Guidelines of Good Practice – VQM:

Voltage Quality Disturbances and Indices, Reporting the Results

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Voltage Quality Disturbances and Indices

Contents

- Disturbances
- Characteristics
  - ✓ Voltages to be used for evaluation
  - ✓ Continuous phenomena
  - ✓ Flagging
  - ✓ Voltage events
- Indices
  - ✓ Continuous phenomena
  - ✓ Voltage events
  - ✓ Indices for benchmarking
- Recommendations

Voltage Quality Disturbances and Indices

Disturbances

The voltage quality **disturbances** that are treated in the European voltage characteristics follow the **standard EN50160**

Continuous phenomena

- ✓ Supply voltage variations
- ✓ Flicker
- ✓ Voltage unbalance
- ✓ Harmonic voltage
- ✓ Interharmonic voltage
- ✓ Mains signalling voltage
- ✓ (Frequency)

Voltage events

- ✓ Interruptions
- ✓ Voltage dips
- ✓ Voltage swells
- ✓ Single rapid voltage changes
- ✓ Transient overvoltages

Voltage Quality Disturbances and Indices

Characteristics

- Voltages to be used for evaluation

In a **three-phase system**, the phase-to-phase, the phase-to-neutral or the phase-to-ground voltages can be measured. However, it is recommended:

Solidly-grounded low voltage networks

- ✓ Phase-to-neutral

All other cases

- ✓ Phase-to-phase

Voltage Quality Disturbances and Indices

Characteristics

- Continuous phenomena

  - ✓ For flicker, voltage unbalance, harmonic voltage, interharmonic voltage, and supply voltage variations the characteristic is, according to EN 61000-4-30, **calculated over a 10-minute interval, using specific time-aggregation rules**.
  - ✓ The standard also allows for **shorter periods**, for example 1-minute.
  - ✓ It is also recommended calculating characteristics over **shorter intervals** (1-cycle or 10-cycle). Especially for supply voltage variations such information is important for understanding the **causes of limits being exceeded**, for **explaining certain equipment problems**, and for the setting of future limits.

Voltage Quality Disturbances and Indices

Characteristics

- Flagging

  The following is considered as good practice:

  - ✓ Flagged 10-minute values (or 1-minute values in case these are used) **should be removed** from the statistics for flicker, voltage unbalance, harmonic voltage and interharmonic voltage.
  - ✓ The same holds for 10-minute or 1-minute values during which a transient or a single rapid voltage change occurs.
  - ✓ For **supply voltage variations only flagged values due to interruptions should be removed**. All other values, included flagged values due to voltage dips, etc, should be included in the calculation of the indices.

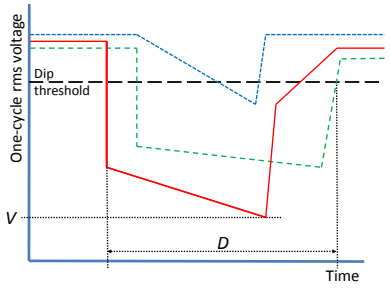
Voltage Quality Disturbances and Indices

Characteristics

- Voltage events
  - ✓ Dips
  - ✓ Swells

EN 61000-4-30

- ➢ Lowest residual voltage
- ➢ Maximum swell voltage
- ➢ Event duration



- Threshold
  - ➢ **Dips**: 90% of nominal voltage (LV and MV) or 90% of sliding reference voltage (HV and EHV)
  - ➢ **Swells**: 110% of nominal voltage (LV and MV) or 110% of sliding reference voltage (HV and EHV)

Voltage Quality Disturbances and Indices

Indices

- Continuous phenomena
  - ✓ From the 1-minute or 10-minute values recorded over a longer period (e.g. one week or one year) **one or more statistical indices** can be obtained.
  - ✓ The **average** value would be an obvious choice, but the average **is rarely** a good indicator for voltage quality.
  - ✓ More appropriate is to **use high-percentile** values like 95% or 99%, as is the case of EN 50160.
  - ✓ Several countries **report** specifically when a **site does not comply** with the requirements.
  - ✓ In other countries, voltage-quality **indices** are calculated based on the **number of sites and weeks not complying** with the requirements.

$$I_{KEE} = \frac{\sum_{i=1}^{N}(N_i - W_i)}{\sum_{i=1}^{N} N_i}$$

Voltage Quality Disturbances and Indices

Indices

- Voltage events

✓ Dips

Residual voltage u %	Duration t ms				
	$10 \le t \le 200$	$200 < t \le 500$	$500 < t \le 1\,000$	$1\,000 < t \le 5\,000$	$5\,000 < t \le 60\,000$
$90 > u \ge 80$	CELL A1	CELL A2	CELL A3	CELL A4	CELL A5
$80 > u \ge 70$	CELL B1	CELL B2	CELL B3	CELL B4	CELL B5
$70 > u \ge 40$	CELL C1	CELL C2	CELL C3	CELL C4	CELL C5
$40 > u \ge 5$	CELL D1	CELL D2	CELL D3	CELL D4	CELL D5
$5 > u$	CELL X1	CELL X2	CELL X3	CELL X4	CELL X5

✓ Swells

Swell voltage u %	Duration t ms		
	$10 \le t \le 500$	$500 < t \le 5\,000$	$5\,000 < t \le 60\,000$
$u \ge 120$	CELL S1	CELL S2	CELL S3
$120 > u > 110$	CELL T1	CELL T2	CELL T3

Voltage Quality Disturbances and Indices

Indices

- Indices for benchmarking

✓ A **set of indices is proposed** for benchmarking the performance of different network operators and of different countries, based on:

- Absolute values
- Average values and percentiles

✓ Additional indices can be used, based on compliance with **national** regulation

Voltage Quality Disturbances and Indices

Recommendations

- **All disturbances as listed in EN 50160 should be monitored**. The lack of standardised measurement methods for some disturbances makes benchmarking impossible, but does not prevent feedback to network operators and NRAs on the performance of the network.
- **Follow the standards** wherever possible.
- **Use a broad set of characteristics and indices, beyond what is used for reporting or benchmarking.** There is no need to be limited to standard methods, but standard methods should be included.
- Use **commonly-agreed indices** for benchmarking.

Reporting the Results

Contents

- The need for VQ data
- Reporting and publishing data
- Details of data to be reported
- Criteria of aggregation
- Frequency of reporting
- Methods of reporting
- Comparative publications
- Usability of data
- Recommendations

Reporting the Results

The need for VQ data

- **NRAs**
  - ✓ System performance monitoring, resolution of conflicts between TSO/DSO and customers…
- **Network operators**
  - ✓ Knowledge of VQ in their networks and its development
- **Individual network users**
  - ✓ Mainly the VQ at their own connection point is of interest
- **General public and other stakeholders**
  - ✓ Trends in the (national) VQ or the regional levels of VQ
- **Research and education institutions**
  - ✓ Extensive raw data sets for studies

Reporting the Results

Reporting and publishing data

- Ensure a **uniform manner** of reporting data
- Adopt a **centralised approach** to data collection
  - ✓ Preferably the NRA should function as the central database for all data
- **Completeness and plausibility** of collected data must be ensured by TSOs/DSOs
- **NRA** should **publish** results **regularly**
  - ✓ At least at a national level to increase awareness of VQ
- Include additional useful information and analysis in publication
- Publication of data as a **regulatory instrument**

Reporting the Results

Details of data to be reported

- Publication of VQ data on a national or regional level
  - ✓ Use indicators as proposed in previous section
  - ✓ Include analysis of data in publication
  - ✓ Consider privacy of some customers
- Publication of raw VQ data
  - ✓ No analysis of data is required
  - ✓ Consider privacy of individual customers
- Reporting to individual customers on their connection point
  - ✓ Raw VQ data
  - ✓ Include analysis of raw data

Reporting the Results

Criteria of aggregation

- A “static” database listing specific **basic parameters** of each **monitoring site** in the VQM program is required:
  - ✓ type of network (cable / overhead / mixed)
  - ✓ length of network cables
  - ✓ type of system earthing (isolated neutral/ compensated)
  - ✓ voltage level (EHV / HV / MV / LV)
  - ✓ type of customer (household / small business / industrial)
  - ✓ DSO (all / only largest / only smallest)
  - ✓ different regions (urban / suburban / rural)
  - ✓ distributed generation (present / high / low / absent)
  - ✓ degree of customers with self generation (yes / no)
- Enables correlation of VQ disturbances and basic parameters

Reporting the Results

Frequency of reporting

- Publication of aggregated VQ data for general public
  - ✓ Frequency should be **at least once a year**
- Publication of aggregated raw VQ data for use by universities and other research institutions
  - ✓ Frequency should be **once a month** if possible
- Publication of individual data upon request by the customer
  - ✓ Frequency should be agreed ex-ante between network operator and the individual customer
  - ✓ Frequency should be at least once a month, but preferably daily or after every major VQ disturbance

Reporting the Results

Methods of reporting

- The **internet** is probably the most powerful way for publication of annual reports as well as raw data (if required with limited access)
  - ✓ Website of NRA
  - ✓ Websites of TSOs/DSOs
- Periodic reports on paper

Reporting the Results

Comparative publications

- Two purposes for benchmarking performances:
  - ✓ Pushing improvements / investments in networks
  - ✓ Providing preliminary information to customers
- Benchmarking is only advisable if data is reported in a **uniform manner** (and thus comparable)

Reporting the Results

Usability of data

- To enable analysis of (aggregated) VQ data, their “usability” is of paramount importance
- Statistical time-efficient data analysis is facilitated by a **common data format**
- Attention should be paid to **interoperability and scalability** of systems

Reporting the Results

Recommendations

- It is recommended that the **NRA publishes the main results from the program**, including compliance with voltage quality regulation and important trends, in a report **at least once a year**.
- Next to these reports, **data should be made available** to other stakeholders, including the general public.
- **Where no objections** from individual network users or other important objections exist, **all data should be made available** for free or at a reasonable cost, **for research and education purposes**.

Thank you for your attention!

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