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IEEE Canadian Review

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Vijay K. Sood, Hydro-Québec

Mes meilleurs voeux pour la nouvelle année, le nouveau siècle et le nouveaumillénaire! Vous aurez sûrement remarqué que la revue a fière allure. J'espère que vous aimerez ce nouveau style.

Lors de mon arrivée à la barre du Canadian Review (CR), mon plan de match était en quatre parties:

- améliorer le contenu, la qualité et l'implication des abonnés,
- rajouter du contenu en français,
- réduire les coûts et améliorer les revenus, et
- mettre sur pied une version électronique du CR (voir www.ieee.ca).

J'espère avoir rencontré vos attentes. Je suis heureux de noter que l'année dernière a été la plus fructueuse au niveau du nombre total de mots et de pages publiés, des revenus et, malheureusement, des dépenses. J'essaie de contrôler le budget, mais les pressions de l'inflation se font sentir. Je tiens à dire que votre appui et vos commentaires sont de plus en plus présents. Toutefois, ne vous relâchez pas tout de suite, j'ai encore besoin d'avoir de vos nouvelles.

Je souhaite la bienvenue à notre nouvelle présidente de l'IEEE Canada, Celia Desmond, et je vous présente son discours inaugural à la page 13 de ce numéro. L'équipe du CR est restée intacte et je remercie Celia pour son appui et ses encouragements. Je souhaite à Dave Kemp, notre président sortant, un repos bien mérité et beaucoup de succès en tant que Secrétaire à la maison mère de l'IEEE. Dave a été pour moi une inspiration. Dave nous a remis un résumé des réalisations de son terme à la page 22.

Le comité organisateur de la conférence CCECE à Halifax travaille très fort. (voir l'annonce à la page 14 et leur site web à http://is.dal.ca/~ccece00).

J'ai bien hâte de rencontrer plusieurs d'entre vous à la conférence CCECE 2000 à Halifax en mai.

Cover picture / *Photo de couverture*

The Plattsburgh APST

The world's first Interphase Power Controller (IPC) installation was commissioned in June 1998 at New York Power Authority's Plattsburgh station.

The project is described in the article on page 9. This type of IPC results from the addition of high-impedance inductors in parallel with an existing phase-shifting transformer (PST) and is called an Assisted Phase-Shifting Transformer (APST). The three single-phase inductors, the circuit breaker and part of a disconnect switch can be seen in the picture. Together with the existing PST, also seen in the background, this equipment constitutes the Plattsburgh IPC.

During the summer period, the PST was the thermally limiting element of the interconnection with Vermont, restricting the pre-contingency loading of the 115 kV line to 105 MW. Following the conversion of the PST into an APST, the transfer capacity of this important interconnection is raised to 140 MW, a very significant increase of 33%. The cost of the IPC installation was approximately half that of a new PST of higher rating.

Compared to the previous year, the total energy transfer for the 1998 summer period was increased by 77 GWh (25.7%). The IPC has been more than incidental in this increase. Indeed, despite different market conditions, strictly speaking, without the higher power flows made possible by the IPC, it would have been physically impossible to transfer at least 40 of these 77 GWh.

Happy New Year, Century and Millennium! As you will no doubt note, we have a new look. I hope that you will like the new image of the journal.

I had adopted the following four-point plan of action when I took over the helm at the Canadian Review (CR):

- improve the content, quality and membership involvement,
- increase the French content,
- reduce costs and improve the revenues, and
- provide an on-line version of the CR, (see www.ieee.ca).

I hope that I have lived up to some of these commitments. I am happy to note that last year was our best so far in terms of written words, printed pages, revenues and, unfortunately, expenditures. I am trying to control the budget, but inflationary pressures are creeping in. I am glad to report that your response and support has been getting better; however, don't quit on me just yet as I still need to hear from you.

I welcome our new President, Celia Desmond, at IEEE Canada and present her inaugural address on page 13 of this issue. The team at the Canadian Review has remained intact and I am grateful to Celia for her support and encouragement. I bid past-president Dave Kemp a well-earned rest and wish him success as Secretary at IEEE headquarters. Dave was an inspiration to me personally. Dave provides a summary of the achievements during his term on page 22.

The organizing committee at the CCECE Conference in Halifax is working hard (see the flier on page 14 in this issue and check out their website: http://is.dal.ca/~ccece00).

I look forward to seeing many of you at the CCECE 2000 conference in Halifax in May.

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Newslog editor

Rédactrice des Coupures de presse

Isabelle Chabot is a patent agent trainee at Swabey Ogilvy Renault, patent and trademark agents in Montreal.

Isabelle Chabot travaille à Montréal chez Swabey Ogilvy Renault, agents de brevets et de marques de commerce, comme agent de brevets en formation.

Send any news clippings you would like to contribute via e-mail to i.chabot@ieee.ca

Veuillez faire parvenir les coupures de presse proposées par e-mail à i.chabot@ieee.ca

OCT 21. L'École de technologie supérieure (ÉTS) annonce l'ouverture, à Montréal, du premier Centre Universitaire de simulation de réseaux électriques au Canada. Hypersim, de conception québécoise (Institut de Recherche en Électricité du Québec), permet de reconstituer en temps réel les réseaux électriques, d'identifier les maillons faibles et de trouver les correctifs à apporter.

NOV 1 Newlix Corp, an Ottawa-based computer firm, has launched its “Omega” server which is based on the Linux operating system. Newlix will develop the software and then hand it to IPC Direct for the hardware development.

NOV 6 Xerox's laboratory of Toronto has come up with a new paper which 3M will manufacture and which is composed of two-colored magnetized marbles, is in plastic and has the thickness of a transparency. the marbles are magnetized and forced to turn on themselves to create the black text and the white background of a page of text and images.

NOV 8 Firms will be able to subscribe to use the WordPerfect Office 2000 software suite from Corel Corp of Ottawa without buying it. FutureLink Corp of California will manage the project on behalf of Corel and will offer its customers to rent the software by the month.

NOV 9 TMI Multipartn'r Technologies Inc. de Québec a reçu un investissement commun de 500,000$ de Compaq Computer Corp. et Microsoft Corp pour développer un laboratoire de développement Windows 2000 qui créera 20 nouveaux emplois.

NOV 13 Cybersurf Corp of Calgary has partnered with Lipton, a division of Unilever Canada Inc. to give away 250,000 copies of its software in Toronto area grocery stores when they buy 3 Lipton products. The customers agree to send personal information and allow advertising on their screens when online in exchange for an unlimited Internet access.

NOV 15 Entrust Technologies Inc. is partnering up with Nokia to develop software to make secure electronic commerce on a mobile phone a reality. Entrust is a spinoff of Nortel Networks Corp whose headquarters are in Texas but who has a plant in Ottawa. The software will be used by banks, e-commerce merchants and network companies.

NOV 17 Le Groupe Vidéotron ltée et son portail InfiniT.com ont englouti Netgraphe Inc, qui publie plusieurs sites web dont La toile du Québec. Ensemble, ces sites produisent des revenus de 4 million $. InfiniT est évalué à 72.7 millions $. InfiniT achètera 7.7million d'actions de Netgraphe pour 13.5 millions $.

NOV 26 An Internet incubator, Brightspark Inc., was launched in Toronto by Mark Skapinker of Delrina Corp, Tony Davis of WinFax and Richard Nathan, a legal practitioner, to hatch high-risk but high-reward online businesses.

NOV 29 Protus IP Solutions Inc of Ottawa who had developed technology to send faxes over the Internet has now launched an IP fax service network across most of Canada. For a small fee a month, it is possible to receive a personal local-area fax number. The faxes are sent by email as attachments.

JAN 18 Skulogix Inc. of Toronto has announced a 7-million $financing round. Skulogix lets on-line vendors sell multiple products from multiple vendors while delivering a single package to the customer. The financing deal beats any deal of its kind for Internet start-up businesses in Canada.

JAN 21 Une firme montréalaise, eResolution, vient de créer un processus de médiation en ligne composé d'un groupe de juristes impartiaux pour mettre fin aux conflits résultant du cybersquattage sans avoir à recourir aux tribunaux.

JAN 29 Telemedia Communications Inc. was acquired by GTC Transcontinental Group Ltd. of Montreal for 150 million $. GTC will become Canada's second largest publisher of speciality magazines. GTC's magazine publishing revenues should increase from 90 million $to 210 million $a year.

JAN 30 iMagicTV, a company affiliated with NBTel in New-Brunswick has announced a new product, VibeVision, which offers to customers of NBTel, 100 audio and digital television channels, a high-speed Internet connection, phone services and an interactive TV guide, all grouped in one bill.

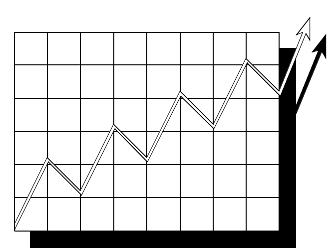
FEB 1 A contract worth 500 million $to build a nationwide mobile phone network in Italy is believed to have been won by Nortel Networks of Ottawa. BLU, a mobile phone operator in Italy would have chosen Nortel.

FEB 3 Bell Canada et Lycos s'associent pour créer Sympatico-Lycos qui mettra à la disposition des utilisateurs canadiens un portail plus complet et dans lequel les internautes trouveront tout ce qu'ils cherchent sans avoir recours à des portails américains. Bell Canada investira un minimum de 95 millions $ dans les trois prochaines années.

FEB 22 QuébecTel utilisera et adaptera les lignes conventionnelles du réseau de télécommunication pour transporter à la fois les signaux de télévision numérique, les transmissions Internet de toutes sortes telles les courriels et les pages web et les conversations téléphoniques habituelles.

FEB 23 Montreal-based Zero-Knowledge has hired Stefan Brands, a Dutch specialist in cryptography, and has become the exclusive owner of his patent rights. Zero-Knowledge will do research and development on creating private and anonymous electronic cash.

FEB 24 David Cliche, Quebec's minister for the information highway announced that the province will introduce a bill to make transactions over the internet more secure. Measures to recognize electronic signatures will be contained in this bill.



DWDM And The Future Integrated Services Networks

by *Shaowen Song*
Wilfrid Laurier University, ON

Abstract

This article provides an overview of the DWDM network and its current technologies. A discussion on DWDM applications and the system requirements, as well as the roles of current network architectures, such as the SONET, ATM and TCP/IP, in the DWDM framework is presented after the overview. An analysis of system requirements for the full optical DWDM integrated services network is then provided.

Sommaire

Cet article fournit un aperçu sur les réseaux de DWDM et de ses technologies actuelles. Une discussion suivra sur les applications de DWDM et les besoins de système, ainsi que le rôle des architectures de réseau actuelles, telles que le SONET, ATM et TCP/IP, dans le cadre de DWDM. Une analyse sur les besoins de système de services intégrés de réseau DWDM entièrement optique sera ensuite présentée.

1.0 Introduction

It is no doubt that the future of the communication network lies on the integrated services given the bandwidth capacity of a single fiber. The competition for the integrated services network has been among three forces, the ATM-based broadband integrated services digital network (B-ISDN), the cable TV, and the Quality of Service (QoS) enabled Internet. Among these three candidates, the B-ISDN has been the most mature and complete system. The QoS enabled Internet is still in its early research stage. The cable TV network has been focused on the access-network level rather than on a global communication network. With its primary success, in terms of point-to-point bandwidth, the Dense Wavelength Division Multiplexing (DWDM) network is reshaping the landscape of the communication networks. All of the above mentioned three types of communication networks plus the circuit switching SONET will unlikely be the framework of the future communication network. Instead, they will have to reposition themselves in order to find a role in the DWDM infrastructure. Given the bandwidth capacity in each channel of the DWDM network, the future of the DWDM also lies on integrated services. To achieve this, a time domain multiplexing (TDM) scheme, e.g., circuit switched SONET or cell switched ATM, is required in each channel and among the channels. The questions that arise are which TDM is the best candidate for this and how can they be implemented. This article provides an overview on the status of DWDM technology. Analyses on the future roles of existent TDM network protocols in the DWDM network and the future DWDM based integrated services are also discussed.

2.0 DWDM Networks

2.1 The Principle and Architecture of DWDM

Wavelength division multiplexing operates by sending multiple light waves (frequencies) across a single optical fiber. Information is carried by each wavelength, which is called a channel, through either intensity (or amplitude) or phase modulation. At the receiving end, an optical prism or a similar device is used to separate the frequencies, and information carried by each channel is extracted separately. Binary digital signal, which is a full on/off intensity modulation, can also be carried by each individual channel, although the bit rate is expected to be lower than the intensity or phase modulation. As in conventional frequency division multiplexing (FDM) used in electrical signal or radio wave transmissions, the carriers can be mixed onto a single medium because light at a given frequency does not interfere with light at another frequency within the linear order of approximation.

The basic principle of optical communication, including DWDM, is depicted in Figure 1, in which the transmitter modulates the input signal using amplitude (or intensity)-shift keying (ASK), frequency-shift keying (FSK), or phase-shift keying (PSK) to a carrier lightwave at frequency Fs with a very narrow frequency linewidth - a single frequency laser (or a single color light). This modulated signal, which combines with other signals of different frequencies, is transmitted along the optical fiber to the receiver. The signal is then converted back to the electrical signal by way of an optical detector and a demodulator. Switches or routers of some kind may also be involved between the transmitter and the receiver.

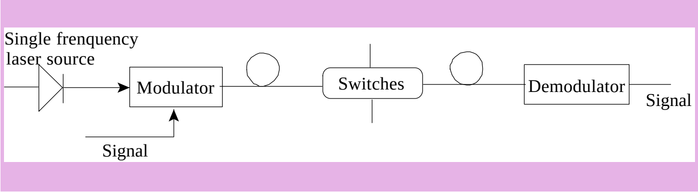


Figure 1: Principle of optical communications

Figure 2 depicts the basic architecture and operations of DWDM networks, which consists of end nodes, switch nodes, and optical fiber links. The end nodes consist of modulators/demodulators (or modems) for every channel, and multiplexers and demultiplexers for combining or separating the lights of different frequencies. The modulators encode digital data into waveform symbols through either an intensity or a phase modulation method, and the demodulator reverses the process to obtain digital data. The switch nodes consist of add/drop multiplexers and demultiplexers, wavelength switches, and wavelength converters. The multiplexers are used to combine the signals of different wavelengths for transmission and the demultiplexers are used to separate the signals of different wavelengths for switching. The wavelength switch cross connects the input channels to the desired output channels. The function of the wavelength converters is to convert the over-demanded wavelengths to free wavelengths in a given fiber to achieve high channel utilization.

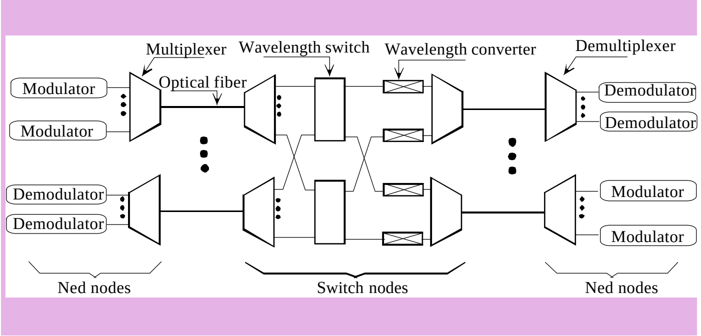


Figure 2: Major components of a DWDM network

2.2 Modulators/Demodulators

The most efficient way to modulate and demodulate the signals is to use semiconductor lasers. Modulating the drive current of a semiconductor laser can produce either frequency/intensity modulation depending on the configuration of the semiconductor modulator. A simple form of phase modulator can be made by passing the light along a strip waveguide formed in an electro-optic material such as lithium niobate, LiNbO3 (Figure 3). Application of the modulating voltage waveform to the electrodes causes a variation of the phase length of the channel. External amplification may be required for this form of modulator.

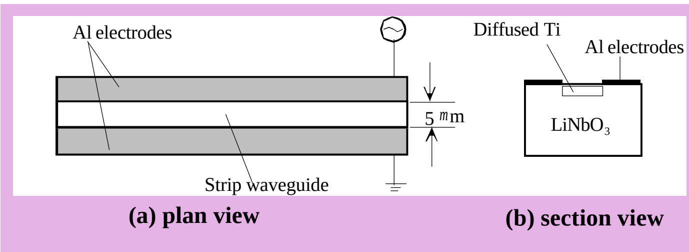


Figure 3: Example of a lithium niobate strip waveguide phase modulator: (a) plan view; (b) section

An amplitude (or intensity) modulator can be constructed by a Mach-Zehnder interferometer. This, too, can be a waveguide in an electro-optic material, as shown in the schematic plan view of Figure 4. The modulating voltage now causes a variation of the relative phase difference between the two paths. At the output waveguide the two waves recombine as the sum of the two modes: the fundamental mode which is guided and a higher-order mode which is unguided and radiated away. As the path difference varies, the proportion of the power in each mode changes and the guided output power is modulated.

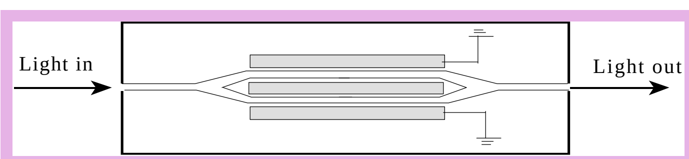


Figure 4: A schematic plan view of a lithium niobate diffused strip waveguide Mach-Zehnder interferometer modulator

A passive Mach-Zehnder interferometer can be used to convert frequency modulation to intensity modulation. Also, a full on/off intensity (or pulse waveform) modulation can be achieved with a reduced amplitude of the modulating current. A system of this kind has been demonstrated in a field trial over an underwater link of 132 km of standard single-mode fiber back to early 90's. Using the interferometer, the required intensity modulation at 1.12 GHz was obtained with an input frequency deviation of 5 GHz (0.04nm) and the link was not dispersion limited. The chirp that would have resulted from direct intensity modulation of the laser at this frequency was nearer to 60 GHz (0.5 nm). With a fiber dispersion coefficient of 15 ps/(km.nm), this would have given rise to a r.m.s. dispersion width of about 1 ns over the 132 km and so would have limited the bit rate to some 250 Mb/s.

Multiplexers/demultiplexers, which are used to combine/separate wavelength channels, are also important components in DWDM networks. The mechanisms have long been well understood, and devices of different types have also been constructed in the optical field. Key technologies underpinning current commercial DWDM Multiplexers/demultiplexers include thin film interference filters, fiber Bragg gratings (FBG), cascaded waveguide- or fiber-based Mach-Zehnder interferometers, bulk diffraction gratings, arrayed waveguide grating, and hybrid combinations of such technologies.

So far, the realization of modulators /demodulators based on the above methods, and multiplexers/demultiplers have been successful, which makes a point-to-point DWDM network possible. Commercial products of modulators /demodulators and multiplexers/demultiplers are generally available. DWDM networks for point-to-point transmission have been deployed by several telecommunication companies, including Nortel networks. In the meantime, the number of channels and the bit rate per channel have been rising exponentially. An 80-channel 50-GHz channel spacing multiplexer/demultiplexer has been reported by JDS Uniphase, an Ottawa based optical communication device company, based on an enhanced interleaving technology[1]. Nortel Networks demonstrated its 6.4 Tbps platform, which is considered as the highest bit rate up to date, at TELECOM'99 in Geneva in December 1999[2].

2.3 DWDM Switching/Routing

A simple routing function proposed to add to the point-to-point DWDM network is the broadcast-and-select routing in which each user on the network transmits its signal into a broadcast star coupler which was used to distribute those signals passively to all other nodes on the network. A media-access protocol is required to control the transmissions of the various network nodes to avoid collisions and to manage contention for the network bandwidth. The potential attractions of this type of network are its simplicity and performance, since no switches or routers are involved. The principle limitation of this network is that it is not scalable to large number of nodes because there is a linear relationship between the number of nodes and the number of wavelengths. Work in this area is still underway for interconnection of computers in local and metropolitan area networks. Application to large-scale networks is however not feasible due to the lack of graceful scaling [3].

Wavelength routing will be the first step of routing ability for DWDM, which is currently in research stage. Wavelength routing is defined to be the selective routing of optical signals according to their wavelengths as they travel through the network elements between source and destination. There are two salient features of wavelength routing. First, wavelength routing determines the path taken by the optical signal, and if multiple signals are launched from a given node, each may go to a separate distinct destination. The number of such destinations is equal to the number of wavelengths generated at each node. The second feature is that because each signal is restricted to a particular path, it is possible to have each wavelength reused many times on different paths throughout the network as long as these other paths do not try to coexist on the same fiber link. A schematic of such type of switching node with wavelength converters for wavelength reusing is shown in Figure 2. Such a wavelength interchanging cross-connect allows any input wavelength on any input fiber to be cross-connected with any output wavelength on any output fiber, provided that the desired fiber has enough channels. This switch partially achieved both wavelength and space (among fiber links) multiplexing.

The importance of the DWDM cross-connect switch, and the closely related DWDM add-drop multiplexer, is that they allow the optical network to be reconfigured on a wavelength-by-wavelength basis to optimize traffic, congestion, network growth, and survivability. They also permit the configuration of special circuits for transmission of alternative format signals. The DWDM cross-connect switch and the DWDM add-drop multiplexer are the essential wavelength-selective format transparent elements upon which multi-wavelength networks will be built.

3.0 DWDM Applications in the Near Future

The first application of DWDM is point-to-point backbone transmissions, which is currently being deployed in many cases. It can be applied to different network frameworks and protocols, such as the circuit switched Synchronous Optical NETwork (SONET, known as the Synchronous Digital Hierarchy (SDH) in Europe), the TCP/IP based Internet, TCP/IP or ATM based Intranet, etc. The applications of DWDM point-to-point will dramatically expand the bandwidth capacity of existing fiber links. It will, therefore, potentially reduce the costs of these networks. One network that seems being left out by this step of DWDM application will be the cable TV network. Although it is possible to replace the coaxial cables by optical fibers and run DWDM for broadcast television services with each wavelength carrying one or more TV channels, the costs may again become the defining factor.

The technologies for interconnecting existing communication networks and protocols with DWDM point-to-point backbones are in the developing stage. Some of these technologies are already commercially available. There are no technological obstacles for building the interface between DWDM and most existing networks. Product development is the current status in this area.

The second step of DWDM applications will be adding optical switches/routers onto the DWDM backbone networks. At this stage, the architecture and the protocol of a network will determine the costs and even the possibility of implementing the switches/routers. Considering the mechanisms of the current networks, including the SONET, the Internet, the ATM, and the cable TV system, the SONET will be the leader in this stage, because of the simplicity of its switching and time domain multiplexing (TDM) mechanisms in comparison with the rest. It is foreseeable to replace the electrical digital switches and its time domain multiplexers by its optical counterparts, while it is much more difficult to replace the routers in the Internet and the switches in the ATM networks, since the control of these routers/switches requires higher intelligence to run the protocols. Therefore, it would not be surprising to see a full optical SONET or SDH in the foreseeable future, while we might have to wait somewhat longer to see a full optical packet switching network.

4.0 Optical DWDM Networks & Integrated Services

A further development after the optical circuited SONET would be packet switching/routing full optical integrated services network. If we compare the suitability between ATM and TCP/IP, it is obvious that the ATM becomes the leader, since the TCP/IP has not yet had the capacity for real-time communications. However, research on enabling the Internet to provide quality of service (QoS) is currently on going in the Internet community. With the DWDM backbone being in place in the near future, which will provide much higher bandwidth between routers, the research on the next generation of the real-time Internet will gain momentum. The major bottleneck comes from the capacity of the electronic routers, which might delay or even prevent the implementation and the test of the QoS enabled TCP/IP protocols.

To implement the full optical ATM switches, a major obstacle comes from the control unit of the switch that is responsible for executing the protocols. The switching fabrics are in the same level of SONET switches in terms of optical implementations. The implementation of the control unit requires logic processing in the light domain. Technologies for logical processing in the light domain are not available at the moment, although it is possible in theory.

To implement the full optical QoS enabled TCP/IP, if we assume that it is ready, we need full optical computers. This will require a revolution in the computer design and manufacturing, but it seems possible. TCP/IP over ATM may find its application again in a full optical ATM over DWDM network.

5.0 Concluding Comments

The article provides an overview of DWDM networks and its current technologies. Analyses of applications and roles of current network protocols in the future DWDM frameworks are also provided. It seems clear that DWDM will reshape communication networks, but the current network architectures and protocols will play their roles in the future DWDM based framework. Because of the switching simplicity and bandwidth availability through DWDM, SONET may well be the first framework for a full optical network. Although ATM has been losing its popularity due to the lack of success of the B-ISDN, it may find a new life on ATM over DWDM for future integrated services networks.

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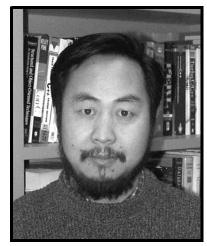
7. Acronyms

ATM	- Asynchronous Transfer Mode
B-ISDN	- Broadband Integrated Services Digital Networks
DWDM	- Dense Wavelength Division Multiplexing
FDM	- Frequency Domain Multiplexing
QoS	- Quality of Service
SDH	- Synchronous Digital Hierarchy
SONET	- Synchronous Optical Network
TDM	- Time Domain Multiplexing
TCP/IP	- TCP: Transmission Control Protocol IP: Internet Protocol
WDM	- Wavelength Division Multiplexing

About the Author



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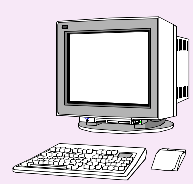
Shaowen received a B. Sc. degree in electrical engineering and a M. Sc. degree in applied mathematics from Tianjin University in China. He received his Ph.D. in engineering from Memorial University of Newfoundland.

Shaowen's current research interests include broadband access networks, residential gateways, optical logic and computing, and DWDM networks. He is a member of the IEEE and a member of the IEEE Communications Society.

Proverbs for the Millennium

1. Home is where you hang your @.
2. The e-mail of the species is more deadly than the mail.
3. A journey of a thousand sites begins with a single click.
4. You can't teach a new mouse old clicks.
5. Great groups from little icons grow.
6. Speak softly and carry a cellular phone.
7. C:\ is the root of all directories.
8. Oh, what a tangled website we weave when first we practice.
9. Pentium wise, pen and paper foolish.
10. The modem is the message.
11. Too many clicks spoil the browse.
12. The geek shall inherit the earth.
13. There's no place like home.
14. Don't byte off more than you can view.
15. Fax is stranger than fiction.
16. What boots up must come down.
17. Windows will never cease.
18. Virtual reality is its own reward.
19. Modulation in all things.
20. Give a man a fish and you feed him for a day; teach him to use the Net and he won't bother you for weeks.



Bob McLoud
Markham, ON

The Engineering Institute of Canada - L'institut canadien des ingénieurs

The Engineering Institute of Canada (EIC) announces its year 2000 Honours, Awards and Fellowships. Seven senior awards and eighteen Fellows were recognized during National Engineering Week, at the Institute's Annual Awards Banquet held at the National Arts Centre in Ottawa, on 6 March 2000.

The recipients are:

CANADIAN PACIFIC RAILWAY ENGINEERING MEDAL

For leadership and service to the Institute and its member societies at the regional and local levels

Mohamed E. El-Hawary
Associate Dean of Engineering and Professor
DalTech, Dalhousie University
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HONORARY MEMBERS

Non-members of the Institute for outstanding distinction and service to the engineering profession

Arthur Carty
President
National Research Council of Canada
Ottawa, Ontario

Robert Bourassa (Deceased)
Former Premier of Québec

JULIAN C. SMITH MEDAL

For achievement in the development of Canada

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THE K.Y. LO MEDAL

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Interphase Power Controllers - complementing the family of FACTS controllers

1.0 Why the IPC?

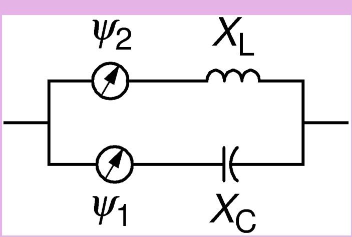
One of the main reasons for developing the Interphase Power Controller (IPC) technology was to create new power flow controllers that would overcome the limitations on system operation caused by high short-circuit levels. In fact, excessive short-circuit levels constitute a widespread problem that has been almost completely overlooked in the development of FACTS controllers [1]. The flexibility of transmission and distribution systems can be greatly enhanced when circuits or interconnections can be added without significantly increasing the short-circuit levels. Despite worldwide efforts being made to develop fault-current limitation devices, the IPC is still the only such device available today at a competitive price.

The conventional solution to the problem of high short-circuit levels is to break up the network, for example by leaving a bus-tie breaker open to allow a new supply, generation or line. Another example is the radial operation of subtransmission systems, however with a loss of flexibility, if not reliability. A third example is the increase in transformer station capacity that can be achieved only by splitting the lower voltage bus. Such network degrading situations are widespread, underscoring the need in T&D systems for fault-current limiting power flow controllers.

2.0 Overview of the IPC technology

The basic design goal in IPC technology is to find passive solutions to fundamental frequency problems. Power electronics modules can be added in situations where rapid control action is required to damp oscillations or prevent excessive voltage variations. Hence, basic IPC solutions utilize only conventional equipment, such as capacitors, inductors and phase-shifting transformers. They generate no harmonics and have no commutation losses. Robustly built, they require much less maintenance than power electronics-based devices.

The IPC does not have a fixed configuration, being more a technology for creating different and innovative power flow controllers with diverse characteristics and configurations. Generically, it is a series-connected device consisting of two parallel branches, each with an impedance in series with a phase-shifting element (Figure 1). The four design parameters (two impedances and two phase shifts) allow enormous design flexibility and make a wide variety of applications possible. Because of the different characteristics these IPC applications can have, they have their own specific names.



$\psi1$, $\psi2$ - Internal phase shifts

X_C - Capacitive reactance

X_L - Inductive reactance

Figure 1: Generic single-line diagram of the interphase power controller.

IPCs can be adapted to specific operating conditions. In general, the adaptation also results in an optimization. For example, the removal of the phase shift in one of the two branches of the IPC reduces the amount of equipment and relocates the control characteristic to a more favorable position in the power-angle plane. The adaptability of the IPC technology is also demonstrated by the various ways in which the internal phase shifts can be implemented. Conventional phase-shifting transformers (PST) are the first obvious choice, but the IPC characteristics can also be obtained using conventional transformers which have auxiliary windings added to create the desired internal phase shift by injecting series voltages from other phases.

Three categories of IPC applications are commercially available today:

- The first subset of the technology, in which the impedances form a parallel circuit tuned to the fundamental frequency of the network, is called the Decoupling Interconnector (DI). These high-impedance IPCs have the unique properties of limiting their own contribution to a fault and of decoupling the voltages at their terminals. They are intended for implementing ties not otherwise possible because of high short-circuit levels.
- When a decoupling interconnector linking two voltage levels is in parallel with conventional transformers, its configuration can be simplified and optimized. It is then called a Fault Current Limiting Transformer (FCLT). The purpose of the FCLT is to increase the total capacity of a transformer station without increasing short-circuit levels.
- In transmission applications, the decoupling characteristics of the DI are detrimental to the stability of the network and the parallel circuit has to be de-tuned. The simplest implementation of a transmission IPC is a phase-shifting transformer (PST) in parallel with a reactive impedance. Called an Assisted Phase-Shifting Transformer

by *Jacques Lemay, ABB Canada*
Jacques Brochu and François Beauregard, CITEQ
Pierre Pelletier, Hydro-Québec

Abstract

The current application of Flexible AC Transmission Systems, or FACTS, solutions does not address the widespread problem of excessive short-circuit levels, for which the only conventional solution is to break up networks, thus reducing operating flexibility if not reliability. The Interphase Power Controller (IPC) technology offers innovative solutions for high short-circuit environments. IPCs provide passive solutions for normal and contingency conditions. Power electronics modules can be added as necessary for dynamic conditions. At the present time, there are three commercially available IPC applications.

Sommaire

Les Systèmes de Transmission Flexibles en Courant Alternatif (FACTS) actuels ne permettent pas de gérer le problème largement répandu des niveaux de court-circuit trop élevés. La solution traditionnelle, qui consiste à fractionner les réseaux, nuit à leur flexibilité d'exploitation, voire à leur fiabilité. Le Régulateur de Puissance Interphases (RPI) constitue une solution innovatrice pour les environnements à niveaux de court-circuit élevés. Le RPI gère, de manière passive, les régimes permanent et post-contingence. On peut aussi lui adjoindre des modules d'électronique de puissance, selon les besoins en régime dynamique. Trois types de RPI sont actuellement disponibles sur le marché.

(APST), this device can be used either to increase the normal and contingency transfer capacity of an existing PST or to implement an equivalent high-capacity PST at lower cost. The Plattsburgh APST, in service since June 1998, belongs to this category.

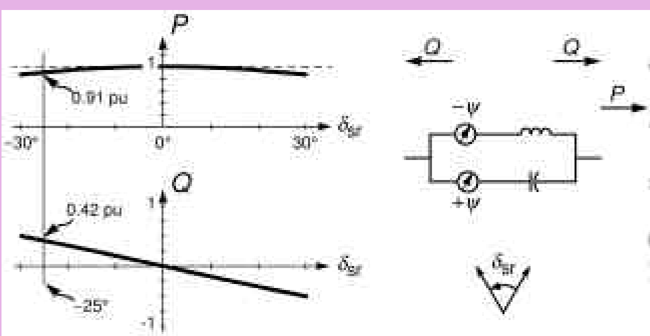
All IPC applications are covered by one or more of five different patents. (The mathematical principles, the method of analysis and basic application examples are found in [2].) As co-developer of the technology, ABB holds a unique worldwide license for marketing all IPC applications.

3.0 The Decoupling Interconnector

In the decoupling interconnector (DI), the impedances form a parallel circuit tuned to the fundamental frequency. Each terminal of the DI behaves as a controlled current source.

In normal operating conditions, the DI provides bidirectional power flow control and voltage support through the generation and absorption of reactive power. The desired operating levels are obtained by adjusting the phase shifts, using either tap-changers or switches. During perturbations, there is no short-circuit contribution from the DI and the voltages on each side are decoupled. In other words, the DI does not transfer the impact of perturbations from one side to the other.

The basic control characteristics of the DI (Figure 2) are obtained by passive means using conventional elements, i.e. capacitors, inductors and phase-shifting transformers. The control functions, being inherent to the controller, are robust and predictable for all pre- and post-contingency conditions.



P - Active power, Q - Reactive power

δ_{sr} - Phase angle between terminals

Figure 2: Basic control characteristics of the decoupling interconnector

3.1 Typical applications

The DI allows the implementation of new interconnections, such as:

- Ties between separate subtransmission systems, for increasing operational flexibility, sharing transmission reserves, and facilitating reactive power management.
- Bus ties, for paralleling generation or transformation without increasing short-circuit levels.

For such ties, there are no conventional alternatives besides uprating the short-circuit interrupting and withstand capabilities of circuit-breakers and other equipment.

The DI can also be used as a blocking circuit for preventing overloads in a subtransmission system following the loss of parallel higher voltage lines. This allows higher pre-contingency loading of the higher voltage lines. Such IPC solutions are expected to be less onerous than increasing the capacity of the overloaded circuit(s) and will avoid the network degradation resulting from these lines being left normally open.

3.2 Demonstration prototype:

The results of an exhaustive prototype demonstration using the power system simulator at the Hydro-Quebec Research Institute are summarized in [3]. The most difficult operating condition for the DI, the one that dictates the final design of the components, is the occurrence of an open circuit on either side of the tuned IPC. In this situation, the two branches of the DI form a series resonant circuit excited by the equivalent voltage source of the phase shift. The design objective is to protect the (already out of service) DI components during shutdown. The solution demonstrated on the simulator uses conventional zinc-oxide energy absorption devices.

4.0 Fault Current Limiting Transformer (FCLT)

Normally, the transformers in large T&D substations are operated in parallel for maximum reliability and flexibility. Once the construction of the station is complete, the short-circuit level on the secondary side does not allow the addition of transformers unless special measures are taken to cope with or to avoid the increase in fault currents. Barring either extensive modifications to the substation or the construction of a new one in the immediate vicinity, two conventional options exist: split the low-voltage bus or, if the design of the station is based on the n-1 criterion, operate a redundant transformer in a standby mode.

Reference [5] presents an application in which a fifth transformer is added in a large 315/120 kV transformer station typical of Hydro-Québec installations in the Montréal area. Although more expensive than a conventional transformer, the IPC solution is definitely more advantageous than replacing or uprating a large number of 120-kV breakers and associated equipment. After [5] was written, optimization studies have shown that the configuration of the FCLT can be simplified provided there are at least two conventional transformers in parallel with the FCLT for all contingency conditions. The inductive branch can be removed as it is shorted by the lower impedance of the parallel transformers. The resulting optimized FCLT consists of a conventional transformer in series with a capacitor bank and a small phase-shifting transformer. Figure 3 shows a typical single-line diagram; the phasor diagrams in Figure 4 illustrate the behavior of the optimized FCLT during steady-state and fault conditions.

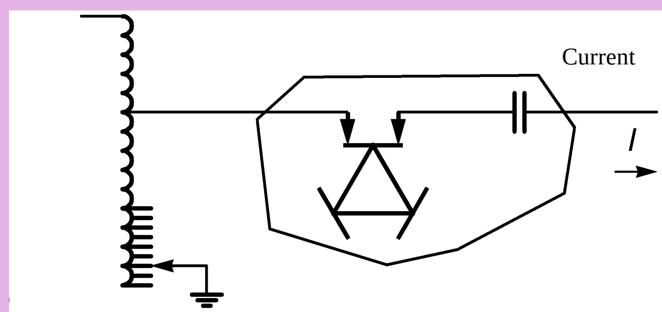
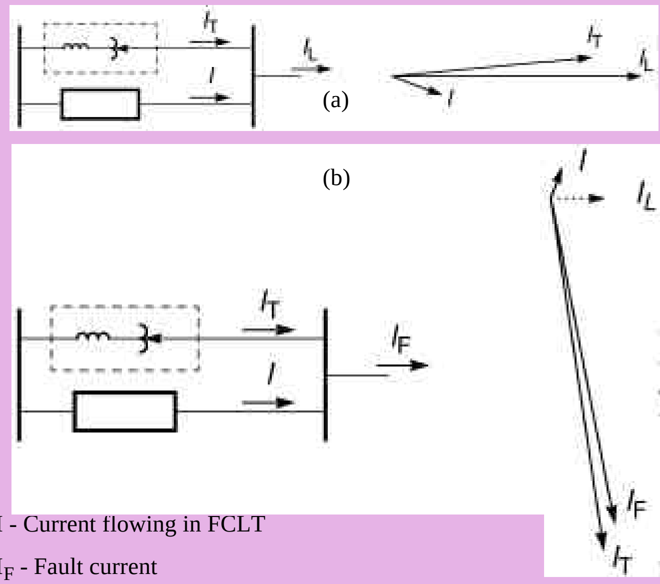


Figure 3: Single-line diagram of an optimized fault current limiting transformer.

Thus, the FCLT technology allows one or more transformers to be added without increasing the short-circuit level. Compared with the split-bus approach, the FCLT solution offers flexibility and reliability, exhibits smaller steady-state and transient voltage drops, requires less shunt compensation, and avoids the need for post-contingency redistribution of loads. Compared with the standby mode, it allows the addition of more than one transformer, exhibits lower losses and requires less shunt compensation.

4.1 Typical applications

The FCLT is designed to increase the total capacity of transformer stations in cases where the short-circuit level is already close to the rating of the circuit-breakers and other equipment. The economic justification is based on the replacement cost of breakers and associated equipment. There is more equipment involved when the increase in short-circuit level is significant (equipment short-time ratings, electrodynamic forces on busbars, etc).



I - Current flowing in FCLT

I_F - Fault current

I_L - Load current

I_T - Current flowing in parallel transformers

Figure 4: Behavior of the FCLT during (a) steady-state and (b) fault conditions

In another application, one of the transformers in a station is converted into a FCLT to reduce the total fault-current contribution. This allows the addition of another source, such as a new generator or a tie line from another network. Both of these options are of interest in the fast-changing open energy market.

5.0 Assisted Phase-Shifting Transformer

The adaptation of IPC technology for an increase in the normal and contingency transfer capability of a transmission line is explained in [4] and [6]. The simplest implementation of an IPC within a transmission system is a reactive impedance in parallel with a conventional phase-shifting transformer (PST). The nature of the impedance depends on the quadrant in which the PST is called upon to operate: capacitors and inductors are used to boost and buck power flows, respectively.

5.1 Typical applications

5.1.1 Addition of capacitors for boosting power flows

Reference [4], in which the Mead-Phoenix 500-kV line is discussed, shows that the maximum steady-state transfer capability of the two 500-kV PSTs at Westwing can be increased from 1300 to 1910 MW by adding 125-ohm, 370-MVAr capacitors in parallel. With the capacitors, the effective internal angle of the IPC is 31 degrees, compared with the 25 degrees of the PSTs.

5.1.2 Addition of power electronics for system damping

The main transmission system in Arizona and southern California, of which the Mead-Phoenix 500-kV line is an important component, is subject to low-frequency (0.7 Hz) oscillations. In order to be able to make use of the increase in steady-state capacity, some means of damping these natural oscillations must be provided. One efficient solution is to use thyristor-controlled series capacitors (TCSC).

Preliminary study results are showing that a TCSC module in series with the two PSTs (one branch of the IPC) can provide as much damping as another TCSC module, of higher rating, in series with the line. Thus, a dynamic APST is possible with conventional components (PST, capacitors) and existing power electronics technology.

5.1.3 Addition of inductors for bucking power flows

The world's first interphase power controller, an APST [6], went into commercial operation at the end of June, 1998, in the Plattsburgh substation of the New York Power Authority (NYPA). This substation connects the NYPA and the Vermont systems through a 115-kV PST. Under normal system conditions, the addition of 75-ohm inductors (Figure 5) increases the summer transfer capacity of the link by 33%, from 105 to 140 MW. The three single-phase inductors, the circuit breaker and part of a disconnect switch are seen in the cover picture of this issue of the Review. Together with the existing PST, also seen in the background, this equipment constitutes the Plattsburgh IPC. The isometric diagram of Figure 6 gives a better general impression of the installation. The two shunt capacitor banks are not part of the APST, but are required for voltage support. They were therefore included in the project. The Plattsburgh installation was designed and built by the Systems Division of ABB Canada.

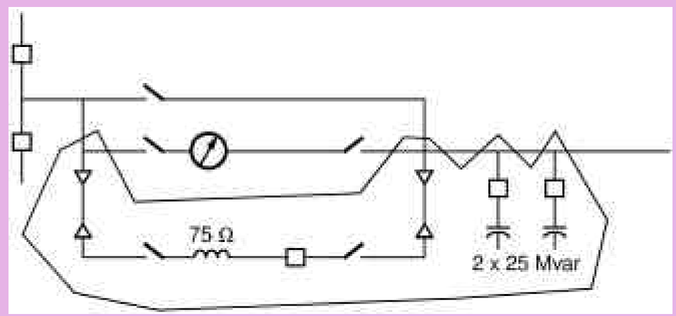


Figure 5: Single-line diagram of the Plattsburgh APST, the world's first IPC

The results of the first year of operation of the Plattsburgh APST show that the total energy transfer for the 1998 summer period increased by 77 GWh (25.7%), compared with the previous year. Although these excellent results reflect different market conditions, it can be said that without the higher flows that the APST allows, it would have been physically impossible to transfer at least 40 of these 77 GWh.

5.2 New APST installations

These two APST applications describe additions to existing PSTs. For a totally new APST installation, it is possible that a lower PST rating can be used in conjunction with the parallel impedances, so that the total cost of the IPC solution would be less than that of a full-rating conventional PST. This is particularly true of applications in which a wide phase-angle control range is required.

6.0 References

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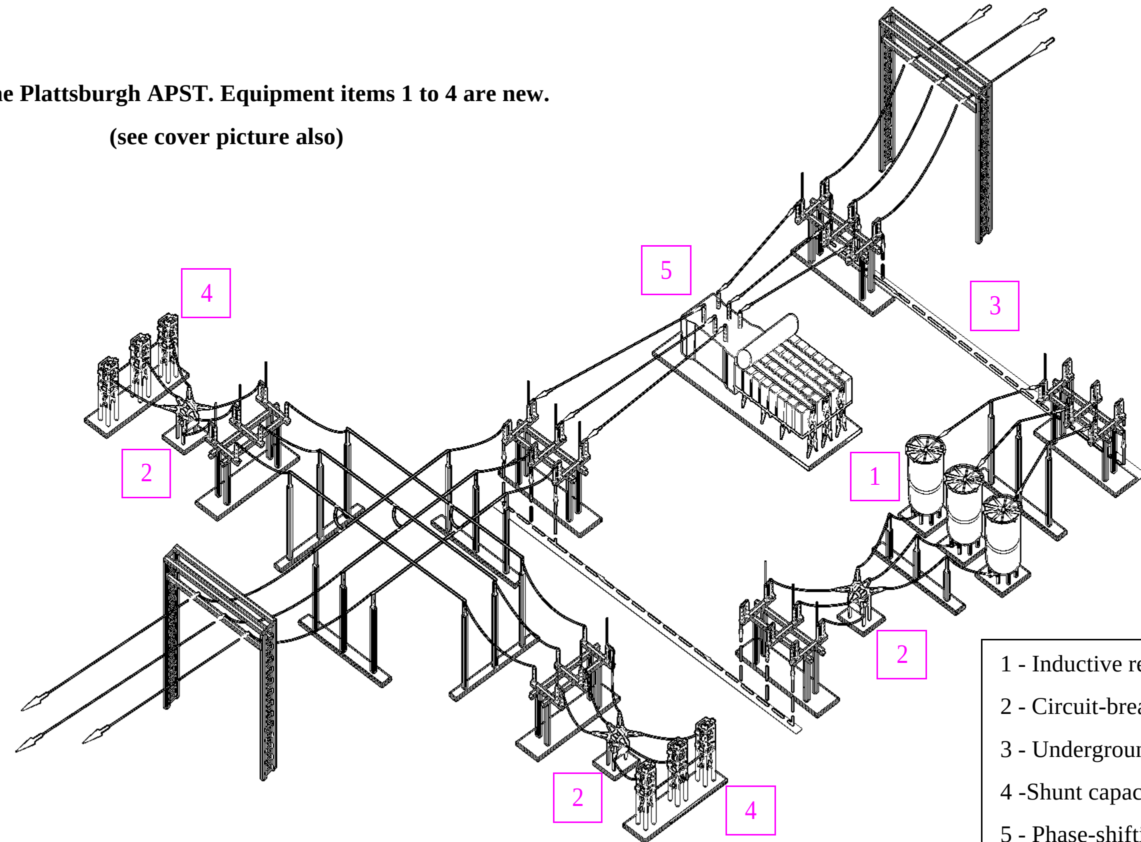
Figure 6: The Plattsburgh APST. Equipment items 1 to 4 are new.

(see cover picture also)



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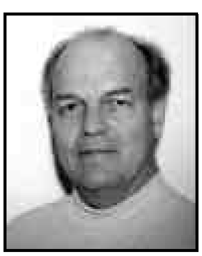
About CITEQ?

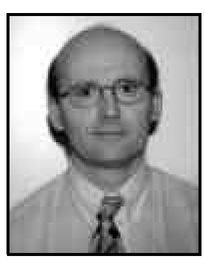
CITEQ (Centre d'innovation sur le transport d'énergie du Québec) is a joint venture between Hydro-Québec and ABB Canada. It concentrates its R&D activities in the areas of high-voltage transmission & distribution equipment. All development activities are closely aligned with market deregulation opportunities.

CITEQ is located in Varennes, close to ABB's Varennes plant and IREQ, Hydro-Québec's high technology research and test center.

About the Authors



Jacques Lemay is a consultant in the field of electric power transmission, HVDC and FACTS. Before his retirement from Hydro-Québec, he was responsible for application studies of the Interphase Power Controller then under development at CITEQ. Previously, he was with Transmission Planning at Hydro-Québec where he was technical coordinator for the Québec/New England 450 kV, 2000 MW multiterminal DC system. Dr. Lemay has long been active in CIGRE and IEEE committees dealing with FACTS, HVDC and interactions between ac-dc systems.



Jacques Brochu obtained his B.Sc.A. and M.Sc.A. degrees in electrical engineering from Université Laval of Québec in 1981 and 1986 respectively and his Ph.D. degree from École Polytechnique de Montréal in 1997. From 1981 to 1983, he was production engineer for Canadian General Electric. He is a research engineer at Hydro-Québec's research center (IREQ) since 1985 where his research mainly revolves around power electronic converters and the IPC. Since 1990, he is involved in the IPC development at Centre d'innovation sur le transport d'énergie du Québec (CITEQ). He is co-author of patents and author of a book on the IPC.

François Beauregard received his B.A.Sc. and M.A.Sc. degrees in electrical engineering from Montreal's Ecole Polytechnique in 1984 and 1987 respectively. He joined Hydro-Quebec in 1986, and began working as a researcher at the utility's research institute (IREQ) in the fields of telephone interference related to HVDC converters and motor drive modeling. In 1990 he joined CITEQ, where he is currently involved in control systems and network modeling. He is co-author of a number of patents relating to the design and the conception of the Interphase Power Controller (IPC) technology.

Salutations de la présidente

Greetings from the new President

C'est avec grande joie que j'accepte le mandat de deux ans de directrice de la région 7 de l'IEEE et de présidente de IEEE Canada. Je prends la relève de Dave Kemp qui a su remplir son mandat de deux ans avec grande compétence. Je le remercie de toutes ses réalisations. Dave s'est attelé à la tâche avec diligence et je crois pouvoir affirmer sans me tromper qu'il y a très peu de soirées ou de fins de semaine où il ne s'est penché sur un dossier de l'IEEE au cours de ces deux années. C'est grâce à son dévouement que bon nombre de choses tournent aujourd'hui aussi rondement à IEEE Canada.

La région prévoit organiser plusieurs fêtes pour célébrer le nouveau millénaire ainsi que bon nombre d'activités; nous avons également des projets pour marquer notre entrée dans le 21e siècle. Tout cela pour faire connaître les réalisations des ingénieurs canadiens et promouvoir l'importance de notre profession au grand public. Nous vous invitons à fêter avec nous.

Au Canada, comme partout dans le monde, l'IEEE se tourne graduellement vers la prestation de ses services sur support électronique. Déjà, nous avons pavé la voie en créant un site Web qui fournit de la documentation aux membres actuels et aux membres éventuels. La région évalue actuellement la façon et le moment d'offrir certaines de nos publications électroniquement aux membres qui privilégient ce mode de diffusion.

Pour bon nombre d'ingénieurs du Canada, le milieu de travail et la nature même de leur travail changent de façon très marquée. Le travail est de plus en plus effectué par voie électronique et les grandes sociétés poursuivent la rationalisation et la restructuration de leurs entreprises. La plupart des ingénieurs constatent qu'ils doivent continuellement étudier pour suivre l'évolution. La région en est bien consciente et fait des efforts pour fournir du matériel utile à ses membres et pour leur permettre de faire progresser leur carrière. Nous prévoyons offrir, au cours de notre conférence annuelle, CCECE 2000, des séminaires techniques ainsi que des activités de perfectionnement professionnel. Pour obtenir plus de renseignements à ce sujet, consultez le site : http://is.dal.ca/~ccece00/.

En ce qui a trait au nombre de membres, nous déplorons que la région 7 soit la seule région de l'IEEE dont l'effectif ne progresse pas. Si vous avez des théories à ce sujet, n'hésitez pas à nous en faire part en communiquant avec Roger Nelson, président, Recrutement des membres, à l'adresse suivante : Roger.Nelson@BCHydro.bc.ca.

Un certain nombre de prix IEEE seront remis cette année à des ingénieurs canadiens. Il y a toutefois, parmi nos 15 000 membres ou presque, beaucoup plus de personnes qui mériteraient un tel honneur. Si vous connaissez quelqu'un dont le mérite devrait être souligné, veuillez en informer le président du Comité des prix et distinctions, Vijay Bhargava, à l'adresse suivante : bhargava@engr.UVic.CA.

L'équipe de direction de la région pour l'année 2000 accueille de nouveaux venus. Parmi eux, Philip Choy, qui prendra charge de nos services électroniques. Je souhaite la bienvenue à Philip et le remercie de nous faire profiter de son expérience.

Au cours de l'année, vous recevrez des renseignements au sujet des efforts de l'IEEE pour accroître sa visibilité. Il est important que nous continuions à être connus comme partie intégrante de l'ensemble de l'IEEE et que nos publications et nos documents soient le reflet de cette appartenance. L'IEEE a décidé de continuer à se servir de son logo actuel, avec quelques restrictions quant à la manière dont il sera utilisé. Au Canada, nous utiliserons encore le logo double avec la feuille d'érable à une extrémité et le logo IEEE à l'autre.

En dernier lieu, j'aimerais vous remercier de m'avoir élue directrice régionale pour 2000-2001. J'espère que nous travaillerons ensemble au cours des deux prochaines années pour que les ingénieurs soient fiers d'être membres d'IEEE Canada.

Celia Desmond,
c.desmond@ieee.org

It is with great pleasure that I take on the role of IEEE Region 7 Director and President of IEEE Canada for the next two years. Over the past two years, Dave Kemp has ably filled this position. I thank Dave for the work he has done. Dave tackled his job diligently, and I suspect there were not many evenings and weekends in the past two years when he was not dealing with an IEEE issue. Because of his dedication, many things within IEEE Canada are running smoothly today.

The Region has plans for some millennium celebrations. We will organize a number of events and projects to mark our entry into the 21st Century. The intent is to promote the accomplishments of Canadian engineers and proclaim the importance of our profession to society at large. We invite you to join us in these celebrations.

In Canada, as in IEEE worldwide, we are gradually moving towards providing more services electronically. The work has already begun with our web site that provides much material to members and potential members. The Region is assessing how and when to provide some of our publications electronically to those members who prefer this format.

For many engineers in Canada, the workplace and the nature of work is changing dramatically. Much more of the work is being done electronically and large companies continue to downsize and to restructure their businesses. Most engineers are finding that continued learning is necessary just to stay current. The Region is aware of this, and is making an effort to provide material that is beneficial to members and their careers. At CCECE 2000, our annual conference, a number of technical seminars are planned and some professional development activities are being offered. For more information, please visit: http://is.dal.ca/~ccece00/.

In terms of membership, Region 7 is the only IEEE Region in which membership is not growing. If you have theories on why this might be, we'd love to know. Please send any comments on this to Roger Nelson, our Membership Chair at Roger.Nelson@BCHydro.bc.ca.

There will be a number of IEEE awards presented this year to Canadians. However, amongst our nearly 15000 members, there are certainly many more individuals who are very deserving of an IEEE award. If you know of someone who should be so honored, please inform our Awards Chair, Vijay Bhargava at bhargava@engr.UVic.CA.

The Region executive for 2000 has some new faces. One new person on the committee this year is Philip Choy, who will handle our electronic services. I welcome Philip and the expertise he brings to the Region.

Over the year, you will see information about IEEE branding efforts. It is important that we continue to be recognized as an integral part of the IEEE whole, and that our publications and material reflect this. IEEE has decided to continue to use its current logo, with some restrictions on the manner in which it will be used. In Canada, we will continue to use the dual logo with the maple leaf at one end and the IEEE logo at the other.

Finally, I thank you for electing me as your 2000-2001 Regional Director. I hope to work productively with you for the next two years to make IEEE Canada an organization to which engineers are keen to belong.

CCECE 2000 in Halifax, Nova Scotia, May 7 - 10, 2000

A diverse high-quality technical program, two career enhancing professional development workshops, and seven leading-edge tutorials are only a few of the reasons to attend the Canadian Conference on Electrical and Computer Engineering in Halifax Nova Scotia May 7 - 10 2000. M.E. (Mo) El-Hawary, the Conference General Chair, welcomes participants from all parts of Canada and from around the world to the World Trade and Convention Centre and "Canada's Smart City - Halifax". Halifax has the greatest concentration of universities per capita in North America.

1.0 Technical Program

The Technical Program Committee, co-chaired by Sherwin Nugent of Dalhousie University and Robert Creighton of Nova Scotia Power, has assembled more than 280 papers, in English and French, in five concurrent sessions over three days. Topics include:

- Speech and face recognition
- Power Electronics, FACTS Devices, and Power System Controllers
- Circuits, CMOS and VLSI
- Computational intelligence
- Wireless communications and CDMA
- Internet protocol, Java applications
- Micro-machines
- Robotics and remote control
- Electric machine modeling, shaft fatigue
- Electrothermal processes
- Signal processing, sonar and radar

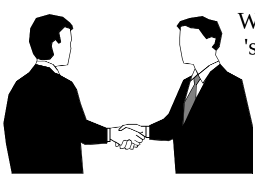
Each day of the conference will begin with a Plenary Session featuring an industry leader, delivering a state of the art update in topics of Communications, Power, and Computing.

Details of the Technical Program and the Plenary Sessions will be posted on the Conference Web site at http://is.dal.ca/~ccece00 as they develop.

2.0 Student Paper Award

CCECE is pleased to continue the tradition of offering electrical and computer engineering student the chance to compete for the Best Student Paper Award. Jack Ilow of DalTech heads the committee to judge the 50 papers that are expected from eight countries, including Canada. Extended versions of the winning student papers will be published in the Canadian Journal of Electrical and Computer Engineering subject to the final editorial acceptance by the Journal.

Professional Development Workshops



With the growing importance of non-technical 'soft' skills in today's work place, IEEE Canada will hold special professional development workshops and seminars on the first day of CCECE 2000. There will be two parallel full day sessions on Sunday, May 7 2000.

In the first session, Ray Findlay, Past President of IEEE Canada and professor at McMaster University, presents "Leadership Training Workshop".

The other session features four well-known leaders of Canada's Technical Community:

- "Leadership and Technical Skills for the Next Millennium" by W. Read, President, REMAS Inc.
- "Canadian Entrepreneur" by L. Weaver, Chief Technical Officer, TecKnowledge Healthcare Systems Inc.
- "Engineering Career Vitality and Survivability in the Next Millennium" by S. Lakhavani, Six Sigma Black Belt, Eaton Corp., USA
- "Succeeding in Today's Business" by C. Desmond President, World Class Telecommunications

Since space is limited, advanced registration using the Conference Registration form will be required. You can get further information on this program from Haran Karmaker at h.karmaker@ieee.org.

3.0 Tutorial Program

On the afternoon of Sunday, May 7, you will have the opportunity to attend one of seven tutorials:

- Wireless Electronic Commerce: Technology and Challenges; Dr. Ramiro Liscano and Dr. Larry Korba - NRC, Ottawa, ON.
- Neural Networks for RF and Microwave Modeling & Design; Dr. Qi-Jun Zhang - Carleton University, Ottawa, ON.
- Fundamentals of Time Domain Computational Electromagnetics; Dr. Greg Bridges, University of Manitoba, Dr.Zhizhang Chen, Dalhousie University, Dr. Joe LoVetri, University of Manitoba
- Agent Technology; Dr. Jean-Charles Bernard, Ecole Polytechnique de Montreal, Mr. Larbi Esmahi, Ecole Polytechnique de Montreal
- RF and Millimeter - Wave Engineering; Dr. Renato G.Bosisio, Ecole Polytechnic de Montreal, Dr. Tajinder Manku, University of Waterloo, Dr. Ke Wu, Ecole Polytechnic de Montreal, Dr. Simon Damphousses, NORTEL
- Requirements Engineering: "Why do we want it? How do we do it?"; Dr. Armin Eberlein, University of Calgary
- Quality of Service on the Internet; Dr. Prashant Mehrotra, Memorial University of Newfoundland

Further details of the individual tutorials can be obtained from the CCECE 2000 web sit. As in the case of the Professional Development sessions, early registration is required to assure a seat.

4.0 Travel and Accommodations

Air Canada / United Airlines have been designated as the Official Conference Airlines. Significant discounts on all fare classes have been arranged. To qualify for these discounts, make sure your Travel Agent quotes Air Canada Convention Registration Number CV006059.

Halifax International Airport (35 km from downtown) is served by non-stop flights from Calgary, Toronto, Montreal, Boston, Fredericton, St. John's, Newark NJ, and Washington DC, London U.K., and as well European service via Iceland. In addition to Air Canada, other airlines with regular service to Halifax include Air Nova, Continental, Business Express, Royal, Canada 3000, and Canadian Airlines. In addition to taxis and limousines, regular shuttle bus service operates between the airport and all major hotels.

The Delta Barrington, Delta Halifax and Prince George have been designated as the CCECE 2000 Conference Hotels. These three Hotels are connected directly with the conference site, the Halifax World Trade and Convention Centre (WTCC). They are ideally situated in the center of downtown Halifax, and within walking distance of all local attractions, including the Historic Properties open-air cobblestone pedestrian malls, which house shops and boutiques in 19th century waterfront buildings. The hotels are connected by an indoor climate controlled pedway to the WTCC, Scotia Square shopping mall, Casino, and over 90 shops and services, including an expanded food court.

A block of rooms with a conference discount rate is being held at these Hotels until March 26, 2000 for the conference attendees. The Conference room rate at each of these hotels is C$125.00. The toll-free number for both Delta Hotels is 800-268-1133, and the Prince George is 800-268-1133. Make your reservation early, since Halifax will be busy at that time of the year.

Students will want to take advantage of on-campus accommodations at Dahousie University. Rates range from $25 for a single room to $43 for a double room at O'Brien Hall on the DalTech campus, only a 15 minute walk to the Conference. Reservations are required before April 1, 2000 at conference.services@dal.ca or phone (902) 494-8840.

5.0 Exhibitors

Conference attendees will have the chance to visit the Exhibition Hall during the continental breakfast and all refreshment breaks. As in past conferences, there will be a wide range of exhibits of interest to students and engineers from industry and academia.

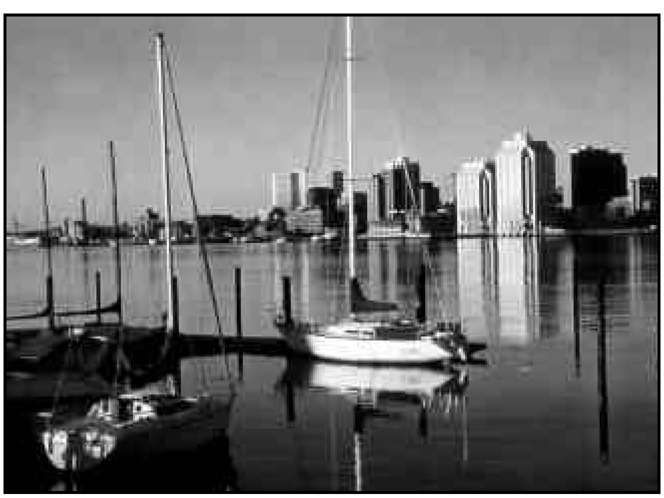
6.0 Receptions and Banquets

CCECE 2000 welcomes you to Halifax with a Cocktail Reception on Sunday evening. You will have an opportunity to sample East Coast delicacies and meet your friends, both old and new. On Monday evening, the Conference Awards Banquet will honour recipients of IEEE Canada awards. The Tuesday luncheon will feature a high-profile guest speaker.

7.0 Further Information and Registration

You are urged to visit the CCECE 2000 web site at http://is.dal.ca/~ccece00 for the latest information on activities and guest speakers. We will also be posting details of the Companion Program and Post-Conference Tours. You will also find a wealth of visitor information to help you plan your visit to Nova Scotia and the Greater Halifax area.

Details of the registration fees for the conference, the tutorials, and the workshops can be found on the Registration Form. We hope to see you in Halifax in May.



IEEE Instrumentation & Measurement Society Award
Jacques Vanier

"To recognize outstanding contribution to and leadership in advancing instrumentation design or measurement technique"

The award, a cash prize of $1000 and a plaque will be presented in May 2000 in Baltimore at the IMTC2000.

Jacques Vanier received his M.Sc. and Ph.D. in physics from McGill University, Montreal, in 1960 and 1963, respectively.

During the period from 1961 to 1963, he was a lecturer in the department of physics at McGill University. He joined Varian Associates, Beverly Ma, in 1963. In 1967 he became a member of the Frequency and Time division of the Hewlett-Packard Company. At both Hewlett-Packard and Varian, his work was oriented mostly towards the application of quantum electronics phenomena to the realization of precision instrumentation. In particular, he did basic research on atomic frequency standards and developed a thermometer based on Nuclear Quadrupole Resonance, on which he holds a patent. From 1967 to 1983 he was professor at Laval University, Quebec, in the electrical Engineering Department, where he founded a laboratory oriented towards studies and applications of quantum physics.He joined the National Research Council of Canada in 1983 until 1994. At this institution he implemented the Institute for National Measurements Standards and was its Director General from 1990 to 1993. He is now Adjunct Professor of Physics at the University of Montreal.

He has been active on several national and international committees and organizations such as: National Committee of the Natural Science and Engineering Research Council (NSERC); Grants and fellowship Committee of the same organization; Commission de la recherche universitaire, Province the Quebec; Assessment Board of the National Bureau of Standards, now the Institute for Standards and Technology (NIST); Consultative Committees of the Bureau International des Poids et Mesures (BIPM); Comité Consultatif International des Radio-communications (CCIR); Union Radio Scientifique Internationale (URSI), President of Commission A (1990-1993); Conference on Precision Electromagnets Measurements (CPEM), President of the 1990 Conference in Ottawa and President of Executive Committee (1990-1994); Frequency Standards and Metrology Symposium (initiator and co-founder); Administrative Committee of the I&M Society of the IEEE (1987-1993); Comité International des Poids et Mesures (1990-1996). Presently he is a member of the Boards of Directors of the Frequency Standards and Metrology Symposium and member of the Program Committee of the European Forum on Time and Frequency (EFTF). He is also a member of the selection committee for the Rutherford Medal of the Royal Society of Canada.

He is a Fellow of the Royal Society of Canada, the American Physical Society, and of the IEEE. He has received the IEEE Centennial Medal (1984), the IEEE Rabi Award (1994) and the PTTI (Precision Time and Time Interval) Award (1998), for his contributions to the field of atomic frequency standards.

He has published over one hundred scientific papers, a book titled "Basic theory of Lasers and Masers" (115 pages, Gordon and Breach, editors, 1971). He is also the co-author (with C. Audoin, University of Paris) of the book, "The Quantum Physics of Atomic Frequency Standards" (1567 pages, Adam Hilger, editor, 1989).

Thought for the Day

When you are going nowhere, any road will get you there.

3D Simulation for Training Mining Equipment Operators

by *Paul Freedman*
Simlog

Abstract

When it comes to mining equipment, “training” means “doing”. But until recently, the only way to “do” was on a real production machine in a real production work environment under the supervision of an experienced operator with all of the risks and associated costs. New 3D simulation training products are changing all this by helping training staff better select the right personnel to train and by helping trainees better prepare for their “seat-time” in a way that is reliable, completely safe, inexpensive, and always available. In this paper, we shall describe such training simulation and then review some of the new products coming to market from companies such as Simlog.

Sommaire

L'apprentissage par expérimentation est essentiel lors de la formation sur les équipements de forage minier. Jusqu'à maintenant, la seule façon d'expérimenter était sur une vraie machine en production, dans un environnement de travail réel, sous la supervision d'un opérateur expérimenté, avec tous les risques et les coûts associés à ce type d'entrainement. De nouveaux produits de simulation 3D pour l'entrainement sont en train de changer cette façon de faire en aidant les formateurs à choisir les meilleurs employés à entrainer et en aidant les employés à mieux se préparer pour les périodes d'entrainement sur les appareils en utilisant un procédé sûr, complètement sécuritaire, peu coûteux et toujours disponible. Dans le texte qui suit, nous décrirons un appareil de simulation pour l'entrainement de ce type, puis réviserons quelques nouveaux produits sur le marché tels ceux de Simlog.

1.0 Introduction

Operator training for heavy equipment is an investment, and the return on that investment is optimum performance from the start with less machine downtime while everyone learns through experience. Well-trained personnel make a difference that's readily noticeable in uptime improvements and reduced maintenance costs.

Training personnel to operate heavy equipment continues to require real production machines in a real production work environment and the supervision of an experienced operator, with all of the risks and associated costs. Worse, scarce resources intended for production are not always available for training operators. And training problems are likely to become more acute due to increasing use of automation on the horizon e.g. remote-controlled equipment.

This is certainly true in the mining industry in particular, where the need to improve productivity has led to extensive use of mechanization and machines which have become progressively larger, more powerful, and more complex. As a result, they have also become increasingly difficult to operate productively. Such is the case for the hydraulic and electric cable-driven face shovels used for surface mining, and the electro-hydraulic articulated booms extensively used underground for drilling, rock-breaking and bolting; see Figure 1. In all cases, the tasks to be performed by the operator typically involves positioning (and perhaps orienting) the tool at the end of the boom using a combination of push-button, single axis levers, and two axis joysticks.

Such face drilling rigs for underground mining, commonly called “drill jumbos”, are expensive single or multi-boom machines costing as much as $1,200,000. Booms typically have six degrees of freedom (dof) to be able to correctly position and orient the rock drill (boom tip) at the rock face, in order to drill holes to follow the trajectory of the ore body e.g. up and to the right. Control is typically via 4 single axis levers plus 1 two axis joystick (along with an “anti-parallel” momentary push-button). Motion errors due to hydraulic limitations are partly compensated by the operator, depending upon his skill and experience. (Additional levers are used to control the drilling parameters.)

Clearly, operating such equipment efficiently is a key part of maintaining the mine's productivity, but learning the necessary skills is difficult and time-consuming. Indeed, according to one industry observer, as much as 160 hours of time at the controls is required to meet production targets.

When a new drill jumbo is purchased, the equipment manufacturer (head office or dealer) typically sends staff to the customer to provide on-site “hands-on” training for customer personnel. In order to maintain “reasonable” production levels, especially at the start, the trainers must spend part of their time operating the machine, while the trainees simply watch and learn. As a result, seat-time is limited; worse, it often takes time to discover that certain trainees are not well suited to this kind of work and never become fully proficient.

Clearly, if trainees could be better selected and better prepared for their seat-time in advance, they could better profit from the training provided by the equipment manufacturer when new equipment is purchased and delivered. In addition, a simulator could be used to help mine personnel maintain their operational skills, i.e. maintain the skills required to efficiently operate the booms and rock drills without having to move the machine, set it up, prepare the drilling targets (“round”), etc.

Figure 1: Drill Jumbo at work underground (photo courtesy of Atlas Copco).

This is where training innovation is required, and where “graphical” or 3D simulation technology can help. The term “virtual reality” is sometimes used to refer to graphical simulation which emphasizes user interaction in real-time with 3D models.) In contrast to computer-based (“multimedia”) training which lead the user through a series of pre-programmed (question/answer) learning steps, 3D simulation means specifying how the virtual environment should respond to each of the user's possible actions. Informally, one does not specify “how the game will go”, since that depends upon the stream of decisions the user makes.

In a nutshell, 3D simulation means learning by doing, but in a simplified and more carefully controlled way than is possible with the real machine in a real work environment. (This is all the more useful when learning operational skills, since so much more can be taught by showing and doing, when compared to traditional classroom instruction. In the educational literature, this is called “situated learning”.

Moreover, graphical simulation can also be used to help select training candidates since anecdotal evidence suggests that 10-30% of trainees lack the necessary aptitudes (e.g.

hand-eye coordination) to eventually become fully productive operators.

But until recently, real-time graphical simulation was extremely costly, due to the nature of the computing platforms required. All this is changing as PC-compatible computers offer faster clock speeds, multiprocessing (e.g. dual CPUs), and improved 3D graphics with hardware acceleration.

And so, for the new millennium, low-cost "desktop" training simulator products are now appearing for the mining industry. One such example, to be described here, is from Simlog (www.simlog.com), a new Canadian company based in Montreal, Quebec, dedicated to heavy equipment operator training. Among their first products are simulators for training operators of forestry machines and mobile cranes.

2.0 Mining Equipment Simulation

To date, graphical simulation of mining equipment has emphasized safety training, not operational (skill-acquisition) training, just like the "full flight simulators" as manufactured by companies such as CAE Electronics in Montreal, Quebec. Here, the idea is to give pilots (who already know how to fly planes) a virtual environment in which to learn to new features of new aircraft and especially to learn to cope with difficult flying conditions and emergencies in the air.

Consider, for example, the "driving simulators" recently developed for training haul truck operators for surface mining operations. There are two such products on the market today, one from an American company Digitran and the other from an Australian company Immersion Technologies. Both simulators incorporate real haul truck controls and instrumentation, a 3-axis motion base to simulate road conditions and grades, sound, and wide angle graphical displays. In addition, they simulate the essential truck dynamics (engine, transmission, brakes, steering, etc.).

Like all driving simulators, including the transport truck simulator developed by the Swedish company Prosolvia, these simulators are intended to help students:

- master the controls, instrumentation, and displays of real haul trucks
- learn to cope with difficult driving conditions including skidding and cornering, equipment failure, etc.

As one marketing brochure suggests, the products simulate "how the truck skids on a wet haul road or interacts with other machinery on the mine site. Operators learn how to make split-second decisions that could prove fatal if they were not practicing on the Simulator".

Note the emphasis on training for safe operation, since trainees must already have, of course, appropriate driving licenses. Stated otherwise, these simulators are not designed to teach trainees the basics of driving trucks, but rather to expose them to the particular difficulties associated with driving trucks for (surface) mining operations. (In the same way, full flight simulators are not designed for people who don't know how to fly planes already.)

The same emphasis on operating equipment safely is found in the hoisting cage simulator recently developed by two Spanish companies, ESM and Hunosa. (The hoisting cage is an elevator in a vertical shaft used to lower people and equipment down into the mine, and bring them back up to the surface.) This simulator was also designed for situational awareness and safety training, along with the evaluation of operator aptitudes and reaction times. Here, real hoist controls are used for operator inputs, and the simulator offers simple 3D graphics and sound; a trainer's station is also provided. Once again, learning to operate the controls (a series of simple levers) is a small part of the simulator-based training.

But experience to date at Simlog with simulating forestry equipment and mobile cranes has suggested that much more added value for training can be found precisely wherever the skills required to operate equipment are difficult to acquire. In such cases, the simulator can provide a virtual work environment ideally suited to the "drill and practice" at the heart of mastering most operational skills, especially where such drill and practice is costly and potentially dangerous. The design of such operational training simulators is the topic of the next section.

3.0 3D Simulator Design For Operational Training

In general, the nature and complexity of the hardware components of a training simulator are largely responsible for the final cost to the customer. Incorporating elements from real machines can make the simulator "feel" more realistic, but they also add complexity and cost. More importantly, when it comes to learning the basic skills to operate heavy equipment, such elements don't always make training more effective. Indeed, training "transfer", i.e. helping trainees come up to speed as quickly as possible on real machines by preparing them first on training simulators, is a key part of the cost-effectiveness analysis of adding simulation aids to existing training programs when their use is not mandated by governmental authorities.

Consider 3D graphics, or the richness of the visual presentation; this is directly related to the choice of computers which drive the simulation: as the scene becomes more detailed, more computing horsepower is required to "render" the visual elements in real-time, driving up cost. But the need for perceptual realism is largely dictated by the kind of training to be provided. Indeed, human factors research about scene quality for flight simulators suggests that different kinds of visual properties are important for different kinds of tasks. For example, recent experiments have reported that real-time interactivity can be more important than pictorial realism for certain manipulation tasks. Indeed, when objects are in motion, image resolution may be reduced while still providing adequate perceptual cues. This suggests that the "basics" can be learned with even simple visual displays.

Audio feedback can also contribute to training. Along with reproducing the essential sounds of the machine at work, extra sounds can be used to provide additional feedback to the operator e.g. to signal undesired contact/collisions among objects.

But recreating the visual and audio elements of the real work is just part of the story. In order to ensure that the operational skills acquired on the simulator transfer to the real world, the simulator must faithfully reproduce the natural behavior of the machine and the "rules of interaction". By "natural behavior", we mean that the simulated hydraulic pistons of the boom, for example, should move in their cylinders with the same speed, and over the same distances, as the actuators in real machines. Reproducing such natural behavior means modeling the physics of how objects behave in the real world. In addition, we typically require collision/contact detection, whereby simple bounding volumes are associated with key objects to detect collision/contact "on-the-fly", in real-time, and with no prior knowledge of how the objects move.

Of course, putting together all of these ingredients (3D graphics, sound, natural behavior, contact/collision detection) in a way that delivers true training added value is in itself a challenge and a recent survey of training simulators developed for the military pointed to two key weaknesses that simulators often exhibit.

Firstly, their training effectiveness is difficult to establish. This means that little or no data exists to describe and especially quantify the benefits of simulator-based training (when compared to training without simulators). Secondly, such systems are typically designed with an eye to machine simulation, not training per se. Stated otherwise, the emphasis is placed on reproducing the operational environment and natural behavior of real machines (an airplane, a tank, etc.) with little attention paid to how people can best learn to operate them.

Consider the analogy of learning to drive a car. Imagine how much simpler and quicker the process would be if we could learn to master just the steering wheel, then just the pedals, and then combine the two skills. Simulators that are well designed do just that, by breaking the learning of the essential elements of machine operation into small "steps" which build upon each other, in addition to varying the difficulty of the simulated task and the sophistication of the simulated machine behavior. In this way, learning is accelerated. By reducing the "cognitive load" at each step.

In the next section, we turn to the development of such a simulator to help train operators of underground mining equipment.

4.0 Drill Jumbo Operator Training Simulator

With these observations in mind, Simlog recently completed the development of a drill jumbo simulator for training underground mining operators in collaboration with Atlas Copco Construction and Mining North America based in Sudbury, Ontario; see Figure 2.

Figure 2: The Simlog simulator with enclosure, colour monitor and operator console.

.The Simlog simulator recreates the essential components of the real drill jumbo control interface using industrial levers, joysticks and pushbuttons. The simulator also includes proprietary interface electronics, a single PC-compatible computer, and a conventional color monitor (which may be replaced, where desired, by more costly video-projection technology to obtain a larger field of view).

Simlog's simulator offers 3D graphics which combines the visual presentation of the boom and drill face with a unique series of artificial (non-real world) cues in order to improve the presentation of depth on the two dimensional computer display; see Figure 3. Indeed, human factors research suggest that such visual cues greatly improve the presentation of depth. In addition, the Simlog simulator carefully reproduces the natural behavior of the rig and the essential sounds of the machine at work, along with the required contact/collision detection.

Work is now underway to harness the power of the graphical simulation by designing a pedagogical framework based on "modules" to lead the trainee step by step through the basics of drill jumbo operation. Indeed, it is this incremental introduction to the full complexity of the machine that makes the simulator such an effective training tool. Along the way, "performance criteria" are used to measure the trainee's progress and evaluate the (simulated) work being performed. All of this data is then stored in the simulator database on a per trainee basis.

For example, one such module is devoted to mastering the drill jumbo controls (levers, joysticks, and pushbuttons). A series of holes to be drilled ("round") is displayed on the rock face and for each trial, just one is identified as a target hole. A cylindrical "tail" extending from the target hole identifies the specified drilling orientation. Now the trainee must use the controls to position the rock drill tip such that drilling would occur, with the specified orientation, at the drilling position The trainee's performance is measured by the following criteria: time to complete the trial, errors in position (horizontal and vertical), errors in orientation (pitch and yaw).

Finally, the simulator will also offer (as all Simlog products do) a Web-based interface for the trainer to monitor at a distance the progress of trainees by reviewing the data files in the simulator's database. In addition, the same interface can be used by the trainer to perform various administrative duties such as creating a new class, adding a trainee to the class list, etc. Just now, work is underway to develop some statistical analyses to help the trainer compare trainees in the same class, and compare classes against each other.

As for the anticipated added value of the simulator for training, we can look to our previous experience in the forestry industry. Indeed, the training challenges of the mining sector resemble those of the forestry sector in at least one way: the machines, by themselves, are insufficient since in both cases, operational resources are required (mine or forest).

Figure 3: A closer view at the 3D graphics of the Simlog simulator.

Consider the results of extensive field trials conducted with Simlog's forestry machine training simulator prototype at an operator training school in Quebec in 1997 and 1998; all told, almost fifty students each received about 25-30 hours of simulator-based training. Note that forestry machines typically have just four directly controllable degrees of freedom, not six, and as a result, positioning and orienting the boom tip is simpler. (The control interface is also simpler than for the drill jumbo: there are just 2 two axis joysticks.)

When grouped together, the results of the four separate field trials clearly demonstrated the added value of simulator-based preparation before the seat-time (about 150 hours per student) in the woods. On average, about 25% more wood was harvested over the same training period and students were 10-15% more productive at the end. As for the costs of equipment maintenance due to training, they were down about 25%. In addition, tests demonstrated that as little as 3 hours on the simulator was sufficient to evaluate aptitudes of training candidates in order to identify those people not suited for this kind of work.

It's with these results in mind that we anticipate the training value likely to be provided by our drill jumbo simulator, the first in what will become a series of products to help train mining equipment operators.

5.0 Conclusions

Interactive graphical simulation (sometimes called "virtual reality") means creating a synthetic (artificial) perceptual experience which corresponds to a real perceptual experience. In this article, we began by describing the essential ingredients of such simulation for training and then presented an overview of simulators now available to help train mining equipment operators, including a new product from Simlog, Canada's leading training simulator specialists.

Looking into the future, it's wise to remember that 3D training simulation is still in its infancy. Simlog, in particular, is committed to working with industry stakeholders to develop new products wherever heavy equipment operator training can benefit. In addition to simulator development, Simlog also provides complete training services using its own products, under the supervision of training professionals. Such services may be provided either on the customer premises or in our corporate offices (at a reduced rate).

About the Author

Paul Freedman holds degrees in Engineering Physics and in Electrical Engineering from the University of Toronto, the University of British Columbia, and McGill University.

He was for many years Lead Researcher at the Centre de recherche informatique de Montreal, one of Canada's leading research institutes in information technologies.

In 1999, he left CRIM to found SIMLOG and commercialize innovative 3D simulation technology developed at CRIM for training forestry equipment operators.

Fully Digital Real-Time Simulation of Large EHV Transmission Systems for Control and Protective System Studies and Testing

by Bahram Khodabakhchian,TransÉnergie Technologies, Louis-A. Dessaint, Michel Lavoie, École de technologie supérieure,

Abstract

Real-time simulation of large AC/DC EHV transmission systems have been until now realized on costly and more-or-less-flexible hybrid simulators which offer some advantages in producing continuous real currents and voltages. Fully digital power system simulators used until now in limited scaled real-time simulations, have reached maturity due particularly to the development of high performance parallel computers. Recent real-time simulations of the Hydro-Québec main 735 kV transmission system with a time-step of 56 µs realized on a 30 processors parallel machine witness the sound applications of such technology in real-time control and protective systems testing of large transmission systems.

Sommaire

La simulation en temps réel de grands réseaux électriques de transport CA/CC à très haute tension a été réalisée jusqu'à maintenant à l'aide de simulateurs hybrides coûteux et relativement peu flexibles. Les simulateurs hybrides offrent néanmoins des avantages quant à leur capacité de produire des tensions et des courants réels. Par ailleurs, les simulateurs entièrement numériques relégués jusqu'à tout récemment à l'étude de réseaux électriques de taille relativement modeste, ont désormais acquis leur pleine maturité grâce à de nouvelles plates-formes basées sur des ordinateurs parallèles. Des simulations récentes du réseau de transport de 735 kV d'Hydro-Québec sur un ordinateur parallèle de 30 nœuds de calcul en utilisant un pas de calcul de 56 µs confirment la viabilité et la précision de cette nouvelle technologie pour la conception des systèmes de commande et de protection.

1.0 Introduction

Traditional power system simulators were assembled from purely analog miniature components for modeling transmission lines, transformers and loads. Hydro-Québec and more specifically IREQ are very well known for their contribution in building and operating one of the largest analog real-time simulator in the world. In the late 80's, computer processing power transformed the analog simulator to an hybrid (analog/digital) one in which fully digital synchronous machine models running on DSP's were interfaced to the rest through D/A conversions. In 1996, IREQ developed Hypersim, a fully digital power system simulator which compare to the hybrid version offers advantages such as compactness, flexibility and scalability. As of today, Hypersim runs on two different platforms: an in-house design based on 533 MHz Alpha processors and a general purpose high-performance parallel machine made by Silicon Graphics.

École de technologie supérieure, an engineering university located in Montreal, bought a 15 nodes in-house version of Hypersim with grants from the Canadian foundation for innovation, the Ministère de l'Éducation du Québec and TEQSIM International. As a result, IREQ, TransÉnergie Technologies and ÉTS recently teamed up to assemble a 30 nodes in-house version of Hypersim still considered to be the most powerful fully digital real-time power network simulator ever devised. The aim of this paper is to describe the large simulated network and some of the real-time simulation results.

2.0 Description of the simulated network

The Hydro-Québec network, one of the largest in North-America consists mainly of over 35000 MW remote hydraulic generation transmitted over 1000 km by eleven 735 kV transmission lines to two major load centers, Montreal and Quebec cities. Steady-state and transient stabilities of such a vast system are insured by the use of dynamic shunt compensation (synchronous and static compensators) and MOV protected series compensation. The actual transmission system simulated on Hypersim, corresponds to a realistic summer load-flow with simplifications in terms of regrouping some generation stations and subtransmission lines and loads. This network contains:

- 6 hydraulic generators with full controls (exciter, speed regulator, turbine and stabilizer);
- 4 synchronous compensators with full excitation system;
- 5 static compensators (1 TCR and 4 TSC branches) with detailed internal controls;
- 20 saturable 2 or 3 windings transformers;
- 40 series-compensated transmission lines;
- 3 dynamic loads (transient stability type with adjustable load coefficients);
- 5 MOV for series capacitor over voltage protection;
- 1 gap and by-pass breaker with controls for MOV energy absorption protection.

Figure 1: 30 nodes digital real time simulator

Out of the 30 nodes assembled (Fig. 1), 28 nodes were used by the automatic task mapper to distribute different computing tasks of the simulated network with a time-step of 56 µs. It is also worthy to mention that some of the nodes were also equipped with I/O boards (16 D/A and 16 A/D) for the purpose of both analog and digital acquisitions.

3.0 Typical simulation results

Many different perturbation scenarios and statistical faults were applied on the system over a period of a week for various purposes such as testing the acquisition and I/O systems, long term numerical stability (over 72 hours) etc., and satisfactory results were obtained. Figures 2a and 2b shows a typical digital acquisition of nearby machine and SVC signals during a 3 ph-g, 6 cycles fault at LG2 735 kV busbar. The machine dynamics and SVC behavior are well

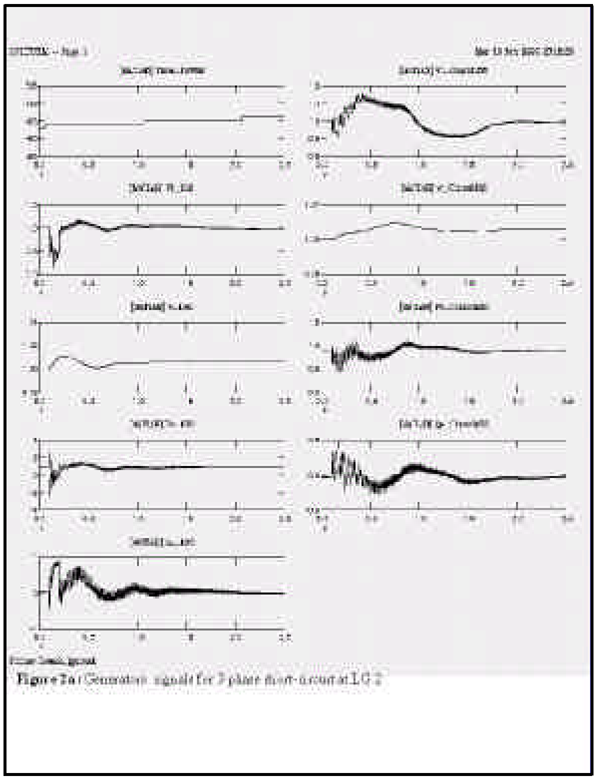


Figure 2a: Generator signals for 3 phase short-circuit at LG 2

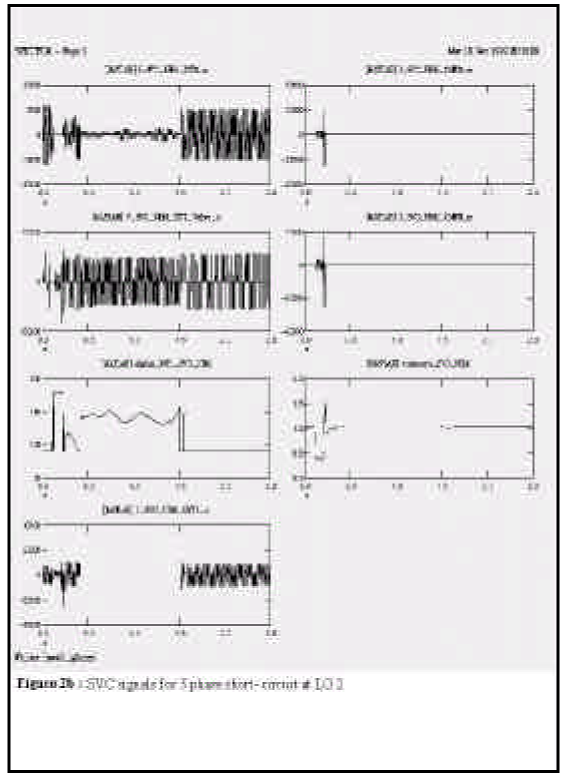


Figure 2b: SVC signals for 3 phase short-circuit at LG 2

within the expected range of variations. A full validation of the transient behavior is currently under way with EMTP and will be published in a later paper. Figure 3 focuses on the aspect of the comparison between digital and analog acquisitions of the TCR valve voltage of the SVC. Again the results show very good agreement in term of frequency bandwidth and time delay (less than 1,5 time-step or 85 µs).

4.0 Conclusion

High performance fully digital real-time simulation of a large EHV transmission system has been demonstrated on a Hypersim 30 processors simulator. Tests and simulation runs showed that the Hypersim technology is mature enough to be used cost-effectively in large scaled real-time simulations taking into account full machine dynamics and a more detailed power system representation. As a result, large fully digital real-time simulators now allow for very realistic control and protective system studies and testing.

About the Authors

Bahram Khodabakhchian holds BS and MS degrees in electrical engineering from École Polytechnique de Montréal. He has over 18 years of experience in power system studies and real-time simulations. He is currently a Product Manager at TransEnergie Technologies which commercializes Hydro-Québec simulation technologies.

Louis-A. Dessaint is currently Professor in Electrical Engineering at the École de Technologie Supérieure, Montréal, P.Q., Canada and Director of GREPCI a research group on power electronics and digital control. He is an author of the MathWorks "Power System" Blockset and in 1997, received the "Outstanding Engineer Award" from IEEE-Canada.

Michel Lavoie is currently a Professor of Electrical Engineering at the École de Technologie Supérieure, Montréal, P.Q., Canada. He is a member of IEEE, and of the Ordre des Ingénieurs du Québec.

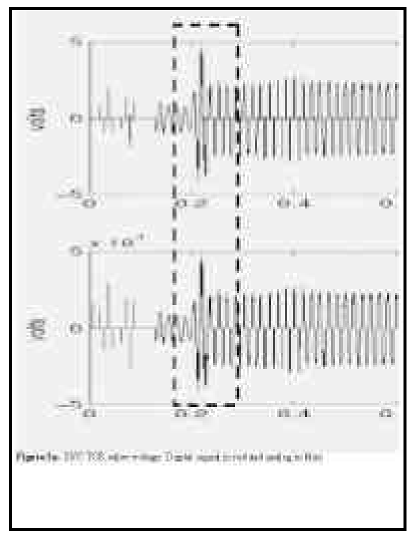


Figure 3a: SVC TCR valve voltage. Digital signal above and analog signal below.

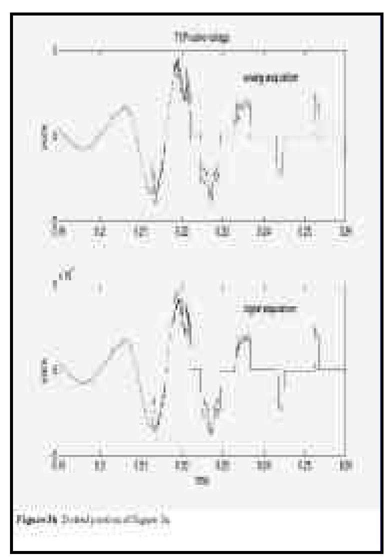


Figure 3b: Dotted portion of figure 3a

Université du Québec
École de technologie supérieure

Compétition de motoneiges écologiques: L'ÉTS fin prête à affronter ses adversaires au Wyoming

Montréal, le 7 mars 2000 - Du 20 mars au 2 avril prochain, l'ÉTS participera à une toute nouvelle compétition de motoneiges écologiques de la prestigieuse Society of Automotive Engineers (SAE): The Clean Snowmobile Challenge 2000 (CSC2000). L'équipe de l'ÉTS se mesurera alors à six autres équipes universitaires des États-Unis et du Canada.

Le défi consiste à modifier une motoneige de 488 cc de type Polaris 98, modèle « Handy Trail », de manière à ce qu'elle émette 50 % ou moins d'hydrocarbures, et 25 % moins de monoxyde de carbone qu'une motoneige conventionnelle. Le niveau de bruit à 50 pieds de distance n'excédera pas 74 dB en pleine accélération, alors que le niveau actuel est de 78 dB. De plus, les performances du véhicule doivent être égales ou supérieures à celles du véhicule original, le tout à coût abordable en vue d'une éventuelle commercialisation. Plusieurs autres critères techniques et de performance seront évalués lors de cette compétition qui se tiendra à Jackson Hole, Wyoming, tels l'économie d'essence, l'accélération, les montées abruptes, la maniabilité, etc.

Au mois d'août 1999, chacune des équipes participantes a reçu sa motoneige de la SAE ; elles ont donc disposé de 7 mois pour adapter et tester le véhicule. Ce défi lancé aux étudiants de génie est une initiative conjointe de plusieurs organismes environnementaux américains alarmés par l'accroissement des rejets d'essence et d'huile des motoneiges dans l'environnement. Cette pollution affecte particulièrement plusieurs parcs importants des États-Unis dont le Voyageur National Park et le Yellowstone National Park, premier parc national de l'histoire.

Les propriétés polluantes des motoneiges actuelles sont stupéfiantes! En effet, la nature même des moteurs à deux temps fait en sorte que plus de 25 % du carburant est directement rejeté par le moteur, sans combustion. Ainsi, pour chaque plein d'essence de 40 litres, soit la capacité d'un réservoir d'une motoneige type, au moins 10 litres seront gaspillés et répandus sur la neige et dans les cours d'eau à la fonte des neiges. Quant aux résidus de combustion, le même 40 litres d'essence produira 9 kg d'hydrocarbures et 13,8 kg d'oxyde de carbone. En considérant qu'un plein d'essence correspond à une excursion moyenne de 5 heures de motoneige, on peut facilement se représenter l'énorme quantité de polluants rejetée dans la nature. En fait, plusieurs organismes aussi sérieux que la U.S. Environmental Protection Agency (EPA) et la California Air Resources Board (CARB), estiment que l'utilisation d'une motoneige pendant une heure rejette autant de polluants dans l'atmosphère que l'utilisation d'une voiture récente pendant une année entière.

Voilà pourquoi les intervenants du milieu font appel à la SAE International, dont le mandat consiste à explorer de nouvelles technologies de la mobilité et à favoriser les échanges entre chercheurs. Par cette compétition, la SAE veut stimuler la force créatrice des étudiants nord-américains de génie pour résoudre cet épineux problème. On peut en effet qualifier ce problème d'épineux puisque le marché de la motoneige connaît actuellement une expansion, que les ventes ont doublé en cinq ans, et qu'à ce jour, rien n'oblige les manufacturiers à modifier leurs véhicules pour les rendre moins polluants.

En tout, 23 000$ US seront remis en prix par la SAE aux équipes participantes. Mais le principal intérêt de cette compétition réside davantage dans les éventuelles applications commerciales de la solution gagnante. En effet, les résultats les plus intéressants au plan faisabilité/prix pourraient déboucher sur de nouvelles normes de fabrication imposées aux manufacturiers de motoneiges. C'est une occasion exceptionnelle pour les étudiants, puisque pour une fois, les résultats d'une compétition serviront directement à l'industrie et offriront une avenue intéressante aux législateurs qui cherchent à adopter des mesures de protection de l'environnement.

Finalement, avec la CSC2000, tout le monde y trouve son compte : tant les amateurs de motoneige qui gaspilleront moins d'essence que les citoyens et législateurs soucieux de préserver l'environnement et, bien sûr, l'équipe de l'ÉTS qui nous fera honneur en démontrant tout le savoir faire de nos étudiants de génie.

Letters to the Editor / Lettres envoyées au rédacteur en chef

In Memory Of Professor Gar-Lam Yip

It is with deep sadness that IEEE Montreal Section mourned, on Oct. 7th, 1999, the loss of one of our distinguished leaders and volunteers, a friend and teacher to many of us who knew him, a man of honor and great respect for his fellow men and women, Prof. Gar-Lam Yip.

Professor Yip showed us the meaning of wisdom and would often enchant us with his humour which so cleverly dissipated tensions that would arise during our Section Meetings. He was an IEEE volunteer for thirty years. His research at McGill University since the 1960's encompassed the areas of Applied Electromagnetic Theory, Antennas & Propagation, and Microwave Theroy & Techniques. Professor Yip was Chairman ot the IEEE Montreal Joint Technical Chapter in these areas.

He is world-renowned in his field of research and will be sadly missed, but God's will has intended for his work to go on in his memory through the formation of a Foundation in his name. This Foundation will receive donations which will be put towards Fellowships at the Dept. of Electrical and Computer Engineering of McGill University.

Contributions can be made to the following address:

Terry Tobin
Development Associate, Major Gifts
Faculty of Engineering, McGill University
Frank Dawson Adams Building, Room 6B
3450 University Street West, Montreal QC H3A 2A7
Telephone: 514.398.4705
Fax: 514.398.7696
email: terryt@eng1.lan.mcgill.ca

June R. Massoud
Past-Chair, IEEE Montreal Section

Consultants Corner

Consultants are invited to publish their business cards and services offered in the ***IEEE Canadian Review***. Please contact the Managing Editor (see page 2) for information regarding publishing dates and rules. The rates are $300.00 for one issue or $750.00 for a series of three issues.

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Le Coin des Consultants

La Revue Canadienne IEEE (***IEEE Canadian Review***) offre aux consultants la possibilité de publier leurs cartes d'affaires ainsi que les services qu'ils offrent. Les coûts sont de $300.00 pour une seule publication et de $750.00 pour trois publications consécutives. Pour plus d'informations au sujet des règles et dates de publication, prière de communiquer avec le rédacteur en chef.

Farewell Message from Dave Kemp, Past President - IEEE Canada

IEEE Canada continues its legacy as an exciting innovative leader region. The Region 7 Committee met four times during 1998 and 99. Looking around the table we took pride in the diverse representation of our leadership. Not only do we see significant IEEE Affinity Group representation such as Graduates of the last Decade (GOLD) and Women in Engineering (WIE) but also diverse cultural and language representations and a balance of academia, consulting, government, and industry. Within Canada, IEEE Canada is the national society representing electrotechnology. As such we are a constituent member of the Engineering Institute of Canada (EIC). The exceptional volunteer talents within Region 7 have been the focus of numerous major awards both by IEEE as well as EIC.

The Region maintains its sound financial foundation while funding an office staffed by IEEE Canada Administrator Cathie Lowell, three publications, awards, Web site, conventional regional activities and a significant array of projects which are described later.

I started my term as Regional Director with a strategic planning workshop in January 1998 in our largest Section Toronto. Eighteen priorities were identified, each having associated goals for the Region to attain. I am pleased to report significant progress on these for the past two years.

With the assistance of IEEE Financial Advantage staff we were able to introduce two unique programs to our members; 1) A Canadian Retiree Medical and Dental program, and 2) a Canadian IEEE credit card.

Our recent innovations deserve some mention:

- in 1999 we resolved to initiate a Standards committee. This is the first and pioneering initiative for a regional entity to lead and support standards activities. The net result we hope will be a more transnational element to IEEE standards credibility;
- to bring value to the Senior Member Grade we resolve to fund and provide all existing Senior Members with a beautiful plaque. This will also complement IEEE's current initiative to provide new Senior Members a plaque;
- to assist members with career development, we are adding professional development workshops to our annual Regional conference CCECE commencing in 2000;
- Region 7 piloted the first two RAB Leadership Development Workshops. These were targeted to GOLD members and oriented to demonstrate IEEE value to industry; recruit volunteers, as well as provide volunteer leadership skills;
- a professional activities brochure was distributed to key member employers in two linguistic versions; English and French;
- membership development workshops were conducted for each of the three councils; these emulating the annual RAB/TAB MDC Retreat;
- the St. Maurice Section was the first to initiate a GOLD Chapter.

We continued our heritage of conducting annual Student Leader and Branch Counselor training workshops. These have taken on increasing importance in our quest to recruit and retain student members and offer valued member programs at the branches. Gratitude is extended to the leaders and active volunteers in the London, Victoria, and South Saskatchewan Sections for their Section revitalization. With pride we welcome our new student branches in Moncton and Mississauga.

Members were well served by many conferences in Region 7 including our showcase Canadian Conference on Electrical and computer Engineering (CCECE); Waterloo in 1998 and Edmonton in 1999; and PACRIM in Victoria.

Several ad hoc groups were established: Addressing to review and correct any problems in address consistence and change processes; Electronic Services, a review of our Web site requirements given that IEEE nor offers entity hosting; Strategic Planning to guide our path through the future; Y2K Compliance; Bylaws Review and Update; Language Translations; Millennium Events and Recognition; and Projects Ranking. In many cases the projects are supported by Region 7 funding.

As we move forward we face challenges; these include membership growth in general and more specifically student membership and associated branch counselor leadership. Establishing Life Member Chapters is depending on finding willing volunteers. Section and Chapter vitality cannot be taken for granted and will need close monitoring and assistance form the region, staff and supporting entities.

It has been rewarding to have led IEEE's global initiatives in chairing the following IEEE Committees: Affinity Groups, Section & Chapter Rejuvenation; and IEEE Branding.

My sincere gratitude is extended to all staff for support in so many areas. I thank members of IEEE Canada for electing me to the position; the IEEE Canada Executive Committee and Region Committee for their support.

Establishment of an IEEE Canada Standards Committee

The IEEE Canada Executive Committee is pleased to announce its approval, in principle, of the establishment of an IEEE Canada Standards Committee as a part of its Board. This committee will work in close partnership with the IEEE Standards Association (IEEE-SA), to facilitate globalization imperatives for the IEEE. The charter is currently being finalized.

The IEEE and the IEEE-SA are looking to Region 7 to set an example of successful national leadership in the critical area of international standards. IEEE national groups, in cooperation with the IEEE-SA will be established in other regions during the coming year. Region 7 has the opportunity to create a model that will lead the way in this activity.

IEEE Canada is pleased to announce the establishment of the IEEE Canada Standards Committee. The initial members are:

- Doug Topping, Chair
- Jim Gurney
- Wally Read
- Helen Sam
- Dave Kemp

Call for Volunteers IEEE Canada Standards Committee

IEEE Canada is seeking individuals to become involved in the global and highly successful standards activities of IEEE. If interested, please see our website:

http://www.ieee.ca

The Committee charter is available at:

http://www.ieee.ca/activ/StdsCmteCharter.html

1999 IEEE RAB Achievement Awards

Ferial El-Hawary: "For sustained achievement in promoting IEEE interest in the oceanic engineering community in Atlantic Canada."

Robert W. Creighton: "For sustained leadership in promoting membership awareness and communications within the IEEE Canadian Atlantic Section."

International Conference on Parallel Computing in Electrical Engineering

August 27-30, 2000, Trois-Rivières, Québec,Canada

PARELEC'2000 will focusing on application of parallel processing in electrical engineering including electrotechnics, electronics, telecommunications and modern computing.

The conference will be held in Trois-Rivières, from August 27-30, 2000. Trois-Rivières is strategically located midway between Québec's two main cities, Montréal and Québec. The region is a popular touristic region, with its nearby national park. Birthplace of hydroelectricity in Canada, the region contributes to the wealth of Québec with its regional industrial parks.

For information contact:

Prof. Adam Skorek
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University of Québec in Trois-Rivières
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Fax : (819) 376-5219
E-mail : info@parelec.com
Conference Home Page : http://www.parelec.com

AS-SPCC

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Total number of participants is limited to 300

Sunday, October 1, 2000: Registration: 1:00 - 4:00 pm; Reception: 6:00 - 8:00 pm

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MONDAY, OCTOBER 2, 2000

8:30 - 9:30 ***Lecture of the Day: Andrew Viterbi - Wireless communication: A Natural Adaptive System Application***

10:00 - 12:00 Fundamentals of Adaptive and Learning Systems I
- Shun-ichi Amari - Information Geometry of Adaptive Systems
- Tomaso Poggio - From bits to information with Learning Machines: theory and applications
- Brendan Frey - Adaptive Bayesian Networks for Computer Vision

1:30 - 3:30 Wireless Communications
- Arogyaswami Paulraj - Space-Time Techniques for Residential Broadband Fixed Wireless Access
- Jack Winters - Smart Antennas for the EDGE wireless TDMA system
- John Proakis - Multiple Transmit and Receive Antenna Diversity Techniques for Wireless Communications
- Michael Honig - Signal Processing Techniques for Short-Code DS-CDMA

4:00 - 5:30 Fundamentals of Adaptive and Learning Systems II
- Vladimir Vapnik - Fundamentals of Adaptive and Learning Systems and Pattern Recognitionn
- Rui de Figueiredo - A RKHS Approach to the Optimal Modeling Identification & Design of Nonlinear Adaptive Systems
- Ben Van Roy - Approximate Dynamic Programming and Temporal-Difference Learning

7:30 - 9:30 Interactive Lectures I

TUESDAY, OCTOBER 3, 2000

8:30 - 9:30 ***Lecture of the Day: Delores Etter - The Role of Signal Processing in Revolutionary Capabilities***

10:00 - 12:00 Adaptive Signal Processing I
- John McWhirter - Adaptive Radar Processing
- James Ward - Space-Time Adaptive Processing for Airborne Surveillance Radar
- Tasos Venetenapolous - Adaptive Filters and Multichannel Signal Processing
- Bernard Mulgrew - Stochastic Gradient Minimum-BER Decision Feedback Equalizers
- James Zeidler - Nonlinear Effects in Adaptive Filters

1:30 - 3:00 Adaptive Communication Receivers
- Louis Scharf - A Review of Matched and Adaptive Subspace Detectors
- Pierre Comon - Block Methods for Channel Identification and Equalization
- Saul Gelfand - Analysis of Adaptive Algorithms for Estimation and Equalization for Fading Channels

3:30 - 5:30 Adaptive Signal Processing II
- Jose Principe - From Linear to Information Filtering
- Norm Owsley - Array Phonocardiography
- Klaus Mueller - Denoising Brain Signals
- Erkki Oja - Independent Component Analysis - Extensions and Applications
- Luis Almeida - Linear and Nonlinear ICA based on Mutual Information

7:30 - 9:30 Interactive Lectures II

WEDNESDAY - OCTOBER 4, 2000

8:30 - 10:00 Nonlinear Dynamical Systems
- Iven Mareels - Complexity in adaptive feedback systems: curse or blessing
- David Broomhead - Nonlinear Signal Processing from a Dynamical Systems'Point of View
- Henry Abarbanel - Mixed Neural Assemblies with Biological and Electrical Neurons

10:30 - 12:30 Nonlinear Dynamical Systems (continued)
- Lou Pecora - Detecting Nonlinear Relationships between Data Sets
- Lenny Smith - Disentangling Uncertainty and Error: On the Predictability and Analysis of Nonlinear Signals
- Sorin Solomon - Microscopic Simulation of Financial Markets
- Eric Wan - The Unscented Kalman Filter for Nonlinear Estimation

2:00 - 4:00 Control
- Bob Narendra - Adaptive Control Using Multiple Models, Switching, and Tuning
- Graham Goodwin - Adaptive control: Where to Now?
- Ing Unbehauven - A Survey of Dual Adaptive Control Systems
- Ioan Landau - From Robust Control to Adaptive Control

6:30 - 9:00 Banquet Dinner
Banquet Lecture: Bernard Widrow - A Microphone Array for Hearing Aids