PQA NEWSLETTER

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Power Quality Benefits for Distribution Network Service Provider Customers

Why PQ matters

Introduction

The core business of electricity distributors is to supply customers with access to electrical power of an appropriate quality. Quality of supply encompasses:

- Customer service
- Reliability (planned and unplanned interruptions and momentary interruptions) and
- Power quality - steady state voltage range, waveform distortion, voltage fluctuations/flicker, voltage sags, voltage swells, oscillatory and impulsive transients

Regulators have focussed on reliability as one aspect of the quality of supply. This is because it is measurable and they see a clear link between network expenditure and reliability. However, there is also a strong link between network expenditure and power quality. At the planning stage, such things as substation placement, feeder length, conductor sizes, customer connection restrictions and voltage regulation policy all have an impact on power quality. At the design phase, conductor size, feeder length, surge arrester installation, capacitor bank installation all contribute to power quality. Other network operating costs are also affected as power quality needs to be considered in:

- Protection settings and design (keeping sags as short and infrequent as possible, by only tripping when necessary and having appropriate clearance times)
- Customer service and installation rules (for example, requirements on starting of air conditioner motors, compliance with harmonic equipment standards in order to manage emissions and immunity)
- Network operation - capacitor bank switching, reclosing, transformer energisation, fault level management (for example, low fault levels can exacerbate harmonic distortion and voltage fluctuations)

Obligations of the Distribution Network Service Providers

Distribution Network Service Providers have an obligation to provide a continuous sinusoidal voltage waveform of the agreed magnitude to their customers. This obligation is enshrined in the National Electricity Rules as well as various state and territory laws and regulations. However, even in the best of regulated networks, things can go wrong. Emissions such as waveform distortion or voltage fluctuations can develop in customer equipment, network equipment or can propagate from transmission networks. The resilience of the network and customer equipment to such emissions depends on the level of immunity of the equipment. Managing the compatibility between emissions and immunity is a constant challenge for all distribution network service providers.

Dangers and Risks

Poor power quality can affect network equipment as well as customer equipment and processes. Modern distribution networks contain a plethora of components which can fail, degrade or operate incorrectly when power quality is poor. Such things as relays, resistors, rectifiers, integrated circuits as well as motors and power transformers (large and small) have limited immunity to disturbances. Some disturbances are very obvious to the customer and network service provider, causing equipment failure or maloperation, and immediately resulting in customer complaints. Others can be invisible without careful monitoring and measurement. High harmonic levels or sustained overvoltage for example may shorten the life of some equipment. The effect of this is an increase in cost to the asset owner – which could be the network service provider or the customer.

The Value of Good Power Quality

It makes sense to have good policies and procedures in place to manage power quality at the planning, design, operation and maintenance phases of the network business. A key component in this management is the collection and analysis of appropriate data. Timely analysis of the right data creates information which can be used by the asset owner to make wise choices. The potential budgetary impact of these choices is huge. Under expenditure on power quality exposes the organisation not only to non-compliance risks but also to the need for expensive retrofitting of mitigation measures. Conversely over expenditure on power quality can have a detrimental effect on the 'bottom line', eroding profits.

2015/2016 PQCA National Report

The results are in

The 2015/2016 PQCA National Report is complete and has been distributed to participants. 2015/2016 saw another marked increase in the number of LV sites, with LV site numbers in the main report increasing from about 4,200 sites in 2014/2015 to about 8,800 sites in 2015/2016. The number of MV sites has remained steady at around 275 sites. For LV sites, the distribution of strong and weak sites is much improved compared to 2014/2015 largely due reclassification of sites by participants. For LV sites, 39% of sites still do not have a predominant load type classification supplied by participants. Supply of this data offers a potential area for improvement by allowing enhanced factor analysis. The disturbances of concern remain much the same as previous years although average trends indicate improvements in performance for most disturbances.

The majority of Australian DNSPs remain involved in the PQCA and with ever increasing numbers of sites, the value of the PQCA to participants is increasing. Recent developments now allow participants to use data directly from PQCA reports in internal PQ briefings as well for regulatory reporting. Continued research into the economic impacts of PQ is giving participants the tools that they need to develop and justify PQ related projects.

Harmonic Allowances for Embedded Generation Connected to the Sub-Transmission System

A Novel approach to a very topical issue

Solar farms are becoming larger and more common in Australia. Installations of up to a couple of hundred MW connected to the 132 kV system are being studied at present. Of the many connection issues, one which is poorly described is that of harmonic management - the determination of the harmonic limits of the installation in order to keep harmonic voltages compliant with planning levels.

The determination of a harmonic allocation for a new load can be divided into three major steps:

1. Determination of harmonic voltage to be allocated
2. Determination of harmonic impedance at the point of connection
3. Determination of harmonic current to be allocated by dividing 1. by 2.

Steps 2 and 3 are relatively well-defined although there can be some problems in step 2 when there are shunt capacitors, long transmission lines or many contingencies to be studied. The major concern is step 1 and this will be the one described below. Subsequent to the allocation process is the compliance assessment which needs to be carried out to ensure that the allocated limits are met.

Harmonic allocation in sub-transmission systems is given some coverage in TR IEC 61000.3.6. The methods discussed are very complex, and involve the calculation of so-called transfer coefficients between each of the relevant nodes for every significant power system contingency. There is no utility known that uses this method because of the difficulty of collecting all the data, the lack of precision in the standard and the need for powerful computer programs. There are some other issues with 61000.3.6 which make it unsuitable for this task.

a. It does not treat embedded generation (EG), which is a distorting load additional to the passive load.
b. There is no mechanism for dealing with the future uncertainties of EG.
c. It is assumed that the system has been consistently managed using 61000.3.6 principles so that the present harmonic levels give a suitable margin for reasonable allocations to future loads. In fact there are parts of the sub-transmission system having harmonic voltages very close to planning levels at some frequencies, leaving little or no margin to be allocated to future passive loads or generation.

A new method has been developed called the "Headroom approach" to take the above concerns into account. The two main aspects of it are:

- Measurement to establish present harmonic levels: measurements need to be taken at the appropriate part of the power system and for a suitable length of time. Where there are strong seasonal variations, it might be possible to correct short-term readings to compensate. From measurements the headroom to the planning level can be determined with an appropriate allowance for diversity.

- Representation of future embedded generation by a probabilistic curve: this allows a proper balance between the allocations for highly likely near-term load and generation and long term uncertain EG which, depending on technical, economic and political factors, might not ever be connected.

As with the 61000.3.6 approach, a number of approximations and assumptions need to be made in the analysis. An advantage of the Headroom approach is that it is self-correcting. For a subsequent allocation, the process starts with a new measurement of the harmonic levels which leads to a recalculation of the harmonic margin. This can be compared with the present 61000.3.6 approach where assumptions made are never tested against actual harmonic levels, with the possibility of errors growing at each allocation step.

The use of prior measurements in harmonic allocation is not new. It was a key component of Australia's former harmonic standard AS2279.2 and it is part of the UK's present Engineering Recommendations G5/4. It seems strange that the measurement step is missing from the present TR IEC 61000.3.6 whose aim is keep harmonic voltages within planning levels but without actually checking their values. The IEC harmonics committee seems to have ignored that harmonic monitors are becoming less expensive and that routine monitoring is increasingly becoming an important part of the management of PQ levels in networks.

At some sites where harmonic levels are high, the headroom can be impractically small or even negative. TR IEC 61000.3.6 states that an allocation no smaller than 0.1% voltage should be given. The principle of a minimum allocation is sound but the choice of 0.1% seems to be arbitrary and could lead to non-compliance at high harmonic orders where the planning levels are very low. A new approach has been developed based on the idea that:

- A new connection should not be made to suffer unduly for a problem that is already in the network
- As it is not possible to completely remove a particular harmonic current component, some allocation is better than no allocation.
- An installation that causes the harmonic voltage to rise by a sufficiently small fraction of the planning level is unlikely to worsen the harmonic situation significantly.

Based on the above, a simple process has been detailed for determining minimum harmonic voltage allocations in situations where harmonic levels are already high.

Latest PQCA Proposal Issued

Continued innovation

Proposals for continuation of the PQCA for the 2016/2017 and 2017/2018 financial years have been issued to participants. These proposals seek to build on the solid foundation of the PQCA to date. Recent developments with smart metering have seen the numbers of sites contributed to the PQCA project skyrocket. This trend is expected to continue. The increase in site numbers increases the statistical confidence in the outcomes of the survey further adding value to participants. However, developing techniques that make best use of the data available and allow for easy visualisation continue to be a challenge for PQCA staff. Key focusses for the next two years include:

- Further development of algorithms relating disturbance levels to an economic impact. This feature has been included for voltage sags and reliability. It is hoped that an ASTP project which is currently underway to investigate the effect of voltage level on equipment life can be incorporated into the PQCA.

- Further development of the PQCA online platform. With the rapid increase in site numbers, techniques of visualising very large data sets are becoming vital. Enhancement and redevelopment of the PQCA Online platform is slated for the next 12 to 18 months. Once completed this update should improve the user experience and also allow increased flexibility of data visualisation.

PQA Organises Second TNSP PQ Forum

TNSP staff meet to discuss PQ

Following the success of the first PQ Forum held in 2016, where all TNSPs from Australia and New Zealand participated to present their PQ activities, PQA issued proposals inviting the TNSPs to join a national PQ benchmarking campaign. As a result of this, while several TNSPs are still considering this invitation subject to the progress of their internal PQ monitoring programs and deployment of PQ monitoring programs, three TNSPs (TransGrid, TasNetworks and Electranet) have already joined the benchmarking program.

With a view to report on the progress made by the various TNSPs in their PQ activities, a 2nd PQ Forum was held on the 21st February this year at TransGrid Offices. The agenda for the day included presentations by TransGrid, TasNetworks and Electranet on their ongoing PQ activities and challenges. An update on the DNSP and TNSP PQ auditing and benchmarking activities undertaken by PQA was provided together with the ongoing activities on PQ economics. The challenges associated with the use of existing IEC methodologies (eg. IEC61000.3.6, 3.7, 3.14) in PQ allocation (harmonics, flicker and voltage unbalance) by the TNSPs and DNSPs were discussed and a progress report on the ongoing activities at CIGRE working group level involving members of PQA were summarised. It was evident that the increasing number and capacity of solar farms are posing significant challenges in the PQ management of networks which were not built for that purpose.

It was evident that PQ compliance is crucial for all TNSPs (and DNSPs) and hence PQA will vigorously engage in discussions with those TNSPs who are yet to join the national PQ benchmarking campaign.

The forum concluded with a proposed to hold a 3rd TNSP PQ Forum in Hobart.

PQ Management in Transmission and Distribution Systems in Sri Lanka

Taking Australian expertise to the world

The Public Utilities Commission of Sri Lanka organised a half day seminar in Colombo, Sri Lanka where Sarath Perera from PQA made a presentation on the subject of PQ management in transmission and distribution systems in the country. The invited audience of approximately 70 individuals were representatives from the Public Utilities Commission of Sri Lanka (PUSCL), Celon Electricity Board (CEB), Lanka Electricity Company (LECO) and Sri Lanka Sustainable Energy Authority (SLSEA).

The objectives of the seminar were:

- To describe the way forward for distribution licensees on how to plan, implement (or improve existing systems) and implement monitoring to ensure power quality of the distribution systems in line with the existing sector regulations and codes,

- To share the world practice/Australian practices on how such systems may be implemented and how they succeeded in ensuring effective management of power quality
- To develop a positive attitude within distribution licensees towards the implementation of codes and regulations related to power quality revealing their importance as well as benefits to the licensees.

In an attempt to meet the objectives of the presentation the seminar covered a holistic approach towards PQ management which included a good understanding on PQ phenomena, regulatory frameworks, standards, emission allocation and assessment, mitigation, monitoring and reporting, benchmarking and economics.

The seminar covered a range of content areas where PQA have specific expertise. Australian know how was provided with a view to promoting PQA as a body which can assist Sri Lankan activities in the PQ domain. These covered content areas included continuing professional development, preparation of guides for customers and utilities and updating of the existing grid codes to incorporate PQ and PQ monitoring and reporting.

Upcoming CPD Courses

Quality of Electrical Supply	19-20 April 2017
Advanced Quality of Electrical Supply	8-9 June 2017
Renewable Energy & Distributed Generation	20-21 July 2017

For information on upcoming training courses visit www.elec.uow.edu.au/apqrc/training.

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