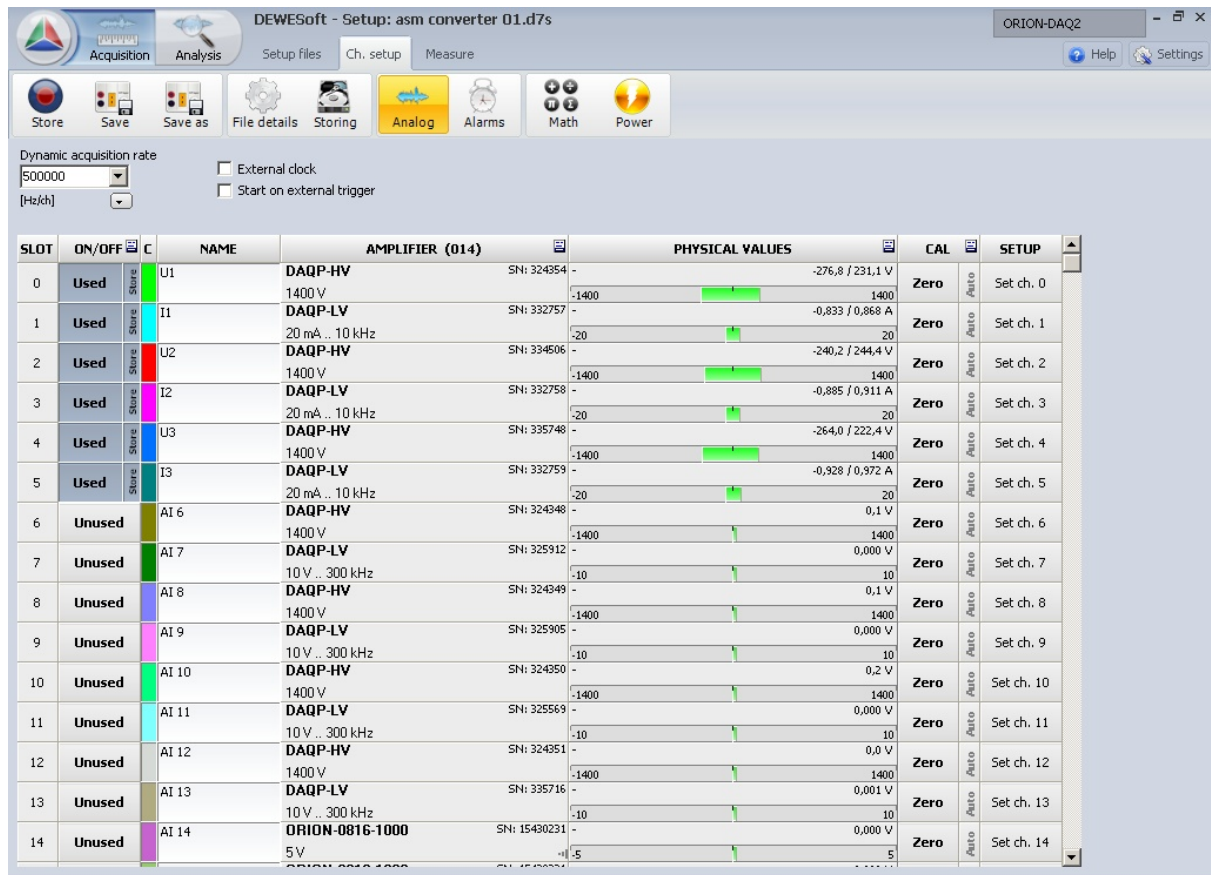


DEWESoft settings:

1) Analogues Setup:



The setting of the measuring channels is done as before (3 voltages and 3 currents):



Look to it that a high acquisition rate is set: 500 kHz

Dynamic acquisition rate

 [Hz/ch]

Advice: If the computing power of your device is not sufficiently you have 4 options:

- lower acquisition rate: the power isn't less accurate, only the RMS values of the voltage is inaccurate.
- lower calculation rate of the power module: like above but the data points still available at full acquisition rate (set "Calculation Sampling Rate" in the power setup).
- Calculation in the post processing, the power module is already preset (Offlinemode).
- Recording raw data, power modules are subsequently added and calculated (Analyzemode).

Set the bandwidth:

as already mentioned, a high acquisition rate for the measurement of voltage is necessary due to pulsed voltages:

Lowpass filter

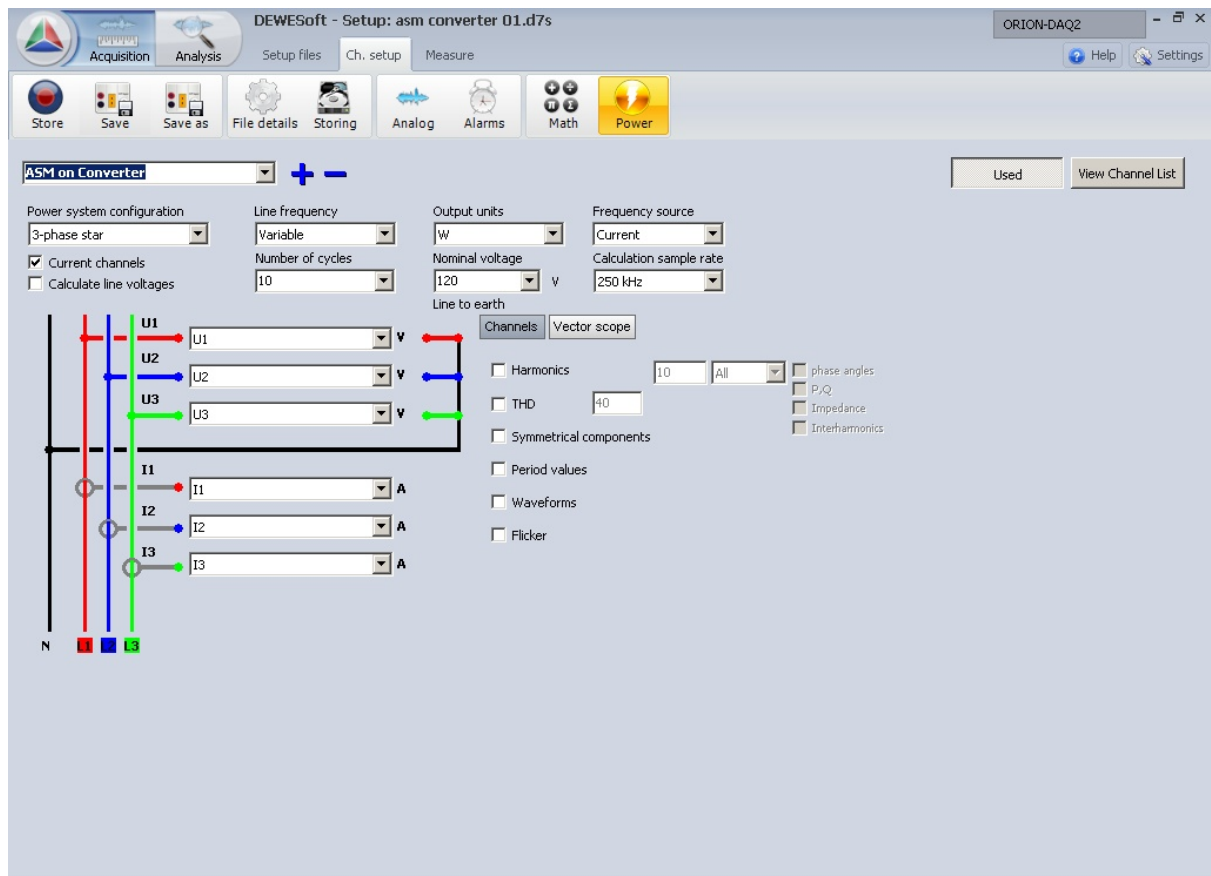
This is not necessary to the measuring of current, because the current is nearly sinusoidal (10 kHz selected).

DAQP-LV
 20 mA .. 10 kHz

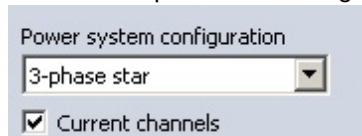
2) Power setup



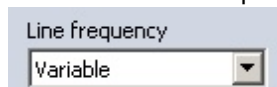
Set-up a 3-phase power module with the proper channels:



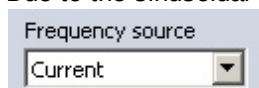
Select the 3-phase star configuration with current measurement:



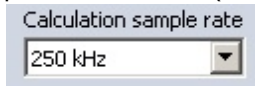
Select a variable frequency("variable"):



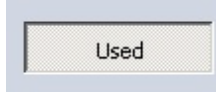
Due to the sinusoidal current the current should serve as frequency source:



If the computer power of your device does not sufficient, then you can reduce the sample rate for the power-calculation (see advice above):



Set the power module to "USED", to enable the power-calculation.



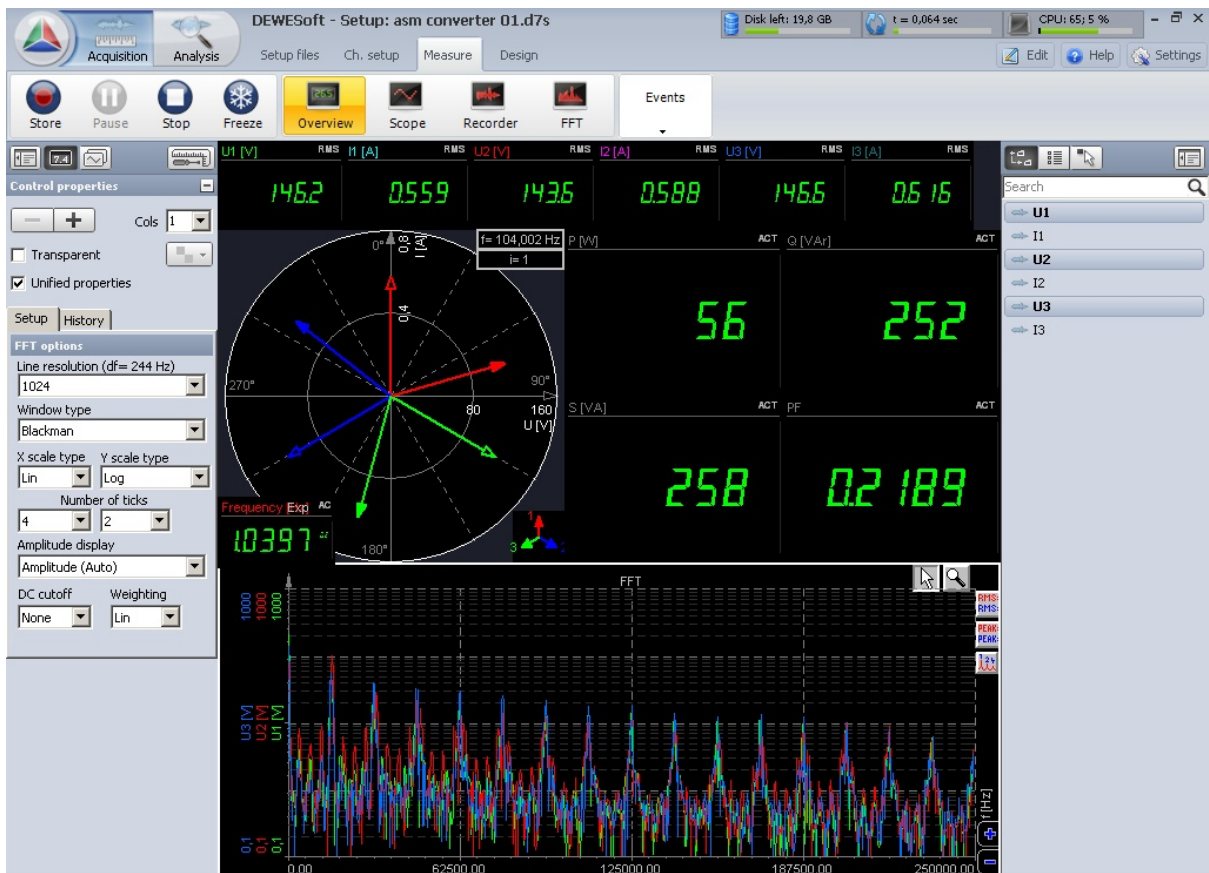
Advices for the calculation after measuring (UNUSED) you will find in the chapters offlinemode and calculation in analyzemode.

3) Measuring:

now change to measuring mode and set up the screen for your own needs:

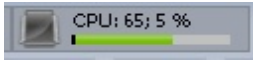
Example:

- display of voltages and currents as numeric values at the top of screen.
- vektorscope on the left.
- power levels (P, Q, S, PF) on the right.
- FFT of the voltages below (up to 250 kHz).
- frequency middle left.



Important is to control the performance of your computer (top right).

If the CPU-performance will reach the red zone, then reduce screen elements or try one of the advices above.



Depending on the task, it may also be necessary to measure rpm and torque.

Advices for the efficiency calculation you will find in chapter efficiency calculation.

3.1.2.1 Offline mode

Prerequisite: Chapter ASM on a converter .

In this chapter you will learn how to calculate values in the analyze-mode. The settings are already done in the measuring-mode.

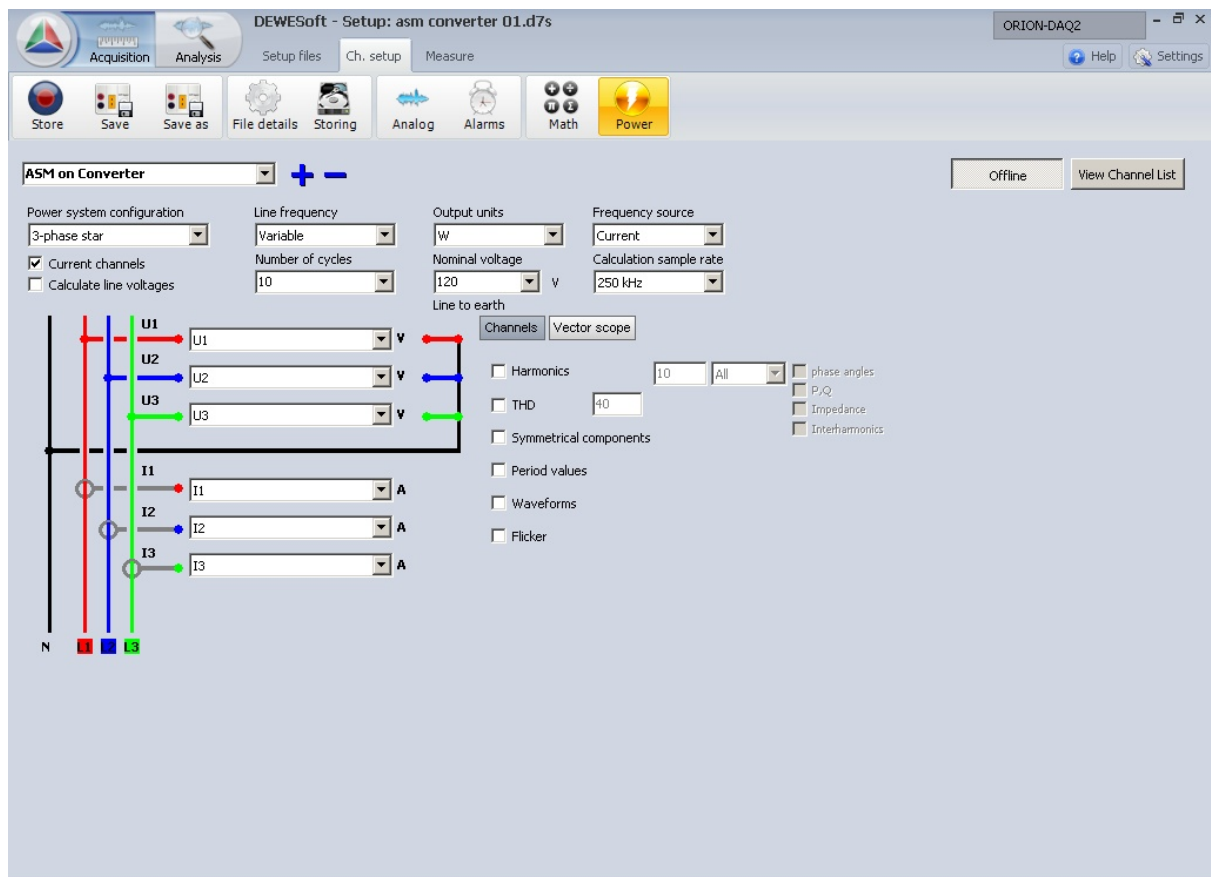
Used for:

- reduce the data volume.
- reduce computing power.

1) Analogue setup: as before

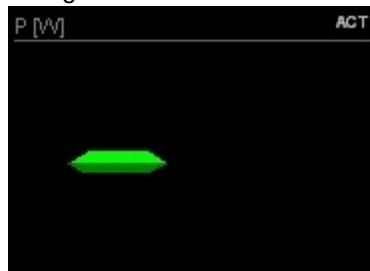
2) Power setup: as before, but set the power module to "OFFLINE" (top right).

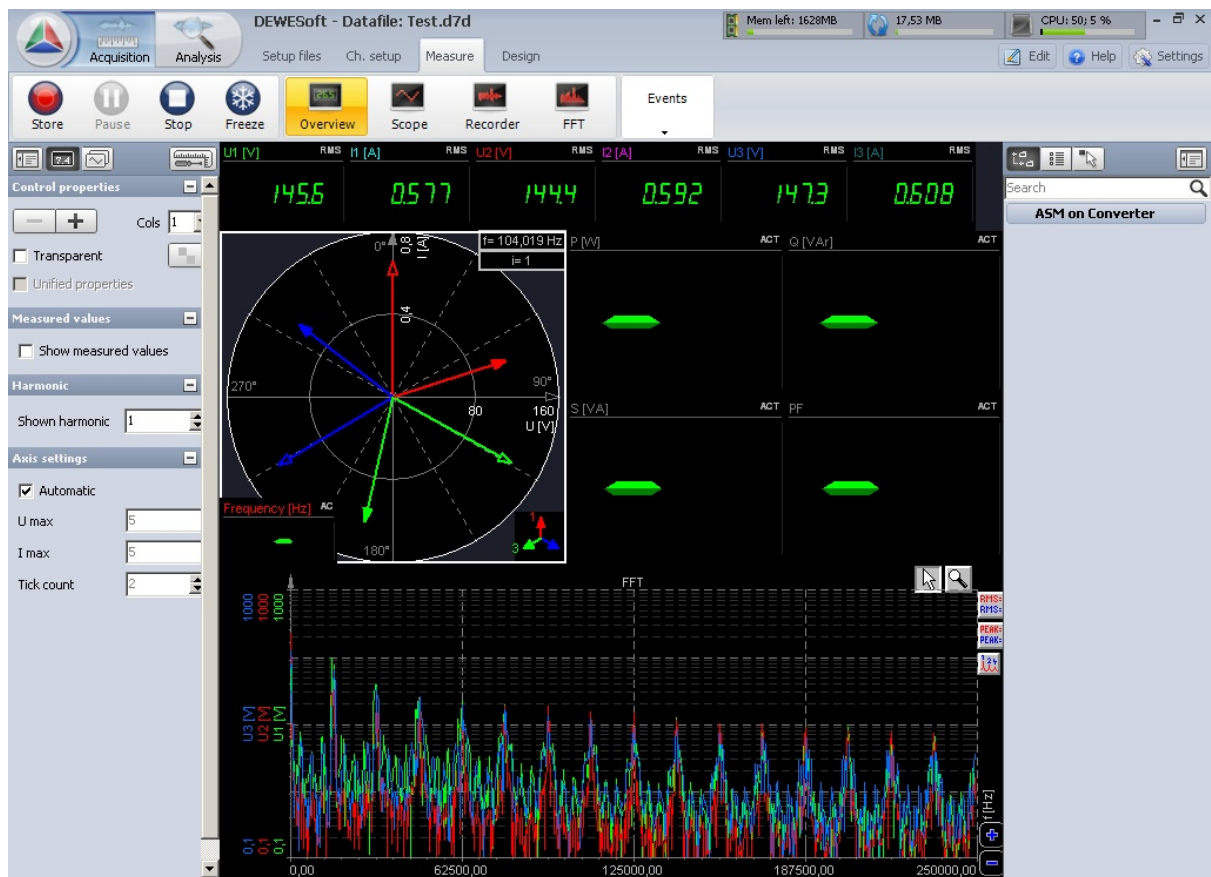




3) Measuring

during the measurement the values of the power module will not be calculated or output:





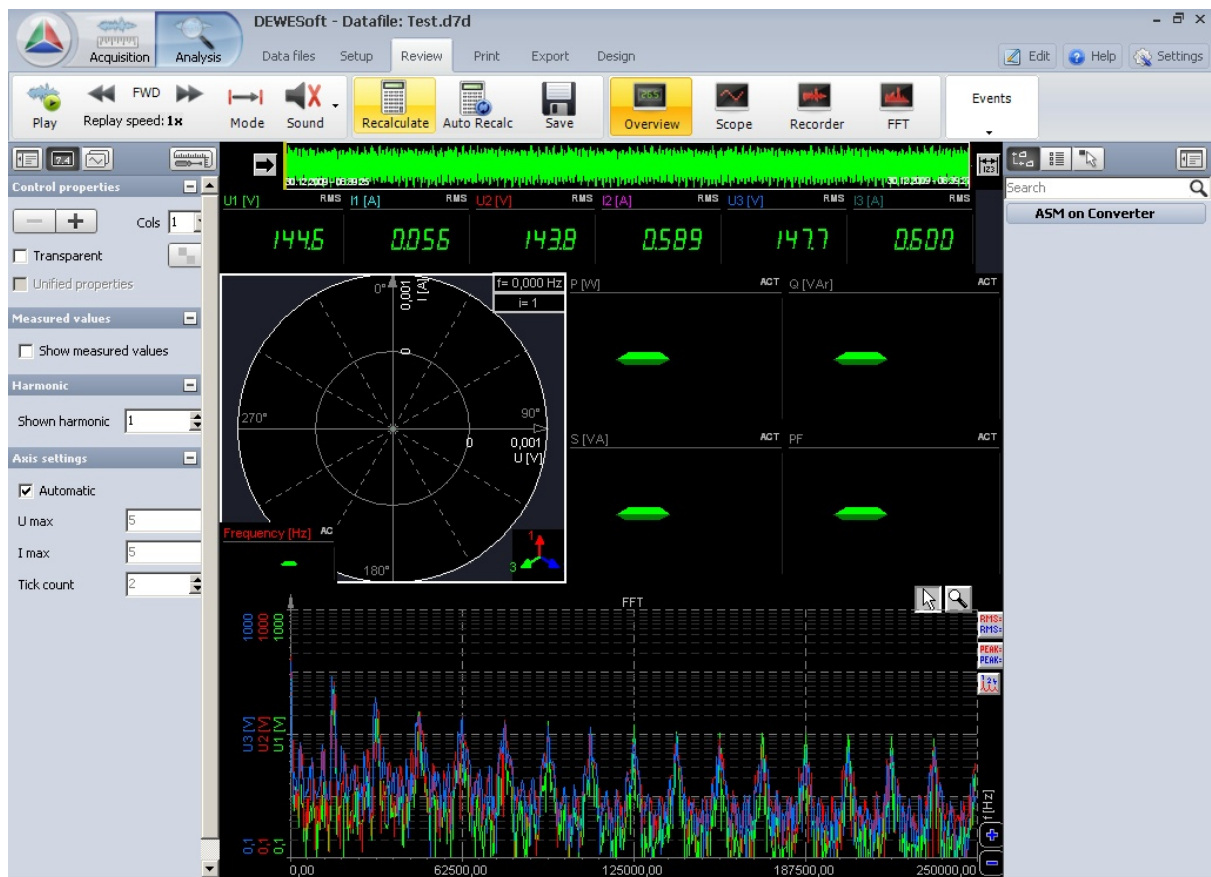
Now run a measurement and store the data.

Note: only data which were recorded with full sample rate can be calculated later.

4) Change to analyze mode:



Data now available in raw form. The power values are not available yet.

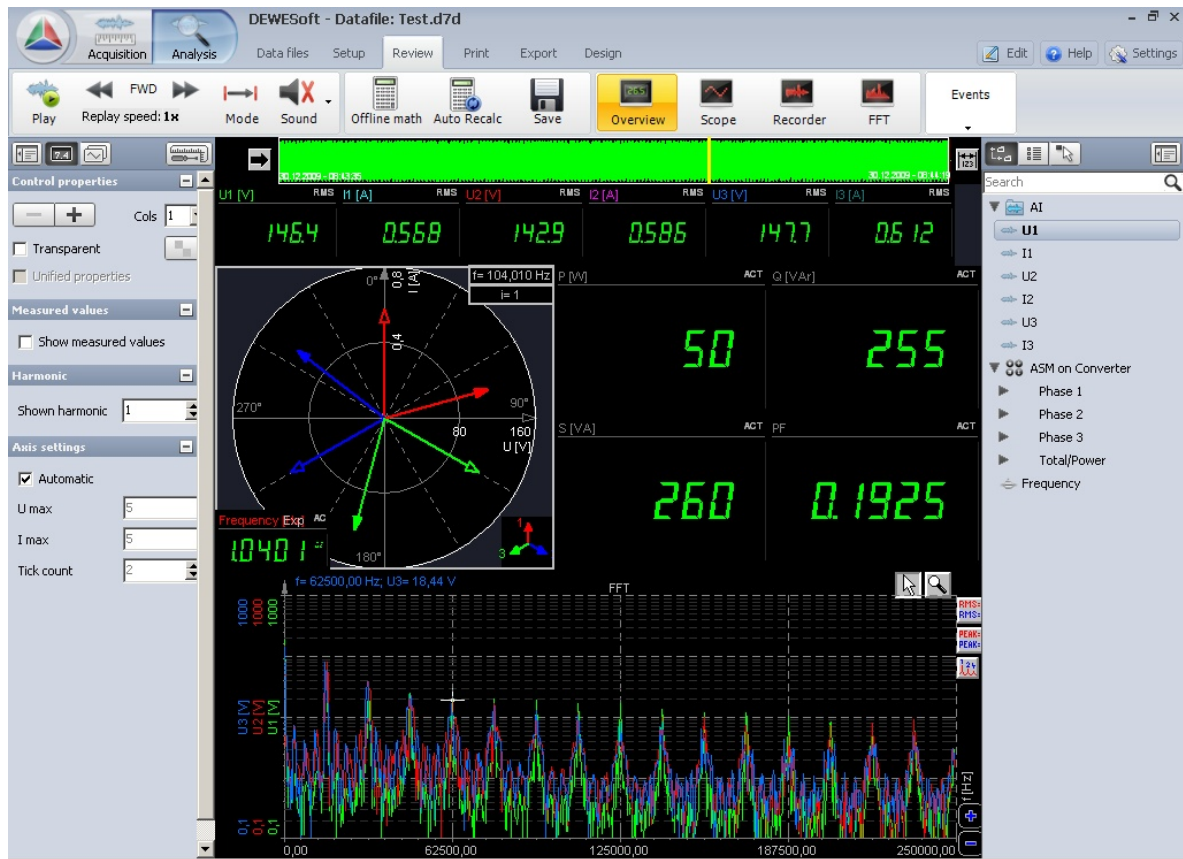


Now click "Recalculate"



The power values be calculated.

Advice: only the zoomed area will be calculated.



After the calculation you can store the values in a data file(a dialog appears when you close the file).

3.1.2.2 Calculation in analyze mode

Prerequisite:

Chapter ASM on a converter

Chapter Offline mode

This chapter will show, how to run a calculation with raw data.

Used for:

- highest acquisition rates or streaming data without any calculation.
- reduce the data volume.
- reduce the computing power.
- full flexibility, but higher effort, because no screens can be predefined.

1) Setup: as before

DEWESoft - Setup: asm converter 02.d7s

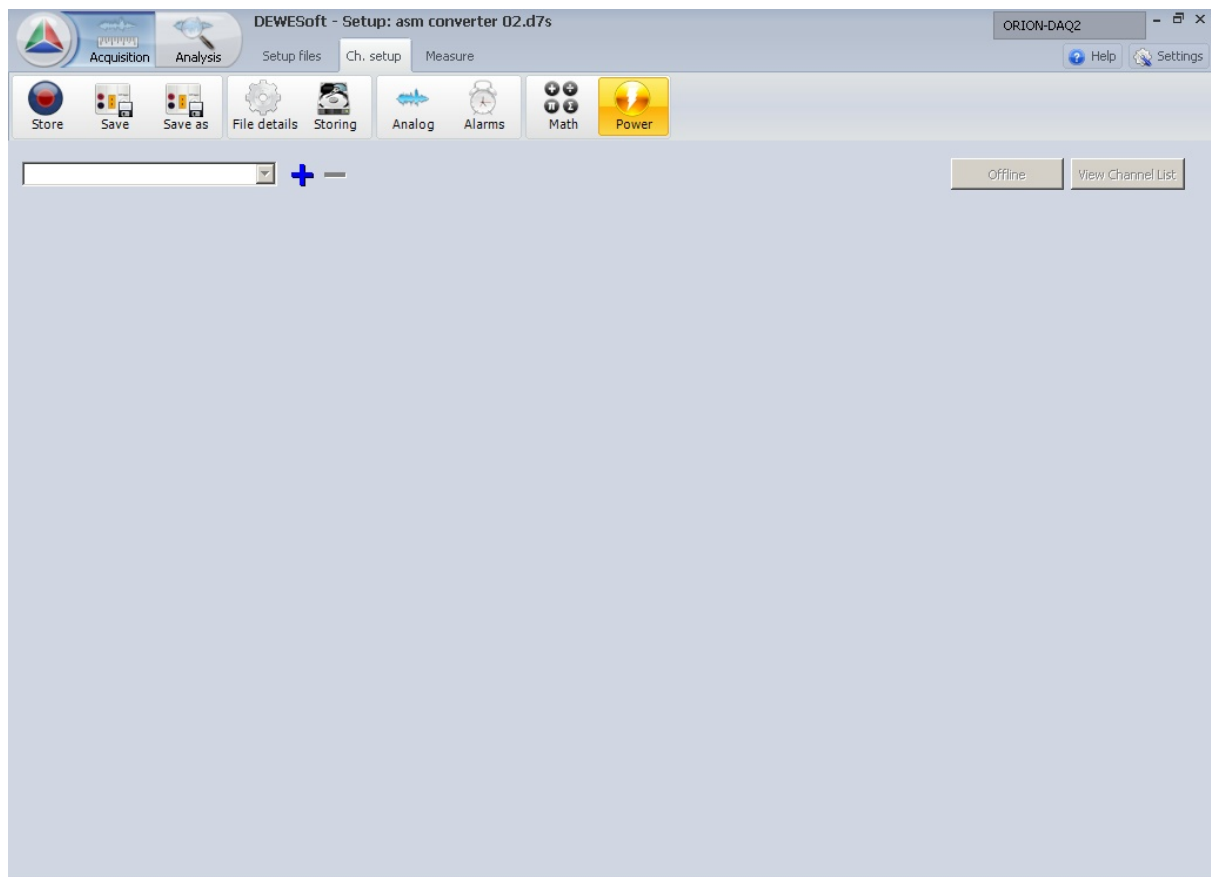
ORION-DAQ2

Dynamic acquisition rate: 500000 [Hz/kh]

☐ External clock
☐ Start on external trigger

SLOT	ON/OFF	C	NAME	AMPLIFIER (003)	PHYSICAL VALUES	CAL	SETUP
0	Used	U1	DAQP-HV	SN: 324354	0,2 V	Zero	Set ch. 0
			1400 V		-1400		
1	Used	I1	DAQP-LV	SN: 332757	-0,005 A	Zero	Set ch. 1
			20 mA .. 10 kHz		-20		
2	Used	U2	DAQP-HV	SN: 334506	0,1 V	Zero	Set ch. 2
			1400 V		-1400		
3	Used	I2	DAQP-LV	SN: 332758	-0,003 A	Zero	Set ch. 3
			20 mA .. 10 kHz		-20		
4	Used	U3	DAQP-HV	SN: 335748	0,0 V	Zero	Set ch. 4
			1400 V		-1400		
5	Used	I3	DAQP-LV	SN: 332759	-0,002 A	Zero	Set ch. 5
			20 mA .. 10 kHz		-20		
6	Unused	AI 6	DAQP-HV	SN: 324348	0,1 V	Zero	Set ch. 6
			1400 V		-1400		
7	Unused	AI 7	DAQP-LV	SN: 325912	0,000 V	Zero	Set ch. 7
			10 V .. 300 kHz		-10		
8	Unused	AI 8	DAQP-HV	SN: 324349	0,1 V	Zero	Set ch. 8
			1400 V		-1400		
9	Unused	AI 9	DAQP-LV	SN: 325905	0,000 V	Zero	Set ch. 9
			10 V .. 300 kHz		-10		
10	Unused	AI 10	DAQP-HV	SN: 324350	0,2 V	Zero	Set ch. 10
			1400 V		-1400		
11	Unused	AI 11	DAQP-LV	SN: 325569	0,000 V	Zero	Set ch. 11
			10 V .. 300 kHz		-10		
12	Unused	AI 12	DAQP-HV	SN: 324351	0,0 V	Zero	Set ch. 12
			1400 V		-1400		
13	Unused	AI 13	DAQP-LV	SN: 335716	0,001 V	Zero	Set ch. 13
			10 V .. 300 kHz		-10		
14	Unused	AI 14	ORION-0816-1000	SN: 15430231	0,000 V	Zero	Set ch. 14
			5 V		-5		

NO Power module is created



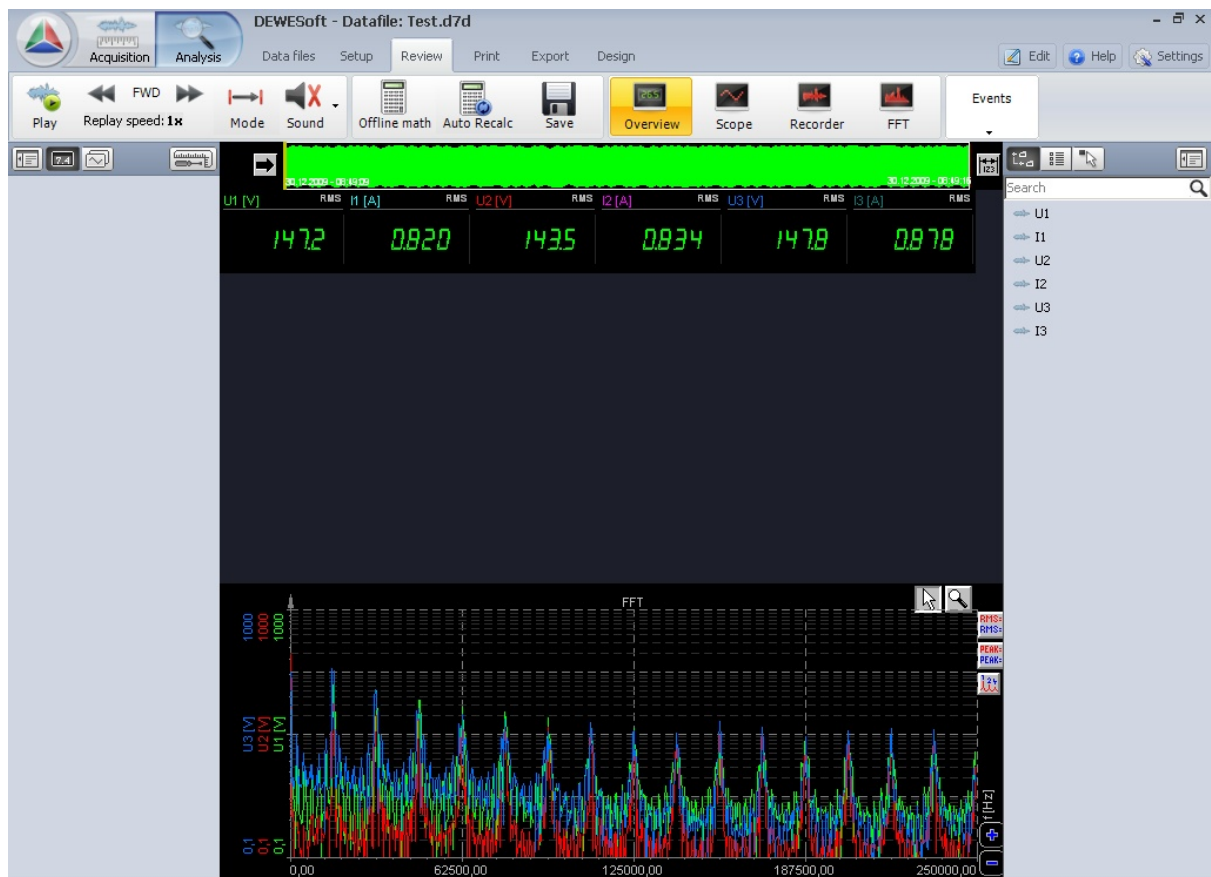
2) Measuring

Run a measurement and store the data (be sure to use the full acquisition rate).

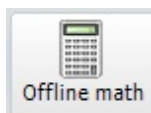
3) Analyze



On the screen there are no power values or placeholder for it.

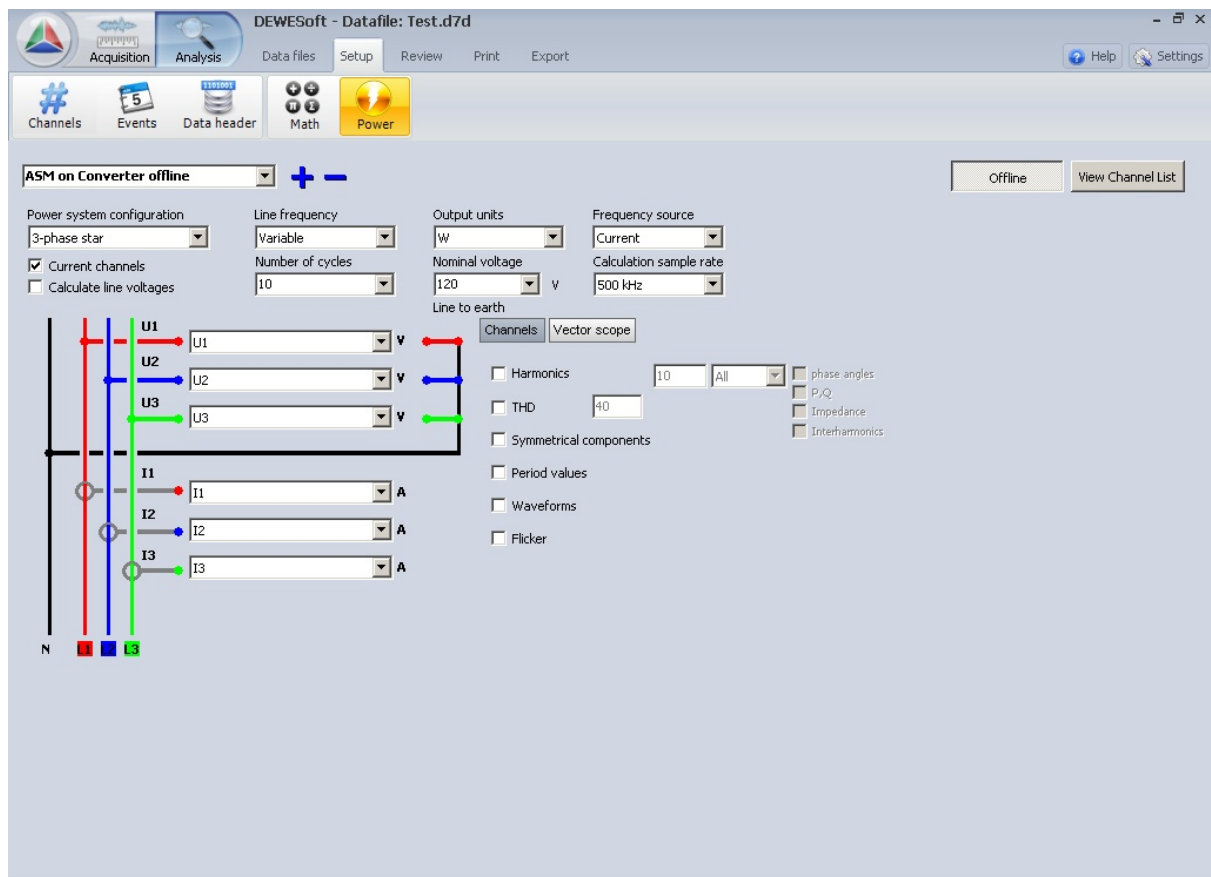


No change to "Offline math"

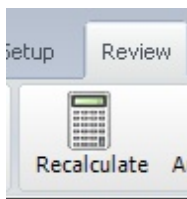


Set-up a power module as done before and assign the channels.

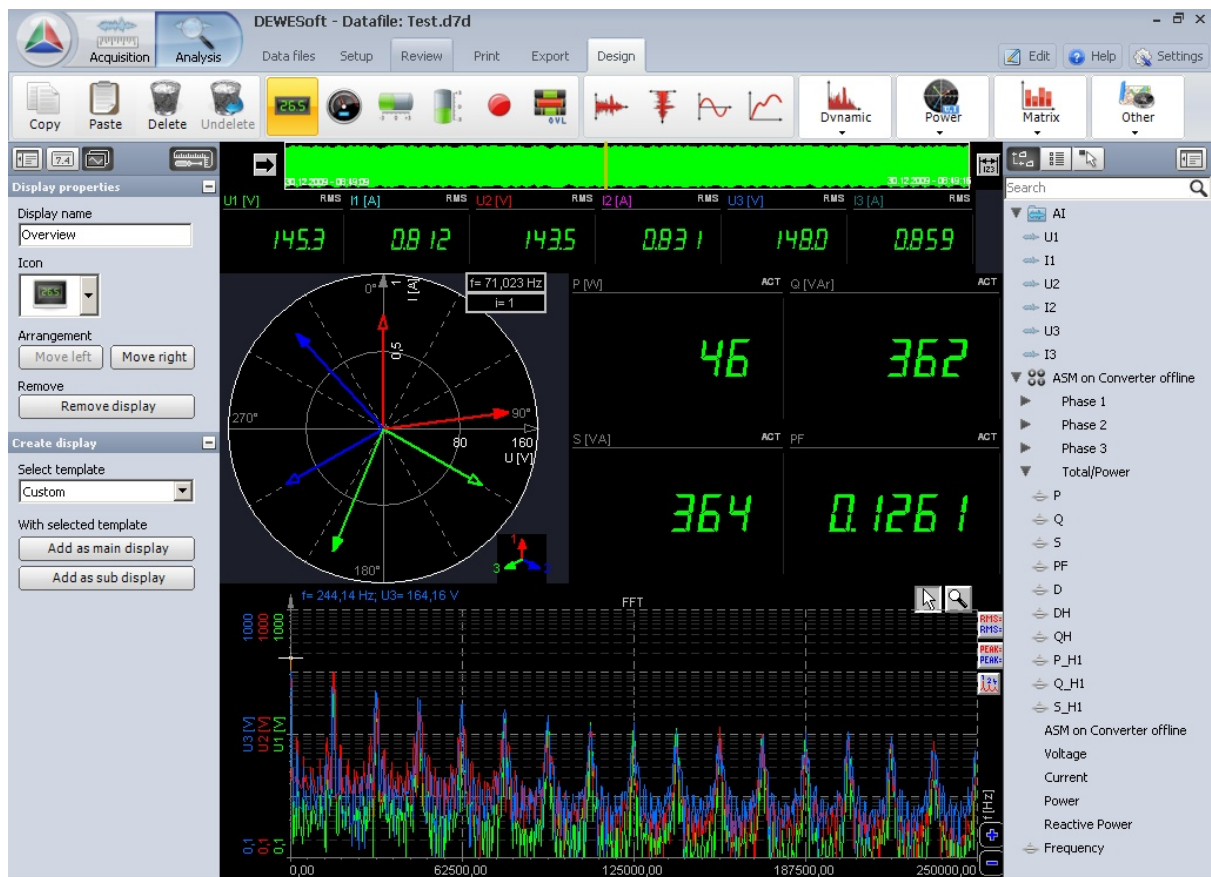




Change to "Review" tab and click "Recalculate"



From now on, the power values are available and you can complete the screen.



Advice: only the zoomed area will be calculated.

After the calculation you can store the values in a data file(a dialog appears when you close the file).

3.1.3 E-Mobility Measurement

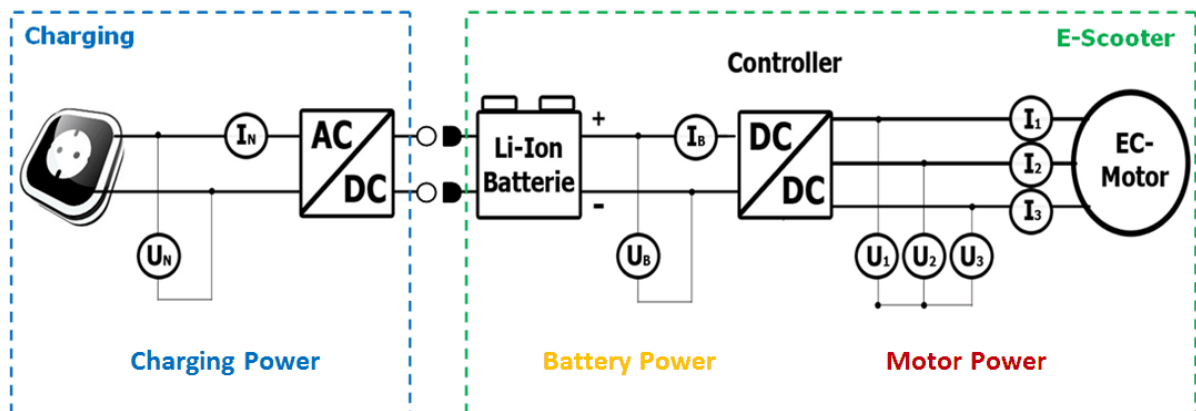
Aim of this chapter is to determine the energy balance of the E-Scooter „EMCO NOVUM“ (emco electroroller Ltd).



The E-Scooter is powered via a brushless DC motor with a nominal power of 3000 Watts. The used battery is a lead-acid battery with 1920 Wh.

The following parameters should be calculated:

- charging energy and power
- battery energy and power for consumption and recuperation
- motor energy and power for consumption and recuperation
- Efficiency: Controller to motor, battery to motor, tank to wheel
- EMC of battery charger
- Webcam for comprehensive analysis



DC - power:

For the DC-power measurement see Chapter Direct Current Power Measurement

AC - power:

For the AC-power measurement configuration see Chapter ASM on a converter.

Important: Use "Variable" as line frequency and "Current" as frequency source.

The switching frequency of the controller is 16 kHz. So we selected a calculation rate in the power

module of 320 kHz.

Energy calculation:

For the calculation of the energy consumption and recuperation see chapter Energy Calculation

For the calculation of the efficiency see chapter Efficiency Measurement

Webcam:

For the connection of a Webcam see Chapter Connection of a Camera

Charging Power:

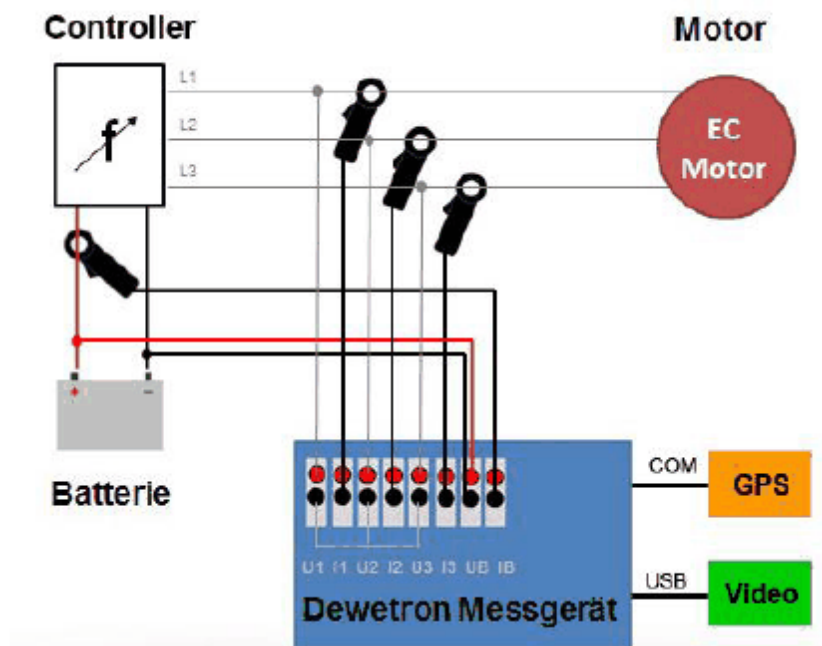
To measure the charging power see Chapter Single-Phase Power Measurement

For the determination of Harmonics enable Harmonics in the Power module.

GPS:

For the connection of GPS see Chapter Connection of GPS

Measurement configuration



Visualization:



3.2 Power Quality Reports

POWER QUALITY MEASUREMENT is the measuring of various voltage parameters, that are relevant to assessing the quality of supply.

These parameters are:

- Waveform
- Frequency
- Harmonic
- THD
- Flicker
- Voltage drops

Beyond it, by the assessment these values are sorted statistically and compared opposite limit values.

This chapter covers application notes for the evaluation according to different standards

- EN50160
- IEC6100-2-4
- ITIC (CBEMA)
- DISDIP Statistic
- [Full FFT](#)

Premises:

a measuring instrument with a rack (z.B DEWE-2600)
 one (or 3 respectively) module(s) type DAQP-HV (or DAQP-DMM)
 software DEWESoft
 option DEWESoft Power
 option DEWESoft DB (PMT4, Database module and report generator)

You should have profound knowledge in measuring voltage

3.2.1 EN50160

EN50160 is the standard which is used to evaluate the power quality in Europe.

In this chapter you will learn:

How to create a setup
 Apply an existing setup

3.2.1.1 Create your own setup

To create a setup for measurement to EN50160 first choose a connection diagram from the list below:

Connection diagram	Application
1 phase	Measurement at the socket, low voltage
3 phase star	Measurement in low voltage, high voltage and industrial grids
3 phase star with evaluation of the line voltages	Measurement in middle and high voltage. The converters are usually connected in star. There should be evaluated the line voltage because of the delta/ star transformers in the low voltage the voltage is visible as phase voltage. Furthermore, this circuit simultaneously with the detection of ground faults.
3 phase delta	Middle and high voltage if the measurement is directly connected in delta.

3.2.1.1.1 Single-phase-system

Follow the steps in the order below:

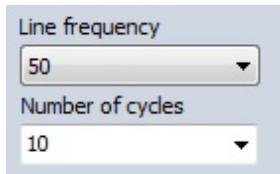
1. DEWESoft settings
2. Settings to store in database
3. Analysis with PMT

3.2.1.1.1.1 DEWESoft settings for the standard En50160

1. Connect the voltage to a suitable module.
2. Set-up the Powermodule
3. Note the following settings:

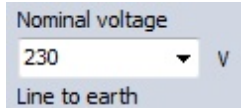
The line frequency must be set to the nominal value (for the calculation the actual frequency will be used).

"Number of cycles" must be set to 10 (this is the number of sine waves, which are used for the harmonic calculation and must be equal to 10 according to EN50160).



Line frequency
50
Number of cycles
10

The nominal voltage must be set.

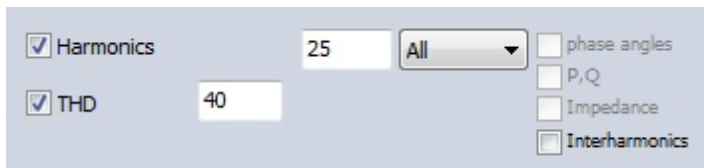


Nominal voltage
230 V
Line to earth

The number of harmonics must be at least 25.

"All" harmonics must be calculated.

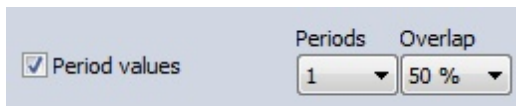
The total harmonic load (THD, Total Harmonic distortion) must be set up to 40th.



☒ Harmonics 25 All ☐ phase angles
☒ THD 40 ☐ P,Q
☐ Impedance
☐ Interharmonics

Period RMS values be used for the voltage drop calculation (DISDIP).

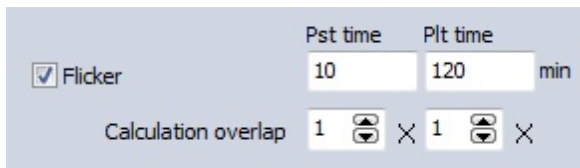
The calculation must be done in all periods (=1) with half-period dislocation (=50%), i.e. every half period a full-period value is calculated.



☒ Period values
Periods: 1 Overlap: 50 %

Flicker must be calculated in 10 min (Pst) or 2h (Plt; equals to 12 Pst Values).

The overlap should be 1.



☒ Flicker
Pst time: 10 Plt time: 120 min
Calculation overlap: 1 X 1 X

Overall, the setup looks like this:

The screenshot shows the 'Power 0' software interface. On the left is a schematic diagram with a vertical black line labeled 'N' (Neutral) and a red line labeled 'U1' (Phase). A red arrow points from 'U1' to a dropdown menu labeled 'U L1', which is set to 'V'. Below this, a red line is labeled 'L1'. On the right is a settings panel with the following sections:

- Power system configuration:** 'Single phase' (dropdown), 'Current channels' (checkbox, unchecked).
- Line frequency:** '50' (dropdown), 'Number of cycles: 10' (dropdown).
- Output units:** 'W' (dropdown), 'Nominal voltage: 230 V' (dropdown).
- Frequency source:** 'Voltage' (dropdown).
- Line to earth:** 'Channels' (button), 'Vector scope' (button), 'Background harmonics' (button).
- Harmonics:** '25' (dropdown), 'All' (dropdown), 'phase angles' (checkbox, unchecked), 'P, Q' (checkbox, unchecked), 'Impedance' (checkbox, unchecked), 'Interharmonics' (checkbox, unchecked).
- THD:** '40' (dropdown).
- Period values:** '1' (dropdown), '50 %' (dropdown).
- Flicker:** '10' (dropdown), '120' (dropdown), 'min' (text).
- Calculation overlap:** '1' (dropdown), '1' (dropdown), 'X' (button), 'X' (button).

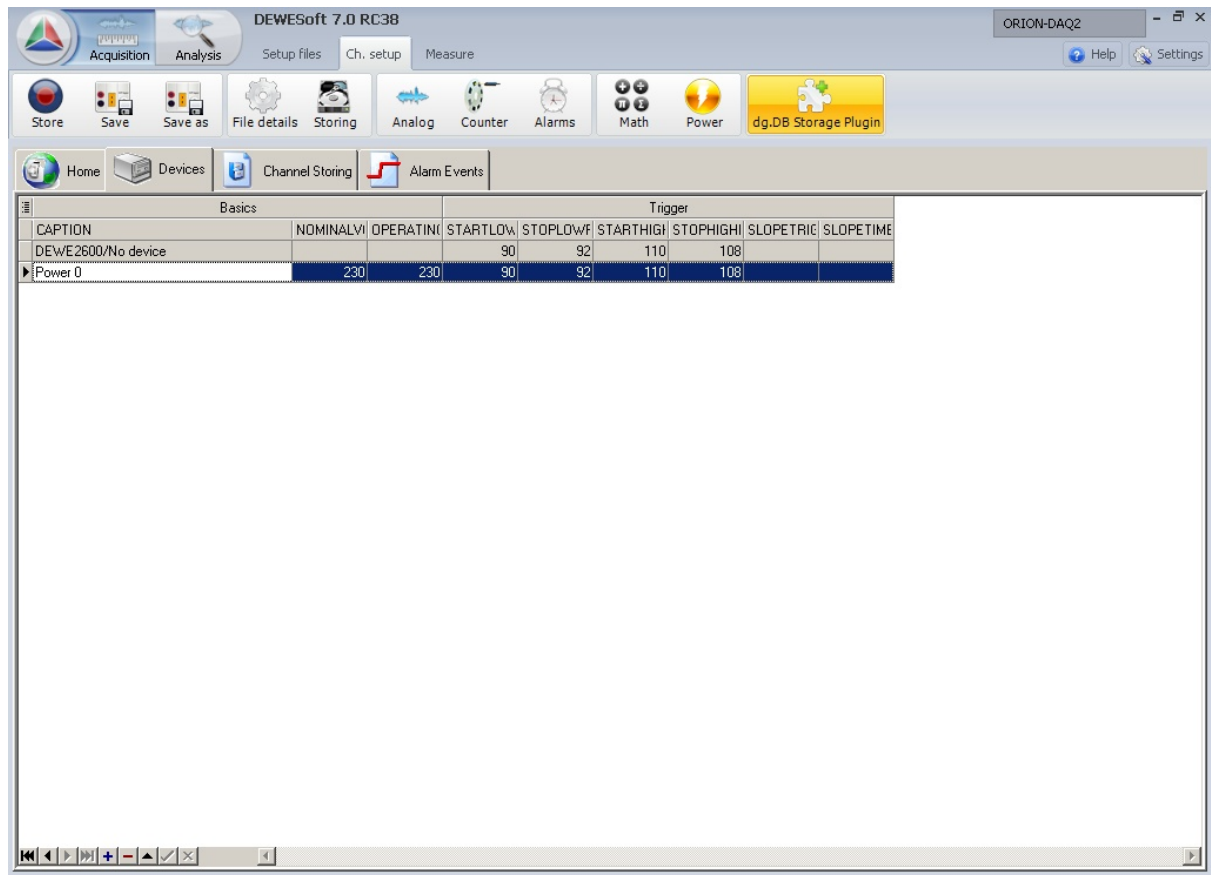
Next, set-up the storage of data.

3.2.1.1.1.2 Settings to store En50160

Before studying this chapter you should work through the general information about the database storage.

The specific settings for the EN50160 are as follows:

1) Devices



In Devices Manager the following limits must be set. These are pre-assigned default.

STARTLOWPERCENTAGE	STOPLOWPERCENTAGE	STARTHIGHPERCENTAGE	STOPHIGHPERCENTAGE
90	92	110	108

Startlowpercentage....determines the lower limit for the start of voltage range violations.

Stoplowpercentage....determines the lower limit for the end of voltage range violations.

Starthighpercentage....determines the upper limit for the start of voltage range violations.

Stophighpercentage....determines the upper limit for the end of voltage range violations.

2) Channel storing

Usually all channels are initialized correctly.

The default storage group is set to 10 minutes and assigned.

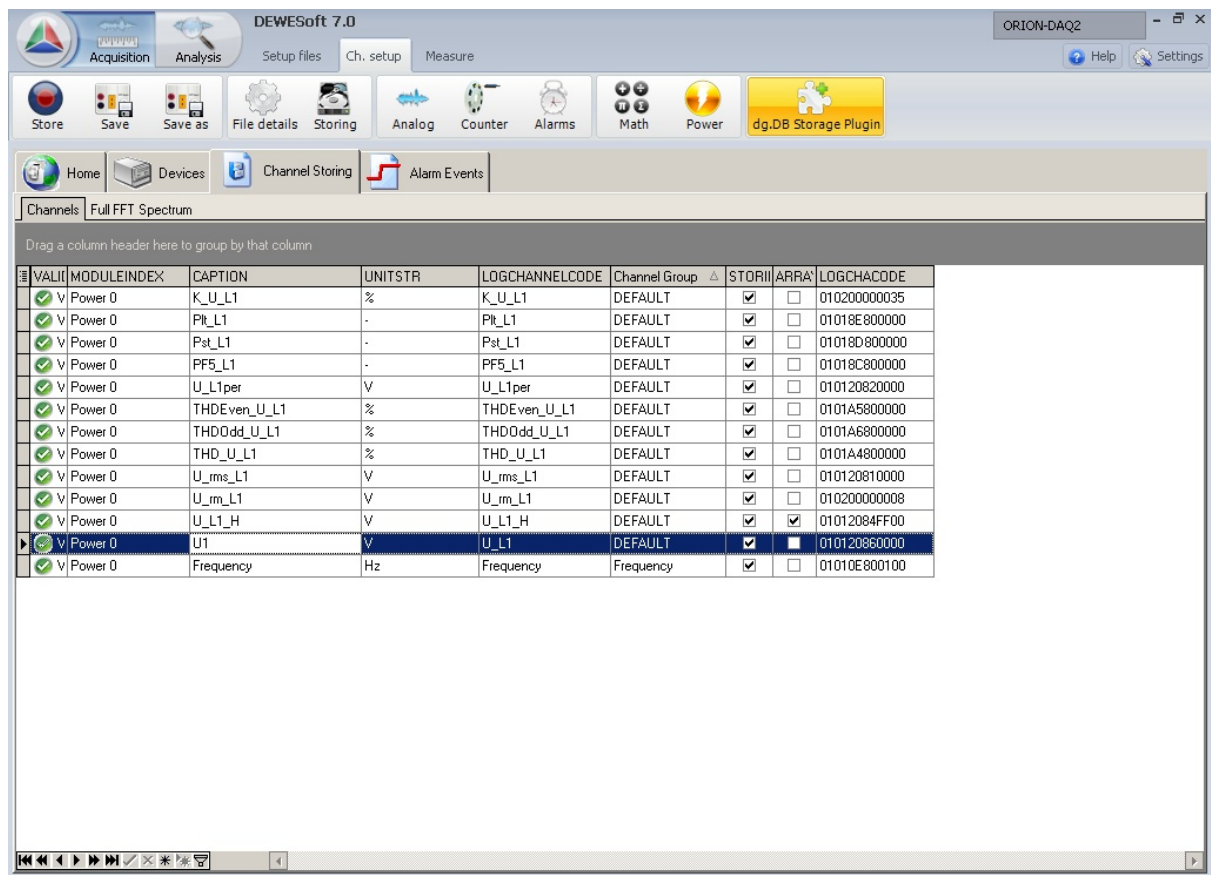
The raw channel (analog input channel) U1 must be assigned manually:

Modulindex=Power 0

LOGCHANNELCODE=U_L1

The frequency must be set to 10 seconds storage interval.

For this reason a separate Channelgroup called "Frequency" with an 10 second interval was created.



3) Alarm Events

For fault detection (voltage range violation, DISDIP) a alarm as follows was created:
Please click "+" on the "Alarm Events" window to add an alarm.

Alarm Event Detail

Index: Alarm Code: Nominal Voltage:

Module: Operating voltage:

Caption:

Opcode at event start: Pretime:

Opcode at event end: Posttime:

Holdoff Time: Max storage time:

☒ **Activate alarm event**

☒ Flagging

☐ Crosstrigger

☐ Posttime Extension

Alarm reset settings:

☐ Immediately

☒ On Condition

☐ After [s]

Storage Type:

☐ None [ms] ☒ Fast [ms] ☐ Slow [s]

STO	LOGCHACODE	CON	EVE	STO	ALARMINI
1	Power 0/U_L1per	☒	☒	☒	0
4	Power 0/U_L1	☐	☐	☒	0

Start Conditions

ID	Type	RE	Mode	Level 1	Level 2
0	Setup	☒	data	253	207

Stop Conditions

ID	Type	RE	Mode	Level 1	Level 2
0	Setup	☒	data	248,4	211,6

Export Import Close

Choose the module (Power 0) and type in "Band" in the field Caption (name of the alarm).

Module:

Caption:

Set up the channels as follows:

"U_L1" just stored (STO)

"U_L1 per" is Condition (COND), event (EVENT) and stored (STO)

The storage numbers 1 to 4 must also be properly assigned. With this Index the transients are later found in the chart.

STO	LOGCHACODE	CON	EVE	STO	ALARMINI
1	Power 0/U_L1per	☒	☒	☒	0
4	Power 0/U_L1	☐	☐	☒	0

Pre- and post-time should be set as follows:

Pretime:	1500
Posttime:	3500
Holdoff Time:	0
Max storage time:	6000

This alarm is intended to serve as an event, therefore "alert event" must be selected. Please select "Flagging" to enable the flagging-function (IEC 61000-4-30).

☒ Activate alarm event
☒ Flagging

The storage type must be set on "fast".

Storage Type
☐ None [ms] ☒ Fast [ms] ☐ Slow [s]

The start- and stop-conditions are automatically according to the limits of the "DEVICE" (see above) created once you click the "+" button.

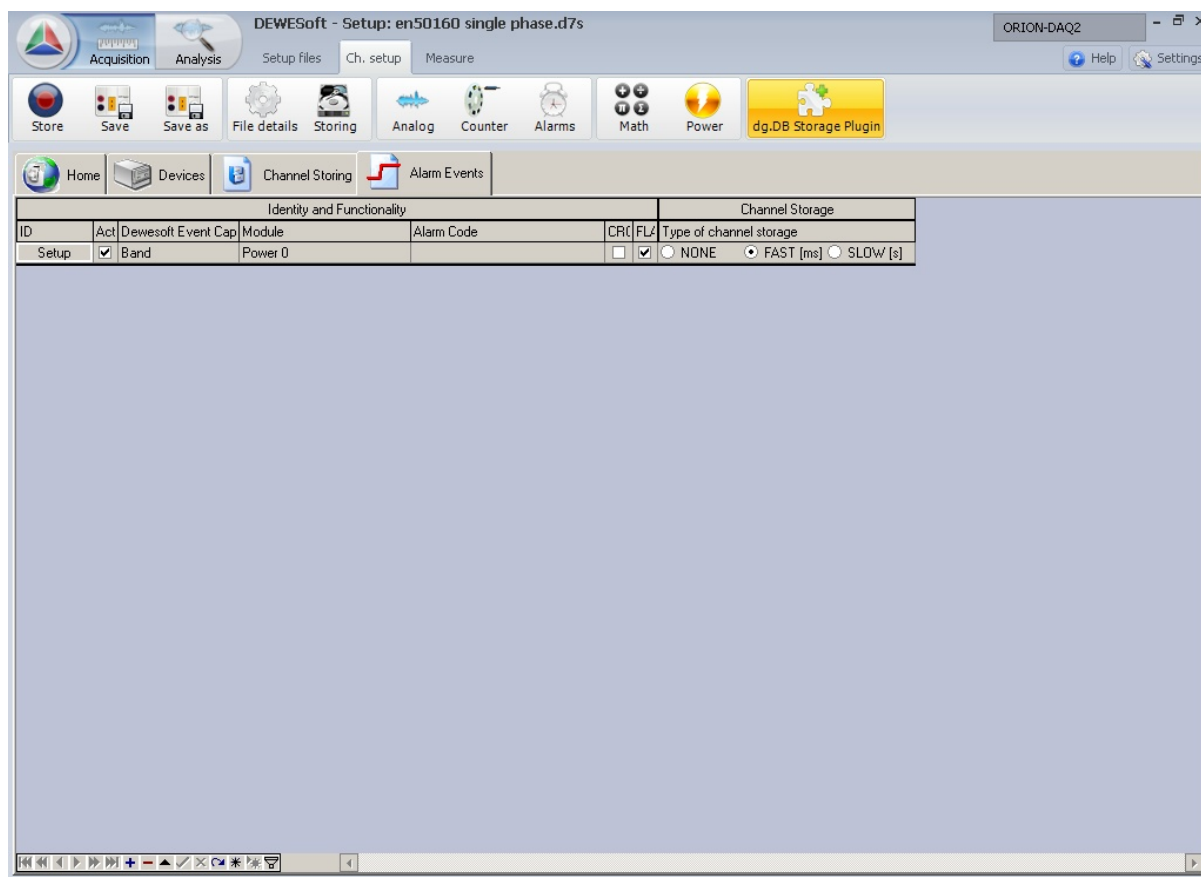
Start Conditions						
ID		Type	RE	Mode	Level 1	Level 2
0	Setup	data	☒	window	253	207

Stop Conditions						
ID		Type	RE	Mode	Level 1	Level 2
0	Setup	data	☒	window	248,4	211,6

According to this, the reset of the alarm must be set to "on condition":

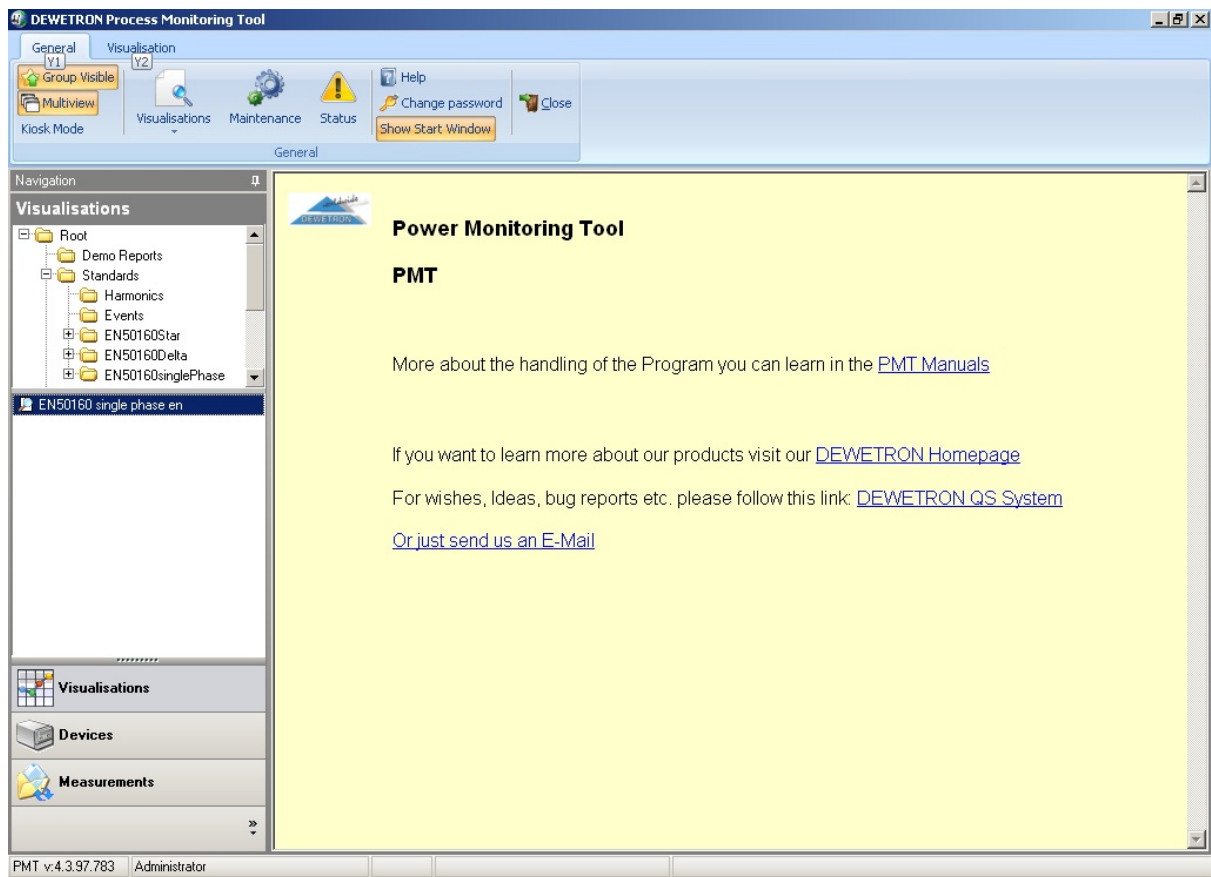
Alarm reset settings
☐ Immediately ☒ On Condition ☐ After [s] 0

After confirming the settings with "Close" the alarm in DEWESoft should look like on the window below:

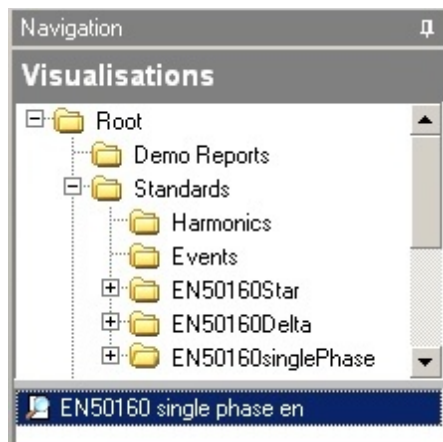


3.2.1.1.1.3 Analyze En50160 in PMT

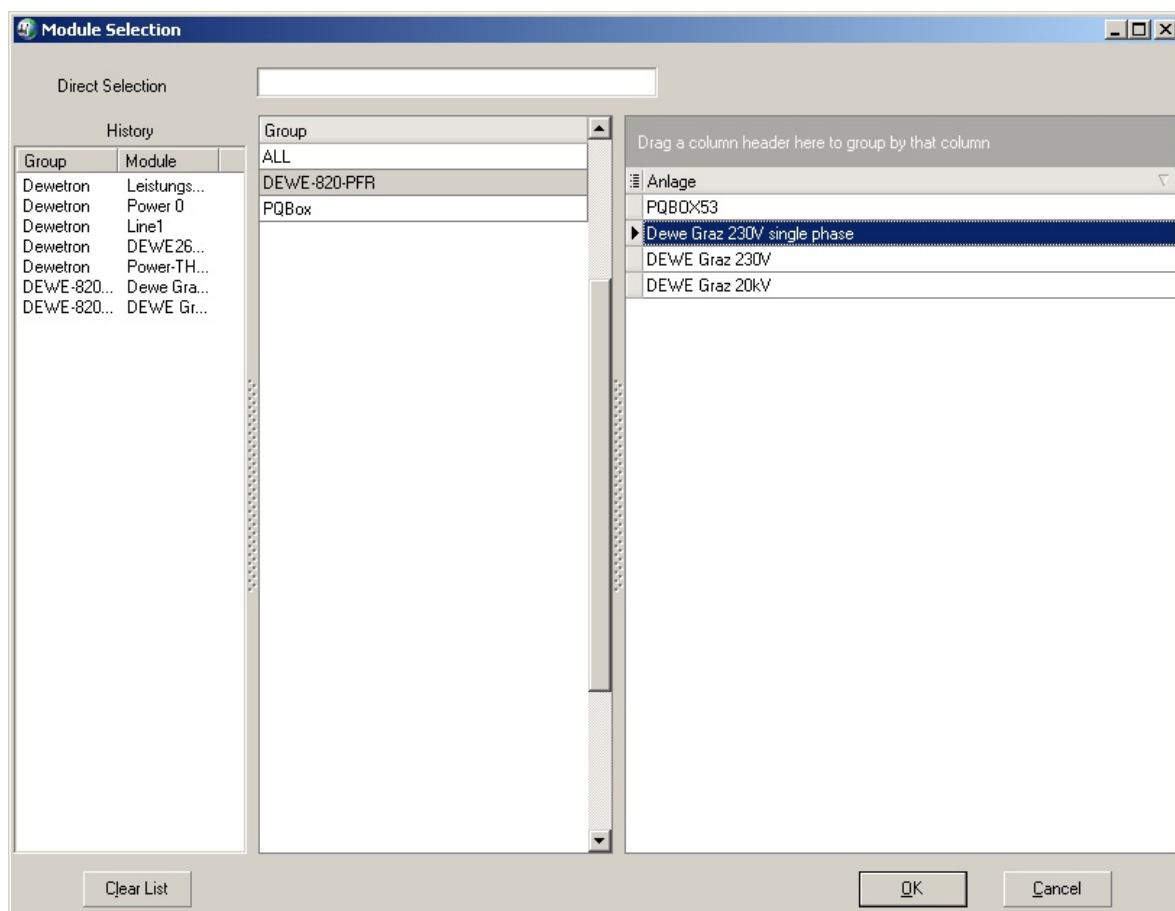
Start PMT and connect to the according database:



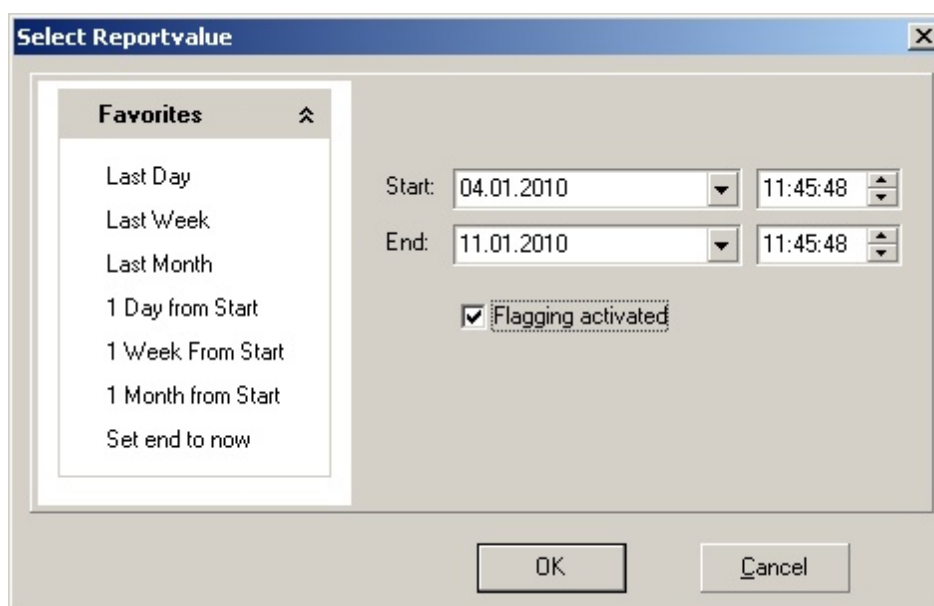
Select the report "EN50160singlePhase" in the navigator on the left side:
You will find the report in the directory: Root/Standards/En50160singlePhase



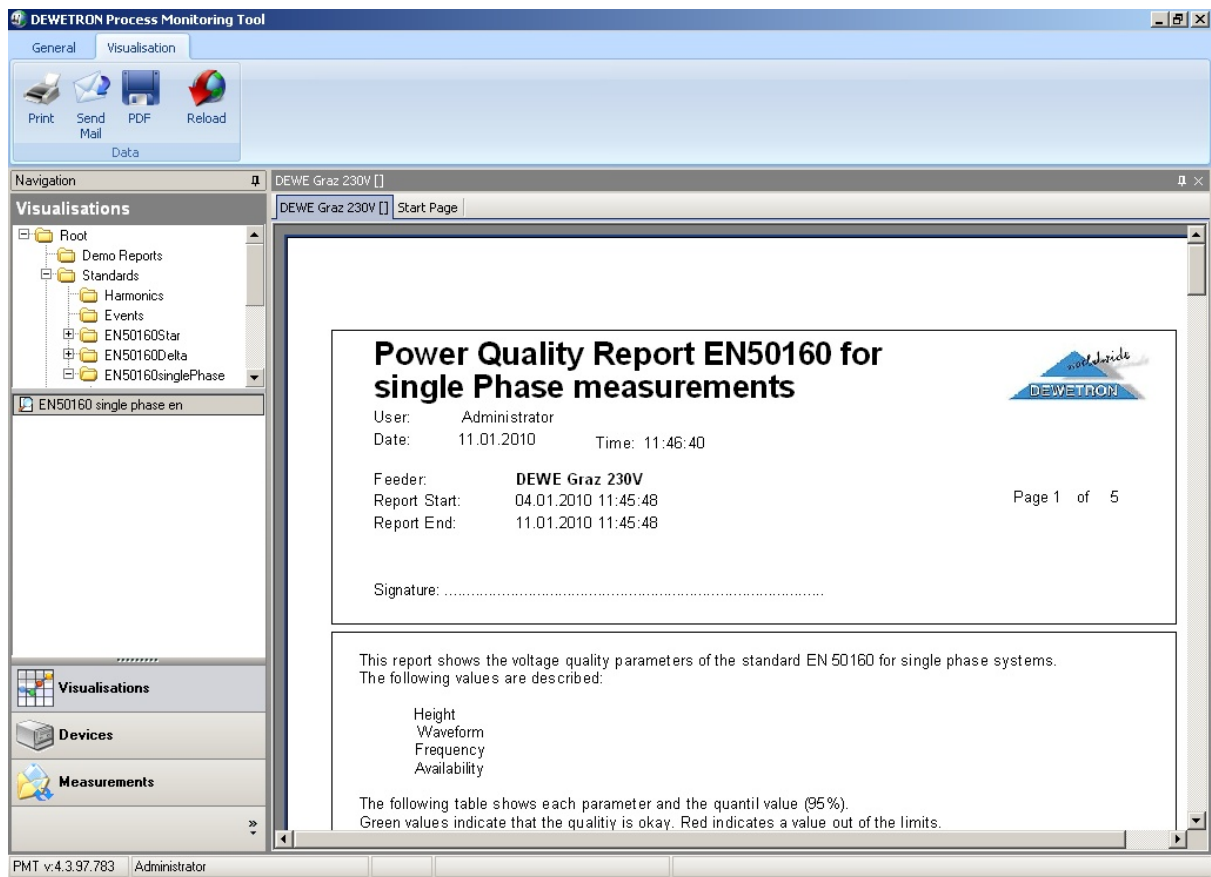
Double click on the report and choose your Powermodule (on the right side):
In our example: "Dewe Graz 230V single phase"



Next select the time period for the report:



Then the report will appear on your screen and can be printed.



3.2.1.1.2 3ph-star-system

Follow the steps in the order below:

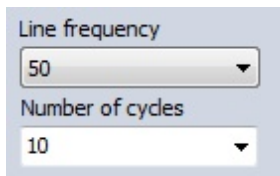
1. DEWESoft settings
2. Settings to store in database
3. Analysis with PMT

3.2.1.1.2.1 DEWESoft settings for the standard En50160

1. Connect the voltages to suitable modules.
2. Set-up the Powermodule.
3. Note the following settings:

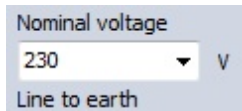
The line frequency must be set to the nominal value (for the calculation the actual frequency will be used).

"Number of cycles" must be set to 10 (this is the number of sine waves, which are used for the harmonic calculation and must be equal to 10 according to EN50160).



Line frequency
50
Number of cycles
10

The nominal voltage must be set.

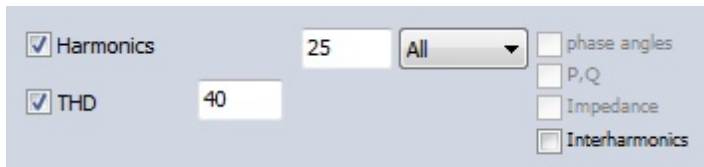


Nominal voltage
230 V
Line to earth

The number of harmonics must be at least 25.

"All" harmonics must be calculated.

The total harmonic load (THD, Total Harmonic distortion) must be set up to 40th.



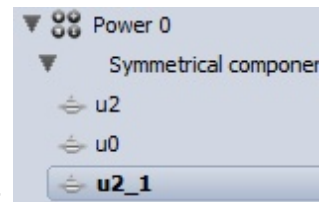
☒ Harmonics 25 All ☐ phase angles
☒ THD 40 ☐ P,Q
☐ Impedance
☐ Interharmonics

In the standard further the imbalance factor is provided.

Enable the symmetrical components and use the parameter u2_1 from the DEWESoft channel-list.



☒ Symmetrical components

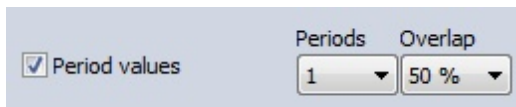


Power 0
Symmetrical componer
u2
u0
u2_1

You will see the value in the measurement-screen on the right side:

Period RMS values be used to calculate the voltage drops (DISDIP).

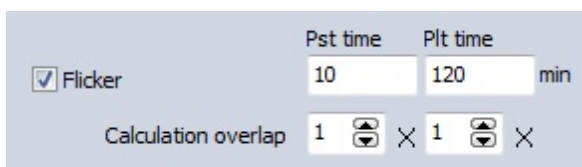
The calculation must be done in all periods (=1) with half-period dislocation (=50%), i.e. every half period a full-period value is calculated.



☒ Period values
Periods: 1 Overlap: 50 %

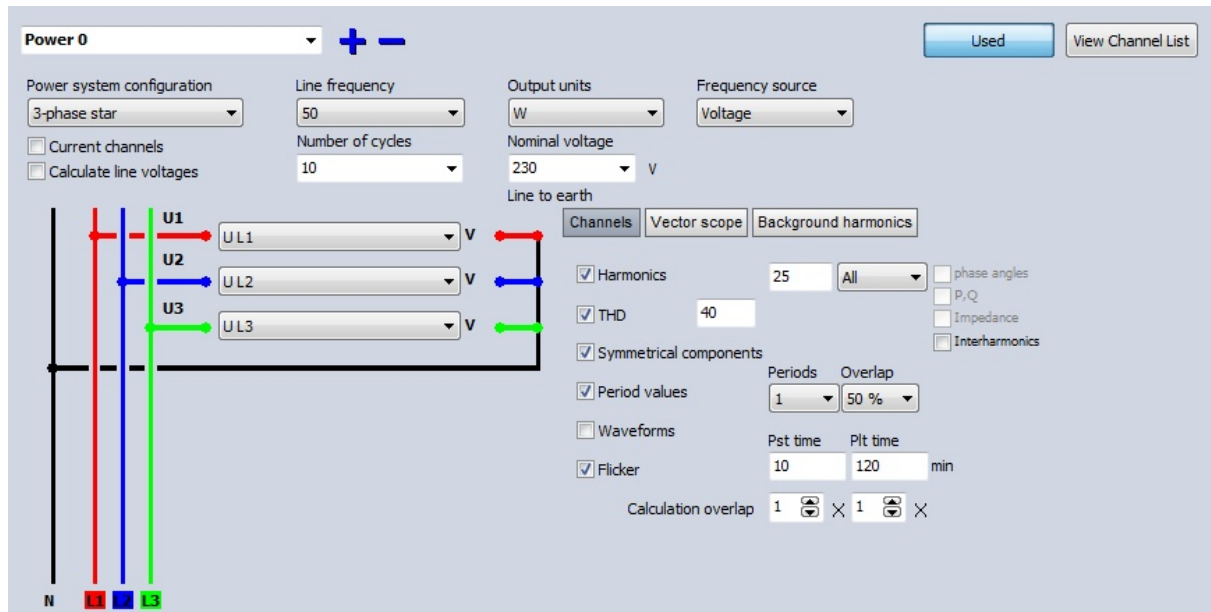
Flicker must be calculated in 10 min (Pst) or 2h (Plt; equals to 12 Pst Values).

The overlap should be 1.



☒ Flicker
Pst time: 10 Plt time: 120 min
Calculation overlap: 1

Overall, the setup looks like this:



Next, set-up the storage of data.

3.2.1.1.2.2 Settings to store En50160

The procedure is essentially the same to the single-phase-system. Therefore, only those points covered, which are different.

Chapter 2) Channel storing

Raw channels (analog input channels) U1, U2 and U3 must be assigned manually:

Modulindex=Power 0

LOGCHANNELCODE=U_L1, U_L2 or U_L3

✓	V	Power 0	U3	V	U_L1	DEFAULT	✓	☐
✓	V	Power 0	U2	V	U_L2	DEFAULT	✓	☐
✓	V	Power 0	U1	V	U_L3	DEFAULT	✓	☐

Chapter 3) Alarm Events

Make sure that all three phases are selected and numbered accordingly.

Alarm Event Detail

Index: Alarm Code: Nominal Voltage: Operating voltage:

Module: Pretime: Posttime: Holdoff Time: Max storage time:

Caption:

Opcode at event start: Opcode at event end:

☒ **Activate alarm event**

☒ Flagging

☐ Crosstrigger

☐ Posttime Extension

Alarm reset settings

☐ Immediately

☒ On Condition

☐ After [s]

Storage Type

☐ None [ms] ☒ Fast [ms] ☐ Slow [s]

STO	LOGCHACODE	CON	EVEI	STO	ALARMIN
1	Power 0/U_L1per	☒	☒	☒	0
2	Power 0/U_L2per	☒	☒	☒	0
3	Power 0/U_L3per	☒	☒	☒	0
4	Power 0/U_L1	☐	☐	☒	0
5	Power 0/U_L2	☐	☐	☒	0
6	Power 0/U_L3	☐	☐	☒	0

Start Conditions

ID	Type	RE	Mode	Level 1	Level 2
0	Setup data	☒	window	253	207

Stop Conditions

ID	Type	RE	Mode	Level 1	Level 2
0	Setup data	☒	window	248,4	211,6

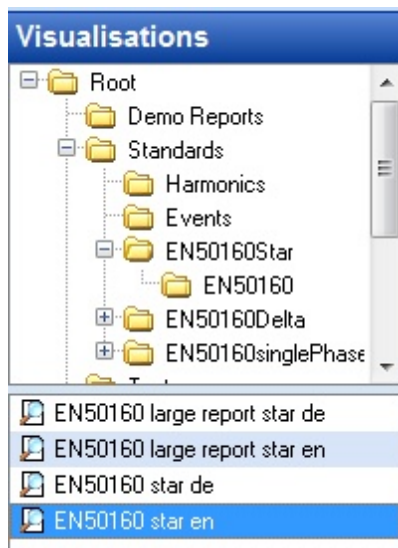
Export Import Close

3.2.1.1.2.3 Analyze according to En50160 in PMT

The analysis is the same as for single-phase-system, but here please choose the star-report (EN50160Star):

Select the report "EN50160 star" in the navigator on the left side:

You will find the report in the directory: Root/Standards/En50160Star



3.2.1.1.3 3ph-star-system with analysis in delta

Follow the steps in the order below:

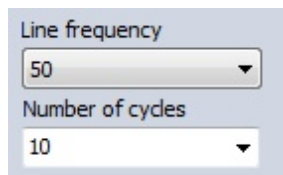
1. DEWESoft settings
2. Settings to store in database
3. Analysis with PMT

3.2.1.1.3.1 DEWESoft settings for the standard En50160

1. Connect the voltages to suitable modules.
2. Set-up the Powermodule.
3. Note the following settings:

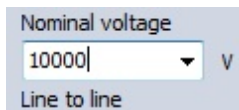
The line frequency must be set to the nominal value (for the calculation the actual frequency will be used).

"Number of cycles" must be set to 10 (this is the number of sine waves, which are used for the harmonic calculation and must be equal to 10 according to EN50160).



The nominal voltage must be set.

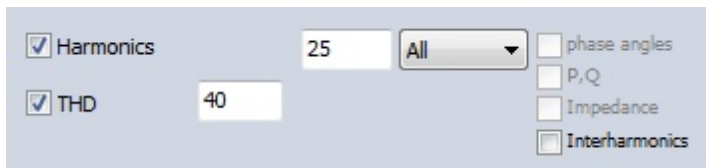
Note: depending on whether the flicker in star or in delta needs to be assessed, the wire (line to line) or the phase voltage (line to earth) must be entered:



The number of harmonics must be at least 25.

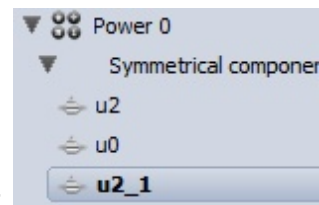
"All" harmonics must be calculated.

The total harmonic load (THD, Total Harmonic distortion) must be set up to 40th.



In the standard further the imbalance factor is provided.

Enable the symmetrical components and use the parameter u2_1 from the DEWESoft channel-list.

You will see the value in the measurement-screen on the right side:

Period RMS values be used to calculate the voltage drops (DISDIP).

The calculation must be done in all periods (=1) with half-period dislocation (=50%), i.e. every half period a full-period value is calculated.

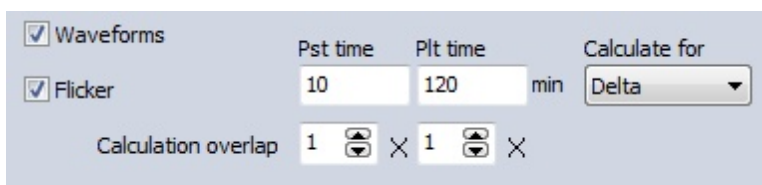


Flicker must be calculated in 10 min (Pst) or 2h (Plt; equals to 12 Pst Values).

The overlap should be 1.

Make sure that "waveforms" is selected.

The flicker now can be calculated for phase voltages (star), line voltages (delta) or both. Particularly note the right attitude of the nominal voltage!



Overall, the setup looks like this:

Power 0

Power system configuration: 3-phase star

Line frequency: 50

Number of cycles: 10

Output units: W

Frequency source: Voltage

Nominal voltage: 10000 V

Line to line: U1, U2, U3

Channels: ☒ Harmonics (25), ☒ THD (40), ☒ Symmetrical components, ☒ Period values (1), ☒ Waveforms, ☒ Flicker

Background harmonics: ☐ phase angles, ☐ P, Q, ☐ Impedance, ☐ Interharmonics

Calculate for: Delta

Next, set-up the storage of data.

3.2.1.1.3.2 Settings to store En50160

The procedure is essentially the same to the single-phase-system. Therefore, only those points covered, which are different.

Chapter 2) Channel storing

Raw channels (analog input channels) U1, U2 and U3 must be assigned manually:

Modulindex=Power 0

LOGCHANNELCODE=U_L1, U_L2 or U_L3

Channel	Modulindex	Channel name	Unit	Channel code	Response	Filter	Channel code
✓ V	Power 0	UL31	V	U_31	DEFAULT	☒	01018B860000
✓ V	Power 0	UL23	V	U_23	DEFAULT	☒	01018A860000
✓ V	Power 0	UL12	V	U_12	DEFAULT	☒	010189860000

Chapter 3) Alarm Events

Make sure that all three phases are selected and numbered accordingly. Only the line voltage (CONDITION) is triggered.

Alarm Event Detail

Index: Alarm Code: Nominal Voltage:
Module: Operating voltage:
Caption:
Opcode at event start:
Opcode at event end:
Pretime:
Posttime:
Holdoff Time:
Max storage time:

☒ **Activate alarm event**
☒ Flagging
☐ Crosstrigger
☐ Posttime Extension

Alarm reset settings
☐ Immediately
☒ On Condition
☐ After [s]

Storage Type
☐ None [ms] ☒ Fast [ms] ☐ Slow [s]

STO	LOGCHACODE	COM	EVEI	STO	ALARMIN
1	Power 0/U_L1per	☐	☐	☒	0
2	Power 0/U_L2per	☐	☐	☒	0
3	Power 0/U_L3per	☐	☐	☒	0
4	Power 0/U_L1	☐	☐	☒	0
5	Power 0/U_L2	☐	☐	☒	0
6	Power 0/U_L3	☐	☐	☒	0
10	Power 0/U_L12per	☒	☒	☒	0
11	Power 0/U_L23per	☒	☒	☒	0
12	Power 0/U_L31per	☒	☒	☒	0

Start Conditions

ID	Type	RE	Mode	Level 1	Level 2
0	Setup data	☒	window	440	360

Stop Conditions

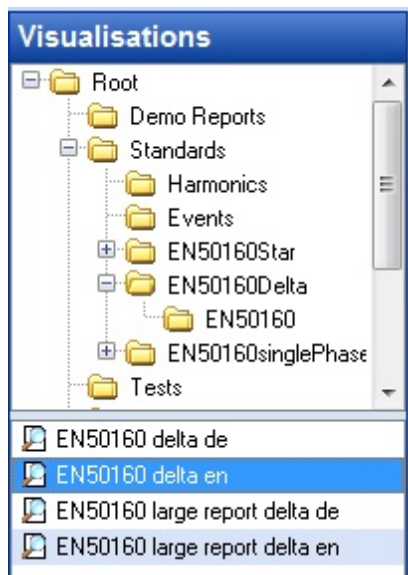
ID	Type	RE	Mode	Level 1	Level 2
0	Setup data	☒	window	432	368

Export Import Close

3.2.1.1.3.3 Analyze according to En50160 in PMT

The analysis is the same as for single-phase-system, but here please choose the delta-report (EN50160Delta):

Select the report "EN50160 delta" in the navigator on the left side:
You will find the report in the directory: Root/Standards/En50160Delta



3.2.1.1.4 3ph-delta-system

Follow the steps in the order below:

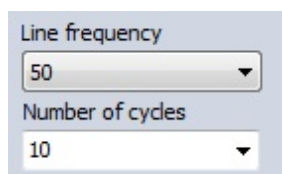
1. DEWESoft settings
2. Settings to store in database
3. Analysis with PMT

3.2.1.1.4.1 DEWESoft settings for the standard En50160

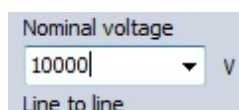
1. Connect the voltages to suitable modules.
2. Set-up the Powermodule.
3. Note the following settings:

The line frequency must be set to the nominal value (for the calculation the actual frequency will be used).

"Number of cycles" must be set to 10 (this is the number of sine waves, which are used for the harmonic calculation and must be equal to 10 according to EN50160).



The nominal voltage must be set. (For delta connection the nominal voltage always is the line voltage).



The number of harmonics must be at least 25.

"All" harmonics must be calculated.

The total harmonic load (THD, Total Harmonic distortion) must be set up to 40th.

In the standard further the imbalance factor is provided.

Enable the symmetrical components and use the parameter u2_1 from the DEWESoft channel-list.

You will see the value in the measurement-screen on the right side:

Period RMS values be used to calculate the voltage drops (DISDIP).

The calculation must be done in all periods (=1) with half-period dislocation (=50%), i.e. every half period a full-period value is calculated.

Flicker must be calculated in 10 min (Pst) or 2h (Plt; equals to 12 Pst Values).

The overlap should be 1.

Overall, the setup looks like this:

Power 0

Power system configuration: 3-phase delta

Line frequency: 50

Output units: W

Frequency source: Voltage

Number of cycles: 10

Nominal voltage: 10000 V

Line to line

Channels: U_L12, U_L23, U_L31

Analysis options:

- Harmonics: 25, All
- THD: 40
- Symmetrical components
- Period values: 1, 50 %
- Waveforms
- Flicker

Calculation overlap: 1, 1

Next, set-up the storage of data.

3.2.1.1.4.2 Sttings to store En50160

The procedure is essentially the same to the single-phase-system. Therefore, only those points covered, which are different.

Chapter 2) Channel storing

Raw channels (analog input channels) U12, U23 and U31 must be assigned manually:

Modulindex=Power 0

LOGCHANNELCODE=U_L12, U_L23 or U_L31

Channel	Modulindex	Channel Code	Unit	Frequency	Frequency	Frequency	Frequency	Channel Code
✓ V	Power 0	UL31	V	U_31	DEFAULT	✓	✓	01018B860000
✓ V	Power 0	UL23	V	U_23	DEFAULT	✓	✓	01018A860000
✓ V	Power 0	UL12	V	U_12	DEFAULT	✓	✓	010189860000

Chapter 3) Alarm Events

Make sure that all three phases are selected and numbered accordingly. Only the line voltage (CONDITION) is triggered.

Alarm Event Detail

Index: Alarm Code: Nominal Voltage:
 Module: Operating voltage:
 Caption:
 Opcode at event start:
 Opcode at event end:
 Pretime:
 Posttime:
 Holdoff Time:
 Max storage time:

☒ **Activate alarm event**
☒ Flagging
☐ Crosstrigger
☐ Posttime Extension

Alarm reset settings
☐ Immediately
☒ On Condition
☐ After [s]

Storage Type
☐ None [ms] ☒ Fast [ms] ☐ Slow [s]

STO	LOGCHACODE	CON	EVEI	STO	ALARMIN
1	Power 0/U_L12per	☒	☒	☒	0
2	Power 0/U_L23per	☒	☒	☒	0
3	Power 0/U_L31per	☒	☒	☒	0
4	Power 0/U_12	☐	☐	☒	0
5	Power 0/U_23	☐	☐	☒	0
6	Power 0/U_31	☐	☐	☒	0

Start Conditions

ID	Type	RE	Mode	Level 1	Level 2
0	Setup data	☒	window	11000	9000

Stop Conditions

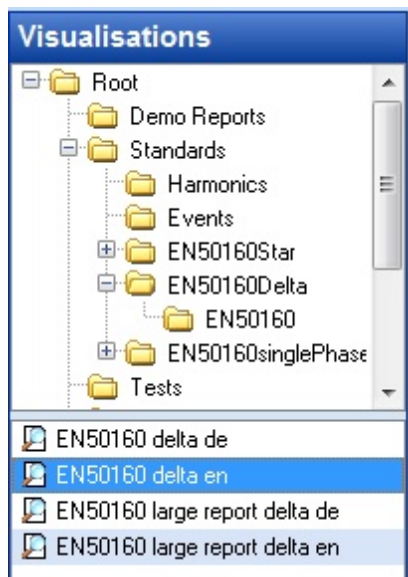
ID	Type	RE	Mode	Level 1	Level 2
0	Setup data	☒	window	10800	9200

Export Import Close

3.2.1.1.4.3 Analyze according to En50160 in PMT

The analysis is the same as for single-phase-system, but here please choose the delta-report (EN50160Delta):

Select the report "EN50160 delta" in the navigator on the left side:
 You will find the report in the directory: Root/Standards/En50160Delta



3.2.1.2 Using existing setups

On POWER SYSTEM DVD you will find the following setups, which can be used immediately.

Start DEWESoft, open the setup and start the measurement.

If the software was installed correctly, the recording starts automatically and the analysis can be made immediately with an appropriate report in PMT.

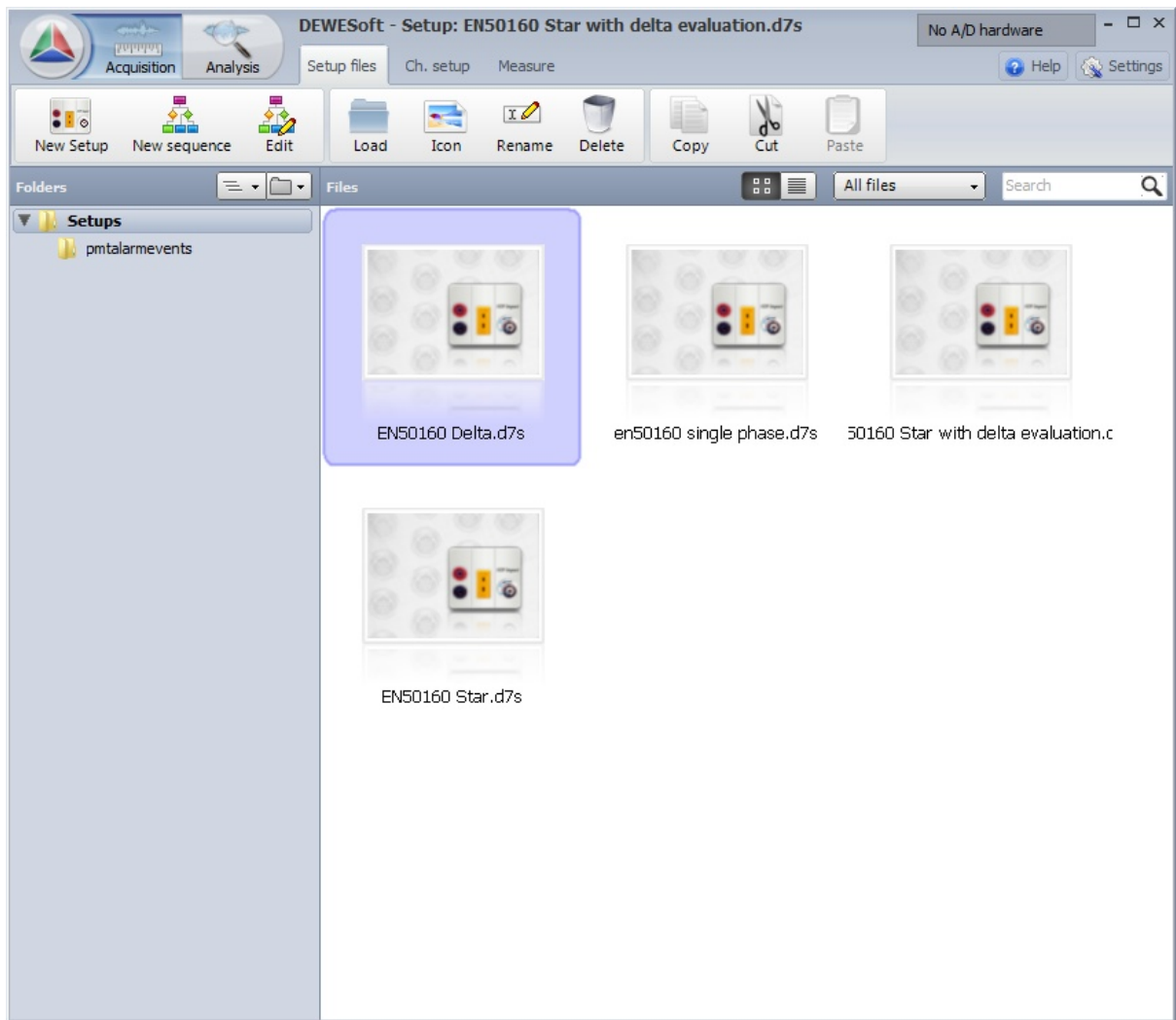
Available setups for the analysis according to EN50160:

single-phase measurement

3~ Star

3~ Delta

3~ Star with analysis in Delta



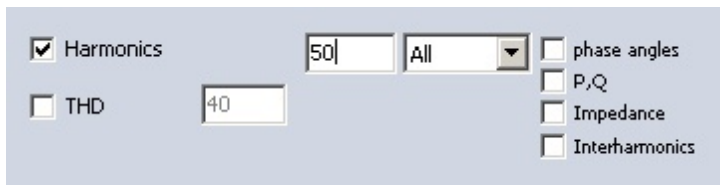
Note: Your meter should be configured so that the hardware channels 0, 2 and 4 are used for the voltage measurement.

3.2.2 IEC 61000-2-4

For a measurement according to IEC 61000-2-4 the detection of the voltage harmonics up to the 50th harmonic is necessary.

1) Measuring

Create a Powermodule and make sure that the harmonics are set up to 50th.



☒ Harmonics 50 All ☐ phase angles
☐ THD 40 ☐ P,Q
 ☐ Impedance
 ☐ Interharmonics

The measurement can be performed for any type of connection.

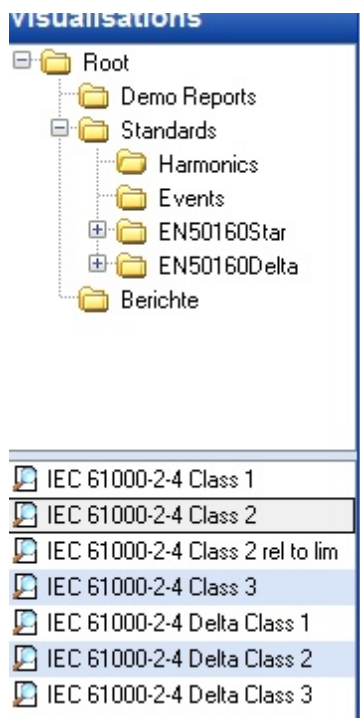
2) Storage

Data must be stored in the database.

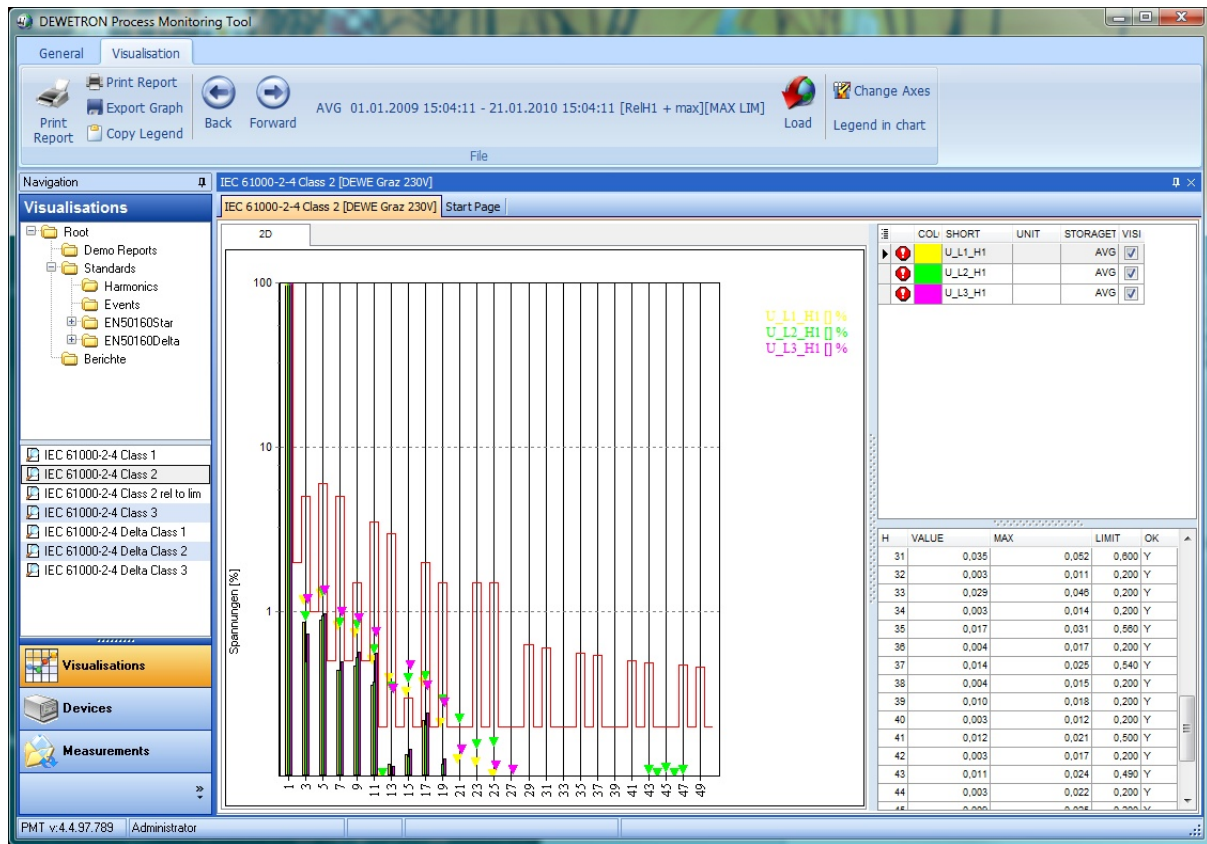
3) Analysis

The Analysis is done in PMT.

In the directory "Root/Standards/Harmonics" you will find various reports for analysis. Basically, a distinction is made between the analysis of Star or Delta. Further the different limits of the 3 network classes are deposited in various reports.

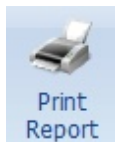


Click on the appropriate report, choose the powermodule and the time period.
You will get following view on screen:



In that case red exclamation marks will appear at the top right, which indicates a limit violation. The list right below and the graph on the left will show you which harmonic is exceeded.

4) Print Report:



The 1st page of the report shows the chart. On the following page you will find a list of values and the limit violations.

IEC 61000-2-4 Class 2 [DEWE Graz 230V]

erstellt von Administrator

am 21.01.2010

um 15:22:33

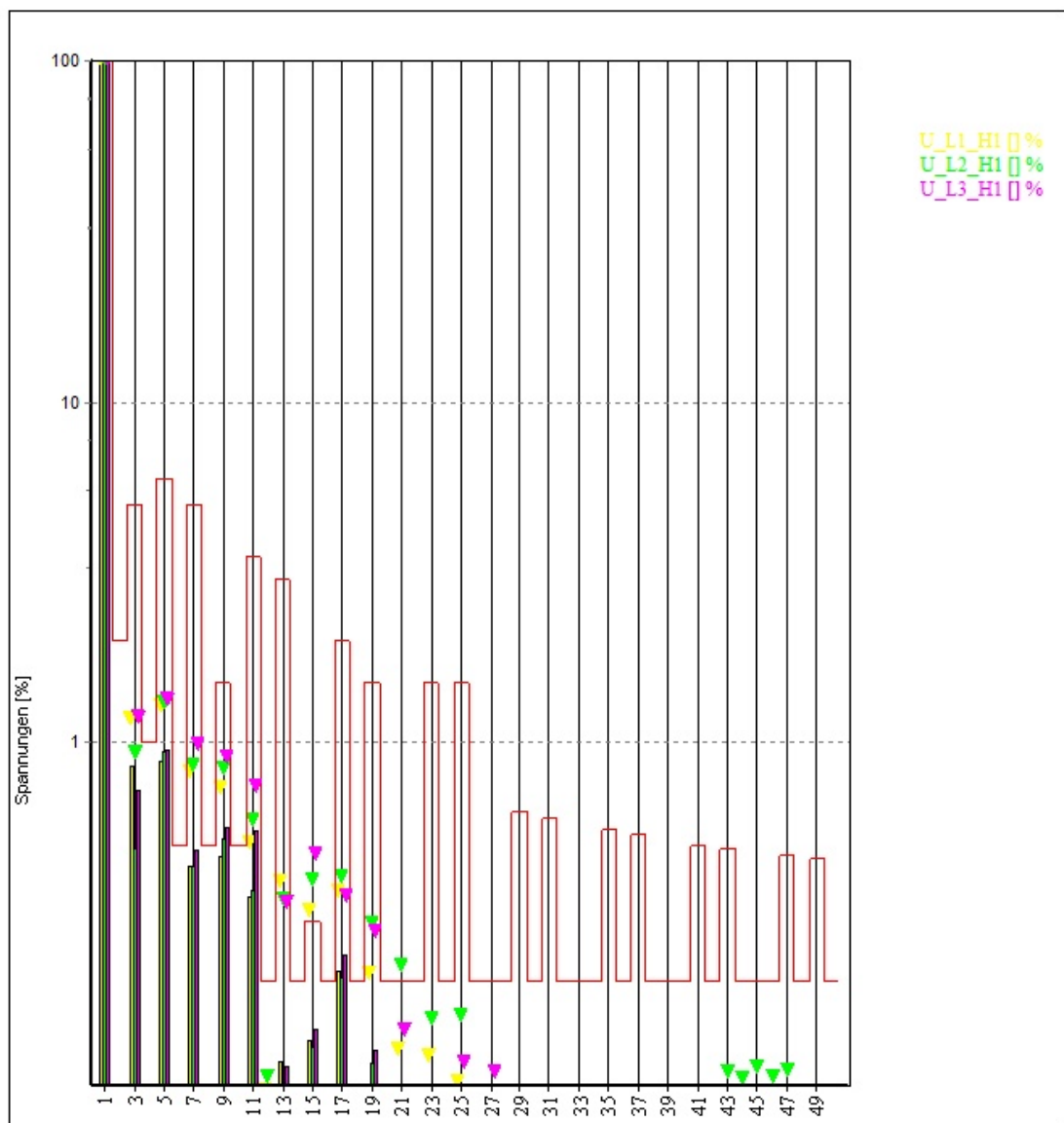
Start: 01.01.2009

Ende: 01.02.2009



Unterschrift:

Seite 1 von 2



IEC 61000-2-4 Class 2 [DEWE Graz 230V]



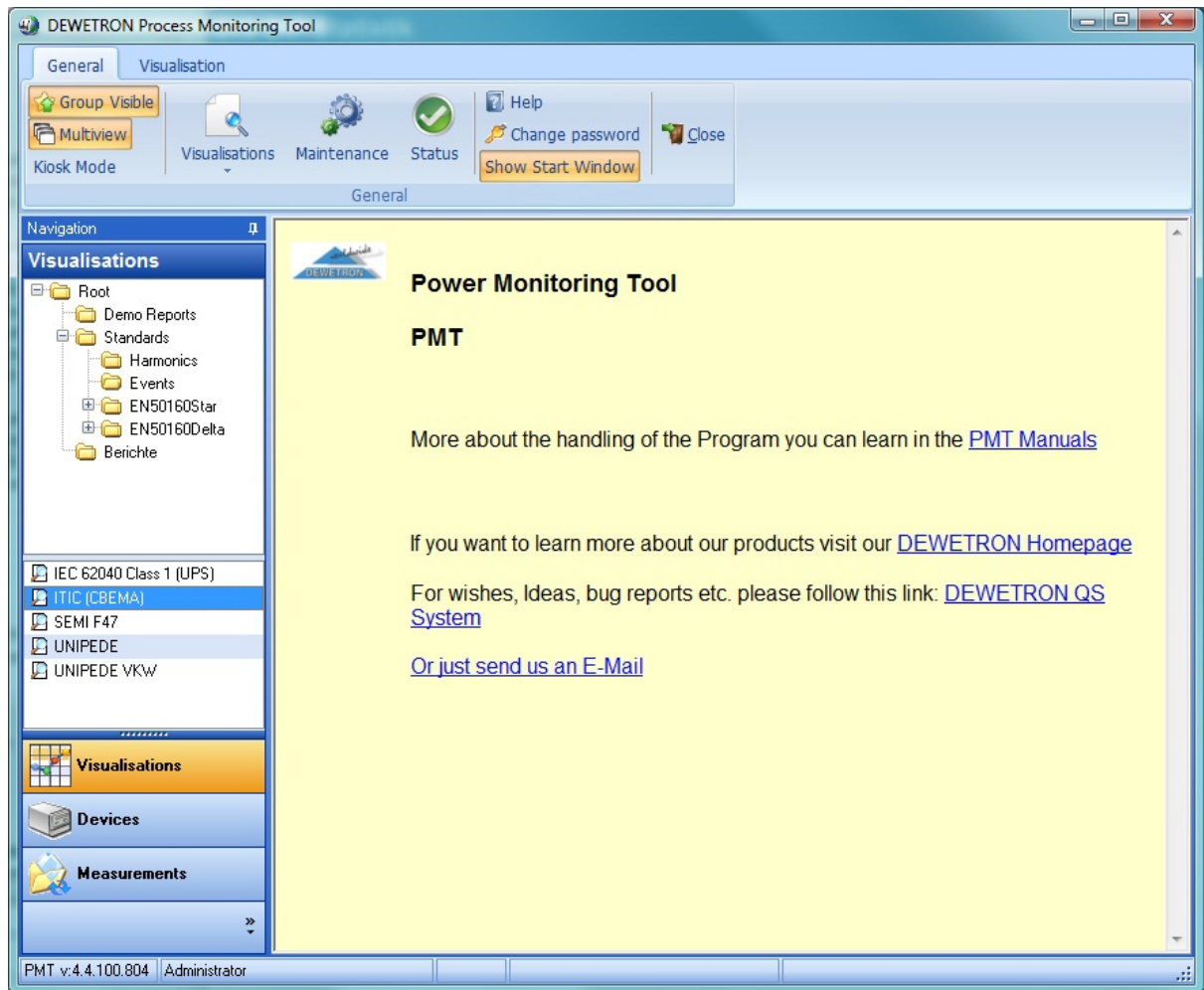
Seite 2 von 2

Order	L1 (V)	L2 (V)	L3 (V)	Limit (%)	L1 L2 L3
1	234,29	233,40	233,44	100	* * *
2	0,09	0,09	0,10	2	* * *
3	2,02	1,16	1,70	5	* * *
4	0,05	0,06	0,06	1	* * *
5	2,09	2,21	2,25	6	* * *
6	0,04	0,04	0,04	0,5	* * *
7	1,03	1,03	1,15	5	* * *
8	0,03	0,03	0,04	0,5	* * *
9	1,10	1,23	1,33	1,5	* * *
10	0,03	0,03	0,03	0,5	* * *
11	0,84	0,87	1,30	3,5	* * *
12	0,03	0,03	0,03	0,2	* * *
13	0,28	0,20	0,27	3	* * *
14	0,03	0,03	0,04	0,2	* * *
15	0,32	0,30	0,34	0,3	
16	0,03	0,03	0,03	0,2	* * *
17	0,51	0,48	0,57	2	* * *
18	0,03	0,03	0,03	0,2	* * *
19	0,23	0,27	0,30	1,5	* * *
20	0,02	0,02	0,02	0,2	* * *
21	0,17	0,19	0,18	0,2	* * *
22	0,01	0,02	0,02	0,2	* * *
23	0,12	0,22	0,09	1,5	* * *
24	0,01	0,02	0,02	0,2	* * *
25	0,13	0,17	0,13	1,5	* * *
26	0,01	0,02	0,01	0,2	* * *
27	0,07	0,05	0,14	0,2	* * *
28	0,01	0,02	0,02	0,2	* * *
29	0,06	0,10	0,07	0,63	* * *
30	0,01	0,02	0,02	0,2	* * *
31	0,08	0,09	0,06	0,6	* * *
32	0,01	0,02	0,01	0,2	* * *
33	0,07	0,03	0,05	0,2	* * *
34	0,01	0,01	0,01	0,2	* * *
35	0,04	0,05	0,05	0,56	* * *
36	0,01	0,02	0,01	0,2	* * *
37	0,03	0,06	0,05	0,54	* * *
38	0,01	0,02	0,02	0,2	* * *
39	0,02	0,04	0,04	0,2	* * *
40	0,01	0,02	0,01	0,2	* * *
41	0,03	0,03	0,04	0,5	* * *
42	0,01	0,02	0,01	0,2	* * *
43	0,03	0,04	0,03	0,49	* * *
44	0,01	0,02	0,01	0,2	* * *
45	0,02	0,04	0,04	0,2	* * *
46	0,01	0,02	0,01	0,2	* * *
47	0,02	0,05	0,03	0,47	* * *
48	0,01	0,02	0,01	0,2	* * *
49	0,03	0,04	0,03	0,46	* * *
50	0,01	0,02	0,01	0,2	* * *

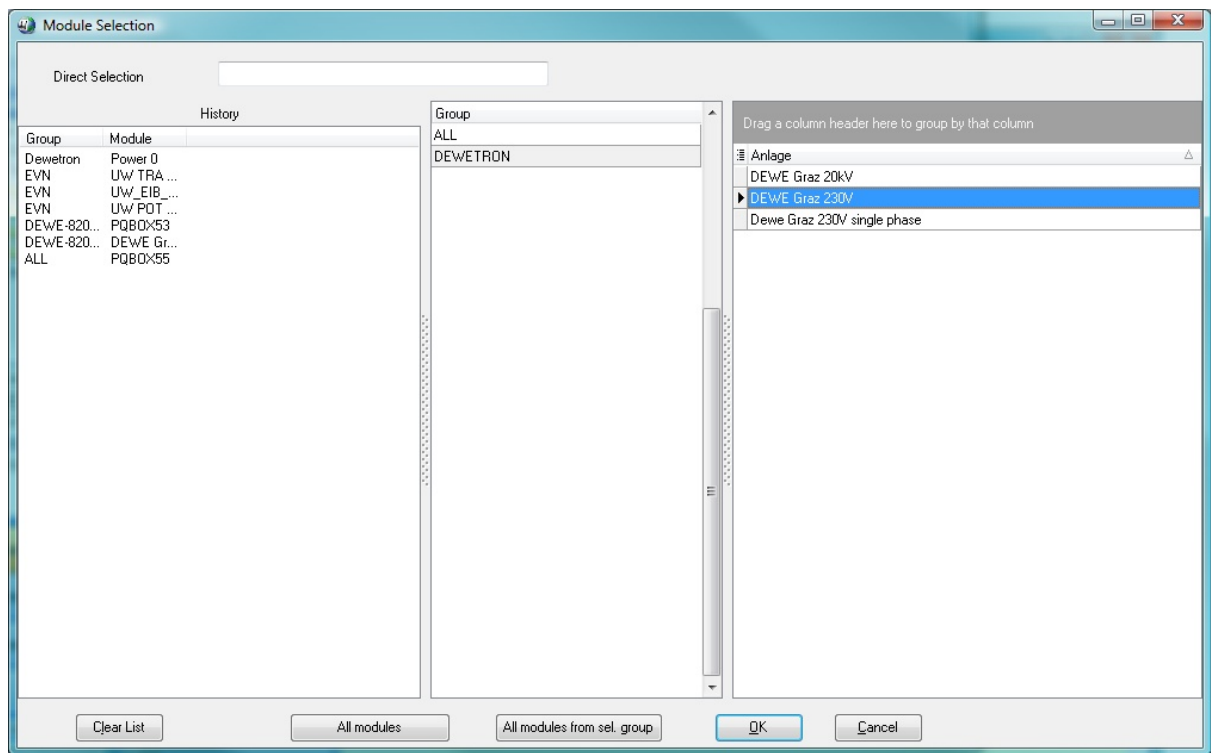
3.2.3 ITIC (CBEMA) curve

Prerequisite: Knowledge about how to create an event list and understanding of the chapter "voltage drops".

In PMT you will find in the directory "Root/Standards/Events" the report according to CBEMA (ITIC).

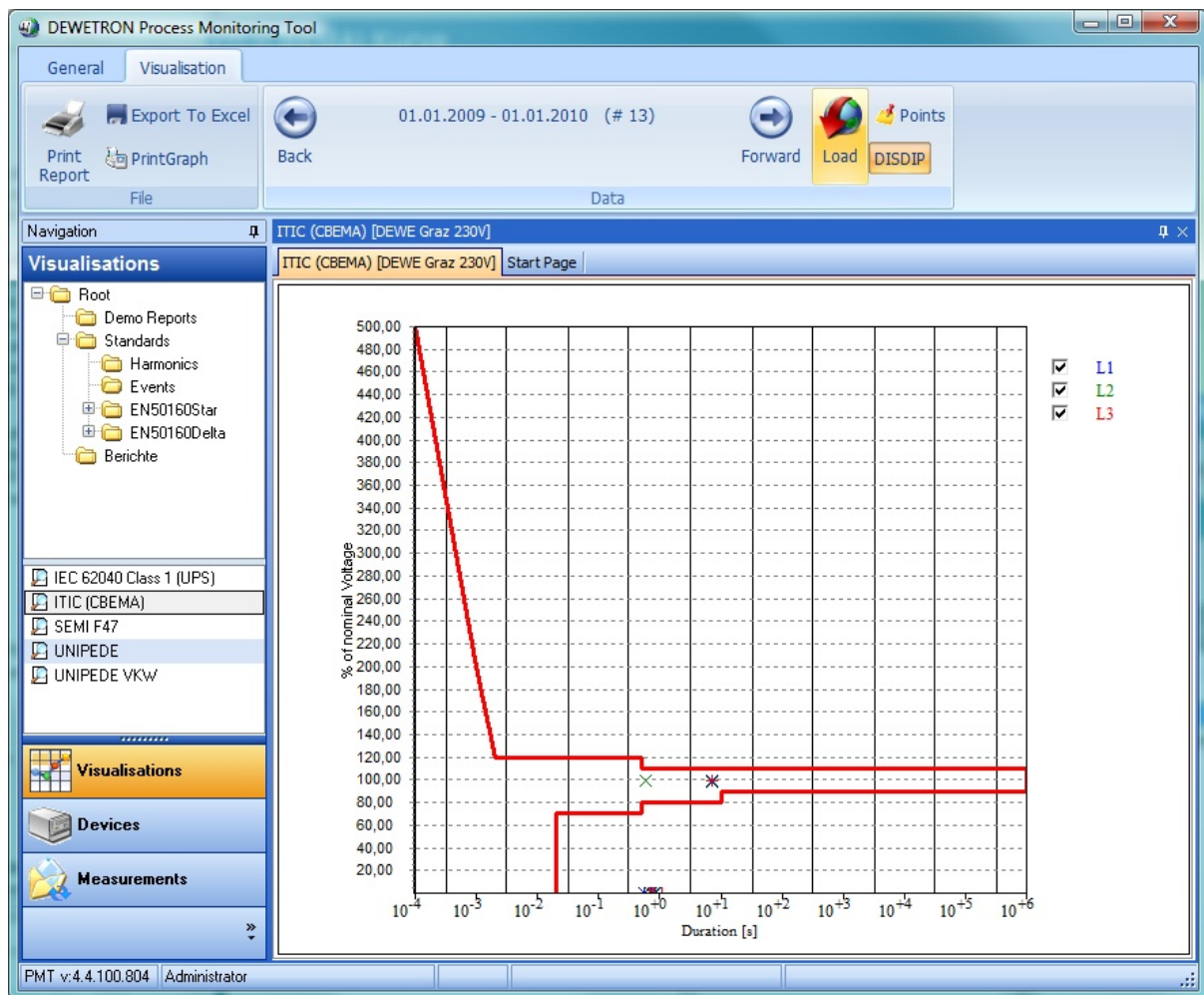


Double Click to open the report and choose the module which you like to analyze.



Next select the time period for the report.

After that you will get an graph displayed on screen. which you can print, export or processed in a report.



If you want to modify the visualization further, open the visualization with a right click and "edit Visualization".

In "curve points" list (on the right below) you can simply add, change or delete curve points.

CBEMA Settings

General | Module Switcher

Caption: ITIC (CBEMA)

Description:

Rights:

Owner: Administrator

Group: root

Others:

Read Write Execute

Owner ☒ ☒ ☒

Group ☒ ☐ ☐

Others: ☐ ☐ ☐

View

Phases: ☒ L1 ☒ L2 ☒ L3

Axis: ☐ log Voltage ☒ log Duration

☐ Show only faults that are visible vor outlines

☐ Use Outline filtering

☐ Absolute Values

Disip ☐ Enabled

Curve Points

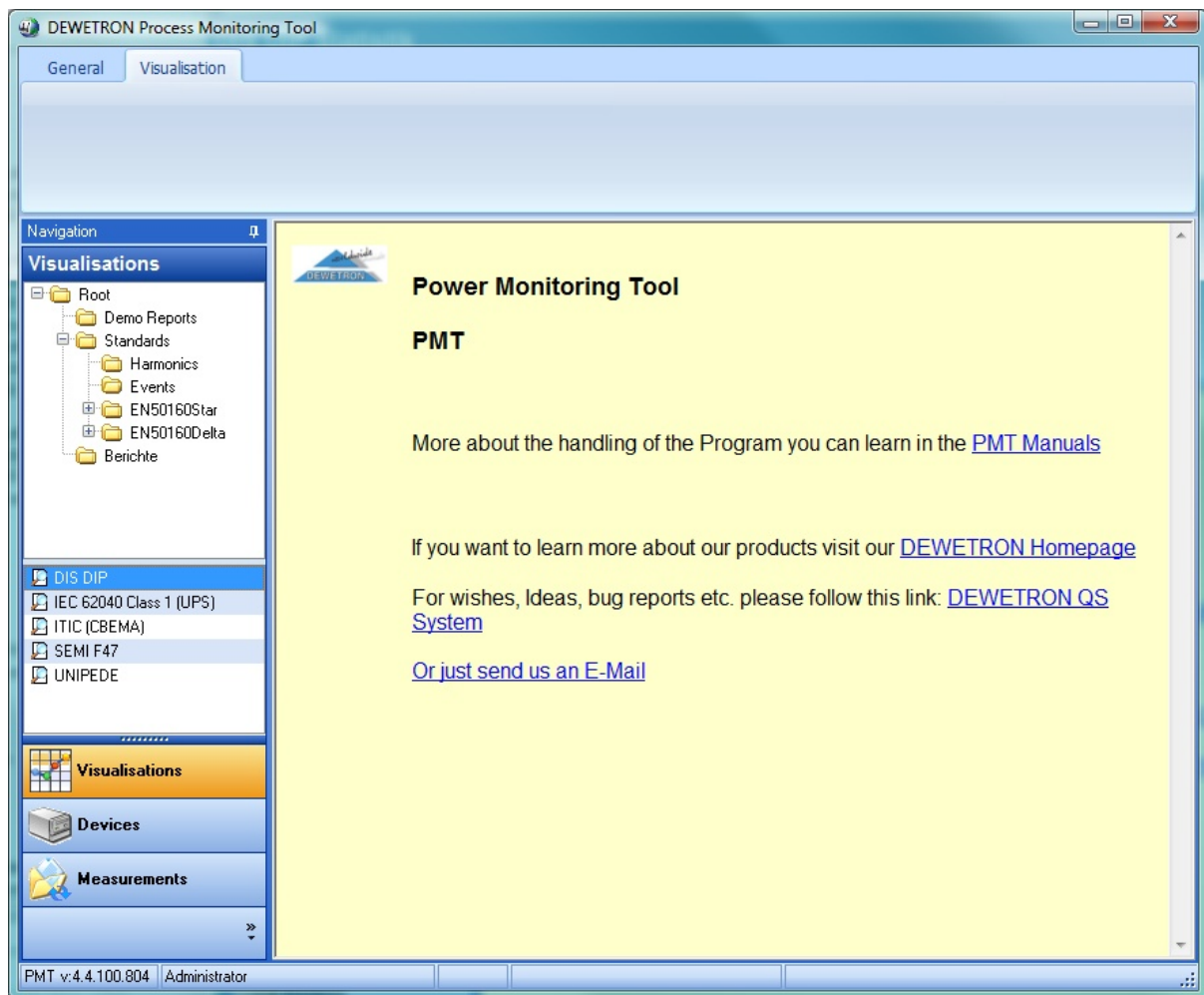
POS	Duration [s]	Voltage [%]
1	0,02	0
2	0,02	70
3	0,5	70
4	0,5	80
5	10	80
6	10	90
7	1000000	90
8	1000000	110
9	0,5	110
10	0,5	120
11	0,002	120
12	0,001	200
13	0,0001	500

Print Template OK Cancel

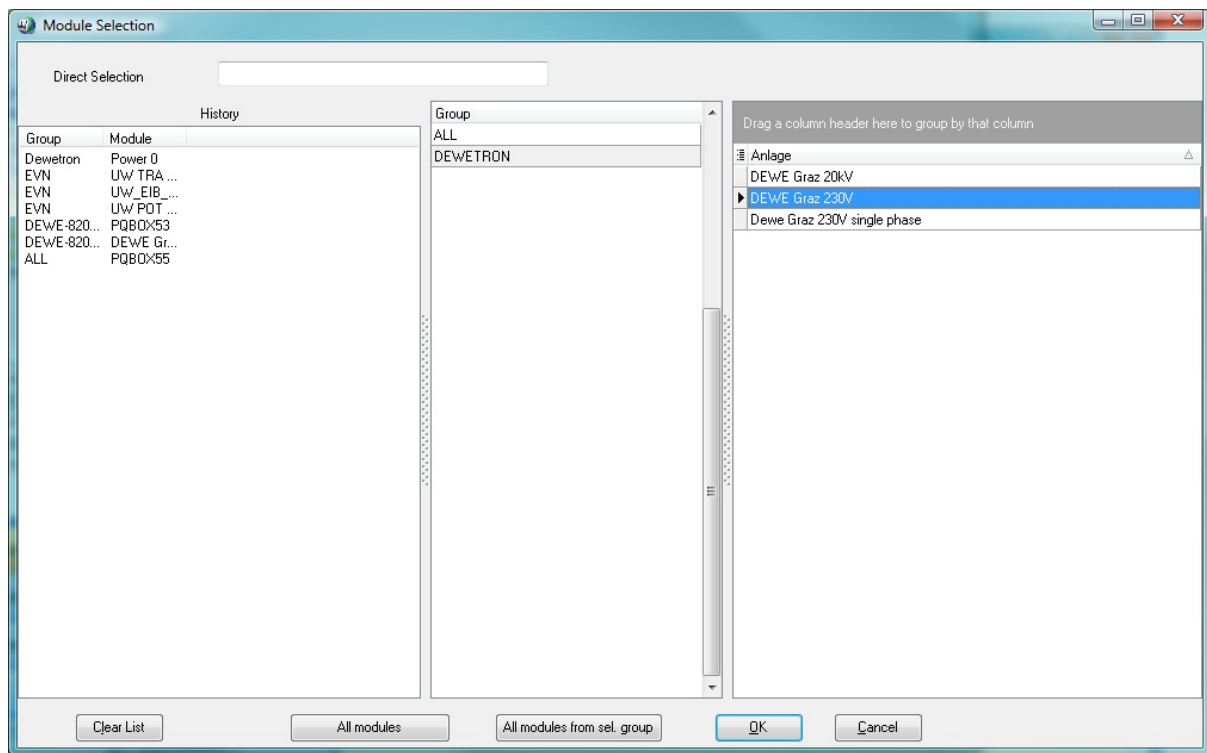
3.2.4 DIS DIP statistic

Prerequisite: Knowledge about how to create an event list and understanding of the chapter "voltage drops".

In PMT you will find in the directory "Root/Standards/Events" the report for the fault statistic (DISDIP).

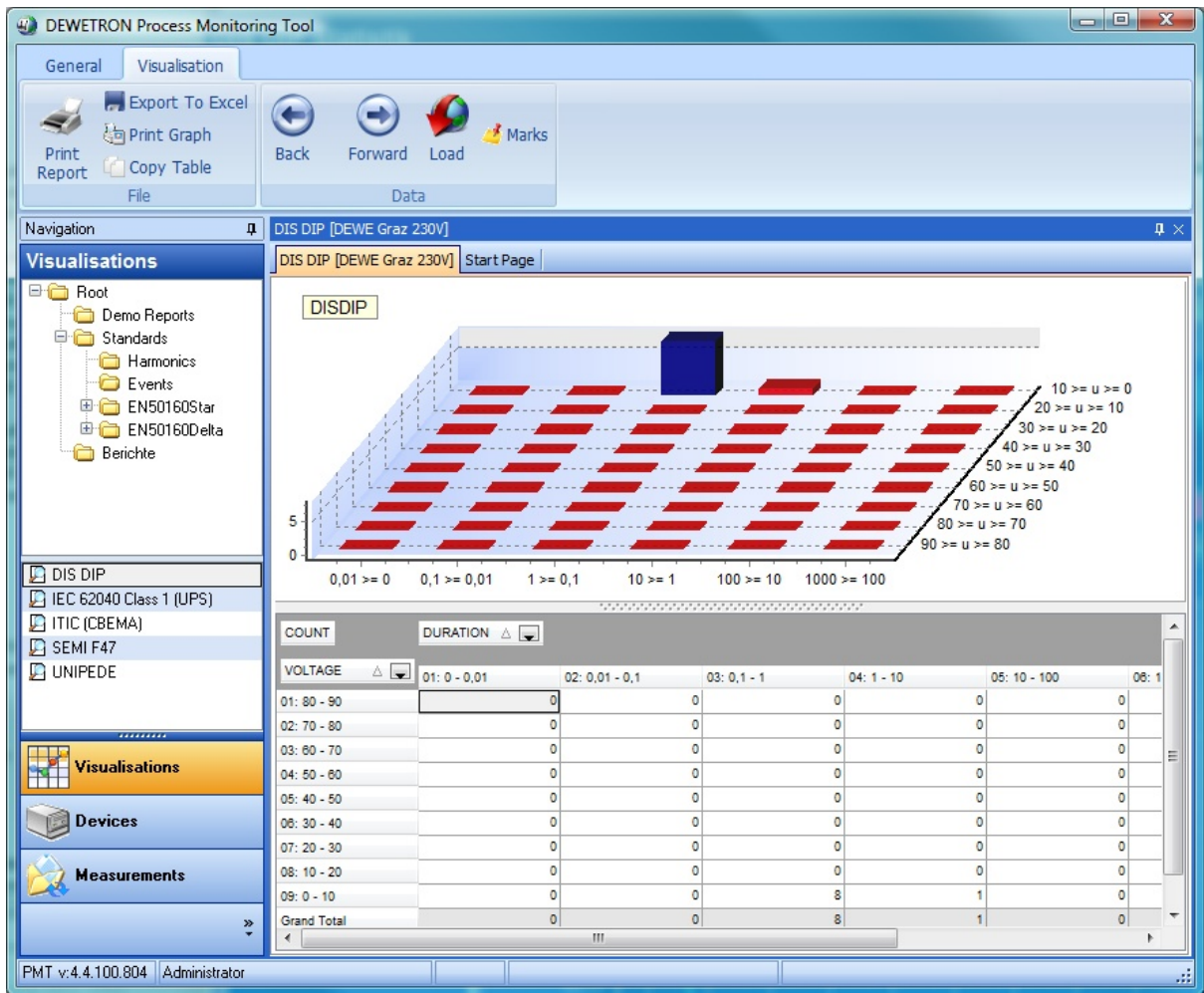


Double Click to open the report and choose the module which you like to analyze.



Next select the time period for the report.

After that you will get a table including an bar graph displayed on screen. which you can print, export or processed in a report.



If you want to modify the visualization further, open the visualization with a right click and "edit Visualization".

In "table settings" (below) you can simply add, change or delete column values.

DISDIP List Settings ...

General **Module Switcher**

Caption: DIS DIP

Description:

Rights:

Owner: Administrator

Group: root

	Read	Write	Execute
Owner	☒	☒	
Group	☒	☐	
Others:	☐	☐	

Colors

Start:  cINavy

End:  cRed

View

☒ L1 ☒ L2 ☒ L3

☐ Show only faults that are visible vor outlines

☐ Use Outline filtering

Table settings:

% Rest voltage:

LL	UL
	80
	70
	60
	50
	40
	30
	20
	10
	0

Durations [s]:

LL	UL
	0
	0,01
	0,1
	1
	10
	100
	1000

Print Template

OK

Cancel

3.2.5 Full FFT - PMT

Full FFT is the storage of all spectral lines in according to the calculation.
 If 10 periods are used for FFT calculation, you get 10 lines between the individual harmonics.
 With 50Hz base frequency signifies all 5Hz a line.

1) Measurement:

Set up a Power module and save it in database.

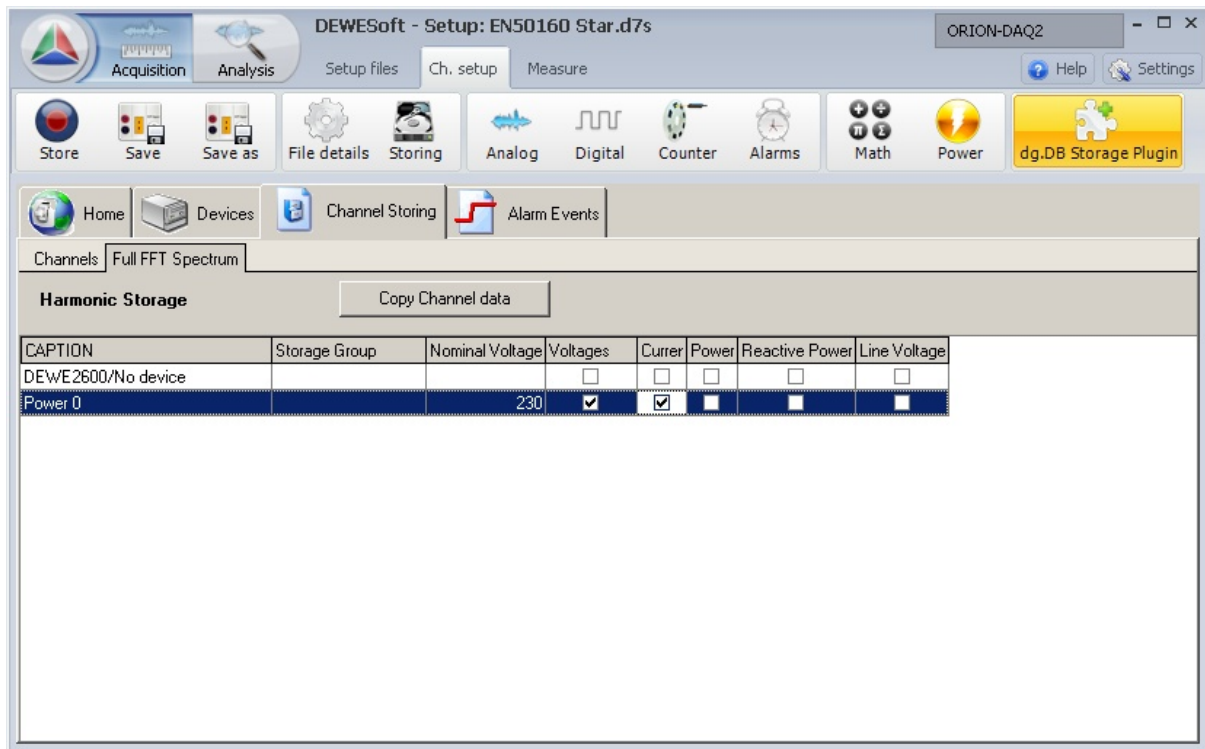
Make the following settings:

DB Storage Plugin

-> Tab "Channel Storing"

-> Lower Tab "Full FFT Spectrum"

Enable those channels which you want to save full resolution FFT.



2) Analysis:

PMT has its own visualization which you can use to analyze the full FFT.

Click "add visualization" and select:



Typical questions are:

select full spectrum FFT output

harmonics output (similar to FFT, but the side bands are self-defined)

harmonics and interharmonics output (similar to FFT, but the side bands are self-defined)

Frequency bands output (e.g. 2-9kHz in 200Hz groups, according to IEC 61000-4-7)

3.2.5.1 Display a full spectrum

1) Create a visualization:



After creating a new visualization fill out the input dialog as follows:

"All frequency lines" must be enabled.

The ending frequency amounts to 2000Hz in our case, that means that all frequency lines 0 - 2000Hz are given.

Full Spectrum FFT Editor

Default | Module switcher

Caption: Full Spectrum

Description:

Time View:
Data Points

☒ Raw Data
☐ Time based
☐ Time based rounded

Time base [s]: 600

☐ Autorefresh 60 [s]

Rights:

Owner: Administrator
 Group: root

	Read	Write	Execute
Owner	☒	☒	☒
Group	☒	☐	☐
Others:	☐	☐	☐

☒ All frequency lines
 End: 2000 Hz

☐ Grouped harmonics

Start: 1 H End: 25 H
 Width: 0

☐ Interharmonics Width: 0 H

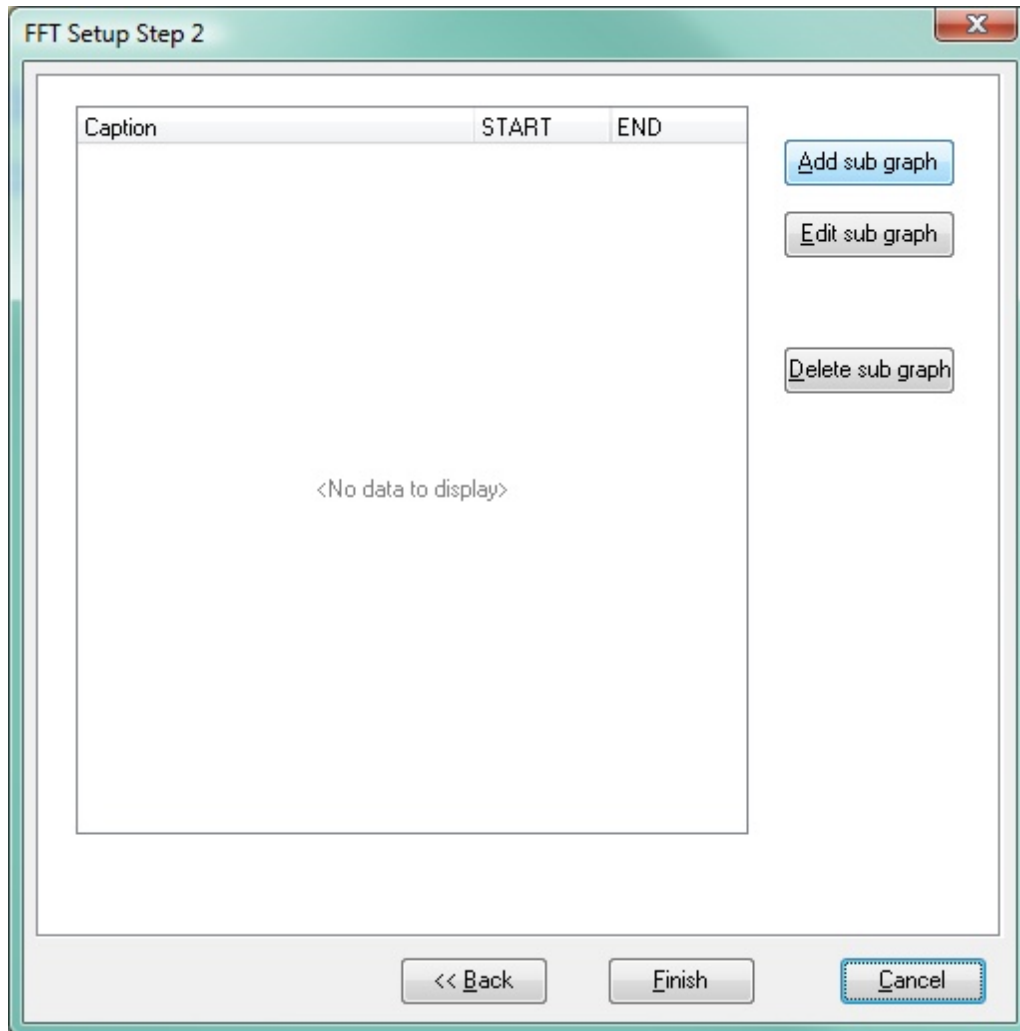
Limit specification:
 Limit Type: ☒ Average ☐ Maximum ☐ Quantile
 Quantil [%]: 95

☐ Frequency bands

Start: 0 Hz End: 2000 Hz
 Width: 200 Hz

Print Template Next >> Cancel

In the next step select the measuring channels to display them.
First of all define a graph "Add sub graph":



Now add a channel to the graph ("Add channel")

FFT Setup Step 3

Sub graph data

Caption: Start [%]: End [%]:

Left axis

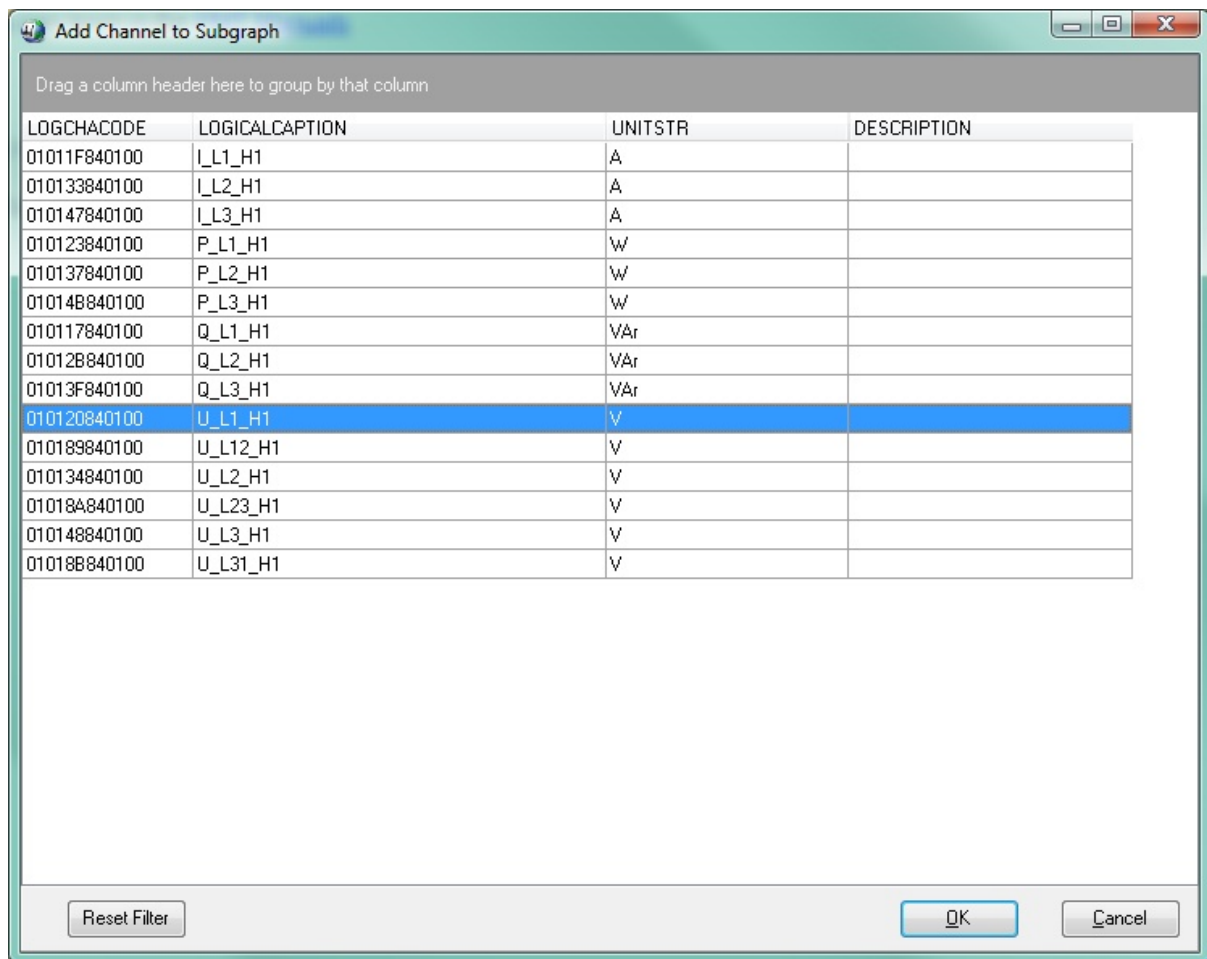
Visible ☒ Log ☐

Min Auto ☒ Val:

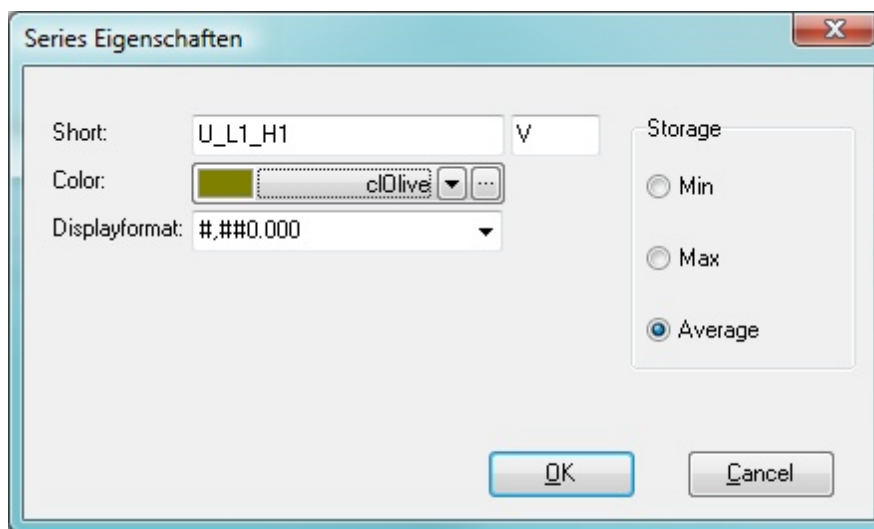
Max Auto ☒ Val:

COL	AXIS	SHORTDESC	RMSTYPE	FIXEDTODEVIC	LOGICALCAPTION	MODULECAPTION
<No data to display>						

In our case we select "U_L1_H". "U_L1_H" is the spectrum of the voltage "L1"



The next step is to select the properties of the measuring channel (color, decimal)

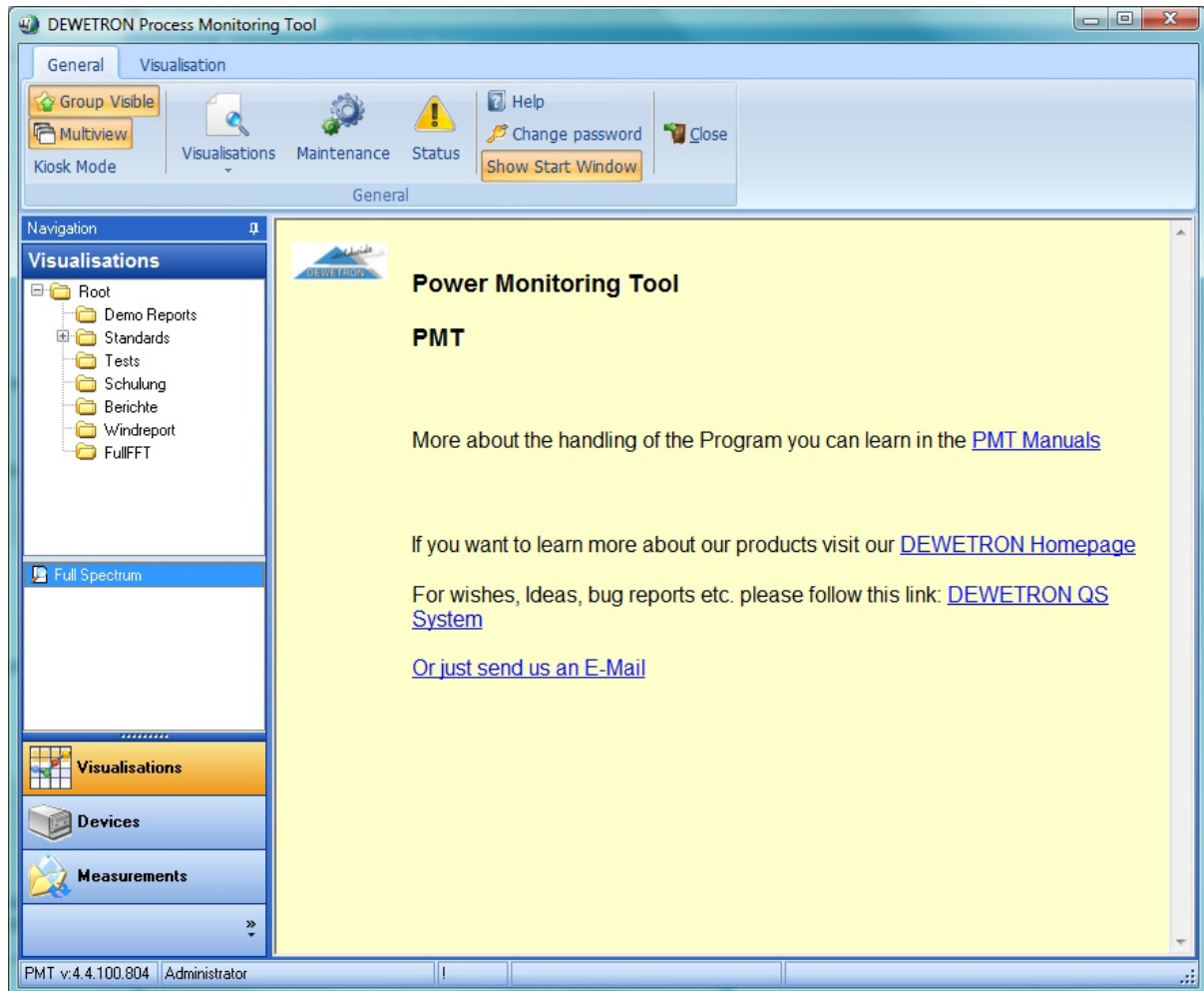


Click "OK" and then "OK" and "finish" to save your settings.

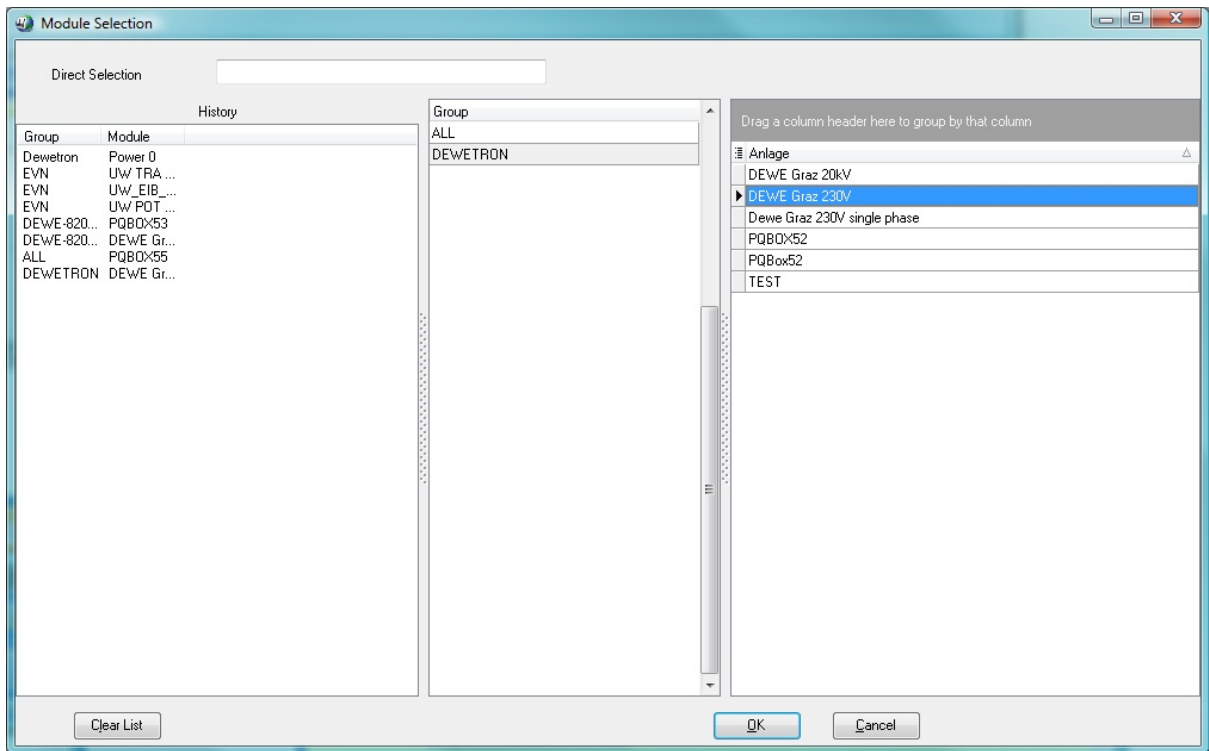
Now your new visualization is visible on the left.

2) Analyze the recording

Open the visualization "Full Spectrum"

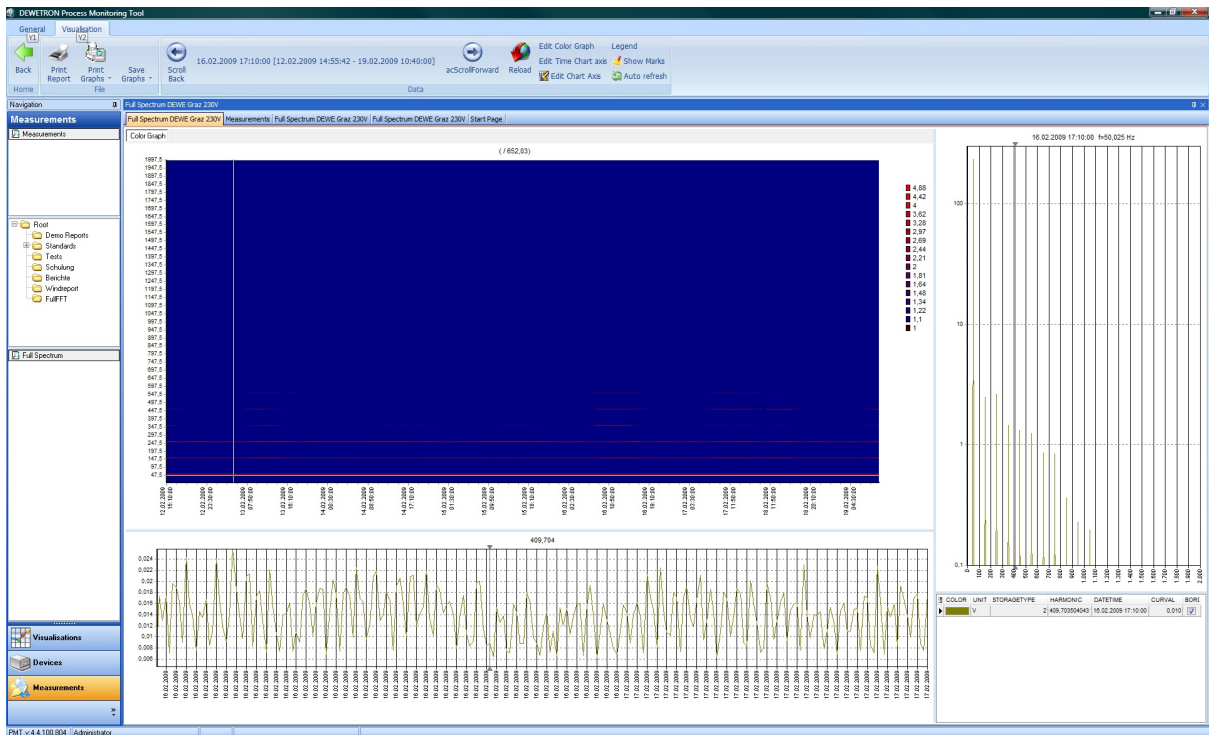


Now select the desired power module



Next, choose the preferred time period and then the graph appears on the screen:

There are 3 sections on the screen. The navigation across the screen is described in chapter "Navigate in full FFT".



3.2.5.2 Harmonics output

The procedure is the same as in chapter "Display a full spectrum", so only the steps are treated they are differently.

1) Create a visualization

To output the harmonics please select "Grouped Harmonics".

"Start" and "End" specify the range of the harmonics to be calculated (1 to 25).

"Width" indicates the number of side bands to be added to the baseline (1).

Full Spectrum FFT Editor

Default | Module switcher

Caption: Harmonics

Description:

Time View

Data Points

☒ Raw Data

☐ Time based

☐ Time based rounded

Time base [s]: 600

☐ Autorefresh 60 [s]

Rights:

Owner: Administrator

Group: root

	Read	Write	Execute
Owner	☒	☒	☒
Group	☒	☐	☐
Others:	☐	☐	☐

☐ All frequency lines

End: 2000 Hz

☒ Grouped harmonics

Start: 1 H End: 25 H

Width: 1

☐ Interharmonics Width: 0 H

Limit specification:

Limit Type

☒ Average

☐ Maximum

☐ Quantile

Quantil [%]: 95

☐ Frequency bands

Start: 0 Hz End: 2000 Hz

Width: 200 Hz

Print Template

Next >>

Cancel

Our example: 50Hz and 10 periods.

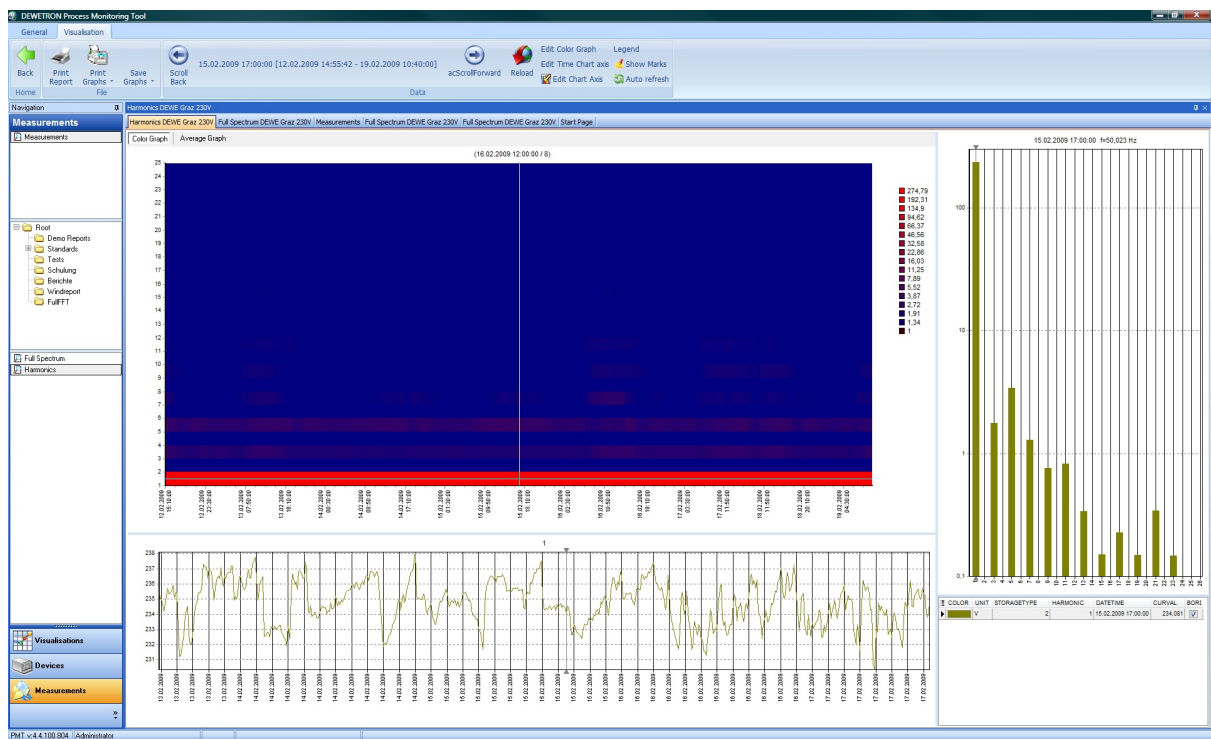
To the 50Hz line 45 and 55Hz are added (rms) and results the 1st harmonic (corresponding to the current IEC 61000-4-7).

To the 150Hz line 145 and 155Hz are added (rms) and results the 3rd harmonic.
and so on...

if you want a value without side bands so you have to select a with equals 0 (e.g. old standard IEC 61000-4-7).

2) Analyze the recording

Open the visualization named "Harmonics".



There are 3 sections on the screen. The navigation across the screen is described in chapter "Navigate in full FFT" .

3.2.5.3 Harmonics and interharmonics output

The procedure is the same as in chapter "Display a full spectrum", so only the steps are treated they are differently.

1) Create a visualization

To display harmonics and interharmonics select the option "Grouped Harmonics".

"Start" and "End" specify the range of the harmonics to be calculated (1 to 25).

"Width" indicates the number of side bands to be added to the baseline (1).

"Interharmonics" enables the calculation of the interharmonics.

"Width" indicates which frequency lines to be used for the calculation of the interharmonics (2-8).

Full Spectrum FFT Editor

Default Module switcher

Caption: Harmonics and Interharmonics

Description:

Time View:

Data Points:

☒ Raw Data

☐ Time based

☐ Time based rounded

Time base [s]: 600

☒ Autorefresh 60 [s]

Rights:

Owner: Administrator

Group: root

	Read	Write	Execute
Owner	☒	☒	☒
Group	☒	☐	☐
Others:	☐	☐	☐

☐ All frequency lines

End: 2000 Hz

☒ Grouped harmonics

Start: 1 H End: 25 H

Width: 1

☒ Interharmonics Width: 2 - 8 H

Limit specification:

Limit Type:

☒ Average

☐ Maximum

☐ Quantile

Quantil [%]: 95

☐ Frequency bands

Start: 0 Hz End: 2000 Hz

Width: 200 Hz

Print Template

Next >>

Cancel

Our example: 50Hz and 10 periods.

To the 50Hz line 45 and 55Hz are added (rms) and results the 1st harmonic (corresponding to the current IEC 61000-4-7).

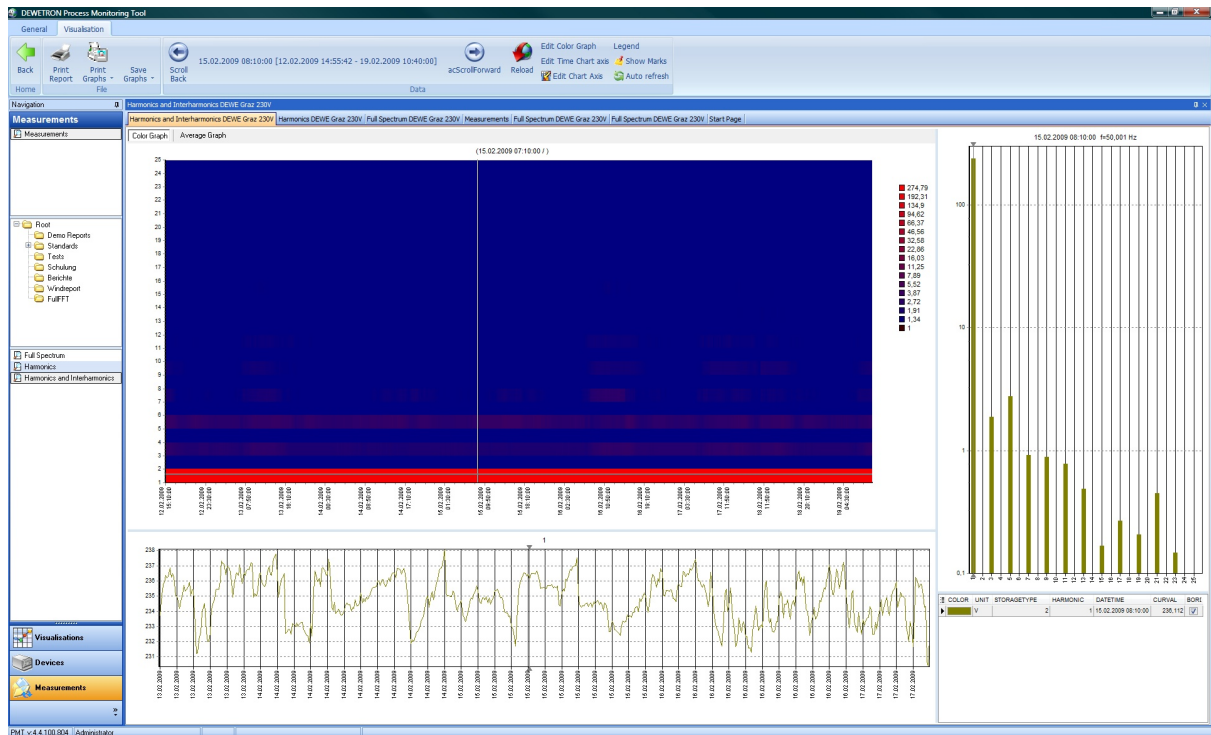
With 60, 65, 70, 75, 80, 85 and 90Hz (lines 2-8) the 1st interharmonic is formed (rms).

To the 100Hz line 95 and 105Hz are added (rms) and results the 2nd harmonic.

and so on...

2) Analyze the recording

Open the visualization "Harmonics und Interharmonics".



There are 3 sections on the screen. The navigation across the screen is described in chapter "Navigate in full FFT" .

3.2.5.4 Frequency bands output

The procedure is the same as in chapter "Display a full spectrum", so only the steps are treated they are differently.

1) Create a visualization

To visualize frequency bands select the option "Frequency bands".

"Start" and "End" specify the range of the bands to be calculated (1000 to 2000Hz).

"Width" indicates the width of the band (200Hz).

Full Spectrum FFT Editor

Default | Module switcher

Caption: higher Frequencies

Description:

Time View:
Data Points
☒ Raw Data
☐ Time based
☐ Time based rounded
 Time base [s]: 600
☐ Autorefresh 60 [s]

Rights:
 Owner: Administrator
 Group: root

	Read	Write	Execute
Owner	☒	☒	
Group	☒	☐	
Others:	☐	☐	

☐ All frequency lines
End: 2000 Hz

☐ Grouped harmonics
 Start: 1 H End: 25 H
 Width: 1
☒ Interharmonics Width: 2 - 8 H

Limit specification:
 Limit Type
☒ Average
☐ Maximum
☐ Quantile
 Quantil [%]: 95

☒ Frequency bands
 Start: 1000 Hz End: 2000 Hz
 Width: 200 Hz

Print Template | Next >> | Cancel

Our example: 50Hz and 10 periods:

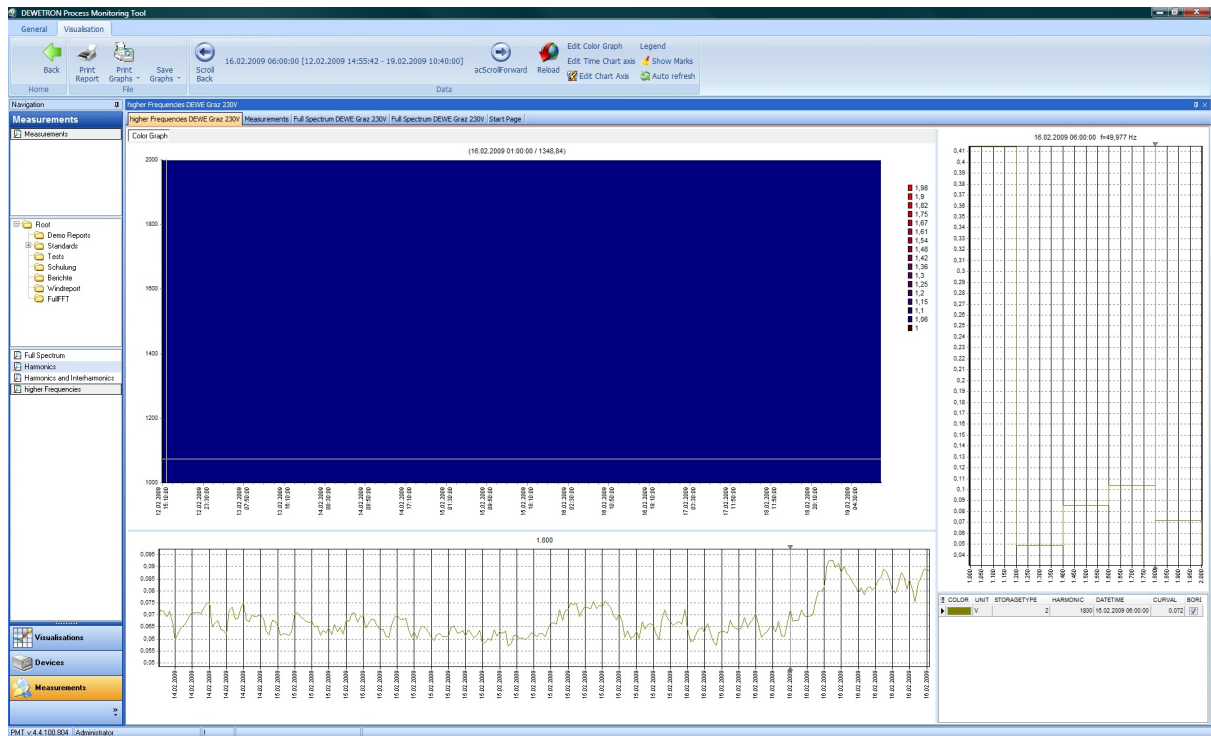
Frequency bands are formed of 1 to 2kHz.

The step size is 200Hz.

This gives a total of 5 bands.

2) Analyze the recording

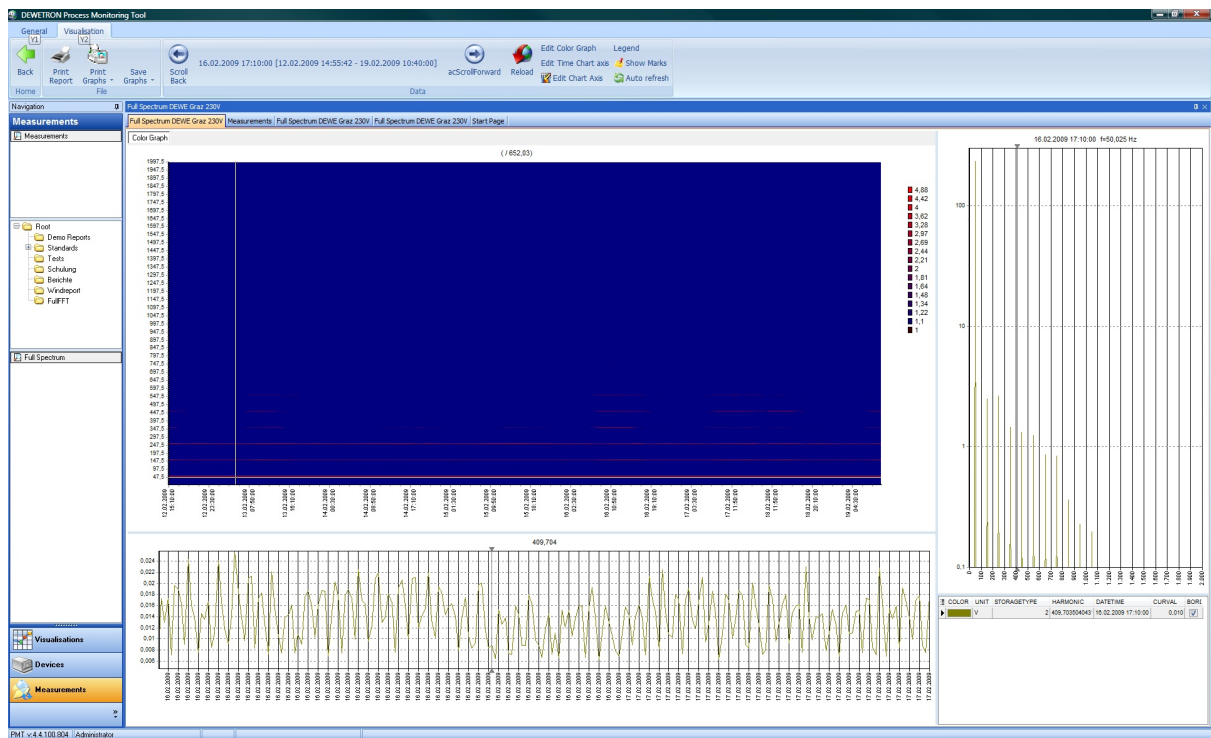
Open the visualization "higher Frequencies".



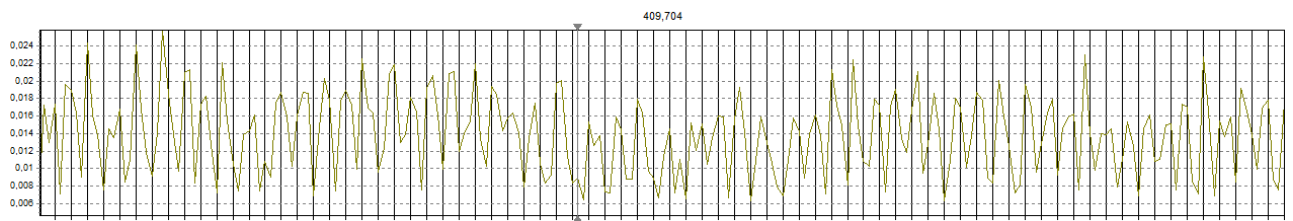
There are 3 sections on the screen. The navigation across the screen is described in chapter "Navigate in full FFT" .

3.2.5.5 Navigate in Full FFT

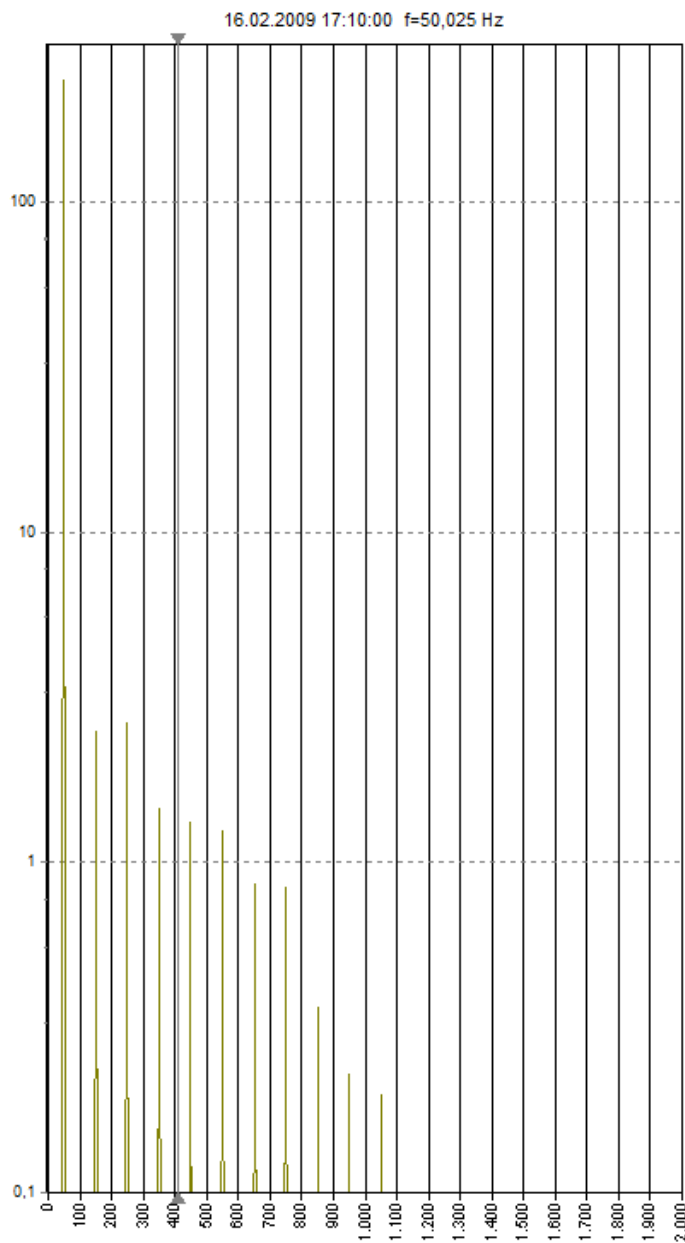
Regardless of what type of Full FFT you have chosen, the screen always contains three interrelated areas:



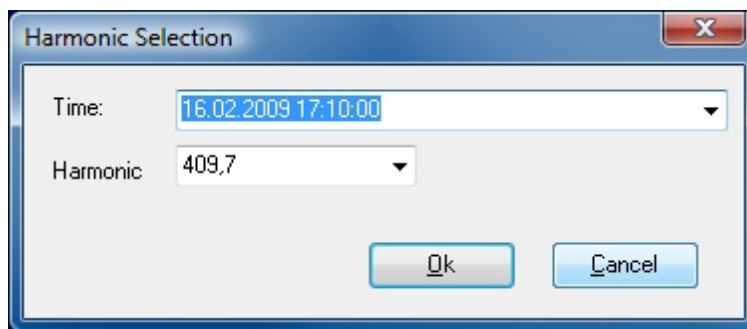
Below: the time series as graph of the selected harmonics. You can take the selection by clicking on the value over the diagram and type in the desired frequency, or set the cursor on specific frequency in the diagram on the right.



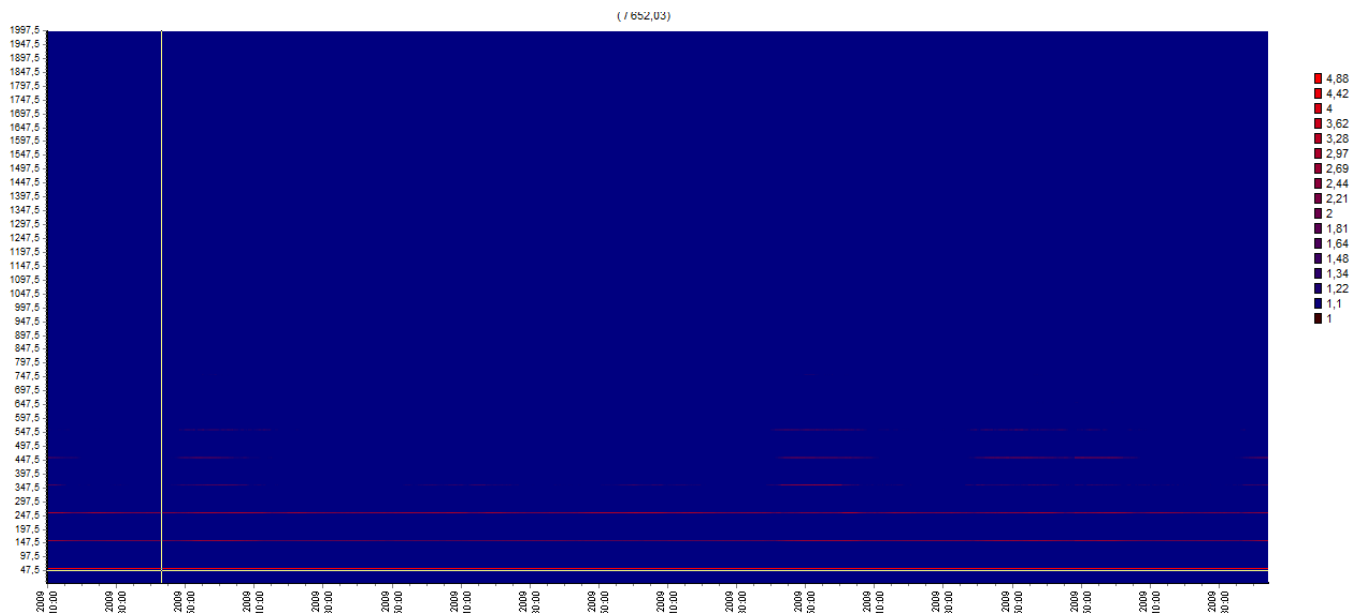
on the right: this view shows the spectrum, which applied to the selected time (marked with the cursor on the picture below).



You can also take the time selection by clicking on the time value on the top and enter it manually.



Picture above: 3D representation of all frequencies (up) and time (to the right).



In the menu bar (color and scales) you can change the view with "Edith color graph".
If you move the cross hair (yellow cursor) the diagrams on the left and below change automatically.

3.3 Fault recorder

In this chapter you will learn about the applications of large fault recorder like the DEWE-8xx-PFR.

Requirements:

- Measurement of voltage, especially with an transducer
- Measurement of current, especially with a current module
- Storing data, especially fast storing on trigger
- Storing of data in a database



There are several ways to run an fault. Here are some of them:

- Fault recorder with local storage of data (DEWESoft file system).

- Fault recorder with storage of data on network (PMT Server).

- Fault recorder with combined PQ-function.

Advice: Storing to a database offers many advantages:

- You can define multiple triggers for different power modules at a time on a device.

- You can set nested triggers.

- You can define exactly which channels are to be stored for any event.

Moreover, any combination or special assignments are possible.

Some special application can be found in Chapter "special measurements".

3.3.1 PFR with local storage of data

Task:

A device connected to the 3-phase supply network in star.

The recording should be started as soon as one of the 3 voltages drops below 150Vrms or rises above 300Vrms.

1) Connect the voltages and set the modules.

first of all connect the voltages, start DEWESoft and set the modules (Measurement of voltage).

DEWESoft - Setup: pfr local.d7s

ORION-DAQ2

Acquisition Analysis Setup Files Ch. setup Measure

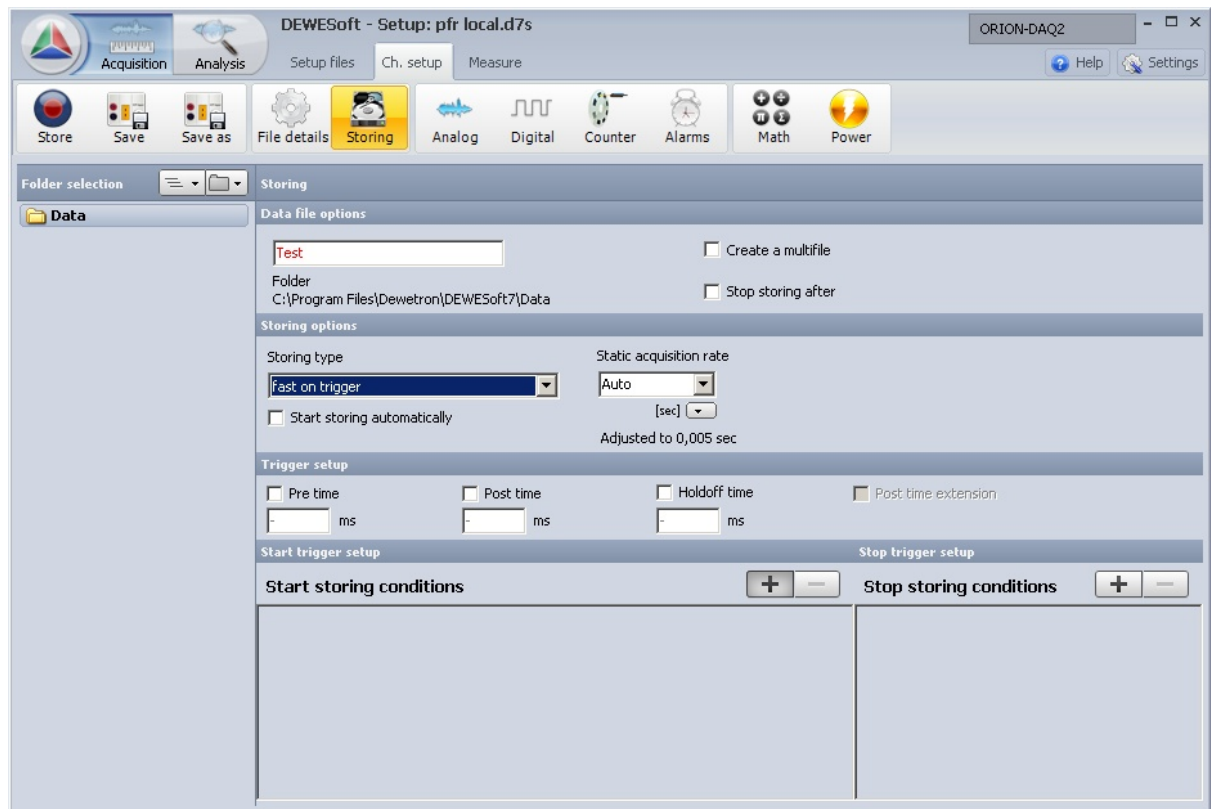
Store Save Save as File details Storing Analog Digital Counter Alarms Math Power

Dynamic acquisition rate: 200000 [Hz/kh] ☐ External clock ☐ Start on external trigger

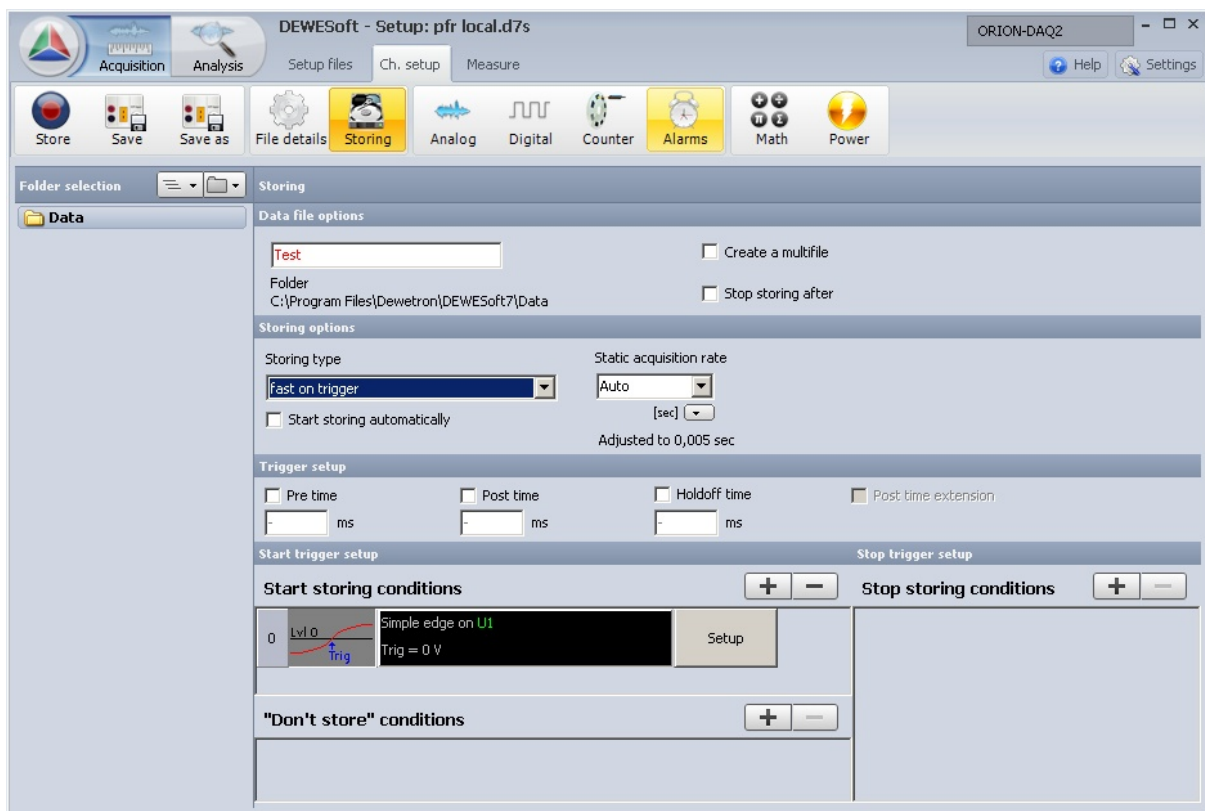
SLOT	ON/OFF	C	NAME	AMPLIFIER (007)	PHYSICAL VALUES	CAL	SETUP
0	Used	Store	U1	DAQP-HV 1400 V .. 100 kHz SN: 324354	-323,7 / 324,3 V	Zero	Set ch. 0
1	Unused		AI 1	DAQP-LV 10 V .. 100 kHz SN: 332758	0,002 V	Zero	Set ch. 1
2	Used	Store	U2	DAQP-HV 1400 V .. 100 kHz SN: 334506	-325,9 / 325,9 V	Zero	Set ch. 2
3	Unused		AI 3	DAQP-LV 10 V .. 100 kHz SN: 332757	-0,001 V	Zero	Set ch. 3
4	Used	Store	U3	DAQP-HV 1400 V .. 100 kHz SN: 335748	-323,9 / 324,0 V	Zero	Set ch. 4
5	Unused		AI 5	DAQP-LV 10 V .. 100 kHz SN: 332759	0,001 V	Zero	Set ch. 5
6	Unused		AI 6	ORION-0816-1000 5 V SN: 15430211	0,000 V	Zero	Set ch. 6
7	Unused		AI 7	ORION-0816-1000 5 V SN: 15430211	0,001 V	Zero	Set ch. 7
8	Unused		AI 8	ORION-0816-1000 5 V SN: 15430231	0,000 V	Zero	Set ch. 8
9	Unused		AI 9	ORION-0816-1000 5 V SN: 15430231	0,000 V	Zero	Set ch. 9
10	Unused		AI 10	ORION-0816-1000 5 V SN: 15430231	0,000 V	Zero	Set ch. 10
11	Unused		AI 11	ORION-0816-1000 5 V SN: 15430231	0,001 V	Zero	Set ch. 11

2) Set the storing of data

Click "storing" and select "fast on trigger".



Next add a start condition with "+".



Settings:

Value: RMS

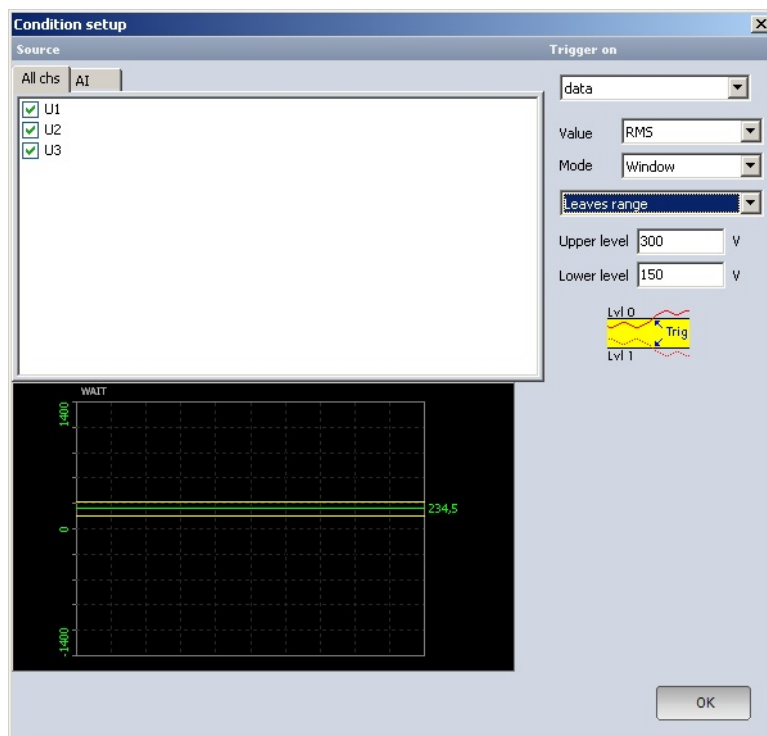
Mode: Window

"Leave Range"

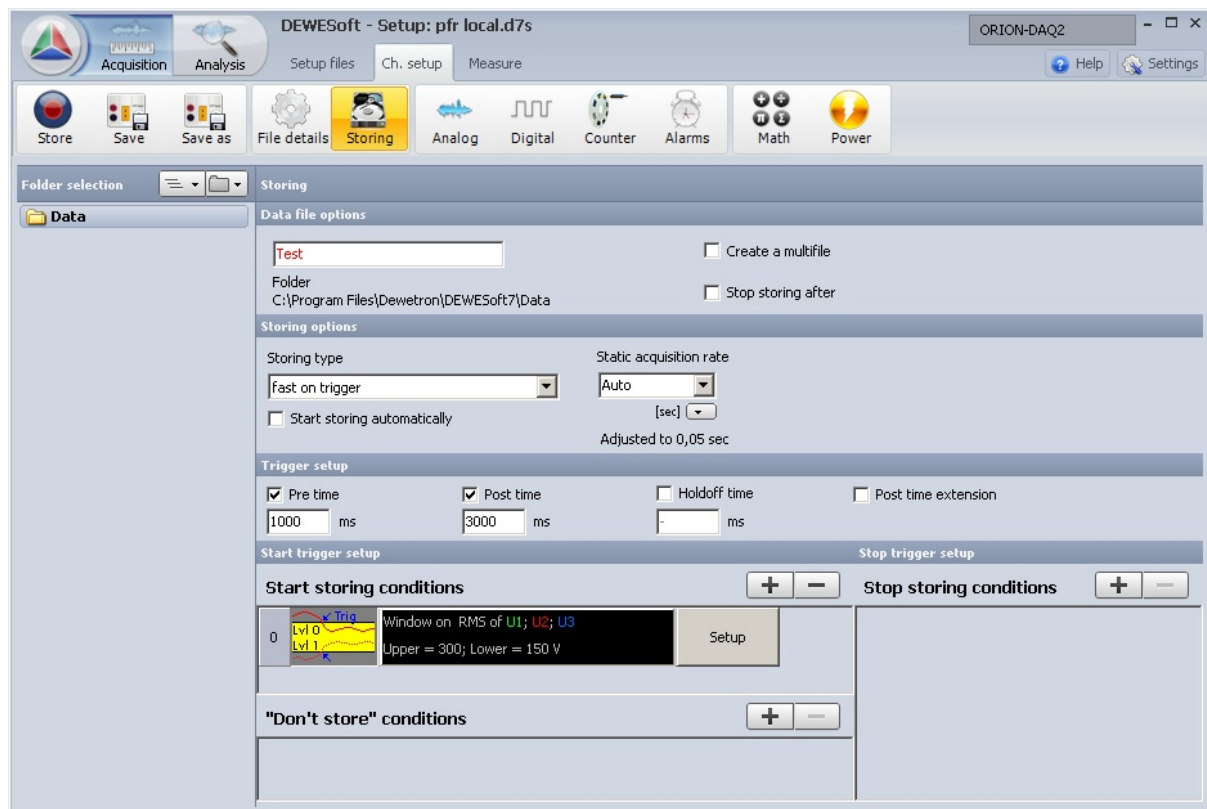
Upper Level: 300 V

Lower Level: 150 V

You can choose several channels with "ctrl+click"

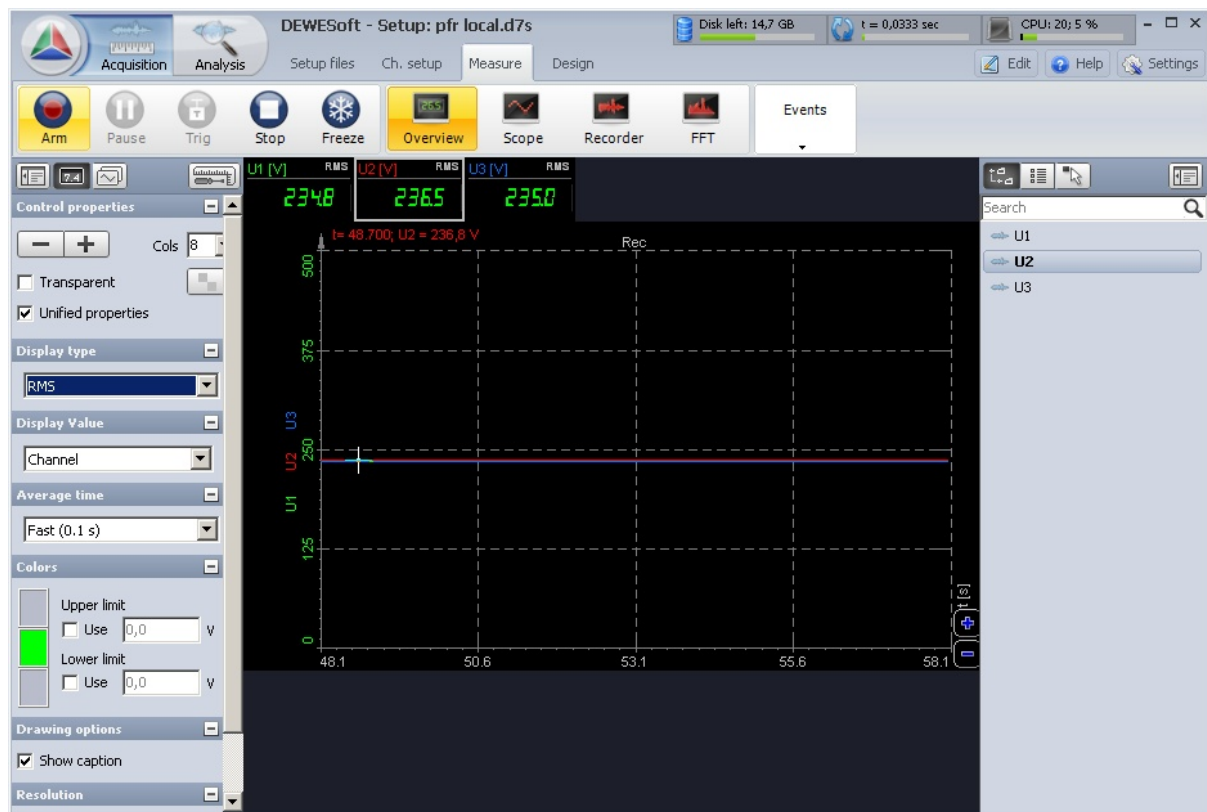


Now please set "Pre time" and "Post time" on the "Storing" page.

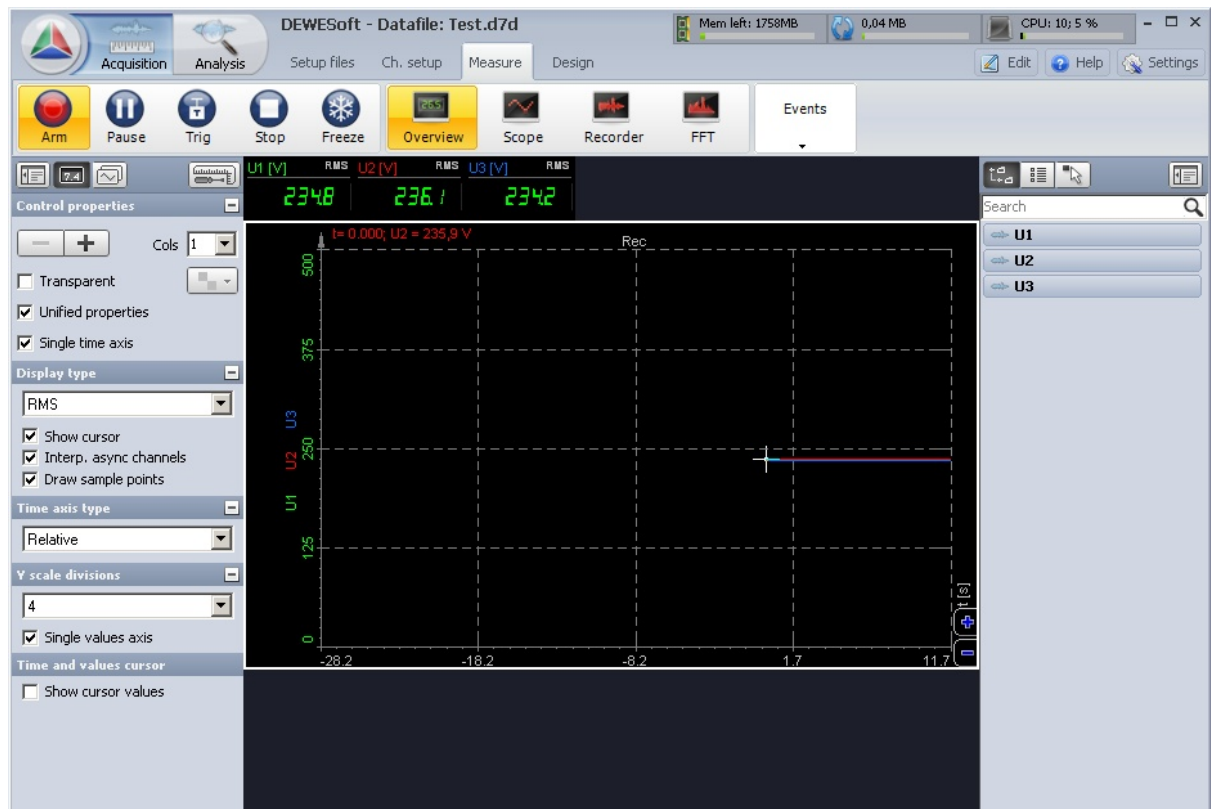


3) Run the measurement:

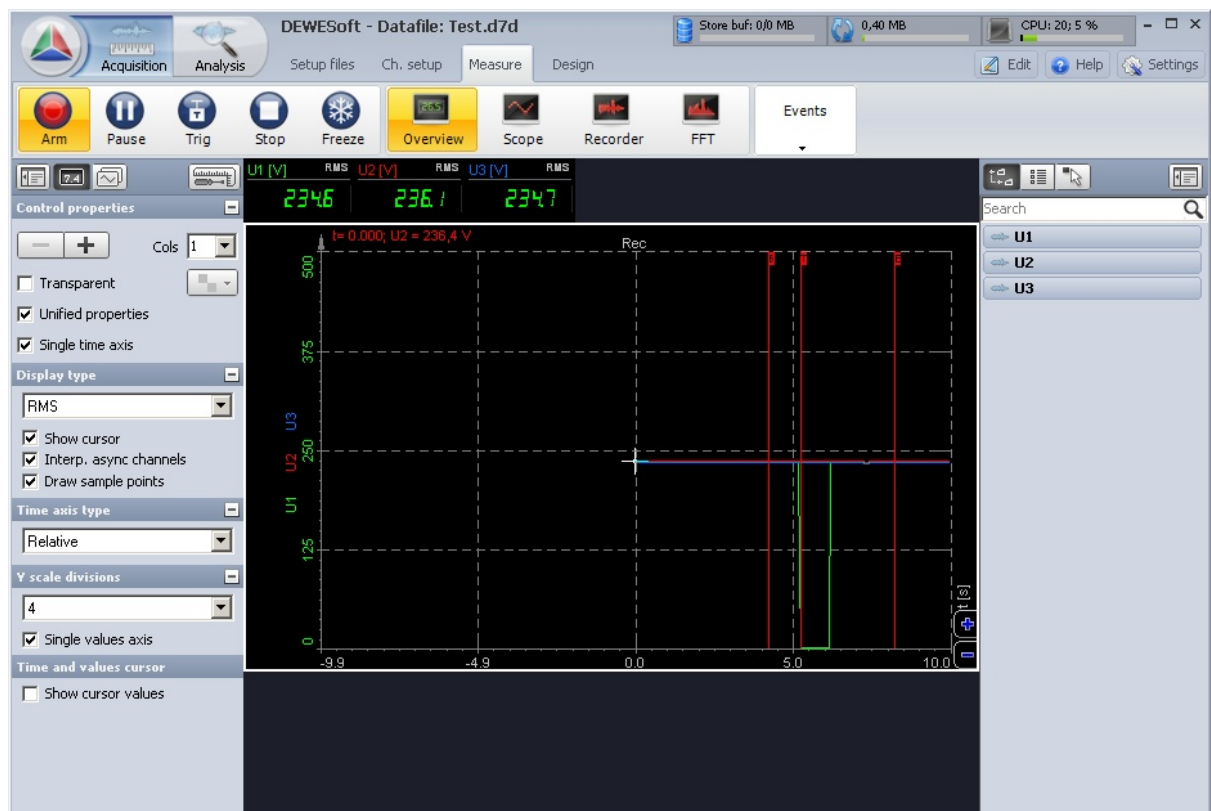
Change to the measurement mode and run the measurement "Measure".



Arm (Arm) the measurement.

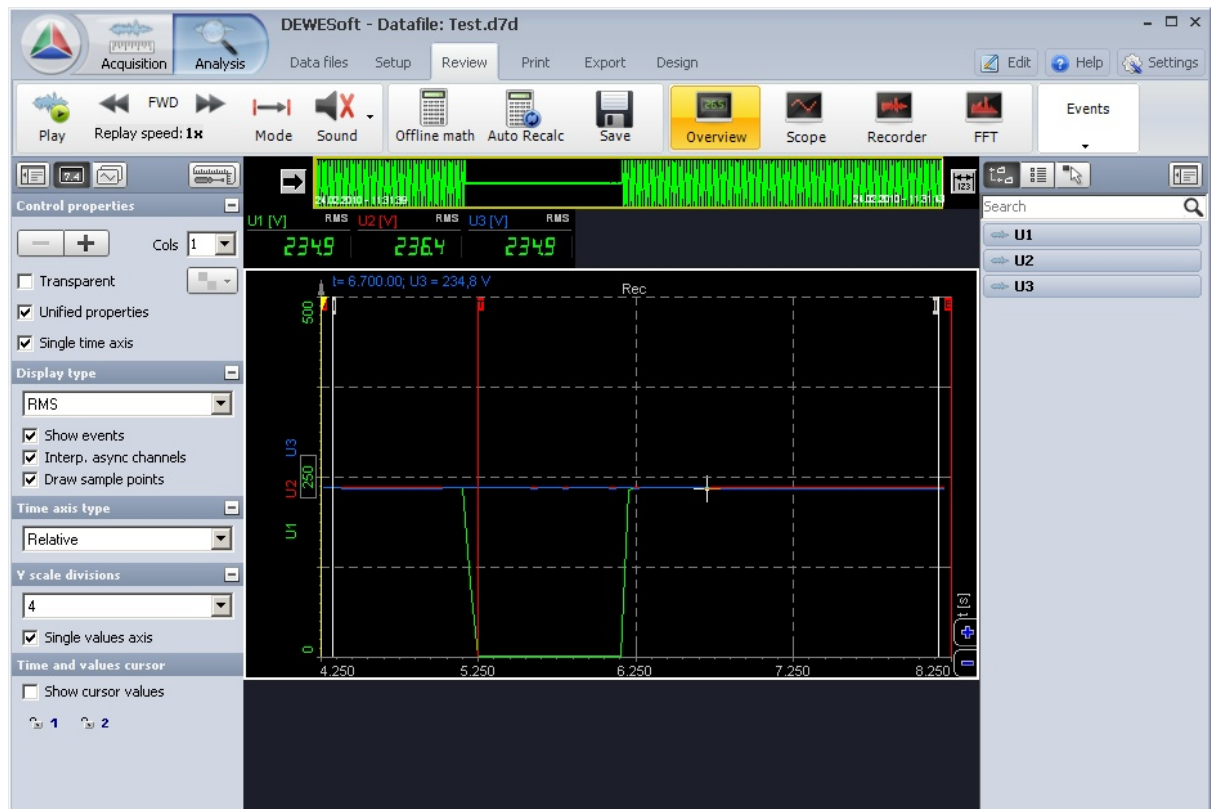


If an error occurs, red vertical bars are displayed, which are located at the start, trigger and the end of the recording.

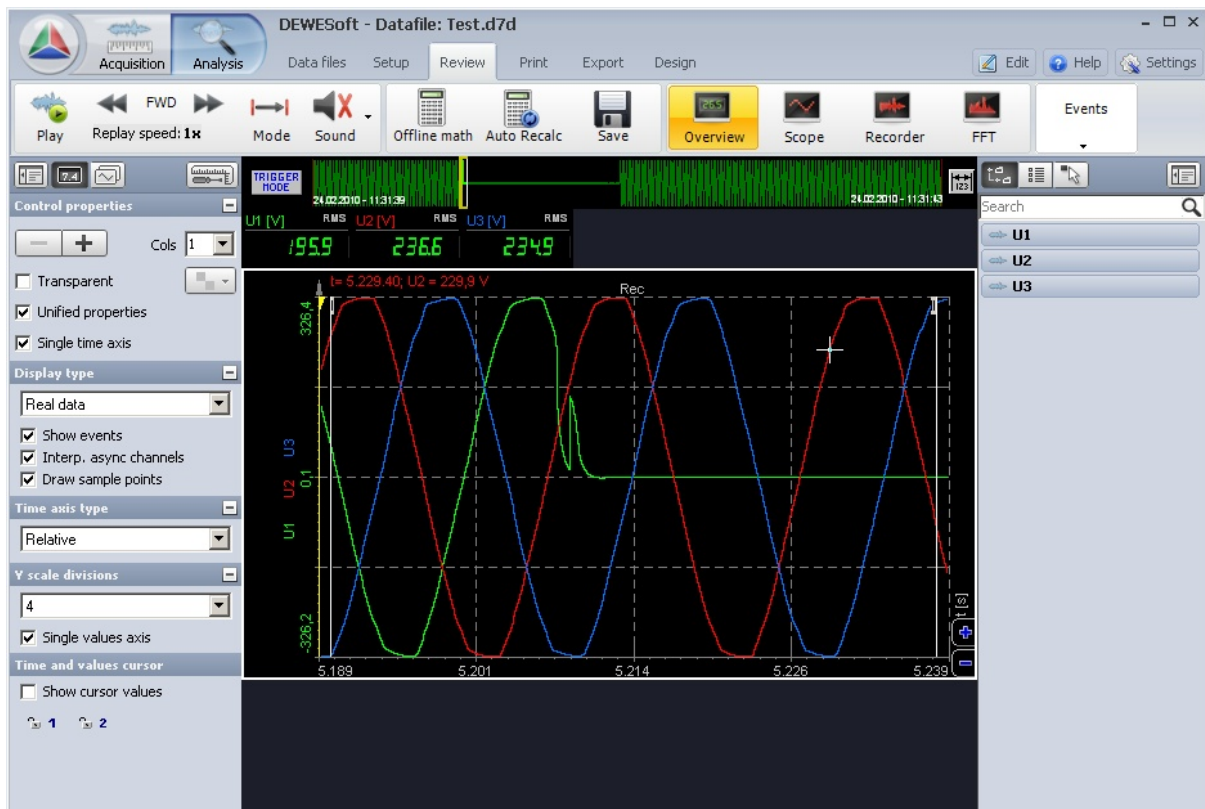


4) Analysis

Stop the measurement and change to the analyze mode (Analysis).



Now you can arbitrarily zoom and you can switch between the display types "RMS" and "Real data".



3.3.2 PFR with storage in database

Task:

A device connected to the 3-phase supply network in star.

The recording should be started as soon as one of the 3 voltages drops below 150Vrms or rises above 300Vrms.

Storage of data in a PMT database.

1) Connection of the voltages an module settings

first of all connect the voltages, start DEWESoft and set the modules (Measurement of voltage).

DEWESoft - Setup: pfr pmt.d7s

ORION-DAQ2

Acquisition Analysis Setup Files Ch. setup Measure

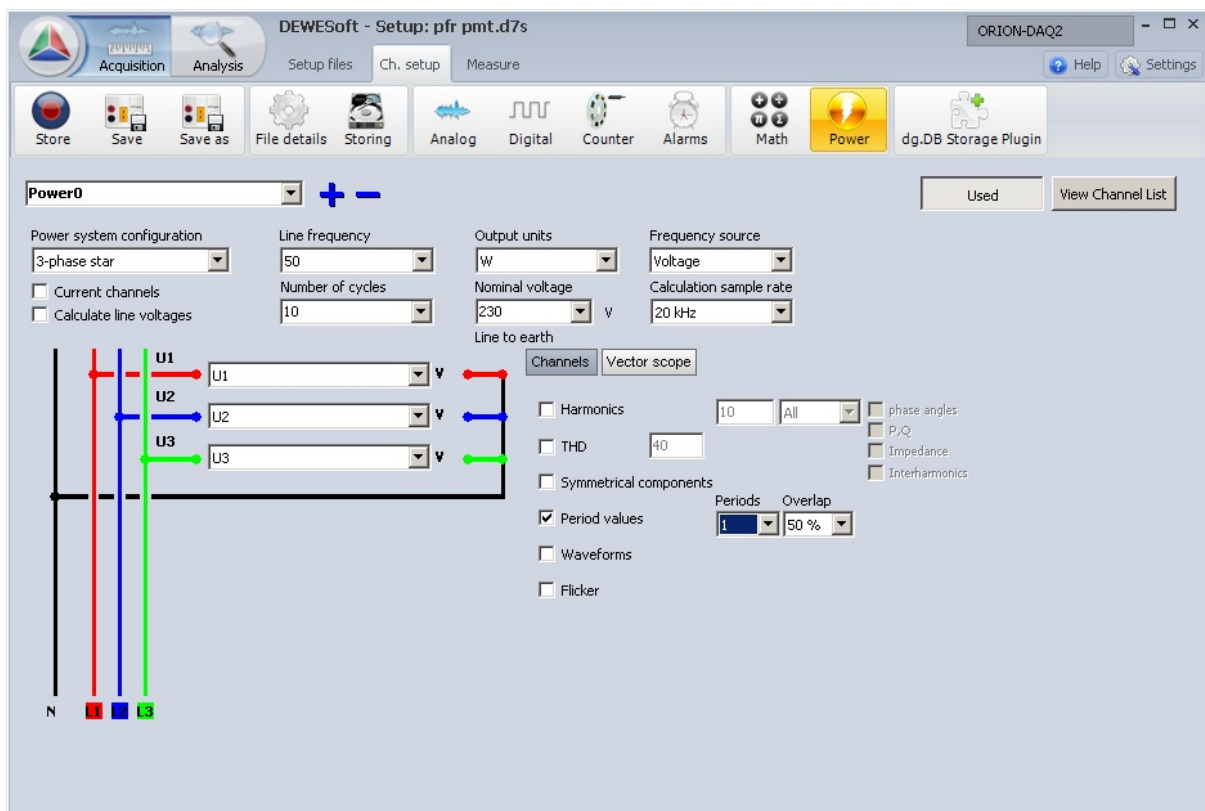
Store Save Save as File details Storing Analog Digital Counter Alarms Math Power dg.DB Storage Plugin

Dynamic acquisition rate: 20000 [Hz/kh] ☐ External clock ☐ Start on external trigger

SLOT	ON/OFF	C	NAME	AMPLIFIER (012)	PHYSICAL VALUES	CAL	SETUP
0	Used	Store	U1	DAQP-HV 1400 V .. 100 kHz SN: 324354	-318,5 / 319,0 V	Zero	Set ch. 0
1	Unused	Store	AI 1	DAQP-LV 10 V .. 100 kHz SN: 332758	0,000 V	Zero	Set ch. 1
2	Used	Store	U2	DAQP-HV 1400 V .. 100 kHz SN: 334506	-321,5 / 321,4 V	Zero	Set ch. 2
3	Unused	Store	AI 3	DAQP-LV 10 V .. 100 kHz SN: 332757	0,000 V	Zero	Set ch. 3
4	Used	Store	U3	DAQP-HV 1400 V .. 100 kHz SN: 335748	-318,1 / 318,1 V	Zero	Set ch. 4
5	Unused	Store	AI 5	DAQP-LV 10 V .. 100 kHz SN: 332759	0,000 V	Zero	Set ch. 5
6	Unused	Store	AI 6	ORION-0816-1000 5 V SN: 15430211	0,000 V	Zero	Set ch. 6
7	Unused	Store	AI 7	ORION-0816-1000 5 V SN: 15430211	0,000 V	Zero	Set ch. 7
8	Unused	Store	AI 8	ORION-0816-1000 5 V SN: 15430231	0,000 V	Zero	Set ch. 8
9	Unused	Store	AI 9	ORION-0816-1000 5 V SN: 15430231	0,000 V	Zero	Set ch. 9
10	Unused	Store	AI 10	ORION-0816-1000 5 V SN: 15430231	0,000 V	Zero	Set ch. 10
11	Unused	Store	AI 11	ORION-0816-1000 5 V SN: 15430231	0,000 V	Zero	Set ch. 11

2) Power module:

Set-up a "3-phase star connection" power module without current channels.
Enable period values (1period, 50% overlap).



3) Storing in database:

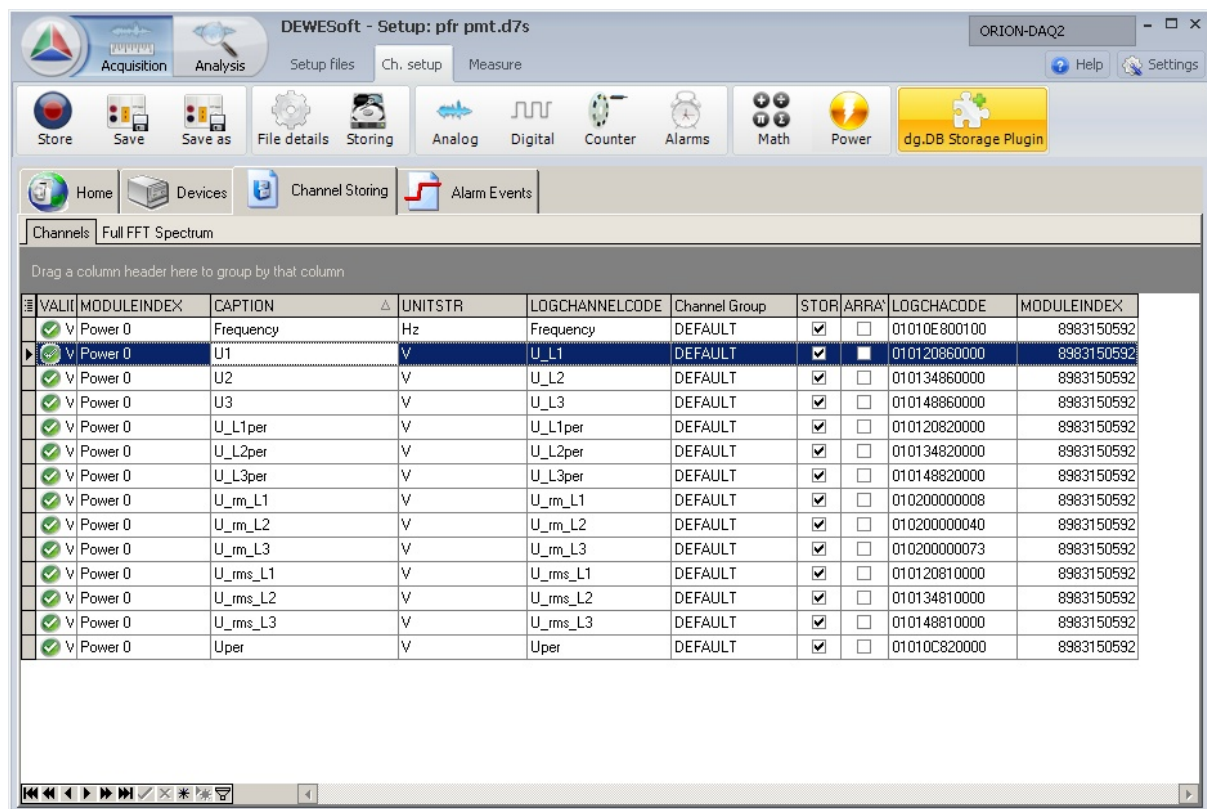
Make sure that the DB plugin is enabled and connected to a server.

Change to the tab "Channel Storing".

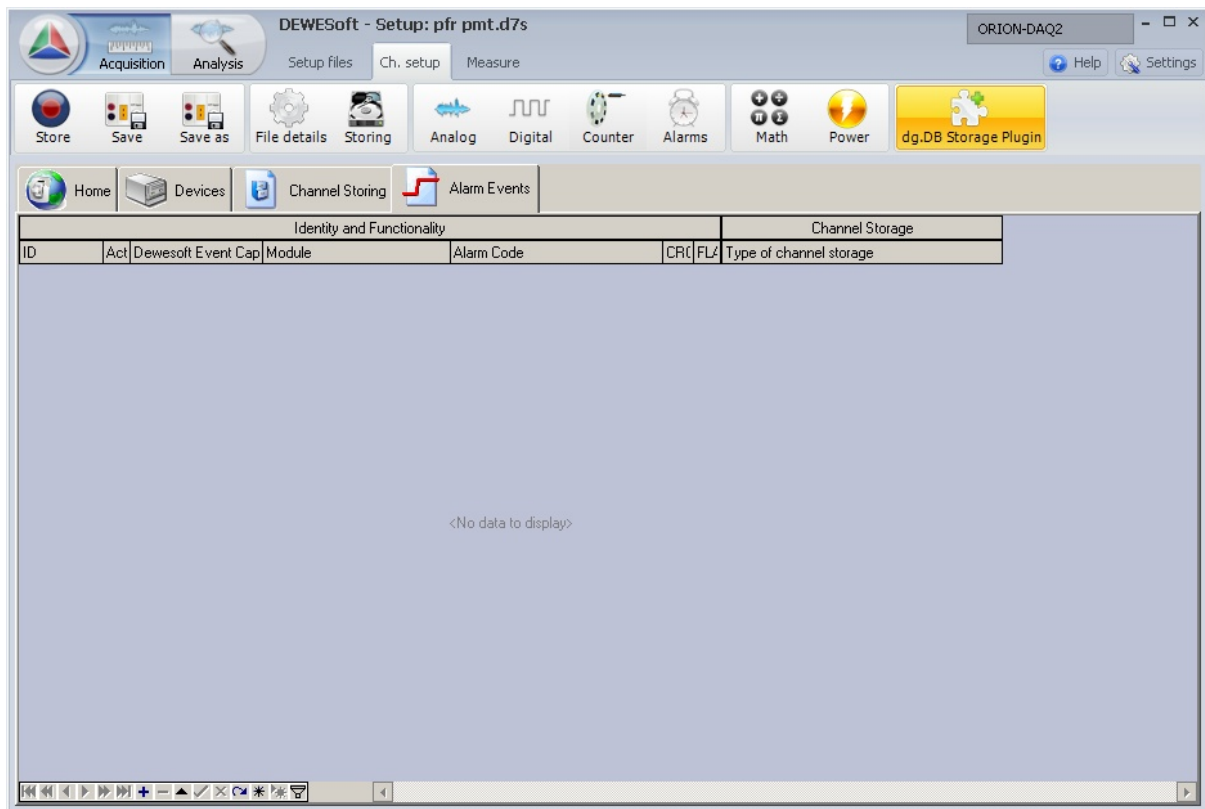
Assign the power module "Power0" to the 3 input channels.

Also assign the LOGCHANNELCODES (U_L1, U_L2 and U_L3) to the 3 channels.

The power-channels should already be assigned.



Now change to the tab "Alarm Events".
Add a new Trigger with "+" on the bottom left.



Assign the channels (Power u_{l1},...).

Define the period values as "Condition" by selecting "con" in the table (UL1per,...).

Define pre- and post-time.

Select "fast" as storing type.

Set the "Alarm reset" to "On Condition".

Alarm Event Detail

Index: Alarm Code: Nominal Voltage:
Module: Operating voltage:
Caption: Pretime:
Opcode at event start: Posttime:
Opcode at event end: Holdoff Time:
Max storage time:

☒ **Activate alarm event**
☐ Flagging
☐ Crosstrigger
☐ Posttime Extension

Alarm reset settings:
☐ Immediately
☒ On Condition
☐ After [s]

Storage Type:
☐ None [ms] ☒ Fast [ms] ☐ Slow [s]

STO	LOGCHACODE	CON	EVE	STO	ALARMINI
1	Power 0/U_L1	☐	☐	☒	0
2	Power 0/U_L2	☐	☐	☒	0
3	Power 0/U_L3	☐	☐	☒	0
4	Power 0/U_L1per	☒	☐	☒	0
5	Power 0/U_L2per	☒	☐	☒	0
6	Power 0/U_L3per	☒	☐	☒	0

Start Conditions

ID	Type	RE	Mode	Level 1	Level 2
0	Setup data	☐	window	300	150

Stop Conditions

ID	Type	RE	Mode	Level 1	Level 2
0	Setup data	☐	window	290	160

Export Import Close

Next, add the start and stop condition:

Value: real Data

Mode: Window

"leave"

Upper Level: 300 V

Lower Level: 150 V

Edit Trigger condition

Trigger on: Data [v] [Dewesoft Editor]

Data

Value: Real data [v]
Mode: window [v]
leave [v]

Upper level: 300 [v]
Lower Level: 150 [v]

☐ Relative condition

Base
☒ Nominal voltage
☐ Operating voltage

OK Cancel

Set the stop condition similar to the start condition, just set "enter" instead "leave".
The limits can be increased if necessary, to reach a degree of hysteresis (160-290 V).

The final setup should look like this:

Alarm Event Detail

Index: Alarm Code: Nominal Voltage:

Module: Operating voltage:

Caption:

Opcode at event start:

Opcode at event end:

Pretime:

Posttime:

Holdoff Time:

Max storage time:

☒ **Activate alarm event**

☐ Flagging

☐ Crosstrigger

☐ Posttime Extension

Alarm reset settings:

☐ Immediately

☒ On Condition

☐ After [s]

Storage Type:

☐ None [ms] ☒ Fast [ms] ☐ Slow [s]

STO	LOGCHACODE	CON	EVE	STO	ALARMINI
1	Power 0/U_L1	☐	☐	☒	0
2	Power 0/U_L2	☐	☐	☒	0
3	Power 0/U_L3	☐	☐	☒	0
4	Power 0/U_L1per	☒	☐	☒	0
5	Power 0/U_L2per	☒	☐	☒	0
6	Power 0/U_L3per	☒	☐	☒	0

Start Conditions

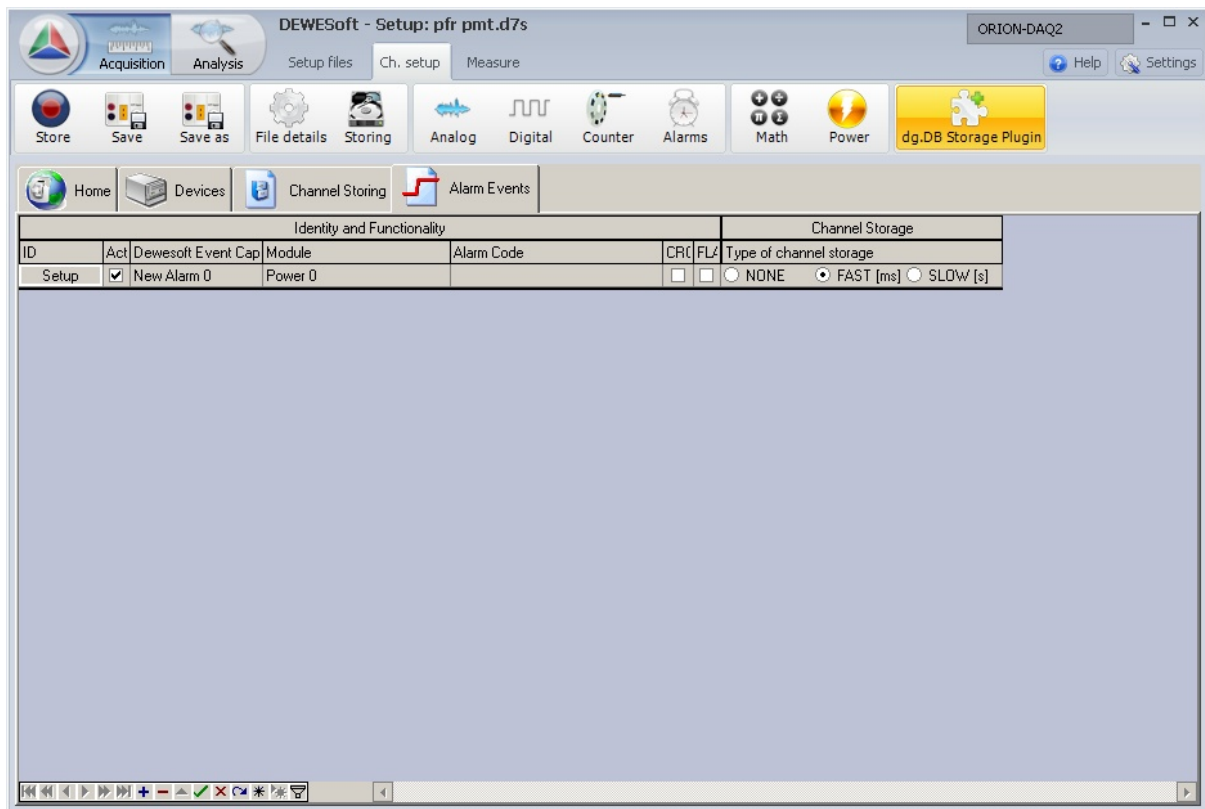
ID	Type	RE	Mode	Level 1	Level 2
0	Setup	data	☐ window	300	150

Stop Conditions

ID	Type	RE	Mode	Level 1	Level 2
0	Setup	data	☐ window	290	160

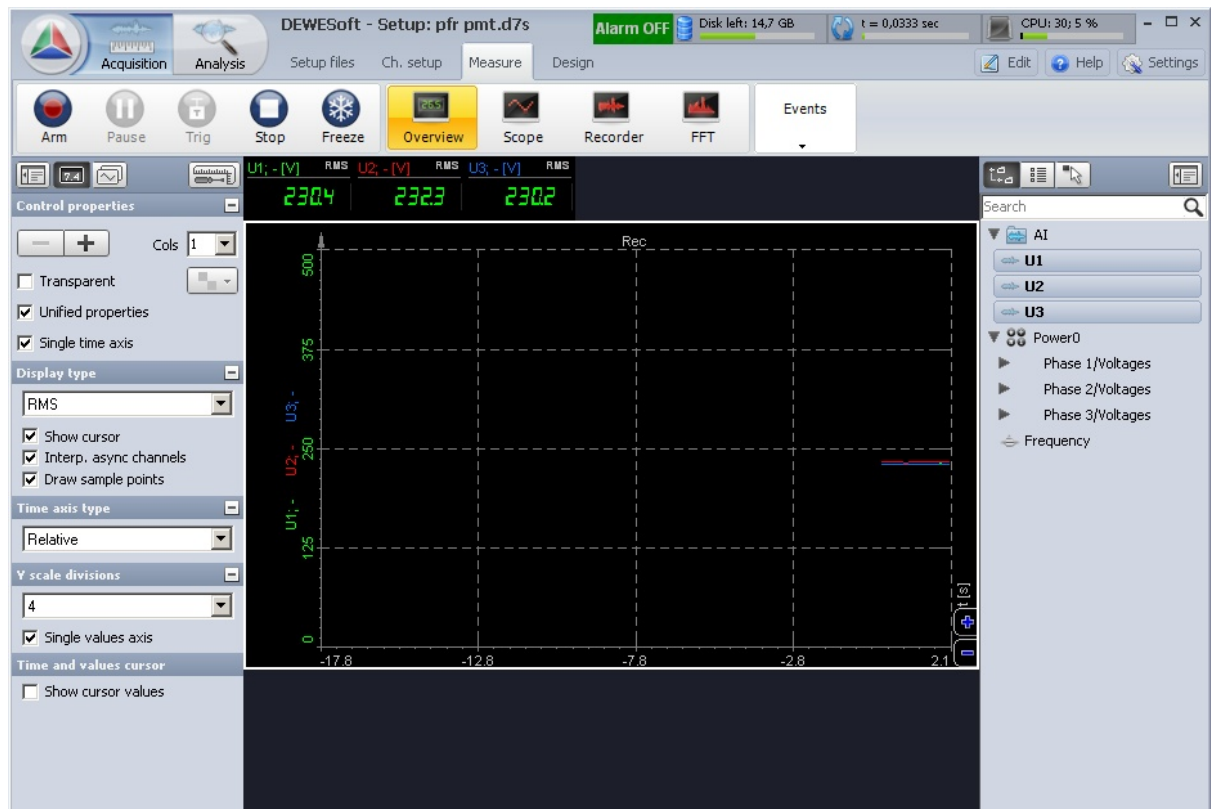
Export Import Close

ADVICE: Note that before you close the window that you click the the green check mark to store your settings. If you do not click the check mark your settings will not be saved.

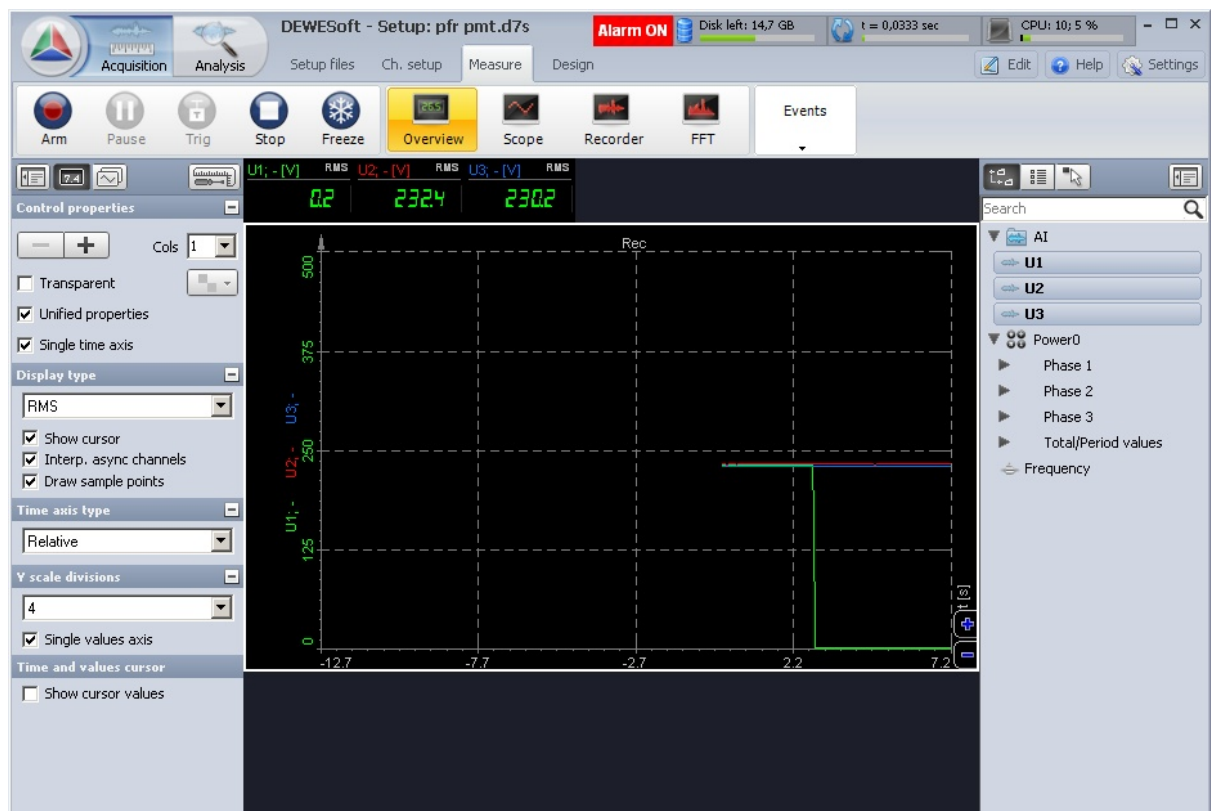


4) Measurement

Now change to the measure mode - the fault recorder is activated immediately and stores the data in the database. The DEWESoft-storing will not be activated.



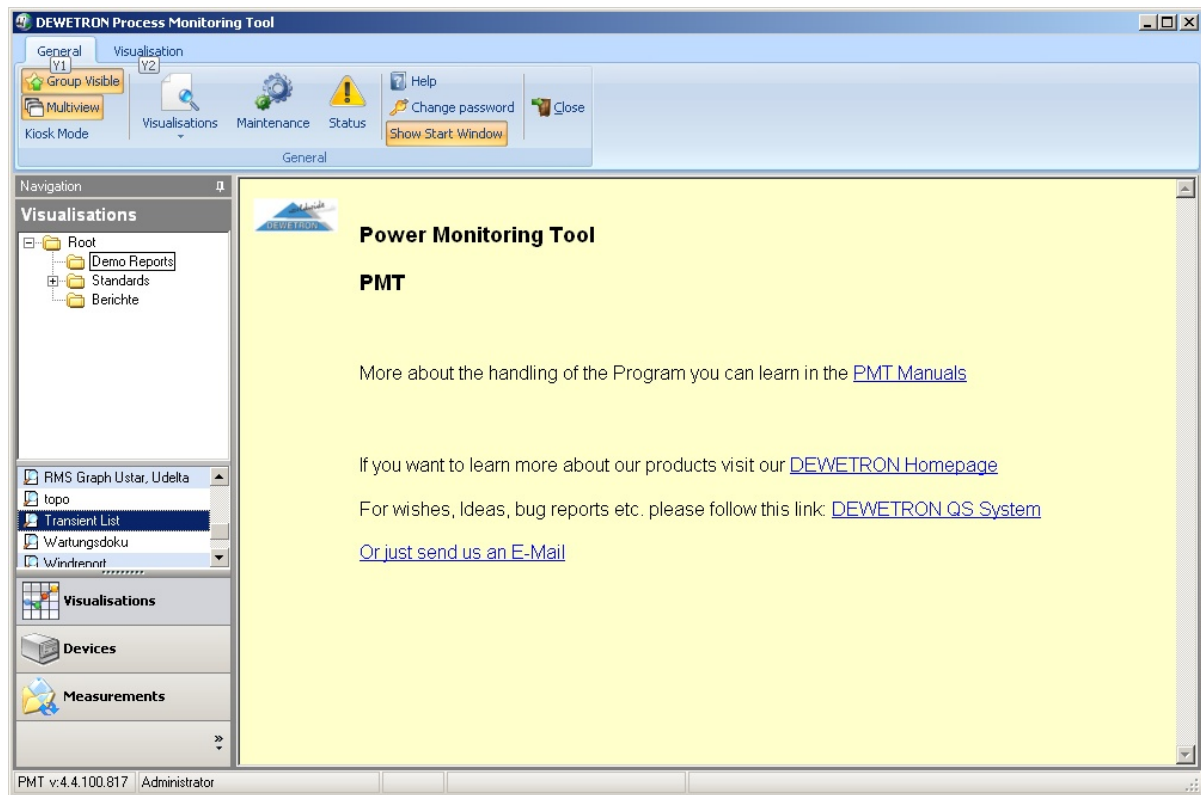
If a fault occurs, this is shown above with "Alarm ON" in red.



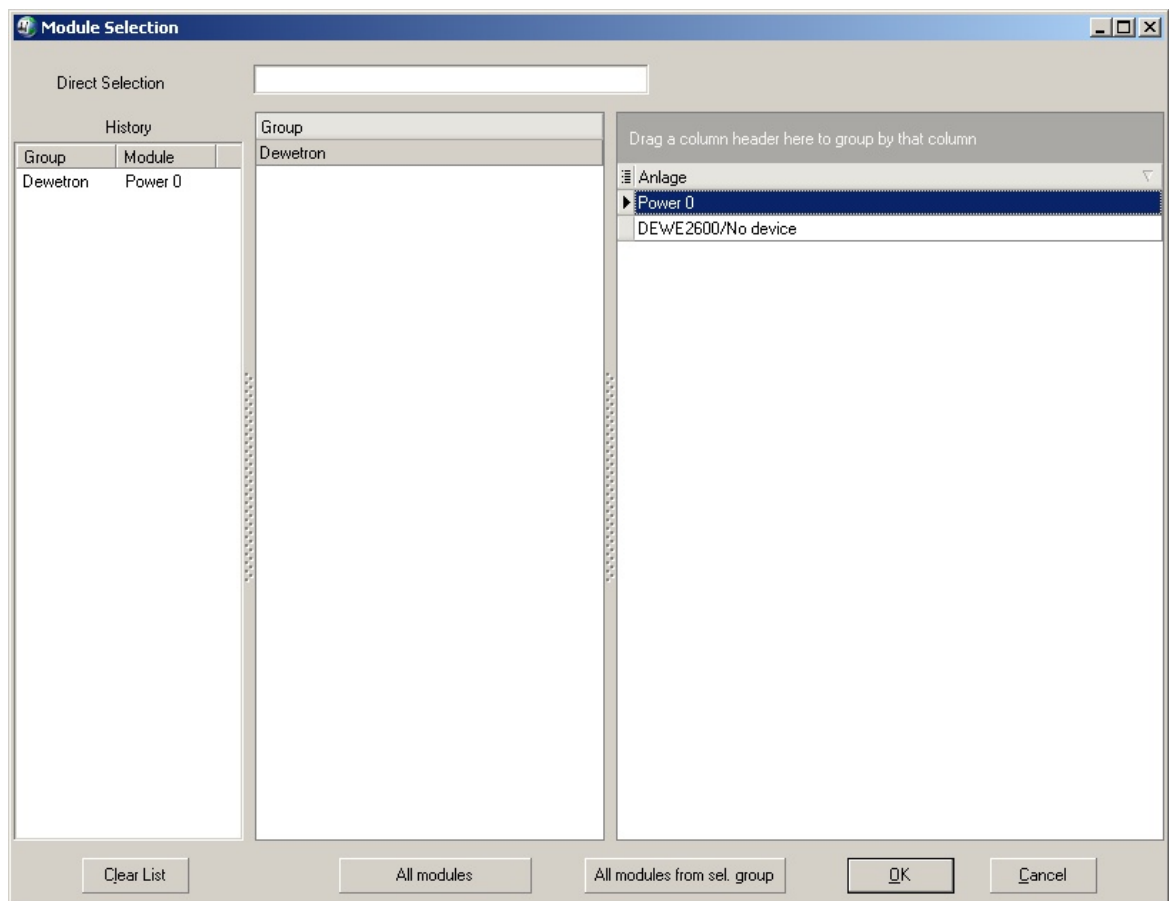
5) Analysis:

Please start PMT.

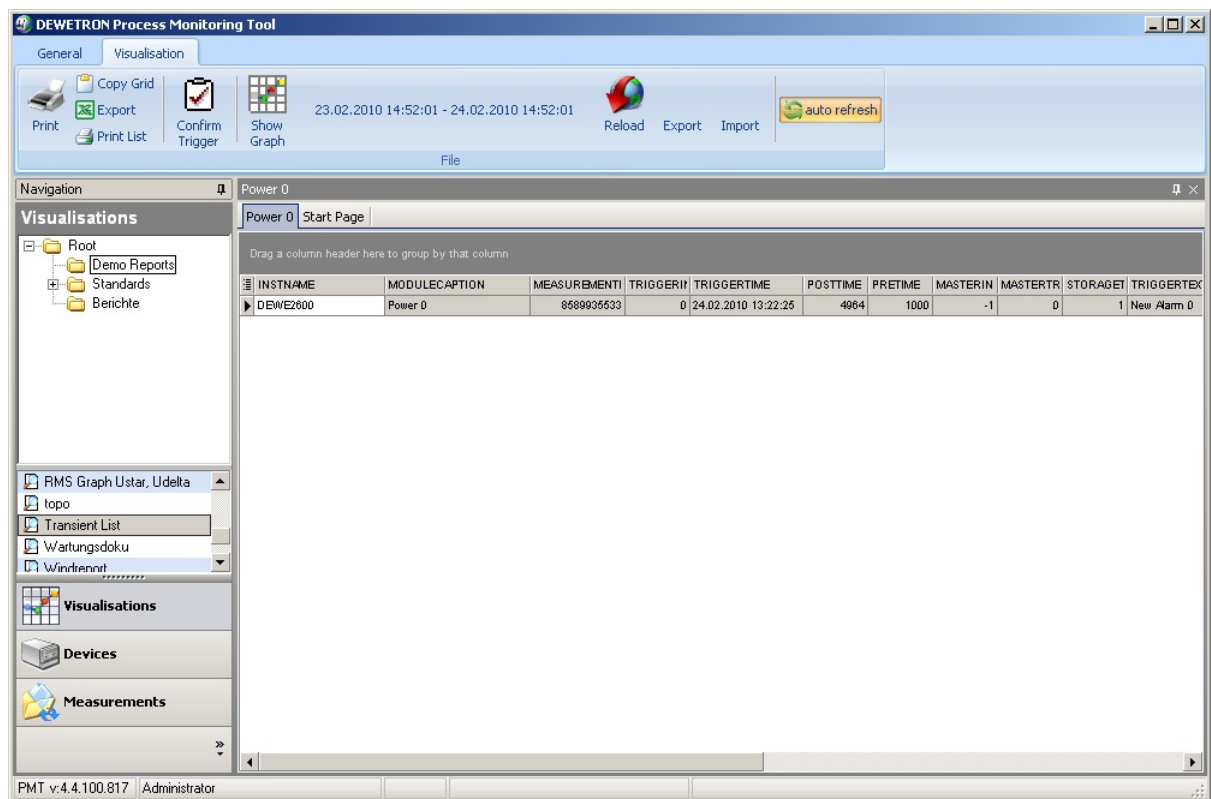
Now open the report "Transient List". You will find the report in the directory "Demo Reports".



Choose the power module which you like to analyze.
You can also choose a group if you want to have a list of fault recorders from several devices.

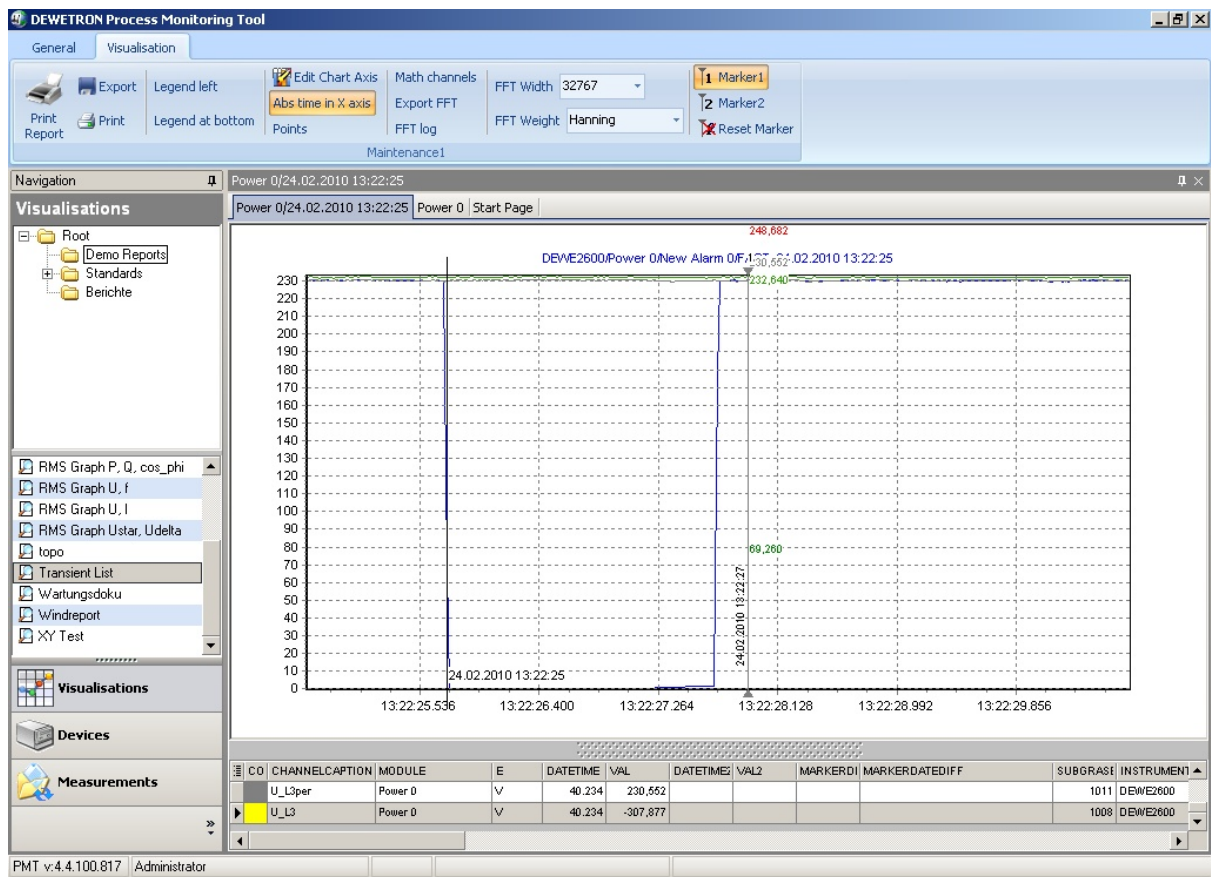


After choosing a time period you will get an list with all recorded faults. In our example:



Now choose a recorded fault and double click to open it.

With "Edit Chart Axis" you can now change the view. In our example, only the period RMS values are shown.



3.4 Wind Report



The Windreport is an additional feature/tool in PMT4 to create reports based on IEC 61400-21/ 61000-4-7/ IEC 61400-12-1.

Prerequisite:

Following Software must be installed:

- Dewesoft
- Option Power
- DB-Plugin (Option DB)
- PMT4 (Auswertesoftware) und SQL Server

Wind Plugin

The following chapters you should work through:

- Basic Information
- Measure Power Quality
- Storing in a DB

Setup Reports:

Basically there are three steps necessary to create a Windreport:

- 1) Setup the Measurement Instrument
- 2) Start a Measurement
- 3) Evaluate the Measurement

3.4.1 Important Note

The Windreport is a plugin which automatically creates a report according to the IEC 61400-21 for long-term measurements.

What does the Windreport include:

- General information about the wind power plant and rated data
- Active Power analysis for Power and Wind Pins for 0,2s, 60s, 600s averaged values
- Reactive Power setpoint control vs. active power bins
- reactive and active power incl. maximal values
- Flicker coefficient for reactive power control for different phase angles and wind speed
- Flicker vs. wind speed
- Voltage and Current spectra
- Status of Harmonics
- Harmonics table for all power pins up to the 50th Harmonic and THC
- Interharmonics up to 2 kHz for all power bins
- Higher Frequencies up to 9 kHz for all power bins

What does the Windreport not include:

- Measurement of the reconnection time of wind power plants. This can be measured directly in Dewesoft.
- Measurement and behaviour analysis of Voltage dips. This can be measured directly in Dewesoft.
- Measurement of the protection relay. This can be measured directly in Dewesoft.
- Measurement of Switching Operations. This can be solved directly in Dewesoft via a special setup (plugin).
- Setpoint control for active and reactive power. This can be measured directly in Dewesoft.

What is to consider for the report generation:

The report is strictly designed to the IEC61400-21 and its requirements. So the following requirements have to be considered that the report will be generated.

Measurement of the active power:

For the measurement of the active power you need **5 x 10 minute BINS** for every Windbin from the cut-in wind speed up to 15 m/s.

Measurement of the reactive power:

For the measurement of the reactive power you need **30 x 1 minute BINS** for every Powerbin from 10% to 100%.

Measurement of Harmonics, Interharmonics and Higher Frequencies:

For this measurement you need **9 x 10 minute BINS** for every Powerbin from 10% to 100%.

Measurement of Flicker:

For this measurement you need **15 x 10 minute BINS** for every Windbin from the cut-in wind speed up to 15 m/s.

Other:

- The Sampling rate for voltage and current should at least be 20 kHz (we recommend 40 kHz)

- The Sampling rate for wind speed should be at least 1 Hz.
- The measurement can be executed at the high or low voltage level of the transformer.
- Analysis for wind speeds bigger than 15 m/s are not required due to their seldom appearance.
- The THD at the measuring point has to be less than 5% (10 minute average)
- The Unbalance at the measuring point has to be less than 2% (10 minute average)
- The voltage has to be at $\pm 10\%$ of the nominal voltage
- The frequency doesn't change more than 0,2% for 200ms values

3.4.2 Setup the Measurement Instrument

Please start DEWESoft and create a new Setup.

Now go through the following points for the channel-setup, the setup of the power-module and the Windreport:

- 1) Setup the Channels
- 2) Setup the Power Modul
- 3) Storing Data in the DB
- 4) Configure the Windreport

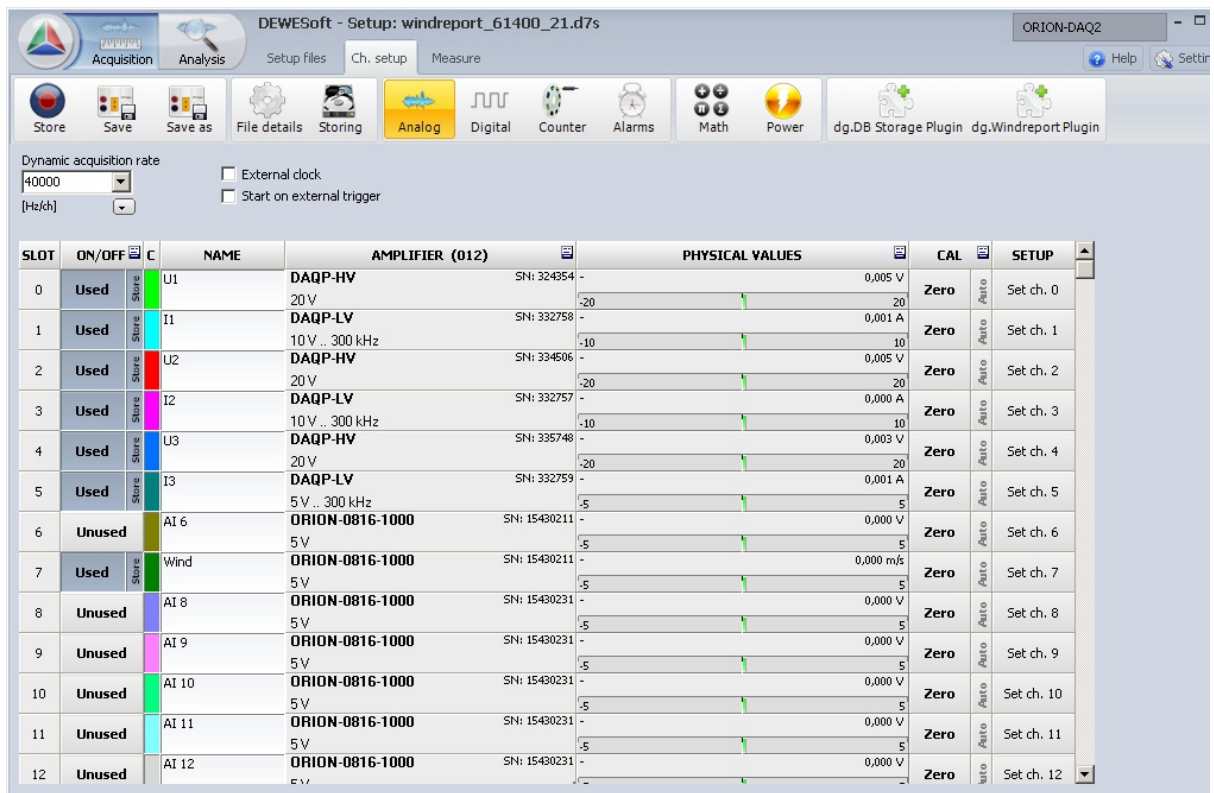
3.4.2.1 Setup the Channels in DEWESoft

Connect the Voltages and Currents to the Analogue-Channels of your DEWE-Instrument.

Connect the Wind-Sensor to the channel "Wind".

Important: Dynamic acquisition rate must be at least 40 kHz!

Filter of amplifiers: at least 10 kHz!



3.4.2.2 Setup the Power Module

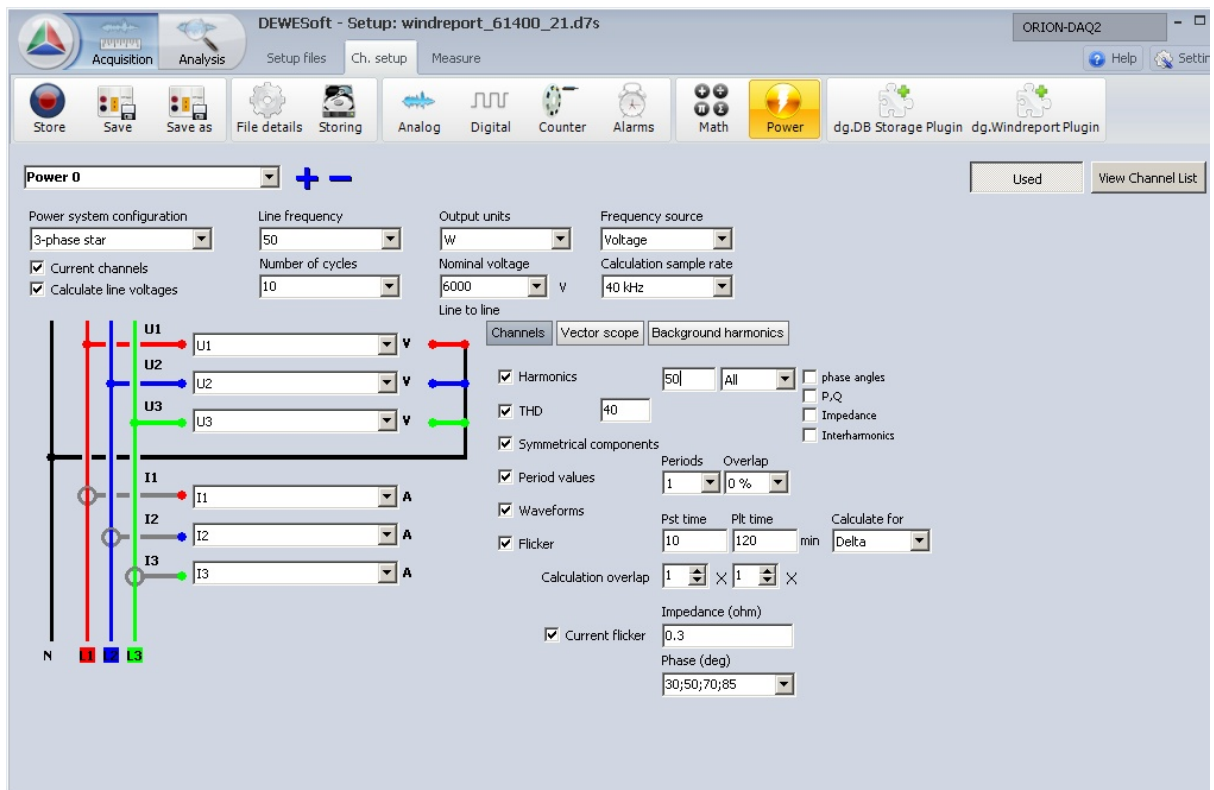
Create and setup a powermodule described as follows:

Important:

Current Flicker: fill in the Impedance of the fictive grid.

You can calculate the Impedance based on the short-circuit-power:

$$\text{Impedance} = (\text{nominal voltage})^2 / \text{short-circuit-power}$$



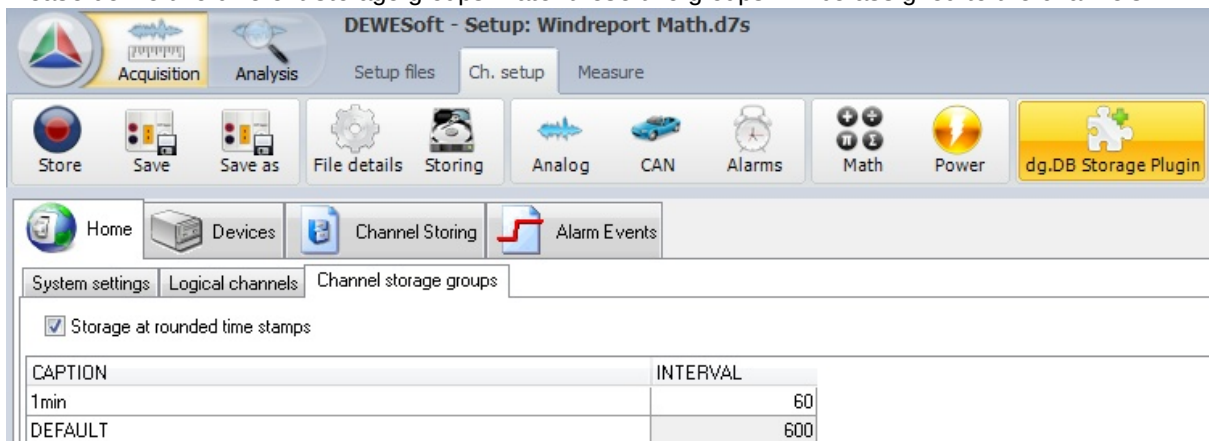
Powermodule Setup

Please keep in mind that the dynamic acquisition rate and the calculation rate of the Powermodule is at least 40kHz!

3.4.2.3 Storing Data in the DB

In the "DB Storage Plugin" the following settings must be done:

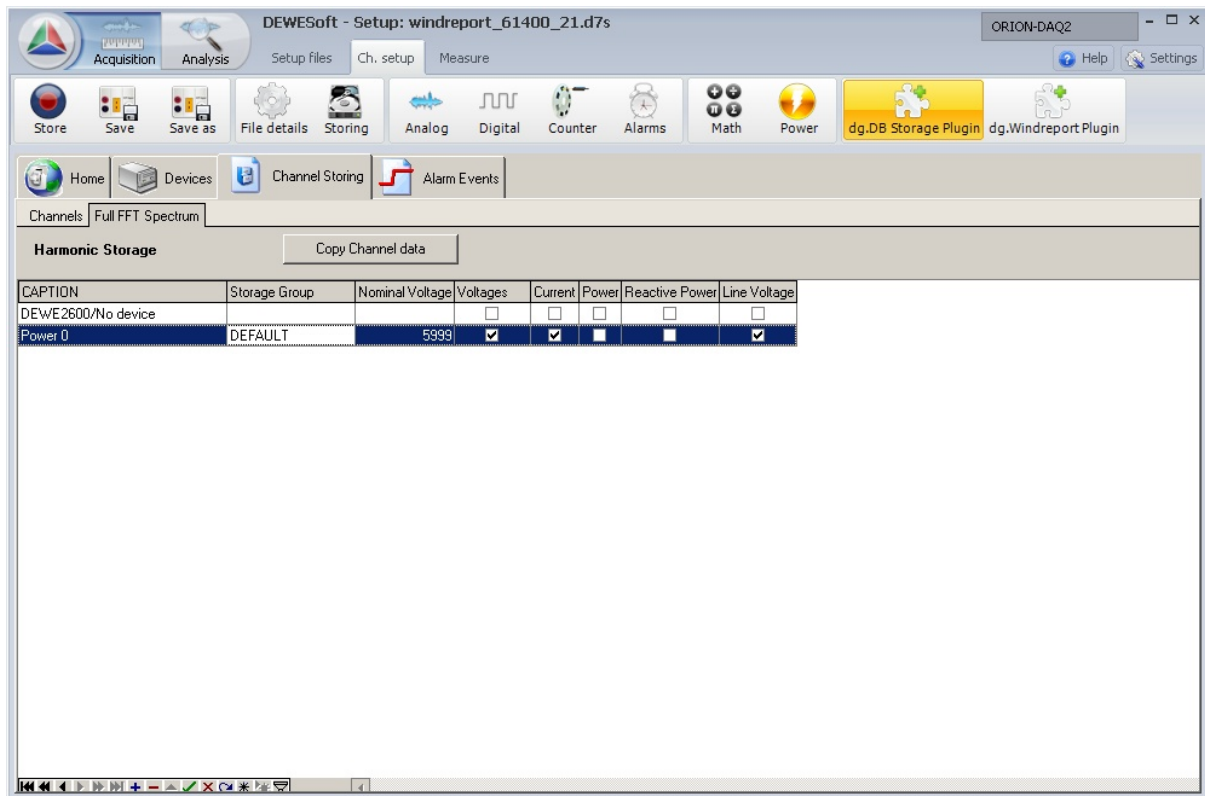
Please define two different storage groups. Later these two groups will be assigned to the channels:



Definition of the storage groups

The unit of the intervals is seconds!

Please activate "full FFT" for the Voltage and the current:



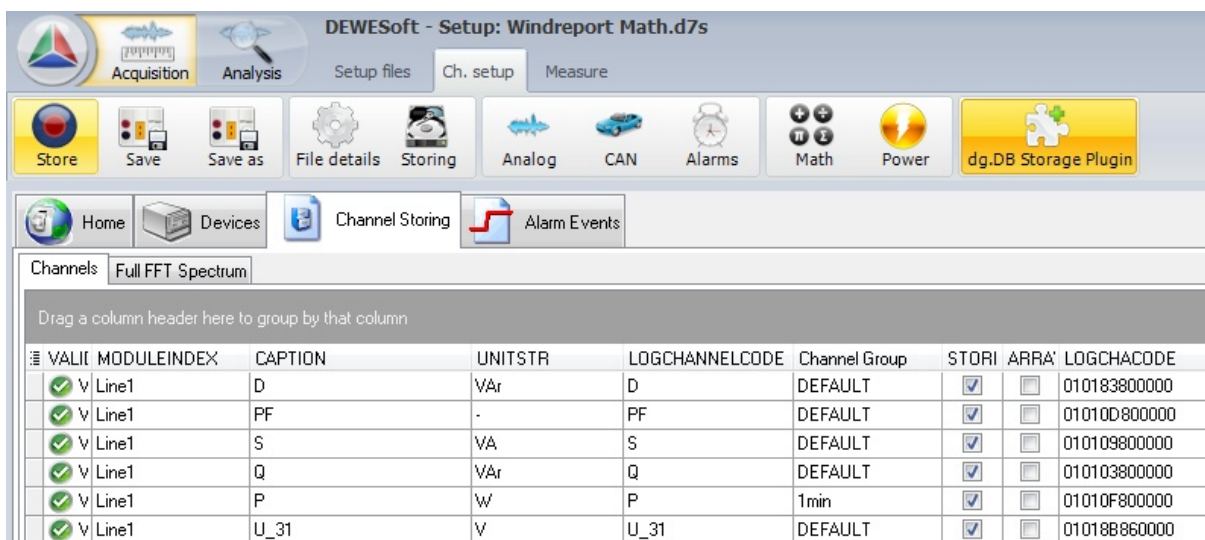
Activate the FullFFT

Please add the storage group "1 Minute" to the channel active power "P" and "Q". The storing group "DEFAULT" would be added to all the other channels!

Logchannelcode: P, Q

Channel group: 1 Minute

Moduleindex: Powermodule-channel (Power Module)



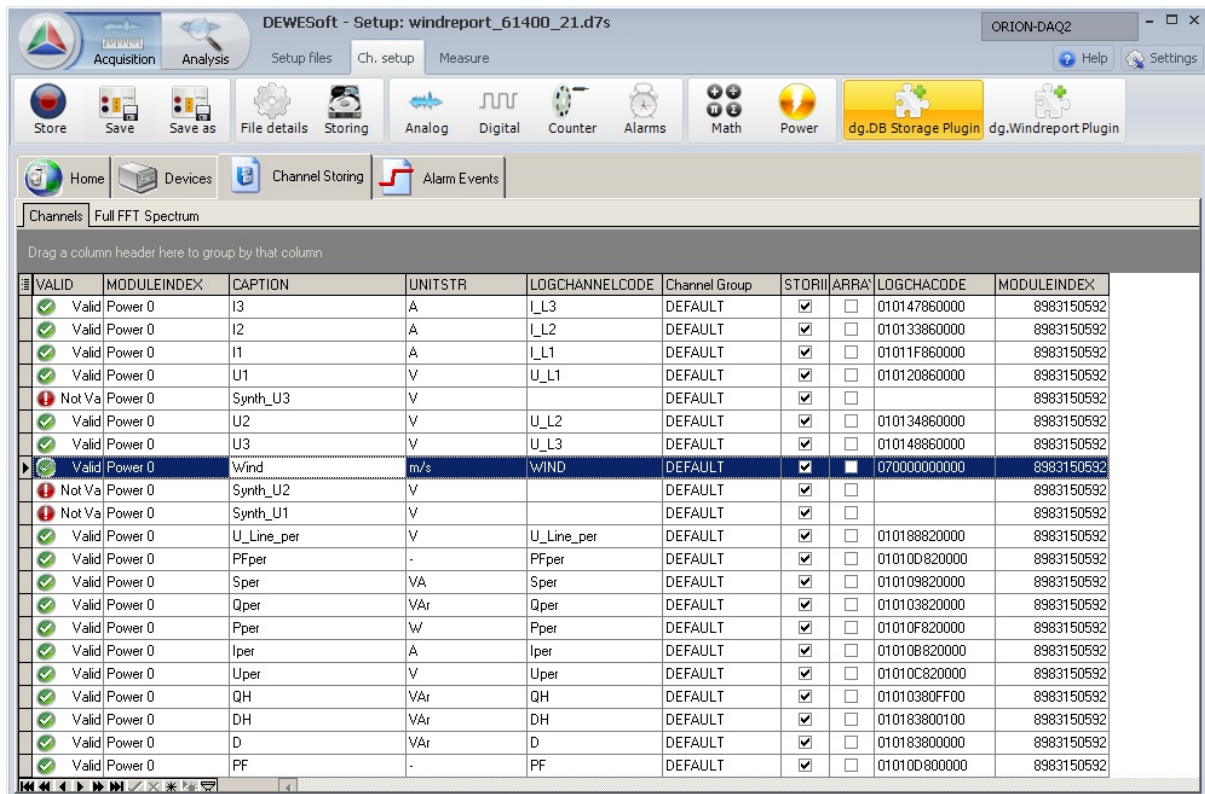
Add the storage group to channel P

Please add the storing group "Default" to the analogue channel wind and define "WIND" as LOGCHANNELCODE.

Logchannelcode: Wind

Channel group: Default

Module-index: the Powermodule-channel (Power 0)



Add the storage group to the channel Wind

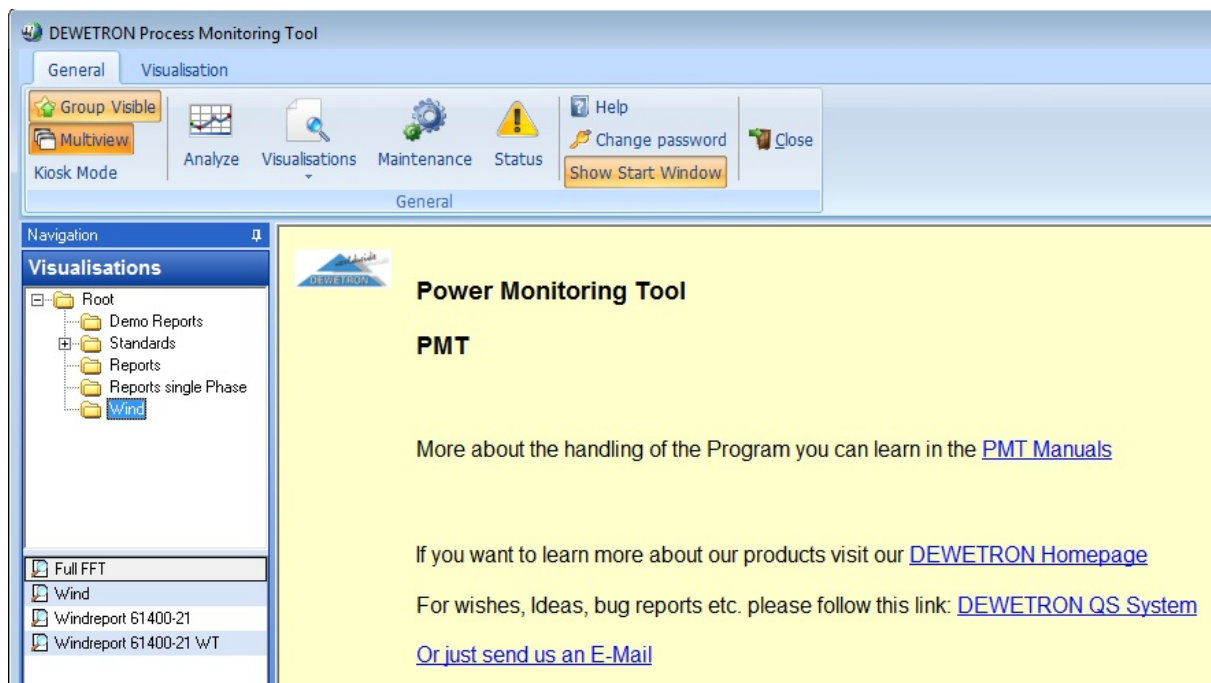
Please remember to save your settings by clicking the green tick!

3.4.2.4 Setup the Windreport

The setting for the Windreport will be done with PMT4.

Please start PMT4. The Windreport based on IEC 61400-21/61000-4-7 is already installed (Option Power +DB+Wind).

Double click on the Windreport to open existing reports or calculate a new one.



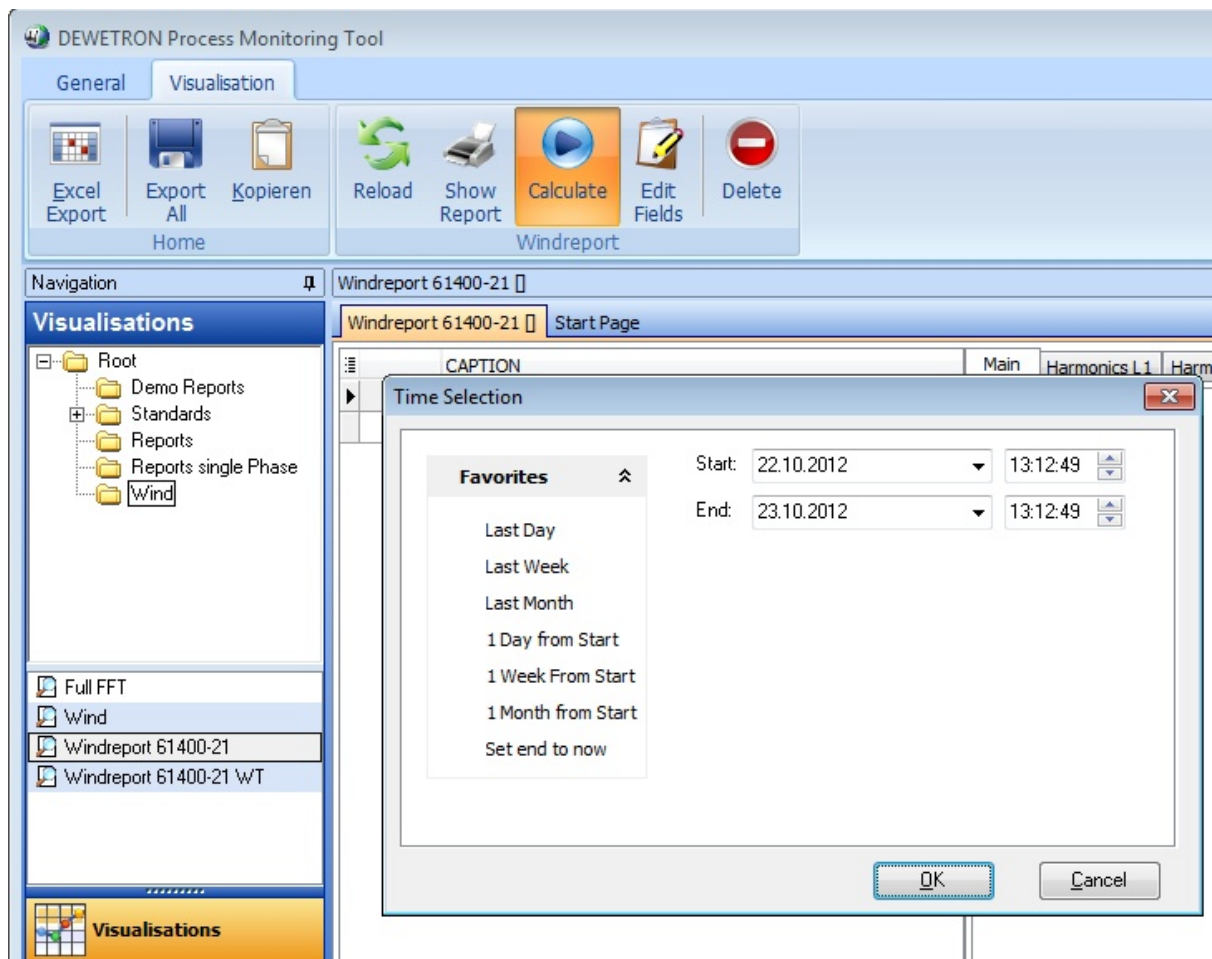
Windreport in PMT4

If no Windreport was calculated yet please click "Calculate" to create a new Report based on a measurement.



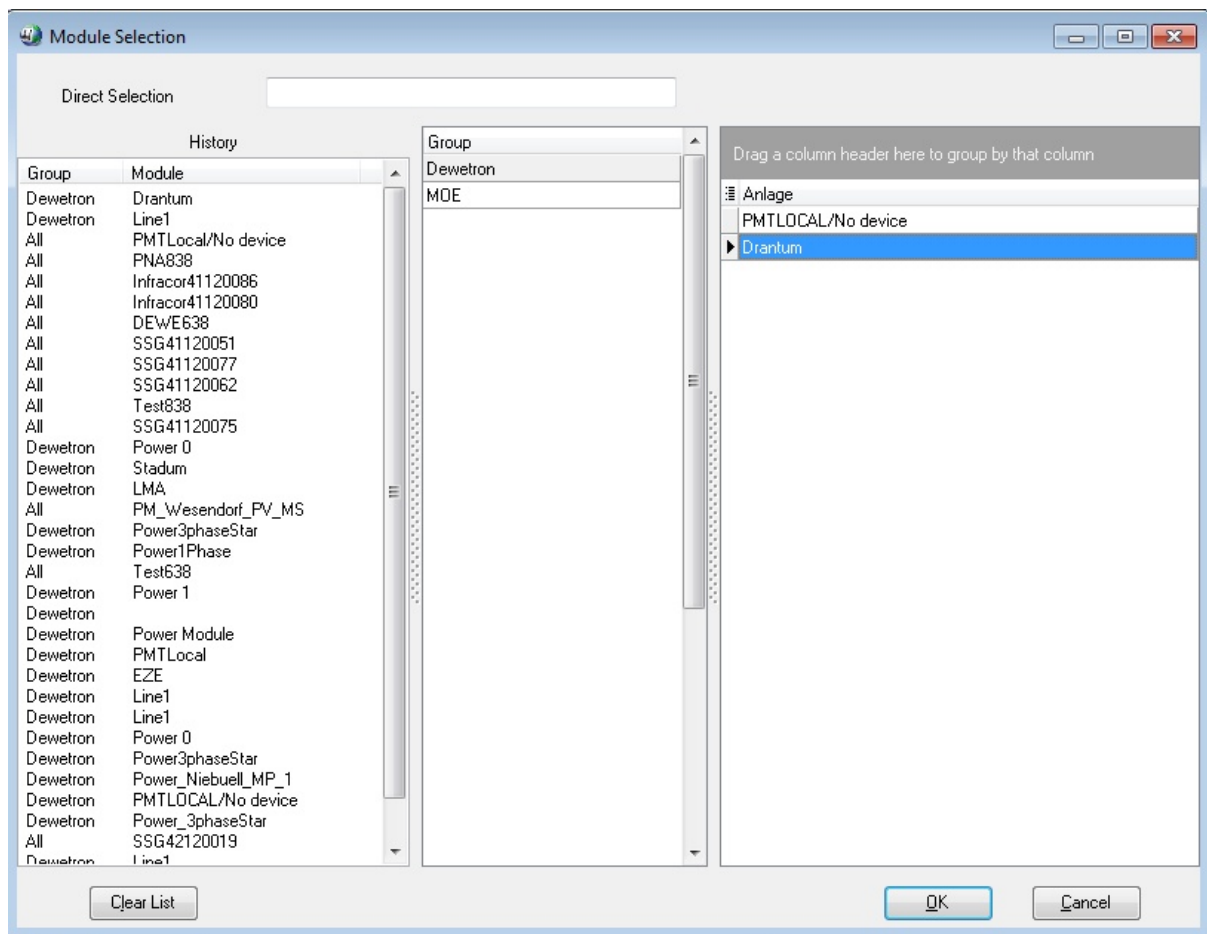
"Calculate" Button

Now the window for the input of the measurement time range will be open. The Windreport will be calculated over this time period!



Choose the time period for the Windreport

Confirm your input "OK". Now please choose your Powermodule (Wind-plant, which was defined in the Powermodule-setup):



Choose the Powermodule

After the definition of your Measurement and Powermodule please input the parameters of your Windpower-plant. The Values for "Min Power bins", "Max Power bins", ... are already filled in (based on the standard 61000-4-7).

Please fill out the the following form and click on "Start Measurement".

Measurement Data

Wind turbine rated data at terminals

Measurement units (Settings in DEWESoft)

☐ W
 ☒ kW
 ☐ MW

Rated apparent power, S_n (MVA):
 Rated voltage U_n (V):
 Rated frequency, f_n (Hz):
 Rated wind speed, v_n (m/s):

Rated current, I_n (A):
 Rated power, P_n (MW):
 Rated Apparent Short Circuit S_n (MVA):
 Cut In Windspeed (m/s):

Min Power bins:
 Max Power bins:
 Min Wind bins:
 Max Wind bins:

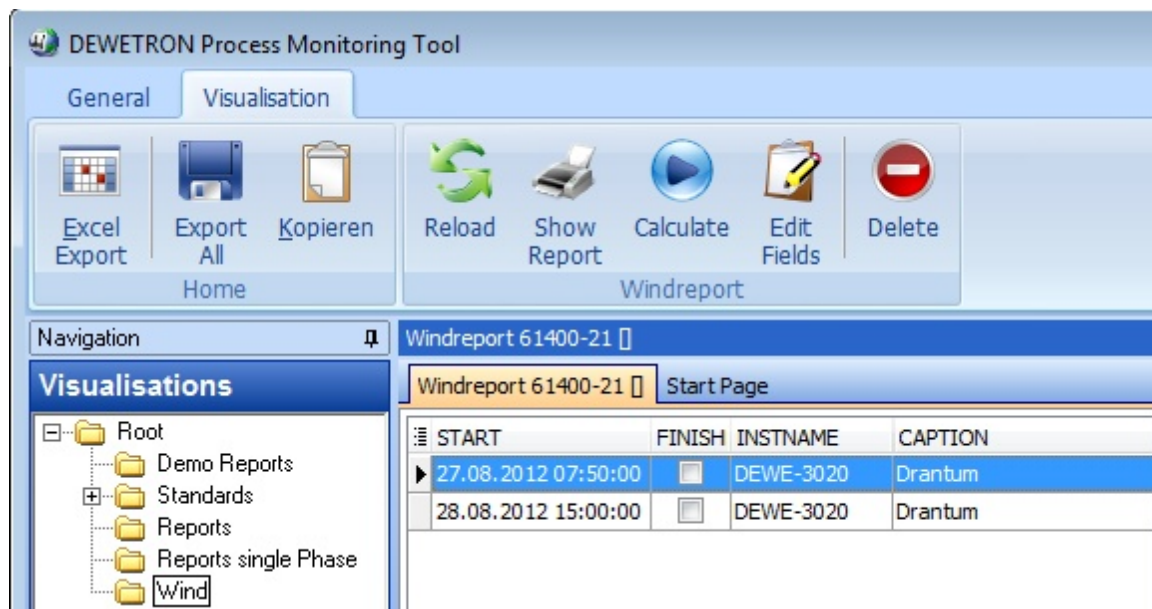
Chart Settings

Wind Min [m/s]: Wind Max [m/s]: ☒ auto
 P Min [MW]: P Max [MW]: ☒ auto
 Q Min [Var]: Q Max [Var]: ☒ auto
 Pst Min: Pst Max: ☒ auto

☐ Ignore Wind and Flicker (just harmonics)

Data to your power-plant

Now the Windreport will be calculated. After the calculation you will get a overview of your report. In the overview of existing reports you will already calculated reports please choose a report to print it out or visualize it (Show Report).

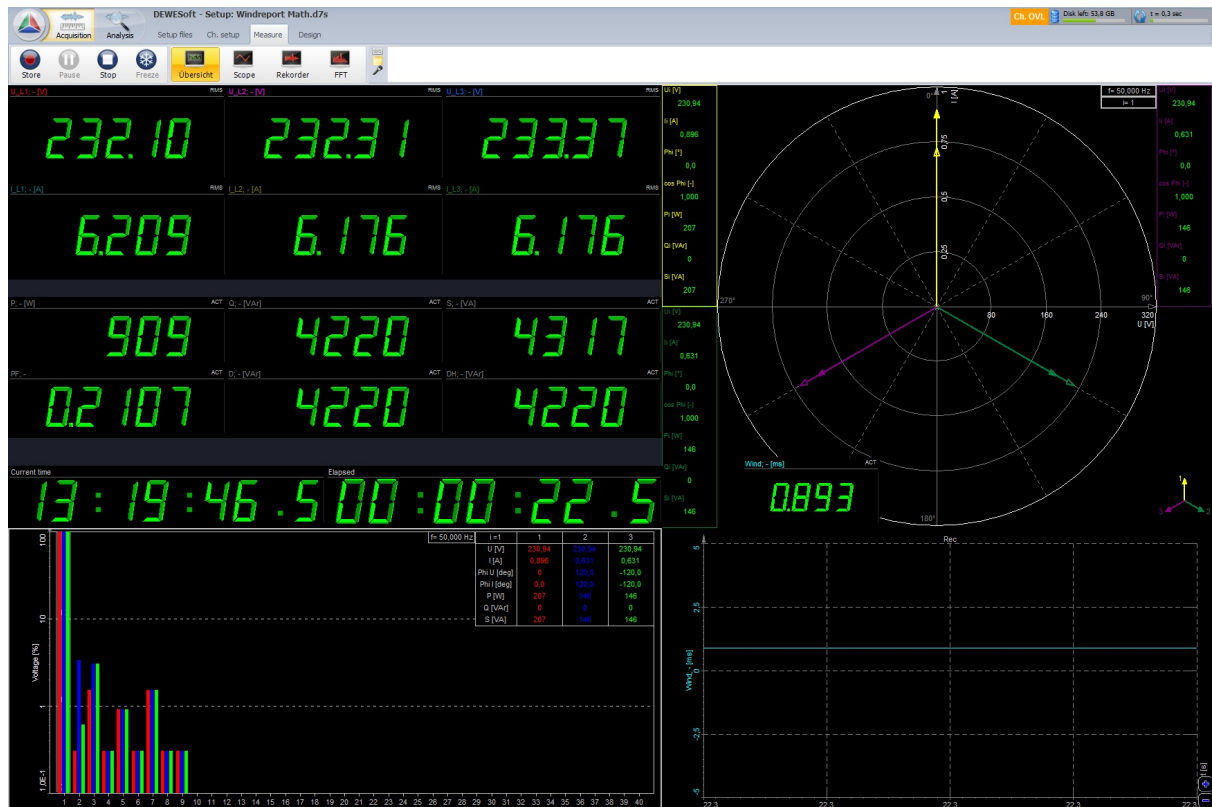


Print/ Export a Windreport

3.4.3 Start a Measurement

Start the Measurement by changing to measure-mode. The data will be transferred automatically to the DB.

The storing button will be not used!



Mesurment-screen in the measure-mode

To stop the measurement please click on channel-setup!

3.4.4 Evaluate a Measurement

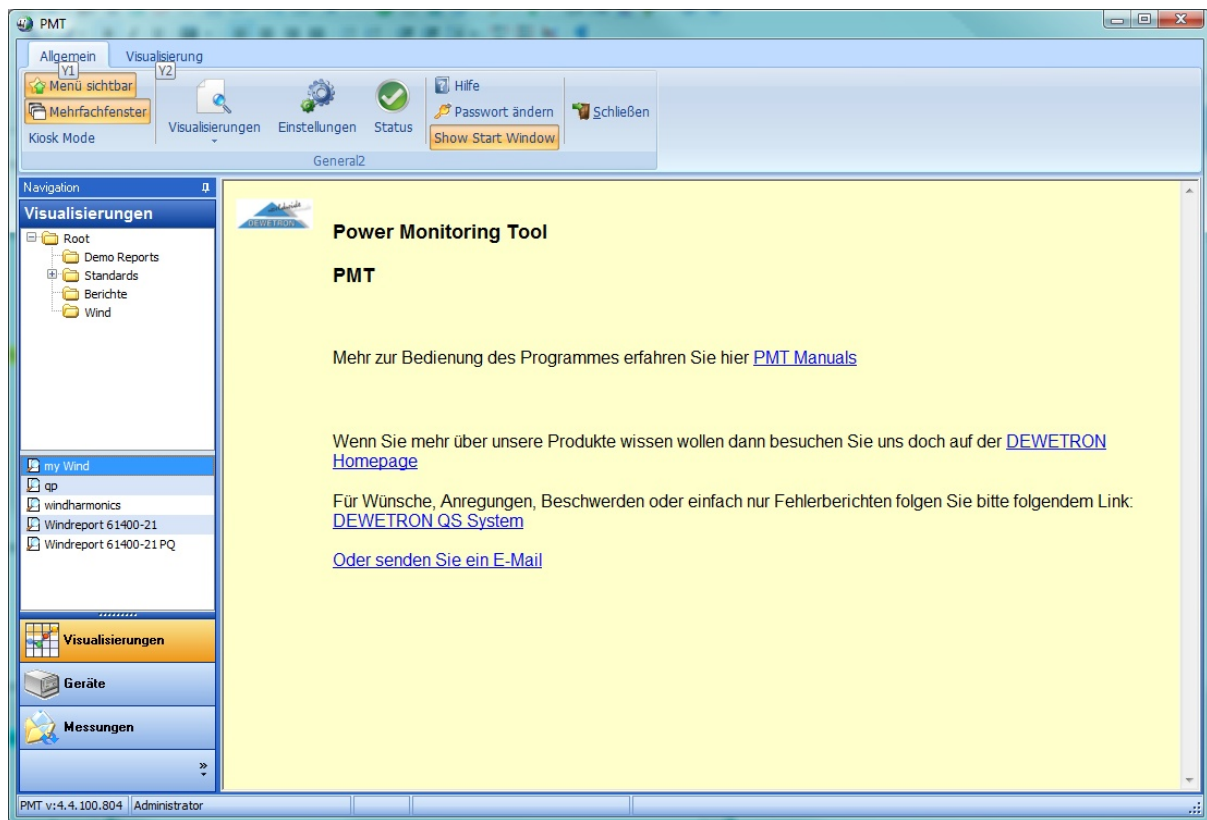
Please start PMT4 and make sure that the connection to your DB is already established! You can test the connection in the dB-Plugin-Setup.

If no Windreport is existing please Create a Report in PMT4.

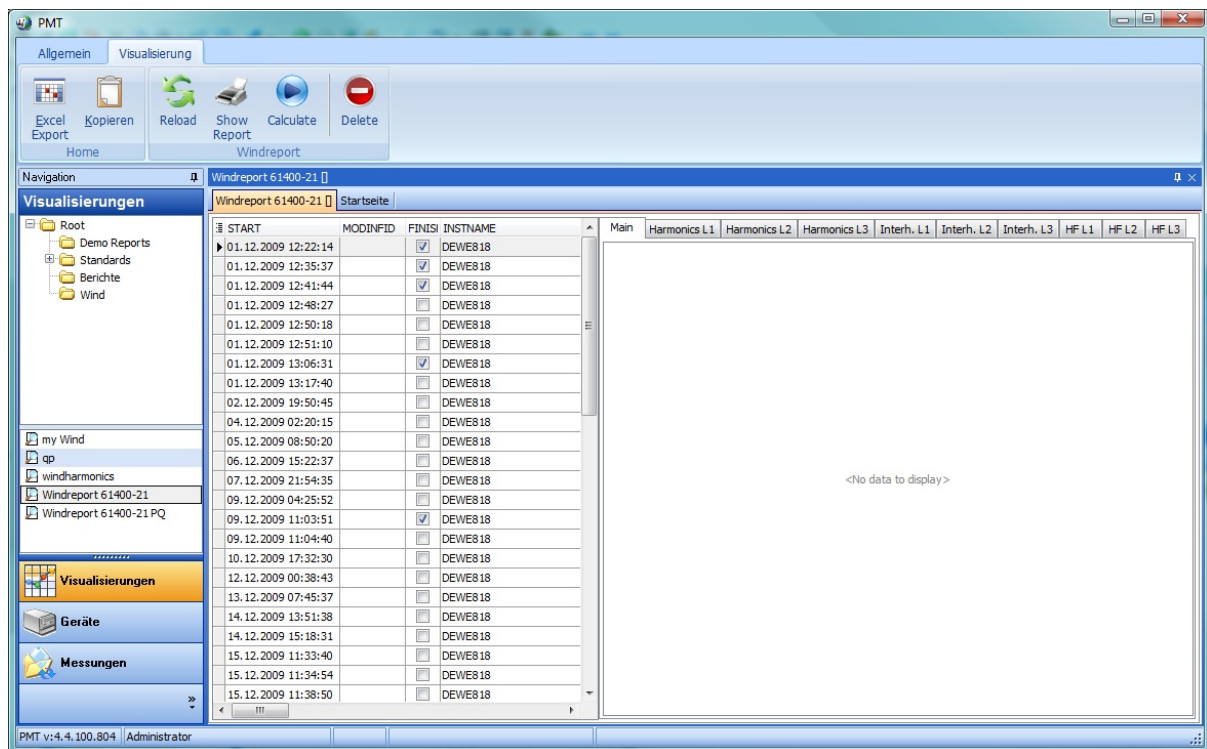
Now please open a existing Windreport.

3.4.4.1 Evaluation with an existing Report

Choose the Windreport in the Visualization-overview and open it by double-clicking ("Windreport 61400-21" folder "Wind").

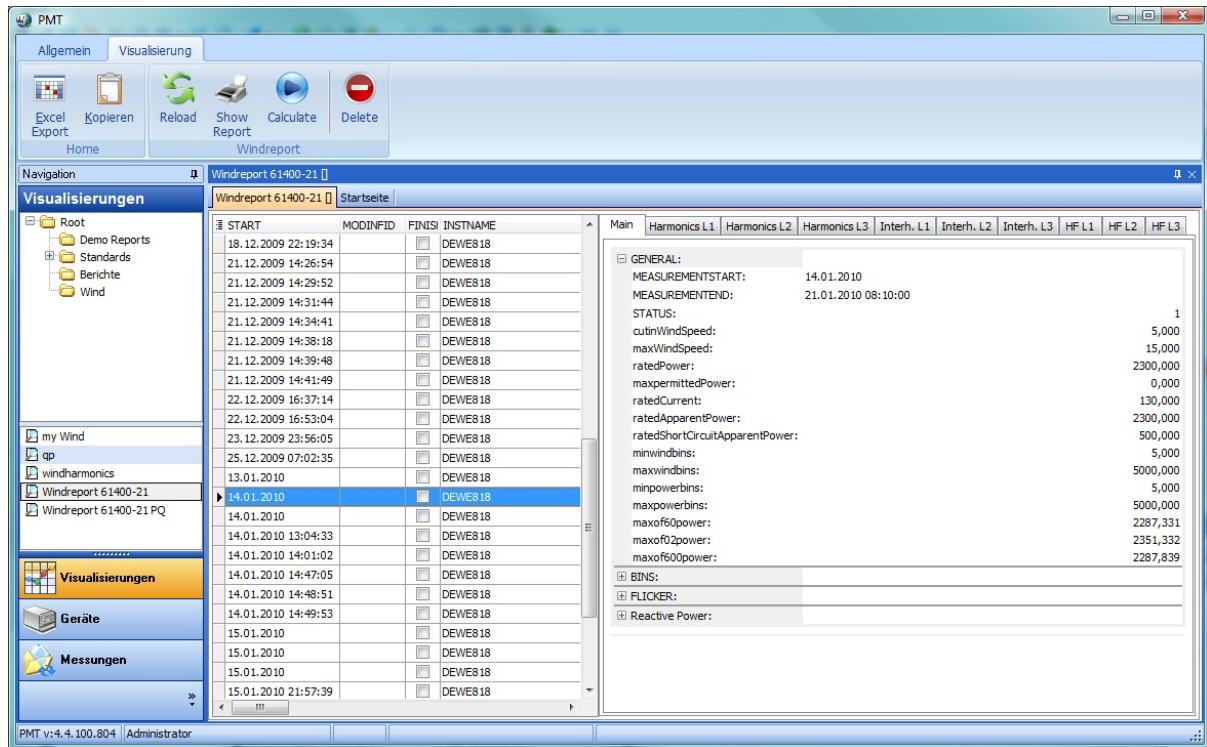


In the center of the screen now a list of reports will appear.



Choose a report by double-click a report!

On the right site you will find the overview of the report/ parameters.



Here you can choose between:

Mainsite (main)

General...all generell parameters and values

Bins...The number of wind- and power-pins

Flicker...The Flicker-coefficient

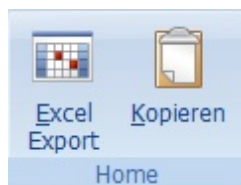
Reactive Power...reactive power values

Harmonics...the even integer harmonics,classification based on active power groups

Interharmonics...the Interharmonics, classification base on active power groups

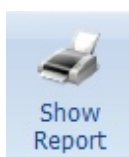
HF...The higher Frequencies 2-9kHz in 200Hz groups, classification base on active power groups

For sure you can export the values to Excel or copy it to the clipboard.



You can also calculate a new "Windreport".

If you click on "Show Report" a vizualisation of the actual Winreport will be shown.

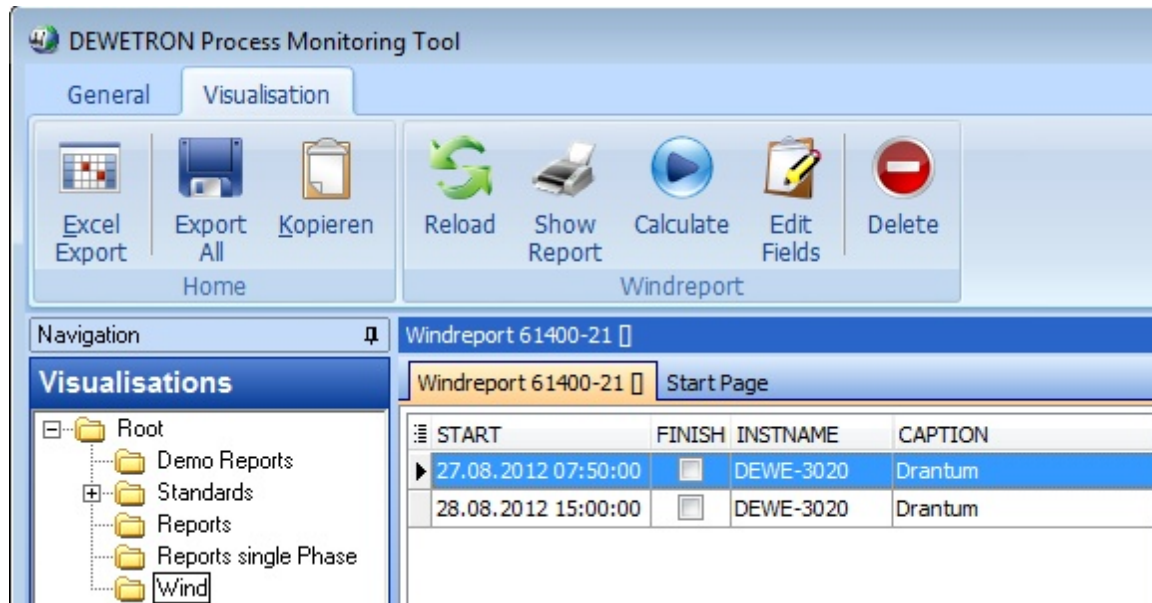


3.4.4.2 Calculate a Windreport

Prerequisite:

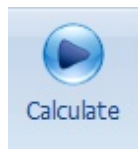
A Measurement will exists.

You have already opened a Windreport-visualization.



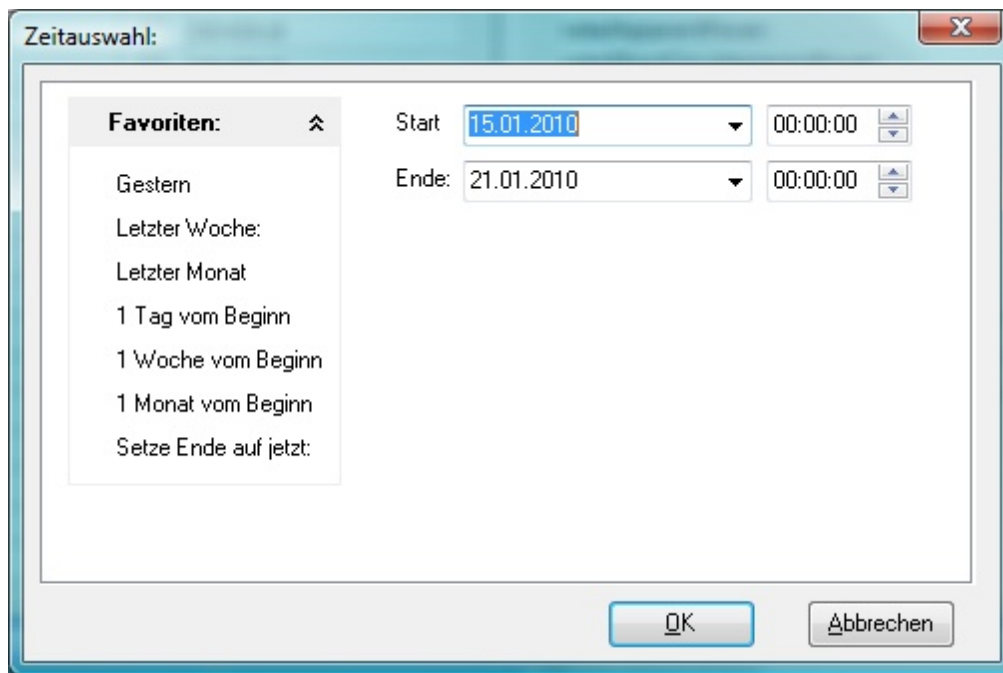
choose a existing Report

First click on "Calculate"

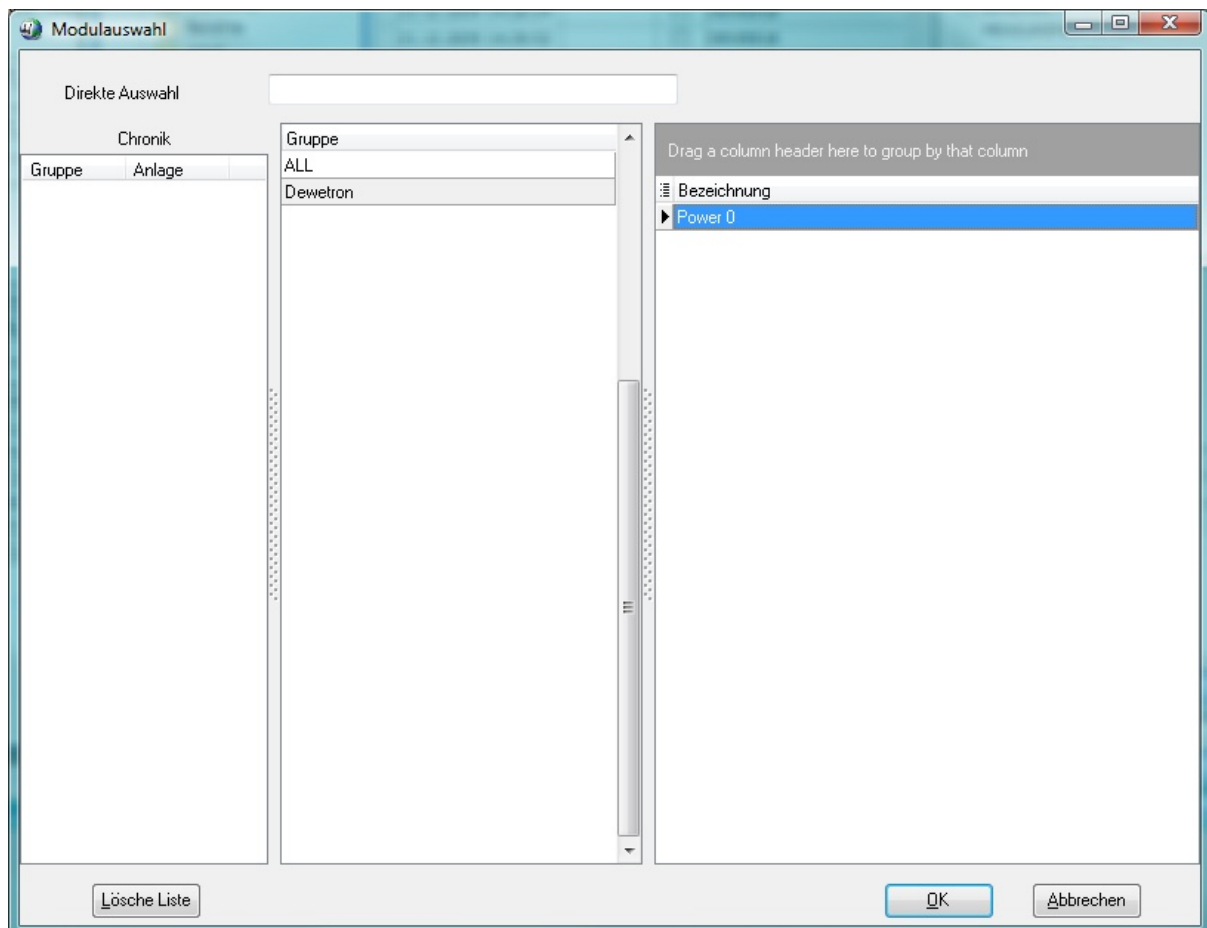


"Calculate" Button

Now choose the time period:



Now choose the powermodule:



Fill out the form and click "Start Measurement":

Measurement Data

Wind turbine rated data at terminals

Measurement units (Settings in DEWESoft)

☐ W ☒ kW ☐ MW

Rated apparent power, S_n (MVA):

Rated voltage U_n (V):

Rated frequency, f_n (Hz):

Rated wind speed, v_n (m/s):

Rated current, I_n (A):

Rated power, P_n (MW):

Rated Apparent Short Circuit S_n (MVA):

Cut In Windspeed (m/s):

Min Power bins:

Max Power bins:

Min Wind bins:

Max Wind bins:

Chart Settings

Wind Min [m/s]: Wind Max [m/s]: ☒ auto

P Min [MW]: P Max [MW]: ☒ auto

Q Min [Var]: Q Max [Var]: ☒ auto

Pst Min: Pst Max: ☒ auto

☐ Ignore Wind and Flicker (just harmonics)

Measurement Data

Wind turbine rated data at terminals
settings must be the same as used in the power module

Measurement units (Settings in DEWESoft)

☐ W ☐ KW ☒ MW

data of the measured power plant

Rated apparent power, Sn (MVA):

Rated voltage Un (V):

Rated frequency, fn (Hz):

Rated wind speed, vn (m/s):

these values are calculated automatically

Rated current, In (A):

Rated power, Pn MW:

Rated Apparent Short Circuit Sn (MVA):

Cut In Windspeed (m/s):

Min Power bins:

Max Power bins:

Min Wind bins:

Max Wind bins:

Chart Settings

Settings for the report chart

Wind Min [m/s]: Wind Max [m/s]: ☒ auto

P Min [MW]: P Max [MW]: ☒ auto

Q Min [VAr]: Q Max [VAr]: ☒ auto

Pst Min: Pst Max: ☒ auto

☐ Ignore Wind and Flicker (just harmonics)

Only activated to generate solar- or VDE report

maximum number of bins used for the report

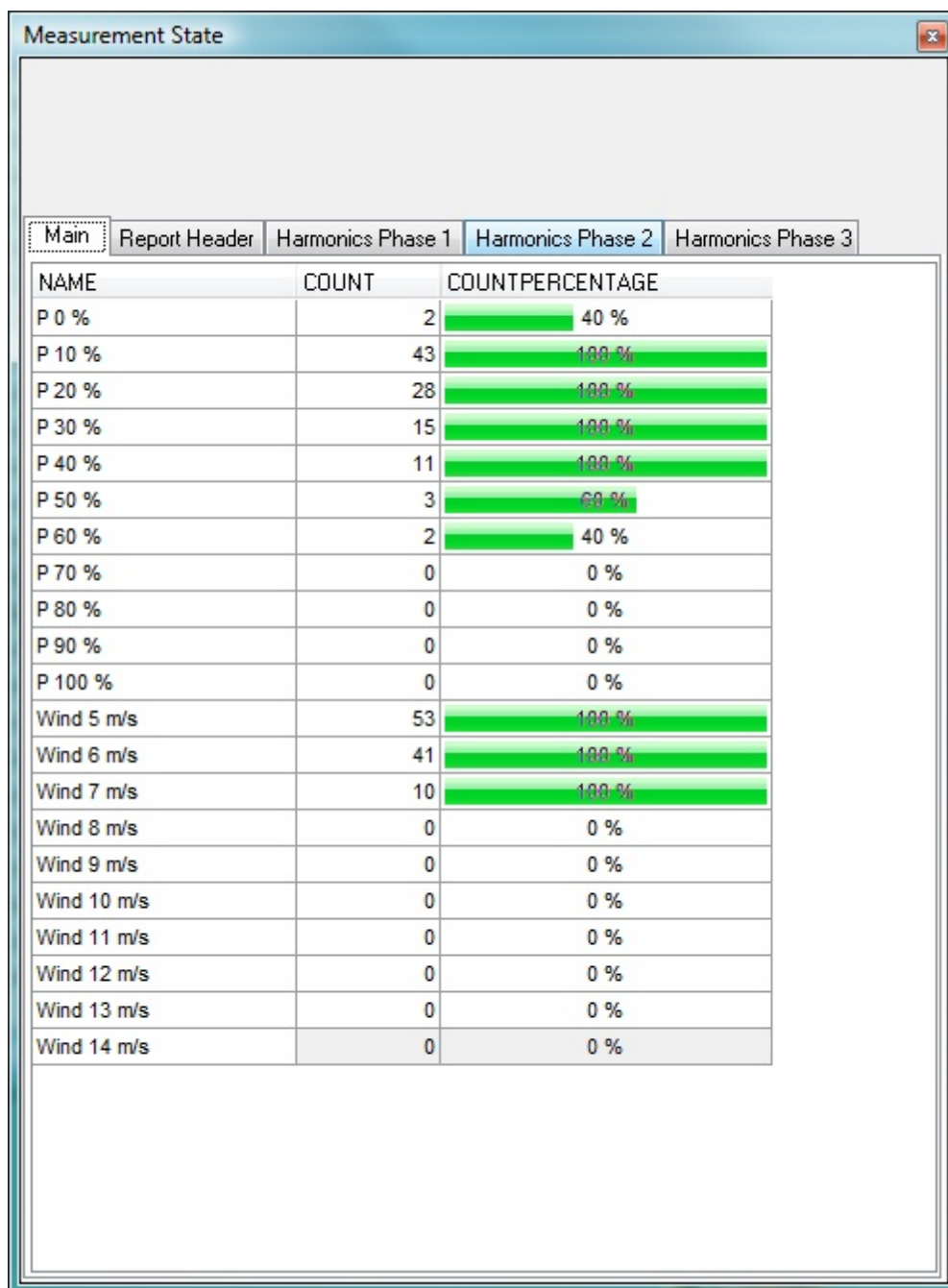
If set to 0, all bins are used in the report

maximum number of bins used for the report

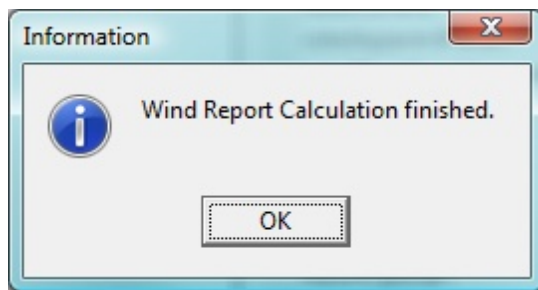
If set to 0, all bins are used in the report

Start Measurement Cancel

Now the measurement data will be loaded and analyzed.
You will see all the number of guilty bins and the data for the bins.



If the measurement analyzation is done you will find the report in the center of the screen.
Now you can evaluate your Report.



3.5 HVDC line

This chapter deals with specific calculations for high-voltage direct-current lines (HVDC).



In specially the following calculations treated:

I_{eq} (equivalent fault current)
 TIF (Telephone Interference Factor)
 THDUN (THDU based on nominal voltage)

3.5.1 I_{eq} (equivalent fault current)

The equivalent fault current is defined as follows:

Measured: $I_{1n}^{\rightarrow}$ Current vector of harmonic "n" line "1"

$I_{2n}^{\rightarrow}$ Current vector of harmonic "n" line "2"

It is calculated: $I_{rn} = abs\left(I_{1n}^{\rightarrow} + I_{2n}^{\rightarrow}\right)$ "residual mode" Current of the harmonic "n"

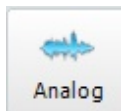
$I_{bn} = \frac{1}{2} \cdot abs\left(I_{1n}^{\rightarrow} - I_{2n}^{\rightarrow}\right)$ "balanced mode" Current of the harmonic "n"

$I_n = \sqrt{I_{rn}^2 + (0.05 \cdot I_{bn})^2}$ Effective current fault of the harmonics "n"

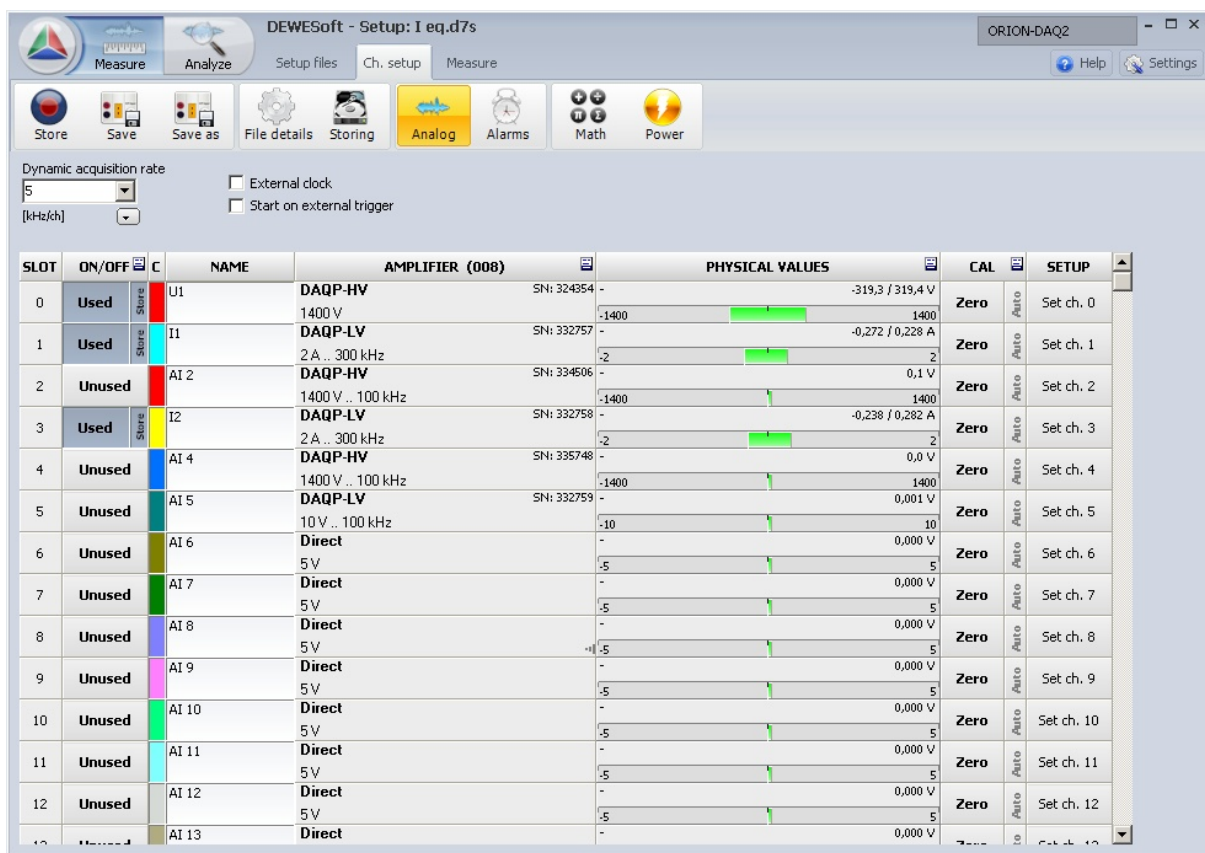
$I_{eq} = \sqrt{\sum_{n=1}^{85} (I_n \cdot C_n)^2}$ Equivalent current fault

Procedure for the determination of I_{eq}:

1. Connect the signals

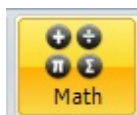


First of all connect the DC currents (I1, I2) and a AC voltage (U1) to the instrument.
(The AC voltage is used to calculate the actual frequency).



2. Create formulas

change to the math toolbox.



Create a formula for $I_m = I1 + I2$.



Formula setup

Output

Name:

Units: Color:

SR div:

Max value 4 A

Min value -4 A

☒ Automatic min/max

Max 0,01593 A
RMS 0,00767 A
Average 0,000189 A
Min -0,01978 A

Formula

'I1'+ 'I2'

Basic operators

+ - x / () ^ div mod

Other math functions

Functions Trigon. Logic
 Signals Measure Events

sqr sqrt abs sgn
 trunc round rnd
 log2 log10 ln exp
 if nan max min

All chs AI Math

I1
 I2
 Irn
 U1

OK

Create a second formula for $I_{bn} = 0,5 \cdot (I1 - I2)$.



Formula setup

Output

Name:

Units: Color:

SR div:

Max value 2 A

Min value -2 A

☒ Automatic min/max

Max 0,2556 A
RMS 0,06693 A
Average -0,0008146 A
Min -0,278 A

Formula

0,5·('I1'-'I2')

Basic operators

+ - × / () ^ div mod

Other math functions

Functions Trigon. Logic
Signals Measure Events

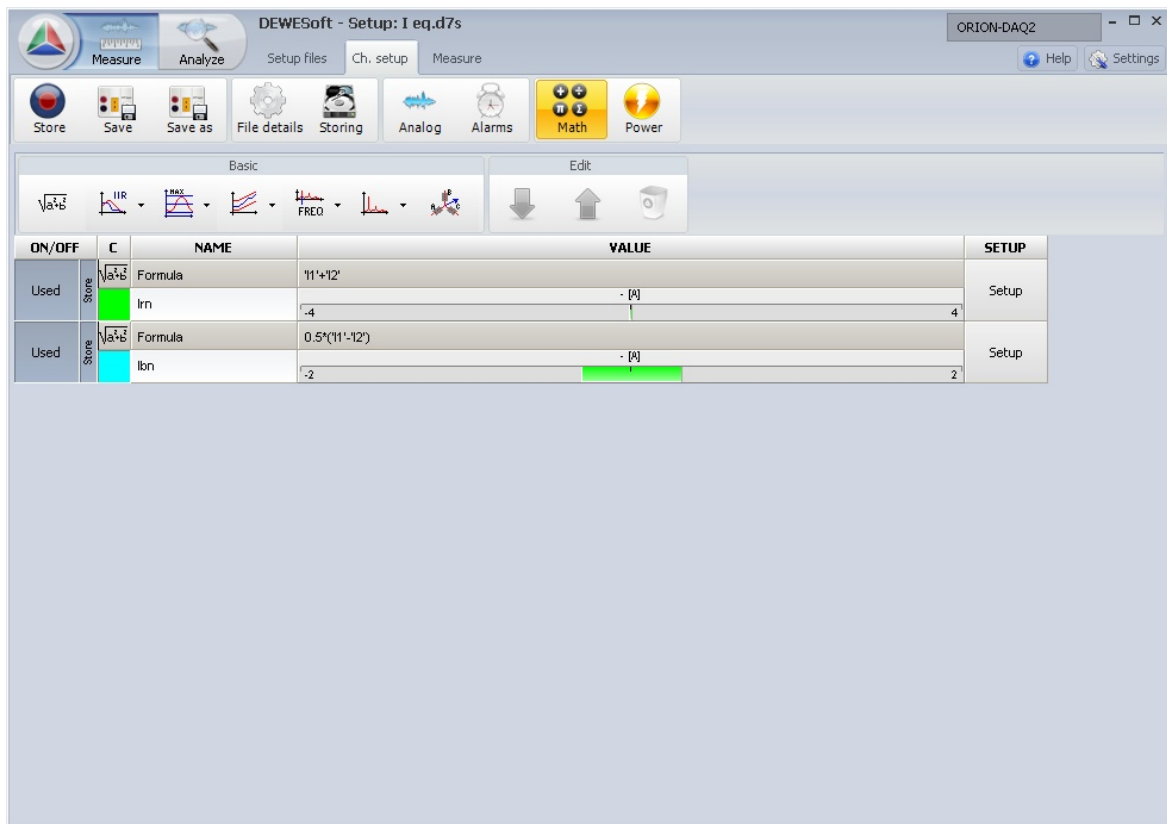
sqr sqrt abs sgn
trunc round rnd
log2 log10 ln exp
if nan max min

All chs AI Math

Formula 1
I1
I2
Irn
U1

OK

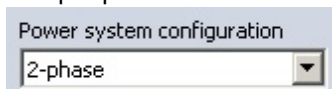
Your screen should look like the following picture:

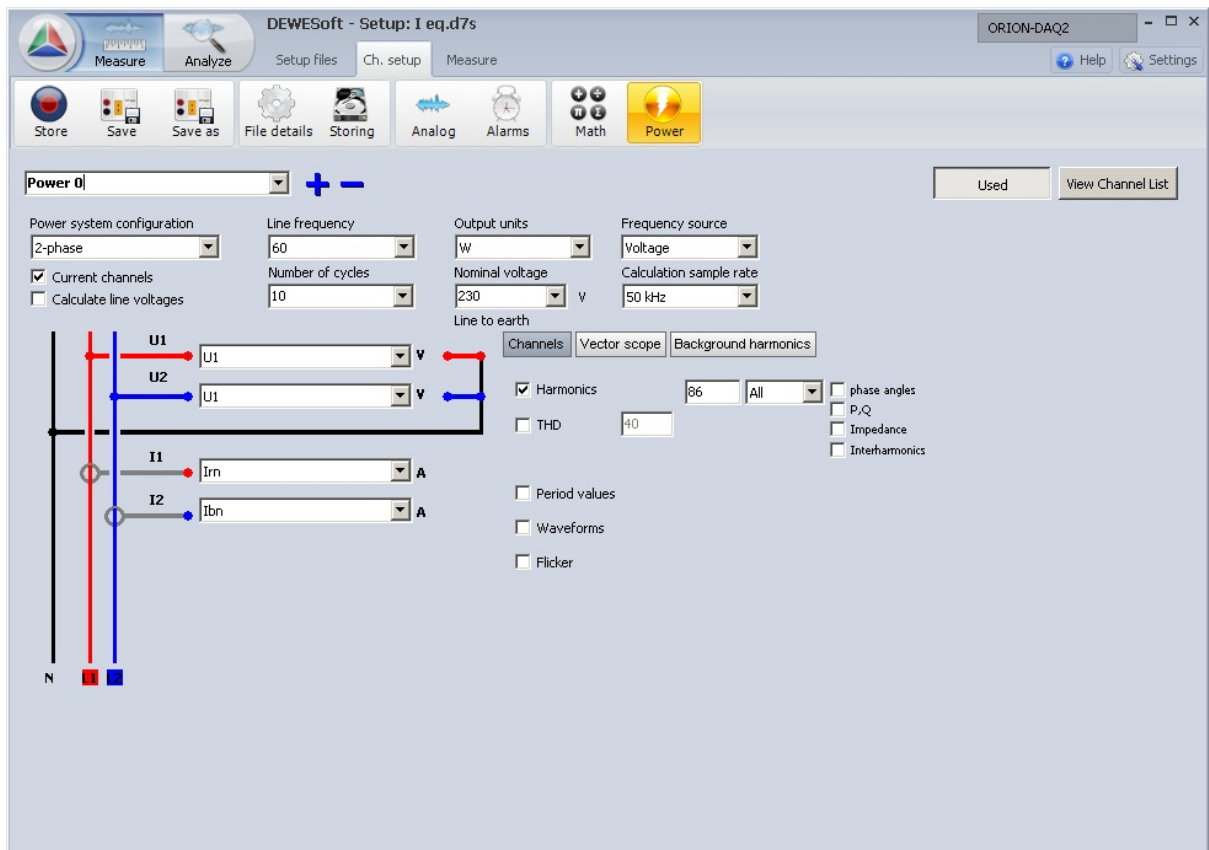


3. Create a power module:



Setup a power module for a 2phase system and assign the values U1, I_{rn} and I_{bn}.

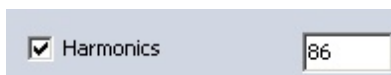




Special settings:



Line Frequency: Select the grid frequency. Example: 60Hz



Harmonics: enter the number of harmonics. Example: 85

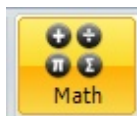
Acquisition rate: Please ensure that the acquisition rate is adjusted accordingly in the "analog setup" (typically 50 kHz)

ATTENTION:

The harmonics of I_{ln} are now called I_{L1_H}

The harmonic of I_{bn} are now called I_{L2_H}

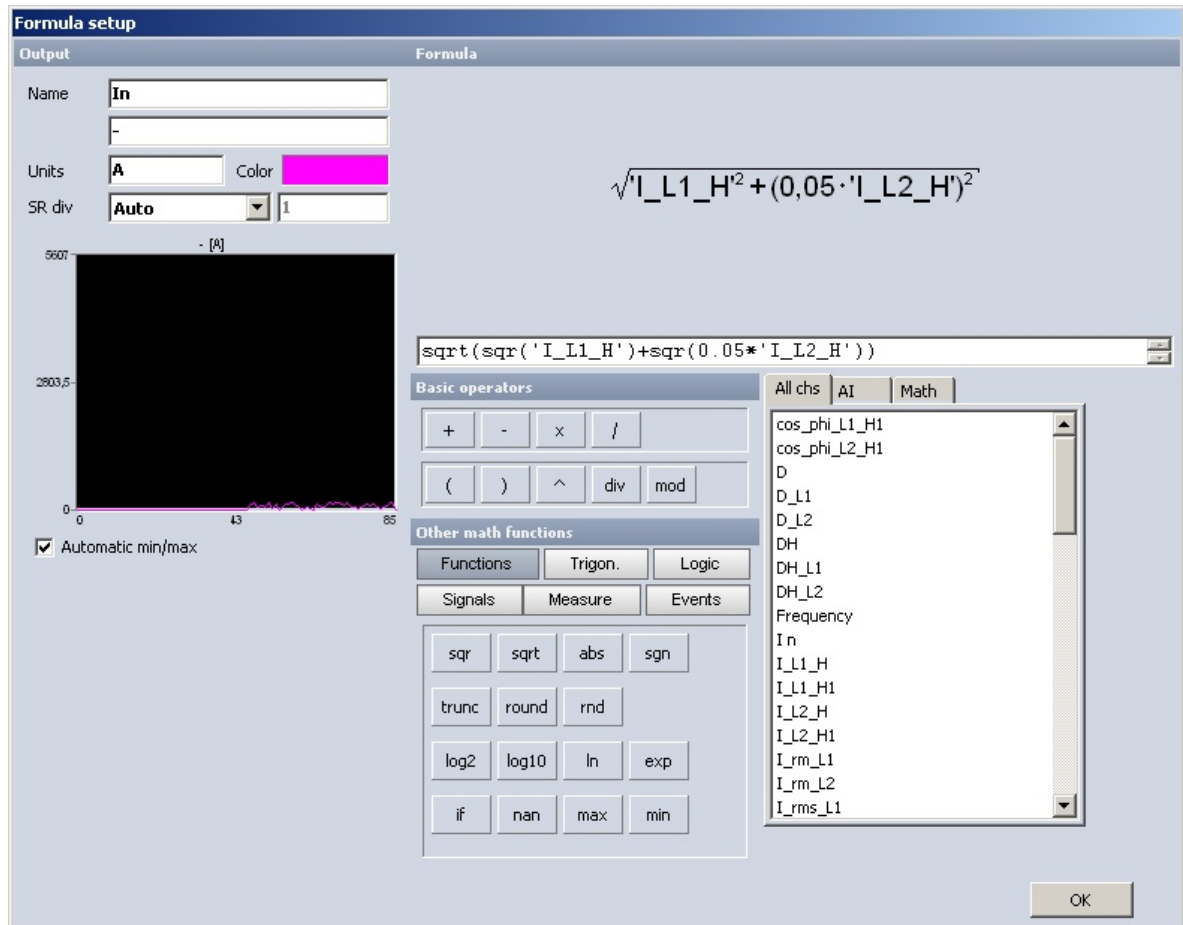
4. Advanced mathematics:



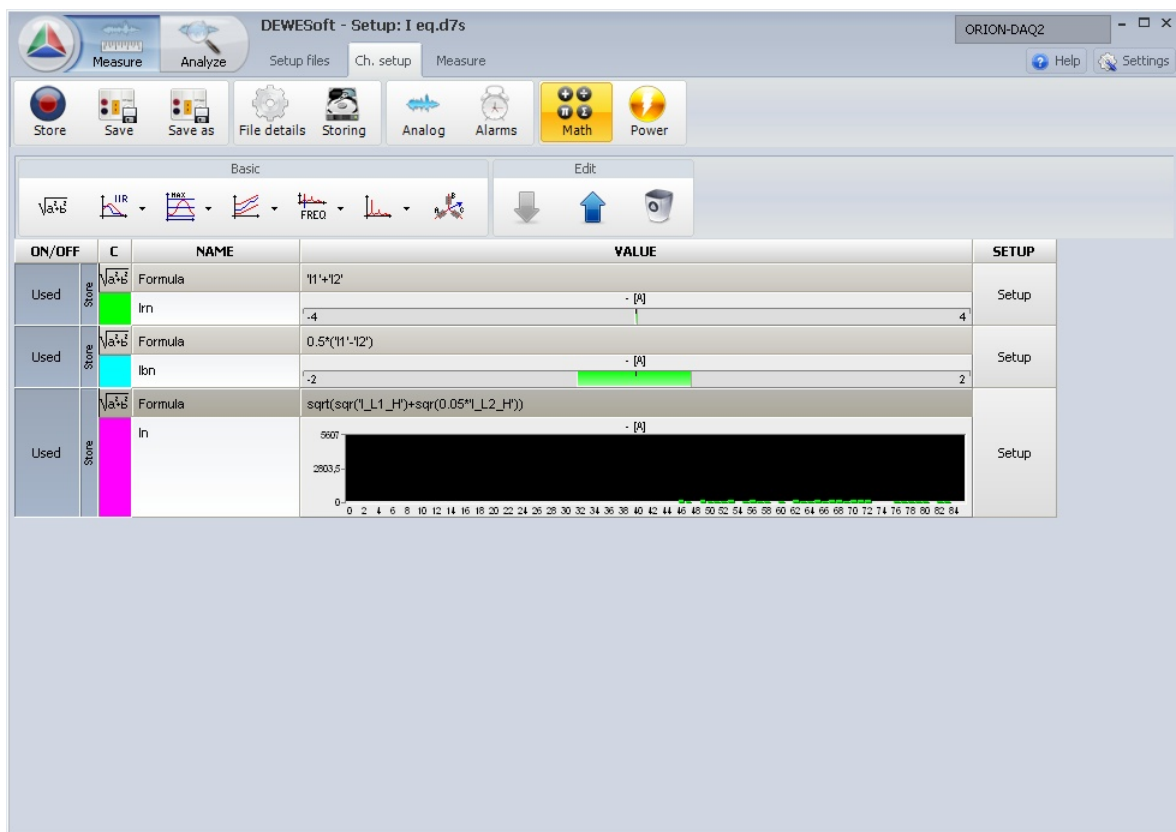
Add another formula in the math:

$$\sqrt{a^2+b^2}$$

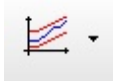
$In = \sqrt{\text{sqr}('I_L1_H') + \text{sqr}(0.05 * 'I_L2_H')}$



Now you should have an array channel in DEWESoft: In



Now create a constant array for Cn:

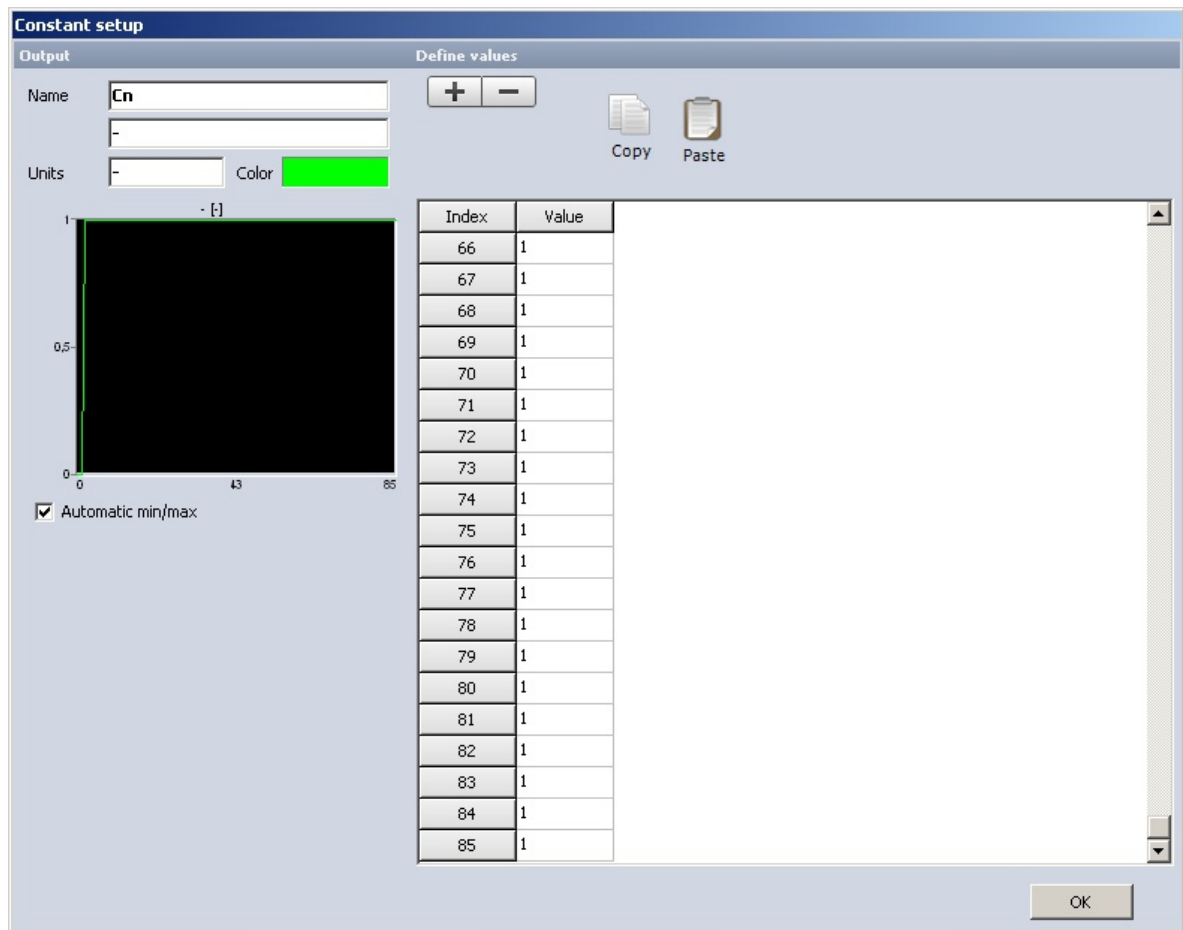


+"CONSTANT"

Click repeatedly on the "+" button to have for example 86 variables (DC+85).

Enter the variables in the table.

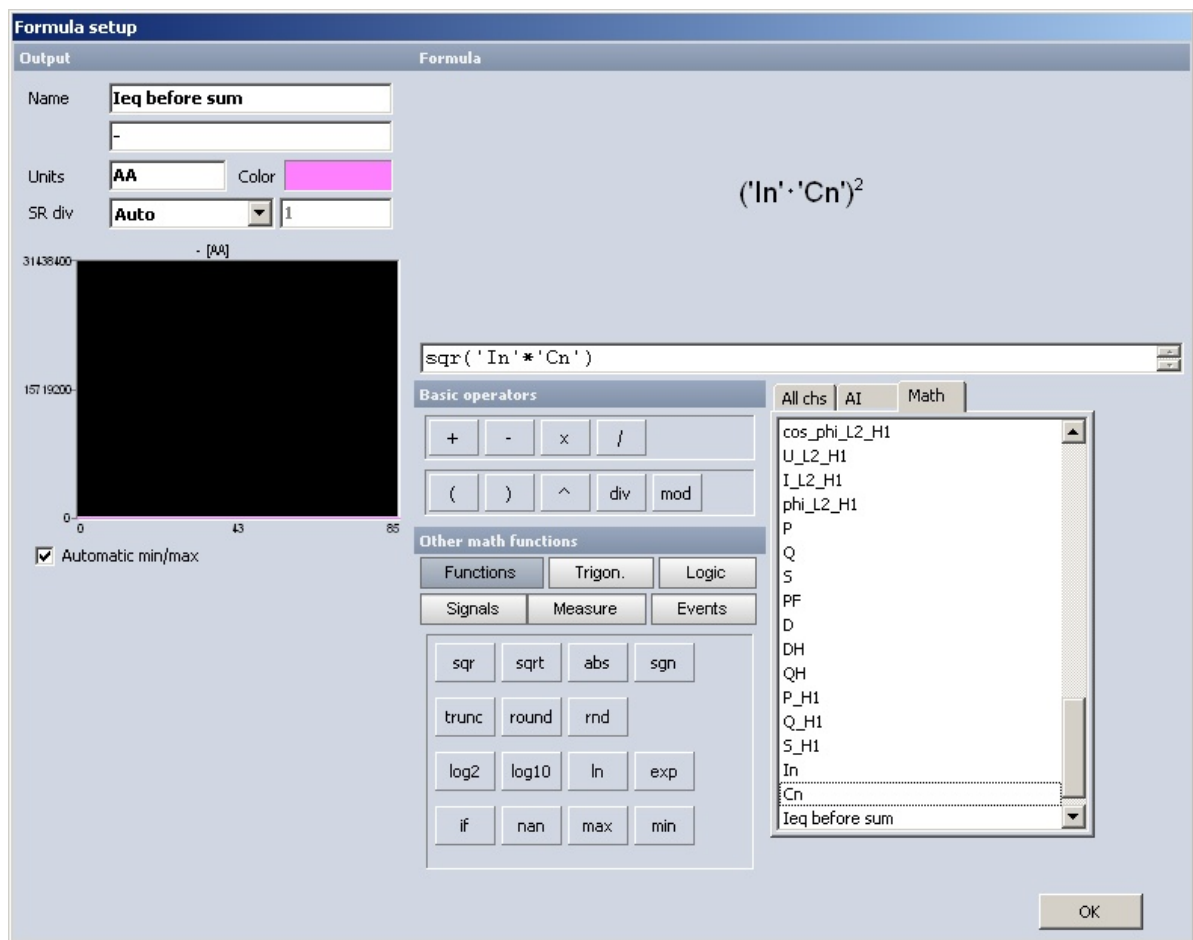
If you don't need a value (for example the DC value) please enter NULL.



Now form the leq in 3 steps:

Step 1: leq before sum=sqr(ln*Cn)

$$\sqrt{a^2 + b^2}$$



Step 2:
leq sum with the array statistics-function



Array statistics setup

Input	Output channels
☐ U_L1_H	☐ Maximum
☐ U_L2_H	☐ Average
☐ I_L1_H	☐ Minimum
☐ I_L2_H	☒ Sum
☐ In	
☐ Cn	
☒ Ieq before sum	

Output

Name:

Units: Color:

Max value: 2,704E009 AA

Max	3,337E005 AA
Average	3,337E005 AA
Min	3,337E005 AA

Min value: 0 AA

☒ Automatic min/max

OK

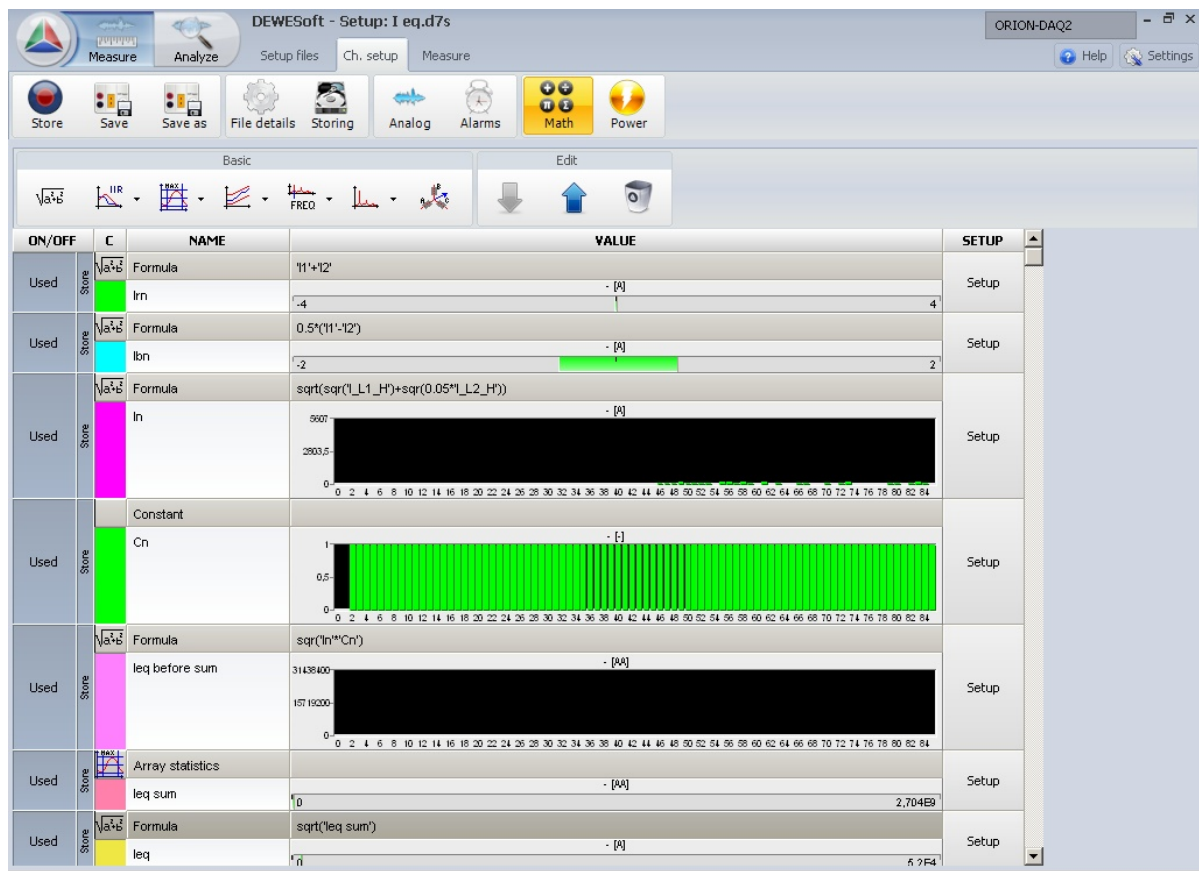
Step 3: Calculate the square root of the sum:
 $\text{leq} = \sqrt{\text{leq sum}}$



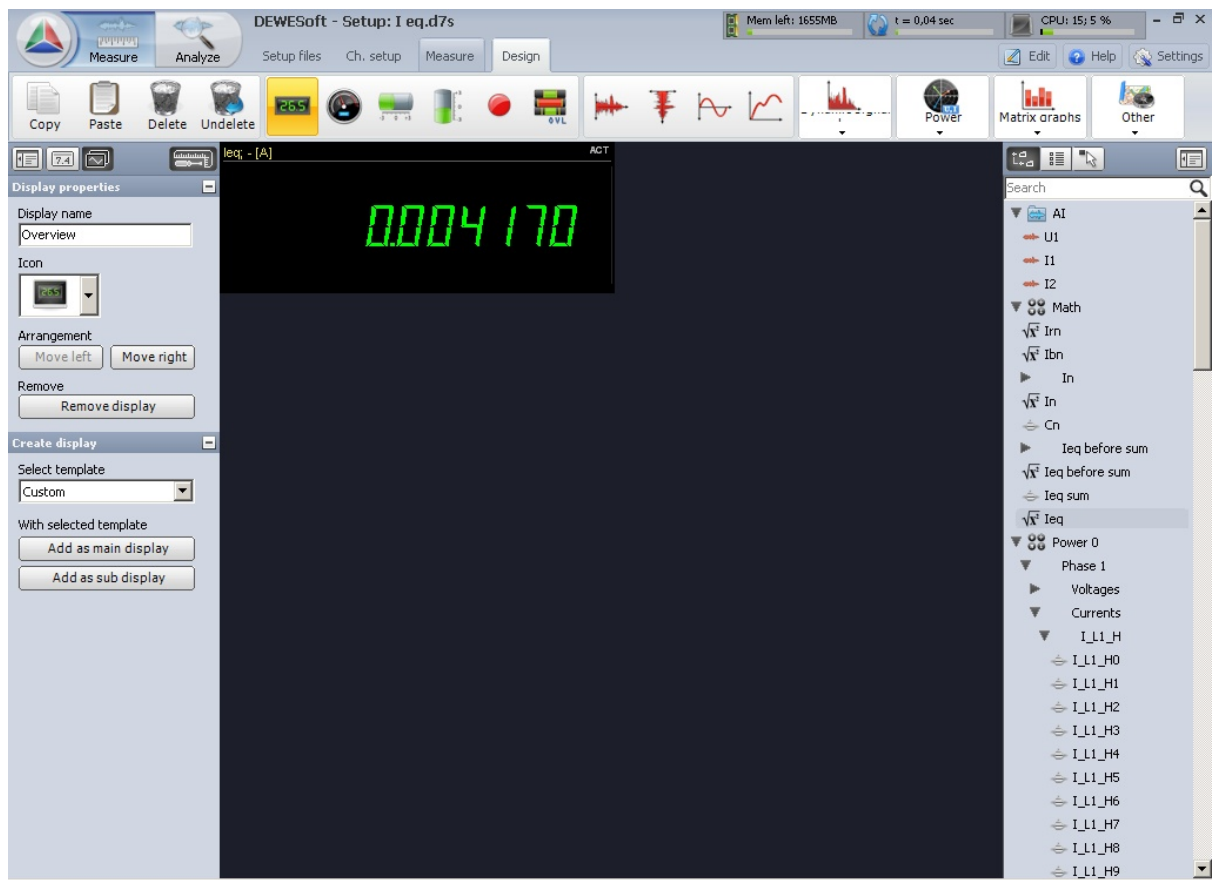
Formula setup

Output	Formula
Name: Ieq	$\sqrt{\text{Ieqsum}}$
Units: A Color: Yellow	
SR div: Auto 1	
Max value: 5,2E004 A	
Max: 667,4 A Average: 667,4 A Min: 667,4 A	sqrt('Ieq sum')
Min value: 0 A	Basic operators + - x / () ^ div mod Other math functions Functions Trigon. Logic Signals Measure Events sqr sqrt abs sgn trunc round rnd log2 log10 ln exp if nan max min All chs AI Math I_L2_H1 phi_L2_H1 P Q S PF D DH QH P_H1 Q_H1 S_H1 In Cn Ieq before sum Ieq sum Ieq
☒ Automatic min/max	OK

Your entire mathematics should look like this:



Now leq is available as a channel in DEWESoft and can be used.



3.5.2 TIF (Telephone Interference Factor)

The TIF (Telephone Interference Factor) is defined as follows:

$$TIF = \sqrt{\sum_{n=2}^{50} (5 \cdot n \cdot f_1 \cdot c_n \cdot ID_n)^2}$$

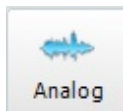
which is:

$$ID_n = \frac{U_n}{U_1}$$

Un Voltage of harmonic n
 U1 Fundamental
 f1 fundamental frequency
 cn C-message weighting factor

Procedure for determination of the TIF factor:

1. Connect the signals

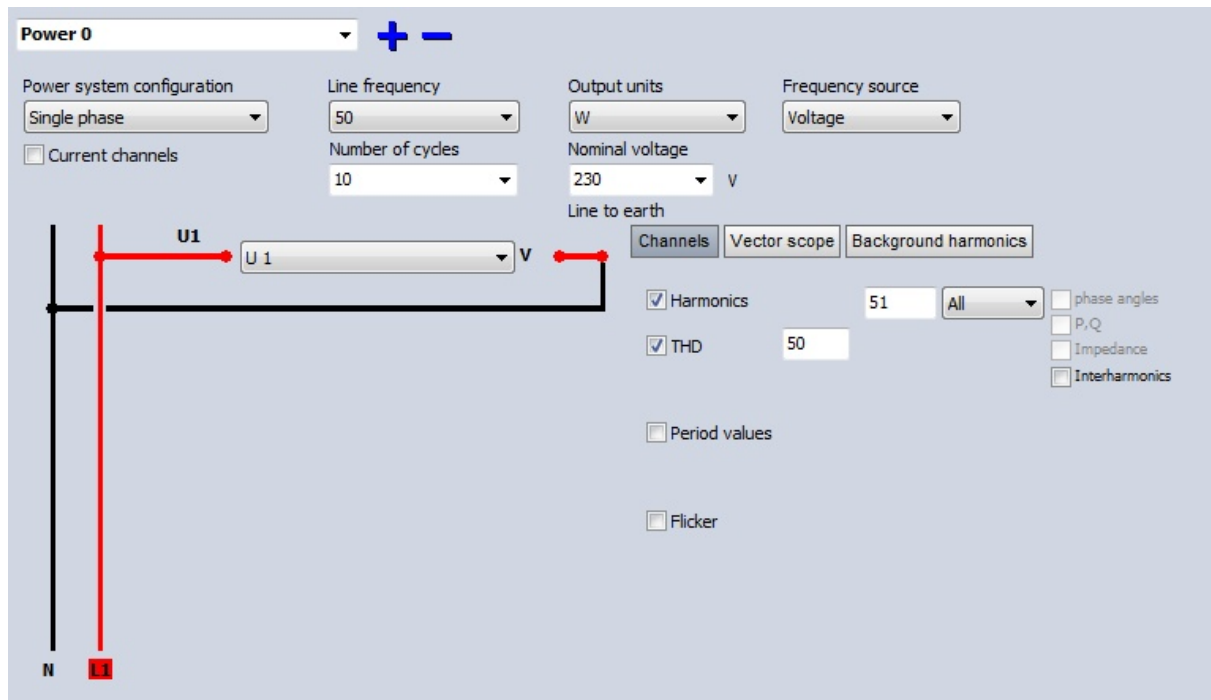


First connect the voltages to the instrument.

2. Setup a power module

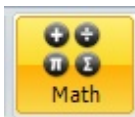


Setup a power module with this voltage

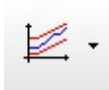


Attention: if you consider 50 harmonics, you need to set 51 because the count starts at the zero harmonic (DC value).

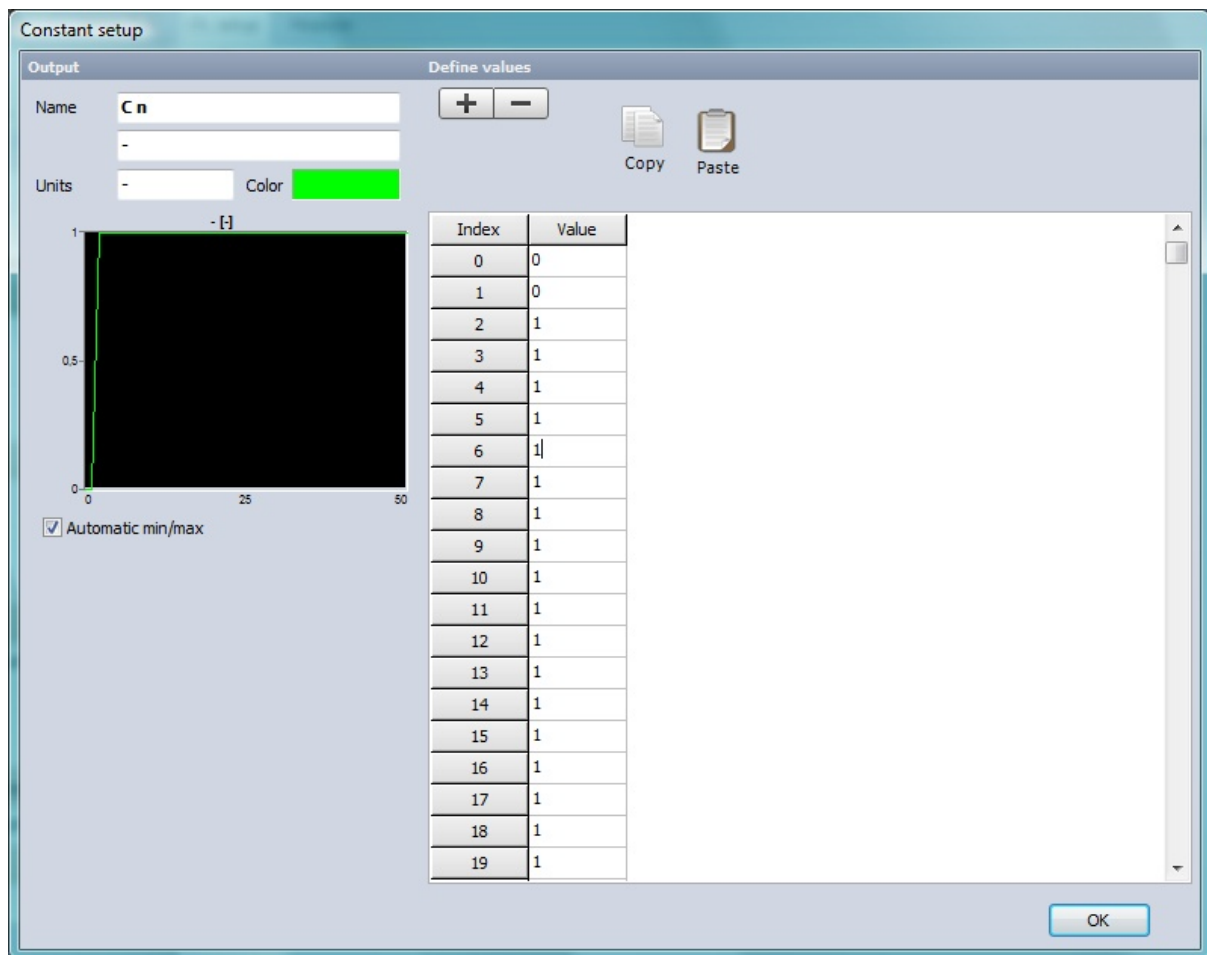
3. Create a formula.



First, define the weighting factors "Cn" by adding a constant array:



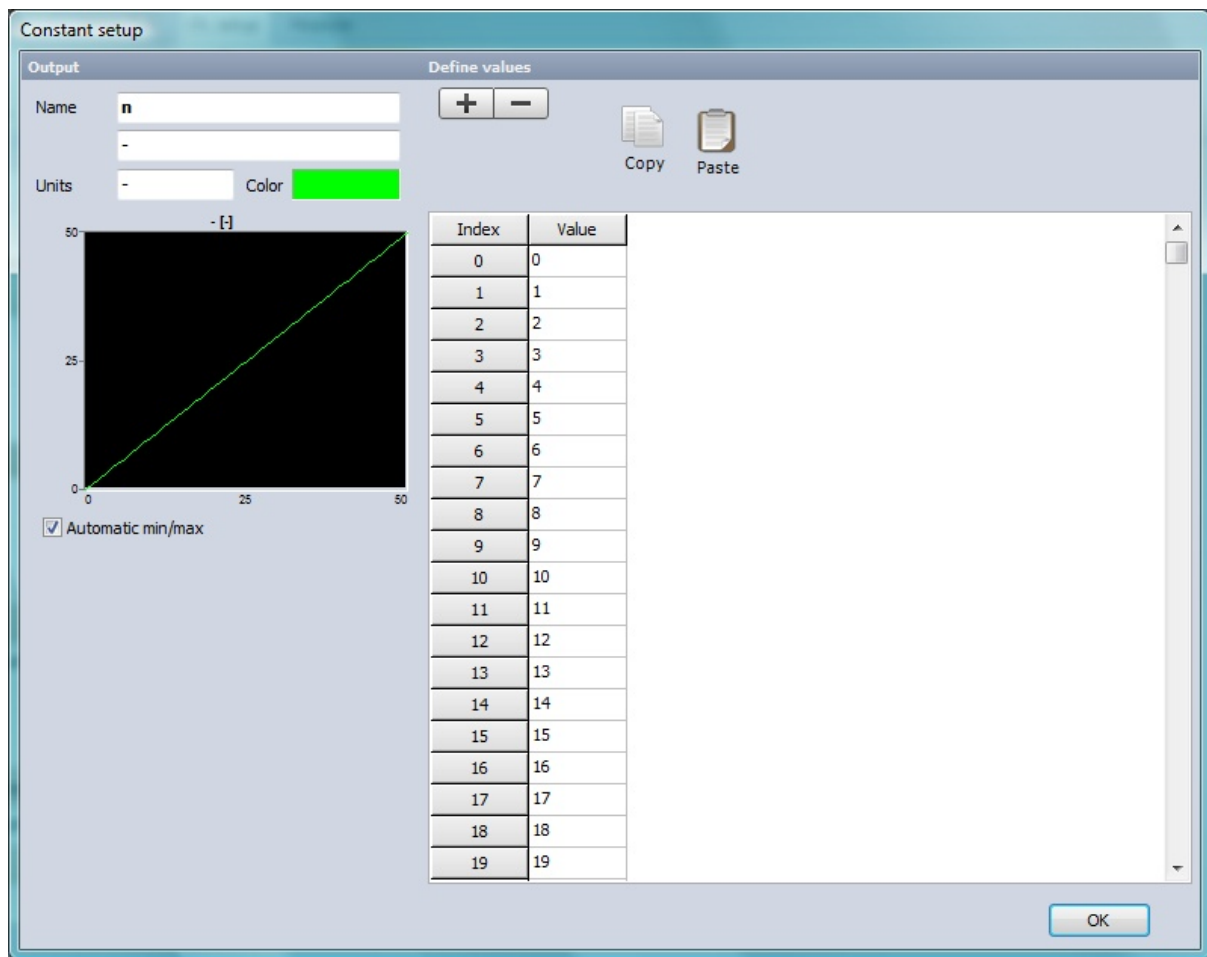
+"CONSTANT"



Since the direct component and the fundamental frequency should not be taken into account, the fields get 0 and 1 is "0".

Into account the atomic number n:

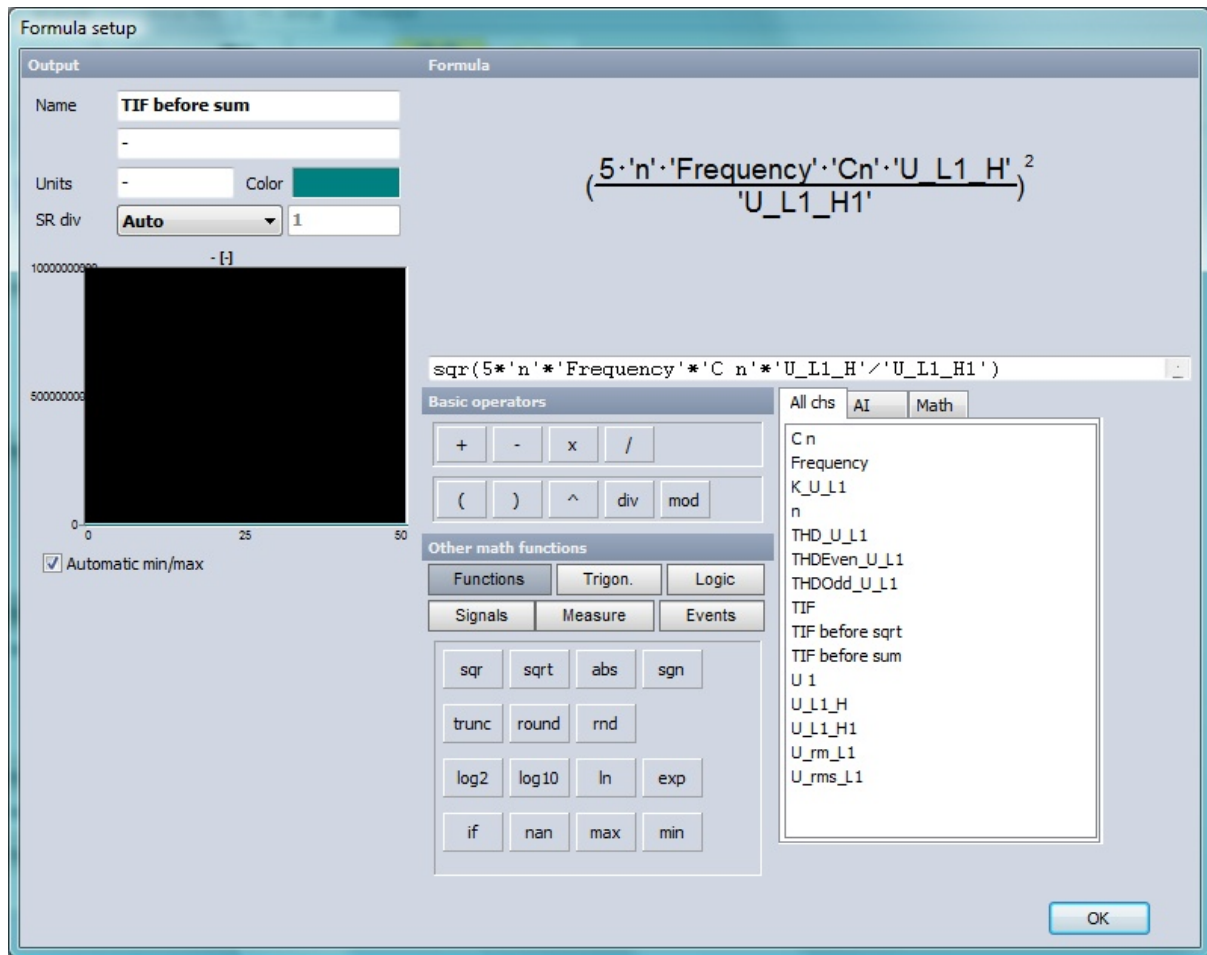
Create a constant array. The order shall be the value.



Calculation:

The main part of the calculation is carried out in a formula as follows:

$$\sqrt{a^2 + b^2}$$



which is:

n...Constant array for the atomic number

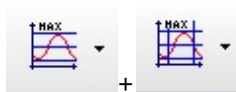
C n...Array of the weighting factors

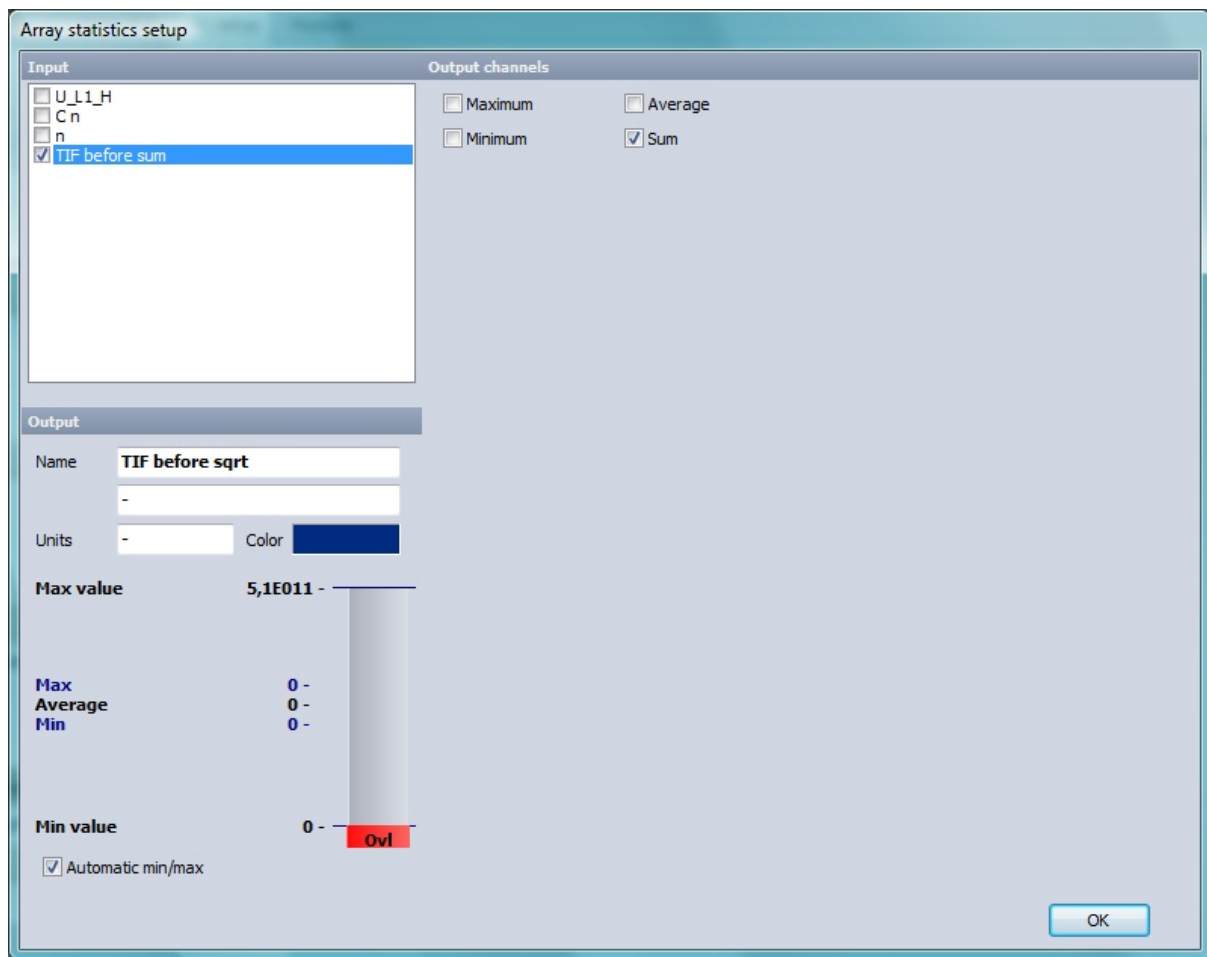
Frequency...The frequency of the power module

U_L1_H...The harmonics of the power module

U_L1_H1...The fundamental of the power module or the nominal voltage

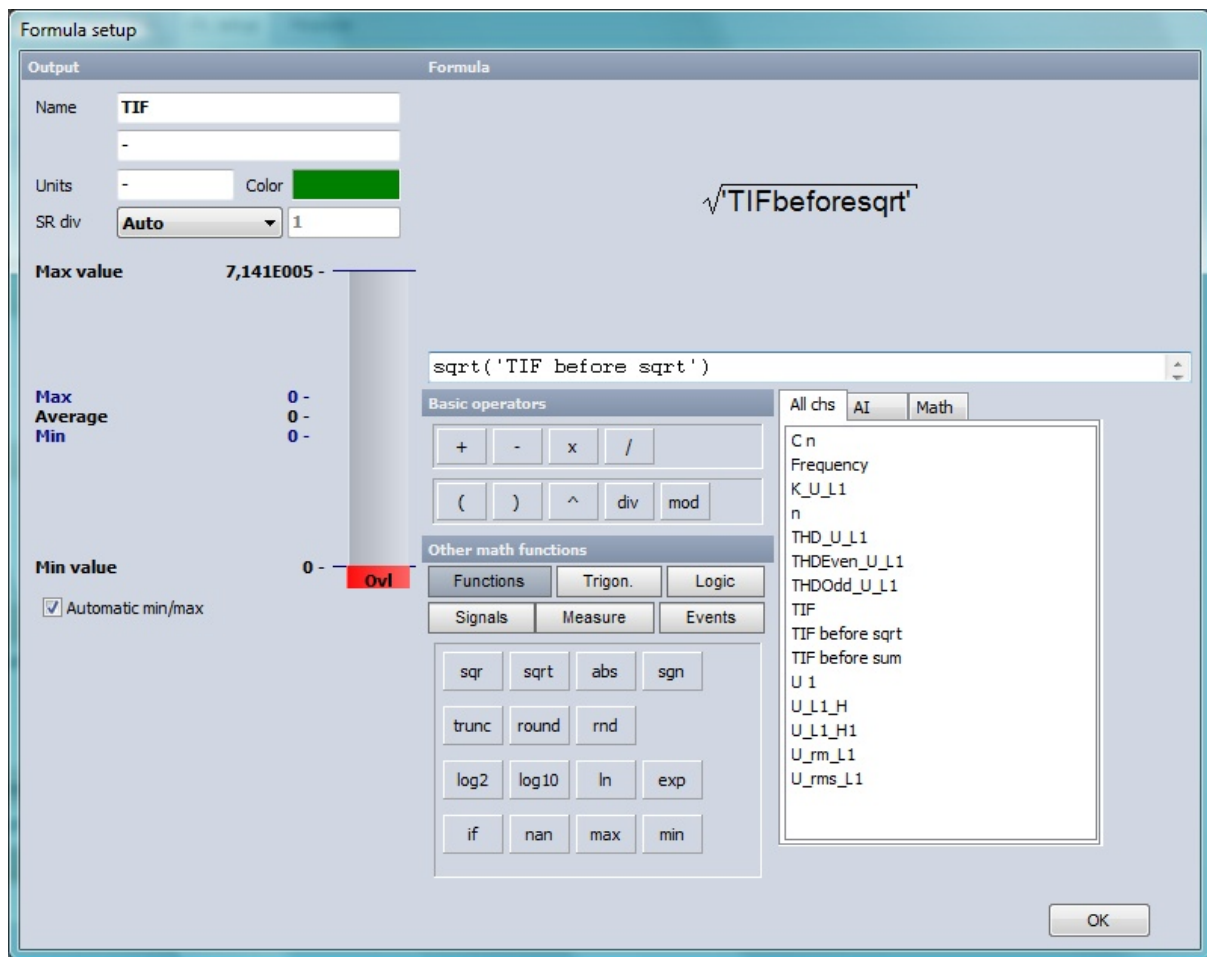
Next, the sum formed:



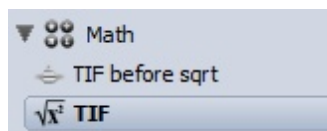


At least calculate the root:

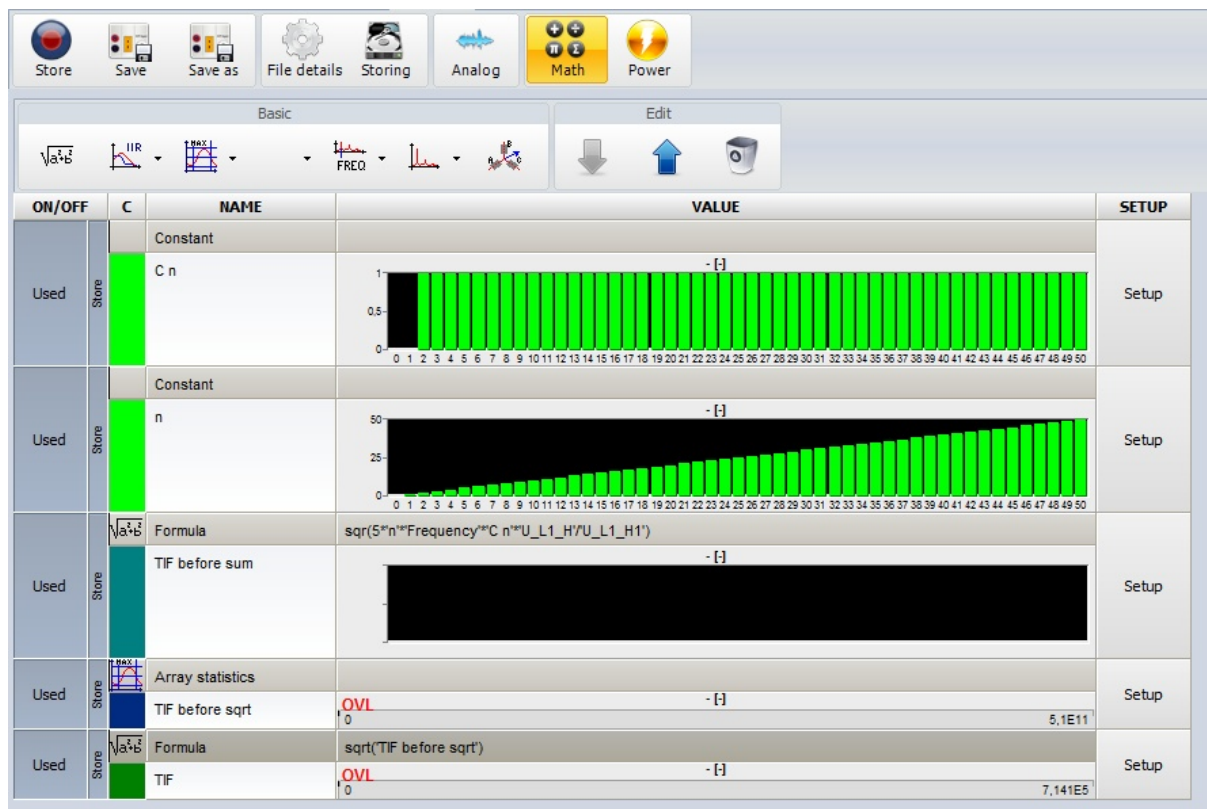
$$\sqrt{a^2 + b^2}$$



TIF is now available in DEWESoft.



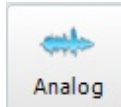
Your mathematics screen should look like the following picture:



3.5.3 THDUN (THDU based on nominal voltage)

Typically, the THD value (Total Harmonic Distortion) is related to the fundamental. In rare cases it may happen that a reference must be made to the nominal voltage. This chapter describes the calculation for this case.

1. Setup the voltages



Connect the voltages (in our example 3 voltages) to your instrument.

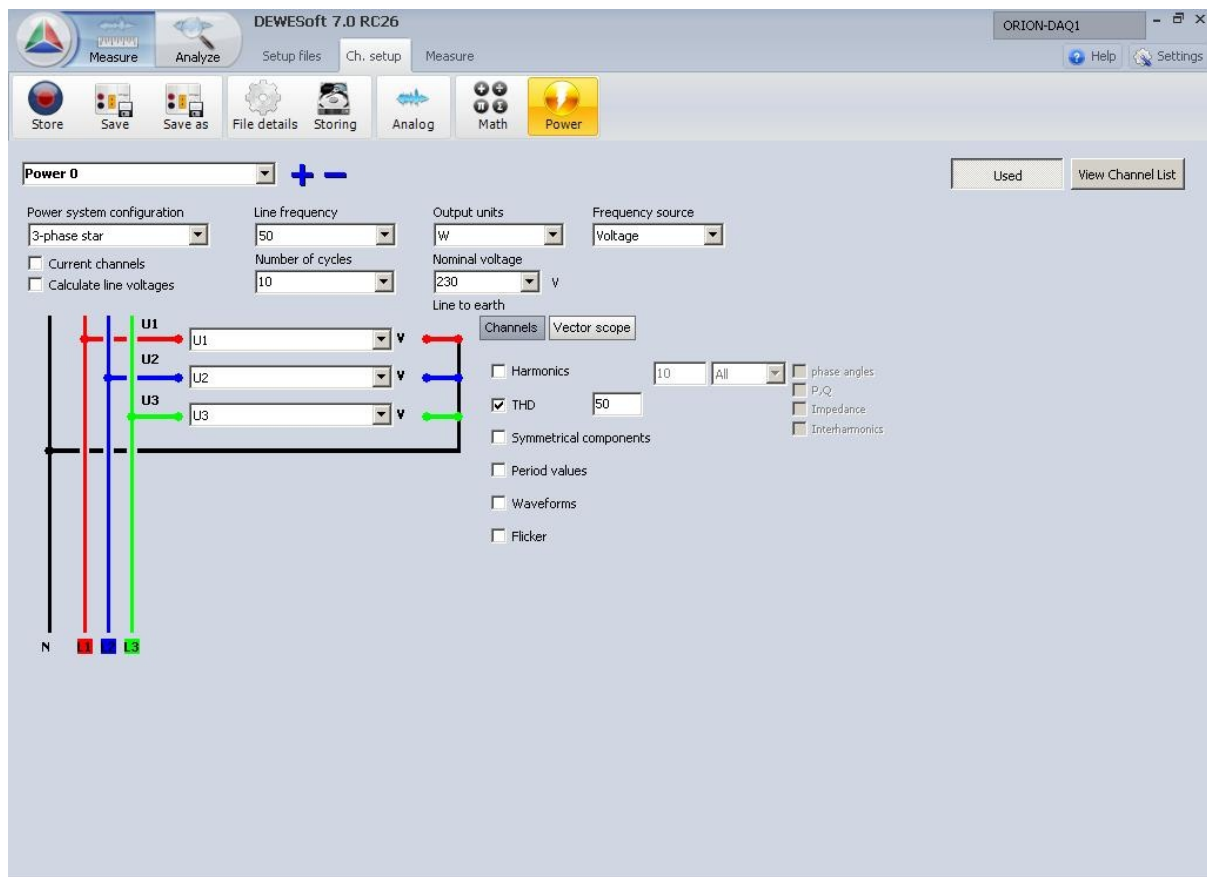
The screenshot shows the DEWESoft 7.0 RC26 software interface. The 'Ch. setup' tab is active, displaying a table of channel configurations. The table has columns for SLOT, ON/OFF, C, NAME, AMPLIFIER (010), PHYSICAL VALUES, CAL, and SETUP. The first three channels (SLOT 0, 1, 2) are 'Used' and configured for DAQP-HV (1400 V .. 100 kHz). The remaining channels (SLOT 3 to 14) are 'Unused' and configured for DAQP-LV (10 V .. 100 kHz) or ORION-1616-501 (5 V).

SLOT	ON/OFF	C	NAME	AMPLIFIER (010)	PHYSICAL VALUES	CAL	SETUP
0	Used	U1	DAQP-HV	SN: 327434	-329,4 / 328,8 V	Zero	Set ch. 0
1	Used	U2	DAQP-HV	SN: 327436	-328,4 / 327,5 V	Zero	Set ch. 1
2	Used	U3	DAQP-HV	SN: 327435	-332,8 / 326,7 V	Zero	Set ch. 2
3	Unused	AI 3	DAQP-LV	SN: 325926	-0,004 V	Zero	Set ch. 3
4	Unused	AI 4	DAQP-LV	SN: 335717	-0,004 V	Zero	Set ch. 4
5	Unused	AI 5	DAQP-LV	SN: 335715	-0,004 V	Zero	Set ch. 5
6	Unused	AI 6	ORION-1616-501	SN: 15380166	-0,001 V	Zero	Set ch. 6
7	Unused	AI 7	ORION-1616-501	SN: 15380166	-0,002 V	Zero	Set ch. 7
8	Unused	AI 8	ORION-1616-501	SN: 15380166	-0,002 V	Zero	Set ch. 8
9	Unused	AI 9	ORION-1616-501	SN: 15380166	-0,001 V	Zero	Set ch. 9
10	Unused	AI 10	ORION-1616-501	SN: 15380166	-0,002 V	Zero	Set ch. 10
11	Unused	AI 11	ORION-1616-501	SN: 15380166	-0,002 V	Zero	Set ch. 11
12	Unused	AI 12	ORION-1616-501	SN: 15380166	-0,001 V	Zero	Set ch. 12
13	Unused	AI 13	ORION-1616-501	SN: 15380166	-0,001 V	Zero	Set ch. 13
14	Unused	AI 14	ORION-1616-501	SN: 15380166	-0,002 V	Zero	Set ch. 14

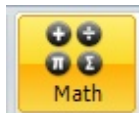
2. Power module



Setup a 3phase power module.



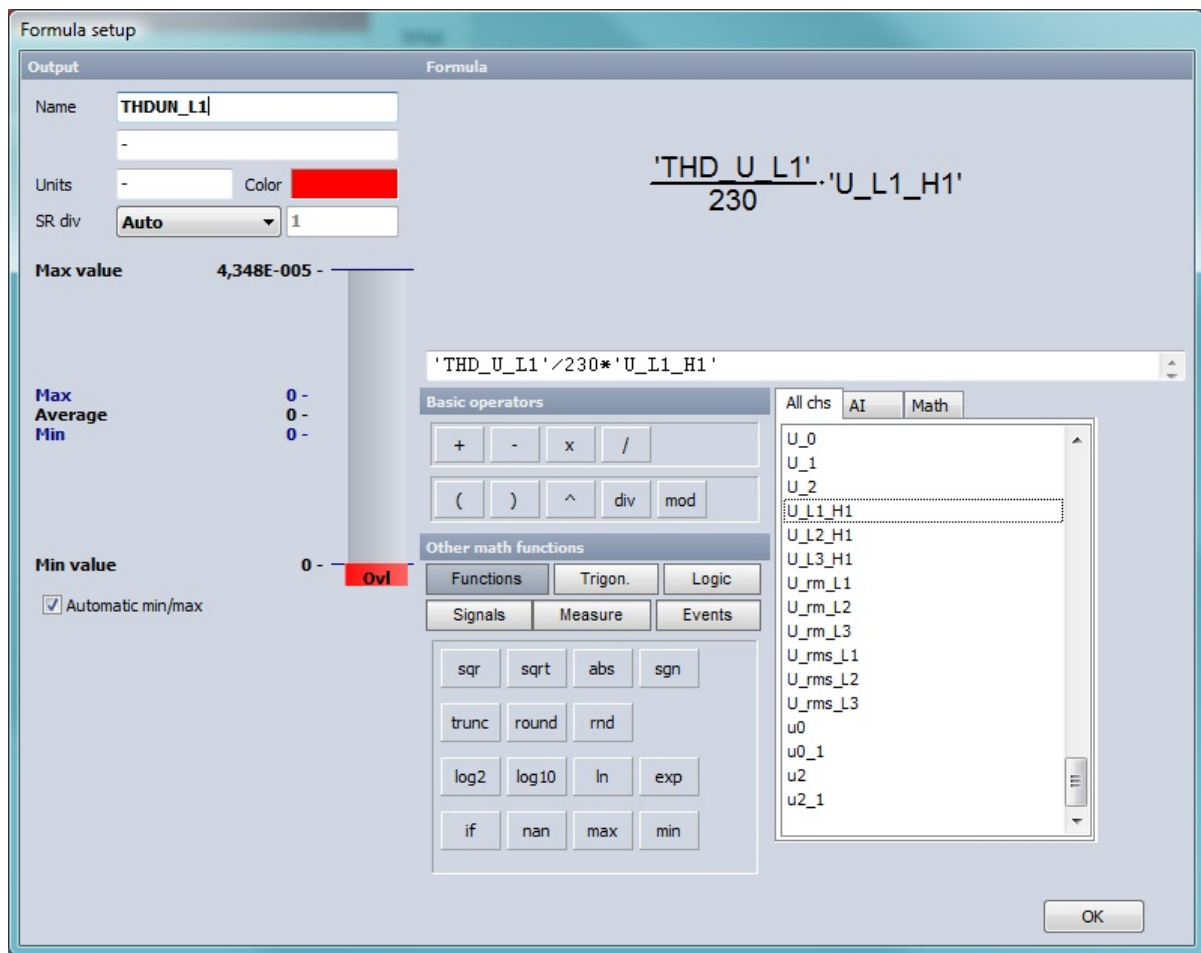
3. Calculation



Now add a formula.

First divide the THD value of the power module (THD_U_L1) by the nominal voltage (230V) and then multiply by the fundamental (U_L1_H1).





Run that through all three phases. The formula screen should look like this:

Basic					Edit	
ON/OFF	C	NAME	VALUE	SETUP		
Used	Store	Formula	'THD_U_L1'/230*'U_L1_H1'	Setup		
		THDUN_L1	OVL 0 4,348E-5			
Used	Store	Formula	'THD_U_L2'/230*'U_L2_H1'	Setup		
		THDUN_L2	OVL 0 4,348E-5			
Used	Store	Formula	'THD_U_L3'/230*'U_L3_H1'	Setup		
		THDUN_L3	OVL 0 4,348E-5			

4. Display

Now display the values in DEWESoft.

The screen below shows the comparison of the THDU (lower values) with the new THDUN (upper values).



4 Technical Reference

In the following chapter you will find the technical reference to the power module.

4.1 General

Technical Reference

Formulas and calculations in the DEWESoft Power module

The software DEWESoft POWER is a software for measuring electrical energy and disturbances in power grids.

Some typical applications are:

- measurements in single-phase and three-phase systems
- energy measurement and load profiles in the supply grid
- measurements of the power usage and energy demand of equipment
- frequency measurement (16,7 Hz, 50 Hz, 60 Hz, 400 Hz, 800 Hz)
- FFT of power networks
- transient fault recorder in power grids
- multi channel energy logger

Values that can be measured are:

- U, I
- f
- P, Q, S, PF
- P1, Q1, S1, cos Phi1
- Q, Q1, D, QH, DH
- Symmetrical Components U, I
- FFT: U, I, cos Phi, P, Q for each Harmonic
- THD, THD even, THD odd

4.1.1 Sine waves and other periodic signals

Electrical energy is mainly generated in rotating generators – three-phase synchronous motors. Due to the nature of this engine the voltage is a pure sine wave with a frequency calculated by the rotation speed and the number of poles of the rotor/stator system.

voltage waveform = sine wave

The RMS value of this sinusoidal voltage is the value which a pure direct voltage would have to produce the same “heat” – which means the area under the curve must be the same. Mathematically it is the so called RMS value and for a pure sine wave it is the peak value divided by SQRT(2).

$$U_{RMS} = \frac{u_{peak}}{\sqrt{2}}$$

formula 1: RMS of a pure sine wave

Due to non linear characteristics of for example transformers and non linear load currents the voltage that is seen at the customer side is not longer the sine wave which came out of the generator – but it is still periodic.

To calculate the RMS value now it is necessary to have a look on the real wave form. The above mentioned formula is only valid for sine waves.

A RMS value can also be calculated as the integration of all squared sample points of the curve and divided by the number of samples and taking the root of the result.

$$RMS = \sqrt{\frac{1}{n} \sum_{i=1}^n u_i^2}$$

formula 2: RMS for non sine waves

The base for this formula is a signal which has no time delay or other shift inside the curve.

For calculations where you have to compensate also non linear characteristics of transformers you must first transfer the signal into the frequency domain, correct it by amplitude and phase, and then you can calculate the RMS values.

Those transformers are typically current clamps, voltage and current measurement transformers but also all measurement amplifiers. Also a sampling shift of non synchronous sampling in digital recorders can be suppressed by the use of this method.

4.1.2 RMS calculation and the problem of non linear signal transformers

To calculate the RMS value with the use of the frequency domain you first have to transfer the input signal from time domain into frequency domain.

(u(t))...time domain

$$U_{FFT} = FFT(u(t))$$

...frequency domain

formula 3: FFT principle

This is done by the use of the fast Fourier transformation [see 2, 11]. The typical window duration in electrical applications are 10 periods [see 3].

Now you can multiply each frequency by itself with the correction factor for the amplitude and for the phase shift.

$$U_{FFTcorrected} = U_{FFT} * FFT_{correction\ factors}$$

formula 4: FFT correction

Typically, you have to calibrate the instrument itself and also external transformers. This can be made with a two-step calibration for inner and outer correction.

$$U_{FFTcorrected} = U_{FFT} * FFT_{innercorrection} * FFT_{outercorrection}$$

formula 5: FFT full correction

In order to get the total RMS value the RMS for each frequency and then the sum of all these values have to be calculated.

$$U_{RMS_{total}} = \sqrt{U_0^2 + U_1^2 + U_2^2 + \dots}$$

formula 6: U RMS total

0,1,2,...harmonic index (including all interharmonics)

The RMS value is now totally corrected in amplitude and phase.

For current correction the way is the same and for power calculations the way is similar. The additional need is that current and voltage have to be exactly in phase and this is done by using the inner calibration values. The calculation of the individual power values is described in chapter 4.1.

4.1.3 General terms

Values in capital letters: RMS or AVG values

Examples:

RMS: U, I

AVG: P, S, Q

Values in small letters are: waveforms or sample point values

Examples:

$u(t)$, $i(t)$, $p(t)$

RMS (root mean square value) is calculated as:

$$RMS = \sqrt{\frac{1}{n} \sum_{i=1}^n u_i^2}$$

formula 7: RMS

AVG (average values) are calculated as:

$$AVG = \frac{1}{n} \sum_{i=1}^n u_i$$

formula 8: AVG

4.2 Voltage and current

As both very accurate values (corrected 10 period FFT values, later called “frequency domain values”) and fast values (half period and multiples of it, later called “time domain values”) are needed, both values for further evaluations are provided.

4.2.1 Frequency domain values

- high accuracy
- phase and amplitude corrected
- typical: 10 period window length

$u_{nh} \dots \text{from FFT}$

$$U_{nh} = \frac{u_{nh}}{\sqrt{2}}$$

$$U_n = \sqrt{\sum_{h=1}^H U_{nh}^2}$$

formula 9: U phase

U...RMS value of the voltage

unit: V (volt)

name in software: U rms_L1, U rms_L2, U rms_L3

directory in software: channels – power – module no. – Phase x – Voltages

u...voltage amplitude for line to neutral voltages (phase voltage) from FFT calculation

h...harmonic order

H...number of harmonics

n...phase number 1,2 or 3

$i_{nh} \dots \text{from FFT}$

$$I_{nh} = \frac{i_{nh}}{\sqrt{2}}$$

$$I_n = \sqrt{\sum_{h=1}^H I_{nh}^2}$$

formula 10: I

I...RMS value of the current

unit: A (ampere)
 name in software: I_rms_L1, I_rms_L2, I_rms_L3
 directory in software: channels – power – module no. – phase x – currents

i...current amplitude from FFT calculation
 h...harmonic order
 H...number of harmonics
 n...phase number 1,2 or 3

4.2.1.1 Calibration

Inner calibration

For amplitude and phase corrections inside the instrument.

Outer calibration

For additional external clamps and transformers.

4.2.2 Time domain values

Typically, the one-period value is needed as a trigger argument for a fault recorder. This can be either voltage or current but also, for example, power, reactive power or the power factor. To provide this the so called period value is implemented. These values are not corrected in amplitude and phase.

$$U_{perRMS} = \frac{1}{n} \sqrt{\sum_{i=1}^n u_i^2}$$

formula 11: U per

unit: V (volt)
 name in software: U_L1per, U_L2per, U_L3per
 directory in software: channels – power – module no. – phase x – period values

U perRMS...period value of the voltage
 n...number of samples = duration * sampling speed
 i...voltage of sample

$$I_{perRMS} = \frac{1}{n} \sqrt{\sum_{i=1}^n i_i^2}$$

formula 12: I per

unit: A (ampere)
 name in software: I_L1per, I_L2per, I_L3per

directory in software: channels – power – module no. – Phase x – Period values

I_{perRMS} ...period value of the current

n ...number of samples = duration * sampling speed

i ...current of sample

Duration: length of the RMS calculation. ½ period, 1 period, 2, 4,...or absolute time: ½ sec

Overlapping: sometimes a sliding window is needed for this calculation. In IEC 61000-4-30 a ½-period RMS value is required which is in real a period value which is shifted all ½ periods. Overlapping in this case is 50%, length is 1 period.

Also power values can be calculated like this – see chapter 4.2.

4.2.3 3 Phase systems

In multiphase systems not only the line-to-earth voltage is of interest but also the line-to-line voltage. For example a line-to-earth voltage is required to detect earth faults. In a delta star transformer line-to-line voltage is converted into the kind of voltage that the customer gets in the end – so in medium and high voltage applications line-to-line voltage is of interest as well.

Line-to-line voltage can be measured directly or calculated as well by using the following formula:

$$u_{ik} = u_k - u_i$$

$$U_{ik} = RMS(u_{ik})$$

formula 13: U line

U_{ik} ...line-to-line voltage (line voltage)

unit: V (volt)

name in software: U 12, U 23, U 31

directory in software: channels – power – module no. – waveforms

for scope mode: channels – power/module no./waveforms

i ...phase number 1

k ...phase number 2

possible values for ik : 12, 23, 31

4.2.3.1 wiring conversions

Depending on the selected wiring schematic the other kinds of voltage can be calculated as follows:

star to delta

$$u_{ik} = u_i - u_k$$

$$U_{ik} = RMS(u_{ik})$$

formula 14: star to delta conversion

delta to star

$$u_1 = \frac{1}{3}(u_{12} - u_{31})$$

$$u_2 = \frac{1}{3}(u_{23} - u_{12})$$

$$u_3 = \frac{1}{3}(u_{31} - u_{23})$$

$$U_1 = RMS(u_1)$$

$$U_2 = RMS(u_2)$$

$$U_3 = RMS(u_3)$$

formula 15: delta to star conversion

4.2.3.2 3-phase systems with missing current (Aron and V connection)

In some wiring schematics one current is not measured but calculated out of the other two. This schematic can be used ONLY when there is NO neutral line !

$$i_3 = -i_2 - i_1$$

formula 16: missing current

i_3 ...missing current

i_1, i_2 ...measured current

4.3 Frequency

The frequency calculation is done based on a software PLL and the sampling window of multiple periods (typically 10 periods).

f...fromFFT

formula 17: frequency

typical value: 16 2/3, 50, 60, 400, 800, variable

unit: Hz (hertz)

name in software: frequency

directory in software: channels – power – module no.

f...frequency of the fundamental oscillation (highest peak in FFT spectrum)

4.4 Power

4.4.1 Frequency domain (high accuracy and calibrated values)

- high accuracy
- phase and amplitude corrected
- typical 10 period window length

4.4.1.1 single phase

As a result of the fast Fourier transformation (FFT) we have the values of u, i and cos Phi for each harmonic. With the help of these values all power values can be calculated as follows. Due to the already done calibration the results have the highest possible accuracy.

4.4.1.1.1 for each individual harmonic h:

$$S_h = U_h * I_h$$

formula 18: S h

S...power of harmonic h
unit: VA (volt ampere)

h...harmonic number
U...phase voltage
I...phase current

$$P_h = U_h * I_h * \cos \Phi_h$$

formula 19: P h

P...active power of harmonic h
unit: W (watt)
name in software: P_L1_H2, P_L1_H3, P_L1_H4, ...
directory in software: channels – power – module no. – phase x – power

Phi...phase angle of harmonic h

$$Q_h = U_h * I_h * \sin \Phi_h = \sqrt{S_h^2 - P_h^2}$$

formula 20: Q h

Q...reactive power of harmonic h
unit: VAr (volt ampere radiant)

4.4.1.1.2 for the fundamental oscillation $h=1$:

$$S1 = U1 * I1$$

formula 21: S1

S1...power of the fundamental

unit: VA (volt ampere)

name in software: S_L1_H1, S_L2_H2, S_L3_H3

directory in software: channels – power – module no. – phase x – power

$$P1 = U1 * I1 * \cos \Phi1$$

formula 22: P1

P1...active power of the fundamental

unit: W (watt)

name in software: P_L1_H1, P_L2_H1, P_L3_H1

directory in software: channels – power – module nr – phase x – power

$$Q1 = U1 * I1 * \sin \Phi1 = \sqrt{S1^2 - P1^2}$$

formula 23: Q1

S1...reactive power of the fundamental

unit: VAr (volt ampere radiant)

name in software: Q_L1_H1, Q_L2_H1, Q_L3_H1

directory in software: channels – power – module no. – phase x – power

Q1 has a positive or negative sign

4.4.1.1.3 for the full waveform:

$$S = \sum_{h=1}^H S_h$$

formula 24: S

S...power of the full signal

unit: VA (volt ampere)

name in software: S_L1, S_L2, S_L3

directory in software: channels – power – module no. – phase x – power

H...number of all Harmonics
h...individual harmonic

$$P = \sum_{h=1}^H P_h$$

formula 25: P

P...active power of the full signal
unit: W (watt)
name in software: P_L1, P_L2, P_L3
directory in software: channels – power – module no. – phase x – power

$$Q = \sqrt{S^2 - P^2}$$

formula 26: Q

Q...reactive power of the full signal
unit: VAr (volt ampere radiant)
name in software: Q_L1, Q_L2, Q_L3
directory in software: channels – power – module no. – phase x – power
Q has no sign !

$$PF = \frac{P}{S}$$

formula 27: PF

PF...power factor of the full signal
unit: 1
name in software: PF_L1, PF_L2, PF_L3
directory in software: channels – power – module no. – phase x – power

$$D = \sqrt{Q^2 - Q_1^2}$$

formula 28: D

D... distortion power of all harmonics components reactive powers (u and I have the same order but not equal 1 or have different order)
unit: VAr (volt ampere radiant)
name in software: D_L1, D_L2, D_L3
directory in software: channels – power – module no. – phase x – power
D has no sign !

$$QH = \sum_{h=1}^H Q_h$$

formula 29: QH

QH...reactive power of all harmonics where u and i have the same harmonics order

unit: VAr (volt ampere radiant)

name in software: QH_L1, QH_L2, QH_L3

directory in software: channels – power – module no. – phase x – power

QH has a positive or negative sign

$$DH = \sqrt{Q^2 - QH^2}$$

formula 30: DH

DH...distortion power of all harmonics components reactive powers where u and i have different harmonic orders

unit: VAr (volt ampere radiant)

name in software: DH_L1, DH_L2, DH_L3

directory in software: channels – power – module no. – phase x – power

DH has no sign !

4.4.1.2 3-phase systems

$$P_{3\sim} = P_1 + P_2 + P_3$$

formula 31: P3~

P 3~...total active power of a three-phase system

unit: W (watt)

name in software: P

directory in software: channels – power – module no. – total – power

$$S_{3\sim} = S_1 + S_2 + S_3$$

formula 32: S3~

S 3~...total power of a three-phase system

unit: VA (volt ampere)

name in software: S

directory in software: channels – power – module no. – total – power

$$Q_{3\sim} = \sqrt{S_{3\sim}^2 - P_{3\sim}^2}$$

formula 33: Q3~

Q 3~...total reactive power of a three-phase system

unit: VAr (volt ampere radiant)

name in software: Q

directory in software: channels – power – module no. – total – power

Q has no sign !

$$PF_{3\sim} = \frac{P_{3\sim}}{S_{3\sim}}$$

formula 34: PF3~

PF 3~...total power factor of a three-phase system

unit: 1

name in software: PF

directory in software: channels – power – module no. – total – power

$$S_{1_{3\sim}} = S_{1_1} + S_{1_2} + S_{1_3}$$

formula 35: S1 3~

S 3~...total power of the fundamentals of a three-phase system

unit: VA (volt ampere)

name in software: S_H1

directory in software: channels – power – module no. – total – power

$$P_{1_{3\sim}} = P_{1_1} + P_{1_2} + P_{1_3}$$

formula 36: P1 3~

P 3~...total active power of the fundamentals of a three-phase system

unit: W (watt)

name in software: P_H1

directory in software: channels – power – module no. – total – power

$$\cos \Phi_{i_{3\sim}} = \frac{P_{1_{3\sim}}}{S_{1_{3\sim}}}$$

formula 37: cos Phi 3~

cos Phi 3~...total power factor of the fundamentals of a three-phase system

unit: 1

name in software: cos Phi_H1

directory in software: channels – power – module no. – total – power

$$Q_{1_{3\sim}} = Q_{1_1} + Q_{1_2} + Q_{1_3}$$

formula 38: Q1 3~

Q 3~...total reactive power of the fundamentals of a three-phase system

unit: VAr (volt ampere radiant)

name in software: Q_H1

directory in software: channels – power – module no. – total – power

Q1 has a positive or negative sign

$$D_{3\sim} = \sqrt{Q_{3\sim}^2 - Q_{1_{3\sim}}^2}$$

formula 39: D 3~

D 3~...total distortion power of a three-phase system

unit: VAr (volt ampere radiant)

name in software: D

directory in software: channels – power – module no. – total – power

D has no sign !

$$Q_{H_{3\sim}} = Q_{H_1} + Q_{H_2} + Q_{H_3}$$

formula 40: QH 3~

DH 3~...total reactive power of all harmonics components of a three-phase system

unit: VAr (volt ampere radiant)

name in software: QH

directory in software: channels – power – module no. – total – power

QH has a positive or negative sign

$$D_{H_{3\sim}} = \sqrt{Q_{3\sim}^2 - Q_{H_{3\sim}}^2}$$

formula 41: DH 3~

D 3~...total distortion power of all harmonics components of a three-phase system

where u and i have different harmonic orders

unit: VAr (volt ampere radiant)

name in software: DH

directory in software: channels – power – module no. – total – power

DH has no sign !

4.4.2 Time domain (period values for disturbance calculations)

4.4.2.1 single phase

$$S_{per} = U_{perRMS} * I_{perRMS}$$

formula 42: S per

S per...power

unit: VA (volt ampere)

name in software: S_L1per, S_L2per, S_L3per

directory in software: channels – power – module no. – phase x – period values

$$p_{per}(t) = u(t) * i(t)$$

$$P_{per} = AVG(p_{per}(t))$$

formula 43: P per

P per...active power

unit: W (watt)

name in software: P_L1per, P_L2per, P_L3per

directory in software: channels – power – module no. – phase x – period values

$$Q_{per} = \sqrt{S_{per}^2 - P_{per}^2}$$

formula 44: Q per

Q per...reactive power

unit: VAr (volt ampere radiant)

name in software: Q_L1per, Q_L2per, Q_L3per

directory in software: channels – power – module no. – phase x – period values

$$PF_{per} = P_{per} / S_{per}$$

formula 45: PF per

PF per...power factor

unit: 1

name in software: PF_L1per, PF_L2per, PF_L3per

directory in software: channels – power – module no. – phase x – period

4.4.2.2 3-phase systems

$$U_{3\sim per} = \frac{1}{3} (U_{1perRMS} + U_{2perRMS} + U_{3perRMS})$$

formula 46: U 3~ per

U 3~ per...average of the voltages in a 3 phase system

unit: V (volt)

name in software: U_per

directory in software: channels – power – module no. – total – period values

$$I_{3\sim per} = I_{1perRMS} + I_{2perRMS} + I_{3perRMS}$$

formula 47: I 3~ per

I 3~ per...sum of the currents of a three-phase system

unit: A (ampere)

name in software: I_per

directory in software: channels – power – module no. – total – period values

$$P_{3\sim per} = P_{1perRMS} + P_{2perRMS} + P_{3perRMS}$$

formula 48: P 3~ per

P 3~ per...total active power of a three-phase system

unit: W (watt)

name in software: P_per

directory in software: channels – power – module no. – total – period values

$$S_{3\sim per} = S_{1perRMS} + S_{2perRMS} + S_{3perRMS}$$

formula 49: S 3~ per

S 3~ per...total power of a three-phase system

unit: VA (volt ampere)

name in software: S_per

directory in software: channels – power – module no. – total – period values

$$Q_{3\sim per} = \sqrt{S_{3\sim per}^2 - P_{3\sim per}^2}$$

formula 50: Q 3~ per

Q 3~ per...total reactive power of a three-phase system

unit: VAr (volt ampere radiant)

name in software: Q_per

directory in software: channels – power – module no. – total – period values

Q 3~ per has no sign !

$$PF_{3\sim per} = \frac{P_{3\sim per}}{S_{3\sim per}}$$

formula 51: PF 3~ per

PF 3~ per...total power factor of a three-phase system

unit: 1

name in software: PF_per

directory in software: channels – power – module no. – total – period values

4.5 Symmetrical components

Symmetrical components of U and I

positive, negative and zero systems

4.5.1 voltage

$$a = e^{\frac{j2\pi}{3}}$$

formula 52: complex factor

a...complex factor

$$\underline{U} = U e^{j\phi_U}$$

formula 53: complex RMS value of voltage

$\underline{U}$...complex RMS value of voltage

unit: V (volt)

$$\underline{U}^0 = \frac{1}{3}(\underline{U}_1 + \underline{U}_2 + \underline{U}_3)$$

formula 54: zero component of voltage

$\underline{U}_0$...zero component of the voltage

unit: V (volt)

name in software: U0

directory in software: channels – power – module no. – symmetrical components

$$\underline{U}^1 = \frac{1}{3}(\underline{U}_1 + a\underline{U}_2 + a^2\underline{U}_3)$$

formula 55: positive component of voltage

$\underline{U}_1$...positive component of the voltage

unit: V (volt)

name in software: U1

directory in software: channels – power – module no. – symmetrical components

$$\underline{U}^2 = \frac{1}{3}(\underline{U}_1 + a^2 \underline{U}_2 + a \underline{U}_3)$$

formula 56: negative component of voltage

U2...negative component of the voltage

unit: V (volt)

name in software: U2

directory in software: channels – power – module no. – symmetrical components

$$u_2 = \frac{\underline{U}^2}{\underline{U}^1} * 100\%$$

formula 57: negative sequence component of voltage (former: alpha)

u2...negative sequence component of the voltage

unit: %

name in software: u2

directory in software: channels – power – module no. – symmetrical components

$$u_0 = \frac{\underline{U}^0}{\underline{U}^1} * 100\%$$

formula 58: zero sequence component of voltage

u0...zero sequence component of the voltage

unit: %

name in software: u0

directory in software: channels – power – module no. – symmetrical components

$$u_{2_1} = \frac{\underline{U}1^2}{\underline{U}1^1} * 100\%$$

formula 59: negative sequence component of fundamental voltage

u2_1...negative sequence component of the fundamental oscillation of the voltage

unit: %

name in software: u2_1

directory in software: channels – power – module no. – symmetrical components

$$u_{0_1} = \frac{\underline{U}1^0}{\underline{U}1^1} * 100\%$$

formula 60: zero sequence component of fundamental voltage

u0_1...zero sequence component of the fundamental oscillation of the voltage

unit: %

name in software: u0_1

directory in software: channels – power – module no. – symmetrical components

Additional symmetrical components

a equals L1

b equals L2

c equals L3

When phase voltages and currents are measured, the fundamental's Fourier coefficients are first calculated over one fundamental cycle T (equation shown here only for phase a voltage u_a ;

other phase voltages and current are calculated similarly)

$$u_{a,cos} = \frac{2}{T} \int_{t-T}^t u_a(t) \cos(2\pi f_1 t) dt$$

$$u_{a,sin} = \frac{2}{T} \int_{t-T}^t u_a(t) \sin(2\pi f_1 t) dt$$

where f_1 is the frequency of the fundamental.

Phase currents ($i_{a,cos}$, $i_{b,cos}$, $i_{c,cos}$ and $i_{a,sin}$, $i_{b,sin}$, $i_{c,sin}$) are calculated in the same way.

$$u_{1-cos} = 1/6 [2u_{a,cos} - u_{b,cos} - u_{c,cos} + \sqrt{3} * (u_{c,sin} - u_{b,sin})]$$

formula 61: negative sequence component of fundamental negative sequence

U_an_cos_per...negative sequence component of the fundamental negative sequence
unit: V

name in software: U_an_cos_per

directory in software: channels – power – module no. – symmetrical components

$$u_{1-sin} = 1/6 [2u_{a,sin} - u_{b,sin} - u_{c,sin} + \sqrt{3} * (u_{b,cos} - u_{c,cos})]$$

formula 62: negative sequence component of fundamental negative sequence

U_an_sin_per...negative sequence component of the fundamental negative sequence
unit: V

name in software: U_an_sin_per

directory in software: channels – power – module no. – symmetrical components

$$U_{1+} = \sqrt{\frac{3}{2} * (U_{1+sin}^2 + U_{1+cos}^2)}$$

formula 63: periodic calculated Voltage of positive sequence

U_1p_per...periodic calculated Voltage of positive sequence

unit: V

name in software: U_1p_per

directory in software: channels – power – module no. – symmetrical components

$$U_{1-} = \sqrt{3/2(u_{1-,sin}^2 + u_{1-,cos}^2)}$$

formula 64: Effective phase-to-phase voltage U_{1-} of the fundamental negative sequence

U_1n_per...Effective phase-to-phase voltage U_{1-} of the fundamental negative sequence

unit: V

name in software: U_1n_per

directory in software: channels – power – module no. – symmetrical components

$$u_{10cos} = 1/3[u_{a,cos} + u_{b,cos} + u_{c,cos}]$$

formula 65: zero sequence component of fundamental zero sequence

U_az_cos_per...zero sequence component of the fundamental zero sequence

unit: V

name in software: U_az_cos_per

directory in software: channels – power – module no. – symmetrical components

$$u_{10sin} = 1/3[u_{a,sin} + u_{b,sin} + u_{c,sin}]$$

formula 66: zero sequence component of fundamental zero sequence

U_az_sin_per...zero sequence component of the fundamental zero sequence

unit: V

name in software: U_az_sin_per

directory in software: channels – power – module no. – symmetrical components

$$U_{10} = \sqrt{3/2(u_{10,\sin}^2 + u_{10,\cos}^2)}$$

formula 67: Effective phase-to-phase voltage U_{10} of the fundamental zero sequence

U_1z_per...Effective phase-to-phase voltage U_{10} of the fundamental zero sequence

unit: V

name in software: U_1z_per

directory in software: channels – power – module no. – symmetrical components

4.5.2 current

$$\underline{I} = I e^{j\varphi_i}$$

formula 68: complex RMS value of current

I...complex RMS value of current

unit: A (ampere)

$$\underline{I}^0 = \frac{1}{3}(\underline{I}_1 + \underline{I}_2 + \underline{I}_3)$$

formula 69: zero component of current

I0...zero component of the current

unit: A (ampere)

name in software: I0

directory in software: channels – power – module no. – symmetrical components

$$\underline{I}^1 = \frac{1}{3}(\underline{I}_1 + a\underline{I}_2 + a^2\underline{I}_3)$$

formula 70: positive component of current

I1...positive component of the current

unit: A (ampere)

name in software: I1

directory in software: channels – power – module no. – symmetrical components

$$\underline{I}^2 = \frac{1}{3}(\underline{I}_1 + a^2\underline{I}_2 + a\underline{I}_3)$$

formula 71: negative component of current

I2...negative component of the current

unit: A (ampere)

name in software: I2

directory in software: channels – power – module no. – symmetrical components

$$i_2 = \frac{\underline{I}^2}{\underline{I}^1} * 100\%$$

formula 72: negative sequence component of current

i2...negative sequence component of the current

unit: %

name in software: i2

directory in software: channels – power – module no. – symmetrical components

$$i_0 = \frac{I^0}{I^1} * 100\%$$

formula 73: zero sequence component of current

i0...zero sequence component of the current

unit: %

name in software: i0

directory in software: channels – power – module no. – symmetrical components

$$i_{2_1} = \frac{I1^2}{I1^1} * 100\%$$

formula 74: negative sequence component of fundamental current

i2_1...negative sequence component of the fundamental oscillation of the current

unit: %

name in software: i2_1

directory in software: channels – power – module no. – symmetrical components

$$i_{0_1} = \frac{I1^0}{I1^1} * 100\%$$

formula 75: zero sequence component of fundamental current

i0_1...zero sequence component of the fundamental oscillation of the current

unit: %

name in software: i0_1

directory in software: channels – power – module no. – symmetrical components

Additional symmetrical components

a equals L1

b equals L2

c equals L3

$$i_{1-cos} = 1/6 [2i_{a,cos} - i_{b,cos} - i_{c,cos} + \sqrt{3} * (i_{c,sin} - i_{b,sin})]$$

formula 76: negativ sequence current component of the fundamental negativ sequence

I_an_cos_per...negative sequence current component of the fundamental negative sequence

unit: A

name in software: I_an_cos_per

directory in software: channels – power – module no. – symmetrical components

$$i_{1-sin} = 1/6 [2i_{a,sin} - i_{b,sin} - i_{c,sin} + \sqrt{3} * (i_{b,cos} - i_{c,cos})]$$

formula 77: negativ sequence current component of the fundamental negativ sequence

I_an_sin_per...negative sequence current component of the fundamental negative sequence

unit: A

name in software: I_an_sin_per

directory in software: channels – power – module no. – symmetrical components

$$i_{10cos} = 1/3 [i_{a,cos} + i_{b,cos} + i_{c,cos}]$$

formula 78: zero sequence current component of the fundamental zero sequence

I_az_cos_per...zero sequence current component of the fundamental zero sequence

unit: A

name in software: I_az_cos_per

directory in software: channels – power – module no. – symmetrical components

$$i_{10sin} = 1/3 [i_{a,sin} + i_{b,sin} + i_{c,sin}]$$

formula 79: zero sequence current component of the fundamental zero sequence

I_az_sin_per...zero sequence current component of the fundamental zero sequence

unit: A

name in software: I_az_sin_per

directory in software: channels – power – module no. – symmetrical components

$$i_{1+} = \frac{S_{1+}}{(\sqrt{3} * U_{1+})}$$

formula 80: positive sequence current calculated periodic

I_1p_per...positive sequence current calculated periodic

unit: A

name in software: I_1p_per

directory in software: channels – power – module no. – symmetrical components

$$I_{P1+} = \frac{P_{1+}}{\sqrt{3}U_{1+}}$$

formula 81: positive sequence active current calculated periodic

I_p1p_per...positive sequence active current calculated periodic

unit: A

name in software: I_p1p_per

directory in software: channels – power – module no. – symmetrical components

$$I_{Q1+} = \frac{Q_{1+}}{\sqrt{3}U_{1+}}$$

formula 82: positive sequence reactive current calculated periodic

I_q1p_per...positive sequence reactive current calculated periodic

unit: A

name in software: I_q1p_per

directory in software: channels – power – module no. – symmetrical components

4.5.3 power

To be read together with Annex C of IEC 61400-21.

$$P_{1+} = \frac{3}{2} (u_{1+,cos} i_{1+,cos} - u_{1+,sin} i_{1+,sin})$$

formula 83: Active power (positive sequence)

P_1p_per...Active power positive sequence

unit: W

name in software: P_1p_per

directory in software: channels – power – module no. – symmetrical components

$$Q_{1+} = \frac{3}{2} (u_{1+,cos} i_{1+,sin} - u_{1+,sin} i_{1+,cos})$$

formula 84: Reactive power (positive sequence)

Q_1p_per...Active power positive sequence

unit: VAR

name in software: Q_1p_per

directory in software: channels – power – module no. – symmetrical components

$$S_{1+} = \sqrt{P_{1+}^2 + Q_{1+}^2}$$

formula 85: Apparent power (positiv sequence)

S_1p_per...Apparent power positive sequence

unit: VA

name in software: S_1p_per

directory in software: channels – power – module no. – symmetrical components

$$\cos \varphi_{1+} = \frac{P_{1+}}{\sqrt{P_{1+}^2 + Q_{1+}^2}}$$

formula 86: power factor (fundamental positive sequence)

cos_phi_1p_per ... power factor (fundamental positive sequence)

unit: -

name in software: cos_phi_1p_per

directory in software: channels – power – module no. – symmetrical components

$$P_{1-} = \frac{3}{2} * (u_{1-,cos} * i_{1-,cos} + u_{1-,sin} * i_{1-,sin})$$

formula 87: Active power (negative sequence)

P_1n_per...Active power negative sequence

unit: W

name in software:P_1n_per

directory in software: channels – power – module no. – symmetrical components

$$Q_{1-} = \frac{3}{2} * (u_{1-,cos} * i_{1-,sin} - u_{1-,sin} * i_{1-,cos})$$

formula 88: Reactive power (negative sequence)

Q_1n_per...Active power negative sequence

unit: VAr

name in software:Q_1n_per

directory in software: channels – power – module no. – symmetrical components

$$S_{1-} = \sqrt{P_{1-}^2 + Q_{1-}^2}$$

formula 89: Apparent power (negative sequence)

S_1n_per...Active power negative sequence

unit: VA

name in software:S_1n_per

directory in software: channels – power – module no. – symmetrical components

$$P_{10} = \frac{3}{2} * (u_{10,cos} * i_{10,cos} + u_{10,sin} * i_{10,sin})$$

formula 90: Active power (zero sequence)

P_1z_per...Active power zero sequence

unit: W

name in software:P_1z_per

directory in software: channels – power – module no. – symmetrical components

$$Q_{10} = \frac{3}{2} * (u_{10,cos} * i_{10,sin} - u_{10,sin} * i_{10,cos})$$

formula 91: Reactive power (zero sequence)

Q_1z_per...Reactive power zero sequence

unit: VAR

name in software:Q_1z_per

directory in software: channels – power – module no. – symmetrical components

$$S_{10} = \sqrt{P_{10}^2 + Q_{10}^2}$$

formula 92: Apparent power (zero sequence)

S_1z_per...Apparent power zero sequence

unit: VA

name in software:S_1z_per

directory in software: channels – power – module no. – symmetrical components

4.6 Additional FFT values

THD for U and I, even and odd

4.6.1 voltage

$$THD_U = \sqrt{\sum_{h=2}^n \left(\frac{U_h}{U_1} \right)^2}$$

formula 93: THD U

THD U...total harmonic distortion of the voltage

unit: %

name in software: THD_U_L1, THD_U_L2, THD_U_L3

directory in software: channels – power – module no. – phase x – THD

n...number of harmonics (typical: 40)

U1...fundamental of the voltage

h...harmonic order

$$THD_{U_{even}} = \sqrt{\sum_{h=1}^n \left(\frac{U_{2h}}{U_1} \right)^2}$$

formula 94: THD U even

THD U even...total harmonic distortion of the voltage for even harmonics

unit: %

name in software: THDEven_U_L1, THDEven_U_L2, THDEven_U_L3

directory in software: channels – power – module no. – phase x – THD

$$THD_{U_{odd}} = \sqrt{\sum_{h=1}^n \left(\frac{U_{2h+1}}{U_1} \right)^2}$$

formula 95: THD U odd

THD U...total harmonic distortion of the voltage for odd harmonics

unit: %

name in software: THDOdd_U_L1, THDOdd_U_L2, THDOdd_U_L3

directory in software: channels – power – module no. – phase x – THD

4.6.2 current

$$THD_I = \sqrt{\sum_{h=2}^n \left(\frac{I_h}{I_1} \right)^2}$$

formula 96: THD I

THD I...total harmonic distortion of the current

unit: %

name in software: THD_I_L1, THD_I_L2, THD_I_L3

directory in software: channels – power – module no. – phase x – THD

n...number of harmonics (typical: 40)

I1...fundamental of the current

h...harmonic order

$$THD_{I_{even}} = \sqrt{\sum_{h=1}^n \left(\frac{I_{2h}}{I_1} \right)^2}$$

formula 97: THD I even

THD I even...total harmonic distortion of the current for even harmonics

unit: %

name in software: THDEven_I_L1, THDEven_I_L2, THDEven_I_L3

directory in software: channels – power – module no. – phase x – THD

$$THD_{I_{odd}} = \sqrt{\sum_{h=1}^n \left(\frac{I_{2h+1}}{I_1} \right)^2}$$

formula 98: THD I odd

THD I...total harmonic distortion of the current for odd harmonics

unit: %

name in software: THDOdd_I_L1, THDOdd_I_L2, THDOdd_I_L3

directory in software: channels – power – module no. – phase x – THD

4.7 Impedances

$$Z = \frac{U}{I}$$

formula 99: Z

Z...impedance for total waveform

unit: Ohm

name in software: Z_L1

directory in software: channels – power – module no. – phase x – impedances

$$Z_h = \frac{U_h}{I_h}$$

formula 100: Zh

Zh...impedance of harmonic h

unit: Ohm

name in software: Z_L1_H1, Z_L1_H2,...

directory in software: channels – power – module no. – phase x – impedances

4.8 Literature

1. Power Quality – the new challenge; Schoeffler W, Gredler P, Gabbauer A.; Dewetron; 2002
2. IEC 61000-4-7
3. IEC 61000-4-15
4. IEC 61000-4-30
5. Wechselströme und Netzwerke; W. Leonhard; Vieweg
6. Ein Beitrag zur Erfassung und Weiterverarbeitung von Oberschwingungsdaten in elektrischen Energiesystemen mittels Prozessrechner; R. Laufen; Westdeutscher Verlag
7. Leistungsmessung bei einphasigen Stromrichterantrieben; F. Holzmann, G. Pauer; Westdeutscher Verlag
8. Leistungselektronik – Messtechnik; Lappe, Fischer; Verlag Technik; 2. Auflage; 1993
9. Leistungselektronik; K. Bystron; Hanser
10. Messungen in Netzen der elektrischen Energietechnik; H. Karger; PIA
11. Skriptum Elektrische Messtechnik 1; TU Graz; 1988