Power Quality Australia Newsletter

Issue 12, March 2019

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2016/2017 PQCA National Report

National Results Released

The 2016/2017 PQCA National Report is complete and has been distributed to participants. Participation in 2016/2017 remained high with close to 9,000 sites amongst 7 participants across Australia. The proportion of LV to MV sites, in addition to the proportions of sites in different categories of site characteristics, remained similar to 2015/2016. Predominant load type remains one site characteristic with a large proportion of sites with an unspecified value, particularly for LV sites. For LV sites flicker remained the disturbance of most concern for the ‘average’ utility. While there were slight improvements in the 95th percentile and median values for P_{lt} both remain above the limit. Performance for P_{st} decreased slightly with the median value now just sitting on the limit. V99 remained high with performance similar to 2015/2016. While the median value for unbalance for the ‘average’ utility remained well below the limit, it has slightly increased compared to the 2015/2016 level, which is also reflected in the percentage of sites nationally exceeding the limit rising from 13% to 16%. On the whole, MV site performance is similar to that of 2015/2016, though flicker saw some lengthening of the ‘tail’ (i.e. increase in 95th percentile values), while for unbalance there was improvement with the 95th percentile value falling below the limit and a decrease of the median value, compared to 2015/2016, indicating possible outliers in the data for 2015/2016. THD for MV sites also saw improvement in the 95th percentile value in addition to the percentage of sites exceeding the limit falling from 9% to 5%, which saw a reverse of the trend over recent years. For sags there was an improvement in the 95th percentile value for number of sags per LV site, though in regards to the percentage of sags at a site that were below the ITI Curve and UOW 230 V Curve there was a slight increase. PQCA participants can read the detailed comments and access the charts and tables in their copy of the 2016-2017 PQCA National Report.

Power Quality 24/7

If there is flicker when the light is off, is it really flicker?

These days we are all too aware of the price we pay for electricity. So as customers, we keep an eagle eye out for any blemishes in the quality of the products we are buying. Interruptions to supply can make us grumpy. So can disturbances to the size and shape of the 230/400 Volt, 50 Hz balanced 3-phase sinusoidal waveform that we know and love. This is especially so if our appliances or plant and equipment start acting "abornery". Motors overheating, lights dimming or flickering - such things can really hurt the bottom line. But are there some times of the day that we care about more than others? Does it matter if the voltage skyrockets at 2am when we are tucked up in bed thinking of England or at least of things not power related? Perhaps power quality indices should have some time weighting to reflect the times of day of most concern to most customers? The best time to have a disturbance to your supply is when it has no material impact on you. A night time voltage dip is not going to interrupt widget or bassoon production if your widget or bassoon factory hours are 8am till 4pm.

To probe further into this time of day issue, let us take a closer look at steady state voltage disturbances as one power quality example. There is now a clear way of checking compliance for steady state voltage in Australia. It is prescribed in AS61000.3.100. Limits are given for V99, V1 and V50. According to the standard, these are measured over one week. Non-compliance could result in significant network expenditure to improve performance over a weekly period. Now, instead of taking a week of contiguous 10 min average readings, we could calculate V99, V1 and V50 for peak, shoulder and off-peak times. In order to get sufficient readings over a reasonable time period, a month of readings rather than a week would be useful. As a further consideration, reporting on a month in each of the four seasons may yield some interesting results.

We plan to do this analysis with a selection of data. Results will be reported in a future newsletter. Watch this space!

Solar Farm Commercial Research Activities

APQRC assisting Network Operators and Proponents to transition to a clean energy future

The APQRC has been undertaking a number of activities for Australian network service providers as well as renewable (principally solar) farm proponents. These activities include:

- Due diligence studies of proponent solar farm NER compliance reports
- Network and solar farm modelling to produce harmonic impedance polygons to be used for harmonic emission allocation studies as well as harmonic filter design
- Modelling to evaluate the impact of solar farms on ripple injection signalling systems
- Provision of advice concerning harmonic emission allocation methodologies

In addition to the above, the APQRC was recently engaged by an Australian DNSP to oversee and assist with power quality monitoring during the R2 commissioning stage of two large solar farms. These activities have provided valuable practical insights to APQRC staff related to the physical construction and operation of solar farms and research ideas. These insights compliment the theoretical studies that have been undertaken to date. Overall, the APQRC now has a comprehensive understanding of both the theoretical and practical operation of large solar farms.

CPD Activities

Training for Industry Professionals

2018 was a busy year at the Australian Power Quality & Reliability Centre (APQRC). The APQRC delivered a number of continuing professional development (CPD) courses, including; Quality of Electrical Supply, Applied Power Quality, Renewable and Distributed Generation, PSCAD Technical Workshops and a Cigre Tutorial on the application of synchrophasor solutions for the monitoring and control of power systems.

The rapid growth of the Australian renewable energy market has increased the demand for training in the areas of energy storage, modelling and grid connection. Recognising this need, APQRC continues to work with industry to produce and deliver high quality industry specific course content.

2019 will see additional PSCAD courses offered in Brisbane, Sydney, Melbourne and Perth, along with other CPD courses aligned with industry conferences, to be delivered in Melbourne and Sydney.

CPD courses can be customised to meet the training needs of any organisation and the APQRC welcome enquiries.

Upcoming Continuing Professional Development Courses

Energy Storage (Sydney)	4-5 April 2019
Renewable & Distributed Generation (Sydney)	8-9 April 2019
Quality of Electrical Supply	4-5 July 2019
Applied Power Quality: Harmonics, Unbalance, Voltage Sags & Power Quality Monitoring	26-27 September 2019

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

Have you considered our modular Master of Electrical Power Engineering (MEPE) program? Click hhttp://www.elec.uow.edu.au/apqrc/?page=study#tab-mepe for more information.

ICHQP 2018 Report

UOW Claims Best Paper Prize

The 18th International Conference on Harmonics and Quality of Power (ICHQP 2018) was held in Ljubljana, Slovenia on May 13 – 16 2018. As usual, The University of Wollongong was represented by a strong contingent with three staff and two students among the approximately 200 delegates from around the world. Papers authored and/or presented by University of Wollongong staff and students covered the following topics:

- High Frequency emissions from Solar PV Inverters
- Impact of power quality disturbances on equipment performance and lifespan
- The interaction between solar PV inverter filtering systems and ripple injection signal magnitudes
- Benchmarking of power quality data in transmission systems
- Overview of the progress of Cigre International Working Group C4.40
- Volt/Var control strategies for management of voltage rise due to distributed generation

Photographs from the 2018 ICHQP Conference:
Top left: UOW Student Dilini Darmawardana presenting at the conference
Top right: APQRC Technical Director Professor Sarath Perera chairing a session at the conference
Bottom: APQRC Research Coordinator Sean Elphick receiving the best paper award for the 2016 conference from ICHQP Steering Committee Co-Chair Professor Dario Zaninelli

The highlight of the conference was the presentation of the best paper for the preceding conference to University researchers for the paper titled "Impact of assessment period on voltage THD measurements" written by Sean Elphick, Vic Smith, Phil Ciufo and Gerrard Drury.

PQ Benchmarking for Transmission Systems

How can distribution system experience be applied to transmission system reporting?

PQA has been involved with benchmarking of distribution utilities for 16 years. In that time we have developed methods for compressing large volumes of measurement data by means of appropriate choice of reporting indices. Innovative graphical presentation of these indices can be used to allow asset managers to quickly appreciate the "PQ health" of their network. Some of our developments include statistical voltage indices, sag indices and combination PQ indices which have been published internationally.

With the Centre's recent work with transmission network service providers, many of the previous methods need review and modification for the new application, accounting for the differences between the participants in the two projects. These include

- The number of monitored sites is smaller
- Sites are generally situated electrically far from domestic loads
- Networks are generally meshed with long lines having significant capacitance
- Compliance levels differ between states
- There can be a wide range of voltage levels owned by transmission companies, ranging from 3.3kV to 500kV

The PQ disturbances of most interest to transmission network service providers are all related to voltage waveform and are:

(a) Long term voltage variation (V)
(b) Voltage Unbalance (U)
(c) Harmonics (THD only at this stage, symbolised as H))
(d) Flicker (P_{st} only at this stage, symbol F)
(e) Voltage sags (S)

The first four of these are called "Variations" and the collected data correspond to readings each 10 minutes, usually one for each phase. In the case of (b), voltage unbalance is represented by a single number, the ratio of the negative to the positive sequence component. This is not measured directly for many sites and has to be determined from the three line-line voltage values. The last disturbance is an "Event" type and is recorded as diary entries of the time, date, depth and duration of the sag on each phase. Note that each of these quantities is often referred to in graphical reports by the symbol shown in brackets.

There are about 11 voltage levels in the range 3.3 kV to 500 kV and reporting on each one separately will lead to more indices and less insight into overall trends. There is a danger here that some voltage levels will include a very few sites and the results will have little statistical significance. We have grouped sites together where it is considered that the different voltage levels have similar functions in the network. Our present classification scheme is shown in Table I below.

Table I: Classification name and groupings for different voltage levels

Classification name	HV transmission	Transmission/ sub-transmission	Distribution	MV
Voltage levels included (kV)	220/275/330/500	110/132	33/66	3.3/11/22

The issue of most importance for transmission company participants is benchmarking, that is, comparing the PQ health of their different systems. If, for example, one company has twice the compliance level of another, then it will be permissible for their corresponding PQ levels to be higher. Should one then compare the actual PQ level or the PQ level relative to the compliance level? There is no clear answer to this question, and so both comparisons are made in our reports, using the terms "Compliance reporting" and "Magnitude reporting". Comparison relative to compliance level shows how companies are performing at meeting stipulated limits, while a comparison in absolute terms could be useful in the future for assessing if uniform compliance levels should be used in Australia and what compliance levels might be chosen.

The first stage in reporting for a site is to reduce the readings over a year to a couple of representative numbers or indices. As an example, for harmonics, we might take the 95% value of the 10 minute readings of THD over the year. Compliance reporting is a network issue and can be given by a single index, for example the percentage of sites which exceed the maximum allowed level for a given disturbance. Magnitude reporting is more complex since PQ managers are interested, not in a single index for their network, but in the spread of site indices from the best to the worst. This can be usefully summarised by the 5%, 50% (median) and 95% value of the site indices.

With the above as background, we can now examine specific reporting graphs and see how they summarise the vast quantity of PQ data which might be obtained from several transmission companies. Figure 1 shows compliance benchmarking involving three partner utilities. There are four panes to the graph corresponding to the four voltage level groupings of Table I. Each pane has 4-5 major horizontal divisions corresponding to the disturbances monitored, noting that sag data is not available for HV Transmission and the Distribution voltage levels. There is a further division into minor horizontal divisions corresponding to the participating utilities – three for all voltage levels except for Distribution where there are two.

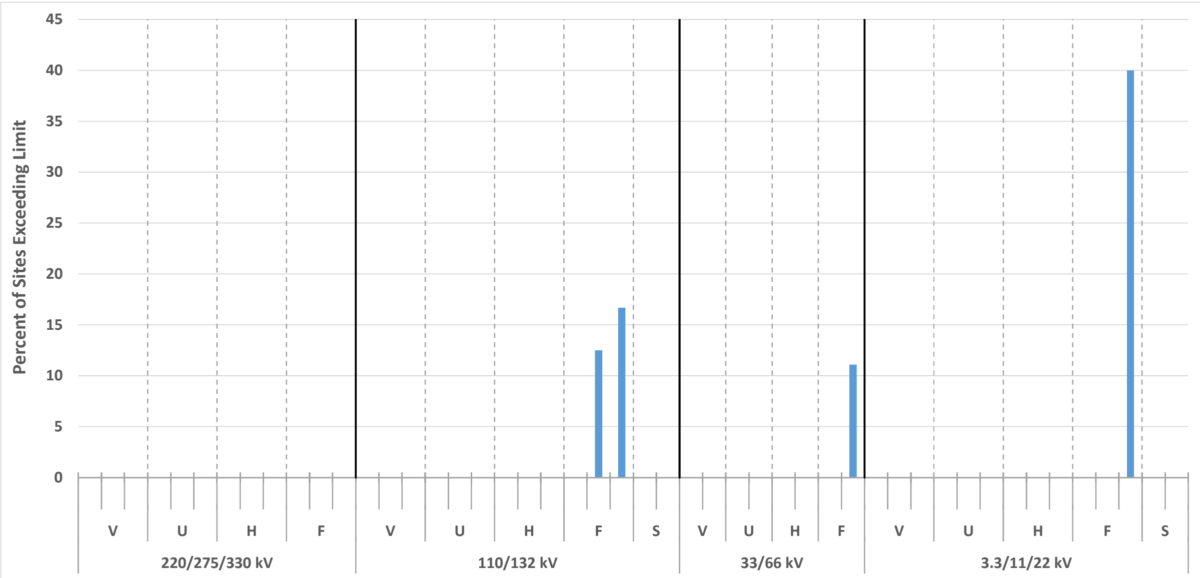

Figure 1: Compliance reporting for a group of transmission participants

Figure 1 demonstrates that, regarding compliance, flicker is the only disturbance of importance, particularly at the lower voltage levels, and that generally only one utility has problems.

Figure 2 shows magnitude reporting for three participants for a particular Variation. The main graphical aid is a column extending from the participants' 5% site value to the 95% value, with a line added indicating the 50% or median value. We could call this a "Site Distribution Column". There are two panes corresponding to the two voltage level groupings for which data was submitted. In each pane we have a Site Distribution Column for each of the participating utilities and an additional column showing the distribution when all sites are lumped together.

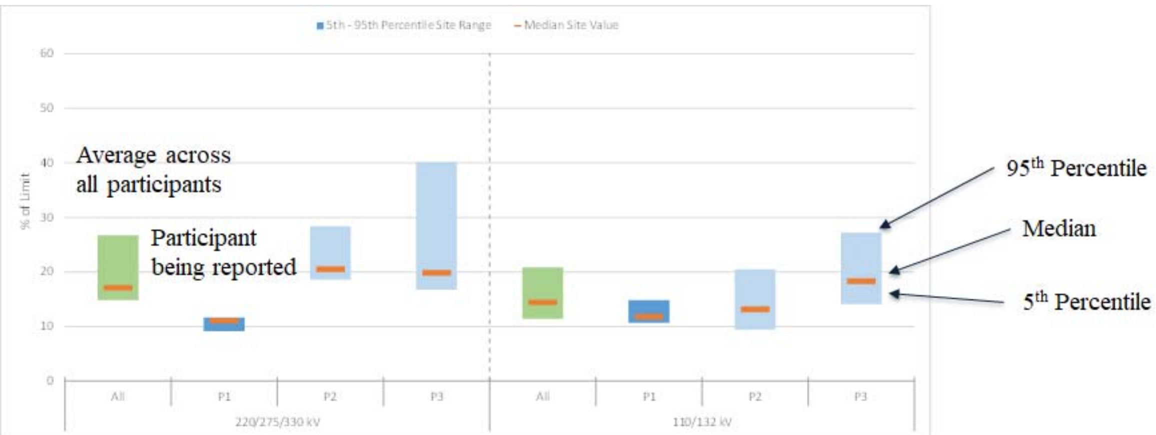

Figure 2: Magnitude reporting for a group of transmission participants

In Figure 2, the values are plotted as a fraction of the limit allowing the relative values of different disturbances to be compared meaningfully. We see that at least 95% of sites are below the limit and there should be no compliance issues for this group. Examining the median values (which can be taken as close to the average values) it can be seen that Participant P1 has a better set of sites than Participants P2 and P3. Participant P3 has median values only slightly worse than the others, but the 95% values are significantly worse, indicating that P3 has some bad "outlier" sites. This suggests that there are no systematic issues with P3 but there are a couple of sites with particular problems.

The above is of the nature of "exploratory statistical analysis" and the conclusions are qualitative only. To go further, one would like to see what conclusions can be stated with statistical significance, for example at the 95% level. This would require one of the standard statistical analysis methods such as ANOVA or chi-squared and also requires that sample sizes are sufficiently large. This type of analysis might be carried out if there is sufficient demand. It can be extended to looking for correlations between PQ disturbances on the one hand and line length, nearness to renewable generation, fault level, etc.

Looking for Further Information?

If you would like more information on any of the articles published in this newsletter, please contact Sean Elphick at the University of Wollongong on 02 42214737 or sean_elphick@uow.edu.au.