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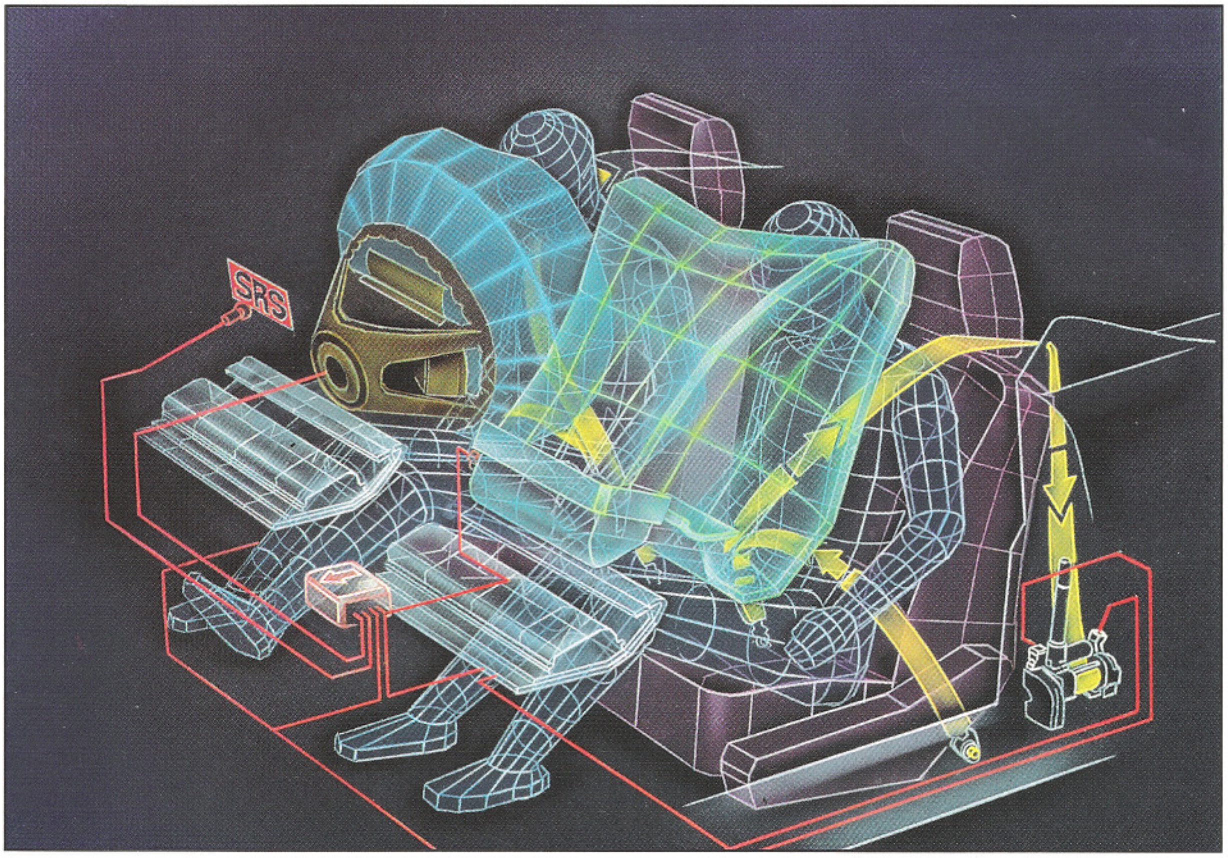

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IEEE Canadian Review General Information

The *IEEE Canadian Review* is published three times per year - Spring, Fall and Winter. The *IEEE Canadian Review's* principal objective is to project an **image** of the Canadian electrical, electronics, communications and computer engineering professions and their associated academic and business communities to :

(i) Canadian members of IEEE;

(ii) Canadian members of the profession and community who are non-members of IEEE;

(iii) the associated academic (i.e. universities, colleges, secondary schools), government and business communities in Canada.

In this context, the *IEEE Canadian Review* serves as a forum to express views on issues of broad interest to its targeted audience. These issues, while not necessarily technologically-oriented, are chosen on the basis of their anticipated impact on engineers, their profession, the academic, business and industrial community, or society in general.

To ensure that the *IEEE Canadian Review* has the desired breadth and depth, Associate Editors are responsible for identifying issues and screening articles submitted to the *IEEE Canadian Review* according to the following general themes:

1- National Affairs
2- International Affairs
3- Industry
4- Education
5- Power
6- Communications
7- Computers

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Information for Authors

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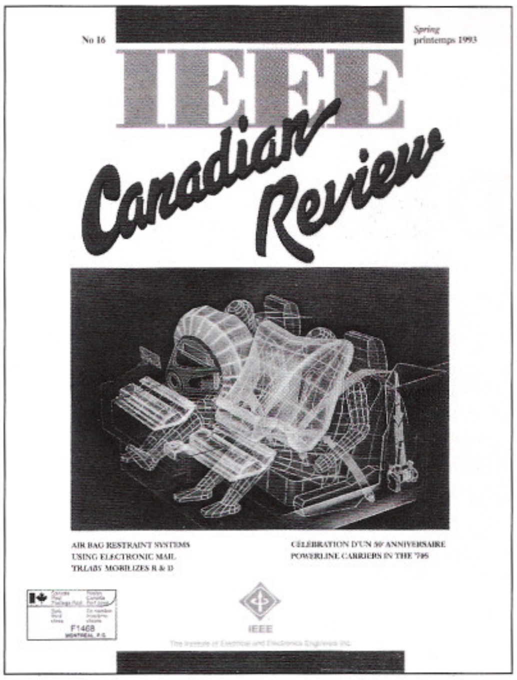
Cover picture

Our cover picture shows a CAD reproduction of a dual air bag system in full deployment. Such computer simulations, supplemented by actual tests using sophisticated dummies, have produced important advances in automobile safety.(*reproduced with permission of Mercedes-Benz Canada Inc.*)

Tableau couverture

La page couverture montre une reproduction CAO (Conception assistée par Ordinateur) d'un système dual de coussin gonflable entièrement déployé. Ces simulations informatiques, completées par des tests physiques utilisant des mannequins sophistiqués, ont permis des progrès importants en sécurité automobile. (*reproduite avec la permission de Mercedes-Benz Canada Inc.*)



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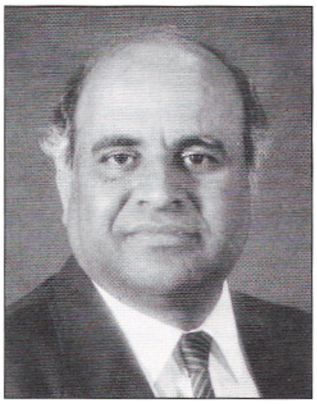
Director's Report

by Dr. Vijay K. Bhargava
Director, IEEE Canada



During my first year as Director, I spent considerable time reviewing the role and cost of the Region 7 office and its ability to service the needs of IEEE Members in Canada. Over the past five years (1988-1992), Region 7 Members, through their assessment, paid $469,5000 towards the operating cost of the office. During this period our Regional assessment rose from US $10 to US $15. Were these costs justified in terms of benefits to our members?

During 1992, I established a **Forward Planning Committee** and a **Volunteer Audit Committee** to get a better understanding of our office operation. In addition, I spent five full days working at the office in Thornhill and undertook extensive consultations with several Region 7 past and present committee members, with several colleagues on the IEEE Regional Activities Board, with IEEE Executive Director (Emeritus) **Eric Hertz**, and with key IEEE Staff in Piscataway. Based on my evaluation of the situation, I found it appropriate and indeed necessary to propose the following actions:

1. Terminate the sale of standards through the Region 7 office.
2. Eliminate the position of Manager, Canadian Members Services, with effect from June 30, 1993 and terminate the contract of the current Manager with effect from June 30, 1993.
3. Terminate the lease of the premises occupied by the Region 7 office, located at 7061 Yonge Street, Thornhill, with effect from June 1993.

These proposals were discussed and endorsed by the Region 7 Executive Committee at its meeting in Montreal, during January 30-31, 1993.

A survey of the R7 membership has been conducted (at no cost to R7). The results are currently being analyzed and will help the **Forward Planning Committee** come up with a plan for the future. The matter will be discussed at the Region 7 Committee meeting, to be held during May 1-2, 1993 on the campus of Memorial University, in St-John's Newfoundland.

I am pleased to inform you of several other activities.

Student Activities

I have appointed **Sheelo McGuire** to be Region 7 Student Representative (2). Sheelo is currently finishing her Bachelor of Engineering degree at the University of Victoria and will then join Queen's University at Kingston.

The IEEE student branches at the Universities of Ottawa and Toronto conducted very successful Student Professional Awareness Conferences (S-PAC).

Region/Section Conferences

The **Fourth Newfoundland Electrical and Computer Engineering Conference** (April 30; Newfoundland – Labrador Section), the **IEEE WESCANEX '93 Conference** (May 16-18; North Saskatchewan and South Saskatchewan Sections) and the **IEEE Pacific Rim Conference on Communications, Computers and Signal Processing** (May 19-21; Victoria Section) all have outstanding technical programs and are examples of what sections can do to raise money and provide service to their membership. The last two conferences are co-sponsored by Region 7. In addition, we will be hosting several Society-sponsored conferences.

Region 7 1993 Goals and Budget

The Goals and Budget have now been finalized and a copy is available from your Section Chair.

Historical Milestone

The IEEE Centre for the History of Electrical Engineering has designated the Alouette / ISIS Program as a *Milestone of Electrical Engineering* at the nomination of **John Palimaka**, Past Chair, IEEE Ottawa Section. The unveiling ceremony for the plaque will be held at the Communications Research Centre at Shirley Bay on the afternoon of May 14, 1993. Our congratulations!

IEEE Chicago Board and related Meetings (February 25-March 2)

At the RAB/TAB Transnational Committee and at the RAB meeting, Past Director **Tony Eastham** made a presentation on IEEE R7/CSECE. This was in accordance with what I reported in my last Perspectives article and was very well received. The Board Meeting itself was historic for several reasons. It was chaired by Dr. **Martha Sloan** – the first woman President of IEEE and it was "paperless" (all IEEE Directors were provided with a laptop computer). IEEE election procedures were discussed. These are detailed in the President's column of the March/April issue of INSTITUTE. You can convey your opinions directly to President Sloan or via your Director.

IEEE Region 7 / CSECE Merger

A detailed proposal and business plan for the merger of IEEE Region 7 and CSECE is in preparation by **John Plant** and **Tony Eastham.** A preliminary draft will be discussed at the Regional Meeting in St. John's. The next (Fall) issue of the IEEE Canadian Review will include an article about the proposed merger and all members will be given the opportunity to express their views and to vote on the merger.

You can contact me by mail, phone, fax or e-mail as follows: c/o Department of Electrical and Computer Engineering, University of Victoria, P.O. Box 3055, Victoria, B.C., V8W 3P6; phone: (604) 721-8617; fax: (604) 721-6048; e-mail: v.bhargava@ieee.org ■

Overview and Update of System SIR

Air bag sensors may be on the verge of a significant transformation

by Gilles Delaire
Siemens Automotive Ltd.

This article describes the principal components, terminology, modelling and testing procedures used in automotive Supplemental Inflation Restraint (air bag) systems. The merits of mechanical and electronic crash sensors are discussed.

Cet article décrit les principaux éléments, la technologie, la modélisation et les procédures de tests utilisés dans les systèmes de coussins de sécurité gonflables pour automobile. Les mérites respectifs des détecteurs de collision mécaniques et électroniques son discutés.

In 1984, Elizabeth Dole, then Secretary of the U.S. Department of Transportation, announced a plan to phase-in automatic crash protection for automobiles. At the time, she called for 10% of automobiles built in 1987 to incorporate such systems, with increasing proportions of 25% in 1988, 40% in 1989, and 100% in 1990. The automatic protection called for was not necessarily an air-bag system; for example, automatic seat belt tighteners fulfill the requirements of the plan. Air-bag systems, however, have been manufactured in large quantities, perhaps due to increased safety-awareness and demand on the part of the consumer.

Automatic protection systems may be classified according to their "passive" or "active" nature. A passive system requires no intervention on the part of the occupant for activation, while an active system requires some occupant-assisted initiation. A seat belt, for example, is an active system because it must be fastened by its user. The air-bag system is of the passive type. There are vehicles still being manufactured which do not meet the requirements of the Dole plan, but much progress toward attaining the original objective has been made.

Not only is there a need for a passive restraint system to protect the driver, but one is also required for the passenger. The latter is more demanding in terms of system design, and more costly. For this reason, a high proportion of new vehicles lack passive passenger protection in the form of air-bag systems.

A supplementary inflatable restraint or SIR system is another way to describe an automobile air-bag system. As implied in the expression, the system is intended to supplement some other restraint, namely, seat belts. Although testing is done without seat belts, perhaps with the intention of establishing the extent to which the air bag alone might protect an occupant, the position taken by the auto industry is that a SIR system is effective only if seat belts are in use at the time of a crash.

A typical SIR system consists of four main components: the air bag, the inflator, the sensors, and the diagnostic system.

The Air Bag

The air bag itself was developed to meet the requirements of the U.S. Federal Motor Vehicle Safety Standard 208, which calls for adequate protection during a 30 mph frontal barrier impact, as well as angular impacts of up to 30 degrees. Canadian standards are similar. The air bag, made of neoprene-coated nylon, must transfer the force of the driver impact to the rim and spokes of the steering wheel as the energy is absorbed by the collapsing steering column. Typically, the air bag measures 58 cm in diameter, and 35 cm in depth above the rim, but actual proportions depend on the particular steering column and knee restraint dimensions. The bag is accordion folded along twelve axes into a rectangular package and sealed inside the steering wheel molding, which rips open upon bag deployment. The driver-side bag inflates in 25 to 40 milliseconds to a volume of 0.03 to 0.07 cubic metres and pressure of about 14 to 21 kilopascals. The passenger-side air bag requires 30 to 70 ms to inflate to 0.15 to 0.21 m^3 at 7 kPa.

The Inflater

Two types of inflator are in current use: (1) a hybrid inflator, utilizing chemical generants to augment stored compressed inert gas such as argon or nitrogen, and (2) a pyrotechnic inflator, which incorporates a solid propellant such as sodium azide to generate gaseous nitrogen. Approximately 100 grams of propellant are used to fill the air bag in 30 ms. Although the propellant burns at 2500 °C, the surface of the air bag does not exceed 70°C. The inflator is cylindrical, measuring about 10 cm in diameter and 5 cm deep, and weighs under 2 kg.

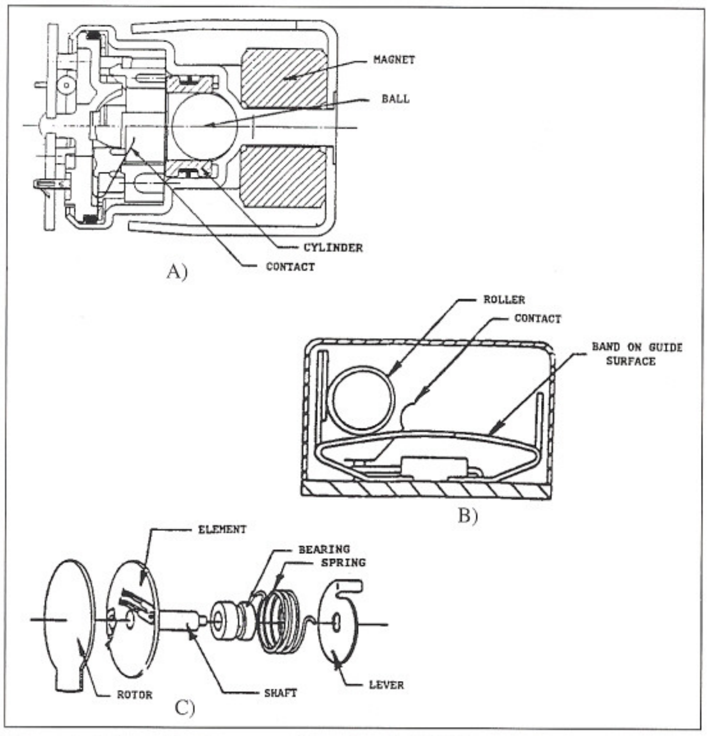


Figure 1. Schematic diagrams of mechanical SIR sensors: A) ball and tube; B) roller band and roller; C) rotary spring and mass.

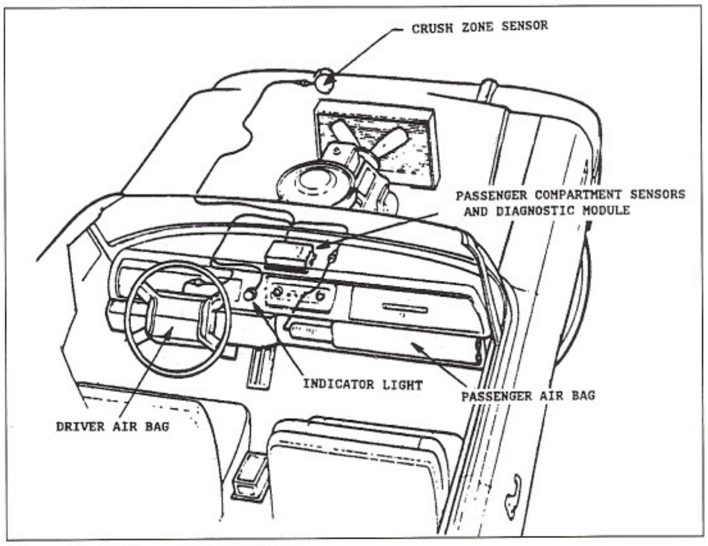


Figure 2. Air bag sensor system.

The Sensor

The sensor, which is a mechanical or electronic accelerometer-based device, is the component which detects if a crash is occurring. Mechanical sensors use component assemblies such as a ball and tube (Figure 1A), a roller band and roller (Figure 1B), or a rotary spring and mass (Figure 1C). In each of these cases, a mass must overcome an inbuilt resistance to motion in order to close a circuit contact.

In the *ball and tube sensor*, the ball must overcome an initial magnetic bias, followed by drag and friction as it moves through the cylinder. When the ball reaches a pair of contacts, a spring force acts against the ball to bring it to rest, and then drives it back toward the magnet.

The *roller band sensor* consists of a roller wound inside a film of metal which has spring-like properties. The film is unwound as the roller moves toward a single contact.

In the *rotary spring sensor*, the spring is attached to a disc which has an eccentric mass mounted off-centre, and a contact is positioned opposite the mass. Under acceleration, the disc rotates, and the contacts are closed after the mass has turned through a given angle.

Accelerometer-based sensors utilize capacitive or piezo-resistive measurement techniques to detect crashes. They may consist of a mass suspended on a cantilever beam, which is subject to oil or air damping and constitutes part of a capacitive circuit (Figure 2). The signal generated by the circuit is altered as the mass is forced to move under an acceleration. The moving parts of a silicon-chip accelerometer can be one hundred times smaller than those of a mechanical sensor.

In a paper presented at the 1990 SAE International Congress on Transportation Electronics [1], it was proposed that accelerometer-based systems may be capable of earlier sensing because of increased flexibility in calibrating the sensor for each vehicle type, as compared to mechanical sensors. It was also suggested that an accelerometer-based system would make single-point sensing possible - an accomplishment unattainable with mechanical sensors.

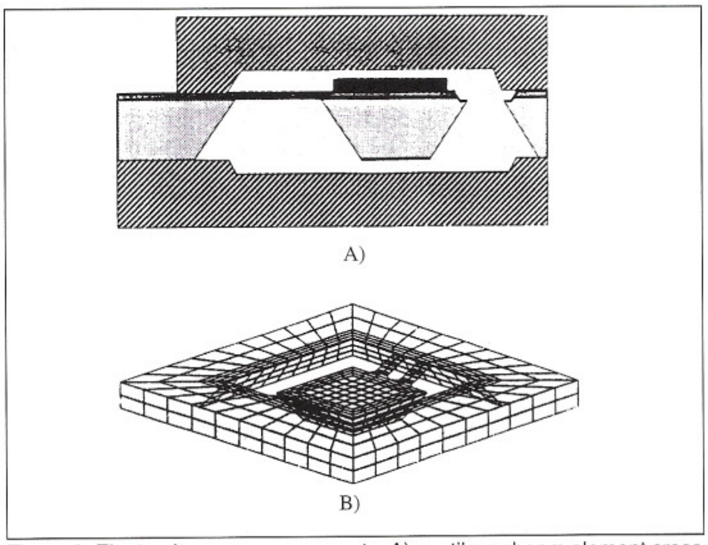


Figure 3. Electronic sensor components. A) cantilever beam element cross section; B) simply supported beam element under load.

Issues that have prevented silicon accelerometers from completely replacing mechanical sensors have been reliability and electromagnetic interference (EMI). The effects of EMI and other environmental influences are reduced by locating the sensing/diagnostic modules in the passenger compartment.

The Diagnostic System

The diagnostic system is responsible for processing the signals produced by the sensors. The diagnostic module can receive signals from three or more sensors with different calibrations in different locations throughout the vehicle (Figure 3). The system determines whether or not SIR deployment is warranted, depending on the received sensor signals. The vehicle may experience a jolt from hitting a curb, or a hammer blow near the sensor from a mechanic servicing the vehicle. In either case, it is undesirable for the bag to inflate.

The timing of deployment depends on how far the occupant has moved forward as a result of his or her momentum during the crash. It has been established that the air bag must be fully inflated by the time the occupant has moved five inches. Since the air bag inflates in 30 ms, the design criteria for initiating inflation has been called the 5 inch - 30 ms mark.

Mathematical Modelling

A mathematical model for the ball-and-tube sensor developed by Siemens Automotive Ltd. Chatham, and the University of Western Ontario, London, [2], uses a fifth-order Runge-Kutta procedure to solve a set of ordinary differential equations as a function of air-drag, magnet attractive force, and friction for a given acceleration. obtain the time-to-close as a function of air-drag, magnet attractive force, and friction for a given acceleration. Spring force is considered as the ball closes the circuit contacts and resets by returning to the magnet.

The mathematical model calculates the position of the ball as a function of time, thus yielding the time required for the ball to reach the contacts (time-to-close). It also establishes how long the contacts can be expected to remain closed (dwell time). A third measure of performance for SIR sensors is velocity change (delta-*V*). This is, in effect, a rate of change of velocity since it is measured as a function of time, but it is left in terms of velocity for convenience. The change of velocity of the passenger at the time of the impact with any part of the vehicle interior, including the air bag, provides some indication of the injury that might be sustained. This can be estimated by knowing the change of velocity of the sensor at a any given time during the crash.

Although the time-to-close is measured in crash tests, where vehicles are instrumented and rammed into a barrier to simulate crash conditions, the procedure is expensive, and mathematical modelling techniques are used extensively to reduce development costs.

With such a model, it is possible to examine the effects of varying design parameters such as the gap between the ball and tube, ball travel, magnetic field strength, and spring constant of the contacts for a variety of acceleration pulses, including both test stand and actual measured crash pulses. In addition, the mathematical model can provide the effects of ambient temperature during such a crash (i.e. from - 40°C to + 105°C).

Non-destructive Testing Methods

Non-destructive testing of sensors is facilitated by the use of test stands. The tests ensure that each sensor meets the specified performance tolerances for (1) time-to-close, (2) velocity change at closure, and (3) dwell time.

The test stand consists of a large electromagnetic coil that moves a shaft attached to a horizontal table upon which several sensors are mounted. A relatively simple haversine pulse is applied to the coil terminals for test purposes, since the coil cannot be used to exactly duplicate the complexity of a true crash characteristic. The haversine pulse, however, closely matches the acceleration experienced at the chest of the driver during a crash, and was therefore selected as a test standard. It is nonetheless necessary to accelerate the sensors in both the forward and reverse directions, to ensure that the sensors experience the velocity changes that are common in a crash.

Single-point Sensing

Since single-point sensing would reduce the number of sensors and wiring required to connect sensors to the diagnostic module, it would also provide a considerable cost advantage. As implied by the name, it would involve activating the air bag based on the information gathered at a single location, although more than one sensor may be involved. The location of the sensor would be in the steering wheel for the driver-side air bag, and all four system components (air bag, inflator, sensors, and diagnostic system) could be integrated into the same package.

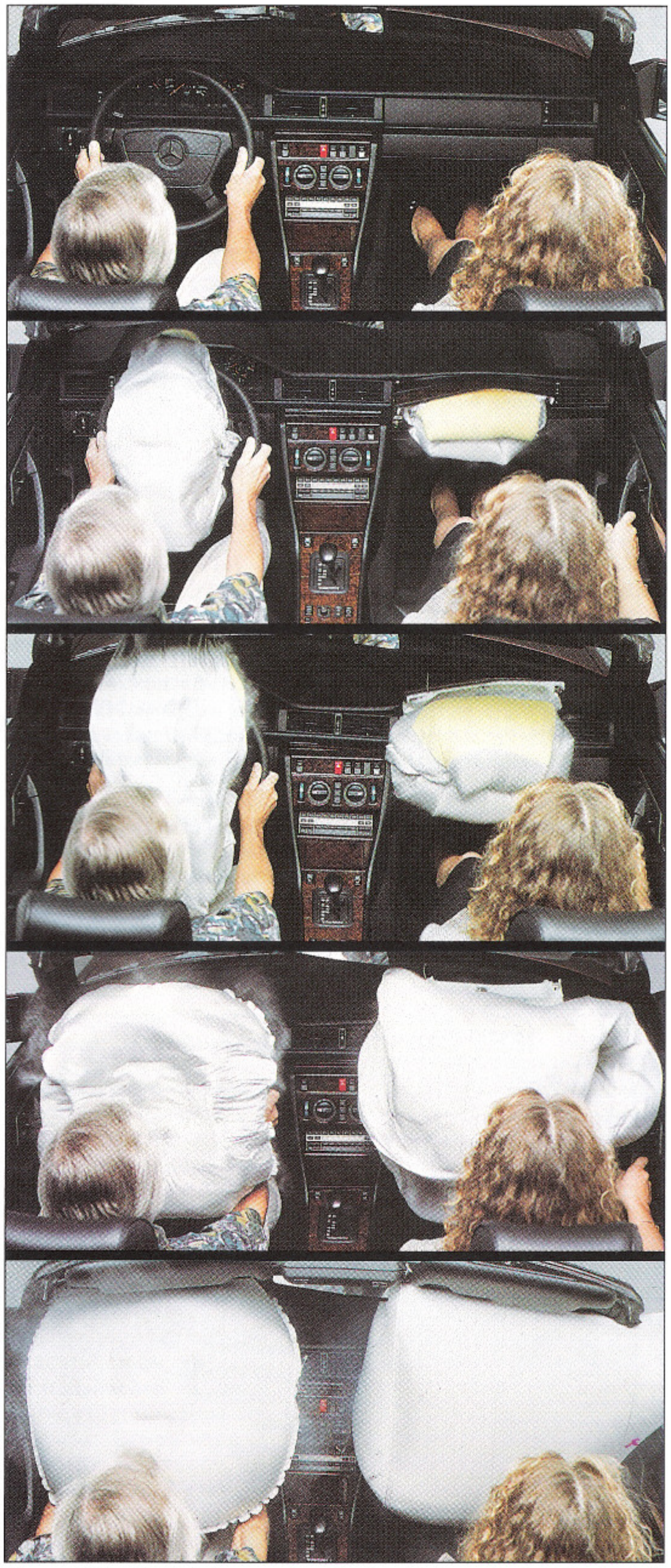


Figure 4. The SRS air bag on the driver's side is packed within the hub crosspiece of the steering wheel. On the passenger side, it is packed in a special compartment. Shown here just emerging, in a sequence of five snapshots, the air bags expand to a volume of 60 litres when fully deployed - and deflate usually within one second. They are triggered by an Electronic Control Unit. Built into the ECU is a crash sensor able to discern two impact thresholds.(*reproduced with permission of Mercedes -Benz Canada Inc.*)

Some experts believe that it would be difficult to acquire enough information from a single-point sensor to adequately and reliably control the activation of the air bag. There are numerous types of impacts which create different crash pulses, for example, direct frontal impacts, centre-pole and offset-pole collisions (to either side of centre), bumper underrides (when the front bumper of a car goes under the rear bumper of a truck), animal hits, and snowbank encounters. In addition, vehicle chassis have structural differences, and hence react differently to any given type of crash. A substantial number of combinations and permutations must be considered to calibrate a system to ensure the air bag is inflated within the 10 ms to 100 ms window. Mathematical modelling has been used to speed-up the design process, to determine the effects of temperature on sensor performance, and to determine the optimum location for mounting sensors.

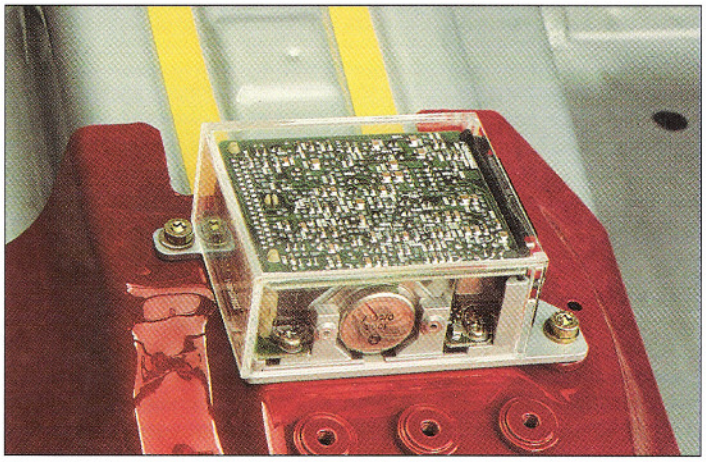


Figure 5. View of the Electronic Control Unit. Built into the ECU is a crash sensor able to discern two impact thresholds.(*reproduced with permission of Mercedes -Benz Canada Inc.*)

In 1991, **David Breed** ***et al***, of **Automotive Technologies International Inc.** [3], prepared a paper which suggested, for cases where the occupant is not wearing a safety belt, that there is insufficient information in the crash pulse for reliable crash sensing, unless it is measured directly in the automobile's crush zone. Current research focuses on whether the information gathering potential of silicon accelerometers can be applied to alleviate this shortcoming, so that reliable air bag deployment using single point sensing may be achieved. It is surmised that wheel speed, steering wheel angle, and vehicle height are parameters which must be incorporated into diagnostic algorithms, thus increasing their complexity. However, the cost savings that single-point sensing permits will make air-bag based, SIR system-equipped automobiles more affordable, and ubiquitous. ■

[1] Hendrix, T.D., Kelly, J.P. Lloyd,-Piper, W., "*Mechanical versus Accelerometer-based Sensing for Supplemental Inflatable Restraint Systems*", SAE paper No. 901121, Oct. 1990

[2] Greydanus, J., et al, "*A Theoretical Analysis of an Air Bag Crash Sensor*", submitted for publication to Mathematical Engineering in Industry.

[3] Breed, S.D., Castelli, V., "*Trends in Sensing Frontal Impacts*", SAE paper No. 890750, 1989.

About the author

Dr. **Gilles Delaire** received his M.A.Sc. and Ph.D. degrees from the University of Windsor, Ontario. He has been employed by Otis Elevator Co. Ltd. as a sales representative and by Laurentian University as an Assistant Professor. Dr. Delaire is currently a computer modelling specialist at Siemens Automotive Ltd. in Chatham, Ontario.

Using Electronic Mail

I t is December in Mississauga, Ontario. The first winter snow storm has arrived with a vengeance. The trees are covered with snow. I have shovelled the driveway twice, and looking outside, I know that at least one more clearing will be needed. The roads are either high with snow or very slippery - or both! The office at work is closed, and in true Canadian tradition, I am cut off from the world for a while.

Or am I? The power is on, and the phone and television are working. Since I am writing this article on my personal computer, it *also* must be working. And, since I have a modem and an e-mail mailbox at the office, I can be connected to my office computer, while working at home. I can access the computer files that I have either at home or at work, transfer files in either direction, and can exchange e-mail messages with my colleagues at work, across the country and even around the world.

This is the power and convenience of electronic mail, known as e-mail. It offers the flexibility to send or read messages whenever I want to. No telephone tag when I want to call someone. No interruption when I don't want to be disturbed. E-mail messages are sent quickly (usually with the speed of a phone call or fax), and they wait for the next convenient time to be read. If I am working with someone to develop a document, I can receive the first draft, do my own editing, and return the second draft without retyping the entire document. And if I use the "reply" mode, I don't even have to type the return address.

As IEEE members, we can use the new e-mail services provided by IEEE to contact our IEEE friends and to gain access to many of the technical services that were the reason we joined IEEE in the first place.

How do you find out what e-mail services are available? Simply send an e-mail message to the address "email.guide@ieee.org" and you will get in reply the 8-page IEEE E-mail Guide. It explains how the IEEE e-mail system works, and how you can get more information on specific topics. Don't worry about the Subject or Content in your message, they are discarded and a text file is automatically returned. Also don't worry that the address that you send your message to doesn't look like a person's mailbox. It isn't. That address is really an alias that redirects your message within the IEEE computer and causes the automatic returning of the E-mail guide (referred to earlier as the text file).

For Potential E-Mail Users

If you don't presently use e-mail, there are several places to look for introductory information. The October 1992 issue of IEEE Spectrum has a series of e-mail related articles. The November/December 1992 issue of THE INSTITUTE has an introduction to IEEE e-mail, and the next issue (January/February) has an article on IEEE e-mail services. If you would like your local IEEE Section to hold an instructional e-mail session, give your local Section Chair a call.

For Current E-Mail Users

If you are an e-mail user (a possibly addictive but not unpleasant condition) here are some additional bits of information that you might find useful. You can contact any of our 20 Canadian IEEE Sections, our IEEE Regional Office, and many volunteers, using the aliases listed in the box nearby. For the most recent information on how to contact Sections, Societies, Student Branches, Volunteers, and Staff, send a message to "info.directory@ieee.org".

If you live in the Toronto, Winnipeg, or South Saskatchewan Sections you can dial up the Section Bulletin Board Service (BBS) - look in your Section Newsletter for the telephone number. A BBS enables you to use

by Robert T. H. (Bob) Alden
Chair IEEE E-mail Committee

your PC/modem/phone line to dial up and browse through the information that is posted electronically on this bulletin board. Some BBS's allow you to leave messages to be mailed and to retrieve messages sent to you, provided the BBS has a connection to Internet (or a provincial digital network that is connected to the Internet).

If you live in the Ottawa Section, you can get a copy of the Section Newsletter via e-mail - look in one of your mailed copies for details.

If you want to help your Section develop it's e-mail services, please send a message to the Section alias listed in the adjacent box. Furthermore, if you have any questions, send e-mail messages to the appropriate address in that box.

By the way, 4 years ago, I had not even heard of e-mail! Now I find that it is indispensable in my work and in my IEEE activities. One learns very quickly to adapt to the convenience and productivity improvement that e-mail usage brings.

Some final comments to those of you thinking about using e-mail. Get a good communications software package to use with your PC/modem - it will minimize any frustration. I am currently using BITCOM software, I have also used XTALK and KERMIT. If necessary, get help to set up your system so that it is easy to use. Have fun and make better use of your time and energy. ■

IEEE Canadian E-Mail Aliases

To use the following aliases, append "@ieee.org" to each of the following - e.g. sec.ottawa@ieee.org (each alias, which is a dummy address and stays the same, is used to redirect your mail to the current e-mail address, which may change from time to time - eg most IEEE volunteers change their duties every year or two).

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Telecommunications Research Laboratories

TR*Labs* *Mobilizes Industry, University and Government in R & D*

by Keith Gylander
Communications Co-ordinator, TR*Labs*
and Avril Hall

Telecommunications Research Laboratories (TRLabs) is a not-for-profit research consortium, based on industry, university and government collaboration. The consortium undertakes applied research in telecommunications, specifically on networks and systems, network access, photonics and wireless technologies. As an accredited affiliate of a number of universities in western Canada, TRLabs provides student training at the graduate level. TRLabs currently operates research laboratories in Edmonton, Calgary and Saskatoon.

Telecommunications Research Laboratories (TRLabs) est un consortium de recherche à but non lucratif, basé sur une collaboration entre l'industrie, les universités et le gouvernement. Le consortium effectue de la recherche appliquée en télécommunications, spécifiquement sur les réseaux et systèmes, l'accès aux réseaux, la photonique et les réseaux sans fil. En tant que partenaire accrédité de plusieurs universités dans l'ouest du Canada, TRLabs procure de la formation à leurs étudiants gradués. TRLabs opère présentement des laboratoires à Edmonton, Calgary et Saskatoon.

In Canada, advanced computer technology joined with sophisticated networking capabilities has drastically changed the way we communicate.

Canada's economic health and future growth is being built on the information highways of the future: fiber optic cables, digital telephone switches, satellite dishes and microwave transmitters. To support our telecommunications infrastructure and provide the foundation for Canada's long-term economic prosperity, we need to build and maintain a strong commitment to research and development.

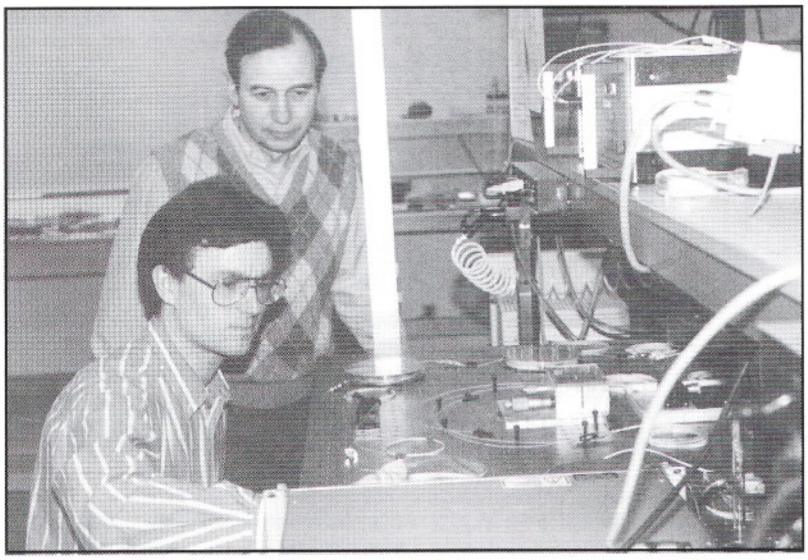
The amount of research and development Canada undertakes in the coming years will determine its share of the global telecommunications market. Canada's private sector expenditures on R & D currently rank second lowest among the G7 countries. Accelerated R & D efforts will be essential to compete globally and increase Canada's share of this strategically important world market.

Canada's telecommunications industry is meeting the challenges of a global economy and shortened product life cycles. There is a need to encourage companies to form cooperative ventures to leverage resources and lower the risk of applied research. This need is being achieved with organizations like Telecommunications Research Laboratories (TR*Labs)*.

TR*Labs* was established in 1986 as a not-for-profit consortium bringing together the **University of Alberta**, **Bell-Northern Research** and the **Government of Alberta**. Since that time, TR*Labs* has developed into one of Canada's success stories in cooperative research among industry, university and government.

The process of changing from an Alberta-based consortium to one which would be based in Western Canada began in 1990 with the development of a five year plan. Recognizing further growth as being dependent on expansion, TR*Labs* moved into Saskatchewan where **SaskTel**, the **University of Saskatchewan** and the governments of Canada and Saskatchewan joined as sponsors.

In September 1991, to encourage affiliation with Saskatchewan research and manufacturing firms, TR*Labs*, together with the Saskatchewan government, launched an innovative program called the TR*Labs* Group Sponsorship Program. By February 1992, **Develcon Electronics**, **Digital Systems Group**, **QCC Communications**, **SED Systems** and **Wavecom Electronics** had joined the TR*Labs* consortium as Small Business Associates. Together, these sponsors are helping TR*Labs* build a research program which will be more responsive to smaller firms.



Jan Conradi (standing) and Terrance Rosadiuk monitor erbium-doped fibre laser characteristics at TR*Labs*' Edmonton research facility. The research consortium blends a unique mix of industry, university and government sponsorship; combining their talents and resources while developing telecommunications technologies.

The consortium has grown to 19 sponsors. Other sponsors include the **University of Calgary**, **AGT Limited**, **Digital Equipment**, **ED TEL**, **LSI Logic**, **Novatel** and **Northern Telecom**.

Sponsors have the opportunity to interact directly with TR*Labs* through five channels: 1) the Board of Directors, 2) the Program Committee, 3) the Thrust committees, 4) industrial representatives, and 5) technical seminars and conferences. TR*Labs* has also developed a number of collaborative relationships with research institutes and laboratories across Canada providing access to additional expertise and facilities. **Michael Leung**, Vice-President of Business Development for TR*Labs*, comments, "*We believe this provides the best possible* *leverage for our sponsors' research dollars and ensures them of an ongoing supply of technical ideas, options and connections for new business relationships.*"

Each sponsor contributes cash and/or services-in-kind and has non-exclusive access to TR*Labs'* research results. "*TRLabs is different than most other research consortia.*" explains Leung; "*Sponsors' funds are pooled to support the total research program of TRLabs. Decisions regarding what projects to include in our research program are based on input from our sponsors through our board of directors, program committee and thrust committees.*"

Sponsors have the opportunity to place employees in TR*Labs* for up to three years to act as industry representatives. This allows research and career development for employees and facilitates the sponsors' direct input into the research and development activities at TR*Labs*. The consortium currently has nine industrial representatives working on research projects at the three different lab locations.

Tom Moore, Research Engineer, explains the function of industrial representatives. "*Think of us as a working level liaison between the industry sponsors and TRLabs.*" he says. "*Industrial representatives assist in the technology transfer from the consortium to their sponsors. We bring experience in return for research knowledge in specific technologies.*"

Among the strengths of the TR*Labs'* formula, the most crucial elements are the people and technology the consortium produces. TR*Labs* has been working with universities to strengthen their engineering programs, partly in response to the industry demand for quality telecommunications graduates.

The relationship between TR*Labs* and the universities has allowed the consortium to attract top graduate and undergraduate students, including gold medalists in electrical engineering. With TR*Labs*, students broaden their knowledge base and make contributions through participation in research projects and publication of results. Through interaction with TR*Labs* and sponsors, students gain an appreciation of both the technical and managerial career paths. These include voice & data communications services, equipment & systems manufacturing, integrated circuit design & manufacturing, and information technology research and development.

Of the 33 students who have graduated from the TR*Labs* program, 20 have been employed by sponsoring companies and the remainder are employed by companies in related industries.

"*TRLabs provides a unique working style environment that is difficult to find anywhere else*" says **Terrance Rosadiuk**, a graduate student working at TR*Labs*. "*The various research projects must be focused on the needs of the industrial sponsors. From this I gain insight into each industrial sponsor's direction and I'm able to plot future career paths.*"

Jan Conradi, Professor of Electrical Engineering at the University of Alberta, and holder of the Natural Science and Engineering Research Council (NSERC) and BNR Chair at TR*Labs*, explains that students are the hands-on researchers in the TR*Labs* program. "*Currently several students are working on fiber optic related research projects. Their interaction with industrial representatives provides excellent real world training for them.*"

At TR*Labs,* research dollars are spent in four thrust areas : 1) Networks & Systems, 2) Photonics, 3) Wireless, and 4) Network Access. The **Networks & Systems** laboratory in Edmonton focuses on issues such as jitter reduction, error-correcting codes and real-time network restoration. Also based in Edmonton, **Photonics** research seeks innovations in switching, multiplexing and fiber optic transmission. The **Wireless** lab in Calgary focuses on cellular and personal communications systems and the **Network Access** lab in Saskatoon develops new methods for efficiently and economically connecting telecommunications users.

The labs are designed to work together as a unit, pursuing research programs complementary to one another and dependent upon the expertise at the local university and the needs of the sponsors. Research focuses on the technologies with the best prospects for future commercialization.

One of the current research projects at TR*Labs* focuses on the area of fiber optics. "*One of our research goals is to increase the carrying capacity of a strand of fiber, and how one can apply fiber to various networks*" says Conradi.

A Word from the President

Global competition is a fact of life. TR*Labs* is engaged in this competition, providing both people and technology for Canada's future.

If we are to succeed in the dynamic environment of rapidly evolving technologies in fields like telecommunications, consortia such as TR*Labs* are necessary components to achieve this success. The consortium model at TR*Labs* demonstrates how our country can be strengthened when industry, universities and governments work together as partners.

At TR*Labs*, our sponsors bring together a powerful mix of the strategic market and technological capabilities of industry, the intellectual and research strengths of universities and the industrial and economic strategies of governments. Working together as players on a team can be more effective and productive for the benefit of all.

The vision for TR*Labs* is to be the premier telecommunications research establishment in Western Canada and to be recognized internationally as a world-class leading institute in this field.

We have a role to play in the success of Canada. We take that role seriously.

Glenn Rainbird,
President and CEO, TR*Labs*

Different wavelengths of light are used to increase the carrying capacity of a single optical fiber. Ultimately, many wavelengths will be transmitted to create an "optical expressway". This means there will be more capacity in the network and more channels, which will facilitate services that require a larger bandwidth, such as video.

"*Our research team has achieved a carrying capacity of 10 gigabits per line. That's the equivalent of 120,000 simultaneous telephone calls or over 1000 video channels. We are currently the only university program that has reached that capacity and it should be commercially available by 1995 or 1996*" says Conradi.

With the assistance of BNR, TR*Labs* has been able to transmit these volumes up to a distance of 160 km, using electronic coding techniques. Optical amplifiers, designed by TR*Labs*, were used to boost the transmission. "*We are able to transmit simultaneously in opposite directions through the amplifiers*" explains Conradi. "*This ultimately increases the utilization of the fiber by carrying two signals.*"

Conradi says optical amplifiers are designed to replace the current and complex repeaters in the fiber network. "*Repeaters take an optical signal, convert it to an electric signal and back again. With the amplifiers we have designed, this conversion-reconversion process is skipped.*"

To date, 10 patents have been registered and more are pending. TR*Labs* owns the rights to all technology developed within the organization. It assigns the rights to its sponsoring companies and universities, according to their level of sponsorship.

TR Technologies Inc., a TR*Labs* subsidiary, was created to undertake commercial activities and transfer technology to third parties through contract research, licensing and joint venture agreements. Last year, TR Technologies completed a research contract with **Telecom Canada** and has licensing agreements with four multi-national telecommunications organizations. A contract research project was also completed for an Alberta company which manufactures and markets photonic sensing devices for the petroleum industry, based on TR*Labs* technology.

The race to ensure a strategic foothold within the competitive global telecommunications industry has begun. TR*Labs* is working to ensure that Canada maintains a leading position in the race. ■

50^e Anniversaire du Génie électrique à l'Université Laval

La première École de génie électrique au Canada français célèbre ses réalisations

Le cinquantième anniversaire du Département de génie électrique de l'Université Laval a été souligné de façon particulière les 15, 16 et 17 avril 1993. Des visites guidées des laboratoires de recherche furent organisées au cours de ces journées de festivités, de plus des expositions de matériel technique et de réalisations d'anciennes et d'anciens y furent présentées. Le tout a été cloturé par un souper et une danse gala où assistèrent près de 400 anciens et anciennes et leurs compagnons.

L'École de génie électrique de l'Université Laval fut inaugurée officiellement le 23 septembre 1942. Une cérémonie solennelle se tint dans l'édifice de l'École des mines, sur le boulevard de l'Entente. Plus de deux cents personnes assistèrent à cette cérémonie, dont le premier ministre **Adélard Godbout,** plusieurs ministres, sous-ministres et députés, le recteur et les doyens des diverses facultés de l'université, de même que les membres du corps professoral de la Faculté. De nombreux représentants importants des industries oeuvrant dans le domaine de l'électricité assistèrent aussi à cet événement; citons entre autres, les compagnies Canadian General Electric, Northern Electric, Quebec Power, et Shawinigan Water and Power. Les participants à la cérémonie y entendirent les allocutions du recteur, **Mgr Camille Roy**, du doyen de la Faculté des Sciences, M. **Adrien Pouliot**, et du premier directeur de la nouvelle école, M. **René Dupuis**. Ce dernier résumait les attentes profondes de la nouvelle institution: *"Notre but principal est que notre province et notre nationalité jouent avec aise dans l'industrie hydro-électrique le rôle que nos ressources hydrauliques nous appellent à jouer"*.

par Pierre Tremblay, ing., Ph.D.

L'École de génie électrique de l'Université Laval, inaugurée en 1942, attira immédiatement une forte proportion de la clientèle étudiante de la Faculté des Sciences. Depuis lors, près de 2500 diplômes y ont été octroyés dans les domaines de l'électrotechnique, des communications, de l'électronique quantique, de la bionique, de l'informatique, et dans tous ces vastes domaines qui constituent aujourd'hui le génie électrique.

When the Department of Electrical Engineering of Université Laval was inaugurated in 1942, it immediately attracted a large proportion of the students enrolled in the Faculty of Science. Since then, over 2500 diplomas have been granted in electric power,communications, quantum electronics, bionics, computers and all those vast domains that today comprise electrical engineering.

La nouvelle École possédait un impressionnant laboratoire de machines électriques. Il y avait aussi une chambre de radio et téléphonie et un atelier de mécanique. Ce n'est qu'en 1949 que fut aménagé le laboratoire d'électronique pour étudier les "ondes ultra-courtes".

La nouvelle École constituait à l'époque la première école pour ingénieurs électriciens au Canada français. Cette École fut logée initialement dans l'édifice de l'École des mines pour ensuite s'installer à l'intérieur du nouveau pavillon Adrien-Pouliot en 1962. Le département s'y étend actuellement sur 5 étages.

Initialement le programme de génie électrique fut établi à partir de celui de l'Université McGill. L'intérêt suscité par ce nouveau programme fut impressionnant car il attira à ses tous débuts 26 des 74 étudiants inscrits à la Faculté des Sciences. Depuis lors, 12 directeurs se sont succédé afin de mener les destinées du département. En ce qui concerne les diplômes octroyés, on en compte aujourd'hui plus de 2000 au premier cycle et près de 400 au niveau supérieur.

Cette photographie montre quelques unes des personnalités présentes lors de la cérémonie d'inauguration officielle de l'École de génie électrique de l'Université Laval, le 23 septembre 1942. On y reconnaît, entre autres, M. **J.-E. Tanguay**, directeur général de la compagnie Quebec Power, l'Honorable **Edgar Rochette**, ministre des mines, M. **C. V. Christie**, directeur du Département de génie électrique de l'Université McGill, le premier ministre **Adélard Godbout**, Mgr **Camille Roy**, recteur de l'Université Laval, l'Honorable **T.-D. Bouchard**, ministre des travaux publics, M. **Adrien Pouliot**, doyen de la Faculté des Sciences, M. **Gilles Sarault**, professeur, M. **René Dupuis**, premier directeur du Département de génie électrique, M. **E.-André Bouchard**, directeur-adjoint et M. **Abbé W. Laverdière**, secrétaire de la Faculté.

Le Département de génie électrique compte actuellement 29 professeurs, 19 employés, 150 étudiants aux études supérieures et 550 étudiants au niveau du baccalauréat. Il est à noter que depuis quelques années, le département possède la plus forte clientèle graduée de toute la Faculté. De plus, la branche étudiante de la section de Québec de l'IEEE est la plus grande au Canada.

Autour de toute cette population gravitent annuellement l'enseignement de 90 cours, des budgets de fonctionnement de 4,0 M $ ainsi que des budgets de recherche dépassant les 1,9 M $ investis dans les axes de recherches privilégiés au département. Ces activités sont regroupées à l'intérieur de quatre groupes de recherche.

Le **Centre d'optique, photonique et laser** regroupe

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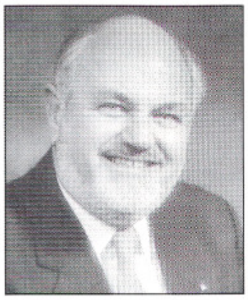
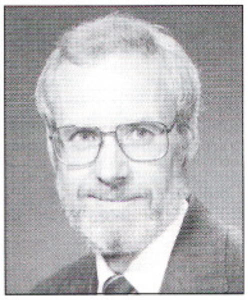
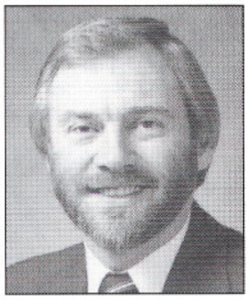


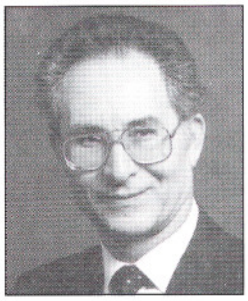
Richard C. Foss, SM 74, F93, President Mosaid Inc., Kanata, Ontario, **"For leadership in the design and testing of memory circuits".**



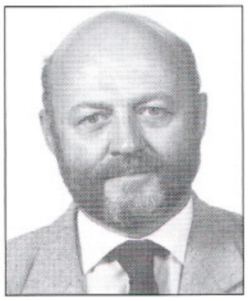
J. Alan George, M85 SM 86, F93, Vice President Academic and Provost, University of Waterloo, Waterloo, Ontario, **"For methods for solving large sparse systems of equations".**



Robert T. H. Alden, S'58-M'60-SM'71, Professor of Electrical and Computer Engineering, McMaster University, Hamilton, Ontario, and currently a member of the IEEE Strategic Planning Committee, has received the *Larry K. Wilson Transnational Award,* **"For exceptional leadership in the promotion of electronic mail worldwide, and promoting IEEE as a leader in the use of communications technology".**



David Haccoun, S62 M67 SM 84, F93, Professeur titulaire, Département de génie électrique et de génie informatique, École Polytechnique, Montréal. Québec, **"For the study of probabilistic decoding algorithm for conventional codes".**



John B. Plant, S63 M65 SM 73, F93, Principal , Royal Military College of Canada, Kingston, Ontario, **"For leadership and creative planning in undergraduate and graduate education".**

Fernand A. Roberge, M64 SM 74, F93, Director, Biomedical Modeling Research Group, Université de Montréal, Québec, **"For leadership in biomedical engineering education and research and/or contributions to mathematical modeling and computerized instrumentation in electrophysiology".**

Gregory C. Stone, M76 SM 88, F93, Director-Research, IRIS Power Engineering, Mississauga, Ontario, **"For development of on-line partial-discharge measuring systems for large rotating machines"**

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au département cinq professeurs; on y travaille dans les domaines des communications optiques multi-longueurs d'ondes, des composants photoniques, des fibres optiques, des antennes réseaux à contrôle optique, ainsi que dans celui de la métrologie de la fréquence des sources lasers.

Le **Laboratoire d'électrotechnique, d'électronique de puissance et de commande industrielle** est formé de trois professeurs. Les principaux thèmes qui y sont traités concernent la production et la conversion d'énergie électrique, les convertisseurs statiques et la commande optimale/adaptative.

Sept professeurs font partie du **Laboratoire de radiocommunication et traitement de signal**, leurs pôles de recherche s'orientent autour des systèmes de communications et de leurs composants, de l'instrumentation et des antennes hyperfréquences, et des sections efficaces de cibles radar.

Les six professeurs du **Laboratoire de vision et systèmes numériques** étudient la vision numérique artificielle, les capteurs optiques intelligents, le traitement d'images, les architectures parallèles, les réseaux neuroniques, de même que la réalisation de circuits par technologie VLSI.

Le génie électrique a particulièrement évolué au cours des cinquante dernières années. Ce domaine en effervescence va assurément continuer de conduire les destinées du département au cours des décennies que suivront. Souhaitons-lui de poursuivre son oeuvre en formant des ingénieures et des ingénieurs qui mettront leurs connaissances au profit du mieux-être de la société de demain. ■

À propos de l'auteur

Pierre Tremblay a reçu les diplômes de B.Sc.A, M.Sc., et Ph.D. en génie électrique à l'Université Laval en 1981, 1983 et 1986, respectivement. Après un séjour d'un an à la Division de physique du Conseil national de recherches, il est devenu professeur au Département de génie électrique de l'Université Laval. Ses intérêts de recherche concernent les étalons de fréquence atomique, plus précisément les problèmes d'interaction laser-matière en présence de bruit. Le Dr Tremblay est membre de l'Ordre des ingénieurs du Québec.

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Powerline Carriers in the '70s

Communications Techniques Applied to Power Utility Needs

by Fred J. Heath, P. Eng.
Past Director of IEEE Region 7

After being involved for over 25 years in the design and manufacture of equipment for TV and Radio Broadcast, Radar, Sonar and Mobile Radio, the writer joined Ontario Hydro in December of 1970 to take charge of the maintenance and installation of Powerline Carrier equipment. The accurate measurement of Powerline Carrier impedances with the aid of a novel directional coupler and a network analyzer permitted servicing the PLC networks with minimum interruption of power system operations.

Après avoir évolué pendant 25 ans dans la conception et la fabrication d'équipement pour la transmission de signaux TV, radio, radar, sonar et radio mobile, l'auteur s'est joint à Ontario Hydro en décembre 1970 pour prendre charge de l'installation et la maintenance des équipements de communication par courant porteur. La mesure précise des impédances de transport du courant porteur, avec l'aide d'un coupleur directionnel innovateur et d'un analyseur de réseau, a permis d'effectuer la maintenance des réseaux de communication avec un minimum d'interruption des opérations du réseau électrique.

Introduction to Powerline Carrier

In addition to carrying their three phase loads, power lines can be used to transmit telephone, control and data signals via powerline carrier (PLC), using frequencies from 30 kHz to 500 kHz. The coupling of these high frequency, low-power transmitters and sensitive receivers to the power lines requires amplifiers, filters, transformers and impedance matching devices (Figures 1, 2).

Ontario Hydro's bulk power system comprises many generating stations, load distribution and switching stations interconnected by a complex network of three-phase transmission lines operating at voltages from 115 kV to 550 kV. They are capable of transmitting powers ranging from 180 to 2000 megawatts at a frequency of 60 Hz. The system extends 2200 km from East to West and 1600 km from North to South, and supplies a peak load of approximately 25,000 megawatts. It is also interconnected with the power grid in the eastern half of the United States.

The loads fluctuate from hour to hour, requiring switching operations and the occasional outage of an individual line. Faults must be isolated quickly, to avoid extensive blackouts, such as the one which occurred in 1965, when large parts of Ontario and many cities in the U.S. were blacked out for extended periods.

A major problem is the measurement of the PLC impedances of the power lines and the impedances at various points in the coupling networks. When these impedances are known, adjustments can be made to transfer the signals efficiently from the transmitters to the powerline, and from the powerline to the receivers. The following obstacles had to be overcome:

1) Power lines have inherently high noise levels.

2) Power lines cannot be disconnected for any length of time because of customer and system considerations.

3) When power lines are in service, the 60 Hz station equipment to which they are connected have a significant effect on the impedances encountered by the powerline carrier signals.

This article describes how the problem of measuring impedances was resolved by the application of basic principles, first with a return loss bridge and selective voltmeter, and later with a directional coupler and a network analyzer.

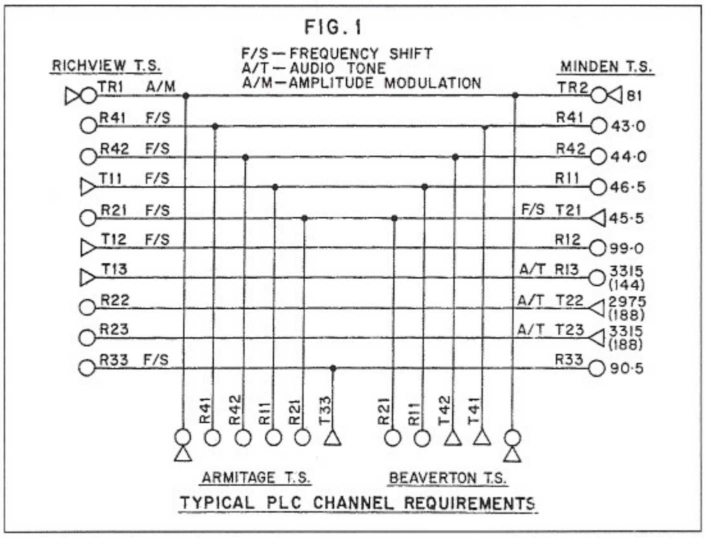


Figure 1. Typical frequency-shift, audio tone, and amplitude modulation PLC channel requirements to link four transformer stations (TS). (*Drawing courtesy Ontario Hydro*)

The Return Loss Bridge

A resistive *return loss bridge* (see box) was first tried in conjunction with a selective voltmeter. Its insertion loss of 6 dB was not a serious problem and power levels could be measured with this arrangement. However, it was incapable of measuring the phase angle of the return signal, and so impedances could not be plotted. At a later stage, a network analyzer was acquired, which could be used to measure the return loss and phase angle of the return signal (Figure 3). This information was then used to plot the impedance on a Smith chart.

The Directional Coupler

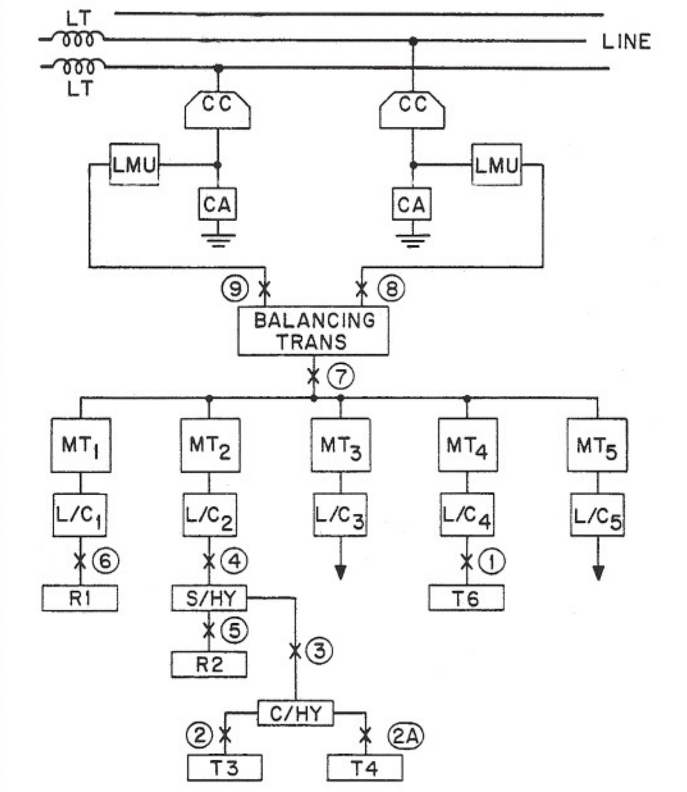
In order to prevent overloading the input of the network analyzer when used with 100 watt transmitters, it was necessary to use a *directional coupler* (see box) with a coupling factor of 40 dB. The latter had an insertion loss of less than 0.1 dB; consequently, impedances could be measured without affecting the normal operation of the PLC system. For most measurements the transmitter output was used as the signal source.

When test signals were required, the network analyzer could be used with an amplifier, making it possible to select precise frequencies without sweeping through frequencies that might trigger line outages. Its input circuit tracked its output frequency, and could be operated with a bandwidth of only 10 Hz, thus minimizing interference from line noise.

With these new methods of measuring PLC power and impedances, it was no longer necessary to schedule line outages.

The reactive impedance seen by a transmitter was compensated for by adjustment of a series L/C unit (Figure 2). In order to avoid affecting other

FIG. 2



TYPICAL PLC SYSTEM

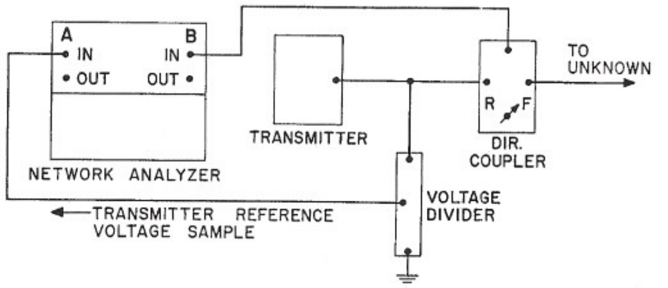
Figure 2. Typical Powerline Carrier (PLC) system linking the radio-frequency transmitters (T) and receivers (R) to the three-phase power line. (*Drawing courtesy Ontario Hydro*)

transmitters connected to the same bus, it had to be operated at a reasonably high "Q"(10 or more). A special matching transformer (MT in Figure 2) permitted adjustment of the resistive component of impedance, and could be connected so that the transmitter always operated into its designed load (usually 50 or 75 ohms).

Previously used matching transformers had limited ranges of adjustment, so a transformer with five independent windings was specified. Its windings could be connected to provide any turns ratio from 40:1 to 40:89 in one turn increments (see Figure 4).

Upon completion of work on a coupling network, it was important to have a record of the signal levels on the PLC bus at each station. Initially, a spectrum analyzer with a cathode ray tube display was used and the results were recorded with a polaroid camera. Later, an x-y recorder was used with the spectrum analyzer. The x-y charts were readily duplicated, the signal levels were more accurately recorded and could be easily compared.

The PLC impedance of a power line conductor is about 200 ohms.



IMPEDANCE MEASUREMENT WITH EQUIPMENT IN SERVICE

Figure 3. Measuring the high-frequency impedance with the power line in service. (*Drawing courtesy Ontario Hydro*)

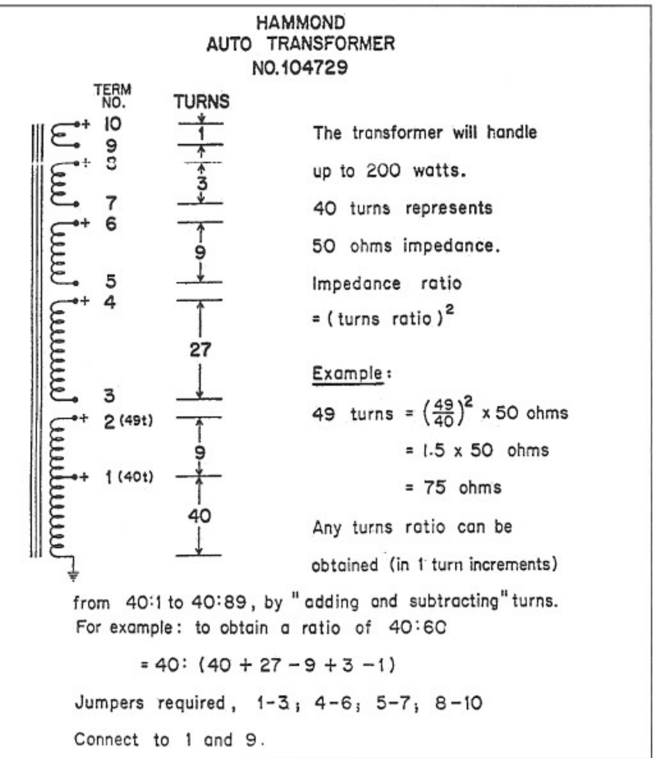


Figure 4. This special matching transformer permitted ratios ranging from 40:1 to 40:89 in 1-turn steps. (*Drawing courtesy Ontario Hydro*)

Coupling to the power line was achieved through a capacitor voltage transformer and line trap* (CC and LT in Figure 2). On a 230 KV circuit, it was usually a 0.011 microfarad unit which was also used to measure the 60 Hz line voltage.

A Line Matching Unit (LMU in Figure 2), was located at the base of the capacitor. It consisted of a series inductance to compensate for the capacitor reactance at PLC frequencies, and a transformer to match a 75 ohm coaxial cable. The cable was connected through a balancing transformer to the PLC bus in the relay building. Note that coupling is typically to two of the three power line conductors to minimize the risk of losing the signal in the event of a single-phase line-to-ground fault.

When switching operations take place at a transformer station, extremely high transient voltages are encountered on the 120 volt 60 Hz circuits used for test equipment. It was found necessary to provide isolating transformers to protect the test equipment.

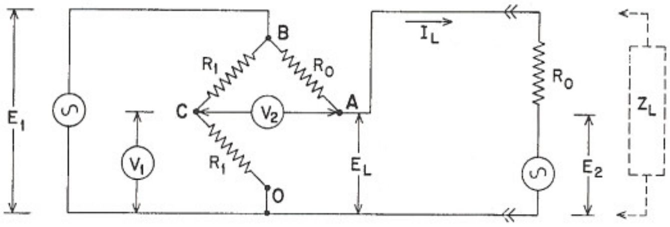
The selectivity of a PLC receiver was achieved by means of a crystal filter that passed only the narrow band of frequencies required for a particular application. This is in contrast to a conventional radio receiver, which uses a mixer and local oscillator to translate incoming signals to a standard intermediate frequency which, in turn, is processed by a highly selective intermediate frequency amplifier.

In the radio broadcast industry, a frequency translator is used to shift the frequencies of a voice channel up by 400 Hz, in order to improve the quality of a telephone circuit. The frequencies are restored to their normal range at the broadcast studio. This technology was applied to shift data channels in the 2400 to 3400 Hz range *down* by 1000 Hz so that they could be temporarily transmitted on an ordinary leased telephone circuit.

When PLC frequencies are used on a power line, it is important to avoid critical lengths of short sections of the line branching from the main line. An "open" line section whose length is an odd number of quarter wavelengths at the PLC frequency will appear to be a short-circuit to the PLC signal. For

**Line Trap (LT). An inductance inserted in series with a power line conductor, usually between the coupling capacitor and the station equipment. It offers a high impedance at PLC frequencies, to prevent the station equipment from absorbing the PLC signals. Line traps are usually furnished with tuning capacitors that increase their impedance still further at the PLC frequencies.*

THEORY OF THE RETURN LOSS BRIDGE



THE RETURN LOSS BRIDGE

Figure 6

The schematic diagram of a return loss bridge is shown in Figure 6.

The theory of the return loss bridge is best understood if it is recognized that any impedance Z_L can be represented by a resistance R_o equal to the system characteristic impedance, plus a generator of voltage E_2 whose amplitude and phase have the required relationship to the system generator voltage E_1.

This relationship is expressed in the following formula:

$$Z_L = R + jX = \frac{Z_0\left((1 - G^2) + j\,(2G\sin\theta)\right)}{1 + G^2 - 2G\cos\theta}$$

where:

Z_o = R_o, the characteristic impedance of the return loss bridge

G = the return loss (usually expressed in dB)

= the scalar E_2/E_1

θ = the phase angle of E_2 measured in reference to E_1

The superposition principle states that in a linear network with more than one voltage source, the node voltages and element currents can be calculated for each voltage source separately, replacing the other sources with short circuits (generators of zero output voltage). The normal operating voltages and currents are obtained by adding the separately calculated values.

Let us apply the superposition principle to figure 6:

For $E_1 = E_1$ and $E_2 = 0$: $V_1 = E_1/2$

$V_2 = 0$

For $E_1 = 0$ and $E_2 = E_2$: $V_1 = 0$

$V_2 = E_2/2$

For $E_1 = E_1$ and $E_2 = E_2$, we combine the above results:

Then: $V_1 = E_1/2 + 0$

$V_2 = 0 + E_2/2$

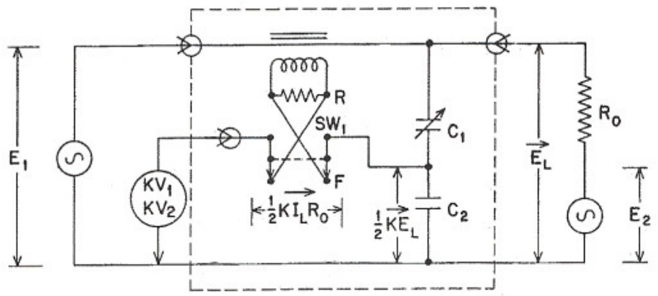
We see that:

V_1 is independent of E_2, and is the voltage which would be applied to a perfectly matched load ($E_2 = 0$).

V_2 is a direct measure of the return signal resulting from the missmatch between the load and the system characteristic impedance.

When the ratio V_2/V_1 and the phase angle θ are known, the impedance can be obtained by plotting on a Smith chart, or by calculation using the formula given above.

THEORY OF THE DIRECTIONAL COUPLER



THE DIRECTIONAL COUPLER

Figure 7

The principle of the directional coupler (Figure 7) can be developed as follows.

By inspection of Figure 6 (return loss bridge):

$E_1 = E_{oa} + E_{ab}$

$E_1 = E_L + I_L R_o$, where I_L is the load current, and E_L is the load voltage.

But $V_1 = E_1/2 = (E_L + I_L R_o)/2$

$V_2 = E_L - V_1$

Substituting for V_1: $V_2 = E_L - (E_L + I_L R_o)/2$

Combining terms: $V_2 = (E_L - I_L R_o)/2$

The reflection coefficient is given by:

$$\frac{V_2}{V_1} = \frac{(E_L - I_L R_o)/2}{(E_L + I_L R_o)/2}$$

The above ratio will be unaffected by a scaling factor (k) that affects all terms equally, ie:

$$\frac{V_2}{V_1} = \frac{k\,(V_2)}{k\,(V_1)} = \frac{(kE_L - kI_L R_o)/2}{(kE_L + kI_L R_o)/2}$$

The schematic diagram of a directional coupler is shown in Figure 7.

For our directional couplers, the scaling factor (k) is in the order of 0.01, or – 40 dB.

$$C_1 = \frac{k/2}{(1 - k/2)} \text{ times } C_2$$

R is selected to provide a voltage of $k/2$ times $I_L R_o$.

The voltage at the junction of C_1 and C_2 is $kE_L/2$, and when the switch SW_1 is in the 'F' position shown, the voltage at the voltmeter terminal is:

$$kE_L/2 + kI_L R_o/2 = k\,(V_1)$$

When the switch SW_1 is moved to the 'R' position, the voltage at the voltmeter terminal is:

$$kE_L/2 - kI_L R_o/2 = k\,(V_2)$$

These values may be used to plot the impedance on a Smith chart or to calculate it using the formula given above.

example, at 500 kHz a quarter wavelength corresponds to 150 meters, while at 30 kHz it is 2.5 kilometers. When such a resonant condition was encountered, it was usually possible to change operating frequencies.

Mode Effects

Three-phase power lines are often carried on towers in pairs, accompanied by two grounded "sky-wires" which protect them from lightning. The six power conductors plus the two "sky-wires" form a structure which supports many modes of wave propagation. These modes have differing phase velocities, which cause significant variations in frequency response. In one case, the pilot tone of a single sideband channel was attenuated 10 dB with respect to the rest of the channel. The resultant automatic gain control voltage caused the receiver to overload, producing severe intermodulation problems. The problem was corrected by modifying the AGC circuit.

In several cases, equalizing audio amplifiers were employed to compensate for frequency response variations caused by such mode effects.

CONCLUSION

Some problems unique to power line carrier applications were overcome, and new measurement techniques eliminated the need for many planned line outages that were previously required for PLC maintenance. ■

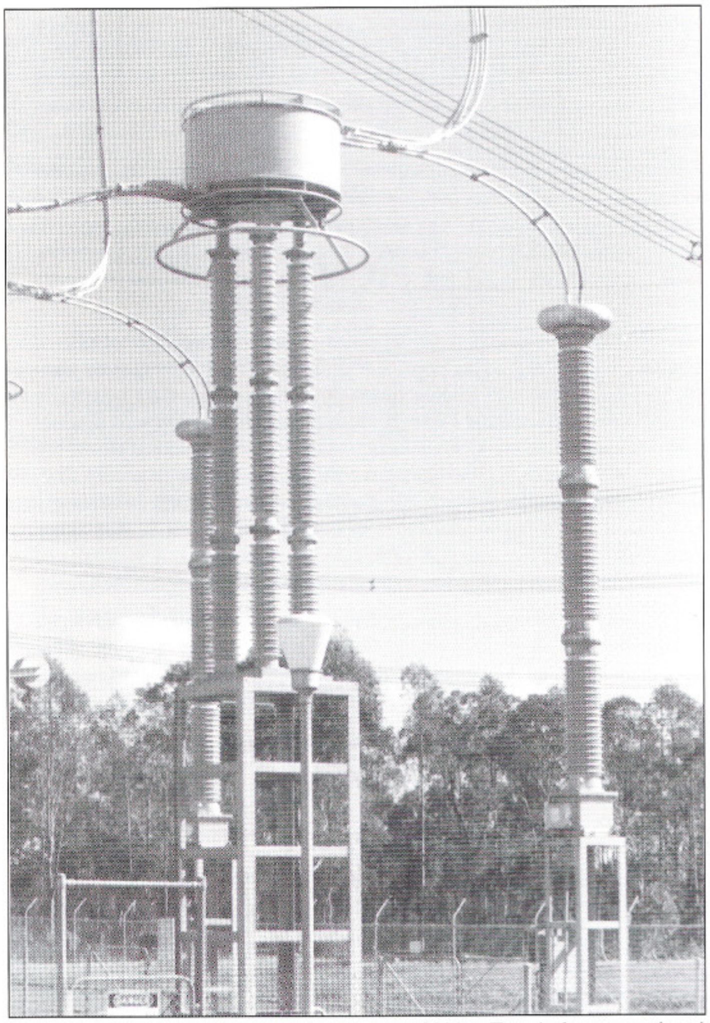


Figure 5. This picture shows a 2500 A, 0.7 mH Line Trap in foreground and a capacitor voltage transformer in the background (*Photo courtesy Trench Electric*).

About the author

Fred J. Heath, P. Eng., LS-IEEE, received his B.Sc. degree in Electrical Engineering from the University of Alberta in 1938. He was enrolled as a Graduate Student at MIT from 1938 - 40. **Employment:** National Research Council of Canada 1940-1945; loaned to MIT Radiation Laboratory in 1941, loaned to the RCAF from 1942 - 1945; joined Canadian General Electric Company 1945-1970; then with Ontario Hydro 1970-1982. Mr. Heath was Chairman of the Toronto Section IRE 1956 and was the Canadian Regional Director of IEEE from 1982-1983. Following retirement, he became Manager of the IEEE Canadian Regional Office from 1984-1987. Mr. Heath was awarded the IEEE Centennial Medal 1984.

The Canadian Space Agency and CNES Sign Memorandum of Understanding

Dr. **Roland Doré**, President of the Canadian Space Agency, and Mr. **Jean-Daniel Lévi**, Director General of the Centre National D'Études Spatiales (CNES) of France, officially signed a *Memorandum of Understanding* for possible future cooperation in Earth observation. This signing, which took place in Montreal on February 19, 1993, initiated discussion on a joint remote sensing satellite program, RADARSAT III.

"Space Agencies around the world realize the need to collaborate rather than duplicate their endeavors," said Roland Doré (*on the right in the above photo*). "Just as environmental problems are now recognized as a global challenge, the solutions that space programs can offer are best developed when we cooperate and pool our resources and expertise."

RADARSAT is an advanced Earth observation satellite project developed by Canada for environmental monitoring and resource management. With the launch of RADARSAT I in 1995, Canada and the world will have access to the first operational radar satellite system capable of large scale production and timely delivery of data.

"I am thrilled with today's signing, " said Mr. Jean-Daniel Lévi. "It provides us with an avenue to investigate the potential of future cooperation in remote sensing. We hope this will lead to a joint undertaking benefitting all parties involved."

The mandate of the Canadian Space Agency is to promote the peaceful use and development of space for the social and economic benefits of Canadians.

Letters to the editor / Lettres à l'éditeur

Dear sir,

A friend of mine just loaned me a copy of the Spring 1992 Issue of IEEE Canadian Review. In the article on page 5, "Gandalf Technologies and Its Surprising Modem Business" By Stephen Bernard I was appalled by the carelessness or lack of knowledge of both the author and the editors about the meaning of the terms used.

For example, in the third paragraph on page 5 the statement is made "A modem (or data set) is a device that receives digital data and converts it to analog...". An analogue signal is one which can have any value between extremes and can occur at any time, such as a voice signal. The signals impressed on a transmission line by data set have only defined values, not any value, and fall under the category of a digital signal. The purpose of the data set is to produce a signal which appears sufficiently similar to an analogue voice signal that it can travel over the telephone or similar networks of analogue channels.

Again on page 5, in the first paragraph under "Technical considerations" the statement is made "A voiceband modem is restricted to a 2.5 kHz frequency band which exists from about 500 Hz up to about 3 kHz." In large parts of the North American telecommunications network it is unwise to expect to have a band useable for data modems above 2.5 kHz. For example, some parts of the network use Single Frequency signalling with a tone sub-channel at 2.6 kHz. Any appreciable energy at this frequency could cause the connection to be dropped! In reality data bandwidth useable universally on dialled circuits is of the order of 1.7 to 2.0 kHz!

One more example. In the last paragraph of the first column on page 6 the statements are made "The next stage was to group data into "bauds". A baud is a modem's way of packetizing the data it receives from the terminal." This is utter nonsense! Baud is a rate, not a thing. I refer you to the attached document I prepared a number of years ago which explains, simply, the meaning of the term baud.

I could make a few more comments but I believe the point has been made – do a better job of editing to avoid misused or wrong terminology which serves to confuse or mislead the uninformed reader looking for guidance. Gandalf has done some good work and its people are to be congratulated, it is a shame to spoil the article with the items mentioned above.

Ernest J. Moore
Nepean, Ontario

Dear sir,

Thank you for passing Mr. E.J. Moore's comments on to me and allowing me the opportunity to respond to them.

In general, I would like to point out that in authoring this article I went to deliberate lengths to avoid excessive technical detail and strove to explain the concepts in terms to which professionals without specific data communications backgrounds could relate. It goes without saying that the interested reader will obtain infinitely more detail and refinement in related texts and scientific papers. I do not feel that Mr. Moore, obviously a learned professional in the field, is reading with that spirit in mind.

On the first point, I feel Mr. Moore is indulging in semantics. Whether the output of a modem (or data set) is an analog waveform or a waveform compatible with an analog channel is of no distinction to a reader who simply wants an overview of what that device does. I disagree with Mr. Moore's definition that an analog signal "... can occur at any time...". This is the definition of randomness, or white noise, and by this definition a sine wave would not qualify as an analog signal since it contains only defined values. The fact that a signal is constrained does not mean it is a digital signal.

I stand by my statement that the basic function of a modem or data set is to convert digital data to an analog waveform equivalent.

Mr. Moore's second assertion that any appreciable energy at certain frequencies could disrupt a dialled circuit is incorrect. Tones are in fact used for functions such as releasing a channel (2.6 kHz) and disabling echo-cancellers (2.1 kHz), however the simple algorithm described would be far too error-prone for reliable deployment. In actuality it is the presence of energy in a specific band <u>in addition to</u> the lack of energy in other bands which constitutes a valid decision criterion, and modems take advantage of that fact.

A modem's training sequence consists of an initial 2.1 kHz tone which disables echo cancellers, allowing full-duplex transmission on the channel. Since the echo cancellers will re-engage if the signal is absent from the channel for a short period, this tone is immediately followed by other patterns and modulated data which maintain the signal level. The combination of data-randomizing scramblers and modulation rules in the transmitters presents the channel with a signal having more or less constant power and flat power distribution across the band. The channel is maintained by the presence of energy in the lower frequencies, even though there is energy in a band around 2.6 kHz and above.

Although the telephone company does not guarantee bandwidth available on dialled circuits, the limits suggested by Mr. Moore are very pessimistic, and they are certainly not dictated by the need to avoid energy at 2.6 kHz. If these constraints were in fact the norm, today's modems would not work and the dialup modem business would not be the $1.6 billion/yr industry it is today.

Mr. Moore is correct on his final point – baud is a measure of rate of change, not a thing. The point I was trying to get across – in non-technical terms – was that modems do indeed group data internally into "packets" of multiple bits. By processing these groups as distinct entities they generate signals which take on more discrete states but change less often. To the modems this packet of bits is a very real, discrete thing, and those working in the industry rightly or wrongly refer to it as "a baud". In the space available, I felt it was more important to convey this and other concepts than to go into details of specific terms, as Mr. Moore was able to do in his 2-page attachment.

I am sorry that certain points offend Mr. Moore's sense of strict definition, but I think in keeping with the non-technical flavour of the article, that the terms and analogies I used were appropriate to convey the essentials and challenges of modem operation without unduly misleading the reader.

Stephen Bernard,
Nepean, Ontario.

Dear sir,

There was an error in the article (The IEEE and Pre-College Education), which did not appear in any draft I saw. At the bottom of page 16, the headline reads

Nominate an Editor

but should read

Nominate an Educator

I am asking readers that I talk to, to make a manual correction. You may wish to acknowledge the error in the next issue.

Robert W. Osborn
Toronto, Ontario.

Dear sir,

It is with great pleasure that I saw Hydro-Québec's name associated with the cover story of the Winter 1993 edition of the IEEE Canadian Review. Unfortunately, the cover picture description (page 3) is inaccurate; our Sarcos master arm is more recent than the one shown, and the slave arm is longer (6 feet).and has a payload of 100 lbs instead of only 40 lbs.

Martin Boyer,
Robotics Laboratory, IREQ,
Varennes, Québec.

Letters to the editor

Letters should be addressed to the Managing Editor. They should include the writer's name, address and telephone number and may be edited for purposes of clarity or space.

1993 IEEE Power Engineering Society

Summer Meeting

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Vancouver, British Columbia

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The Vancouver Chapter of the Power Engineering Society (PES) cordially invites you to attend the electric power industry's most prestigious technical conference, the 1993 IEEE/PES 1993 Summer Meeting to be held from July 18 to July 22, 1993 in Vancouver, the largest city in Super-Natural British Columbia. This transnational conference will focus on the most recent developments in electric power generation, transmission, distribution and energy use. Technical paper presentations, panel sessions, tutorials, technical tours, social events and many opportunities to visit old friends and colleagues and to meet new ones, are just some of the meeting attractions.

In addition to the planned technical programs and social events, Vancouver is one of the most attractive tourist destinations on the West Coast - and for many good reasons: natural beauty, cultural diversity, world class accommodations, an overwhelming selection of dining, entertainment and sporting options, and the marvellous Summer climate, especially in July.

The Vancouver area offers great adventures: walk or cycle through the 1000 acre urban forest by the harbour in Stanley Park; relax on one of the many beaches near the heart of downtown; rent a sailboat for a day on English Bay; or wander through one of the many ethnic areas such as Chinatown, where you will find gifts available nowhere else. All these are just a few blocks from the Summer Meeting headquarters.

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