DEWETRON

OXYGEN TRAINING
> POWER

CONTENT

DEWETRON

GENERAL FEATURES

DEWETRON

Benefits of a DEWTRON POWER ANALYZER

- Full flexible input configuration
- Simple setup within seconds
- Individual phase groups (up to 9 phases per PowerGroup)
- Free selectable sync channel
- Unlimited recording (only limited by harddisk space)

Type	Hardware	Bandwitdh	Samplerate	Phasecount
DEWE3-PA8	TRION3-1810M-POWER-4	5 MHz	10 MS/s	16
DEWE2-PA7	TRION-1820-POWER-4	5 MHz	2 MS/s	12
DEWE2-A7	TRION-1820-POWER-4	5 MHz	2 MS/s	12
DEWE2-A4L	TRION-1820-POWER-4	5 MHz	2 MS/s	8

In addition to the great measurement functions of OXYGEN, the POWER-Option enables the detailed analysis of the phase values and total values in L-N configuration (each total and fundamental):

- Voltage (RMS, AVG, PHI, Peak-Peak) → OPT-POWER-BASIC
- Current (RMS, AVG, PHI, Peak-Peak) → OPT-POWER-BASIC
- Active Power (AVG, PHI) → OPT-POWER-BASIC
- Reactive Power (AVG) → OPT-POWER-BASIC
- Apparent Power (AVG) → OPT-POWER-BASIC
- Power Factor (AVG) → OPT-POWER-BASIC
- Fundamental Frequency (0.2 – 200 kHz) → OPT-POWER-BASIC
- Harmonics (up to 1000th order) → OPT-POWER-ADV
- Interharmonic (up to 1000.5th order) → OPT-POWER-ADV
- Higher Frequencies (2-9 kHz Grouping) → OPT-POWER-ADV
- Voltage Fluctuation → OPT-POWER-ADV
- Flicker Emission → OPT-POWER-ADV
- Mechanical Power Computation → OPT-POWER-ADV
- Rolling Computations → OPT-POWER-EXP

CREATING A POWER GROUP

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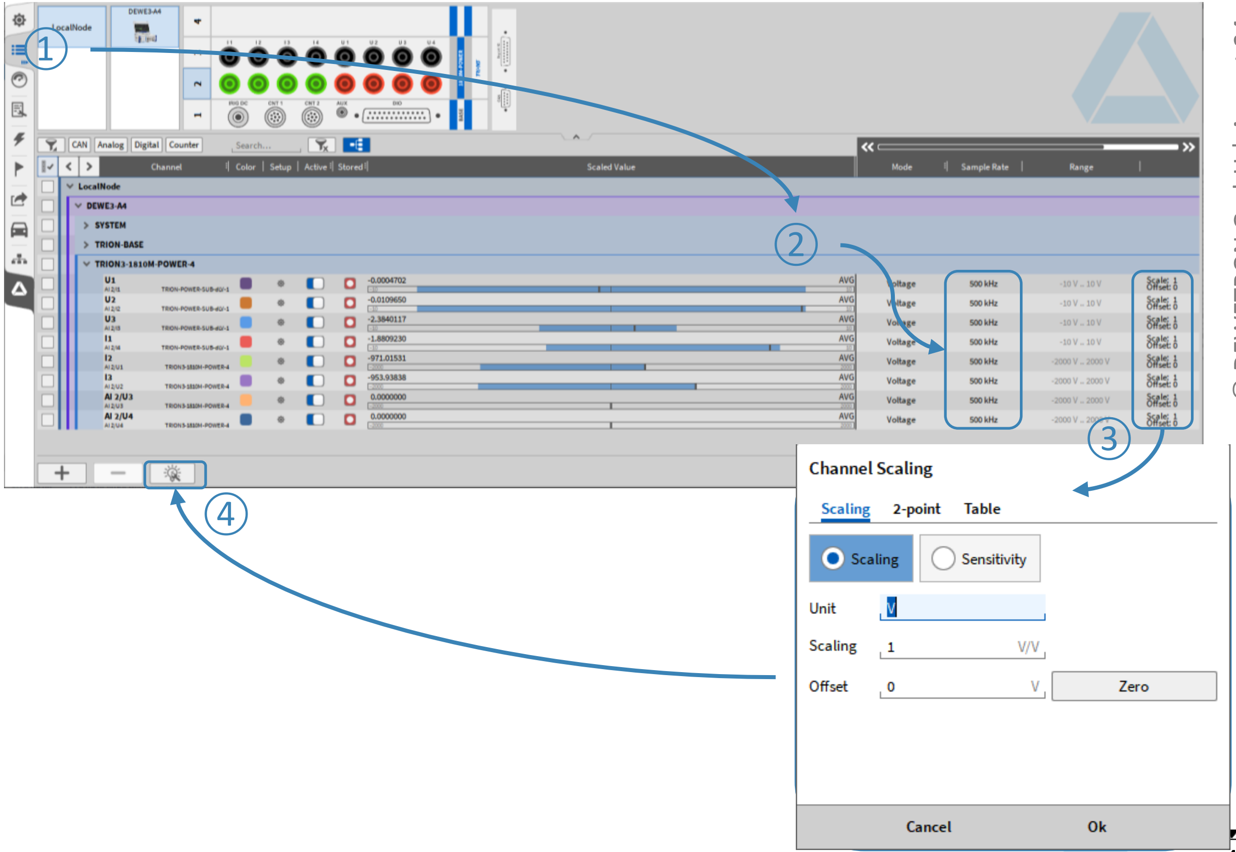
①	Open the Channel List
②	Select the desired Sample Rate (min. 10 kHz, calculation disabled below)
③	If current transducers are used, open the scaling menu of the current channel and enter the scaling factor
④	Press the *Add Power Group* button



POWER GROUP SETTINGS – WIRING TYPE

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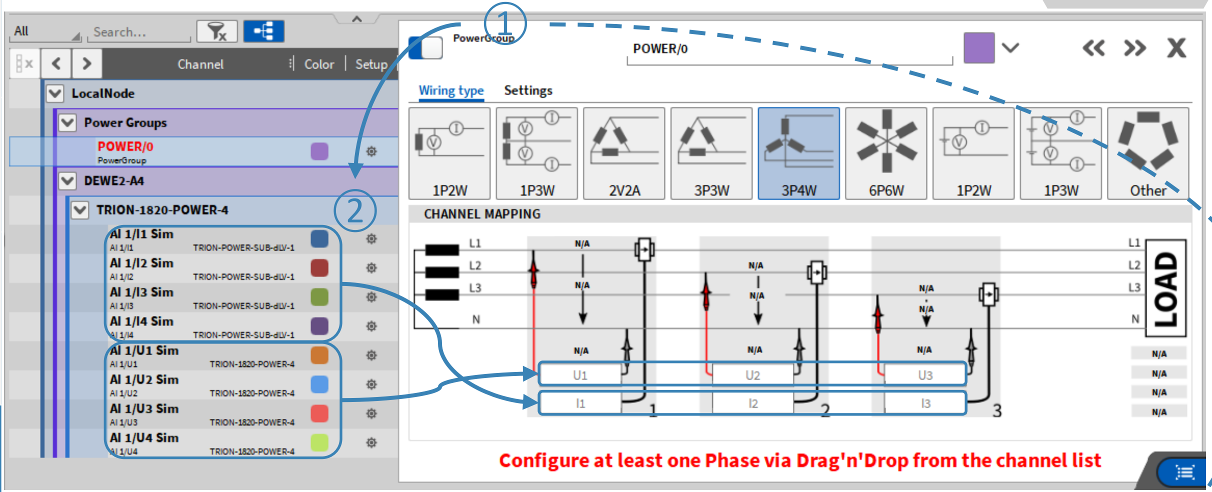
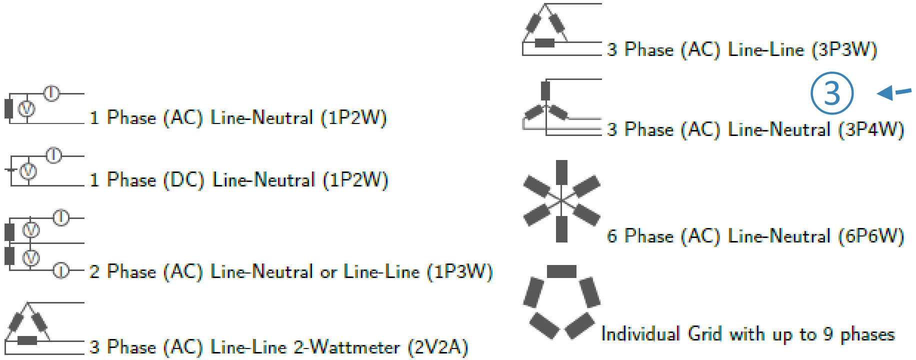
①	Select the correct Wiring type of the DUT Wiring schematics below will demonstrate the individual wiring
②	Assign the current and voltage channels from the Channel List to the Power Group via drag and drop
③	Overview of the predefined schematics available here; Additional information and connection schemes can be found in the manuals





CREATING A POWER GROUP

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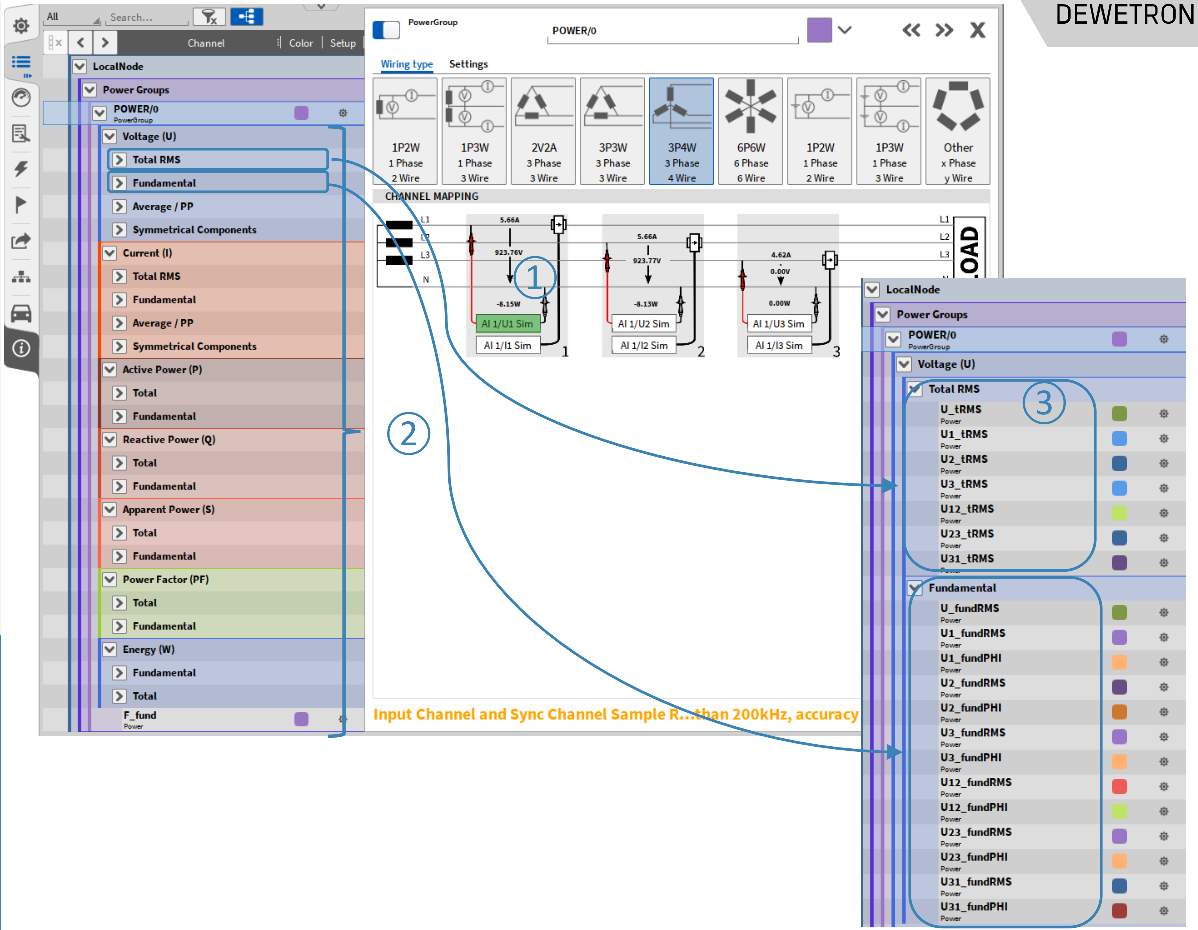
①	After drag and dropping all channels into the schematics, a value preview will be available
②	The calculated power values will be automatically added as separate channels to the Channel List
③	Single channel‘s phase values and total values in L-N configuration can be accessed by further expanding the Channel List; Listed channels will depend on the Wiring type
	Creation of several and different Power Groups in one setup supported



POWER GROUP SYNC SETTINGS

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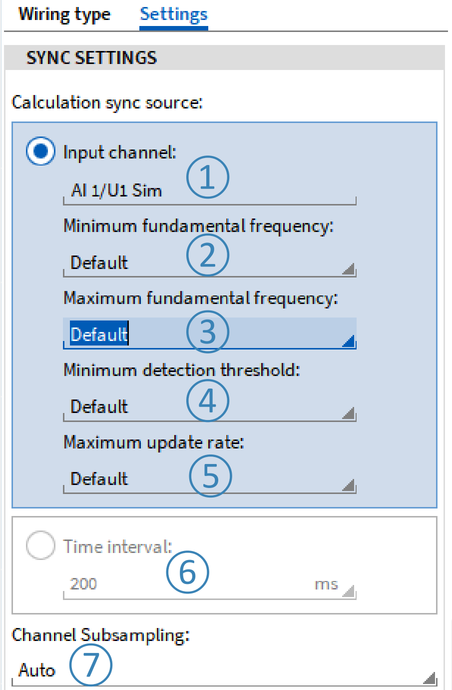
1	Synchronization Channel for fundamental frequency detection; Freely definable, per Default Voltage of Phase 1
2	Minimum fundamental frequency input field (0.2 Hz - f_{max})
3	Maximum fundamental frequency input field (f_{min} – 0.1*SR [Hz])
4	Threshold of the amplitude of the synchronization channel that needs to be exeeded for fundamental frequency detection, per default >0.1%
5	Maximum update rate of the output channels, 1ms per default; 1 … 5000 ms
6	For DC applications, Update rate for power calculations
7	Subsampling factor selection for calculation load reduction



Samplerate	Subsampling Factor
<= 2 MS/s	1 (= no Subsampling)
> 2MS/s - 4 MS/s	2
> 4MS/s - 6 MS/s	3
> 6MS/s - 8 MS/s	4
> 8MS/s	5

Samplerate	Minimum Fundamental
< 10 kHz	None
10 kHz - 20 kHz	0.2 Hz
20 kHz - 1 MHz	0.2 Hz
1 MHz - 2 MHz	0.5 Hz
2 MHz - 4 MHz	1 Hz
> 5 MHz	2 Hz

Minimum fundamental frequency

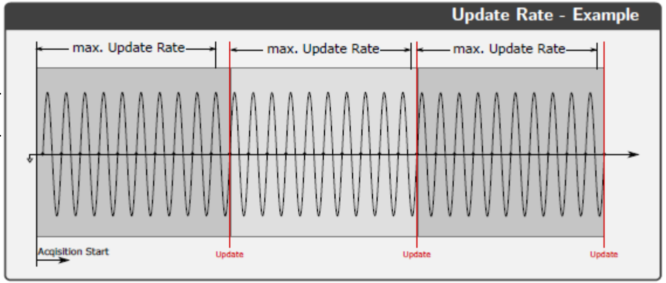
This input field holds the setting for the minimum fundamental frequency in Hz which can be measured (lower limit). The following settings are available:

- **Default:** Standard setting, uses 0.2 Hz internally (up to 1MS/s) and >0.5 Hz above. The actual value is the lower bound of the F_fund channel range.
- **0.2 .. f_max Hz:** User defined setting, the possible range is between Default and 100 Hz.

Maximum fundamental frequency

This input field holds the setting for the maximum fundamental frequency in Hz which can be measured (upper limit) The following settings are available:

- **Default:** Standard setting, uses 1500 Hz internally (>20 kS/s). The actual value is the upper bound of the F_fund channel range.
- **Auto:** Uses 1/10 of Samplerate
- **f_min .. Samplerate/10 Hz:** User defined setting, the possible range is between f_min and 1/10 of Samplerate.



DATA VISUALIZATION

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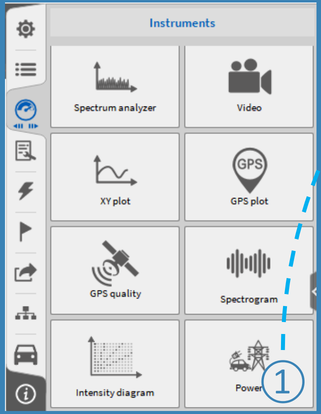
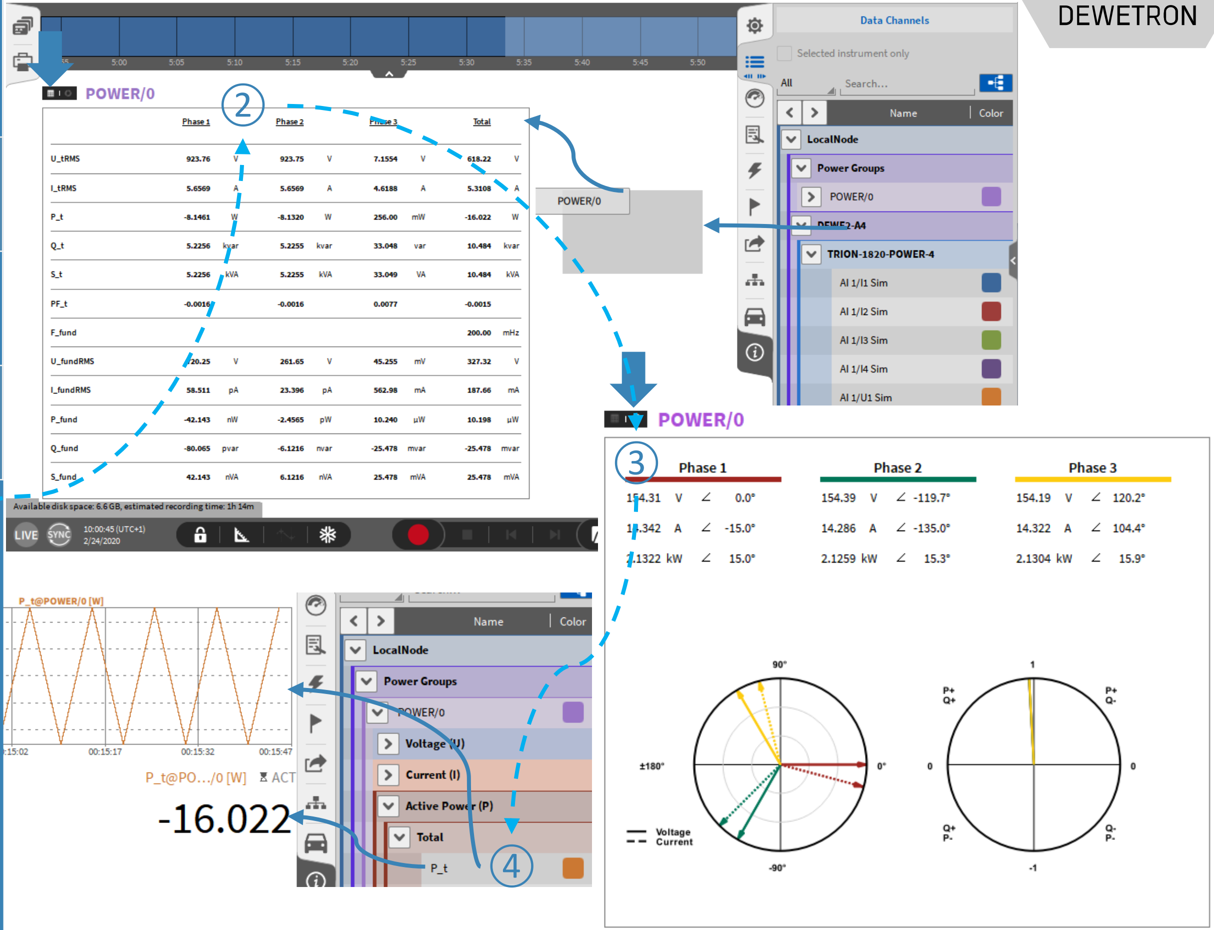
①	Power instrument for general data overview
②	Drag and drop Power group to the instrument to get an RMS value overview
③	Or a vectoral visualisation of the voltages and currents
④	All Power channels can be added to others displays like Recorders or Meters





HARMONICS

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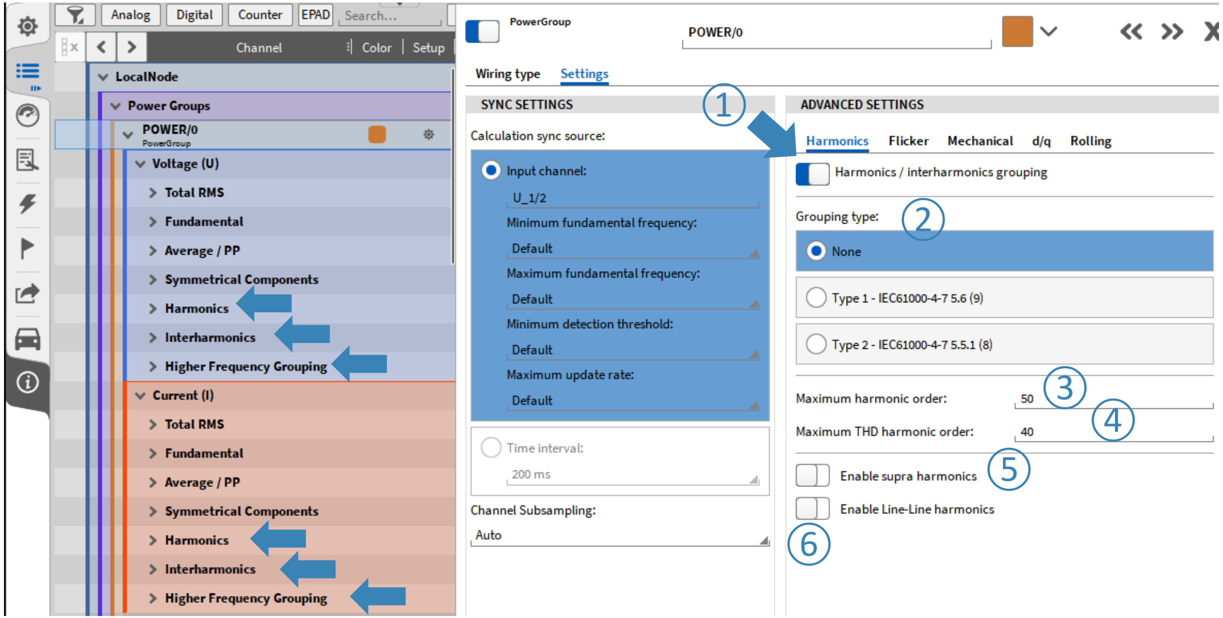
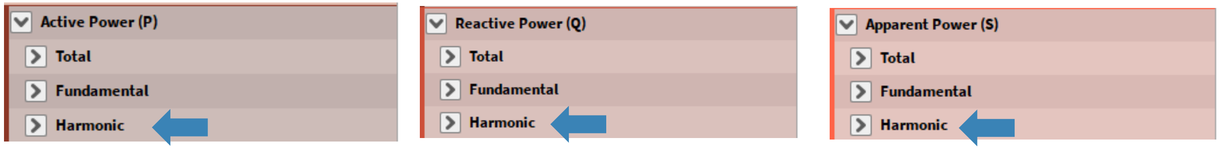
①	Enable Harmonics calculation
②	Select a harmonics grouping type
③	Specify the maximum harmonics order 1 … 1000; Default: 50
④	Specify the maximum THD harmonics order; 1 … 1000; Default: 40
⑤	Optionally enable supra harmonics
⑥	Optionally enable calculation of Voltage Line-Line Harmonics & THD



OXY-OPT-POWER-ADV required

- Harmonics from 0 to 1000thorder
- Interharmonics from 0.5 to 49th order
- Higher Frequencies from 2 to 9 kHz
- Supraharmonics from 8 to 150 kHz
- Calculations comply with IEC 61000 4-7



HARMONICS VISUALIZATION

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①	Additional window in the Power Instrument for Harmonics
②	Higher frequencies can be enabled in instrument settings
③	Cursors can be enabled in instrument settings
④	Harmonics can be displayed phase-wise

HARMONICS VISUALIZATION CONT'D

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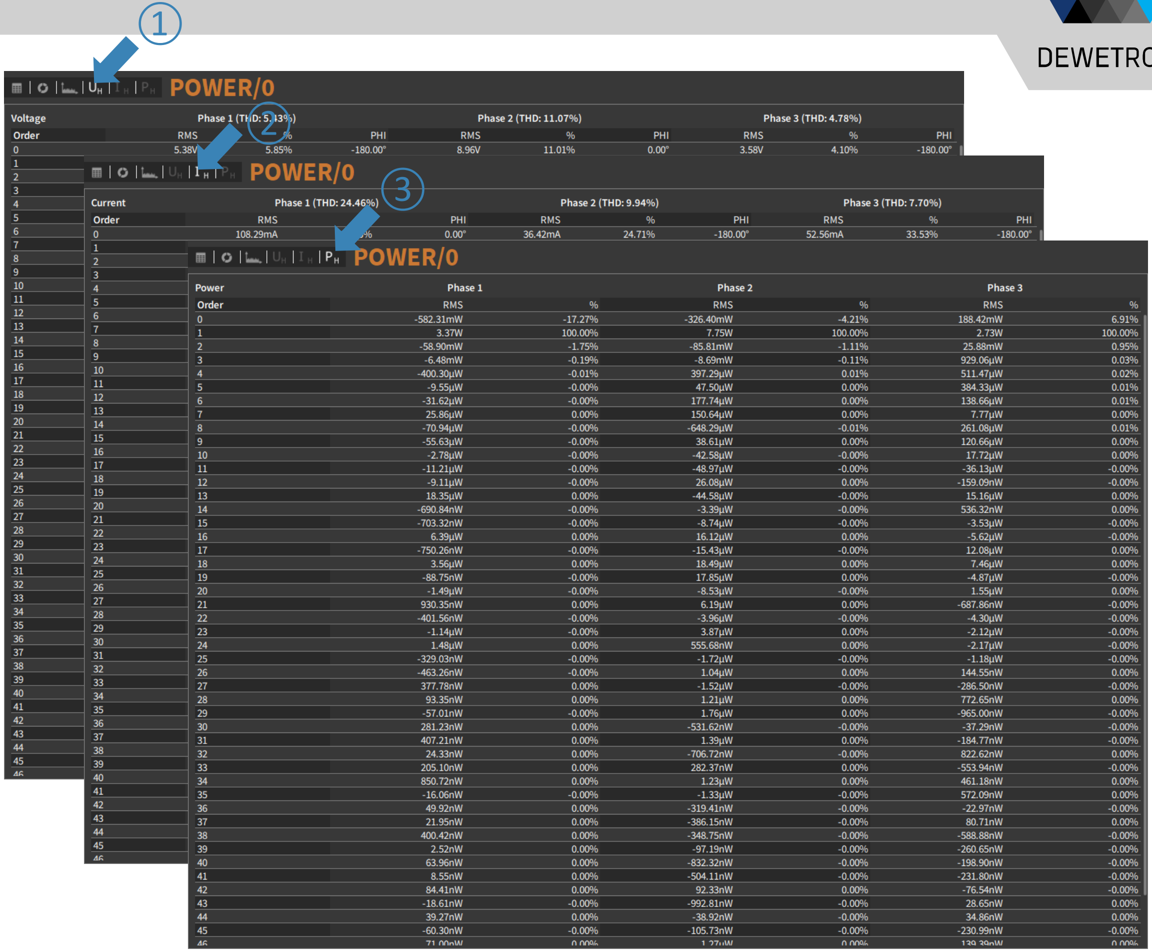
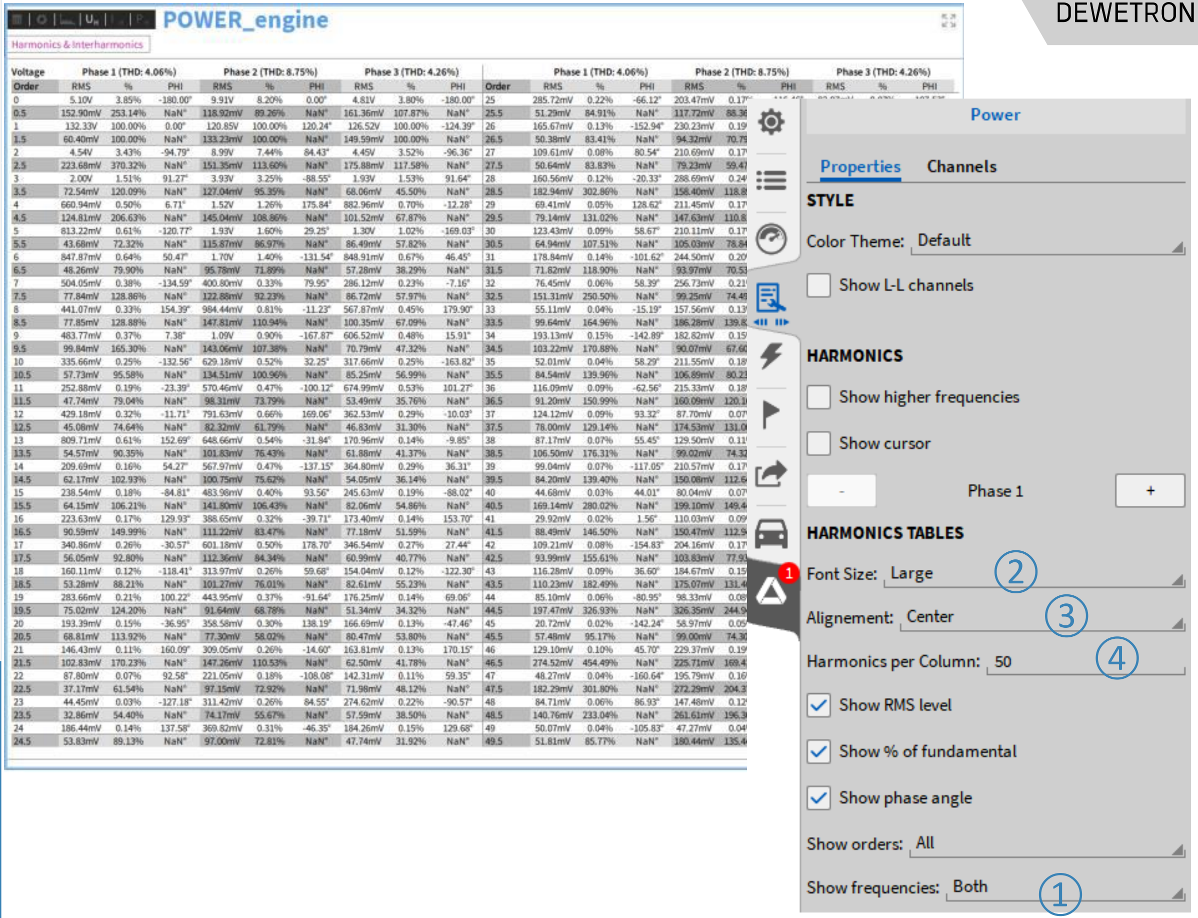
①	Voltage Harmonics table included in Power Instrument
②	Current Harmonics table included in Power Instrument
③	Power Harmonics table included in Power Instrument



Power	Phase 1		Phase 2		Phase 3	
Order	RMS	%	RMS	%	RMS	%
0	-582.31mW	-17.27%	-326.40mW	-4.21%	188.42mW	6.91%
1	3.37W	100.00%	7.75W	100.00%	2.73W	100.00%
2	-58.90mW	-1.75%	-85.81mW	-1.11%	25.88mW	0.95%
3	-6.48mW	-0.19%	-8.69mW	-0.11%	929.06µW	0.03%
4	-400.30µW	-0.01%	397.29µW	0.01%	511.47µW	0.02%
5	-9.55µW	-0.00%	47.50µW	0.00%	384.33µW	0.01%
6	-31.62µW	-0.00%	177.74µW	0.00%	138.66µW	0.01%
7	25.86µW	0.00%	150.64µW	0.00%	7.77µW	0.00%
8	-70.94µW	-0.00%	-648.29µW	-0.01%	261.08µW	0.01%
9	-55.63µW	-0.00%	38.61µW	0.00%	120.66µW	0.00%
10	-2.78µW	-0.00%	-42.58µW	-0.00%	17.72µW	0.00%
11	-11.21µW	-0.00%	-48.97µW	-0.00%	-36.13µW	-0.00%
12	-9.11µW	-0.00%	26.08µW	0.00%	-159.09nW	-0.00%
13	18.35µW	0.00%	-44.58µW	-0.00%	15.16µW	0.00%
14	-690.84nW	-0.00%	-3.39µW	-0.00%	536.32nW	0.00%
15	-703.32nW	-0.00%	-8.74µW	-0.00%	-3.53µW	-0.00%
16	6.39µW	0.00%	16.12µW	0.00%	-5.62µW	-0.00%
17	-750.26nW	-0.00%	-15.43µW	-0.00%	12.08µW	0.00%
18	3.56µW	0.00%	18.49µW	0.00%	7.46µW	0.00%
19	-88.75nW	-0.00%	17.85µW	0.00%	-4.87µW	-0.00%
20	-1.49µW	-0.00%	-8.53µW	-0.00%	1.55µW	0.00%
21	930.35nW	0.00%	6.19µW	0.00%	-687.86nW	-0.00%
22	-401.56nW	-0.00%	-3.96µW	-0.00%	-4.30µW	-0.00%
23	-1.14µW	-0.00%	3.87µW	0.00%	-2.12µW	-0.00%
24	1.48µW	0.00%	555.68nW	0.00%	-2.17µW	-0.00%
25	-329.03nW	-0.00%	-1.72µW	-0.00%	-1.18µW	-0.00%
26	-463.26nW	-0.00%	1.04µW	0.00%	144.55nW	0.00%
27	377.78nW	0.00%	-1.52µW	-0.00%	-286.50nW	-0.00%
28	93.35nW	0.00%	1.21µW	0.00%	772.65nW	0.00%
29	-57.01nW	-0.00%	1.76µW	0.00%	-965.00nW	-0.00%
30	281.23nW	0.00%	-531.62nW	-0.00%	-37.29nW	-0.00%
31	407.21nW	0.00%	1.39µW	0.00%	-184.77nW	-0.00%
32	24.33nW	0.00%	-706.72nW	-0.00%	822.62nW	0.00%
33	205.10nW	0.00%	282.37nW	0.00%	-553.94nW	-0.00%
34	850.72nW	0.00%	1.23µW	0.00%	461.18nW	0.00%
35	-16.06nW	-0.00%	-1.33µW	-0.00%	572.09nW	0.00%
36	49.92nW	0.00%	-319.41nW	-0.00%	-22.97nW	-0.00%
37	21.95nW	0.00%	-386.15nW	-0.00%	80.71nW	0.00%
38	400.42nW	0.00%	-348.75nW	-0.00%	-588.88nW	-0.00%
39	2.52nW	0.00%	-97.19nW	-0.00%	-260.65nW	-0.00%
40	63.96nW	0.00%	-832.32nW	-0.00%	-198.90nW	-0.00%
41	8.55nW	0.00%	-504.11nW	-0.00%	-231.80nW	-0.00%
42	84.41nW	0.00%	92.33nW	0.00%	-76.54nW	-0.00%
43	-18.61nW	-0.00%	-992.81nW	-0.00%	28.65nW	0.00%
44	39.27nW	0.00%	-38.92nW	-0.00%	34.86nW	0.00%
45	-60.30nW	-0.00%	-105.73nW	-0.00%	-230.99nW	-0.00%
46	71.00nW	0.00%	1.27µW	0.00%	139.39nW	0.00%

HARMONICS VISUALIZATION CONT’D

	The harmonics tabs have several property options. One useful is to define the maximum orders shown in one column at ④
①	Possibility to display Harmonics, Interharmonics, or both in Power Instrument
②	Possibility to change font size
③	Possibility to align text to left, right, center
④	Option to define maximum number of lines per column and to split view into several columns



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HARMONICS VISUALIZATION CONT'D

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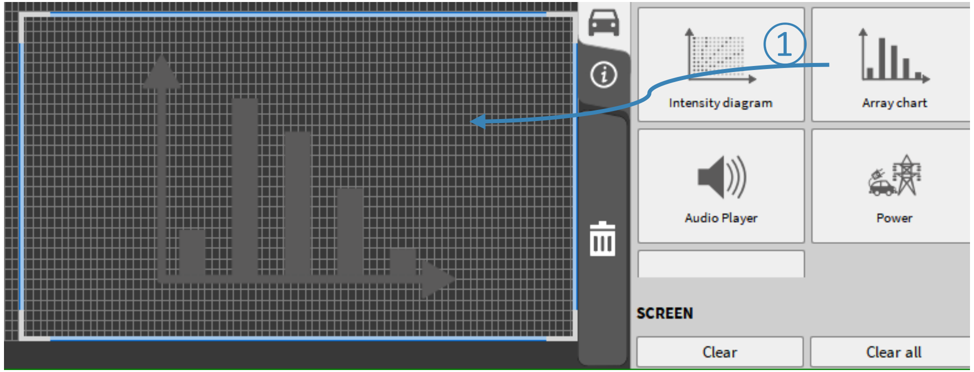
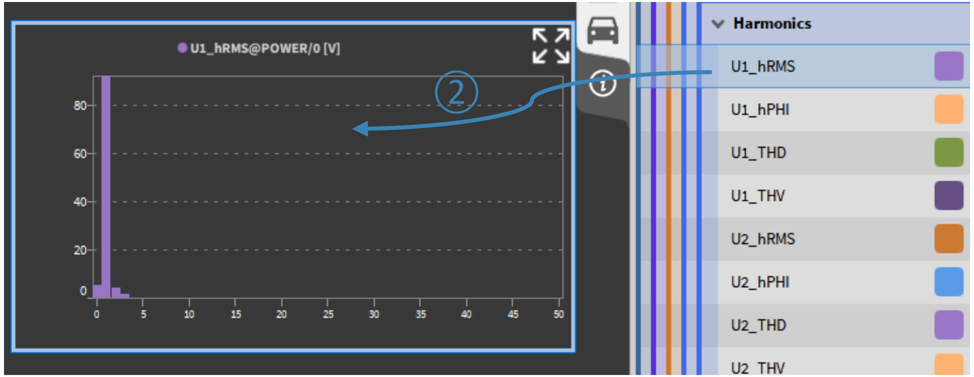
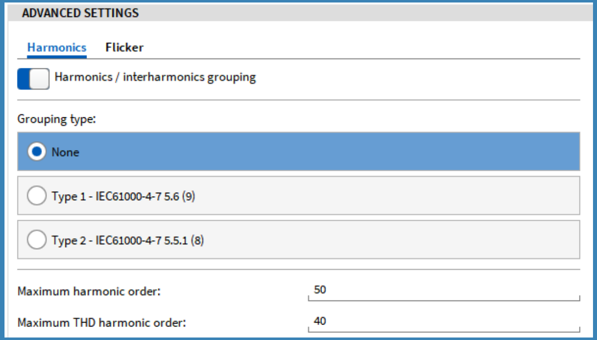
①	Drag and drop the Aray Chart to the screen…
②	…and assign any Harmonics channel Supports: - Harmonics - Interharmonics - Higher Frequency Groupings - Supraharmoncis





GROUPING MODE - *NONE*

DEWETRON

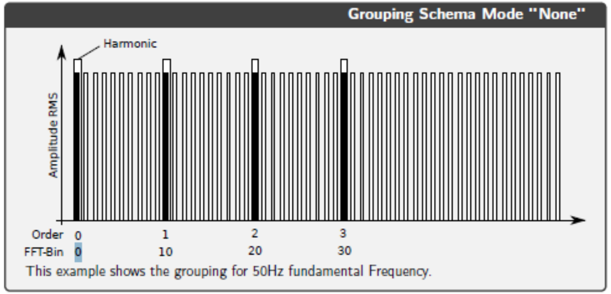


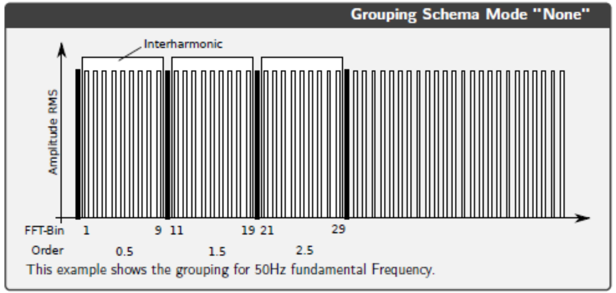
Symbol	Description
Y_c	RMS Magnitude of FFT-Bin
Y_h	RMS Magnitude of Harmonic Order h (Grouping "None")
$Y_{sg,h}$	RMS Magnitude of Harmonic Order h (Grouping "Type 1")
$Y_{g,h}$	RMS Magnitude of Harmonic Order h (Grouping "Type 2")
NP	Number of fundamental Periods
h	Harmonic Order

- When this mode is selected, only the harmonic bins are taken for generation of the harmonic data. $Y_h = Y_c[NP \cdot h]$
- When this mode is selected, all bins (except of harmonic bin) are taken for generation of the interharmonic data.

$$Y_{ih} = NaN \qquad NP = 1$$

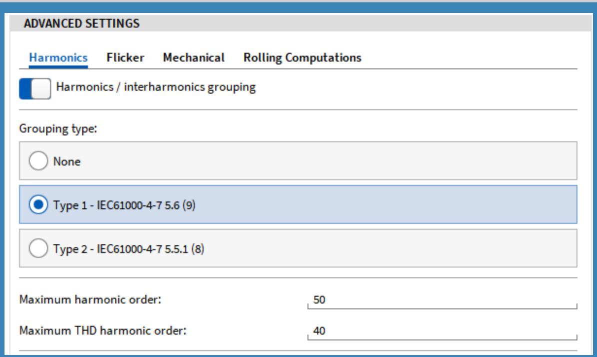
$$Y_{ih} = \sqrt{\sum_{k=1}^{N-1} Y_c\,[NP \cdot h + k]^2} \qquad NP > 1$$





GROUPING MODE - *TYPE 1 – IEC61000-4-7-5.6*

DEWETRON



Symbol	Description
Y_c	RMS Magnitude of FFT-Bin
Y_h	RMS Magnitude of Harmonic Order h (Grouping "None")
$Y_{sg,h}$	RMS Magnitude of Harmonic Order h (Grouping "Type 1")
$Y_{g,h}$	RMS Magnitude of Harmonic Order h (Grouping "Type 2")
NP	Number of fundamental Periods
h	Harmonic Order

- When this mode is selected, the harmonics are grouped according to IEC61000-4-7 Section 5.6

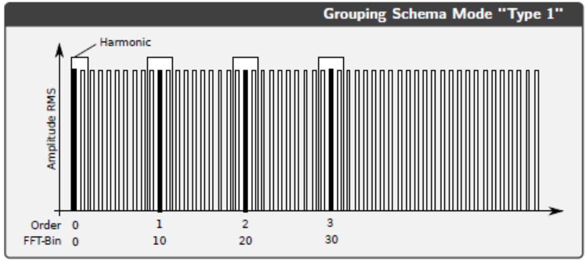
$$Y_{sg,h} = Y_c[NP \cdot h] \qquad NP < 2$$

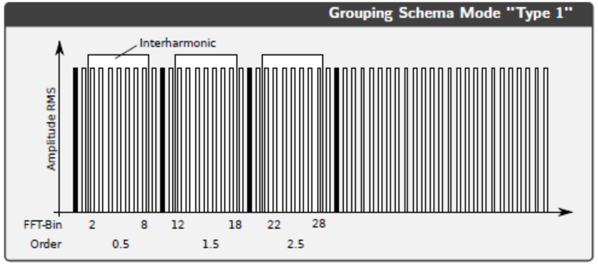
$$Y_{sg,h} = \sqrt{\sum_{k=-1}^{1} Y_c\left[NP \cdot h + k\right]^2} \qquad NP >= 2$$

- When this mode is selected, the Interharmonics are grouped according to IEC61000-4-7 Section 5.6

$$Y_{isg,h} = NaN \qquad NP <= 2$$

$$Y_{isg,h} = \sqrt{\sum_{k=2}^{N-2} Y_c\left[NP \cdot h + k\right]^2} \qquad NP > 2$$





GROUPING MODE - *TYPE 2 – IEC61000-4-7-5.5.1*

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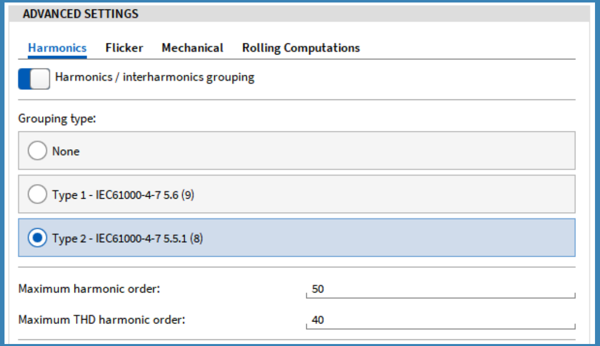


Symbol	Description
Y_c	RMS Magnitude of FFT-Bin
Y_h	RMS Magnitude of Harmonic Order h (Grouping "None")
$Y_{sg,h}$	RMS Magnitude of Harmonic Order h (Grouping "Type 1")
$Y_{g,h}$	RMS Magnitude of Harmonic Order h (Grouping "Type 2")
NP	Number of fundamental Periods
h	Harmonic Order

- > When this mode is selected, the harmonics are grouped according to IEC61000-4-7 Section 5.5.1

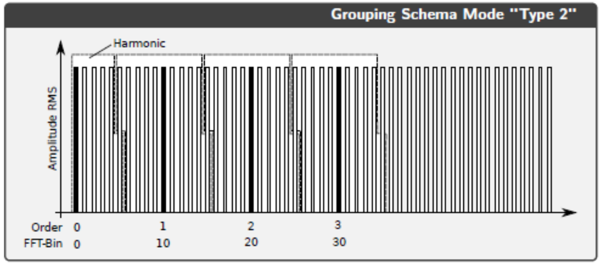
$$Y_{g,h} = Y_c[NP \cdot h] \qquad NP < 2 \quad (7.4)$$

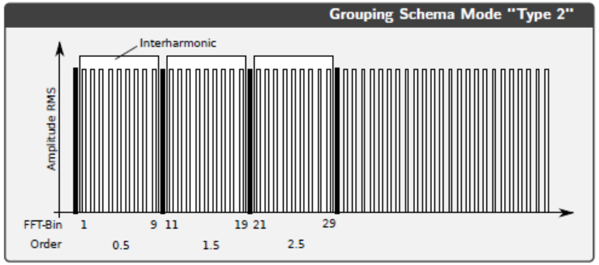
$$Y_{g,h} = \sqrt{\frac{1}{2}Y_c\left[NP \cdot h - \frac{N}{2}\right]^2 + \sum_{k=-\frac{N}{2}+1}^{\frac{N}{2}-1} Y_c[NP \cdot h + k]^2 + \frac{1}{2}Y_c\left[NP \cdot h + \frac{N}{2}\right]^2} \qquad NP >= 2 \quad (7.5)$$

- > When this mode is selected, all bins (except of harmonic bin) are taken for generation of the interharmonic data.

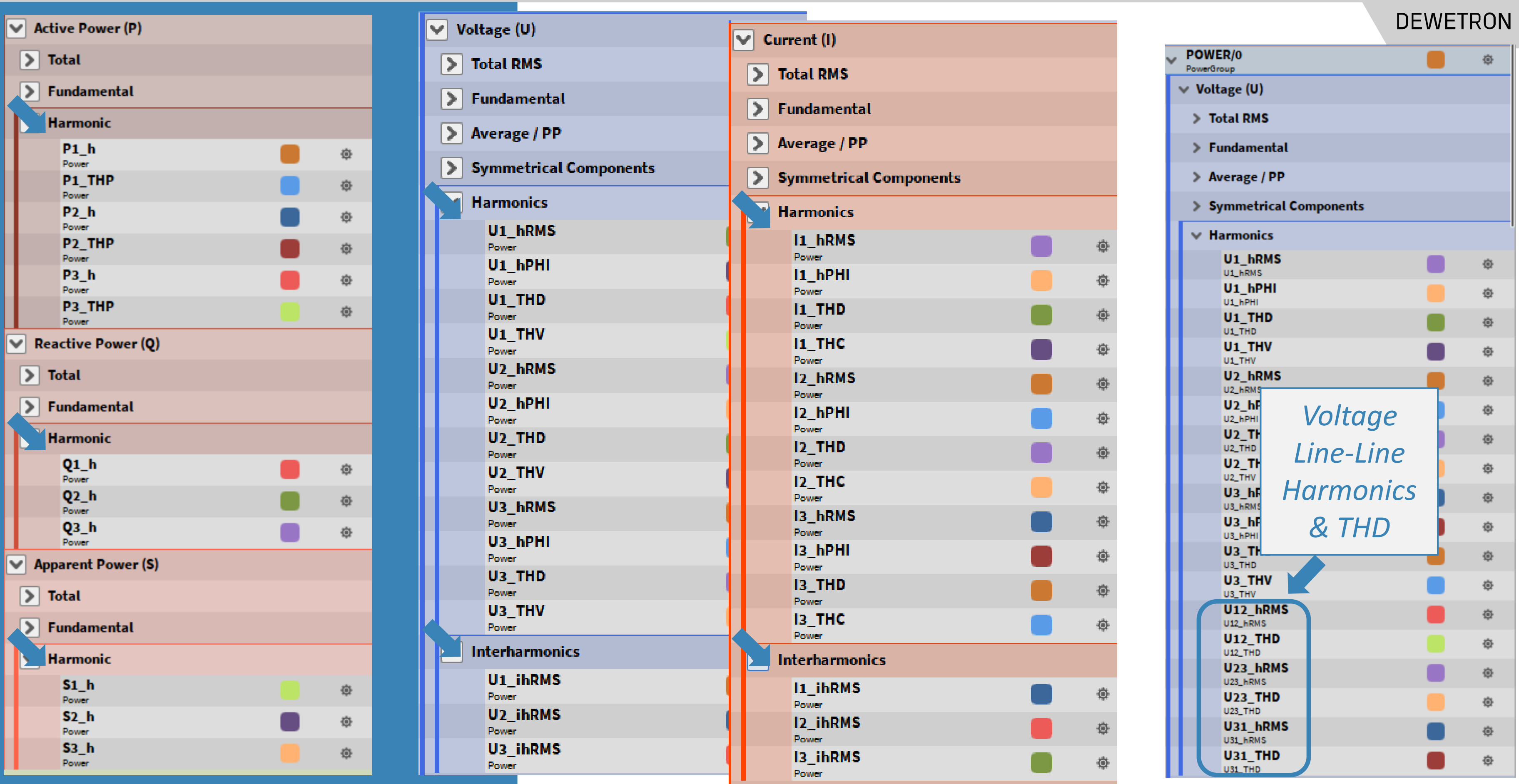
$$Y_{ig,h} = NaN \qquad NP = 1$$

$$Y_{ig,h} = \sqrt{\sum_{k=1}^{N-1} Y_c[NP \cdot h + k]^2} \qquad NP > 1$$





HARMONICS/INTERHARMONICS - OUTPUT CHANNELS



HIGHER FREQUENCY GROUPING

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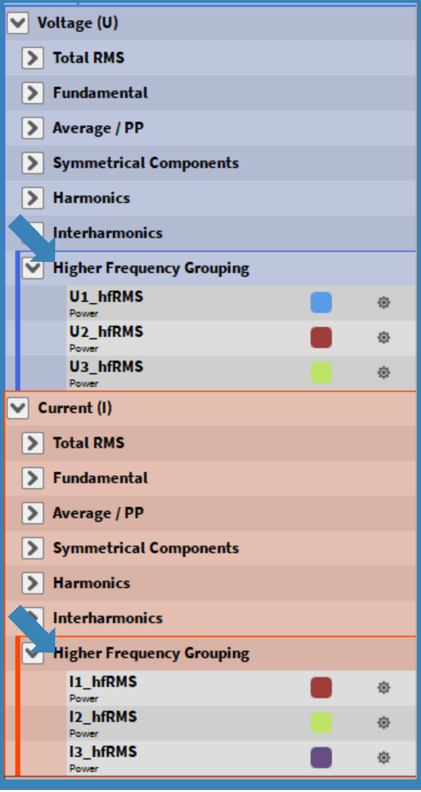
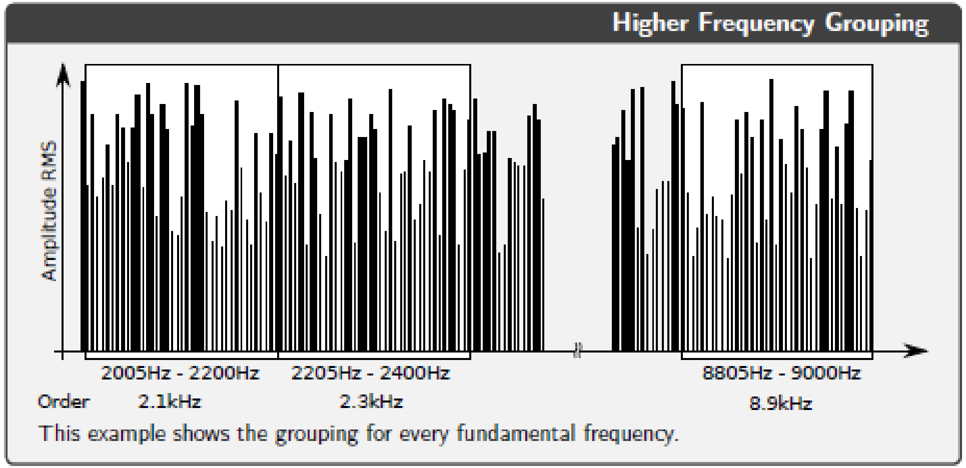


Symbol	Description
$Y_{C,f}$	RMS Magnitude of FFT-Bin
$Y_{B,b}$	RMS Magnitude of Higher Frequency Order b

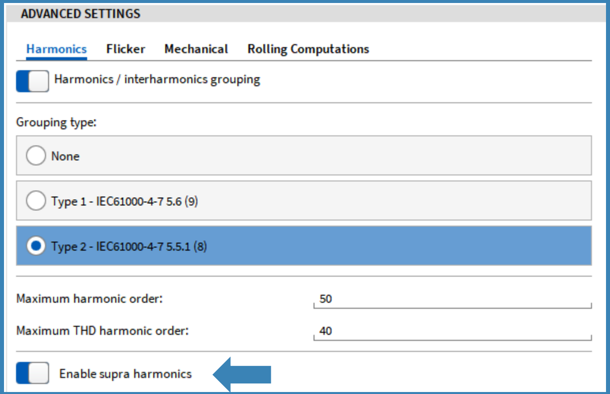
> The Higher Frequency Grouping is orientated on fixed frequency bands (see IEC/EN61000-4-7 Appendix B)

$$Y_{B,b} = \sqrt{\sum_{f=b-95\mathrm{Hz}}^{b+100\mathrm{Hz}} Y_{C,f}^2}$$



SUPRAHARMONICS

DEWETRON



Symbol	Description
$Y_{C,b}$	RMS Magnitude of FFT-Bin b
$Y_{SH,i,min}$	Minimum RMS Magnitude of Supraharmonics order i
$Y_{SH,i,avg}$	Average RMS Magnitude of Supraharmonics order i
$Y_{SH,i,max}$	Maximum RMS Magnitude of Supraharmonics order i
NP	Number of fundamental periods (10 @ 50Hz, 12 @ 60Hz)
N_{FFT}	Number of Short Time FFTs in time interval of NP
SR	Samplerate

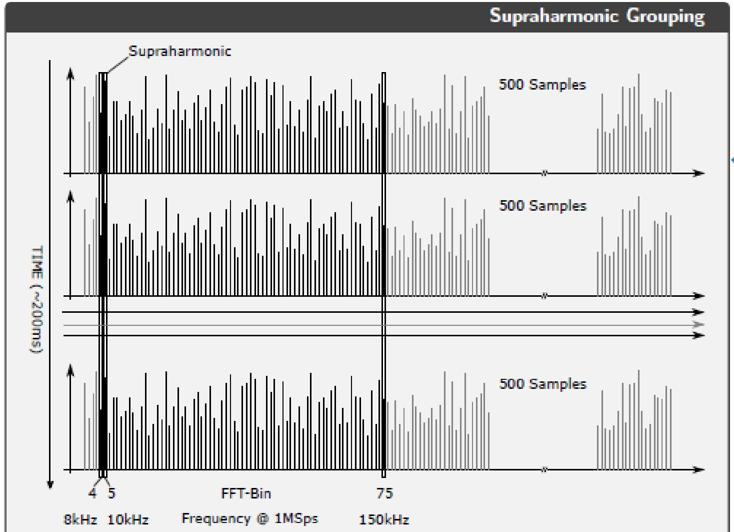
$$N_{FFT} = \frac{\frac{NP}{F_{fund}} \cdot SR}{500}$$

$$Y_{SH,b,min} = min(Y_{C,b})$$

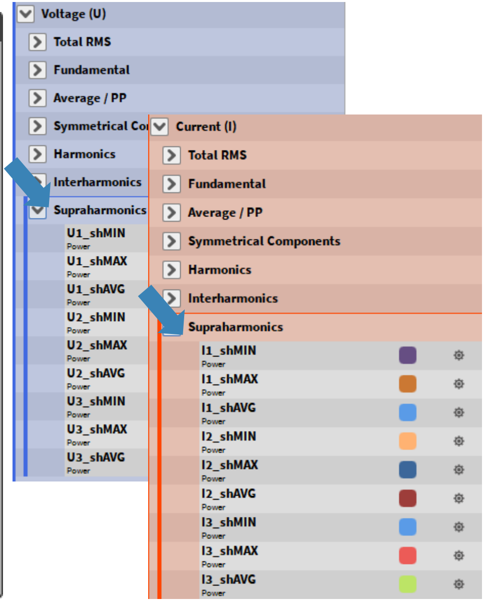
$$Y_{SH,b,avg} = avg(Y_{C,b})$$

$$Y_{SH,b,max} = max(Y_{C,b})$$

- Unlike the other grouping methods, the Supraharmonics are aggregated in time
- Minimum Sample rate = 1 MHz

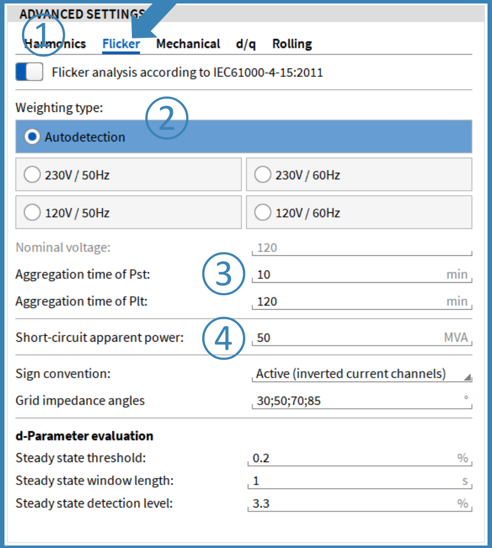


This graphics shows the time domain aggregation of the short time FFT results. The number of FFTs is orientated on the number of fundamental periods.



VOLTAGE FLUCTUATION AND FLICKER EMISSION

DEWETRON



Working conditions for voltage fluctuation:

Fundamental Frequency	10 to 1000 Hz
Nominal Voltage	> 5% of Input Range
Weighting Functions	120V/50Hz, 120V/60Hz, 230V/50Hz, 230V/60Hz
Aggregation Time Pst	1 to 60 min
Aggregation Time Plt	1 to 1440 min
Short Circuit Apparent Power	0.001 to 10 000 MVA

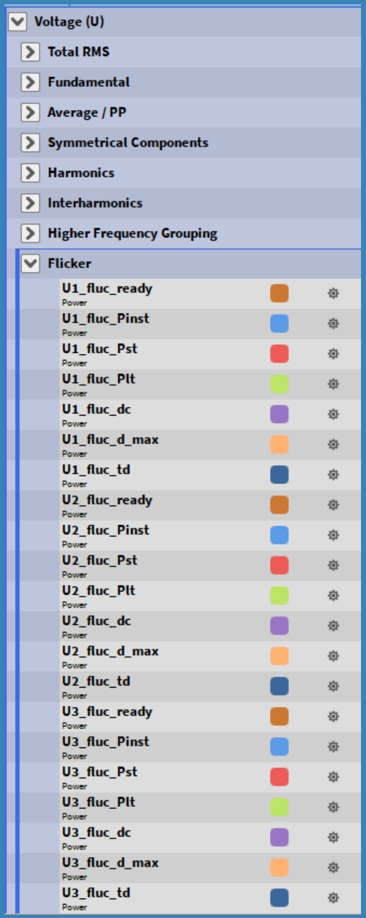
Measurement parameters according to IEC61000-4-15 and IEC61400-21 Section 7.3.

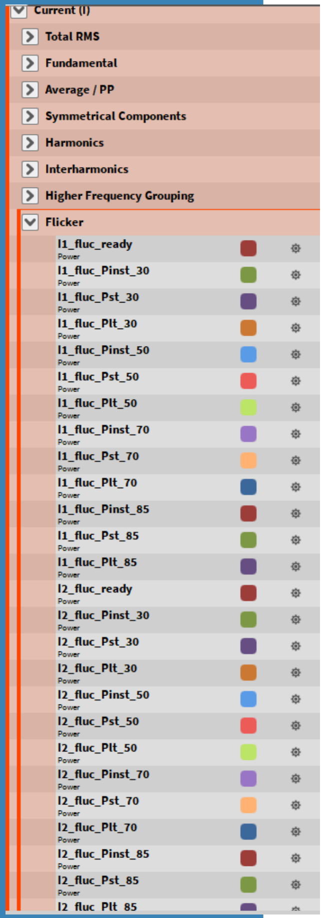
Flicker Analysis procedure

> Switch on the Feature ①
> Select the Weighting Type ② for your Application. Use Autodetection in low voltage grids (120V/230V). If you want to use the Voltage Fluctuation Algorithm outside these Conditions, please select the weighting type manually and insert the nominal voltage in ③
> Change the Aggregation Time of Pst and Plt if needed ④
> Go back to Measurement Screen, take an indicator instrument and assign the U[i]_fluc_ready Channel
> Take a Table Instrument and assign the U[i]_fluc_Pst Channels or any other Instrument to visualize the Voltage Fluctuation Values
> Wait for Channel Ready
> Start the Recording

VOLTAGE FLUCTUATION AND FLICKER EMISSION

DEWETRON

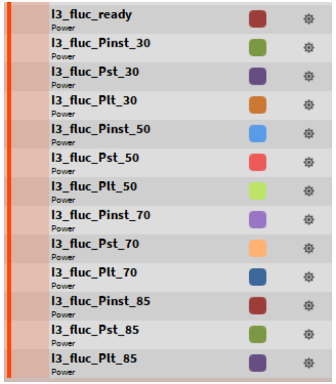




Output Channels:

Parameters according to

IEC61000-4-15 and IEC61400-21 Section 7.3.



8.5.1 U[i]_fluc_Pst

The short-term flicker severity

8.5.2 U[i]_fluc_Plt

The long-term flicker severity

$$U[i]\_fluc\_Plt = \sqrt[3]{\frac{1}{N}\sum_{k=0}^{N-1} U[i]\_fluc\_Pst[k]^3} \qquad Unit : \mathbf{A} \tag{8.148}$$

8.5.3 U[i]_fluc_Pinst

The instantaneous flicker sensation

8.5.4 U[i]_fluc_ready

Indicator value for steady state of algorithm filters

8.5.5 I[i]_fluc_Pst_[ψ]

The short-term flicker emission severity according to IEC61400-21. Equal to $P_{st,fic}$. $\psi \in [30^\circ, 50^\circ, 70^\circ, 85^\circ]$

8.5.6 I[i]_fluc_Plt_[ψ]

The long-term flicker emission severity. $\psi \in [30^\circ, 50^\circ, 70^\circ, 85^\circ]$

8.5.7 I[i]_fluc_Pinst_[ψ]

The instantaneous flicker emission sensation. $\psi \in [30^\circ, 50^\circ, 70^\circ, 85^\circ]$

8.5.8 U[i]_fluc_dc

Steady state voltage change

8.5.9 U[i]_fluc_dmax

Maximum voltage change during a voltage change characteristic

8.5.10 U[i]_fluc_td

Duration of Voltage change below 3.3%.

8.5.11 U[i]_fluc_fic_[ψ]_hp_RMS

The Phase's i half period RMS value of the fictitious grid, used for Stage 1 in the IEC-Flickermeter. Can be used to calculate the Voltage change factor ku.
$\psi \in [30^\circ, 50^\circ, 70^\circ, 85^\circ]$

FLICKER EMISSION – THEORETICAL BACKGROUND

DEWETRON

Sign convention:	Passive
Grid impedance angles	30;50;70;85 °
d-Parameter evaluation	
Steady state threshold:	0.2 %
Steady state window length:	1 s
Steady state detection level:	3.3 %

Symbol	Description
$S_{K,fic}$	This is the short circuit power of the fictitous grid. To be given for one phase in MVA!
U_N	Nominal Voltage (U_{L-N}) of the analyzed grid.
ψ_K	Phase Angle of the Grid Impedance (pre-defined with 30/50/70/85 deg)
R_{fic}	Fictiteous Ohmic impedance
X_{fic}	Fictiteous Reactive impedance
f_N	Nominal Frequency (50 or 60 Hz, depending on the selected Weighting)

$$S_{K,fic} = \frac{U_N^2}{\sqrt{R_{fic}^2 + X_{fic}^2}} \qquad Unit: \mathbf{VA}$$

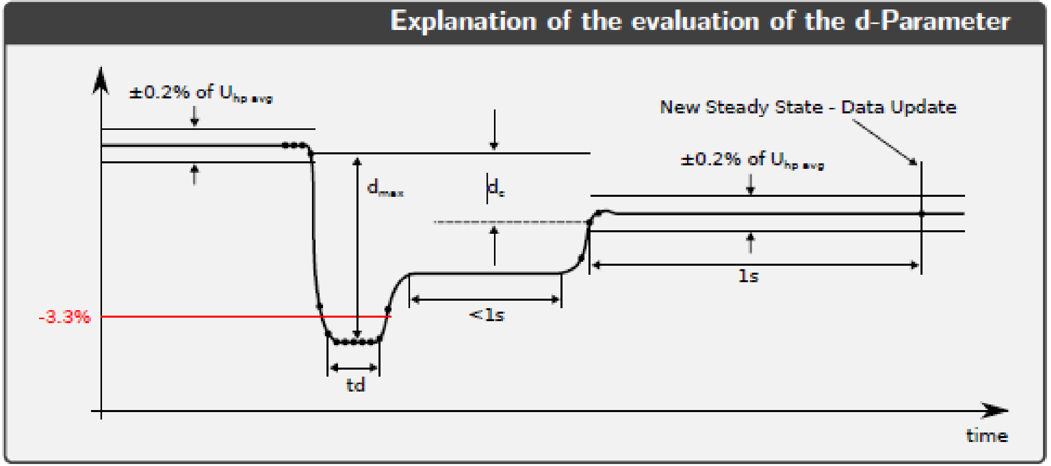
$$Z_{fic} = \sqrt{R_{fic}^2 + X_{fic}^2} = \frac{U_N^2}{S_{K,fic}} \qquad Unit: \Omega$$

$$R_{fic} = Z_{fic} \cdot cos(\psi_K) \qquad Unit: \Omega$$

$$X_{fic} = Z_{fic} \cdot sin(\psi_K) \qquad Unit: \Omega$$

$$L_{fic} = \frac{X_{fic}}{2 \cdot \pi \cdot f_N} \qquad Unit: \mathbf{H}$$

- Short Term Voltage fluctuations evaluate the voltage change characteristics according to IEC61000-4-15. For this analysis, the half-period rms values from the voltage channels are calculated internally.
- Explanation of the evaluation of the d-Parameter



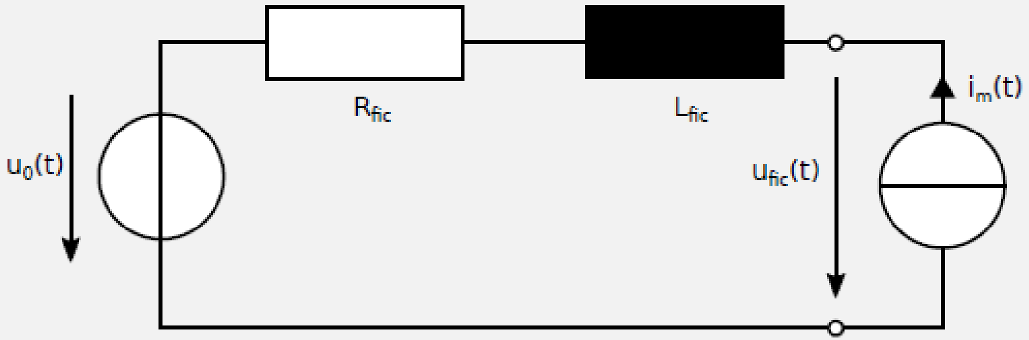
- d-Parameters can be modified since Oxygen 6.6

VOLTAGE FLUCTUATION – THEORETICAL BACKGROUND

DEWETRON

> Flicker Emission is the Analysis of the virtually generated voltage fluctuation caused by the emitted current. This analysis procedure is described in the IEC61400-21 Standard. It uses a fictitious grid for simulation of a fictitious voltage, which is then processed with the flicker algorithm to get the Pst, fic.

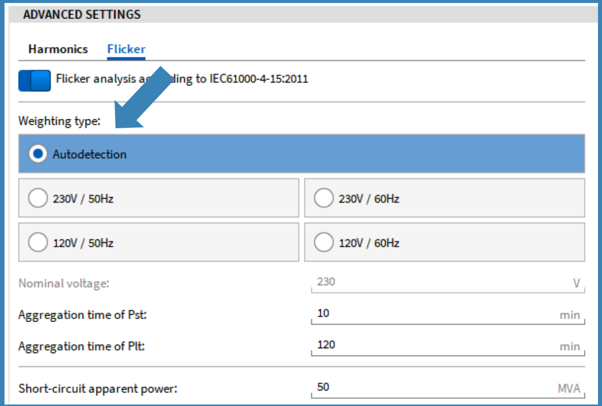
Fictitious grid for simulation of fictitious voltage



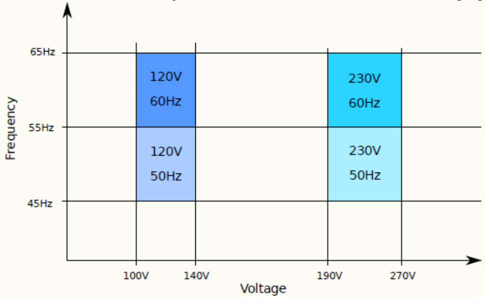
$$u_{fic}(t) = u_0(t) + R_{fic} \cdot i_m(t) + L_{fic} \cdot \frac{di_m(t)}{dt} \qquad (8.1)$$

FLICKER ANALYSIS – AUTO DETECTION & AGGREGATION TIME

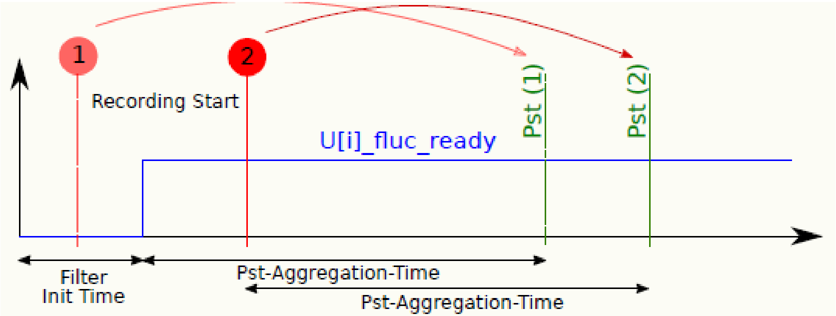
DEWETRON



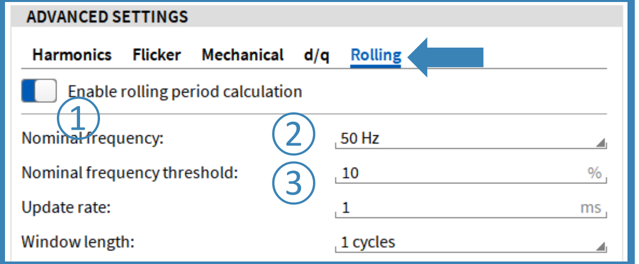
> The Auto-Detection Mode is useful for the most applications. In the following graph you can see, which Mode is applied under different circumstances.



> Pst/Plt Aggregation Time: If the Recording is started before ready (1), the aggregation is started when ready. When recording is started while ready (2), the aggregation will be started with the recording start..

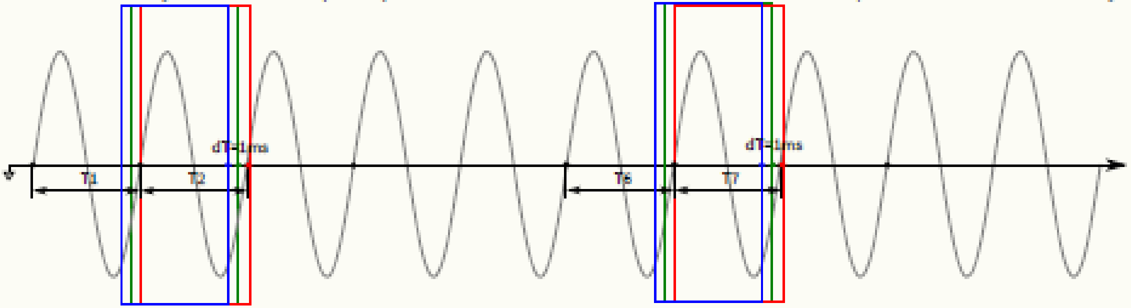


ROLLING COMPUTATIONS - GENERAL



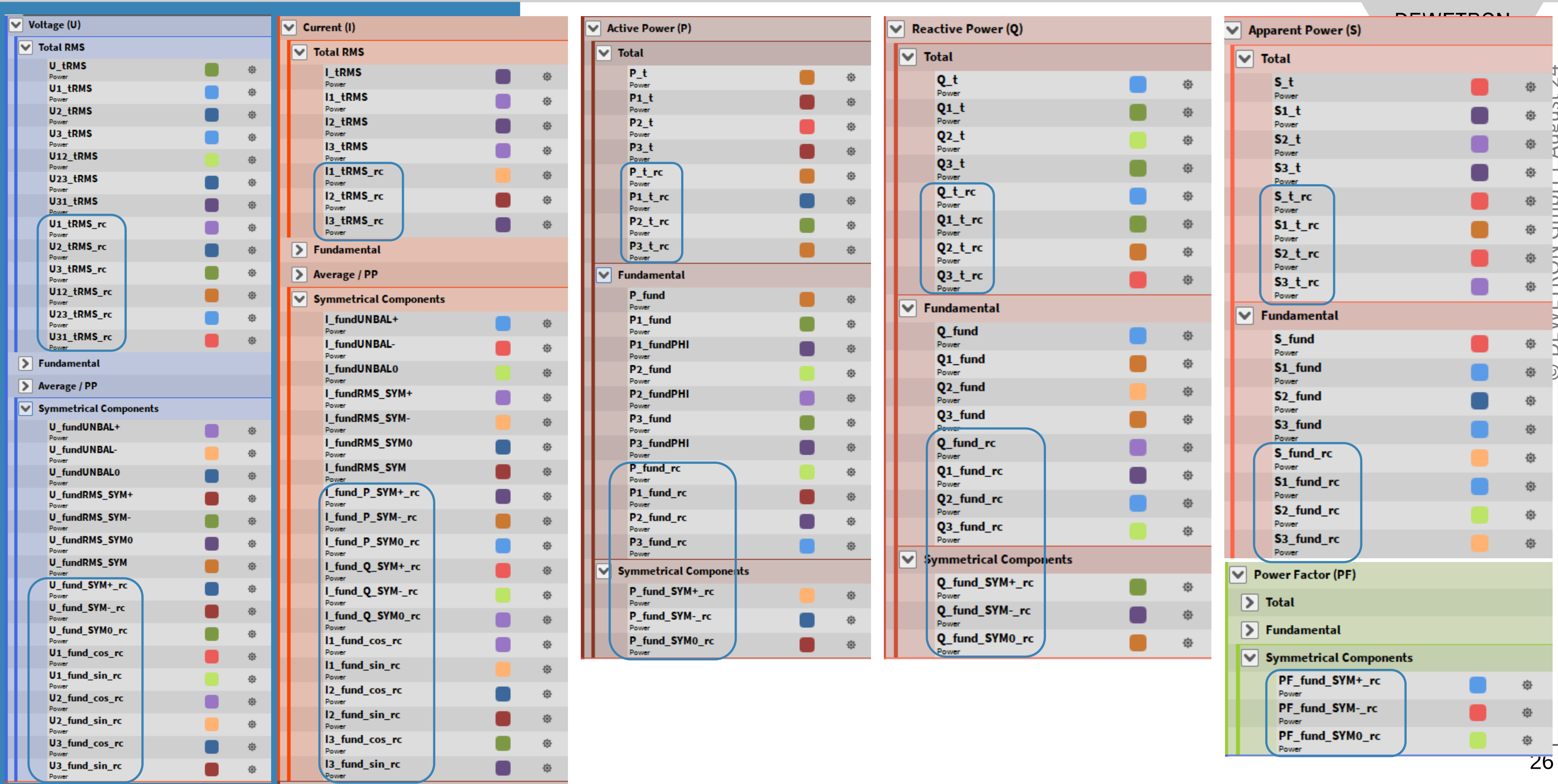
①	Enable/Disable Rolling Calculation
②	Selector for nominal frequency fallback
③	Input field for frequency threshold. If a frequency is detected within the nominal frequency threshold %, the rolling window size is the actual period duration. Otherwise, e.g. in the case of a voltage interruption, where no frequency can be measured, the window size is the inverse nominal frequency.

The following graph shows the details of the operation principle. It is similar to a moving average calculation, but with a variable window size, which depends on the actual measured fundamental frequency. If the calculate window size exceeds the maximum allowed size, which is given by (1/Nominal Frequency)*(1 + Frequency Threshold/100), the window size is set to 1/Nominal Frequency.



Usecase: Testing of Renewable Energy Sources according to IEC 61400-21 and FGW-TR3 where some tests require the analysis of fast transitions

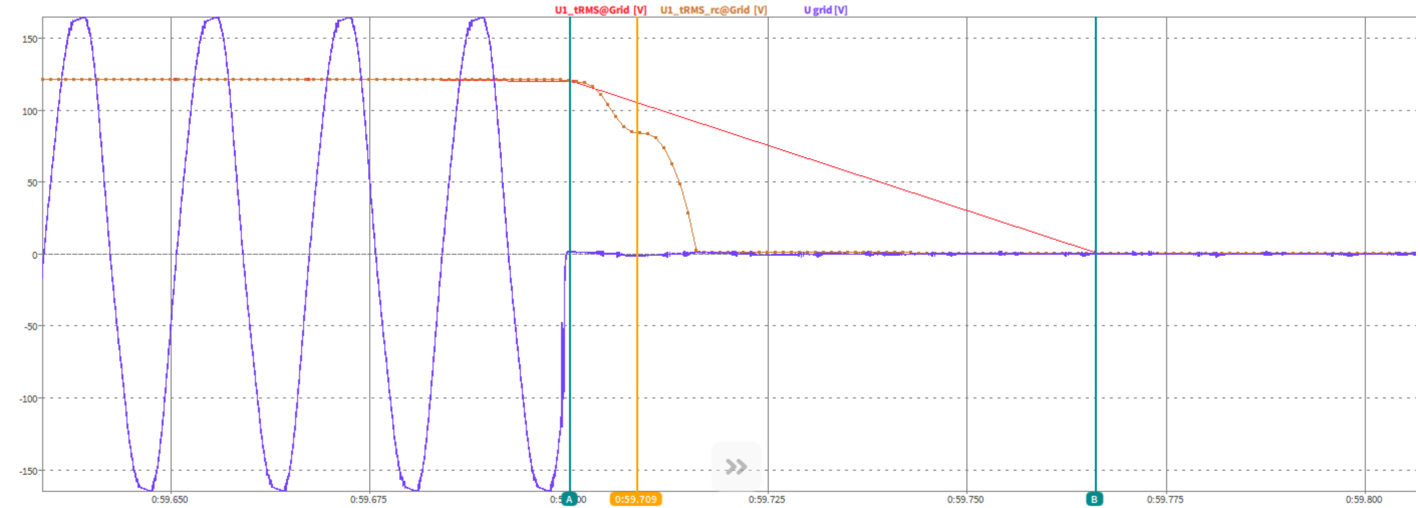
ROLLING COMPUTATIONS – OUTPUT CHANNELS



ROLLING COMPUTATIONS – EXAMPLE 60 HZ GRID

DEWETRON

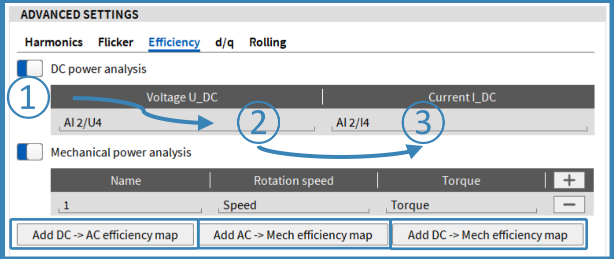
> Whenever the voltage drops the frequency cannot be detected anymore and the calculation interval switches to a fixed time. The last calculated value (U1_tRMS in figures) can be seen at marker A and the next calculated value of the fixed time at marker B. Therefore, there is no information available during the drop, neither are correct values. For the rolling computations (with extension _rc) it can be seen though, that the calculation goes on and we still get values every 1 ms.



	A	B	Delta
Time [s]	0:59.7001699	0:59.7660886	0.0659187
U1_tRMS@Grid [V]	120.4709	119.4933	-0.977577
U1_tRMS_rc@Grid [V]	119.5651	0.124121	-119.4410
U grid [V]	1.403830	0.122072	-1.281758

MECHANICAL POWER COMPUTATION + DC-POWER

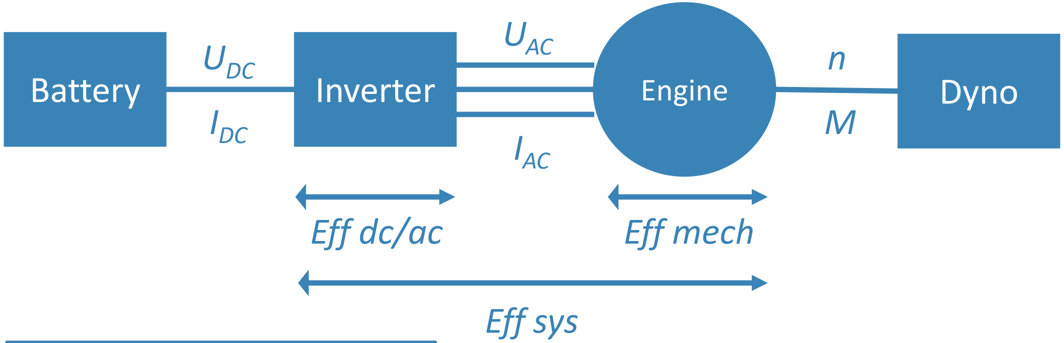
DEWETRON

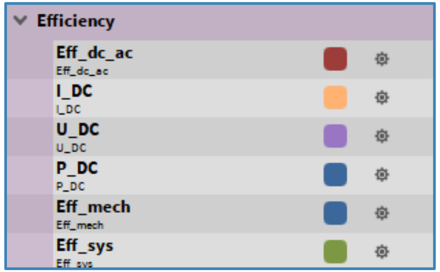


1	Enable/Disable DC power calculation
2	Add Voltage U_DC
3	Add Current I_DC

The **Efficiency** Tab includes DC Power Analysis and
Mechanical Power Analysis

OXY-OPT-POWER-ADV required





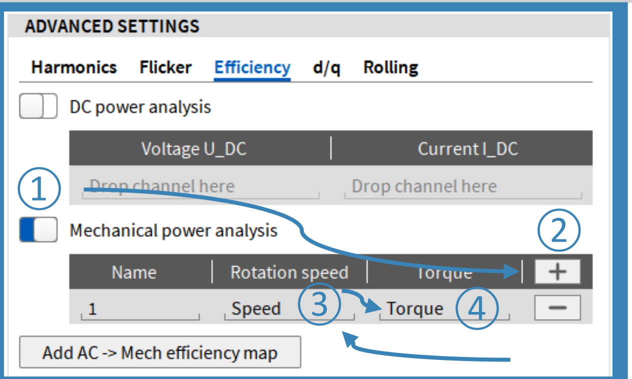
3 different Efficiency maps can be created

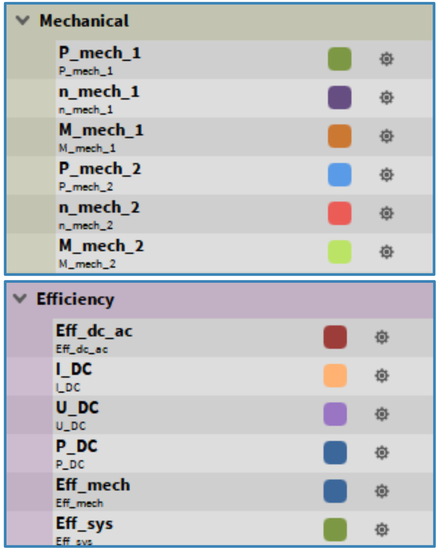
U_DC vs I_DC vs Eff_dc_ac
n_mech vs M_mech vs Eff_mech
U_DC vs I_DC vs Eff_sys

- *Channels are updated every calculation cycle given by calculation sync source (same as electrical power).*
- *This way, DC-POWER and AC-POWER are synchronised*

MECHANICAL POWER COMPUTATION + DC-POWER

DEWETRON





$$P_{mech} = \frac{1}{N}\sum_{n=0}^{N} speed[n] \cdot torque[n] \cdot \frac{2 \cdot \pi}{60}$$

$$n_{mech} = \frac{1}{N}\sum_{n=0}^{N} speed[n]$$

$$M_{mech} = \frac{1}{N}\sum_{n=0}^{N} torque[n]$$

$$Eff_{mech} = \begin{cases} \frac{P_i}{P_{mech}} \cdot 100 & \text{if } P_{mech} < 0 \\ \frac{P_{mech}}{P_i} \cdot 100 & \text{if } P_{mech} >= 0 \end{cases}$$

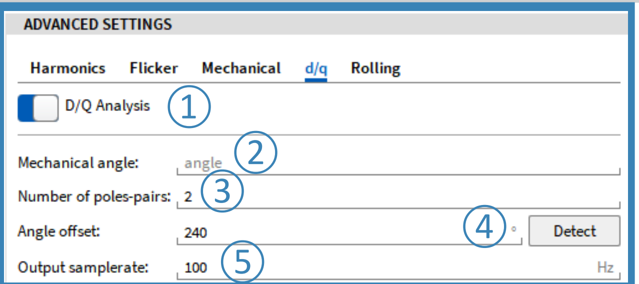
①	Enable/Disable mechanical power calculation
②	Add mechanical "phase"
③	Input field for rotation speed channel (unit must be rpm)
④	Input field for torque channel (unit must be Nm)

OXY-OPT-POWER-ADV required

> *Channels are updated every calculation cycle given by calculation sync source (same as electrical power).*
>
> *Up to 6 Mechanical Pairs (n & M) can be added.*
>
> *Each Mechanical Power P_mech_x is added up to P_mech for Efficiency Calculation*

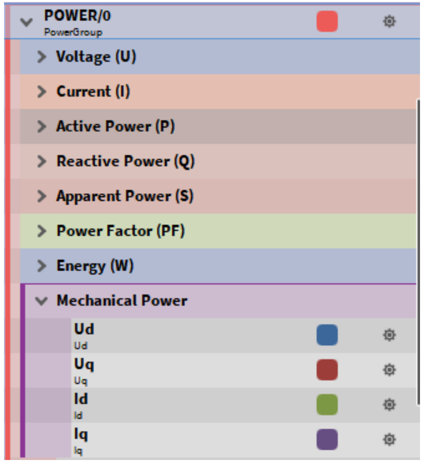
DQ-ANALYSIS

DEWETRON



①	Enable dQ analysis feature
②	Assign the angle channel
③	Enter th number of pole-pairs according to your engine
④	Drive the DUT with an auxikiary engine at constant speed and press the *Detect* button to measure the angle offset or enter it manually
⑤	Define the output rate of the output channels

OXY-OPT-POWER-ADV required



d-Axis Voltage, reduced with block-wise average to given output samplerate.

$$U_d^* = \frac{2}{3}\cdot\left(U_{1N}\cdot cos(\theta) + U_{2N}\cdot cos(\theta - \frac{2\pi}{3}) + U_{3N}\cdot cos(\theta + \frac{2\pi}{3})\right)$$

$$U_d = \frac{red\_SR}{SR}\cdot\sum_{i=0}^{\frac{SR}{red\_SR}} U_d^*$$

$Unit : \mathbf{V}$

q-Axis Voltage, reduced with block-wise average to given output samplerate.

$$U_q^* = \frac{2}{3}\cdot\left(-U_{1N}\cdot sin(\theta) - U_{2N}\cdot sin(\theta - \frac{2\pi}{3}) - U_{3N}\cdot sin(\theta + \frac{2\pi}{3})\right)$$

$$U_q = \frac{red\_SR}{SR}\cdot\sum_{i=0}^{\frac{SR}{red\_SR}} U_q^*$$

d-Axis Current, reduced with block-wise average to given output samplerate.

$$I_d^* = \frac{2}{3}\cdot\left(U_1\cdot cos(\theta) + I_2\cdot cos(\theta - \frac{2\pi}{3}) + I_3\cdot cos(\theta + \frac{2\pi}{3})\right)$$

$$I_d = \frac{red\_SR}{SR}\cdot\sum_{i=0}^{\frac{SR}{red\_SR}} I_d^*$$

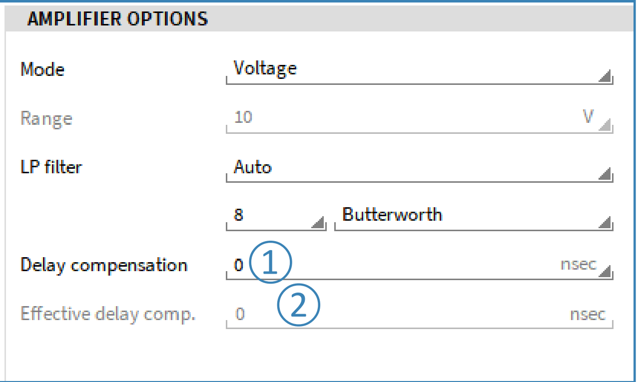
q-Axis Current, reduced with block-wise average to given output samplerate.

$$I_q^* = \frac{2}{3}\cdot\left(-I_1\cdot sin(\theta) - I_2\cdot sin(\theta - \frac{2\pi}{3}) - I_3\cdot sin(\theta + \frac{2\pi}{3})\right)$$

$$I_q = \frac{red\_SR}{SR}\cdot\sum_{i=0}^{\frac{SR}{red\_SR}} I_q^*$$

DELAY COMPENSATION – TRION-POWER- CURRENT INPUT

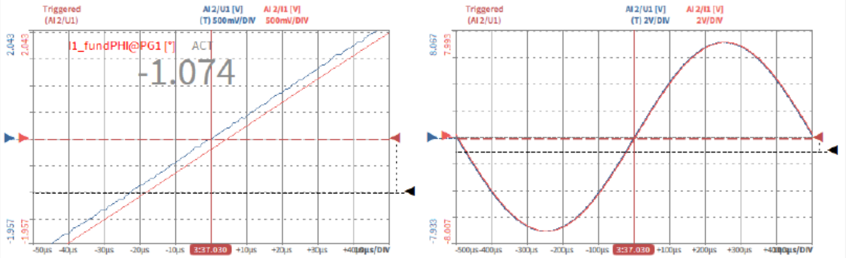
DEWETRON



1	Input field for target delay compensation in nanoseconds (ns). Allowed range is +/- 10000ns. Negative Values shifts the current backwards in time, positive forward.
2	Display of effective set delay compensation, the resolution is fixed to 100ns.

Current and voltage signals are often not perfectly synchronous due to group delays from the sensors.
To compensate this delay (phase shift) between voltage and current input, a new function was added to the TRION-POWER hardware. This function is also known as Deskew.

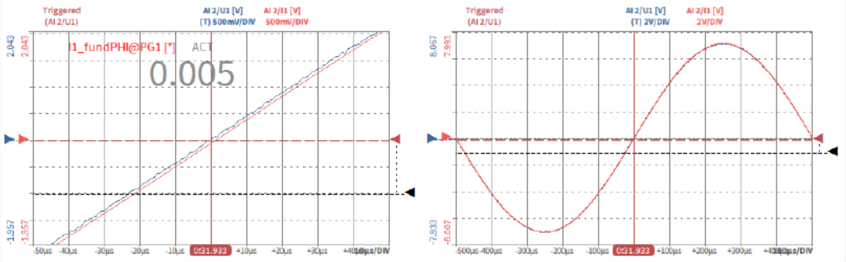
Before adding a compensation value, in this example (Sine Signal with 1 kHz fundamental frequency), the current lags a few degree. This can be seen in the scope as well as in the phase shift of the fundamental:



After adjusting the value to

$$t = \frac{1}{1000Hz} \cdot \frac{1}{360^\circ} \cdot (-1.074^\circ) \cdot 10^9 = -2983ns \qquad (6.1)$$

the result is now nearly perfect:



EXERCISE – LET'S DO A ONE-PHASE POWER MEASUREMENT!

DEWETRON