Author
Victor Bagge +46 735 09 86 12
victor.bagge@dlaboratory.com

Date
2020-02-27

Version
Revision 1

Document Type
White Paper

WHITE PAPER

Power Quality monitoring with dQuality

Victor Bagge
Senior Engineer, Electrical Transmission and Distribution
2020-02-27

CONTENTS

1 INTRODUCTION

dQuality is a power quality monitoring service that uses the dBox hardware platform to record and analyze PQ events, both in voltages and currents.

The current version of dQuality is 3.0, which is a major update, both in terms of functionality and performance. The measurement functions have been improved and verified to follow applicable standards, additional functionality has been added, and the user interface is even more versatile.

2 CONCEPT

dBox records voltages and currents in the substation and does the PQ-related calculations before the results are sent to the centralized database. The results are then accessed using dInsight, dLab's powerful tool for visualization of measurement results. This makes the data handling an integrated part of the product, as opposed to traditional hardware focused PQ instruments where obtaining the measurement results can be more time consuming.

3 FUNCTIONS

The power quality measurements are carried out according to IEC 61000-30-4 standard and conforms to Class S functionality and accuracy.

There are also a several functions included that are specified in the standard but are optional for fulfilling Class S, such as data flagging and flicker measurement.

3.1 VOLTAGE RELATED MEASUREMENT FUNCTIONS

Most of the voltage related measurements are done over 10 cycles (200 ms) and are aggregated over 3 seconds, 10 minutes and 2 hours respectively, all according to the standard.

The 3-second values (also called 150/180-cycle aggregation) are used for testing purposes and the 2-hour aggregation is mandatory only for the flicker measurement.

3.1.1 VOLTAGE LEVEL

The voltage level is evaluated on 10-minute basis and compared to the nominal level and the limits according to the chosen standard. Values outside the limits are flagged.

3.1.2 VOLTAGE UNBALANCE

Unbalance between the three phases creates a negative sequence current that can cause premature aging of electric motors and other negative consequences. The negative sequence voltage is compared to the positive sequence voltage to get an unbalance ratio in percent.

3.1.3 VOLTAGE VARIATIONS

The voltage variation measurement includes dips, swells, rapid changes and interrupts. The waveform of each recorded event can be viewed, refer to chapter 5.1.2 for more information.

3.1.4 FREQUENCY STABILITY

The system frequency is monitored on 10-second basis, as demanded by the standard.

3.1.5 FLICKER

Flicker is optional for fulfilling Class S but is widely demanded when it comes to PQ measurements. dQuality measures flicker according to the standard.

3.1.6 HARMONICS

The voltage harmonic content is measured up to the 40th harmonic (2 kHz) according to the Class S requirements. The total harmonic content (THDF) is also monitored.

3.2 CURRENT RELATED MEASUREMENT FUNCTIONS

3.2.1 HARMONICS

For the currents, the harmonic content is analyzed even if there are no requirements to do so according to the standard. However, the standard does cover the measurement method for currents if the measurement is carried out.

A big advantage of analyzing the current harmonics is that the source of harmonics is easier to find, since the harmonic content will be different in different feeders. This is not visible when monitoring the harmonic content of the busbar voltage.

The observed harmonic content of the current is often much higher than the harmonic content of the voltage, but this is not a problem until the levels are high enough to influence the voltage harmonics so that they reach the threshold of what is acceptable.

3.2.2 POWER AND PHASE VECTORS

Since measurements of both voltages and currents are made, the calculation of power and phase vectors is a simple task. These measurements are useful in multiple ways, for example to monitor reactive power on individual feeders. In most substations and SCADA systems, only a limited number of feeders in a medium voltage grid have power monitoring since it has not been needed before.

With increasing amount of cables, the reactive power generation, especially in low load conditions, is an increasing issue where the DSO might need to pay penalty fees to the TSO for pushing reactive power upstream or getting undesirably high voltages.

With dQuality, active and reactive power measurements are available from all feeders without adding separate measurement converters in the substation and/or reconfiguring of the SCADA system. In Figure 1 an example of the power measurement of a single feeder is shown.

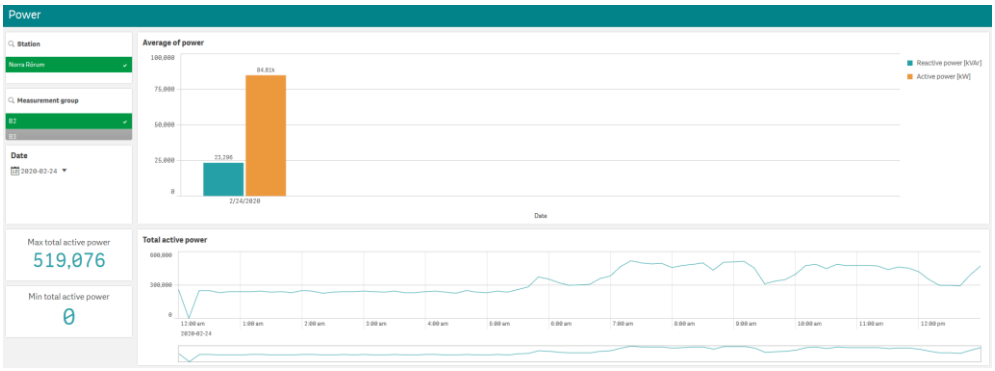

Figure 1: Power graphs for a feeder of a substation. An average over the chosen time is shown in the bar graph, and the 10-minute values are shown in the line graph.

3.3 OTHER FUNCTIONS

3.3.1 DATA FLAGGING

In the case of a detected voltage dip, swell or interrupt, the data values during the event are flagged. The reason is to be able to know if a data value for any other measurement might be flawed due to the voltage deviation present.

3.3.2 DATA MARKING

Data marking (data quality check) is now fully supported. The data flagging described in chapter 3.3.1 is a part of the data marking together with other data quality aspects, such as when the measurement values are outside limits or when an input signal is too low to be measured.

3.3.3 LINKING OF POWER QUALITY EVENTS TO INCIDENTS

When dQuality has identified a power quality event, a check if dAnalyzer has recorded and categorized an incident at the same time is carried out. If there is one or more incidents at the same time as the power quality event, these are presented together with the power quality event since the root cause most probably is the same for these events. In Figure 2 the listing of related incidents is shown.

Summary of number of voltage dips

Start time	Length [s]	Category	Amplitude [%]	Nominal voltage	File	Related incidents
2020-02-22 11:24:10	0.10	A	48.3	11000	Comtrade	T_F15_2020-02-22_...
2020-02-22 11:24:10	0.10	A	48.3	11000	Comtrade	
2020-02-20 13:01:08	0.03	A	60.6	11000	Comtrade	T_F15_2020-02-20_...
2020-02-20 13:01:08	0.03	A	60.6	11000	Comtrade	T_F15_2020-02-20_...
2020-02-20 13:01:08	0.03	A	60.6	11000	Comtrade	
2020-02-20 13:00:52	16.49	C	0.0	11000	Comtrade	T_F15_2020-02-20_...

Figure 2: List of voltage dips. Note the right-hand column showing related incidents identified by dAnalyzer.

The ease of integration between dQuality and dAnalyzer shows the strength of software-based analysis that shares the same hardware and platform.

4 IEC 61000-4-30 CLASS S

All measurement functions have been tested and verified to conform to the Class S standard. This includes the measurement intervals and aggregation. All mandatory functions are included, and most of the optional functions as well, as described in chapter 3.

5 INTERFACE

The user interface of dQuality 3.0 is a part of dInsight, which is based on Qlik Sense for maximum flexibility and ease of use. All power quality data and results gathered over time is available for reviewing with just a few clicks.

5.1 DASHBOARDS

There are multiple dashboards available for the different PQ measurement functions.

5.1.1 REPORT DASHBOARD

The first dashboard gives a summarized report of the power quality status of one or more substations. Figure 3 hows an example of the report dashboard.

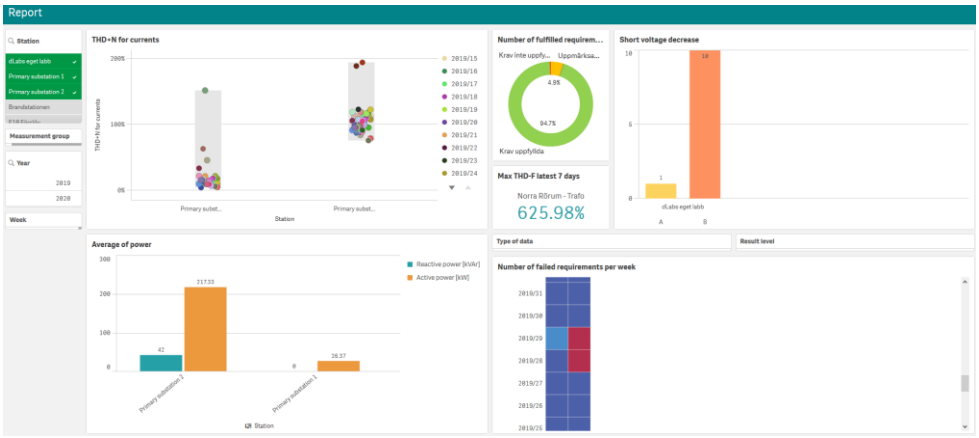

Figure 3: Report dashboard

A quick overview of voltage variations, fulfillment of requirements, power and total harmonics is available in the report dashboard, and the fulfillment heat map can be customized to show the measurements of choice.

5.1.2 DETAILED DASHBOARDS

Separate dashboards are available for the different power quality measurements such as voltage level, harmonics etc. In Figure 4 the frequency stability dashboard is shown.

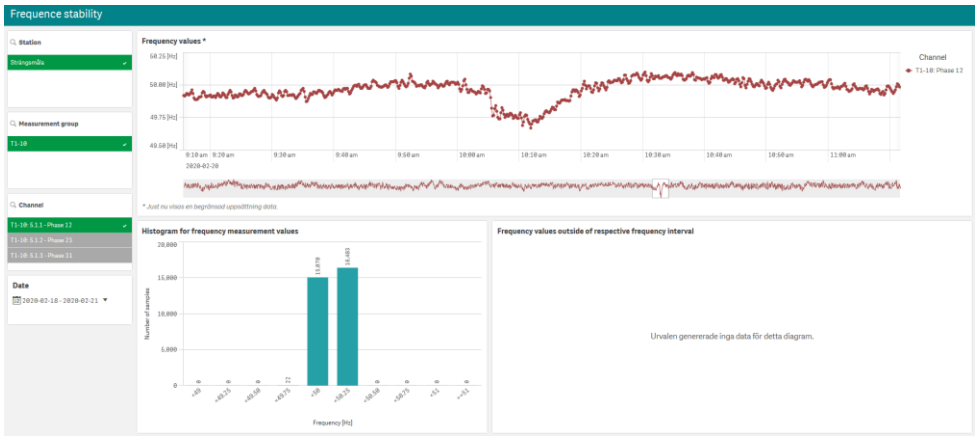

Figure 4: Frequency stability dashboard

The different graphs can be shown in full screen and the date interval can be chosen to fit the needs at hand.

Figure 5: Voltage variations dashboard viewing the waveform of a voltage dip

For voltage variations, the waveform of the event can be shown in a separate graph with just a single click. Refer to Figure 5.

5.2 REPORTS

dQuality 3.0 can produce power quality reports on different formats, depending on which standard of requirements the report is based on.

The report clearly states if each measurement is OK or NOT OK, and what requirements that were not met in case of a failed report.

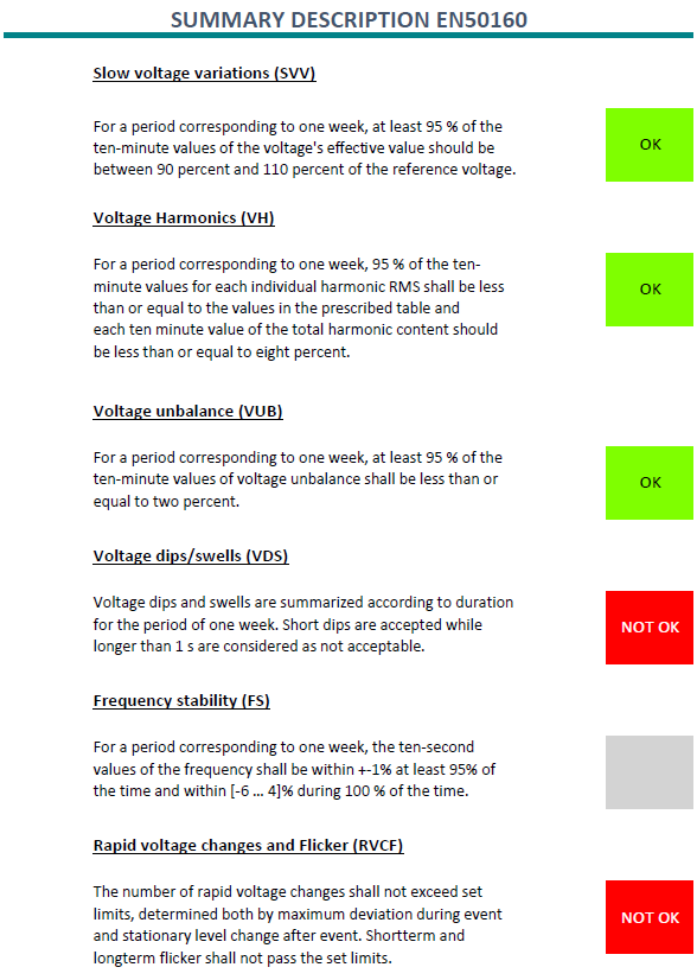

Figure 6: Summary page of the EN50160 weekly report.

5.2.1 EN 50160

The European requirements for power quality are described by the EN 50160 standard where limits and measurement intervals are defined.

5.2.1 EIFS 2013:1

This is the Swedish standard for power quality requirements. It is based on the European standards with some deviations.

6 BENEFITS/SUMMARY

Power Quality issues are of increasing interest for both grid operators and customers. dQuality provides power quality measurements meeting the increasing demands of monitoring of grid conditions to ensure a stable energy distribution.

dQuality fulfills the requirements of IEC 61000-4-30 Class S standard and includes optional further functions as well, such as flicker monitoring and current measurements. Reports fulfilling the EN 50160 and EIFS 2013:1 standard are available.

The integration of dQuality with dAnalyzer incident analysis gives a convenient way to link disturbances and resulting power quality events together.

dInsight is a powerful and versatile tool to handle and get an overview of the power quality data gathered by dBox and analyzed by the dQuality software module. The dashboard-based layout combined with powerful filtering and sorting functionality makes the information easily available to users.

7 REVISION HISTORY

Revision	Date	Description
1	2020-02-27	First version