



# INTEGRAL ENERGY POWER QUALITY CENTRE

## NEWSLETTER

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### The Australian Power Quality Service Centre

In late 1998, the Illawarra Technology Corporation (ITC), the commercial arm of the University of Wollongong, via its Technological Development Fund, gave financial assistance to the Integral Energy Power Quality Centre to establish the Australian Power Quality Service Centre. This joint commercial venture aims to provide a wide range of power quality services to Australian industry including:

1. Emission and susceptibility testing of electrical appliances for users, suppliers and manufacturers. Such testing would include the effects of harmonic voltages, voltage sags/dips, voltage unbalance and voltage fluctuations. The acoustic response of fans to mains signalling and immunity of clocks to "racing" can be examined. Conducted EMI and low-frequency magnetic fields produced by equipment can also be measured.

2. Testing of power quality measuring equipment and instruments.
3. Industry seminars and courses on power quality issues including specialist courses for electricity distribution companies.
4. Specialist consulting services including:
  - harmonic, sag and transient analysis of power systems;
  - power quality prediction, monitoring and mitigation;
  - interpretation and application of Australian and overseas standards.

The Australian Power Quality Service Centre will be administered by the ITC which is responsible for provision of quotes, invoicing and marketing. All inquiries should be directed to Mr. John Weidemier on mobile telephone number 0412 423 571.

### Major Energy Award for Superconductor Technology

High Temperature Superconductors (HTSC) potentially make it possible to produce 'lossless' power engineering devices which could provide revolutionary environmental and commercial benefits world wide. For example, HTSC provide potential for lossless transmission, generation and use of electricity which would eliminate much existing energy wastage. Similarly, HTSC can be used to build lossless energy storage devices which would make renewable energy technology, such as solar power, more practical.

For the last two years the Power Quality Centre has been involved in the development of new mathematical models and experimental testbeds to help electrical engineers use HTSC in practical devices such as coils. This work has been performed by a PhD student, Mr. Tri Hardono, supervised by Professor Cook and Dr. Sarath Perera. Also Metal Manufacturers, lead by Professor Beales, has constructed a pilot plant to

manufacture HTSC wire and tape, and the University of Wollongong through Professor Dou's HTSC research team is at the forefront of world research in developing new compounds and manufacturing methods for producing high quality HTSC.

This combined experience has now led to a new grant of \$238,520 to the Beales, Cook and Dou trio from the NSW Sustainable Energy Research and Development Fund. This will provide for the construction and evaluation of larger scale prototype HTSC devices, such as a 100kVA transformer coil, and a superconducting magnetic energy storage system. This work is intended to improve Australia's chances of playing a leading role in what is estimated to be an annual multi-billion dollar world market for HTSC by the year 2010.



University of Wollongong



## **New Staff: Mr. Duane Robinson**

Duane Robinson has recently joined the Integral Energy Power Quality Centre, being jointly funded by the Centre and an Australian Postgraduate Award (Industry) Scholarship, to study for an Honours Master of Engineering (by Research) degree. He currently works under the supervision of Associate Professor Vic Gosbell and Dr. Sarath Perera. His research area includes the study of harmonics and related effects in utility power systems.

Duane was born at Hay, in south west New South Wales in 1974. In January 1992 he accepted a position with BHP as an Electrical Engineering Cadet at the Port Kembla Steelworks. So he packed his bags and moved from the flat dry arid zones to the beautiful coastal areas of the Illawarra. The BHP cadetship involved full time work at the steelworks and part time study at the University of Wollongong.

As a cadet in the steelworks Duane spent the first twelve months of his cadetship at the Electrical Apprentice Training Centre learning commercial and industrial wiring, plant equipment maintenance, and electronics. From the Training Centre he spent the next 18 months in Technical Sections at the Tin Mill, Hot Strip Mill, and Skin Pass Mill, installing

and maintaining plant equipment, fault finding during breakdown situations, and programming PLCs.

Duane then moved to Engineering Services where he worked for the Power Systems Section for 18 months. There he worked in conjunction with the Senior Power Systems Engineer on management of high voltage transformer installations, design of circuit breaker tripping circuits, interfacing high voltage control with PLC control systems, and fault finding on high voltage transformers and transmission cables.

During the later stages of the cadetship Duane spent time designing closed circuit television installations, for security and plant monitoring, installing radio controlled crane systems, and providing technical support to the Maintenance Department at the Slabcaster and BOS areas. Duane's last section at BHP was working for the Engineering Drives Group where tasks involved design, installation and commissioning of AC and DC drives throughout the steelworks.

Duane completed his undergraduate degree in Electrical Engineering in November 1998 and graduated with First Class Honours in May 1999.

## **Upgrading of Waveform Generator**

The School of Electrical, Computer and Telecommunications Engineering over the last five years has been developing a 10kVA waveform generator to study the effects of power quality disturbances on electrical equipment. The power quality disturbances of interest include harmonic distortion, undervoltage, overvoltage, voltage fluctuations, frequency variations, sags, swells, and unbalance.

The waveform generator is a programmable IGBT voltage source inverter controlled by a microcontroller. Space vector modulation is used to determine the required IGBT switching configuration to give the desired output voltage. Previously the waveform generator was able to produce controlled levels of balanced non-triplen odd harmonics up to the 20th.

In 1998, Mr. Duane Robinson, for his undergraduate thesis project, upgraded the waveform generator to include the production of controlled voltage sags, voltage swells, and unbalance, with and without harmonic distortion.

The upgrade included changes to both the PC user interface software and the real time microcontroller software. All software was written using C

programming language with the microcontroller requiring a conversion to Assembler language before compilation. Ensuring the safe operation of the waveform generator during implementation of the new controller software was an integral part of the project with simulations completed using C programming language and MATLAB.

The waveform generator is now able to produce three phase voltage waveforms with an unbalance factor (negative to positive sequence ratio) up to 100%. The voltage unbalance can be user specified by entering the three voltage magnitudes or by specifying a given unbalance factor. The simulated output voltage waveforms are displayed to the user if desired before generator operation.

For voltage sags and swells the waveform generator has been developed such that normal steady state voltages are first applied to the test load and a voltage sag/swell of the required duration and magnitude is initiated from the keyboard of the PC. For voltage sags, voltage swells, and unbalance, the inclusion of controllable levels of harmonics up to the 20th is also available to the user.

For more information on the Waveform Generator please contact the Power Quality Centre.

## Centre acquires Electromagnetic Interference (EMI) measurement equipment

An important area of electromagnetic compatibility is the conducted and radiated interference caused by various types of electrical and electronic equipment. Immunity to this interference is critical to the operation of sensitive equipment. The IEC 61000 series of standards gives emission and immunity limits for EMI. The Power Quality Centre has recently purchased equipment which can measure conducted and radiated interference in the range 150kHz to 1GHz. Measurement of radiated

EMI requires expensive shielded rooms and hence the Centre will concentrate only on conducted EMI in the range 150kHz – 30 MHz. The EMI measurements can be performed for equipment with current rating up to 16A single-phase and 64A three-phase.

Currently, undergraduate project work is being undertaken on modelling and measurement of power electronic converter systems.

## Progress on SPIRT project

In 1998, The University of Wollongong received a Commonwealth Government SPIRT grant (Strategic Partnership with Industry - Research and Training) to investigate part of the broad topic of power quality. The aim of this power quality research is to examine the harmonics in a particular section of Integral Energy's 11kV distribution network.

The principal investigators are Vic Gosbell and Sarath Perera. Damian Mannix and Duane Robinson have been appointed as the Research Associate and Research Student respectively to work on this research project.

The outcome of the SPIRT research project in simple terms is to determine what the current harmonic situation is in a typical 11kV distribution system and then predict what level of harmonic distortion will be present over the next decade.

In doing this, analysis techniques for accurate modelling of the distribution system in the presence of harmonics will need to be developed.

Forecasting and quantification of the growth of harmonics at particular points in the system taking into account the development of industrial technology over the next decade, development of general guidelines for identifying the most suitable connection point for future large distorting loads and general planning strategies for maximising the harmonic capability of the power system all need to be addressed.

Two outcomes of the research so far have been a modelling paper for the Australasian Universities Power Engineering Conference 1998 (AUPEC '98) entitled 'Distortion load modelling for distribution system harmonic studies' written by Vic Gosbell and Damian Mannix, and the evaluation of several harmonic monitoring instruments.

The site evaluation, installation of the harmonic meters and the measurement phase of the project are now complete. Analysis techniques such as correlation and probability methods are currently being developed and applied to the sampled data.

## Final Year Thesis Projects

The following power quality thesis projects have been investigated by final year students:

1. Sensitivity study of Harmonic standards: IEC standard 61000.3.6 has a complex set of rules for allocating the consumer's share of distorting current. The project looks at which of the many parameters required in calculation have an important effect and therefore need to be accurately known.
2. Harmonics due to photovoltaic systems: The project involves the simulation of a "typical" distribution feeder with a percentage of photovoltaic generation having a known harmonic current. It is aimed to see how harmonic voltages are affected as the penetration of renewable generation increases.
3. Capacitor switching transients: When there are several power factor correcting capacitors on feeders from the one zone substation, there are many possible combinations of installed

capacitors which can occur. A study of switching overvoltages can quickly grow to encompass hundreds of simulation studies. The project will attempt to find a technique with less computational effort, possibly based on a frequency response or eigenvalue approach.

4. Application of wavelets to power quality instrumentation: The aim is to survey papers in this field, look for an application of local interest, and then investigate in detail, possibly making use of the MATLAB wavelet facilities. One problem of strong interest is the automatic classification and parameter extraction of disturbed waveforms.
5. Modelling of power electronic converter system for conducted EMI: The project aims to produce accurate circuit models which can be used to investigate the ways in which the conducted EMI can be minimised.

6. Development of a calibrated fluctuating voltage source and implementation of a flicker meter on a PC: The project involves the development of a fluctuating voltage source which can be used to test flicker meters built to the IEC868/AS4376 standard. Also the source can be used to examine human eye irritability due to voltage flicker, enabling verification of the IEC flicker curve. As a second phase of the project, a PC based flicker meter is to be developed.
7. Ferroresonance in power distribution systems: A practical instance where live-line single-phase disconnection of a long cable section led to a lightning arrester failure is being investigated. The suspected reason for the arrester failure is ferroresonance but other reasons can not be ruled out. The project involves network modelling and simulation using PSCAD/EMTDC, a software package which enables fine control of transformer saturation.
8. Impact of power quality problems on variable speed drives: Power quality problems such as voltage unbalance, voltage sags and swells and transients have differing impacts on the drive as well as on the supply system. The project involves using the PSCAD/EMTDC software package to simulate and investigate a diode front end rectifier feeding a PWM inverter supplying an induction motor. The effects of line and dc link inductors on the performance of the variable speed drive are to be investigated. Also, the sensitivity of the dc link capacitor and the line inductors will be examined.

### **Technical Director on Study Leave**

Technical Director Vic Gosbell had a 6 month period of study leave at the end of 1998. Two months of this was spent at the Power Quality Centre at the University of Tasmania run by Dr. Michael Negnevitsky. During this time, Vic was involved with teaching and research activities.

The research activity involved looking at a methodology for setting up Australian Power Quality Standards in software. Two types of user were identified (a) the beginner, (b) the power quality engineer who would need to refer to a particular standard about once every few months. The first case has been handled by building in an extensive set of linked help screens so that the user can easily find additional tutorial material to guide them. For the second user the software has been organised to take the user automatically through the correct stages of assessment, prompting when information has to be entered, suggesting default parameters when there is uncertainty and making all calculations and logical decisions. This work is now continuing at the Integral Energy Power Quality Centre using the new Australian MV & HV fluctuations standards.

Vic also presented a power quality course to the final year power engineering students at the University of Tasmania. It is believed that this is the first time that a course specifically on power quality has been given to undergraduates. The main aims of the course were:

- (i) Classification of the main types of power quality disturbances, their sources and effects;

- (ii) Analytical techniques for calculating disturbance magnitudes and their propagation;
  - (iii) Power Quality standards;
  - (iv) Methods of solving power quality problems.
- The course was accompanied by computer-aided exercises in which EXCEL, MATLAB & PSPICE were used.

While in Hobart, Vic attended AUPEC'98, the annual power engineering conference, organised by Dr. Michael Negnevitsky. As would be expected, the theme of the conference was power quality and there was a panel discussion and two sessions devoted to this topic. Vic gave one of the keynote papers and discussed the setting up of the Integral Energy Power Quality Centre and the work it was doing. There were several technical papers from Centre personnel covering harmonics from rectifier/capacitor loads, flicker measurement, arc furnace simulation and the use of the web in the dissemination of technical information.

A paper on the Centre's load-testing facility was presented at ICHQP'98 (International Conference on Harmonics and Quality of Power) in Athens in October. There were over 1200 pages in the two volumes of the proceedings, many of which are quite relevant to current Australian power quality problems. An interesting session concerned European experience with the IEC standards on harmonics and flicker at present being adopted by Australia. It was felt at the session that these standards will need further development work. In particular, it was difficult to meet the low levels specified at HV and for high frequency harmonics.

If you require further information about any article in this newsletter, please contact:

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