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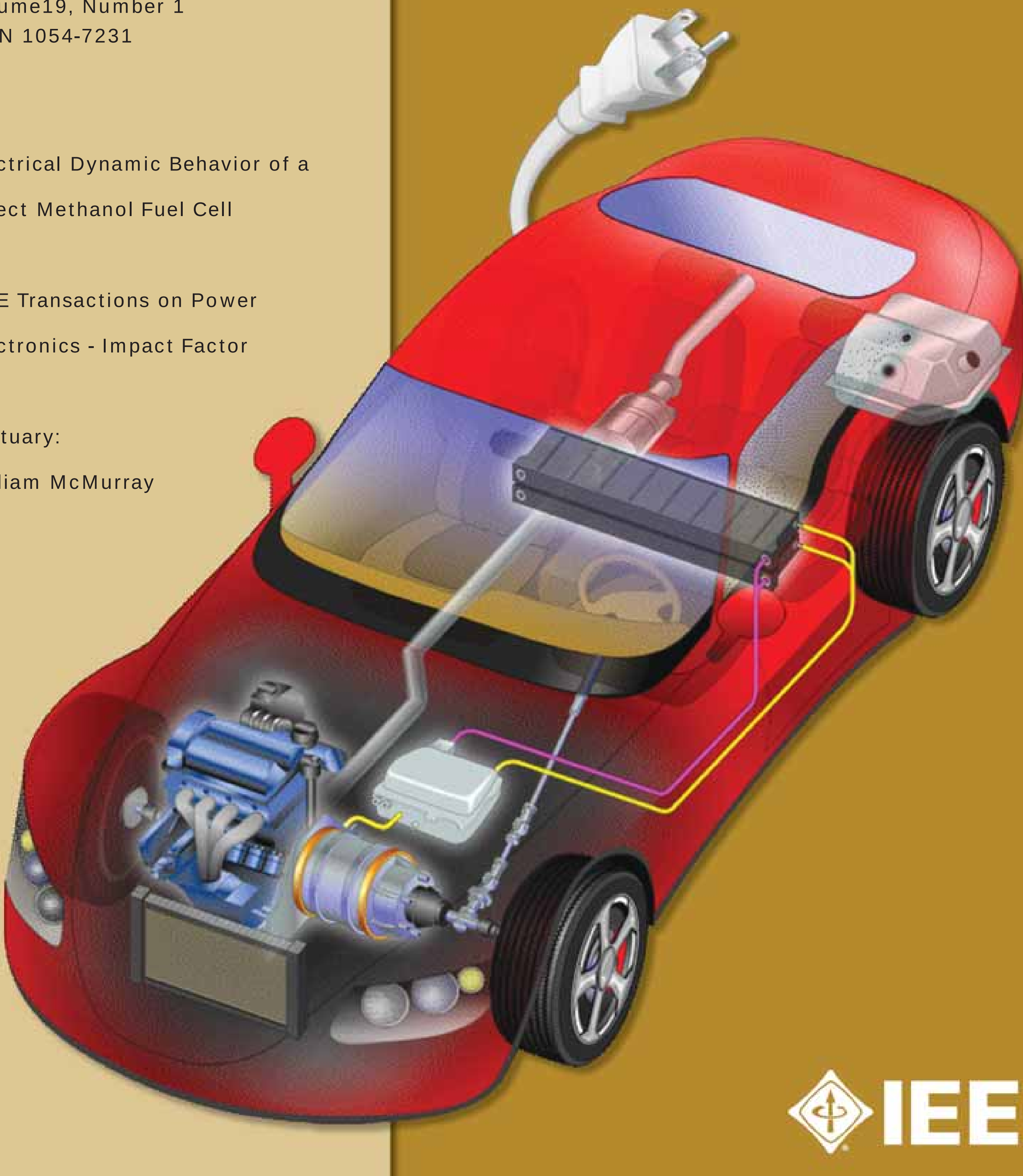
Electrical Dynamic Behavior of a Direct Methanol Fuel Cell

IEEE Transactions on Power Electronics - Impact Factor

Obituary:
William McMurray



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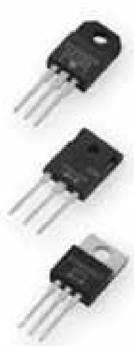

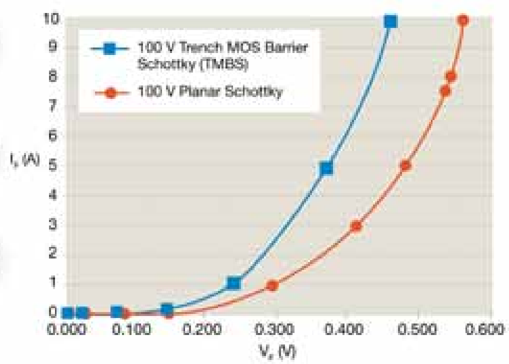

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From The Editor

John M. Miller

Another year is upon us and it is hard to believe how fast 2006 has gone by. For 2007 PEL's welcomes Prof. Hirofumi Akagi as incoming president. We look forward to his leadership and at the same time pass along our sincere thanks to Prof. Rik DeDoncker for his commitment to excellence. IEEE Power Electronics Society is dynamic and growing. I'm sure 2007 will see this Society prosper and continue to offer our members the most opportunities in professional involvement. The Transactions on Power Electronics publication is among the best in the industry and I welcome our readers to please see the article in this issue by our Transactions editor-in-chief, Prof. Frede Blaabjerg and his discussion of journal impact factor.

Errata:
In the previous issue (Vol. 18, Nr. 4) there were two misprints in Prof. Tsuyoshi Funaki's technical article, High Power Electronics in Japan- Backgrounds and Applications, page 13-15. The corrections are:

1 - Table 1 Higashi Shimuzu rating should be 100 MW, not 10 MW
2 - Page 15 Acknowledgement of the materials supplied by Y. Ishikawa (not H. Ishikawa).

My apology for the typos.

John M. Miller, EIC
pelsnews@ieee.org

Plug-in Hybrid Electric Vehicle front cover illustration by Dean Armstrong and Jim Synder of DOE National Renewable Energy Laboratory, Golden, CO. Used with permission.

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President Column

As 2006 is drawing to a close, my term as your society president is ending, I 'd like to thank all PELS members, officers and AdCOM members for your support of the society.

Our society is one of the very few IEEE societies which had a continuous growth (+ 3.5%) in 2005 and 2006. This clearly shows that electrical power conversion technology is a growing field supporting societal needs.

Starting Jan. 1, 2006, Prof. Hiro Akagi, Tokyo Inst. technology, Japan will lead as President our society, together with the two newly elected Vice Presidents, Prof. Deepak Divan and Prof. Ralph Kennel. We also welcome our newly elected members-at-large: Vassilios Agelidis, Maeve Duffy, Grahame Holmes, Ron Hui, Ralph Kennel, and Paolo Mattavelli. Furthermore, starting Jan. 1, our society welcomes Prof. Tom Habetler, PELS Sr. Past President as our incoming Div. II Director.

I wish you a Merry Christmas and a Happy New Year! See you at one of our upcoming conferences!

Sincerely,

Rik De Doncker
IEEE PELS President
RWTH-Aachen, ISEA

Member Update

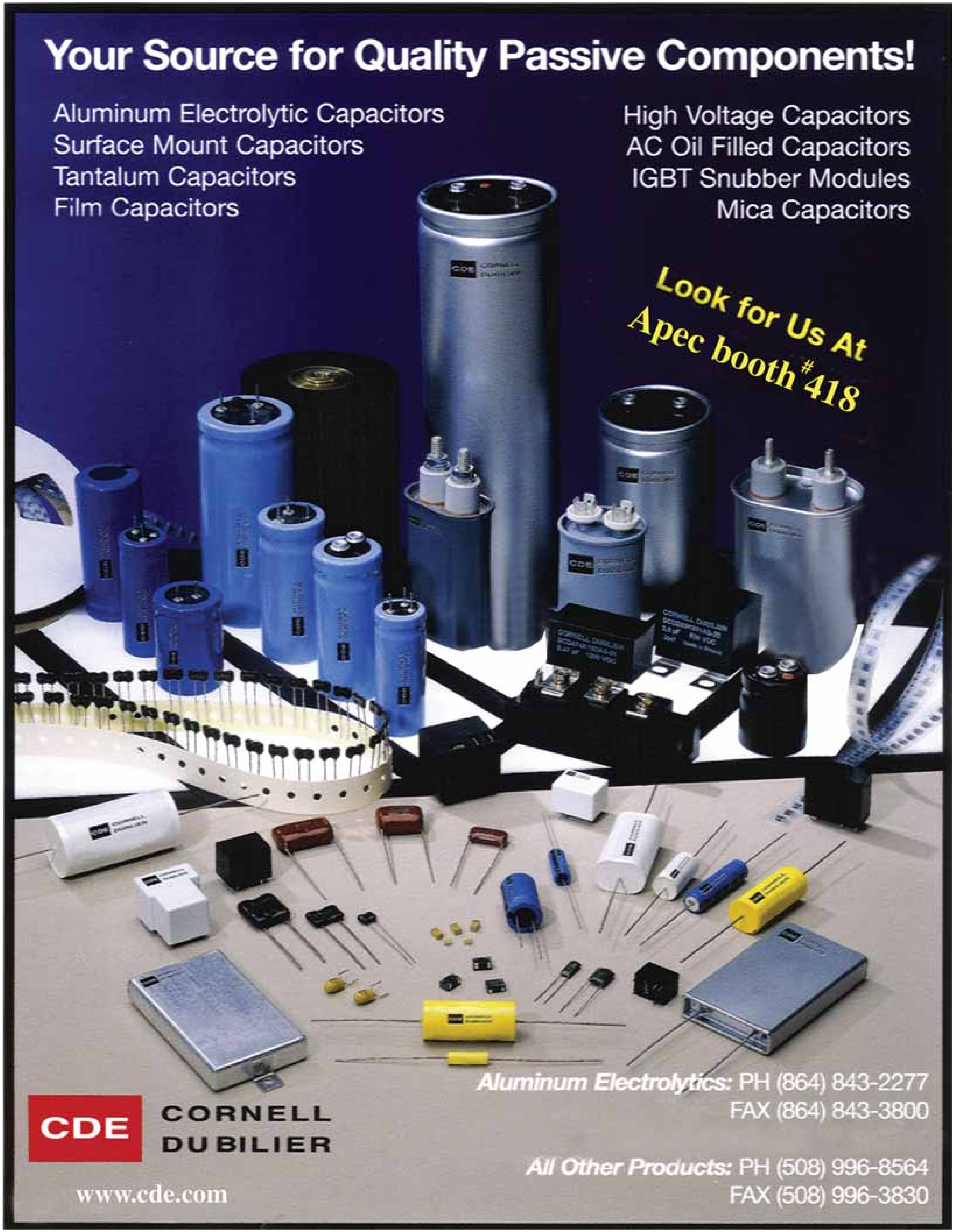
Members on the Move

This column is updated periodically with input from you, the PEL's members, about members who have recently moved, assumed new employment positions, taken on different professional roles or retired. Please send your inputs along with a brief comment and include a color photo of the individual involved, which could be yourself, to PEL's newsletter editor-in-chief at pelsnews@ieee.org.

Vassilios G. Agelidis has been appointed Professor at the University of Sydney, Australia, holding the Energy Australia Chair of Power Engineering. Energy Australia is one of the local utilities in Sydney and funds this position, the only industry funded university chair in power engineering in Australia. The University of Sydney is Australia's oldest university (established in 1880) and the number one ranked research leading university in the country (when considering funding from the Australian Research Council). Prior to joining the University of Sydney, Prof. Agelidis was Chair of Power Engineering, School of Electrical, Energy and Process Engineering at Murdoch University, Murdoch, Australia.

Kaushik Rajashekara has joined Rolls-Royce Corporation, Indianapolis, IN as a Senior Technologist on May 1, 2006. Dr. Rajashekara is working in the area of More Electric Engines for More Electric Aircraft and other applications. Prior to joining Rolls-Royce, he was a Chief Scientist and Technical Fellow for advanced energy systems, Delphi Corporation in Kokomo, IN. Dr. Rajashekara is a fellow of IEEE.

John M. Miller has joined Maxwell Technologies, Inc in San Diego, CA, as vice president advanced transportation applications on Jan. 9, 2006. At Maxwell he is responsible for strategic business in the transportation and industrial sectors. Prior to joining Maxwell, Dr. Miller was principal engineer at J-N-J Miller, PLC, located in Cedar, MI. He continues his service to IEEE as Editor-in-Chief, Power Electronics Society newsletter.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IEEE Trans. On Power Electronics – Impact factor

By Editor in Chief, Frede Blaabjerg, Aalborg University, Denmark

Our IEEE Transactions on Power Electronics has been in a very positive progress the last years under the leadership of Dr. Daan van Wyk. Papers have been processed efficiently both in review time and publication time. This has fortunately been spread in the whole power electronics community which has caused that more papers are submitted to the Transactions every year. We have been able to increase the number of papers published but still be have a relative large backlog. In 2007 we will then increase the number of published papers close to 2000 pages. This popularity gives now a transient problem for many authors. The impact factor of the IEEE Transactions on Power Electronics has dropped significantly. This parameter was not important years ago for the society but now universities all over the world try to benchmark each other and one of the factors are publications in high impact journals.

A Journal impact factor is calculated by Thompson Scientific Institute (Web of Science) based how many times journal is cited in the past. The exact calculation is for the calculated impact factor in 2005 is

Journal Impact Factor (IEEE Trans. on Power Electronics)
Cites in 2005 to articles published in: 2004 = 409
Cites in 2005 to articles published in: 2003 = 686
Sum: 1095
Number of articles published in: 2004 = 141
Number of articles published in: 2003 = 137
Sum: 278
Calculation: Cites to recent articles 1095 citation/278 papers = 3,939

Every year this is calculated and in Fig. 1 you can see the development of IEEE Trans. on Power Electronics.

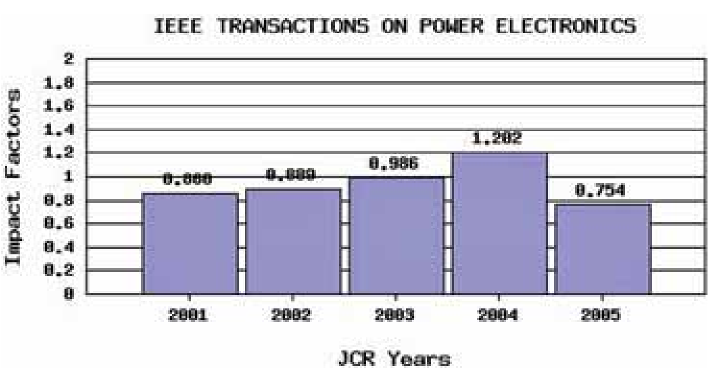

Fig. 1. Impact factor of IEEE Transactions on Power Electronics (ISI Thompson)

The main reason for this drop is that papers which are published in IEEE Trans. on Power Electronics have been in process for more than a year mainly because we have many papers which are accepted and in the pipe-line to be published. If a paper is one a half year from submission to publication it will be very difficult for the paper at all to cite a recent published paper. Therefore – help is needed to improve the impact factor which is an important goal for the editorial board and the IEEE Power Electronics Society. Following will be addressed the next year

1. All papers published in IEEE Trans. on Power Electronics are expected to have an updated and comprehensive reference-list. Only in the case of a real break-through less than 10-20 references can be expected. It will be ground for immidiately rejection of the paper if the reference-list is too short and not up to date with recent publications.

2. IEEE Trans. on Power electronics is the leading journal for power electronics and it is expected that authors have knowledge to and cite the latest papers published in IEEE Transactions on Power Electronics . Journal papers are more in-deepth peer reviewed than conference papers – therefore those contributions are most relevant for citing. I will ask my Associate Editors to take an active part in this

3. I have agreed with the staff at the IEEE production center, that an author who is proof-reading a paper for publication and finds that one or two recent published papers are relevant to include into the reference-list (due to the back-log) will be done easily.

4. We will as mentioned before increase the number of pages to reduce the backlog in the processing over the years.

5. We will try to reduce review time even though the pressure on IEEE Trans. on Power Electronics has increased. We have received more than 650 manuscripts for review in 2006. And we have processed more than 475 which is a very good performance.

By those means I expect that we will come on tract at latest in 2008 with even higher impact factor. Year 2006 will not be better.

The change to Manuscript Central has been very positive and we feel all that this choice was appropriate. Please keep up your good work and submit papers to our Transactions.

Announcement: International Conference on Optimization of Electrical and Electronic Equipments, OPTIM 2008.

Prof. I. Boldea, IEEE Fellow, General Chair of OPTIM-2008, and

Prof. Mihai Cernat, IEEE Member, General Program Chair of OPTIM-2008, and Conference Secretary.

OPTIM-2008 venue: Biannual (in same Mountain Resort), on Power Electrical and Electronics Enginnering; May 22-24, 2008, Brasov, Romania and technical co-sponsored by IEEE – IAS, IES, and PEL's. For details please visit: http://info-optim.ro and http://optim.8m.com

The Conference OPTIM holds its own domain and has its own management system. All reviewing process will be managed electronically. You only have to fill in your data as author (section Authors); we apologize for this small extra effort but we hope the process will get smoother and we all will benefit. To submit your paper please access: http://www.info-optim.ro/conforg

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PESC 2007 Tutorial - Call for Proposals

Several tutorials will be held on Sunday June 17, 2006 as part of the PESC 2007 technical conference program.

Authors who are interested and willing to propose a tutorial for PESC 2007 are invited to e-mail a copy of their proposal to both Dr. Ali Emadi (emadi@iit.edu) and Dr. Sudip K. Mazumder (mazumder@ece.uic.edu).

Tutorial proposal submissions are due by February 1, 2007 to Dr. Emadi and Dr. Mazumder.

The proposal should comprise no more than a three-page (3) single column summary using single space paragraphs and a minimum of 10 pt. font, including:

- tutorial title
- name of presenter(s)
- affiliation/institution
- contact details of the authors(s)
- objectives of the tutorial
- significance and impact of the tutorial
- intended target audience
- technical outline
- tentative duration and schedule of the tutorial

Tutorial proposals on any related topics are invited. Examples of such topics include:

1. Wide-bandgap devices and technology for power electronics
2. Design and packaging issues with high power density
3. Power electronics and power-management controls for standalone and grid-connected alternative and renewable energy systems
4. Fuel-cell vehicle (FCV)/hybrid-electric vehicle (HEV) power converter designs for vehicular auxiliary and main power units (APU/MPU)
5. New concepts and applications in motor drives
6. Technology applications of power electronics in power systems
7. New modeling, analysis, and control approaches in power electronics
8. Digital power-management technology
9. Standards related to power electronics applications and their implications
10. Education issues
11. Other related topics

Again, submissions should be e-mailed by February 1, 2007 to:

Dr. Ali Emadi (emadi@iit.edu) and Dr. Sudip K. Mazumder (mazumder@ece.uic.edu)

The Hilton in the Walt Disney World Resort, Florida, USA is the site of PESC 2007 and the tutorial site. The registration for hotel rooms will be available in the coming weeks.

Notification of tutorial acceptance will be given by February 16, 2007.

Electrical Dynamic Behavior of a Direct Methanol Fuel Cell

M. Ordonez, P. Pickup, J.E. Quaicoe, and M.T. Iqbal
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Fuel cells (FC) are devices that convert electrochemical energy into electrical and thermal energy. Among several types of fuel cells, Direct Methanol Fuel Cells (DMFCs), also known as Alcohol-fed Fuel Cells, are considered more practical than hydrogen based cells for portable applications. The main reasons are that additional equipment required to run the cell is reduced to a minimum and the storage of methanol is much more convenient than for hydrogen. With a view to clarify the electrical behavior of the DMFC, this article focuses on the dynamic response of a single cell. A brief overview of the electrochemical processes of the DMFC is first described, and a simple equivalent circuit model relating the equivalent electrical parameters to the electrochemical processes is presented. Experimental results on the single cell are presented from an electrical point of view to cover the most important expected dynamics. Discussions regarding the operating points and power extraction for various tests in relation to the FC model are also included.

I. Direct Methanol Fuel Cell Description

Figure 1 shows the cross-section of a DMFC, where three different layers can be identified as: Polymer Electrolyte Membrane (PEM) in the center, catalyst coated porous electrodes for methanol oxidation in the anode, and oxygen reduction in the cathode. These three components comprise the DMFC Membrane Electrode Assembly (MEA). The PEM is a perfluorosulfonic acid based polymer (Nafion), the anode catalyst is a Platinum-Ruthenium (Pt–Ru) alloy, and the cathode catalyst is Pt black. The Pt-Ru and Pt catalysts are spread onto a porous carbon fiber to form the conductive electrodes of the anode and cathode respectively.

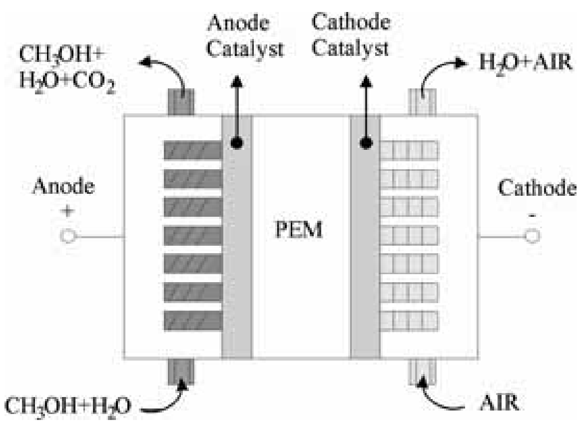

Fig. 1 Cross-section of the DMFC

Figure 2 shows a picture of a 5.3 cm^2 MEA including the PEM and the two electrodes. The MEA is placed between plates that contain channels (flow fields) for fuel or air distribution and provides electrical contact with the porous electrodes. Figure 3 shows a picture of the internal view of the plates where the small channels can be identified.

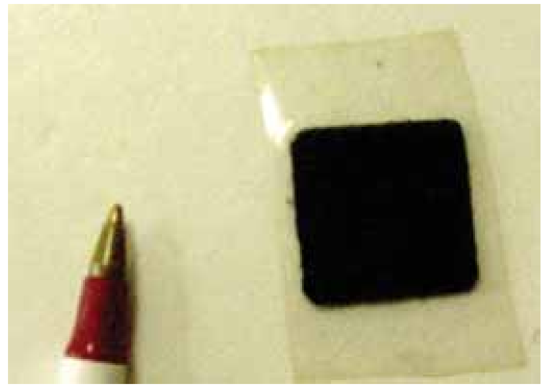

Fig. 2 Electrode membrane assembly: PEM, anode and cathode porous electrodes

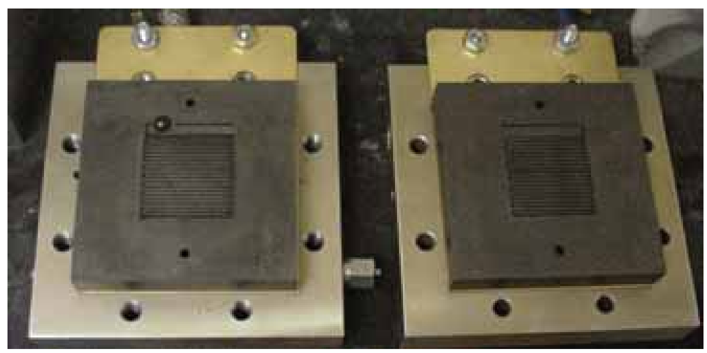

Fig. 3 FC plates: anode (left) and cathode (right)

As the name suggests, the DMFC is directly supplied with methanol (as an aqueous solution) through the reactant channel of the anode plate. The fuel reaches the catalyst layer where the electrochemical reaction occurs resulting in carbon dioxide, protons, and electrons. The protons are transported through the PEM towards the cathode. The electrons circulate externally through the desired electrical load towards the cathode producing work. Since the cathode is fed with air, the protons and electrons that reach the cathode reduce the oxygen in the air to form water. The electrochemical reaction in the anode of the DMFC can be described as:

$$anode: CH_3OH(l) + H_2O(l) \rightarrow CO_2(g) + 6H^+ + 6e^-, \quad (1)$$

where (l) and (g) represent liquid and gaseous states, respectively. On the cathode side the reaction is:

$$Cathode: \frac{3}{2}O_2(g) + 6H^+6e^- \rightarrow 3H_2O(l) \quad (2)$$

Finally, the overal reaction is given by

$$Overal: CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \quad (3)$$

II. A Simple Fuel Cell Equivalent Circuit

The dynamic electrical behavior of a DMFC reported here can be understood in terms of the equivalent circuit shown in Fig. 4. This circuit and its scientific basis are described before the experimental work so that the origins of the unusual behavior of the cell will become clear. As will be seen, the key component is the large capacitance (C) of the cell. The many models that have been developed for fuel cells have been comprehensively reviewed [1]. What follows is a description of the basic features needed to understand the dynamic behavior of the fuel cell.

The theoretical voltage (E) developed by a fuel cell is given as a function of the methanol and oxygen feed concentrations by the Nernst equation. The theoretically predicted value lies around 1.2V for a single cell. However, typically, the practical open circuit output voltage stays below 0.8V, and the voltage drops further as current is drawn from the cell (Fig. 5). Several effects cause a voltage drop or irreversibility, namely, activation losses (Tafel equation), fuel crossover and corrosion internal currents, ohmic losses, and mass transport. A simple general equation (4) gives a conceptual description of these combined effects [2], and their influence on the fuel cell polarization (voltage vs. current) curve is illustrated in Fig. 5.

$$V - o = E - \Delta V_{Ohmic} - \Delta V_{Trans} \quad (4)$$

The second term in (4), ΔV_{Ohmic}, represents the voltage drop due to the resistance of the electrodes (electrons) and membrane (protons). The third term of the equation, ΔV_{Act}, corresponds to the activation of the anode and cathode, which depends primarily on the cell temperature, the catalyst effectiveness, and the active areas of the electrodes. Finally, $\Delta V_{Trans}$is due to decreases in the concentrations of the reactants within the electrodes (methanol at the anode and oxygen at the cathode).

In the equivalent circuit shown in Fig. 4, the Ohmic loss is represented by R_{Ohmic}, while the activation and mass transport losses are combined as R_a, which acts in parallel with the double layer capacitance (C) of the electrodes. Although R_a exhibits a complex dependence on the current drawn from the cell, it can be considered as approximately constant for the discussion here, as indicated by the almost linear steady state voltage vs. current behavior seen in the experimental polarization curves for currents above 100 mA (e.g., Fig. 7).

The double layer capacitance (C) is a characteristic of any interface between an electron conducting phase and an ion conducting phase. It arises from the fact that (in the absence of a Faradaic process) charge cannot cross the interface when the potential across it is changed [3]. In a PEM fuel cell, this interface is the 3-D, high surface area interface between the catalyst particles in the electrode and the Nafion solid electrolyte. The double layer capacitance of each electrode is thus proportional to the surface area of the active catalyst (typically 50-80 % of the total catalyst area). Platinum based catalysts typically have a surface area of 10-100 m^2 g^{-1} and a double layer capacitance of 10-30 μF cm^{-2}. The capacitance of a fuel cell is thus typically 10-30 μF per cm^2 of MEA (note that the capacitances of the anode and cathode act in series to give the cell capacitance, C in (4)). Electrode capacitances vary with potential [3], particularly for Pt based electrodes, but this complication will be neglected here. The action of the cell capacitance in conjunction with ΔV_{Act} and ΔV_{Trans} is described using Kirchhoff's current law, as follows:

$$\frac{d(\Delta V_{Act} + \Delta V_{Trans})}{dt} = 1_o \cdot \frac{1}{C} - \frac{\Delta V_{Act} + \Delta V_{Trans}}{R_a \cdot C} \quad (5)$$

where i_o is the FC output current, and R_a is a non-linear resistor that produces both ΔV_{Act} and ΔV_{Trans} drops during steady state operation.

For a given set of operating conditions (i.e., specified temperature, fuel concentration, and air flow), the parameters in the model will remain approximately constant, except for R_a at low current densities. A change in the operating conditions produces a change in the values of the model parameters.

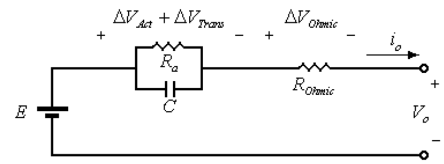

Fig.4 Electrical equivalent model the FC

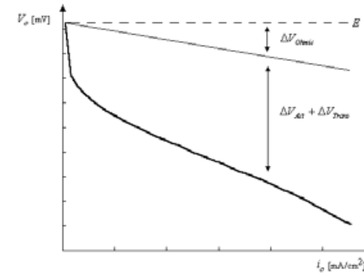

Fig.5 A schematic DMFC polarization curve (note that the cell output voltage is much lower than E)

III. Fuel Cell Setup Description

The single FC used in this work was of a DMFC type and is shown in Fig. 6. The anode consisted of 4 mg/cm^2 Pt/Ru blank, 15% Nafion and 14% Polytetrafluoroethylene (PTFE) on Toray carbon fiber paper. The cathode consisted of 4 mg/cm^2 Pt black on PTFE treated Toray carbon fiber paper. The Nafion115 membrane (Aldrich) was cleaned using 5% H_2O_2(aq), 1M H_2SO_4(aq) (1 h at 60-80ºC in each solution) and water. The membrane and electrodes (5.3 cm^2) were placed into a brass die and pressed for 3 min at 130ºC with a Carver Laboratory Press (model M) under pressure.

The MEA was evaluated in a commercial 5.3 cm^2 active area cell (Fuel Cell Technologies) fed with 1 M aqueous MeOH at 0.15 *mL/min* and dry air at a fixed flow rate of 75 *mL/min*. Experiments were conducted at a cell temperature of 60±1 ºC. A number of tests were performed to determine the dynamic behavior of the fuel cell.

Fig. 6 DMFC experimental setup

IV. Dynamic Behavior of the Fuel Cell

For the FC setup described above the steady state polarization curve basically depends on the cell operating temperature, methanol concentration, and flow rates (operating conditions). A change in the operating conditions modifies the performance of the FC, and hence the polarization curve. It should be pointed out that the transition from a given polarization curve to another is sluggish. The main reasons for this behavior are the high heat capacity of the cell, and the slow mass transport processed in the flow fields and electrodes. Hence, a fast dynamic response of this power source should not be expected by means of modifying the operating conditions. However, a dynamic behavior of the FC exists when the output current changes for fixed operating condition. A number of tests described below were performed to determine the dynamic behavior of the fuel cell. In this section the dynamic behavior of the single DMFC is investigated for the following operating conditions:

- 1 M aqueous MeOH at 0.15 *mL/min*
- Dry air at fixed flow rate of 75 *mL/min*
- Cell temperature at 60±1 ºC.

The goal of the investigation is to characterize the behavior and determine the operating limits of the FC for step changes in the output current, output power demands, sudden resistive load changes, and current ripple operation.

A. Current steps

An electronic load was programmed to draw a constant current output from the FC. As a result of the current demand, the FC output voltage changed dynamically. Figures 7 and 8 show the experimental results obtained for a series of current steps. The FC under test was able to cope with the sudden current demands, delivering the output current immediately. The bold line of the *v-i* plot of Fig. 7 represents the steady state polarization curve. The Operating Point (OP) after a transient completion should therefore lie on this steady state curve. The dashed curves on the *v-i* plot correspond to the OP trajectories or dynamic paths for the series of current steps. The initial OP starts at 20 *mA* and 650 *mV*. Once the first current step is applied, the OP "jumps" to the demanded 100 *mA* while the voltage decreases to 625 *mV*. Thereafter, the OP remains at a constant current locus of 100 *mA*, and at steady state, the voltage settles to 500 *mV*. For the remaining current steps the OP continues behaving in the same fashion. Two important points can be highlighted from this experiment: 1) The FC is able to adjust its output current instantaneously to match the current demand, and 2) the OP can depart significantly from the steady state polarization curve during transients. Since the area under the OP represents the instantaneous output power of the FC, its trajectory during current step transients reveals output power beyond and below the steady state power availability. It can be noted from Fig. 7 that positive current steps (i.e. from 100 *mA* to 200 *mA*) lead to a transitory OP over the polarization curve, thus providing extra power during transients. On the other hand, negative current steps (i.e. from 200 *mA* to 100 *mA*) result in a transitory OP below the polarization curve leading to reduced power delivery during transients. From consideration of the equivalent circuit shown in Fig. 4, it is clear that these differences in power output result primarily from charging and discharging, of the cell's double layer capacitance.

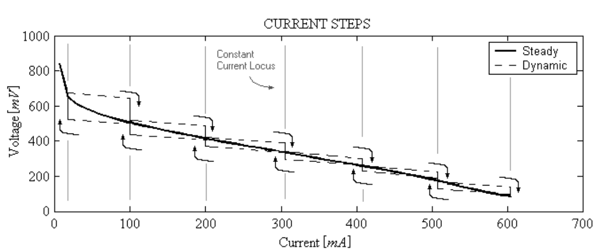

Fig. 7 The dynamic response of the DMFC to a series of current steps: v-i plot.

The *v-i* plot presented in Fig. 7 provides a simple approach to represent both the steady state polarization curve and the trajectory of the OP during transients without time as a variable. In order to clarify the time evolution of the FC dynamics, a time domain plot is included in Fig. 8. Similar to Fig. 7, the initial current step of Fig. 8 was from 20 *mA* to 100 *mA* at $t = 0$. The FC output voltage starts at 650 *mV* and decreases during the transient until it reaches 500 *mV*. A second current step from 100 *mA* to 200 *mA* was applied at $t = 6s$ and the output voltage decreased again as a result of the higher output current. For the remaining positive current steps, the voltage continued to decrease until it reached the steady state value for the current being drawn from the cell. After $t = 36s$ the successive negative current steps applied resulted in an increase of the output voltage. The voltage transient for each current step (both positive and negative) behaved like a first order system with a time constant of ~1.5 *s* except for the very first and last current steps. This anomalous behavior at low currents is due to the highly non-linear nature of the FC in this region. The instantaneous power evolution is also shown in Fig. 8 with a thin line, which shows instantaneous peak power beyond the steady state power for positive current steps, and instantaneous power below the steady state power for negative current steps.

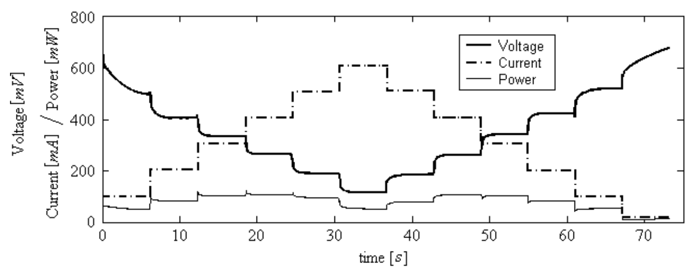

Fig. 8 The dynamic response of the DMFC to a series of current steps: Time domain plot.

B. Constant Power Steps

A test of constant power steps was performed with the objective of demonstrating that the DMFC can cope with sudden power demands within its power limits. In order to obtain constant power steps, the electronic load adjusts the current dynamically to maintain the output power constant despite the FC output voltage. Figures 9 and 10 depict the *v-i* and time domain plots for this test. The dashed line on the *v-i* plot shows the trajectory of the OP for consecutive power steps demand (52.4 *mW*, 86.0 *mW*, and 104.5 *mW*). The initial OP is located at the top of the steady state curve and it denotes a no-load condition. When the first power step demand is applied the OP "jumps" to the corresponding constant power locus. After that the OP progressively moves towards the intersection between the power locus and the steady state polarization curve. The remaining power steps behave in the same way. The time domain plot shows how the current increases to compensate for the progressive voltage reduction until the final OP is reached after a transient of 17 s for the first step and about 3 s for the subsequent steps.

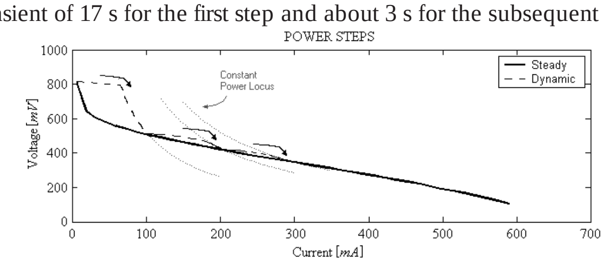

Fig. 9 The dynamic response of the DMFC to a series of power steps: v-i plot

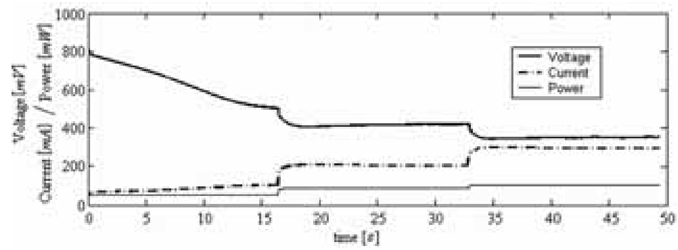

Fig. 10 The dynamic response of the DMFC to a series of power steps: Time domain plot

C. Peak Power Availability

Peak power availability beyond the steady state power was detected during the experimental tests. Whenever the OP is below the maximum power point, a sudden current demand could force the OP to "jump" to a location where the instantaneous power is greater than the maximum power point. An explanation from the point of view of the model indicates that the transient lasts while *C* is charged to reach the final steady state condition. Figure 11 shows a constant current step able to extract a peak power twice the maximum power point. The final OP on the steady state curve corresponds to the maximum power point. The area under the OP trajectory is the instantaneous power delivered by the FC. The thin dashed line on the *v-i* plot shows the power for the steady state OP. A time domain plot is included in Fig. 12 to clarify the transient evolution.

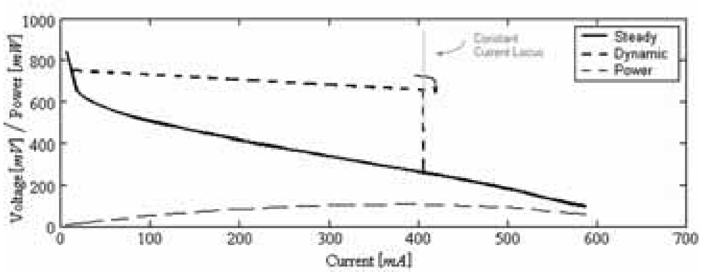

Fig. 11 FC peak power extraction from no-load to 400mA: v-i plot

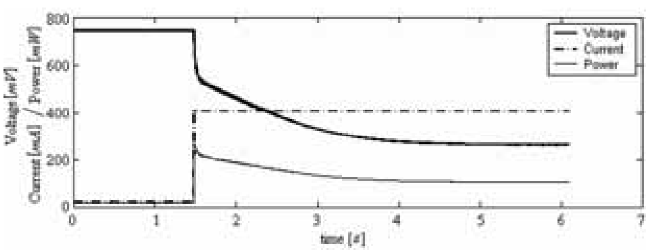

Fig. 12 FC peak power extraction from no-load to 400mA: Time domain plot

D. Resistive Steps Test

This test consisted of sudden resistive changes and was intended to explain the behavior of the FC under a simple load resistance variation. The experiment was performed with 4.76 Ω for the first step, followed by 2.11 Ω, 1.11 Ω, 0.64 Ω, 0.41 Ω, and 0.21 Ω. The experimental results shown as *v-i* and time domain plots are depicted in Figs. 13 and 15, respectively. The application of a resistive load to the FC forces the OP on the *v-i* plot to move to a steady state point on the corresponding constant resistance locus (gray straight lines). At the beginning of the transient, the OP lies far from the steady state polarization curve. Thereafter, the OP is directed towards the polarization curve following the trajectory of the constant resistance locus. When the following step change in resistance is applied, the OP is forced to "jump" to a new constant resistance locus as can be seen on the *v-i* plot of Fig. 13. While the dashed line on the v-i plot represents the OP dynamic trajectory, the time domain plot of Fig. 14 gives more insight into the transient duration. The voltage transient for each resistive step shows a time constant of about 1.50 *s*, except for the very first step in the non-linear low current region.

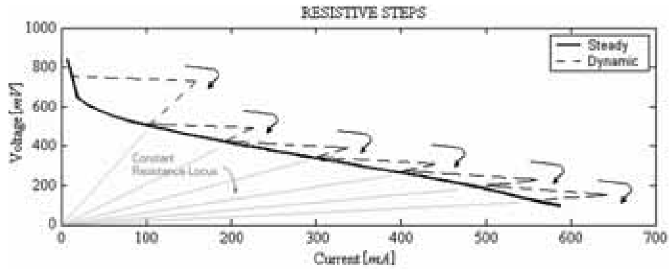

Fig. 13 The dynamic response of the DMFC to a series of resistive steps: v-i plot.

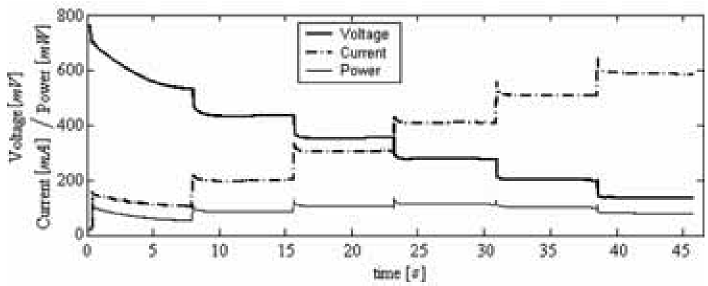

Fig. 14 The dynamic response of the DMFC to a series of resistive steps: Time domain plot

E. Current Ripple Test

Fuel cell inverters are included among the promising applications for FC systems. Portable inverters, distributed power generation, Uninterruptible Power Supplies (UPS), and avionics inverters, are some of the application areas of FCs [4], [5]. An ac current ripple on the dc power source is inherent to single-phase and three-phase inverters. For single-phase inverters, the frequency of the ripple is double the frequency of the output voltage. Commercial FC behavior under 120Hz current ripple has been recently evaluated [6] and an analysis of its impact on the FC is a topic under study [7]. A conceptual understanding of the issue is essential for power electronics designers. Eliminating the ripple could imply a large FC output filter or an additional power electronics converter for the system.

Experimental results and discussion for a better understanding of the current ripple effect are presented in this section. Figure 15 shows a *v-i* plot with a dc OP at 325 *mA* with a superimposed 25Hz and 400Hz current ripple. Each frequency was tested individually but the plot includes an overlap for the two tests. Figure 16 is a zoom-in of the previous *v-i* plot, which highlights the difference between the 25Hz and 400Hz tests. It can be noted that the current ripple for both frequencies has the same average value and its amplitude is 50% of the declared central OP.

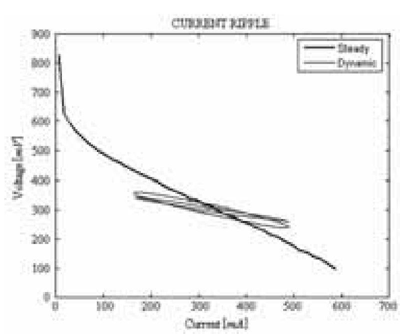

Fig. 15 DC+AC current test of the DMFC for 25Hz and 400Hz: v-i plot

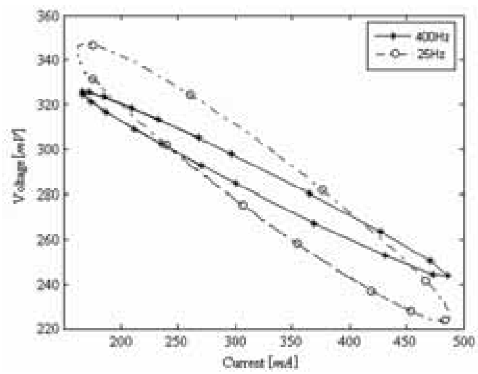

Fig. 16 DC+AC current test of the DMFC for 25Hz and 400Hz: Zoom of the v-i plot

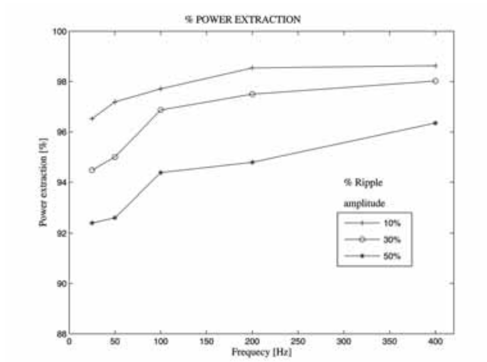

Fig. 18 FC power extraction with current ripple as a percentage of the power extraction without ripple.

As can be seen in the 400Hz test, the slope and amplitude of the hysteresis trajectory are reduced. This leads to an increase in the output power availability in comparison with the 25Hz case. The hysteresis behavior, which denotes a phase difference between the output current and voltage, is associated with the double layer capacitor. If the frequency of the current ripple increases further, the hysteresis behavior disappears (the double layer capacitor impedance is significantly reduced) and the trajectory becomes a straight line with a slope equal to R_{Ohmic}. This results in an increase of the output power. However, the average output power with current ripple always stays below the output power for the dc operating point. This is explained by the fact that the average current values for dc and dc+ac are the same and the only way to achieve the same output power is with a completely horizontal trajectory (constant voltage), which is not feasible due to the effect of R_{Ohmic}. Figure 17 shows the time domain plot for the current ripple test. The difference in voltage excursion is better appreciated in this plot.

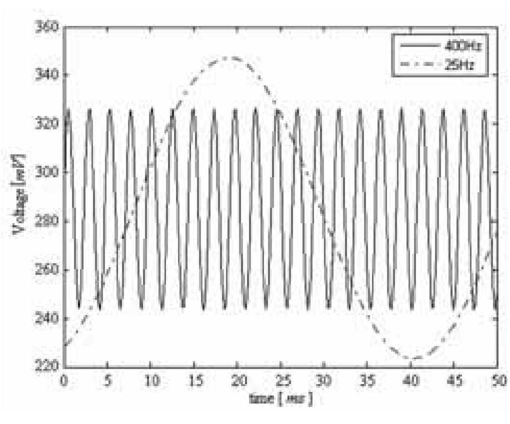

Fig. 17 DC+AC current test of the DMFC for 25Hz and 400Hz: Time domain plot

The power extraction for different current ripple amplitudes and frequencies as a percentage of the power without ripple is presented in Fig. 18. The test was performed for amplitudes of 10%, 30% and 50% of the dc OP (3235 *mA*). The curves show the decrease in power extraction when the amplitude of the ripple increases. An increase in the frequency of the current ripple helps to increase the power extraction. Similar effects have been reported of hydrogen fuelled FCs, also know as Proton Exchange Membrane FC (PEMFC) [6].

V. Experimental Results and the Fuel Cell Model

The electrical model of the FC introduced in section II and illustrated in Fig. 4 provides a reasonable model representation of the real FC considering its simplicity. However, obtaining the electrical parameters in this model is complex [8]. Determination of R_a is particularly difficult because many effects that depend differently upon the OP contribute to it. As well, R_a is highly non-linear at low current densities. The following discussion is intended to provide a qualitative analysis of the experimental results from the viewpoint of the generic electrical model of the FC.

An inspection of the generic model presented in Fig. 4 reveals that the transitions on a v-i plot for any sudden current demand is transitorily driven by the double layer capacitance (*C*). This means that the resistor R_a is by-passed while *C* is being charged or discharged. Tests on the actual FC show that a sudden increase in the current demand produces an instantaneous voltage drop on the FC, which can be associated with the drop due to R_{Ohmic} in the model. Thereafter, a first order voltage transient can be observed according to the capacitor charging process. During steady state operation, the capacitor is charged and its voltage is $\Delta V_{Act} + \Delta V_{Trans}$, which is the product $i_o \cdot R_a$. There is also evidence to support the idea of an almost constant R_{Ohmic} since every current jump is associated with a constant slope trajectory on the *v-i* characteristic. With respect to the hysteresis trajectories under current ripple operation, there is some coincidence between the model and the actual behavior. The hysteresis on the *v-i* plot is basically due to current and voltage phase shift. The current ripple is leading in relation to the voltage for frequencies where *C* has impedance on the order of the value. For a current ripple with a very low frequency (i.e. 0.1 Hz), *C* is negligible and the OP trajectory follows the steady state curve determined by R_a and R_{Ohmic}. Alternatively, a high frequency current ripple (i.e. 1 kHz) defines a linear OP trajectory. The slope of the trajectory corresponds to R_{Ohmic} but the pivot point is still the dc OP on the steady state polarization curve.

VI. Summary

The dynamic behavior of a Direct Methanol Fuel Cell has been described to illustrate key aspects of the electrical behavior of fuel cells. The results have been interpreted and discussed with the aid of a generic equivalent circuit model of the fuel cell. The large capacitance of the cell, in series with a small Ohmic resistance, is shown to provide high transient power capabilities. This unique characteristic of fuel cells makes them well suited for applications with transient high power demands, and can eliminate the need for extra capacitors. In addition, when the cell is operated under current ripple (inverter connected to the cell), it has been shown that the capacitance of the cell in combination with the equivalent resistances produce a hysteresis behavior, which leads to a reduction in the output power available.

Acknowledgments

The fuel cell setup was made available to us at the Chemistry Department, Faculty of Science, Memorial University of Newfoundland.

Discussion, comments, and technical support provided by Dr. Omar Yepez from the same department, is greatly acknowledged. The authors would like to thank the Natural Sciences and Engineering Research Council (NSERC), Canada for the financial support for this research.

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Authors Biographies

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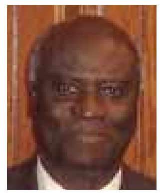
Peter Pickup obtained a B.A. in Chemistry from Oxford University in 1979 and a D.Phil. in Inorganic Chemistry from Oxford in 1982.

Following postdoctoral Research Associate appointments at the University of North Carolina at Chapel Hill (1982-3), State University of New York at Buffalo (1983-4), and The University of Calgary (1984-6), he joined the faculty of the Chemistry Department at Memorial University of Newfoundland (1986). He was promoted to the rank of University Research Professor in 2005. During a leave in 1993-4, he worked as a Senior Scientist at Ballard Power Systems and at the Philips Research Laboratory in the Netherlands. He has published extensively on the electrochemistry of fuel cells, the development of new materials and diagnostic techniques for fuel cells, and on the study of new materials of fundamental interest in the areas of molecular electronics and energy technology.



John E. Quaicoe (S'75-M'76-SM'93) received the B.Sc. degree from the University of Science and Technology, Kumasi, Ghana in 1973, and the M.A.Sc. and Ph.D. degrees from the University of Toronto, Canada in 1977 and 1982 respectively. In 1982 he joined the Faculty of Engineering and Applied Science at Memorial University of Newfoundland, where he is presently a Professor and Associate Dean (Undergraduate Studies) with research and teaching activities in power electronics and related areas. His research activities include inverter modulation and control techniques, utility interface systems and power quality, and uninterruptible power supplies. Recent research activities include the development of power electronic systems and control strategies for fuel cells and wind generation systems. Dr. Quaicoe is a member of the Association of Professional Engineers and Geoscientists of Newfoundland and Labrador.

M. Tariq Iqbal was born in Layyah, Pakistan, in 1963. He received the B.Sc.(EE) degree from the University of Engineering and Technology, Lahore in 1986, the M. Sc. Nuclear Engineering degree from the Quaid-e-Azam University, Islamabad in 1988 and the Ph.D. degree in Electrical Engineering from the Imperial College London in 1994. From 1988 to 1991 and from 1995 to 1999 he worked at the Pakistan Institute of Engineering and Applied Science, Islamabad, Pakistan as an Assistant Engineer and later as a Senior Engineer. From 1999 to 2000 he worked as an Associate Professor at IIEC, Riphah International University. Since 2001 he is working at Faculty of Engineering and Applied Science, Memorial University of Newfoundland. Presently he is an Associate Professor. His teaching activities cover a range of electrical engineering topics including electronics devices, control systems, filter synthesis and power electronics. He also teaches graduate courses in the area of advanced control systems and renewable energy systems. Currently, his research focuses on modeling and control of renewable energy systems with interests in the areas of design of control systems and comparison of control strategies of hybrid energy systems.

COMPEL'06 Set New Records

The 2006 IEEE Workshop on Computers in Power Electronics (COMPEL'06) was held at Rensselaer Polytechnic Institute in Troy, New York, from July 16 to 19, 2006. The event drew about 80 attendees worldwide who contributed 56 papers and gave 67 oral and poster presentations in 10 different sessions, all setting new records for COMPEL.

The workshops started on Sunday, July 16, with a tutorial on digital control given by Prof. Philip Krein from University of Illinois at Urbana-Champaign. Highlights of the technical program in the following three days included two invited sessions, one on complex power electronics systems modeling and control, and another on digital control of switching-mode power supplies. In each session, six experts from the industry and different US government organizations presented their view of the trends, challenges, and opportunities in the area of complex power electronic systems integration and digital power. There were two additional oral presentation sessions dedicated to digital control. The technical program also included a special session on aircraft power system modeling and analysis organized by Dr. Kamiar J. Karimi of The Boeing Company.

Among the different social activities held during the workshop, the dinner cruise on Tuesday at Lake George was probably most memorable for many attendees (see the picture to the right). In addition to enjoying the mountain sceneries around the Lake, attendees also had a taste of the natural beauty that Upstate New York has to offer through the one-hour drive from Troy to Lake George.

COMPEL is sponsored by the IEEE Power Electronics Society, and is held every other year. The workshop is organized by the PELS Technical Committee on Modeling and Control, and was first started in 1988. The next COMPEL will be held in 2008, and the venue will be decided at APEC'07.

The Workshop published both printed and CD-ROM version of proceedings. Both are available from IEEE. The Workshop also received financial support from Powersim Inc. and Astec Power. For additional information, please contact the General Chair at the following address.

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CPES congratulates Prof. Daan van Wyk -- recipient of two IEEE awards in 2006!!

IEEE honors Prof. Daan van Wyk with two major IEEE awards this year!

CONGRATULATIONS, Prof. van Wyk!!

IEEE PELS 2006 Distinguished Service Award presented at PESC

In June 2006, at the annual Power Electronics Specialists Conference (PESC) held in Jeju, Korea, Prof. van Wyk was honored with the IEEE Power Electronics Society (PELS) 2006 Distinguished Service Award!

PELS presented the award to Prof. van Wyk in recognition of his exceptional dedication and outstanding service to the IEEE Power Electronics Society. The award consists of a plaque and an honorarium.

IEEE IAS 2006 Outstanding Achievement Award presented at IAS

In October 2006, at the 41st IEEE Industry Applications Society (IAS) Conference held in Tampa, Florida, Prof. van Wyk was honored with the 2006 IEEE IAS Outstanding Achievement Award!

IAS presented the award to Prof. van Wyk in recognition of his outstanding contributions in the application of electricity to industry. The award consists of a handcrafted statuette and an honorarium.

Prof. van Wyk joined CPES in 1999 and has provided strong leadership in the Center's efforts in packaging and high density integration.

He has made numerous contributions in various capacities in IEEE's PELS and IAS, having served as Editor-in-Chief for the IEEE Transactions on Power Electronics from 2002 to 2006, served on the Editorial Advisory Board of IEEE Spectrum from 1996-1998, and contributed to the 1994 IEEE Special Issue on Power Electronics and Motion Control. He has chaired the steering committee for the international IEEE Workshops on the Future of Electronic Power Processing and Conversion (FEPPCON), and was a Guest Editor of the 2001 Special Issue on Power Electronics Technology of the IEEE Proceedings with Fred Lee and Dushan Boroyevich.

Among other honors and awards from IEEE PELS and IAS, the South African IEEE and Foundation for Research Development, Prof. van Wyk was elected a Distinguished Lecturer by PELS in 1996-1998 and by IAS in 1997-1999. He is a Fellow of the IEEE, recipient of the PELS 1995 William E. Newell Power Electronics Award, and recipient of the IEEE Third Millennium Medal in 2000.

Meetings of Interest

The 22nd Annual IEEE Applied Power Electronics Conference, APEC®2007, is scheduled for 25 Feb. through 1 March, 2007 at the Disneyland Hotel, Anaheim, CA. Co-sponsored by IEEE PEL's, IEEE IAS and Power Sources Manufacturers Association. See announcement in this issue. For more information visit the website at: www.apec-conf.org.

4th Power Conversion Conference, PCC2007 will be held 2-5 April 2007 at the Nagoya Congress Center, Nagoya, Japan. Important dates: author's notice of acceptance 30 November 2006, and final paper due 31 January 2007. For more information please visit the PCC'07 website: http://www.ics-inc.co.jp/pcc/

International Electric Machines and Drives Conference, IEMDC 2007, is scheduled for 3-5 May 2007 in Antalya, Turkey. IEMDC 2007 is jointly sponsored by the IEEE Power Electronics Society. For more information, please visit the conference website http://www.iemdc07.org/ or contact the General Chair, Okyay Kaynak kaynak@boun.edu.tr or the Technical Chair, Herb Hess, hhess@ieee.org

The 38th IEEE Power Electronics Specialists Conference, PESC'07, is scheduled for 17-21 June, 2007 at the Hilton in the Walt Disney World® Resort, Orlando, FL. PESC'07 is sponsored by IEEE PEL's. Deadline for abstract and digest submission is 10 Nov. 2006. General Chair is Prof. Issa Batarseh, batarseh@mail.ucf.edu and technical program chair Prof. John Shen, johnshen@mail.ucf.edu. For more information visit the website at www.pesc-conf.org.

12th European Conference on Power Electronics and Applications, EPE2007, is scheduled for 2-5 Sept. 2007 in Aalborg, Denmark. Intending authors should note these deadlines: receipt of synopses by 1 Nov.1, 2006, notification of acceptance March 1, 2007, final review May 15, 2007. Further information can be found at http://www.epe2007.com/

4th Vehicle Power and Propulsion (VPP) Conference is announced for Arlington, Texas from 9-12 September 2007 at the Wyndham Hotel in Arlington. Prospective authors are directed to the website for further details: http://www.vppc07.com/ and notified to submit proposal via that site. Important dates: April 1, 2007 for submission of the paper proposal (abstract and digest); June 1, 2006 author's notification of acceptance; August 1, 2007 for submission of camera-ready manuscript. VPP'07 general chair: Dr. Babak Fahimi, University of Texas-Arlington: fahimi@uta.edu VPP'07 is co-sponsored by PEL's.

International Telecommunications Energy Conference INTELLEC® rome'07 will be held 30 September to 4 October 2007 at the Rome Marriott Park Hotel, Rome, Italy.

5th Vehicle Power and Propulsion (VPP) Conference is announced for 3-5 September 2008 in Harbin, China. Correspondence may be directed to: vppc2008@hit.edu.cn. VPP'08 general chair: Prof. C.C. Chan, Harbin Institute of Technology. Abstracts with contact details should be submitted by 1 March 2008. VPP'08 is co-sponsored by PEL's.

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- Dr. L. Tolbert, Univ. of Tennessee, USA
- Dr. R. Zhang, GE Global Research Ctr., USA

September 9-12, 2007, Wyndham Hotel, Arlington, Texas, USA

Co-sponsored by: IEEE Vehicular Technology Society (VTS) and IEEE Power Electronics Society (PELS)

Call for Papers

2007 IEEE Vehicle Power and Propulsion (VPP) Conference

The 2007 IEEE Vehicle Power and Propulsion (VPP) Conference is located in Arlington, Texas, USA.. VPP conference will include sessions in different technical tracks and potential authors are invited to submit their papers on the following or related topics.

VPP Track 1: Vehicular Electric Power Systems and Loads
VPP Track 2: Vehicular Power Electronics and Electromechanical Actuators
VPP Track 3: Advanced Vehicles
VPP Track 4: Energy Storage Components/Systems
VPP Track 5: Modeling, Analysis, Dynamics, and Control

Papers should make a timely contribution to state-of-the-art technology, be of high technical and editorial quality, and be devoid of commercialism. Papers should not have been published elsewhere and, if accepted, should not be released for publication through other media. All authors must obtain company and government clearance (if necessary) prior to submission of paper proposals. Authors of accepted VPP papers must submit signed copyright transfer forms to IEEE.

Paper Submission Guidelines:

Prospective authors of papers are asked to submit their paper proposals through the conference Web site (http://www.vppc07.com/). Each paper proposal must include:

• Technical track number and name, paper title, name(s) of author(s), business affiliation(s), mailing address(es), phone and fax numbers, and e-mail address(es). If there are multiple authors, the corresponding author must be clearly identified.

• An abstract of 50-100 words and a digest of 3-5 pages (including figures and tables) stating the objective of the paper, outlining the problem requiring solution or the method of approach to research, being explicit with respect to the type of data to be included in the full paper, and summarizing the conclusions being made. The digest must not exceed 5 pages in length. The conference program committee may make reassignment of accepted papers to different sessions, if necessary.

Deadlines

April 1, 2007: Submission of paper proposals (abstracts and digests)
June 1 , 2007:Author's notification of acceptance
August 1, 2007: Submission of camera-ready manuscripts

Organizing Committee:

VPP'07 General Chair: Dr. Babak Fahimi, University of Texas at Arlington, EML: fahimi@uta.edu
VPP'07 Program Chair: Dr. G. Suresh, GM Research and Development center, EML: suresh.gopalakrishnan@gm.com
VPP'07 Seminar and Invited Speaker Chair: Dr. C.S. Edrington, Arkansas State University, EML: cedrington@astate.edu

IEEE VTS   IEEE   pels

Book Review: Power Electronics and Motor Drives – Advances and Trends, 917 pages

By Prof. Bimal Bose, The University of Tennessee, Knoxville, TN

Academic Press, 2006

The newly published book by Prof Bimal Bose on 'Power Electronics and Motor Drives' is very interesting and unique, dealing with a number of topics related to power electronics and motor drives. This book is in presentation format that is very helpful for teaching undergraduate and graduate students, and also to all practicing power electronics engineers. The book covers almost all aspects of power electronics including thyristor converters, to the latest control and converter technology in power electronics like multi-level converters, neural/fuzzy control and DSP applications. Many examples of recent industrial applications have been included to make the presentation very interesting. The question and answer chapter is very useful to answer many questions, which makes to clearly understand the concepts and principles of the converters. The book consists of the following chapters:

1. Introduction and perspective
2. Power semiconductor Devices
3. Phase controlled converters and cycloconverters
4. Voltage-Fed Converters and Cycloconverters
5. Current-fed converters
6. Electrical Machines for Variable Speed Drives
7. Induction Motor Drives
8. Synchronous Motor Drives
9. Computer Simulation and Digital Control
10. Fuzzy Logic ad applications
11. Neural Networks and Applications
12. Some Questions and Answers

The information presented in the book provides the latest advances in power converters and adjustable speed drives including analysis of power converter topologies, modulation strategies, multi-level converters, drive system configurations as well as advanced motor control strategies such as fuzzy logic and neural network based systems. Connecting the applications to power electronics technology is well done.

An important topic lacking adequate discussion in the book is on DC-DC converters. Several topologies of this class of converters have been discussed in first part of Chapter 4. However, a separate chapter on DC-DC converters and their control strategies was desirable.

The book is easy to read and the material flows logically. Almost every page of the book features either a detailed figure or a chart, accompanied by clear description of the figure. It would be a good reference book and also can be used as a text book.

Dr. Kaushik Rajashekara
Senior Technologist
Rolls-Royce Corporation, Indianapolis, IN, USA

Dr. Kaushik Rajashekara, Fellow IEEE joined Rolls-Royce Corporation, Indianapolis as a Senior Technologist on May 1, 2006. He is working in the area of More Electric Engines for More Electric Aircraft and other applications. Prior to joining Rolls-Royce, he was a Chief Scientist and Technical Fellow for advanced energy systems in Kokomo, IN.

William McMurray, 1929 - 2006

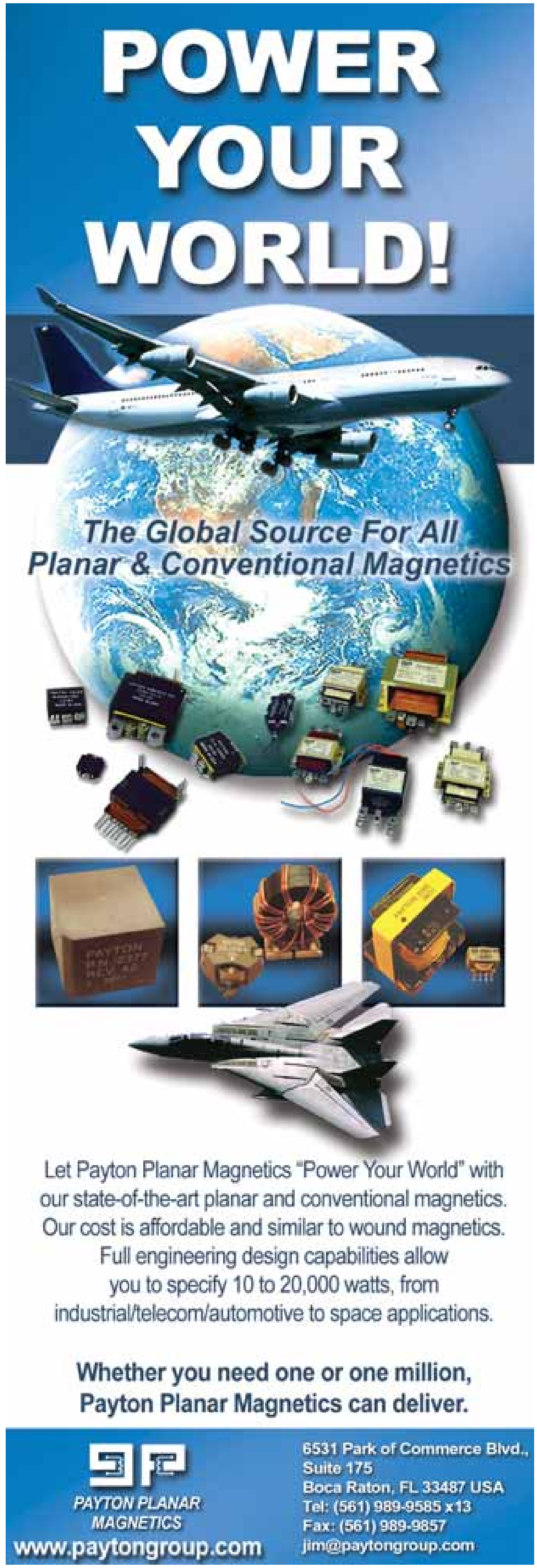
Bill McMurray, an Icon in Power Electronics, passed away on December 25, 2006 after a long illness. One of the “founding-fathers” of power electronics, he was world renowned for his invention of the “McMurray Inverter” as well as the “McMurray-Bedford Inverter” and other snubber and commutation circuits. The power electronics community has indeed lost one of the greatest power electronics men of all time.

He received the B.Sc.(Eng) degree in 1950 in engineering from Battersea Polytechnic (since renamed The University of Surrey) in London, England and a M.S. degree in 1956 from Union College in Schenectady, NY.

Bill joined the General Electric Company in their Test Engineering Program in 1950 and had assignments in the Power Transformer Department (Pittsfield, MA) and the Aircraft Gas Turbine Department (Lockland, OH). He then was in the Army (U.S. Army Signal Corps) from April 1951 to March 1953 after which he joined GE’s General Engineering Lab (a predecessor of today’s GE Global Research). He worked there until retirement in 1988. After his GE retirement, he was a consulting engineer in power electronics and magnetics. At GE, Bill was responsible for the conception and development of solid-state power conversion circuits just as the Silicon-Controlled Rectifier (now called a Thyristor) was invented and being developed. He first applied this new device in the “McMurray-Bedford” inverter which became an industry standard for many years. A short time later, he invented the “McMurray Inverter” circuit that allowed more sophisticated Pulse-Width Modulated inverters to be built for many applications including ac motor drives. When the Gate-Turnoff Thyristor (GTO) began to supplant the Thyristor, Bill invented an efficient energy recovery snubber circuit and greatly simplified symmetrical snubbers which became named after him. Most recently, when “soft-switching” techniques became popular, he published a paper on “Resonant Snubbers with Auxiliary Switches” in 1989 that, through control improvements, is known today as the ARCP inverter.

He holds 23 patents and published 35 technical papers. He was a contributor to the book "Principles of Inverter Circuits" and was the author of the book "The Theory and Design of Cycloconverters." Bill was a member of the Industry Applications, Power Electronics, Industrial Electronics, and Magnetics Societies. He was an associate member of the Institution of Electrical Engineers (British) and a Professional Engineer in NY State. He was a fellow of the IEEE. Among his awards and honors are the 1978 William E. Newell Award for outstanding achievement in power electronics (considered the highest award in power electronics), the 1984 IEEE Lamme Medal and the Third Millennium Medal that was presented in 2000. He also received the honorary Doctor of Laws degree from Concordia University, Montreal, Canada in 1986.

Bill’s publications were written in a crystal clear style and were always filled with analyses and waveforms to explain circuit operation in detail. These papers were studied by industrial project teams and students alike. At GE, he always had the last word when it came to the best circuit configuration for a given application. GE engineers would travel to Schenectady from Erie, Pennsylvania, Salem, Virginia, and many other cities just to sit down with Bill to get his opinion and advice on a proposed approach. A request of every visitor or interviewee that came to GE R&D was to meet Bill McMurray. When news of Bill’s passing became known, e-mails began to pour in from around the world with such comments as:



- "…..I remember this scene well, and I realized that he is really one of the greatest research scientist/engineers in the power electronics community.."
- "…..I read the bible of power electronics, "The Principles of Inverter Circuits" with consulting a dictionary. When I was a graduate student ….I read this book "The Theory and Design of Cycoconverters" carefully. Actually, these two books have had a significant impact on my following career."
- "He was the king of commutation."
- "In the very beginning of my engineering career I always followed McMurry's ideas as soon as they were published."
- "Dr. Bill McMurray's death comes as the saddest news to the power electronics community. He was not only the Father of Power electronics, in my definition, he was the greatest power electronics man of all ages. It is a serious loss to the power electronics community of the whole world."

With all his fame, Bill was always a humble and soft spoken colleague. In addition to his professional exploits, he enjoyed hiking and canoeing in the Adirondack Mountains north of Schenectady. He was also an avid amateur Egyptologist.

Bill was born in Los Angeles, CA to William A. and Genevieve Arnold McMurray just at the beginning of the great depression in 1929 and shortly after moved to England. He held dual citizenship (U.S. and British). After his undergraduate education he returned to the United States and joined GE. He is survived by his wife, Marion Schnipp McMur-ray of Johnstown; son, William B. McMurray of Columbus, OH; daughter, Shirley A. McMurray of' Niskayuna; son, Robert C. McMurray of Co-hoes; and daughter, Barbara C. Rathburn and her husband, David of Hartford, NY.

Memorial contributions may be made to the American Lung Association, 3 Winners Circle, Suite 300, Albany, NY 12205.

Robert L. Steigerwald, IEEE Fellow
GE Global Research (retired)

42ND INTERNATIONAL UNIVERSITIES POWER ENGINEERING CONFERENCE (UPEC 2007)

UNIVERSITY OF BRIGHTON, UK

SEPTEMBER 4-6, 2007

Call for Papers

Abstract Deadline: February 7, 2007

The 42nd International Universities Power Engineering Conference (UPEC 2007) will be hosted by the Faculty of Science and Engineering, University of Brighton, UK, September 4-6, 2007. It will be located at the University's Falmer campus that is located approximately 2 miles northeast of central Brighton. The city of Brighton is located on the South East coast of England and is easily accessible by road (M23 from the London orbital Motorway M25), by numerous airlines (London Gatwick airport is within 18 miles of Brighton), and by rail. The Falmer campus is served with a rail station. The conference is co-sponsored by IEEE, IEE, and CIGRE. Its aim is to provide a professional forum for engineers and research scientists from the universities, consultants, and in the manufacturing and supply industries to present their work and explore potential trends and recent developments, current practices in Power Engineering and related fields. Although the forum is open to all levels of participants, the Secretariat particularly encourages young academics and research students to attend. The conference will cover all aspects of power engineering. It will be residential for three nights. There will be a technical exhibition by invited sponsors, and a number of keynote addresses will be scheduled. A number of technical and cultural visits are also planned. The working language is English. Accepted papers will be presented in oral and in interactive sessions.

UPEC 2007 seeks papers in all aspects of power engineering, including the following topics:

1) Power Generation
2) Power Utilization
3) Future Power Networks
4) Machines and Drives
5) System Integrity and Protection
6) Power System Operation and Control
7) High Voltage Engineering and Dielectrics
8) Expert Systems
9) Power Quality
10) Power Electronics and Devices
11) Renewable Energy Systems
12) Electromagnetic/Electrostatic Effects
13) Distributed Generation
14) Power / HV Engineering Education
15) Power Conversion
16) Lightning Protection

Prospective Authors are invited to submit an abstract (max 2 A4 pages) in the relevant subject area to the UPEC 2007 Secretariat, either electronically by E-mail or by PO Mail, before February 9 2007. The PO address is: School of Engineering, The University of Brighton, Cockcroft Building, Lewes Rd, Brighton, BN2 4GJ, UK, Tel: +44 1273 642 234, Fax: +44 1273 642 301. The Conference organizer is Dr. Peter Howson (E-mail: P.A.Howson@bton.ac.uk). On the front page Prospective Authors should give the full name, address, affiliation, and E-mail address of the author to communicate with, the number of the area the paper is from taken from in the above list, the preference for presentation (oral or interactive), and title of the paper, Notification of acceptance will be by 23 March 2007. Final camera-ready papers are to be received by May 18, 2007 for final review. Style of submission is available on the conference web site www.upec2007.org At least one of the authors for each paper will be required to register and attend the conference. Registration will be available on the conference website.

Organization and Venue

The European Power Electronics and Adjustable Speed Drives community will gather in Aalborg, Denmark, in September 2007 to exchange views on research progresses and technological developments in the various topics described hereunder. The EPE 2007 conference is sponsored by the EPE Association and will be held in the Aalborg Congress & Culture Centre from 2 to 5 September 2007. It is hosted by Aalborg University's Institute of Energy Technology. Denmark is the distributed power generation nation. More than 20% of the electricity is covered by wind and small combined heat and power plants are covering even more. A perfect place for new power electronic solutions.

Aims of Conference

EPE is the place for specialists in power electronics, systems and components, to present papers and attend sessions on state-of-the-art technology in this challenging and evolutionary sector. The conference aims to be a meeting forum for researchers, developers and specialists from the industry. Papers are encouraged on all topics described hereunder for interdisciplinary discussions of new ideas, research, development, applications and the latest advances in the field of power electronics and adjustable speed drives.

Topics

Advances in Energy Conversion and Conditioning Technologies (ECCT), exploiting new power electronic systems, energy conversion devices and system control regimes, are all fundamental and crucial to the development of the clean, efficient and sustainable technology of the future. Over 50 % of the European, Japanese and North-American electric energy consumption passes through electronic conversion and conditioning equipment. This exploitation of ECCT increases steadily. Next to the improved behaviour of systems, the reduced energy consumption is a key factor, helping to achieve the Kyoto requirements and to address key issues related to the reduction of Greenhouse gases and pollutant emissions in industrial processes and transport; to increase the use of renewable energy sources and to allow their integration in the grid. Most of the electricity production based on alternative energy sources must undergo conditioning through ECCT equipment before use. ECCT is also a major means to achieve enhanced competitiveness of all industrial processes. Basic ECCT technologies alone constitute a world market estimated at multi-billion Euro value of which the EU has a 40% share. Significantly, ECCT is a core enabling technology providing the central electrical, control, diagnostic and management systems. The EPE 2007 conference will offer a wide discussion forum on all topics related to these aspects.

The list of topics hereunder holds only the headlines. A detailed list of subtopics is available at: http://www.epe2007.com

A. DEVICES, PACKAGING AND SYSTEM INTEGRATION

Topic 1: Active devices

Topic 2: Passive components, system integration & packaging

Topic 3: Power system integration

B. POWER CONVERTERS TOPOLOGIES AND DESIGN

Topic 4: Soft switching converters and control

Topic 5: Hard switching converters and control

C. MEASUREMENT AND CONTROL

Topic 6: Modulation strategies and specific control methods for static converters

Topic 7: Application of control methods to electrical systems

Topic 8: Measurements and sensors (except speed and position sensors)

D. ELECTRICAL MACHINES AND DRIVE SYSTEMS

Topic 9: Motion control and robotics, communication in drive systems

Topic 10: Electrical machines

Topic 11: Adjustable speed drives

Topic 12: High performance drives

E. APPLICATIONS OF POWER ELECTRONICS IN GENERATION, TRANSMISSION AND DISTRIBUTION OF ELECTRICAL ENERGY

Topic 13: Electrical energy generating systems, renewable energy systems

Topic 14: Transmission and distribution of electrical energy

F. APPLICATIONS OF POWER ELECTRONICS IN USERS DEVICES / PROCESSES

Topic 15: Power supplies

Topic 16: Electrical systems in aerospace, space, surface and marine transport

Topic 17: Operating quality of systems

Topic 18: Industry specific energy conversion and conditioning technologies

Topic 19: Energy saving technologies

Topic 20: Energy conversion and conditioning technologies in physics research and related applications

G. EDUCATION

Topic 21: Education

Presentation of Papers

Contributions to EPE 2007 must be presented either as a lecture presentation or as a dialogue presentation. A manuscript must be submitted in English in both cases for inclusion in the Conference Proceedings (CD-ROM). Papers for lecture sessions will be strictly limited and selected on the basis of wide audience appeal, ease of understanding and potential stimulation of broad ranging discussion.
Dialogue presentation will take place in the afternoon. No lecture session will be organized during the dialogue sessions.

Tutorials - Call for Proposals

Several tutorials will be held prior to the conference. Authors willing to propose a tutorial at EPE 2007 are invited to send a proposal to the scientific secretariat (EPE Association, c/o VUB-IrW-ETEC, Pleinlaan 2, B-1050 Brussels, Belgium, e-mail: epe-association@vub.ac.be) before January 15, 2007. The proposal will consist of a three-page summary including tutorial title, name and affiliation of the lecturer(s), tutorial objectives and audience, topical outline and provisional schedule of the tutorial. Tutorials will be organized at the University of Aalborg on Sunday September 2nd, 2007.
Tutorial proposals are particularly welcome in the following topics, although other topics may be proposed as well:

- New Devices for Sustainable Energy Applications
- Understanding the Electrical Grid Behaviour and Management
- Building and Connecting Wind Energy Sources
- Building and Connecting PV Energy Sources
- Connecting Fuel Cells to the Electrical Applications
- Power Electronics and Adjustable Speed Drives for Clean Road Transport
- Application of Drives
- New Topologies for Sustainable Energy Applications
- Storage of Electrical Energy in the Electrical Grid
- Storage of Electrical Energy for Transport Applications
- Education issues
- More…

CALL FOR PAPERS

IEEE SDEMPED'07

Cracow (Poland), September 6 - 8, 2007

6th IEEE International Symposium on Diagnostics for Electric Machines, Power Electronics and Drives

Sponsor: IEEE Power Electronic Society

Technical co-sponsors: IEEE Industry Applications Society, IEEE Industrial Electronics Society, IEEE France Section, Cracow University of Technology

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G. Pascoli

The purpose of this symposium is to provide a forum for presentation and discussion of the state-of-the-art of diagnostics and monitoring for electric machines, power electronics, and adjustable speed drives and related areas. Topics within the scope of the symposium are:

I. ELECTRIC MACHINES: Failure detection and location in electric machines using vibration, audible noise, electrical or mechanical variables, sensors, insulation failures, electrical, mechanical and thermal models.

II. POWER ELECTRONICS: Diagnostics in power converters using input-output monitoring, thermal and/or electrical measurements on power semiconductors, control supervision, signal processing.

III. ADJUSTABLE SPEED DRIVES: Monitoring and diagnostics for ASDs using electric machines, power converters and control systems supervision, computer-based signal processing and data analysis.

IV. TOOLS FOR DIAGNOSTICS: Neural networks, fuzzy logic, artificial intelligence, genetic algorithms, expert systems, identification, signal processing techniques, observers.

V. MATERIALS FOR ELECTRIC MACHINES: Insulating and magnetic materials, remaining life models, ageing tests.

VI. TESTS FOR PREDICTIVE MAINTENANCE: Partial discharge analysis, tests, new instruments for diagnostics.

Regular papers: Submit extended digests or provisional versions of full papers in English as follows. Limitation to **6 full pages**, including paper title, authors and affiliations, figures and references (maximum size 2MB). Authors are requested to prepare the manuscripts in the IEEE two-column format, using the template available in the SDEMPED Website and to translate it in PDF using the IEEE PDF eXpress™ facility. No other format in the submission and in the final version can be accepted.

Special sessions: The symposium will feature special sessions on topics of special interest. The proposal of a special session must provide the session name and a list of about 6 potential papers together with their digests. All special session papers will be reviewed in the usual way.

All submissions should be in electronic form. Instructions will be posted in due course on the web at: www.sdemped07.iut-amiens.fr

Venue: Hotel Novotel Cracow - Poland

Deadlines for paper digest and special session proposals

Submission:	**February 15, 2007**
Notification of acceptance:	**April 15, 2007**
Final manuscript due:	**June 15, 2007**

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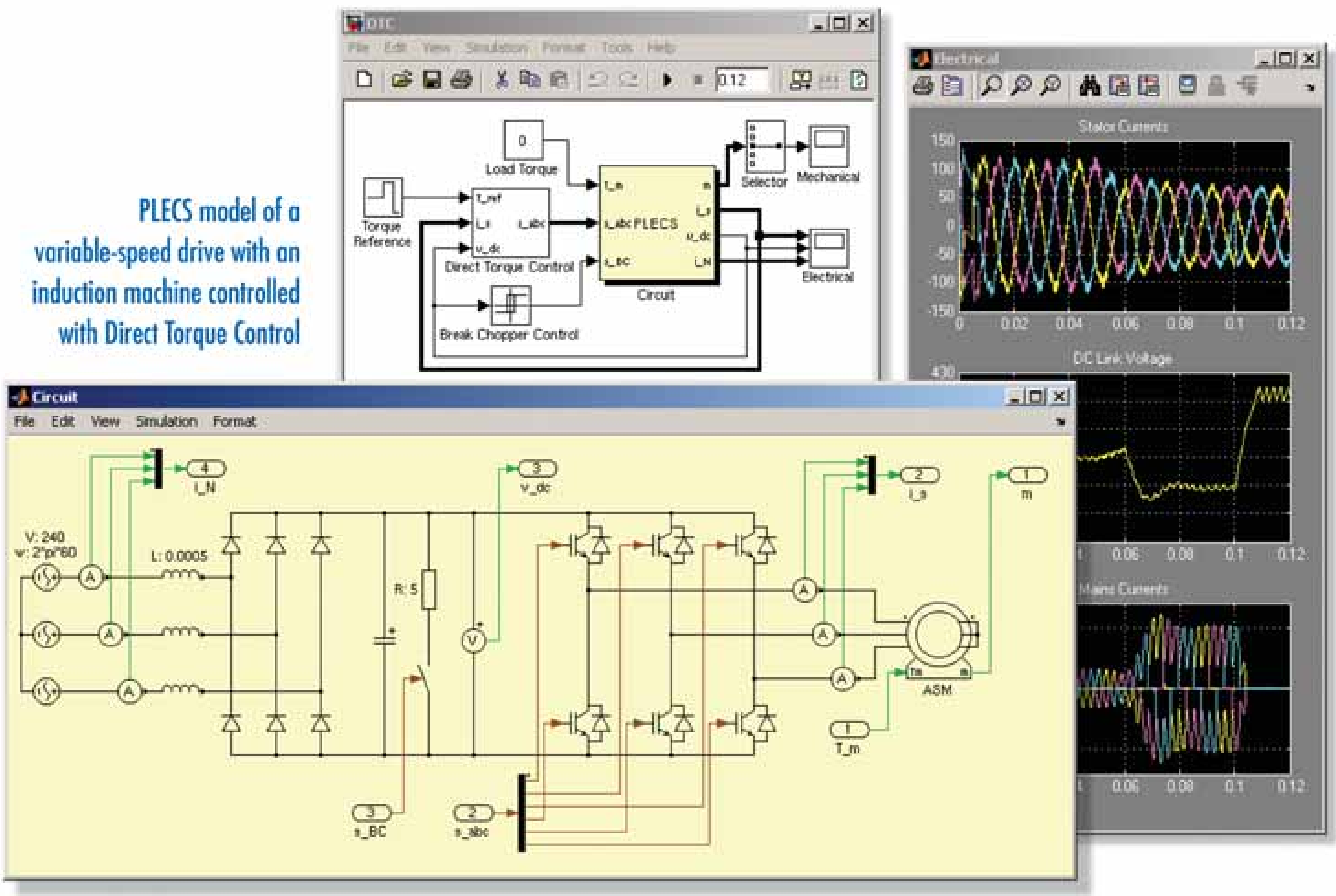

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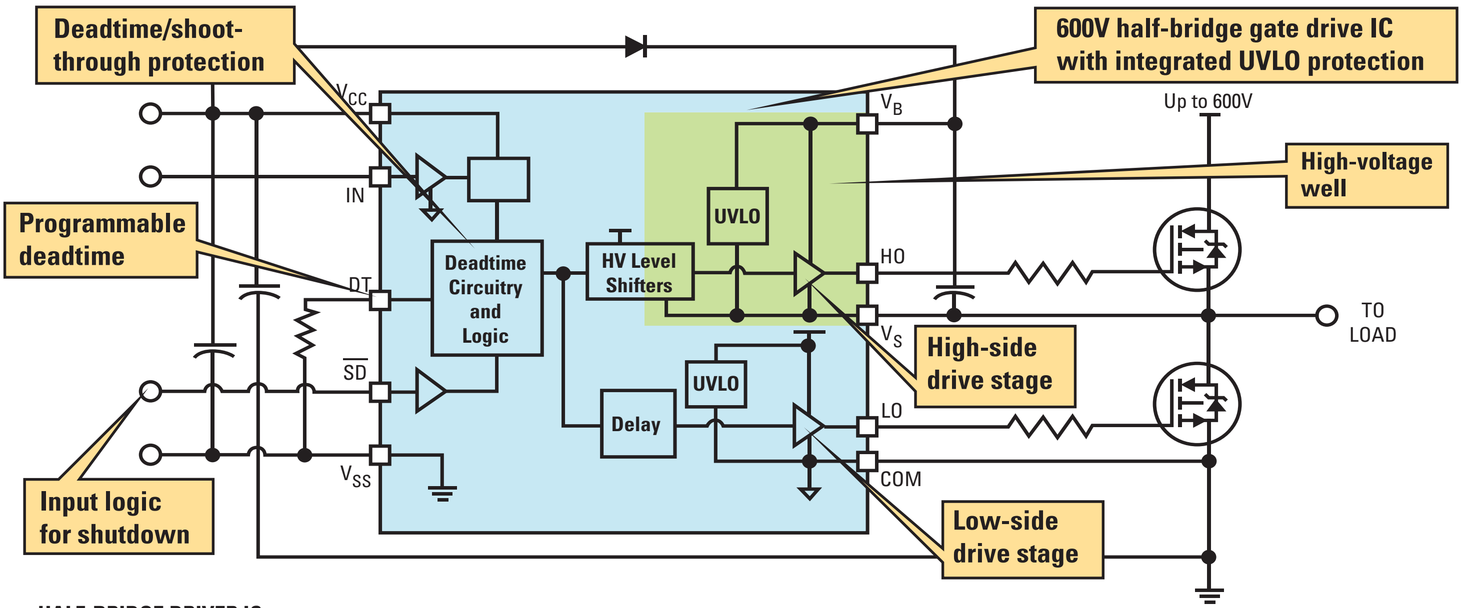

HALF-BRIDGE DRIVER ICs

Part Number	Pin Count	Sink/Source Current (mA)	Comments
IRS2103(S)PBF	8	290/600	UVLO V_{CC}
IRS2104(S)PBF	8	290/600	Input logic for shutdown; UVLO V_{CC}
IRS2108(S)PBF	8	290/600	UVLO V_{CC} & V_{BS}
IRS21084(S)PBF	14	290/600	Programmable deadtime; UVLO V_{CC} & V_{BS}
IRS2109(S)PBF	8	290/600	Input logic for shutdown; UVLO V_{CC} & V_{BS}
IRS21094(S)PBF	14	290/600	Input logic for shutdown; programmable deadtime; UVLO V_{CC} & V_{BS}
IRS2183(S)PBF	8	1900/2300	UVLO V_{CC} & V_{BS}
IRS21834(S)PBF	14	1900/2300	Programmable deadtime; UVLO V_{CC} & V_{BS}
IRS2184(S)PBF	8	1900/2300	Programmable deadtime; UVLO V_{CC} & V_{BS}
IRS21844(S)PBF	14	1900/2300	Input logic for shutdown; programmable deadtime; UVLO V_{CC} & V_{BS}

INDEPENDENT HIGH- AND LOW-SIDE DRIVER ICs

Part Number	Pin Count	Sink/Source Current (mA)	Comments
IRS2101(S)PBF	8	290/600	UVLO V_{CC}
IRS2106/IRS21064(S)PBF	8 / 14	290/600	UVLO V_{CC} & V_{BS}
IRS2181/IRS21814(S)PBF	8 / 14	1900/2300	UVLO V_{CC} & V_{BS}

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