

**HV Power hints and tips:  
PQ-Box 100 Power Quality Recorder**

Issue 13b

August 18<sup>th</sup> 2015

WinPQ mobil V3.1.5  
RMS frequency trigger added 27/1/2017

**PQ-Box 100/150/200 Recorder Triggers**

**voltage- / current trigger**

	lower threshold [%]	upper threshold [%]	step [%]	phase step [°]
UL1:	<input checked="" type="checkbox"/> 90.00	<input checked="" type="checkbox"/> 110.00	<input type="checkbox"/> 10.00	<input type="checkbox"/> 6.00
UL2:	<input checked="" type="checkbox"/> 90.00	<input checked="" type="checkbox"/> 110.00	<input type="checkbox"/> 10.00	<input type="checkbox"/> 6.00
UL3:	<input checked="" type="checkbox"/> 90.00	<input checked="" type="checkbox"/> 110.00	<input type="checkbox"/> 10.00	<input type="checkbox"/> 6.00
UNE:	<input type="checkbox"/> 0.00	<input type="checkbox"/> 30.00	<input type="checkbox"/> 10.00	<input type="checkbox"/> 0.00
U12:	<input type="checkbox"/> 90.00	<input type="checkbox"/> 110.00	<input type="checkbox"/> 10.00	<input type="checkbox"/> 6.00
U23:	<input type="checkbox"/> 90.00	<input type="checkbox"/> 110.00	<input type="checkbox"/> 10.00	<input type="checkbox"/> 6.00
U31:	<input type="checkbox"/> 90.00	<input type="checkbox"/> 110.00	<input type="checkbox"/> 10.00	<input type="checkbox"/> 6.00
IL1:	<input type="checkbox"/> 10.00	<input type="checkbox"/> 3000.00	<input type="checkbox"/> 300.00	<input checked="" type="checkbox"/> Auto-Trigger
IL2:	<input type="checkbox"/> 10.00	<input type="checkbox"/> 3000.00	<input type="checkbox"/> 300.00	
IL3:	<input type="checkbox"/> 10.00	<input type="checkbox"/> 3000.00	<input type="checkbox"/> 300.00	
IN:	<input type="checkbox"/> 0.00	<input type="checkbox"/> 3000.00	<input type="checkbox"/> 300.00	

**frequency trigger**

	lower threshold [Hz]	upper threshold [Hz]	frequency change [df / f]
F:	<input type="checkbox"/> 49.50	<input type="checkbox"/> 50.50	<input type="checkbox"/> 0.50

**Hysteresis**

Hysteresis 10ms RMS voltage [%]:

Hysteresis 10ms RMS current [A]:

**Parameter**

pre-event time:  [sec]      Recorder time:  [sec]

Figure 1. 10 ms RMS recorder settings.

**voltage- / current trigger**

	lower threshold [%]	upper threshold [%]	step [%]	phase step [°]	envelope [%]
UL1:	<input checked="" type="checkbox"/> 90	<input checked="" type="checkbox"/> 110	<input type="checkbox"/> 10	<input type="checkbox"/> 6	<input checked="" type="checkbox"/> 20
UL2:	<input checked="" type="checkbox"/> 90	<input checked="" type="checkbox"/> 110	<input type="checkbox"/> 10	<input type="checkbox"/> 6	<input checked="" type="checkbox"/> 20
UL3:	<input checked="" type="checkbox"/> 90	<input checked="" type="checkbox"/> 110	<input type="checkbox"/> 10	<input type="checkbox"/> 6	<input checked="" type="checkbox"/> 20
UNE:	<input type="checkbox"/>	<input type="checkbox"/> 30	<input type="checkbox"/> 10	<input type="checkbox"/>	<input type="checkbox"/> 20
U12:	<input type="checkbox"/> 90	<input type="checkbox"/> 110	<input type="checkbox"/> 10	<input type="checkbox"/> 6	<input type="checkbox"/> 20
U23:	<input type="checkbox"/> 90	<input type="checkbox"/> 110	<input type="checkbox"/> 10	<input type="checkbox"/> 6	<input type="checkbox"/> 20
U31:	<input type="checkbox"/> 90	<input type="checkbox"/> 110	<input type="checkbox"/> 10	<input type="checkbox"/> 6	<input type="checkbox"/> 20
IL1:	<input type="checkbox"/> 10	<input type="checkbox"/> 3000	<input type="checkbox"/> 300	<input checked="" type="checkbox"/> Auto-Trigger	
IL2:	<input type="checkbox"/> 10	<input type="checkbox"/> 3000	<input type="checkbox"/> 300		
IL3:	<input type="checkbox"/> 10	<input type="checkbox"/> 3000	<input type="checkbox"/> 300		
IN:	<input type="checkbox"/>	<input type="checkbox"/> 3000	<input type="checkbox"/> 300		

**External Trigger**

falling Edge     rising Edge

**Intervaltrigger**

[min]

**Envelope**

Envelope-Trigger Hold [s]:

**Hysteresis**

Hysteresis 10ms RMS voltage [%]:

Hysteresis 10ms RMS current [A]:

**Parameter**

pre-event time:  [msec]      Recorder time:  [msec]

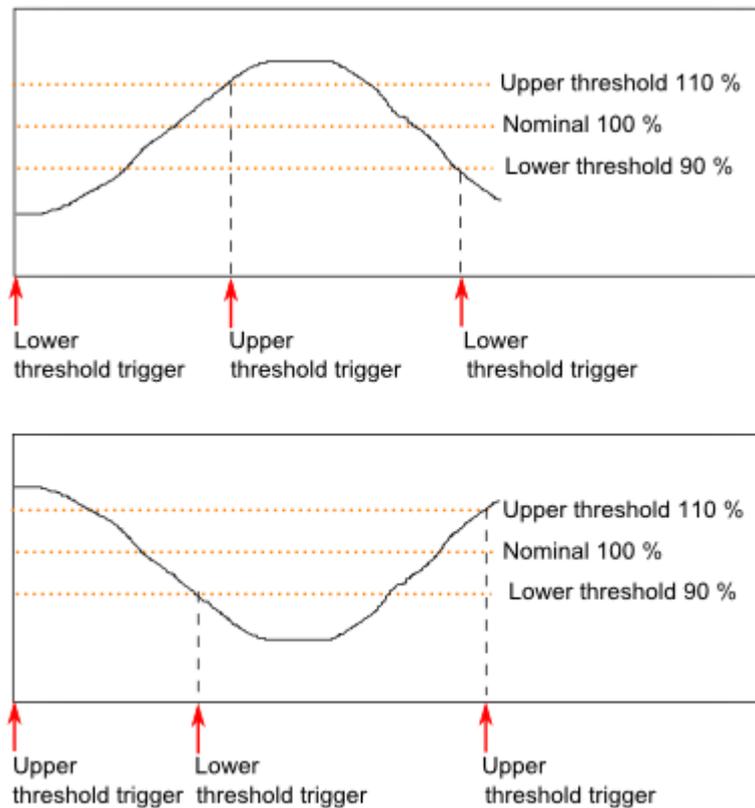
Figure 2. Oscilloscope recorder settings.

**Lower Threshold triggers – Oscilloscope & 10 ms RMS recorder**

The PQ-Box monitors the RMS value of each 10 ms half cycle current/voltage, and Lower Threshold triggering is based on these values.

For example, if the Oscilloscope recorder is set with a Lower Threshold setting of 90 % (and Nominal Voltage setting of 230 V), an Oscilloscope event will be triggered when a 10 ms RMS value falls below 207 V.

The RMS recorder has independent threshold settings, but the same process follows, the RMS recorder will be triggered when a RMS value falls below the Lower Threshold setting.



**Figure 3. Lower and Upper Threshold trigger examples.**

As shown in Figure 3, at device start up, a Lower Threshold event is triggered at start-up if the RMS value is less than the Lower Trigger settings, and an Upper Threshold event will be triggered if an RMS value is greater than the Upper Trigger setting at start-up.

In a three phase system, it is common for multiple trigger conditions to occur at or near the same time. The Oscilloscope and RMS recorder will each be triggered by the first detected trigger condition, with that being noted as trigger condition. All subsequent trigger events for that recorder are ignored till the end of the recording period (a second trigger condition during the recording period does not extend the recording period). At the end of the recording period that recorder can be triggered again from the same or different trigger provided the Hysteresis conditions are met (Refer to the section on Hysteresis for more information).

The PQ-Box trigger defaults are set differently for 1-wire and 4-wire system settings. **If using 3-wire settings, you will need to manually disable the L-N & N-E voltage triggers and enable the L-L triggers.**

Take care when using lower/upper threshold **current** triggers – especially where recording is to be undertaken for a long period. Experience shows these current triggers can lead to many events being generated if the setting value is not chosen carefully. Additionally consider increasing the current hysteresis setting to reduce the occurrence of many triggered events.

In the 'WinPQ mobil' listing of Oscilloscope and 'RMS recorder' events, the trigger type and triggered input will be shown with the date/time of the event. Voltage Lower Threshold triggers are reported in the format '**Voltage dip ULx**', and current Lower Threshold triggers in the format '**Lower threshold Ix**'.

## Upper Threshold triggers – Oscilloscope & 10 ms RMS recorder

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The Upper Threshold triggers work in a similar fashion to the Lower Threshold triggers.

For example, if the Oscilloscope recorder is set with a Upper Threshold setting of 110 % (and Nominal Voltage setting of 230 V), an Oscilloscope event will be triggered when a 10 ms RMS value increases above 253 V.

Voltage Upper Threshold triggers are reported in the format '**Overvoltage ULx**', and current Upper Threshold triggers in the format '**Upper threshold Ix**'.

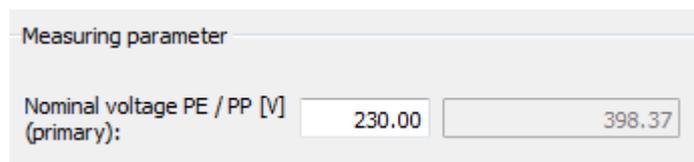
## Step triggers – Oscilloscope & 10 ms RMS recorder

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Recall that the PQ-Box 100 is measuring the RMS voltage value of each applied 10 ms half cycle, and at the end of the measuring interval averaging all these values. At the end of each measuring interval the "permanent recorder" records the average (and maximum & minimum) 10 ms values.

The Step [%] trigger works by comparing each successive 10 ms value. If a successive value is greater than the prior value by the set percentage, the Oscilloscope and/or RMS recorder is triggered. The percentage setting, like other triggers, is a percentage of the "nominal voltage setting". The default value is 10 %. A different percentage setting can be set for the Oscilloscope and the RMS recorder, and they can be independently enabled/disabled.

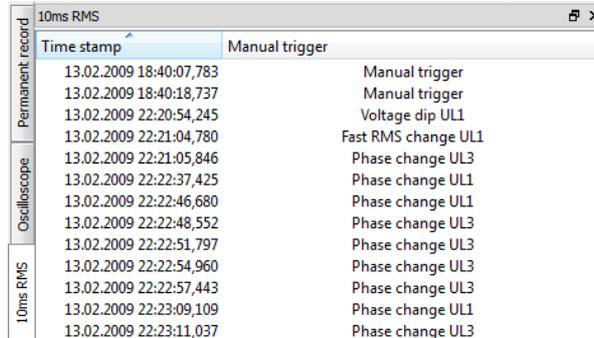
For example, with a 230 V nominal setting and 10 % step setting, if one 10 ms RMS voltage value exceeds the prior value by more than 23 V, then the Step [%] trigger will trigger the Oscilloscope/RMS recorder.



**Figure 4. Nominal Voltage setting on Basic Setting tab – most triggers are expressed as a percentage of this setting.**

A current 'Step' trigger is also possible, with the setting value entered in Amps. If the RMS value of one half of the current sine wave exceeds the prior half sine wave RMS value by more than the setting value (in Amps), then the Oscilloscope/RMS recorder can be triggered.

In the 'WinPQ mobil' listing of Oscilloscope and 'RMS recorder' events, the trigger type and triggered input will be shown with the date/time of the event. Voltage Step triggers are reported in the format '**Fast RMS change ULx**', and current Step triggers in the format '**Fast current change Ix**'.



	Time stamp	Manual trigger
Permanent record	13.02.2009 18:40:07,783	Manual trigger
	13.02.2009 18:40:18,737	Manual trigger
Oscilloscope	13.02.2009 22:20:54,245	Voltage dip UL1
	13.02.2009 22:21:04,780	Fast RMS change UL1
	13.02.2009 22:21:05,846	Phase change UL3
	13.02.2009 22:22:37,425	Phase change UL1
	13.02.2009 22:22:46,680	Phase change UL1
	13.02.2009 22:22:48,552	Phase change UL3
	13.02.2009 22:22:51,797	Phase change UL3
	13.02.2009 22:22:54,960	Phase change UL3
	13.02.2009 22:22:57,443	Phase change UL3
	13.02.2009 22:23:09,109	Phase change UL1
10ms RMS	13.02.2009 22:23:11,037	Phase change UL3

Figure 5. Example recorder events, showing time, trigger type and trigger source.

## Phase Step triggers – Oscilloscope & 10 ms RMS recorder

This monitors the zero crossing point of each voltage input. For each phase (at 50 Hz), a zero crossing will occur each 180 degrees. Should a zero crossing point shift by more than the setting (6 degrees default), the Oscilloscope and/or RMS recorder can be triggered. A different percentage setting can be set for the Oscilloscope and the RMS recorder, and they can be independently enabled/disabled.

Faults in the MV and HV networks can produce phase steps, but perhaps easier to visualise would be the effect of an unsync'd generator being connected, or a fault in an unsync'd UPS bypass switch.

In the 'WinPQ mobil' listing of Oscilloscope and 'RMS recorder' events, the trigger type and triggered input will be shown with the date/time of the event. Phase Step triggers are reported in the format '**Phase change ULx**'. Examples are shown in Figure 5.

## Auto-Trigger

Refer to Hints and tips Issue #5 for information on the operation of the Auto-Trigger function.

## Frequency trigger – 10 ms RMS recorder

The RMS Recorder can be triggered by an under/over frequency event, and/or if the absolute frequency change during a 1 second period is greater than the setting value.

## External trigger – Oscilloscope & 10 ms RMS recorder – PQ-Box 200 only

The PQ-Box 200 has external trigger inputs, where the leading or falling edge of an applied voltage can be used to trigger the Oscilloscope and/or RMS recorder.

In the 'WinPQ mobil' listing of Oscilloscope and RMS recorder events, the trigger type and triggered input will be shown with the date/time of the event. PQ-Box 200 External triggers are reported as '**rising Edge**' or '**falling Edge**'.

## Envelope trigger – Oscilloscope recorder

The default setting for the envelope trigger is 20 %, which like other triggers is a percentage of the nominal voltage setting.

For example, with a 230 V nominal voltage setting, 20 % equates to 46 V. Therefore in the example provided by **Figure 6**, if the black nominal 230 V was to exceed any point of the red +/- 46 V (+/-20 %) envelope, an oscilloscope event would be generated.

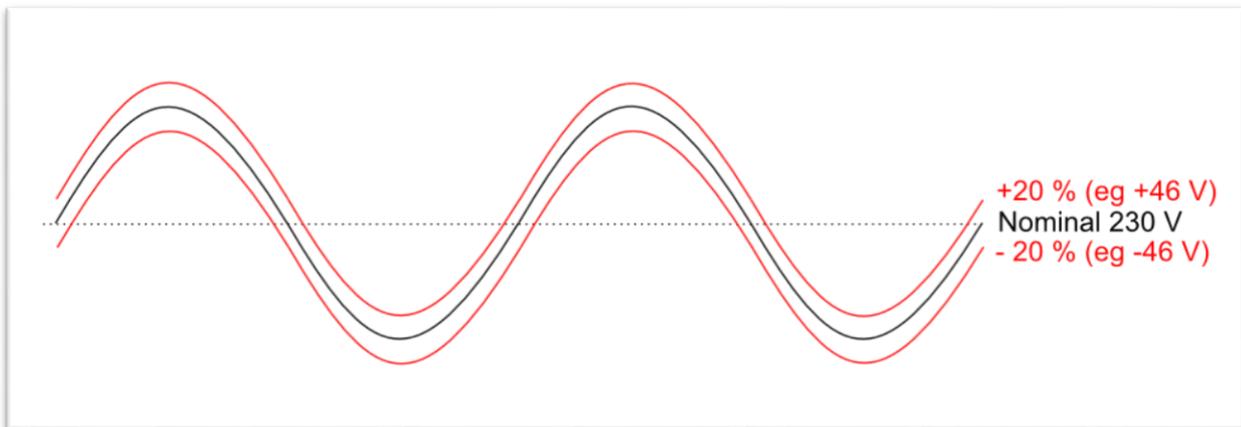


Figure 6. Example of Envelope trigger.

As the Envelope trigger can easily trigger many events, an Envelope-Trigger Hold setting (in seconds) is provided. Simply after each Envelope trigger event, the 'hold time' is waited before another envelope event is allowed to trigger another record. The 'hold time' only applies to envelope events.

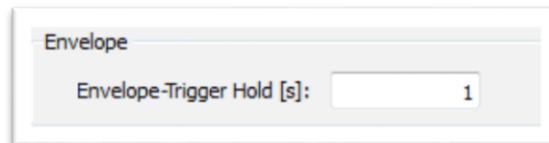


Figure 7. Envelope Trigger Hold.

Note that **Figure 6** is provided to illustrate the envelope concept. Internally the PQ-Box actually filters out the fundamental wave, so this trigger will also work with pure DC measurements.

In the 'WinPQ mobil' listing of Oscilloscope recorder events, the trigger type and triggered input will be shown with the date/time of the triggered event. Envelope triggers are reported in the format '**Envelope ULx**'.

## Interval trigger – Oscilloscope recorder

The Oscilloscope recorder can also be triggered at a user defined interval. The setting can range from 1 to 240 minutes in one minute increments. The default setting is 10 minutes, but with the trigger not enabled.

Note that the Interval trigger timer starts counting from when the start button is pressed – the time is not synchronised to the measuring interval.

In the 'WinPQ mobil' listing of Oscilloscope recorder events, the trigger type and triggered input will be shown with the date/time of the event. Interval triggers are reported as 'Intervalltrigger'.

### The Hysteresis settings

Both the Oscilloscope and RMS recorder setting pages have hysteresis settings (% and A). These are applied to all the relevant trigger settings to stop continuous triggering if the measured level is sitting around the trigger level setting. For example with a Lower Threshold setting of 90 % and Hysteresis setting of 2 %, the event will be triggered when level passes below 90 %. Another event cannot be triggered until the level first returns to above 92 %. This stops multiple triggers being generated if the level was to hover about the 90 % point. Refer example Figure 8.

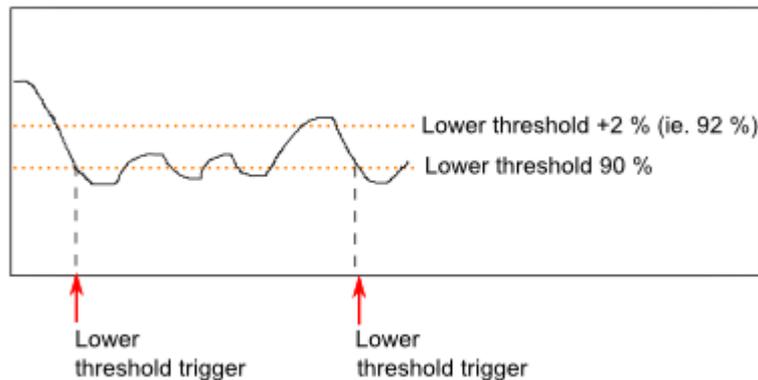


Figure 8. Example of effect of Hysteresis setting with Hysteresis = 2 %.

The default Hysteresis settings are 2 % nominal voltage and 2 A current.

Additionally the hysteresis setting is used to determine the end-time of the relevant PQ-Events. For example with a Limit setting for a voltage dip of 90 % and a Hysteresis setting of 2 %, the reported duration of the event will be the time from when the network voltage went below the 90 % limit, till the time the network voltage reaches back up to 92 % again.

### Sampling speed, recorder time & file size:

Many of the trigger conditions are based on the calculated 10 ms RMS values. However, the Oscilloscope Envelope recorder is based on individual sample points. For the PQ-Box 100 this occurs each 98  $\mu$ s, for the PQ-Box 150 this is each 48  $\mu$ s and for the PQ-Box 200 each 24  $\mu$ s. The PQ-Box 200 Transient recorder is faster again – refer to that section.

The Recorder time setting is the time for the total recording which includes the “pre-event” time setting. The time of the event reported in WinPQ mobil as the “timestamp” for the event is that of the trigger point, not the start of the pre-trigger period.

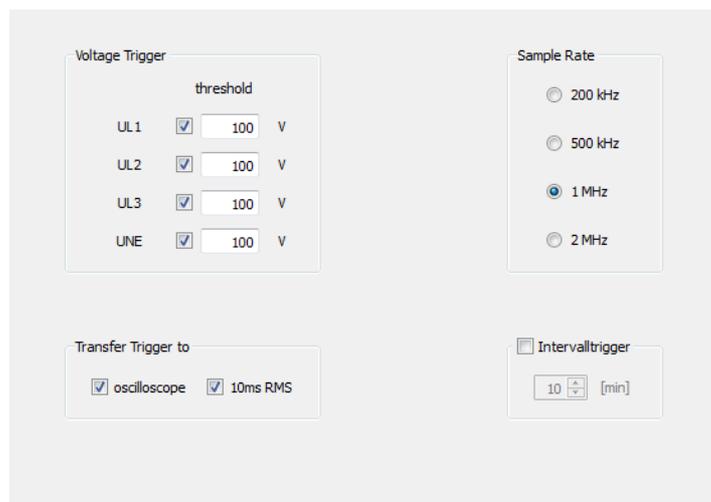
- The Oscilloscope recorder can be set for duration between 200 ms and 4000 ms (default = 2000 ms)
- The RMS recorder can be set for duration between 1 and 600 s (default is 3 seconds).

Note:

- The 10 minute RMS recorder length is intended only for special applications - do not use this length of recording time for standard monitoring, as file size at 600 seconds is approx. 4 MB per event. (A 3 second recording in comparison is approx. 20 kB).
- When using the PQ-Box with very long RMS recorder lengths, keep in mind that the PQ-Box does not indicate the capture of an event on its LCD Recorder count screen, till the end of the event. Therefore if using a 600 second RMS recorder – it will take 10 minutes before the count increments. It will also take some further time (approx. 5 minutes) for the record to be copied to permanent memory before the PQ-Box can be shut down (wait for the LCD display to change from 0/1 to 1/1 records displayed etc)

The PQ-Box 200 has twice the sampling speed of the PQ-Box 150, and the PQ-Box 150 has twice the speed of the PQ-Box 100. Thus for the same recording duration, PQ-Box 150 Oscilloscope records will be twice the size of the PQ-Box 100 and PQ-Box 200 four time the size of the PQ-Box 100. File size is also proportional to the recording length. A typical PQ-Box 500 ms duration Oscilloscope record is approx. 220 kB, but a 4000 ms file from a PQ-Box 200 would be in the order of 6 MB.

## Transient Recorder – PQ-Box 200 only



The screenshot shows the configuration interface for the PQ-Box 200 Transient recorder. It is divided into four main sections:

- Voltage Trigger:** A table with columns for input (UL1, UL2, UL3, UNE), a checked checkbox, a threshold value (100), and the unit (V).
- Sample Rate:** Radio buttons for 200 kHz, 500 kHz, 1 MHz (selected), and 2 MHz.
- Transfer Trigger to:** Checkboxes for 'oscilloscope' and '10ms RMS', both of which are checked.
- Interval trigger:** A checkbox labeled 'Interval trigger' which is unchecked, and a numeric input field set to '10' with '[min]' next to it.

**Figure 9. PQ-Box 200 Transient recorder settings.**

The PQ-Box 200 (with T1 option – Transient Measuring circuit board) has transient voltage triggers that can be set in the range of 30 to 4000 V (The same trigger voltage setting is applied to UL1/UL2/UL3/UNE inputs). The maximum measured transient is +/- 5kV.



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Essentially the fundamental frequency is ignored, with the trigger looking for any voltage excursion exceeding the setting value.

Sampling rate of the recorder can be selected as 200 kHz, 500 kHz, 1 MHz or 2 MHz:

- 200 kHz sampling has fixed recorder time of 327 ms, with data values plotted at 5  $\mu$ s increments
- 500 kHz sampling has fixed recorder time of 130 ms, with data values plotted at 2  $\mu$ s increments
- 1 M Hz sampling has fixed recorder time of 65 ms, with data values plotted at 1  $\mu$ s increments
- 2 M Hz sampling has fixed recorder time of 30 ms, with data values plotted at 0.5  $\mu$ s increments

Each transient event requires approx. 0.5 MB per event for storage.

The Transient recorder can also be triggered by its own Interval timer trigger.

A useful feature is the ability of the Transient recorder to also trigger the Oscilloscope recorder and/or the RMS recorder, allowing an “overview” of the event. As the Transient recorder only captures voltage information, cross-triggering the Oscilloscope/RMS recorder can be useful if current information is also required.

In the ‘WinPQ mobil’ listing of Transient recorder events, the trigger type and triggered input will be shown with the date/time of the event:

- Voltage triggers are reported in the format ‘**Spike at ULx**’.
- Interval triggers are reported as ‘**Intervalltrigger**’.

## Ripple Control

Refer to Hints and tips Issue #4 for information on the operation of the different ripple control recorders.

## Summary of WinPQ mobil trigger descriptions

WinPQ mobil trigger description displayed	Trigger setting responsible	Osc	RMS	Trans
<b>Manual trigger</b>	Recording triggered by manual front panel key press	Y	Y	
<b>Intervalltrigger</b>	Recording triggered by set interval timer	Y		Y
<b>rising Edge</b>	PQ-Box 200 External trigger input detected rising edge	Y	Y	
<b>falling Edge</b>	PQ-Box 200 External trigger input detected falling edge	Y	Y	
<b>Cross trigger</b>	PQ-Box 200 Transient Event has been captured and optional “Transfer Trigger to 10ms RMS” and/or “Transfer Trigger to oscilloscope” has been enabled	Y	Y	
<b>Voltage dip ULx</b>	Lower threshold [%] setting exceeded	Y	Y	
<b>Overvoltage ULx</b>	Upper threshold [%] setting exceeded	Y	Y	
<b>Fast RMS change ULx</b>	Step [%] setting exceeded	Y	Y	
<b>Phase change ULx</b>	Phase Step [deg] setting exceeded	Y	Y	
<b>Envelope ULx</b>	Envelope [%] setting exceeded	Y		
<b>Lower threshold Ix</b>	Lower threshold [A] setting exceeded	Y	Y	
<b>Upper threshold Ix</b>	Upper threshold [A] setting exceeded	Y	Y	

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<b>Fast current change I<sub>x</sub></b>	Step [A] setting exceeded	Y	Y	
<b>Frequency event</b>	Under/Over frequency setting exceeded		Y	
<b>Frequency step</b>	Rate-of-frequency setting exceeded		Y	
<i>Where x= 1/2/3/NE as appropriate.</i>				