PQ Report: Centralized Power Quality Reporting

PQ Report is software solution that runs on top of ION Enterprise, power measurement software from Power Measurement, now part of Schneider Electric. PQ Report uses ION Enterprise as data collection engine. The main advantage of our solution is that we fully respect the dynamic nature of ION architecture. So PQ Report can automatically accommodate to changes in meter configuration that users can implement. Also we support all standard and user-defined devices that might be installed in ION Enterprise system.

PQ Report only works with ION database, we do not support real time data display. The PQ Report software consists of two distinct parts: interactive web interface and PQRepGen program for background report processing.

PQ Report is fully server based solution, no special software is needed on client workstations. Typically we only need one server for the whole power measurement system. This single server can collect data and process reports for hundreds of metering points and multiple concurrent users that display data on workstations over the web interface.

Parts of PQ Report project

PQ Report was originally designed in three parts:

- ION Data is web based interactive data plotting system.
- ION Events is web based event aggregation & analysis tool.
- ION Reports is web based report configuration and display system.

At this time the distinction between these components is less visible: we can display events in ION Data plots for example. The black dot on the data plot below is a disturbance and user can explode the details, including the wave forms, by clicking on the black dot.
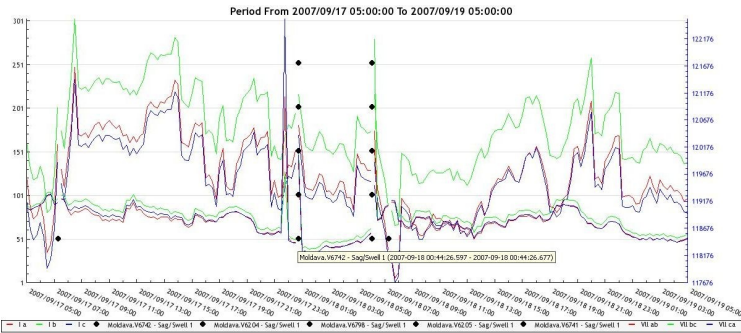
Interactive display of historic data

PQ Report uses the power of modern computers to plot data interactively. The data plots are always refreshed on the fly. User configures his own data plots using our interactive database explorer. The configuration tool is sophisticated enough to allow the user to define derived data using arithmetic operations, so data aggregation is easy. The time span for the plot can be set dynamically, users can use pre-defined time intervals like "current week", "week to date", "yesterday", "last month", etc. Events can be added to data plots – this feature integrates ION Data and ION Events parts of the project. Configured plots can be labeled with a descriptive name and saved for one-click instant plotting. Saved data plots belong to groups, each group can have its own or shared plots.

Users, groups and access control

PQ Report has its own administration. Administrators can define groups, users and access rights for users and groups. Administrator can also define which users and groups can share objects, like pre-defined plots and event definitions. Access control is role based. Each user interaction goes through access control check. Features for which the given user has restricted access are not displayed on user screen.

User groups have double purpose: they are used for access control and to organize and share user configured plots, event definitions and reports. One user can be a member of several groups.

Internationalization: interactive translation tool

PQ Report has a built-in translation tool, it is part of administration menu. All the features, menu items and texts of PQ Report have an English language name used internally in PQ Report software. For each name there is an alternative display text for each language. Users can add unlimited number of languages and provide alternative text for each language. This way PQ Report can speak unlimited number of languages. At this time we only support Czech and English, but users can do their own translations.

Event analysys and aggregation

PQ Report solves important problem: elementary events that originate in ION power meters are stored in database as flat list and are difficult to interpret, especially in big systems.

PQ Report contains a tool that allows the user to define his own event group definition. Event definition is a set of rules that allow for automatic event aggregation. PQ Report then automatically groups multiple elementary events into one. This group then takes the name and description of relevant event group definition. Users can define unlimited number of event groups. The result is that now users can see the list of event groups instead of elementary events. Since these event groups have descriptive user defined names, this list is much easier to interpret. The group definitions also contain the wave forms that are related to the events and users can view waveform plots right from event group list.

Event group list allows the user to display the elementary events and waveforms. This detailed view also have a graphic time line of related events that happened about the same time. This time line is interactive: using green arrows users can go one event back or one event forward to get a system-wide view of what happened elsewhere in about the same time. On this time line we can have a graph symbol meaning there is a waveform picture for this given event. Users can click this icon to see the waveforms.

Waveform and RMS displays

PQ Report automatically associates relevant waveforms with events based on user defined event group definition.

Waveforms are pre-processed under the hood, so we merge multiple waveform records from the same channel to one plot, and if there are multiple waveforms recorded back-to-back, they also appear as one. Waveforms taken on the same channel with different resolution triggered with overlapping time are treated correctly and plotted as single waveform as well.

Waveforms can also be plotted as RMS. User can configure to display both waveform and RMS for the same channel.

Waveforms and RMS graphs from different channels can be plotted on one plot or on separate plots one under the other.

The plot dimensions and axis ranges are automatically set based on data derived from the database, so waveform and RMP plots are displayed on single click.
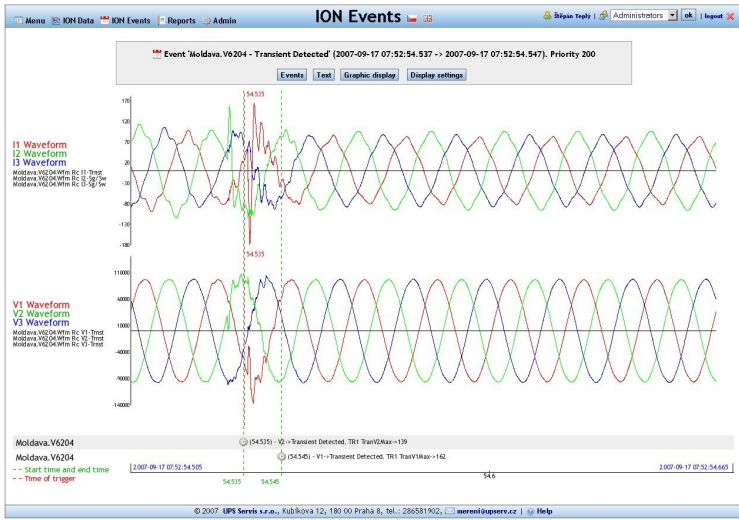
Report processing

The ultimate goal of PQ Report is to have a report editing system that would allow the user to draw his reports from dynamic text elements, data and waveform plots. Sample reports will be provided, so users can have a quick start for their creativity.

```xml
<?xml version="1.0" encoding="utf-8" ?>
- <Report type="PQ Report">
    <DataTemplate>7650_UPSSERV_PQ_V01</DataTemplate>
    <EvaluationTemplate>EN 50160</EvaluationTemplate>
    <GeneratedAt>2007/10/19 16:31:18</GeneratedAt>
    <StartTime>2007/09/08 00:00:00</StartTime>
    <EndTime>2007/09/15 00:00:00</EndTime>
    <Week>37</Week>
    <SourceMeter>KE_Stanicne.V373</SourceMeter>
- <Parameters>
  - <Parameter name="Frequency">
      <SystemFrequency>50Hz</SystemFrequency>
      <TimeStep>600</TimeStep>
    - <Data label="F_10m_Avg">
        <ExpectedRecords>1008</ExpectedRecords>
        <DefinedRecords>1008</DefinedRecords>
        <MissingRecords>0</MissingRecords>
        <FlaggedRecords>0</FlaggedRecords>
      - <Range High="1%" Limit="99.5%" Low="-1%">
          <In>1008</In>
          <Out>0</Out>
          <Score>100%</Score>
          <Result>Passed</Result>
        </Range>
      - <Range High="4%" Limit="100%" Low="-6%">
          <In>1008</In>
          <Out>0</Out>
          <Score>100%</Score>
          <Result>Passed</Result>
        </Range>
      </Data>
      <Result>Passed</Result>
    </Parameter>
  + <Parameter name="V-Magnitude">
  + <Parameter name="V-FastChanges">
  + <Parameter name="Flicker">
  + <Parameter name="V-Unbalance">
  + <Parameter name="Harmonics">
  + <Parameter name="Overvoltage">
  + <Parameter name="V-Dips">
  + <Parameter name="V-Interruptions">
  + <Parameter name="Interharmonics">
  + <Parameter name="MainsSignaling">
  </Parameters>
  <Result>Failed</Result>
</Report>
```

Today we only have a full Power Quality reporting system that is user configurable to support many reporting needs. This system is good enough to support the new edition of EN50160 standard to be approved in 2008.

Our PQ Reporter is based on two definition files, both are XML based:

- **Data Source Definition** file describes the data sources for each data channel used for each power quality parameter. We use our own special framework for ION7650 to collect our data, but the definition file can also use the standard factory PQ framework optionally delivered with ION meters by Schneider Electric. By deleting some processing sections in Report Definition file, we can report power quality data collected by meters with limited PQ capabilities, like ION7350.

- **Report Definition** file describes evaluation parameters for each data channel and for each PQ parameter. The definition is hierarchical — for example voltage magnitude is evaluated for each phase channel first and then as a whole for all voltage channels. Users can add processing sections to the definition to accommodate for complex evaluation requirements that utilities might have in their internal or country specific power quality standards.

Users can configure different report definitions each measured site, so we can have one report definition for LV, other for MV and yet another for high voltage.

The reports are processed in background by our "PQRepGen" program that runs under system account. The program takes both definitions, then starts to crunch the database data and saves ready reports. Unlimited number of reports can be processed in one run. The resulting reports are saved in the database as structured XML files. The database has some additional fields that allow for fast post-processing of saved reports. Resulting reports are dynamic: the resulting report structure reflects the report definition. The example of the final report in XML is shown on the picture, we used Notepad++ to highlight the XML structure.

The presentation of reports is easy because the hard work is already done in PQRepGen. Actually there can be many ways to present the same report, for example the report language can be changed interactively.

Currently we are presenting two types of user output:

- System Overview shows all the metering points and simply marks the sites as "passed", "failed" or "not processed" for each power quality parameter. This view is generated using the list of power quality analyzers configured in ION Management Console. If some of these meters are disabled, they are still in the list, but results are "not processed".

- Detailed report displays all power quality parameters for the selected site. This report is dynamic. So, for example, if user would want to add one more range for sag/swell depth, duration or both in his/her report definition, the presentation table in the report will change accordingly. Text description for each parameter is provided with the limits that were actually used for evaluation. These descriptions take data from the XML report and they always reflect the limits used for report processing.

Report printing

We have provided separate style for printing, so reports can be printed from the web browser and still look great on paper.

We recognize that correct printing is extremely important, so carefully formatted PDF output will soon be available as well.

Measurement interval flagging

Interval flagging is important feature for any power quality reporting system. Basically we need to flag intervals for frequency, flicker and some other when sags or swells are detected. This kind of flagging is defined in EN61000-4-30.
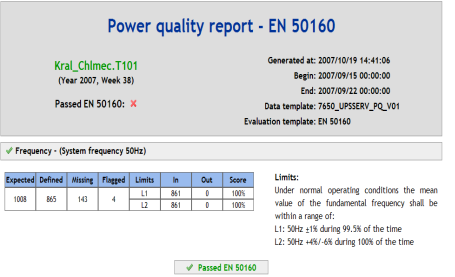
For real world PQ monitoring we also need to flag measurements for sites which are switched off for planned maintenance or other reasons.

PQ Report handles both flagging needs by storing separate data points for EN 1000-4-30 flags and user defined flags. The flags are simply zeros and ones recorded with the same time stamp as the data we want to use the flags with. The flags data sequences are part of Data Source Definition file. The matching between processed parameter and flags is done in Report Definition file. Users can define more then one flag sequence for each processed parameter, so both EN61000-4-30 flags and maintenance equipment shutdown flags can be handled using the same processing logic.

To facilitate the maintenance intervals flagging, we designed a web tool that allows the users to enter the equipment shutdown schedule manually. This schedule is a simple database table: it only contains description, start and end time stamps. This schedule is processed before we generate reports. The result of this processing is the flag data sequence that is then used during report generation the same way as meter-generated flags are used.

Power quality report - EN 50160

Kral_Chlmec.T101
(Year 2007, Week 38)

Generated at: 2007/10/19 14:41:06
Begin: 2007/09/15 00:00:00
End: 2007/09/22 00:00:00
Data template: 7650_UPSSERV_PQ_V01
Evaluation template: EN 50160

Passed EN 50160: ✗

Frequency - (System frequency 50Hz)

Expected	Defined	Missing	Flagged	Limits	In	Out	Score
1008	865	143	4	L1	861		100%
				L2	861		100%

Limits:
Under normal operating conditions the mean value of the fundamental frequency shall be within a range of:
L1: 50Hz ±1% during 99.5% of the time
L2: 50Hz +4%/-6% during 100% of the time

✓ Passed EN 50160

Back

Voltage magnitude - (System voltage 22kV)

	Expected	Defined	Missing	Flagged	Limits	In	Out	Score
V12	1008	865	143	4	L1	861		100%
V23	1008	865	143	4	L1	861		100%
V31	1008	865	143	4	L1	861		100%

Limits:
Under normal operating conditions the mean r.m.s. values of the supply voltage U shall be within the range of:
L1: 22kV ±10% during 95% of the time

✓ Passed EN 50160

✗ Flicker

	Expected	Defined	Missing	Flagged	Limits	In	Out	Score
Plt	84	73	11	3	L1	60	10	85.7143%
Pst	1008	865	143	4	L2	836	25	97.0964%
Plt	84	73	11	3	L1	61	9	87.1429%
Pst	1008	865	143	4	L2	835	26	96.9803%
Plt	84	73	11	3	L1	60	10	85.7143%
Pst	1008	865	143	4	L2	832	29	96.6318%

Limits:
Under normal operating conditions the long term flicker severity caused by voltage fluctuation P and short term flicker severity P should be within the range of:
L1: Plt ≤ 0.6 during 95% of the time
L2: Pst ≤ 0.8 during 95% of the time

✗ Failed EN 50160

✓ Voltage dips

V12

Depth d[%] / Duration t[s]	10ms ≤ t ≤ 100ms	100ms < t ≤ 200ms	200ms < t ≤ 500ms	500ms ≤ t ≤ 1s	1s < t ≤ 3s	3s < t ≤ 20s	20s < t ≤ 1min	1min < t ≤ 3min	t > 3min
85% < d ≤ 90%	0	0	0	0	0	0	0	0	0
70% < d ≤ 85%	0	1	0	0	0	0	0	0	0
40% < d ≤ 70%	0	3	1	0	0	0	0	0	0
5% < d ≤ 40%	0	0	0	0	0	0	0	0	0
d ≤ 5%	0	0	0	0	0	0	0	0	0

V23

Depth d[%] / Duration t[s]	10ms ≤ t ≤ 100ms	100ms < t ≤ 200ms	200ms < t ≤ 500ms	500ms ≤ t ≤ 1s	1s < t ≤ 3s	3s < t ≤ 20s	20s < t ≤ 1min	1min < t ≤ 3min	t > 3min
85% < d ≤ 90%	0	0	0	0	0	0	0	0	0
70% < d ≤ 85%	1	0	0	0	0	0	0	0	0
40% < d ≤ 70%	0	0	0	0	0	0	0	0	0
5% < d ≤ 40%	0	0	0	0	0	0	0	0	0
d ≤ 5%	0	0	0	0	0	0	0	0	4

V31

Depth d[%] / Duration t[s]	10ms ≤ t ≤ 100ms	100ms < t ≤ 200ms	200ms < t ≤ 500ms	500ms ≤ t ≤ 1s	1s < t ≤ 3s	3s < t ≤ 20s	20s < t ≤ 1min	1min < t ≤ 3min	t > 3min
85% < d ≤ 90%	0	0	0	0	0	0	0	0	0
70% < d ≤ 85%	0	1	0	0	0	0	0	0	0
40% < d ≤ 70%	0	0	0	0	0	0	0	0	0
5% < d ≤ 40%	0	0	0	0	0	0	0	0	0
d ≤ 5%	0	0	0	0	0	0	0	0	4

✓ Passed EN 50160