INTEGRAL ENERGY POWER QUALITY CENTRE

NEWSLETTER

August 2001 No. 5

Completion of National Power Quality Survey

As mentioned in Newsletter #4, the Power Quality Centre has been conducting a national power quality voltage survey over a 12 month period involving 9 electricity distributors spread over all states except Western Australia. The survey was completed on 30th April with a presentation of the final report to participants.

To summarise, the aims of the survey were:

1. Choose 8 sites at 240/415 V within each network representing a range of extreme and average power quality, the sites being chosen to reflect a range of load types, namely, commercial, industrial, residential, rural and remote.
2. Choose appropriate instrumentation.
3. Set up a database to store and allow querying and reporting of the survey data.
4. Examine the level of power quality for one week at each site for 6 disturbance types (voltage, unbalance, harmonics, sags/interruptions, swells, transients) and compare them with standards where they existed. Where disturbance levels were higher than existing standards, determine a level that could be met by the majority of sites.
5. Examine the variation between Distributor types Average and Extreme and among Load types Commercial, Industrial, Residential, Rural and Remote and recommend if there was a case for using different standards in some situations, especially for rural sites.
6. Identify areas for improvement in the developed survey methodology.
7. Recommend further actions to the industry for the improvement of power quality.

Although the results of the survey are confidential to the participants, some comments can be made about the survey methodology.

Instrument development: For permanent monitoring, there is a need for more cost-effective instrumentation, with attention required for unbalance calculation, flicker indices and transient capture.

Disturbance characterisation: At present, this is poorly defined for discrete events. For example, for sags there needs to be an investigation of the importance of the shape of the sag envelope, unbalance across the three phases and the effect of several sags closely spaced in time. This could be investigated by long term sag monitoring in conjunction with investigation of correlated customer complaints.

Setting of standards: Acceptable values for discrete disturbances need to be determined. This must await the outcome of satisfactory disturbance characterisation.

Reporting: The reporting of discrete events over a long survey period needs to be simplified. A method must be used that allows ranking of sites so that the worst ones can be easily identified for mitigation works.

Cost-effective monitoring: Several questions need to be resolved

- Should monitoring occur at both LV or MV levels?
- Can an LV survey be used to characterise the local MV system or vice versa?
- How many sites should be monitored? Where should instruments be placed?
- Can supporting data be obtained from intelligent tariff meters?
- What are minimum survey periods for different PQ disturbance types?
- How can the PQ levels at non-monitored sites be interpolated from available data?

The Power Quality Centre is actively pursuing solutions to these problems.

Evaluation of Microsoft Access for producing a PQ database

As part of the national power quality survey mentioned earlier, a database was developed to store and analyse the data obtained. MS Access was chosen as the database for this initial pilot study. The report for the survey was generated using MS Access and MS Excel and comprised results from 70 different 240/415 V sites. The sites were classified on the basis of load type and distributor type. The database that resulted exceeded 500 MBytes in size.

Access comes with Visual Basic functions that allow manipulation of the data which were taken advantage of during this project. For the survey, a basic statistical analysis was performed on the raw data which included RMS voltages, harmonics, voltage sag parameters and captured waveforms of transients. Access itself was not very user friendly when it was required to produce plots of data. In fact, it was found that MS Excel was better at presenting the data than MS Access, so once the statistical calculations had been performed using Access, the data was transferred to MS Excel for plotting. These plots then formed the information that was included in the formal report of the survey.

The database was very slow in operation, mainly due to the large number of entries in the database. Also it was not an easy task to manipulate the data as often tables that needed to exchange data were of different length. This was overcome by using the Visual Basic built in database functions and creating new tables with intermediate and final statistical data. Other problems were also encountered in that Access did not always handle errors well e.g. if an entry was read as a string rather than a number, Access would not generate a warning but the results of queries that expected a number were generally incorrect. Sometimes an error message would occur but it would not state anything about the data being of incompatible types. As this was only a pilot study the use of Access was just satisfactory, but for a larger study (one that would extend over months rather than a week), other databases should be examined for their suitability (e.g. Oracle).

PQC awarded $250,000 Commonwealth grant to study PQ monitoring methodologies

The PQC has been awarded a Commonwealth Government SPIRT grant in conjunction with industry partners Integral Energy and CHK Wireless Technologies. The grant, worth more than $250,000 over three years, is to study power quality survey and monitoring methodologies for the Australian electricity distribution industry.

Deregulation of the Australian electricity supply industry is being accompanied by state regulator requirements for explicit statements of quality of supply backed up with field survey results. The continuous recording and storage of every voltage waveform at every electricity supply point will add significant expenses to the cost of supply and produce an enormous quantity of information to be processed. There is a need for a less comprehensive approach which will be accepted as a standard and consistent method of characterising the supply and allow different sites within a utility and the overall performance of different utilities to be objectively compared. This project will study (A) the development of a survey methodology for using existing power quality monitors in a cost-effective manner, (B) development of algorithms giving more powerful and consistent classification features for use in the next generation of power quality monitors.

The stream A work, in conjunction with Integral Energy, will study which types of PQ disturbances should be measured:

- should they be measured in the low or medium voltage part of the power system or for both?
- what minimum subset of sites will indicate the worst-case performance of the system?
- which PQ indices give a useful measure of the performance of the network, suggest appropriate corrective action and input for asset management decisions?

The stream B work is in association with CHK Wireless Technologies and will examine:

- waveform acquisition and storage
- analysis and classification of disturbance waveforms.

The work should give distributors better tools for monitoring and managing their overall power quality.

Compliance of a Harmonic Load with AS/NZS 61000.3.6

(modified IEC 61000-3-6)

Recently a customer approached Integral Energy with a proposal to connect a harmonic load that varied much with time. The point of connection of the load to the 11kV distribution system was to be towards the end of a feeder. This raised some interesting questions in the interpretation of the new harmonics standard AS/NZS 61000.3.6. In particular

(i) determining the allowed harmonic current with incomplete network data

(ii) determining the 95% value of the customer's current from available data.

AS/NZS 61000.3.6 involves a number of stages and tests that are applied in order to determine compliance. As the harmonic load of concern was greater than 0.1% of the fault level rating at the point of common coupling (PCC) the load was too large for Stage 1 to be applied. So Stage 2 of the standard was required to determine compliance. There are 3 tests in Stage 2, Test 1 is relatively simple to apply and it involves only a small amount of data, including, estimated harmonic impedance at the point of common coupling (PCC), load rating, and maximum total rating of the distribution system. From this data the allowable harmonic voltage contribution is determined and can be compared to the design values of the load for compliance. The harmonic load of concern did not comply with Test 1. Test 2 was not applied in this case, as it is believed to be difficult to apply without extensive data collection preceding load connection. It also involves poorly understood concepts such as the "typical" diversity in harmonics between MV and LV loads.

Stage 2, Test 3 of the standard involves allocating allowable harmonic voltage contributions in such a way to not penalise loads towards the end of feeders which see a much higher system impedance. The example in the standard is of a homogeneous system, whereby all loads and feeders are identical, and analysis is straight forward. For realistic systems there is no clearcut analytical approach.

The Power Quality Centre proposed a new methodology basing the allowable harmonic contribution of all loads on the harmonic levels of the weakest feeder. The data required for the calculations using the proposed method include the rating and fault levels of each load point along the weakest feeder, and the total rating of each of the other feeders connected to the same point of supply. From this data a harmonic allocation constant is determined by utilising the 2nd summation law outlined in AS/NZS 61000.3.6. The harmonic allocation constant can then be used to calculate the allowable harmonic contribution for each customer given the load rating and estimated harmonic impedance at any PCC having the same point of supply.

The harmonic load of concern was assessed using the new methodology and it was found that the maximum levels of harmonic current produced by the load were greater than the 95th percentile levels calculated for compliance. The values of the customer's 95th percentile current levels were difficult to accurately estimate from design data. However, as the load was installed and commissioned, field measurements were possible. The nature of the load differed from most other harmonic sources in that the harmonic currents of concern only appeared in short duration peaks throughout the day. From a recording of a number of load cycles and knowledge of how often these cycles repeated throughout the day, the 95th percentile current could be estimated. The exercise illustrated that the proposed method was practicable to apply.

Details of the proposed method for applying Stage 2, Test 3 of AS/NZS 61000.3.6 can be found in Gosbell et al, "The application of IEC 61000-3-6 to MV systems in Australia", ERA Technologies International Conference on Quality & Security of Electrical Supply, February 2001, Paper 7.1.

Well known Power Quality Researcher visits the Centre

Dr Czarnecki of Louisiana State University is well-known for his work on the definitions of power quantities under non-sinusoidal conditions. He visited the PQ Centre on April 6 and gave a seminar on "Misinterpretation of power phenomena and power definitions in circuits with non-sinusoidal voltages and currents" which gave a review of the main line of his publications over the last few years. He looked at common misconceptions held about reactive power, apparent power and power factor.

There are currently two definitions of reactive power in non-sinusoidal situations, Fryze's and Budineau's. The Budineau definition is the one most commonly adopted. It was shown that it is not a measure of energy oscillation, contrary to the interpretation often given in undergraduate courses. Load compensation is not related to making the Budineau reactive power equal to zero. There are similar problems with Fryze's definition. Nor are these reactive power definitions related to energy storage since they exist in circuits containing only SCRs and resistors.

Similarly he looked at the concept of power factor. Even in non-distorted circuits, there are uncertainties in the definition of power factor when the load is unbalanced.

A clear conclusion from Dr Czarnecki's talk is that reactive power and power factor can be defined in several different ways leading to different values. Since tariff metering can depend upon both reactive power and power factor, it is clearly important for power utilities to know what value is being used. The definition needs to be spelled out in the contract.

Book Review

"Power Quality Primer" by Barry Kennedy, McGraw-Hill, 2000

ISBN 0-07-134416-0

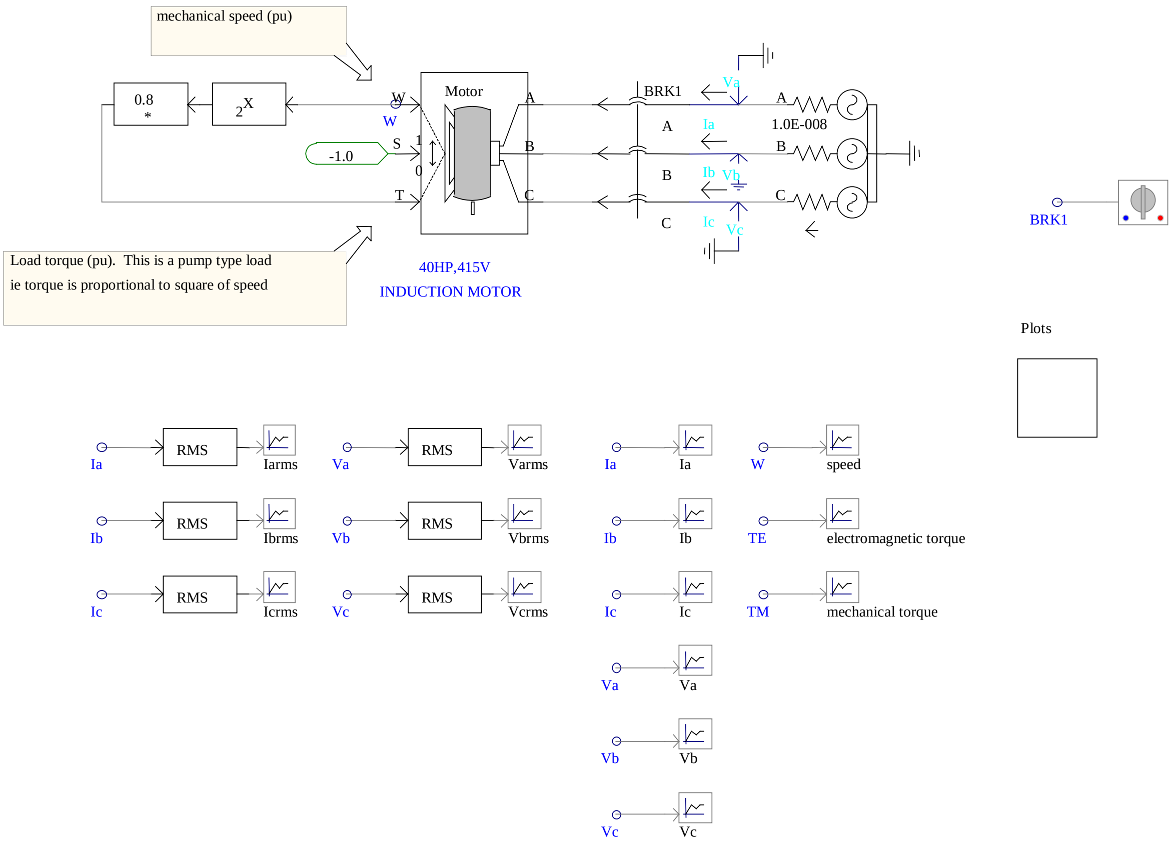
"Power Quality Primer" is a book that is suitable for both the expert and novice in the area. Starting from the basics of power quality the book goes on to cover aspects where there have been significant growth and interest in recent years. The book is excellent for general reading on the subject and presents many concepts on power quality without difficult mathematics or other tools one needs for detailed analysis.

The need for power quality is highlighted while identifying the interested parties, some of which include standardising bodies, end users and lawyers who bring a different but important dimension. An introduction to power quality problems is given together with their origin, their effects and solutions. A full chapter gives a comprehensive coverage to the standardising bodies and the relevant power quality standards. It is interesting to see this chapter giving a good overview of the manner in which the standards have evolved over many years. The three key areas, emission, immunity and the medium which carry the power quality problems from the source to the victim are highlighted together with possible solutions to different types of power quality problems. Wiring and grounding which is considered to be a key area of relevance at the plant level is given a very special emphasis. For the person looking for information on power quality measurement there is one complete chapter which discusses the different tools that are available together with a discussion on the way the results could be summarised. The importance of monitoring is given its due attention by covering aspects such as compliance to standards, system performance and problem diagnosis. The purpose of a power quality survey and its planning is well covered in the book which is good reading for utility personnel. It mentions the important issues such as coordination of parties, selection of instruments and analysis of data. Power quality economics, where there is growing interest by many parties, has been given a comprehensive coverage. A good account on the cost of power quality problems and the cost of power quality solutions is given. It is pleasing to note that the book has devoted one complete chapter to future trends in power quality where utility deregulation can have a significant impact.

Power quality contracts that can exist in a deregulated environment have been given a good introduction.

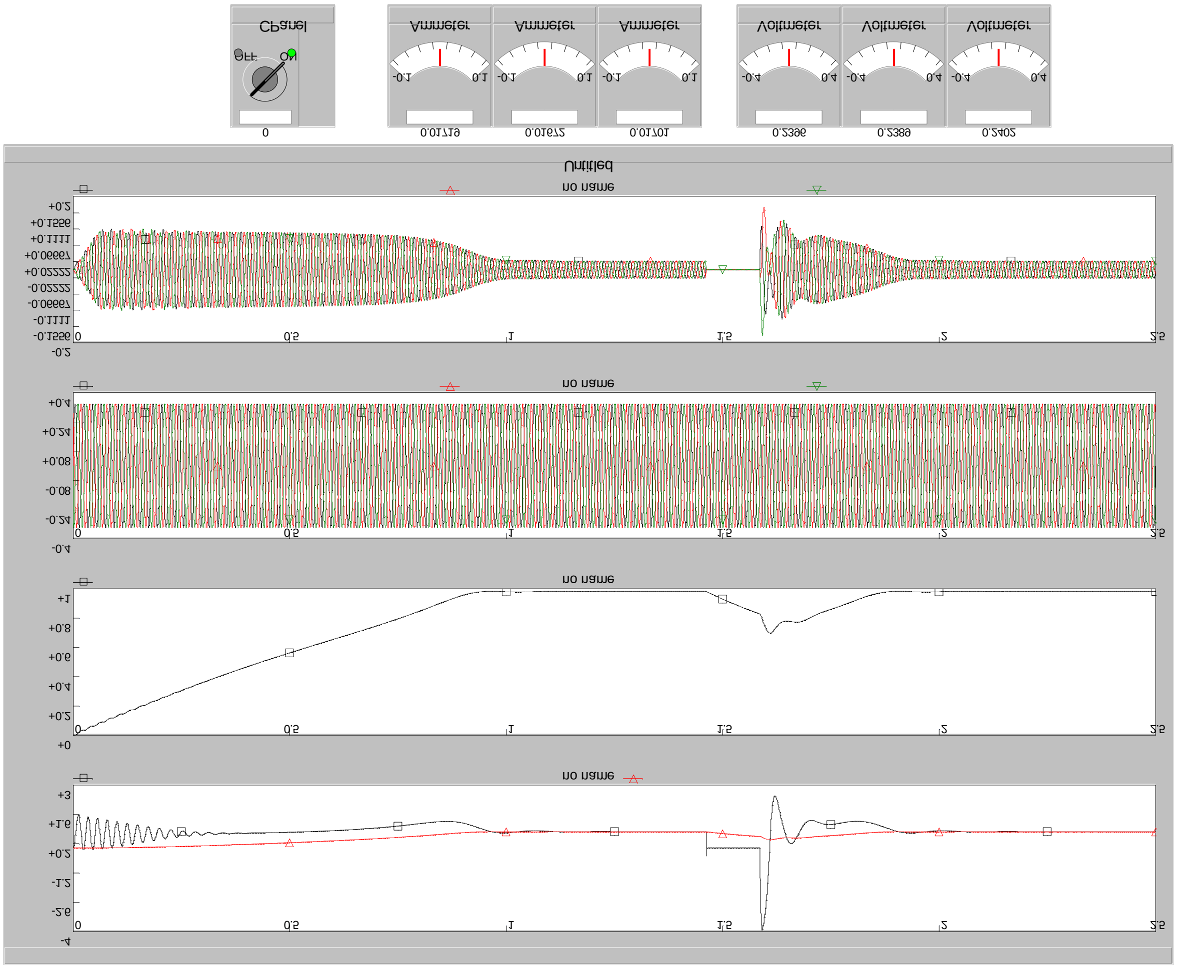
Barry Kennedy's 'Power Quality Primer' is a good companion volume to the well known book 'Electrical Power Systems Quality' by Dugan, McGranaghan and Beaty (McGraw Hill, 1996).

PSCAD Tutorial



The following PSCAD/EMTDC™ simulation shows the transients associated with starting and subsequent disconnection/reconnection of a three phase induction motor. On direct-on-line starting of the motor, as expected, the starting currents are high. The characteristic oscillations of the electromagnetic torque are quite evident as the motor accelerates towards its running speed (close to 1pu). The simulation demonstrates what could happen if the AC supply is interrupted and reconnected to the running induction motor. During the interrupted period the motor slows down and the rotor currents are still in the decaying process which means that the stator terminals are induced with a voltage that is not in synchronism with the AC supply when it is restored. The reconnection process therefore can lead to a very severe transient leading to over currents as well as a severe electromagnetic torque transient. The torque transient has the potential to damage the shaft and other connected loads.

Integral Energy Power Quality Centre has the capability to use PSCAD/EMTDC™ effectively to investigate electromagnetic transient problems of this type.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