Study Committee C4 PS 1

Challenges and advances in power system quality (PQ) and electromagnetic compatibility (EMC)

Paper 10818

Swedish voltage quality regulation development for the challenges imposed by the energy transition

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Motivation

- The energy transition imposes several challenges on the power system in general and the voltage quality in particular. Electrification of industrial processes and the transport sector, larger share of renewables, and more devices connected through power-electronic converters will have a significant impact on the voltage quality.
- This article consists of a literature study with recommendations on how to develop the regulation on voltage quality taking into consideration the challenges imposed by the energy transition.

The Main Findings of the Study

A brief description of the literature for some of the voltage quality parameters:

- The energy transition causes more supply voltage variations. This combined with more sensitivity in new equipment decreases the hosting capacity for renewables.
- The voltage harmonic levels are not increasing in the power system at the moment but many stakeholders do expect them to due to the increasing number of devices emitting harmonics.
- The threshold limits for voltage unbalances should be altered to the specific voltage level.
- Voltage dips are a controversial topic to both customers and network operators.
- Voltage swells needs further attention in research studies.
- Rapid voltage changes and their relation to lamps remain significant.
- Voltage transients remain unexplored and is currently not included in the regulation.

Literature Study and Proceedings of Work

- The literature study outlines contemporary research for each of the voltage quality parameters and describe how each parameter best could be regulated given the particular circumstances of research results and the parameter is affected by the energy transition.
- The literature study is also combined with statements made by a reference group consisting of stakeholders from industry, member organizations and consultants.

Discussion

- The main findings of the study are recommendations on how the regulation could be developed. These recommendations are taken into account by the national regulatory authority (NRA) in the ongoing analysis and the regulatory process.
- As an important example in the regulatory process the consequene analysis should be mentioned. That step weighs the cost and the benefits from introducing a voltage quality parameter in the regulation. In order for a voltage quality parameter to be introduced, there should be a clear societal value associated with doing so.

Conclusion

The main recommendations for regulatory development concerns voltage harmonics, voltage dips, rapid voltage changes, interharmonics and supraharmonics. Other general recommendations concerning all the voltage quality parameters are also given and also minor changes that would improve communication between network operators and customers.

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Recommendations for Regulatory Development

- Each of these sections summarizes the recommendations for regulatory development. The recommendations are weighted assessments of the literature study, the statements made by the reference group and the expertise of the group performing the study. These recommendations have been given to the NRA and will be a part of the ongoing regulatory process.

Voltage harmonics

- The harmonic voltage, for every harmonic order, for one or more phase-to-neutral (less than 1 kV nominal voltage) or phase-to-phase (1 kV and above) voltage, should be less than the corresponding limits. For customers connected to low voltage (LV) the recommendation is that the limit for harmonic 15 be increased from 0.5% to 1.0% of fundamental; the limit for harmonic 21 is recommended to be increased from 0.5% to 0.75% of the fundamental. This change is based on limits in a recent revision of EN 50160.
- For customers connected to higher voltage (HV) levels the recommendation is that the limit for THD is reduced from the existing limit of 8%. The limit should be selected to provide a necessary margin between LV and HV levels.

Voltage dips

- The regulatory text is recommended to be improved as the current formulation often leads to misunderstandings and does even make communication between network operators and their customers difficult.
- The Swedish regulation on voltage dips is rather different from EN 50160 and from regulation in other countries. Voltage dips are to be characterized through residual voltage and duration as in IEC 61000-4-30, Class A. Different rules apply based on characteristics of the dip (defined as zones A, B and C, see article) for customers connected to voltage levels up to 45 kV. The same principle holds for higher voltage levels, but with different borders between the zones. For the discussion in this article, it is only necessary to understand the implications from each zone rather than their exact definitions, hence only information on the implications is included here.

Voltage dips (continued)

- It is recommended that the meaning of Zone B is clarified further. The occurrence of voltage dips within this zone can sometimes not be prevented by network operators which does not necessarily imply that the network is deficient, but neither that the supply is of good quality.
- Dips with less than 40% of residual voltage and duration less than 100 ms, due to short circuits at higher voltage levels is recommended to be classed as Zone A also for customers connected at LV and MV. The technology currently used at such voltage levels, results in fault-clearing times that are typically around 100 ms. Fault-clearing time much less than this would require a large technological development. Therefore, it is considered unreasonable to require voltage dip durations (and thus fault-clearing times) less than 100 ms.

Rapid Voltage Changes

- It is recommended that the regulatory text makes a distinction between individual and continuous RVC. In addition, continuous RVC (light flicker) should be specifically addressed. Specific limits for continuous RVC are recommended to wait for immunity requirements on LED lamps in international product standards.
- It is recommended to better clarify that what is currently referred to as a limit for the number of individual RVC, is a limit on the sum of individual RVC and voltage dips.

Interharmonic and Supraharmonic

- It is recommended that interharmonics and supraharmonics are specifically mentioned in the Swedish decision, without specific limits.

General Recommendations

- A few general recommendations were made regarding for instance how some of the parameters should be measured, and further harmonization with the standard EN 50 160. It is also recommended that the Swedish NRA Ei should continue the inclusive discussion regarding the regulation, the acceptance and the applicability increases if all stakeholders understand the regulation and the motivation behind possible changes.