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From The Editor

John M. Miller

This issue begins my third year as editor-in-chief and I'm very pleased to continue in this position and to bring relevant and late breaking news to all our members. I'm joined in this endeavor by some very able individuals: associate editor, Prof. Juan Balda, electronic media editor, Prof. Issa Batarseh, executive officer, Bob Myers, and our regional sales managers, Mr. Walter Chapula, Eastern U.S.A., and Mr. Mal Elgar, West and Central U.S.A. plus international. For 2006 we will continue with the issue as it is currently formatted with four color front and back covers on high quality paper as well as both inside covers allocated to full page advertisements. Inside two color format has very substantially added to clarity and readability. The general organization of each issue will continue with updates on the membership, PEL's chapter reports, and meeting announcements and second call for papers with the most near term meeting announcements up front. The center portions of each issue continue to be set aside for technical tips and tricks and focus articles that reflect the theme assigned. Moving to the back of the issue readers will continue to find articles on recent awards, requests for award nominations, various technical committee and society initiatives, book reviews, future meetings of interest, first call for paper announcements and past meeting or conference synopsis reports.

Planned themes for future issues have been modified somewhat because of the need to accommodate more extensive treatments of topics that are becoming more relevant to the power electronics professional. In this issue we introduce a very timely article on extreme environment electronics beginning with part one, high temperature. The remainder of the year is planned out as:

January 2006	extreme environment electronics part 1
April 2006	extreme environment electronics part 2
July 2006	power dense converters and inverters
October 2006	transmission and distribution of power

John M. Miller, EIC
pelsnews@ieee.org

High temperature amplifier (developed for U.S. Dept. of Energy Deep Trek program) die background courtesy Honeywell

Space shuttle and Engine courtesy of PhotoDisc™

Power Electronics Society Forms New Standards Sponsoring Committee

The Power Electronics Society has recently begun the formation of the Power Electronics Standards Committee (PELSC) under my direction, H. Alan Mantooth, Professor of Electrical Engineering at the University of Arkansas. I will serve as the committee's first chairman. PELSC will act as the IEEE sponsor for all power electronics standards that emerge from within PELS. PELSC will not directly work on specific standards, but will provide organizational oversight for working groups and standards committees and help to maintain continuity when these groups become dormant in the period after a standard has been published or successfully reaffirmed.

This article is intended to raise awareness of the society leadership's desire to make sure that PELS plays an active role in standards activities that are vital to the power electronics industry. Many of our sister societies have done a much better job at identifying and pursuing standards for their industries. As power electronics grow into more applications ranging from consumer electronics, industrial electronics, military electronics, and beyond it is important that the "machinery" be in place to facilitate the necessary standards formation.

On behalf of PELS, it's AdCom and the PELSC, I would like to send out this request for volunteers to serve on the inaugural PELSC. To begin our activities, I have contacted all of the technical committee chairs within PELS requesting that they suggest one name to serve as a representative from their committee on PELSC. From these individuals, the other officers for PELSC will be elected (Vice-Chair, Secretary, and Treasurer). Working group chairs will also have a seat on the PELSC and as each technical committee becomes represented by one or more working group chairmen, that committee may no longer be required to appoint someone to PELSC specifically. PELSC will meet approximately four times per year at some of the major conferences sponsored by the society and spaced out somewhat equally throughout the year. For example, the next meeting will be held at APEC in Dallas in March, one meeting at PESC in Korea in June, one at IAS in October in Tampa, and one strictly teleconference call to be determined. Teleconference facilities will be available for individuals to phone in whenever they are unable to make the meetings in person. These meetings will be conducted in accordance with IEEE Standards Association rules for reporting on the status and progress of ongoing standards activities. PAR approval, working group formation approval, balloting, and many other items of business for PELSC will be performed via e-mail as much as possible.

As a matter of information, there are currently nine standards that, as of this writing, are in danger of being administratively withdrawn if they are not reaffirmed by a simple ballot. These are listed below:

- 1515-2000 IEEE Recommended Practice for Electronics Power Subsystems: Parameter Definitions, Test Conditions, and Test Methods
- 111-2000 IEEE Standard for Wide-Band (Greater Than 1 Decade) Transformers
- 295-1969 (R2000) IEEE Standard for Electronics Power Transformers
- 388-1992 (R1998) IEEE Standard for Transformers and Inductors in Electronic Power Conversion Equipment
- 389-1996 IEEE Recommended Practice for Testing Electronics Transformers and Inductors
- 390-1987 (R1998) IEEE Standard for Pulse Transformers
- 393-1991 (R1998) IEEE Standard for Test Procedures for Magnetic Cores
- 436-1991 (R1998) IEEE Guide for Making Corona (Partial Discharge) Measurements on Electronics Transformers
- 449-1998 IEEE Standard for Ferroresonant Voltage Regulators

Based upon the request of PELSC, these standards have been granted a one-year extension (Dec. 2006) to perform a reaffirmation ballot, if no changes are to be made. If changes are warranted or desired by the working groups, then a project revision can be initiated to activate that work. Otherwise, the standards are administratively withdrawn, which simply means the standards documents are not actively being maintained. The standard still exists, of course.

The last eight of the nine standards listed above fall under what is known as PEL/ET or Power Electronics/Electronics Technical committee. This is a perfect example of how a technical committee will coordinate standards activities. PEL/ET has been very active comparatively to the rest of PELS technical committees regarding standards. As mentioned earlier, each of the working group chairpersons will occupy a seat on the PELSC in addition to the technical committee appointee. As PELS attempts to "institutionalize" its standards activities other technical committee-based standards activities will have representation on PELSC for reporting and voting. Matt Wilkowski is the current standards liaison for PEL/ET and is working with me to get PELSC off the ground along with addressing the needs of the standards listed above.

In other relevant news regarding PELSC, Ahmed Zobaa has been appointed as the PELS representative to SCC-22, the Standards Coordinating Committee on Power Quality. Further, Ahmed will be serving as the representative to PELSC from the Technical Committee on Simulation, Modeling and Control. I would like to request that all technical committee chairs that have not responded to me with a standards representative for PELSC please do so immediately. I would encourage all PELS members to consider volunteering for standards activities such as this opportunity by working through your technical committee. Feel free to contact me if you need guidance in getting connected with the right people within PELS.

- Alan Mantooth

First IEEE William E. Newell Technical Field Award Announced

By Randy Frank, PELS Awards Chair

The first IEEE William E. Newell Technical Field Award was awarded for 2006. The recipient is Deepakraj M. Divan, a professor at Georgia Institute of Technology in Atlanta, GA., "For leadership in the development of soft-switching power converters."

This prestigious award is sponsored by the Power Electronics Society and until recently was the society's highest award. With the recent elevation to an IEEE Technical Field Award, the recipient receives a newly created bronze medal, certificate and honorarium. The new nomination procedure and additional information on the IEEE William E. Newell Technical Field Award is available at http://www.ieee.org/portal/pages/about/awards/sums/newellsum.html

The deadline for nominations for the 2007 award is Jan. 31, 2006.

International FEC 2005 winner: Post script

This is a photo of the University of Belgrade team which won first place honors as part of the Future Energy Challenge this summer in a meeting with the president of Serbia, Mr. Boric Tadic. The Belgrade team was selected as the first place winner in the Motor Drive Design Topic A Category and a $10,000 prize, Outstanding Presentation and a $2,000 Prize and Outstanding technical Report and a $2,000 prize.

Submitted by,
Bob Myers
PEL's Executive Officer

University of Belgrade team

Second Call for Papers

pesc06

Jeju korea

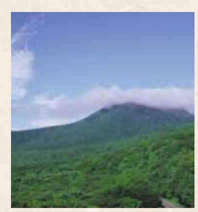
Topics of Interest

- Aerospace Power Applications
- Automotive Applications
- DC-DC Converters
- Education
- Energy Storage
- Inverters and Inverter Control Techniques
- Motor Drives
- Power Quality and Utility Applications
- Rectifiers and AC-AC Converters
- Other Power Electronic Applications
- Alternative Energy Resources / Distributed Generation
- Consumer Application
- Digital Techniques Applied to Power Electronics
- EMI-EMC
- Integration, Packaging and Modules
- Modeling, Analysis and Simulation
- Passive Components
- Power Semiconductor Devices
- Resonant Converters

Paper Submission

To be considered for the conference program, authors should submit electronically in pdf format only:

- An abstract of 300 words maximum. The abstract should contain the title, author's name(s), affiliation(s), contact author and his/her, mailing address, and telephone and fax numbers. Abstracts exceeding the maximum length will not be considered.
- A digest of 5 pages maximum. Outlining the work to be presented, it should consist of the objectives of the paper and the results obtained. Key equations, figures and tables should be included within the page limit (reference list should be submitted as a separate page). Digests exceeding the maximum length will not be considered.



Paper submissions will be accepted electronically. Detailed instructions will be available on the PESC06 website. (Technical Program Chair: Prof. Seung-Ki Sul / E-mail: sulsk@plaza.snu.ac.kr)

Important Dates

- Submission of Abstract and Digests
  November 4th, 2005
- Author's Notification of Acceptance
  February 17th, 2006
- Submission of Final Manuscripts
  April 21st, 2006

pels KIPE IEEE KOSEF 한국관광공사 KOREA NATIONAL TOURISM ORGANIZATION

IEEE IAS/PELS/IES German Chapter meets at Goldisthal

By: Dr. Ingo Hahn

More than 60 engineers and students met in central-German Thueringen on October, 13th and 14th, 2005 during a joint meeting of the Joint IAS/PELS/IES German Chapter and the PES German Chapter. It has been hosted by the Technical University of Ilmenau and by Vattenfall Europe who presented their unique pump storage plant at Goldisthal.

After an introduction and a report about the planned chapter activities in 2006 by our chairman Prof. Lindemann, University of Magdeburg, an overview about the research areas of the institute of electrical energy and controls was presented by Prof. Dirk Westermann, TU Ilmenau, followed by detailed introductions of the respective chairs:

Prof. Westermann himself is head of the research group for energy supply. The group's special interests are the security of energy grids, their control and optimization, and real time simulations. In the sequel all research groups presented themselves.

The research group for electrical equipment was presented by Dr. Reichert. The research areas of this group are high-voltage technology, especially switching devices, location of partial discharges, impulse and lightning protection. To develop the necessary equipment finite-element analyses, computational fluid dynamics and circuit simulation tools are in use.

Prof. Petzoldt presented the research group for power electronics and controls. The research areas are power electronics, controls and electrical drives. Actually this group consists of four research assistants at the university and about 16 researchers at the associated industry-driven ISLE GmbH. Also the ISLE GmbH is one of competence centers of ECPE (European Center for Power Electronics). Some of the projects are steer-by-wire systems, power quality analysis, switched-reluctance machines as a pump drive and fuel cells.

Next Prof. Oesingmann presented the research group for small electrical machines. Some examples of the research are small vibrational motors in mobile phones and motors with bell-shaped rotors, which costs should be smaller than 0.37 Euro. The main competence of this research group is the electromagnetic design of such small machines.

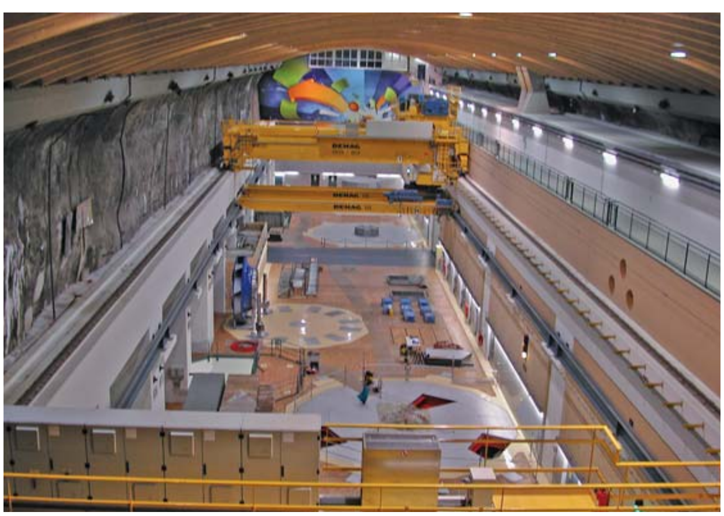
The last presentation was given by Prof. Schulze about the research group of electro-thermal energy conversion. The classical field of this research group is induction heating. An actual research topic is the dynamic of magneto-fluids. Special projects are the electromagnetic support of molten metals, turbulent flow of metals and the crystallization of metals in high magnetic fields with flux densities up to 5 T. Furthermore the research group performs numerical simulation for coupled electromagnetic, thermal and flow fields.

After these presentations the participants have had the opportunity to visit the laboratories of the institute of electrical energy and controls.

In the evening, the social meeting took place at the Romantik Hotel Gabelbach in the woody mountainside close to Ilmenau. Besides tasty local food and beverages in homelike atmosphere, the participants enjoyed a program comprising a stirring presentation of Prof. Petzoldt, President for Education of Ilmenau University and Academic Relation Officer of the Joint IAS/PELS/IES German Chapter, about current and foreseeable development of engineering education, academic structure and university financing. Further, PES German Chapter used the event to honour a student with its annual Best Diploma Thesis Award 2005, awarded by Prof. Kindersberger from Technical University of Munich.

The second day, October, 14th, 2005, started in the technology center of Ilmenau with three presentations about the pump storage plant. First Dr. Möhlenkamp, Alstom, explained the behavior of converter controlled renewable energy production like wind power generators in case of blackouts. When the voltage of the grid returns after a shortage, an overshoot of the mechanical torque up to four times of the rated torque is possible. Usually three different types of electrical machines are used for wind power generators: the doubly-fed induction machine, the squirrel-cage induction machine without pitch control of the rotor blades and the synchronous machine with pitch controlled rotor blades.

The presentation given by Prof. Kindersberger, Technical University Munich, dealt with gas-insulated tube conductors for high voltage transmission. With these conductors voltages of about 420



View in the turbine cavern showing generator opened for maintenance

Chapter members at the upper basin (left side) and downhill is the valley (right side).

kV to 550 kV can be transmitted. They consist of an outer cylindrical aluminium tube with a wall thickness of about 8 mm and an inner concentric conductor. The inner conductor carries the high-voltage. Because of this construction there are minimal outer magnetic fields. About each 11 m additional supporting insulators are foreseen to fix the inner conductor. The cavity between the inner conductor and the outer cylindrical tube is filled with a mixture of nitrogen and sulfur-hexafluoride for electrical insulation.

In the following Mrs. Bocquel, Alstom, presented the 300 MW variable speed drive for the pump storage facility of Goldisthal. Four turbines are installed there equipped with two synchronous machines and two doubly-fed induction machines each with a rated power of about 340 MVA. The synchronous machines have a bore diameter of 6 m and a classical excitation. The rotor circuits of the two induction machines are supplied by a 100 MVA cycloconverter each, carrying a rated current of 9 kA. The speed control of these electrical machines uses the concept of a Kalman filter to estimate flux and torque.

The presentation by Mr. Voigt, Vattenfall Europe, gave an introduction to the history, technical aspects, and economic use of the pump storage facility of Goldisthal. Planned in 1965 for 3000 MW the geological exploration was finished in 1972. Official approval started in 1991. In 1997 the construction started and in 2002 the pump storage facility of Goldisthal was connected to the power grid. Continuous operation started in 2003. The upper basin has a capacity of 12 million cubic meters of water. The falling height is nearly 330 m. The peak current of each turbine-generator set is 12 kA. The two synchronous machines and the two doubly-fed asynchronous machines each have a bore diameter of 6 m. The synchronous machines have an air gap of 35 mm. The asynchronous machines have an air gap of 15 mm.

The very highlight of the meeting was the following visit of the pump storage facility itself operated by Vattenfall Europe. During this excursion all participants have had the opportunity to visit the turbine cavern nearly 800 m inside a mountain and both basins. The turbine cavern has a length of 150 m, a height of 50 m and a width of 30 m to 40 m. The water flows from the upper basin to the four turbines through two tubes, each having an inner diameter of 6 m. The peak water flow is 80 cubic meters to 100 cubic meters per second. The upper basin is located on the leveled top of a mountain about 330 m over the turbine cavern. The Vattenfall team had thoroughly prepared the reception of the large group. The guides gave a deep insight into the impressive technology, related potential and challenges and its daily operation.

To obtain copies of various presentations and for further information about the IEEE Joint IAS/PELS/IES German Chapter in general including 2006 meeting plan, please visit our homepage at http://www.ewh.ieee.org/r8/germany/ias-pels

Dr. Ingo Hahn, IEEE Joint IAS/PELS/IES German Chapter

Emerging Capabilities in Electronics Technologies for Extreme Environments Part I – High Temperature Electronics

H. Alan Mantooth, IEEE Sr. Member
Mohammad M. Mojarradi, IEEE Member
R. Wayne Johnson, IEEE Fellow

Abstract

This article describes the current status of technologies used to realize electronics for extreme environments. While VLSI technologies predominantly focus on supporting commercial applications ranging between -55ºC and 75ºC, many applications such as electronics for under the automobile hood and electronics for geothermal systems would be best served by technologies that could survive the environmental conditions in which the system is deployed. While each of these applications could be considered as niche, together they form the basis for research into extreme environment electronic systems. Power electronics are widely used in these applications, but constitute only one facet of a fully integrated system. Focusing primarily on temperature effects, this article indicates the areas of research needed to move forward with a sound design methodology for realizing high performance, fully-integrated electronic solutions.

I. Introduction

Electronics have dramatically changed the way we live our lives, conduct business, communicate, and educate. However, the environments in which electronics can reliably operate are at present limited. For example, in consumer applications, typical operating temperatures range from -40 oC to +85 oC and the 'wider' military standard is still just -55 oC to +125 oC. The Semiconductor Industry Association (SIA) 2003 International Technology Roadmap for Semiconductors (ITRS) only extends the ambient operating temperature for integrated circuits in harsh environments to -40 oC to +150 ∞C in 2005 and to -40 ∞C to +200 ∞C beginning in 2010 [1]. Electronics are also susceptible to radiation exposure, not just in space applications [2] but also here on Earth. This is because the continued scaling of device dimensions has made the effects of residual radiation a critical reliability issue for manufacturers of consumer electronics [3, 4]. For example, single-event effects (SEE) caused by cosmic rays, which can produce either hard or soft errors, have been observed both on the Earth's surface at levels that can measurably impact commercial microelectronics technologies [2-5], and in avionics at levels that would jeopardize the reliability of these systems if mitigation strategies are not employed [6]. Using electronics in corrosive chemical or high vibration environments also places severe constraints on system complexity and reduces overall reliability.

Future advances in engineering, scientific discovery, and exploration of key importance to national priorities will require advanced electronic systems to operate in environments that combine extremes of temperature with corrosive chemistry/biochemistry, mechanical vibration, and radiation. The narrow confines of commercial electronics are such that it will be impossible to address many of these priorities such as those related to energy, transportation and Earth and space exploration. A new approach will be needed; one that allows electronics to function in a combination of extreme environments.

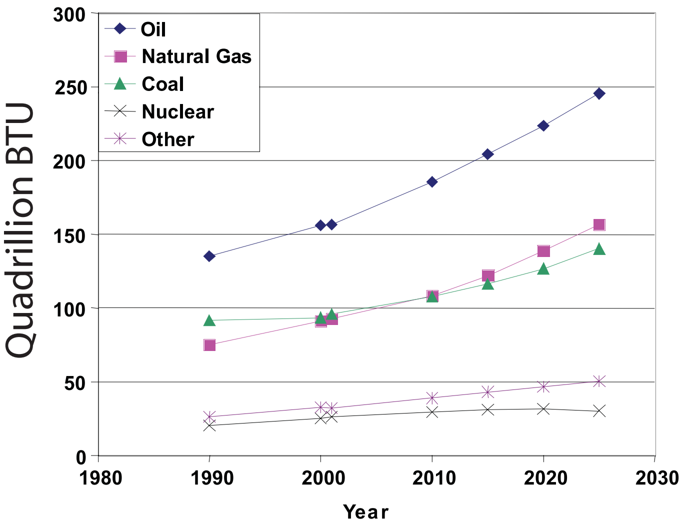


Fig. 1. World Energy Consumption. [7]

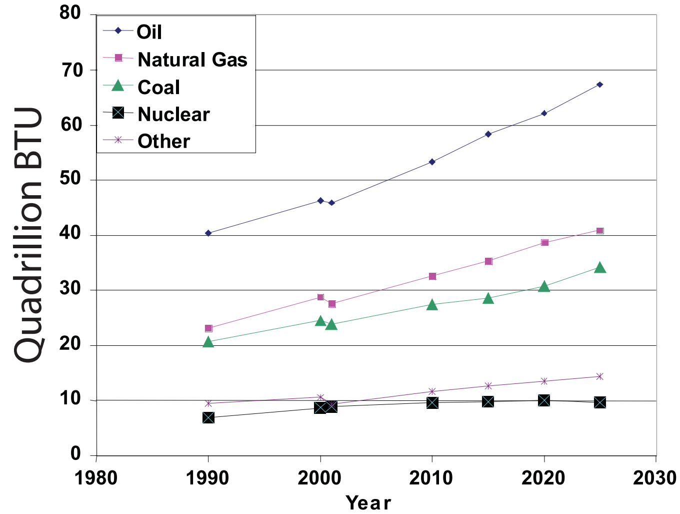


Fig. 2. North American Energy Consumption. [7]

This article is the first of two that will focus on the technologies required to achieve wide temperature operation beyond the military range. Part I will describe issues and barriers to achieving high temperature operation. In this context, two regimes are found about the maximum military temperature. The first regime is the 300 ∞C neighborhood, while the second is the 500 ∞C vicinity.

Other extreme conditions such as corrosiveness and mechanical shock and vibration are primarily addressed through advanced electronic packaging technologies, which will be described in the context of wide temperature electronics. Another environmental effect that can be very important is radiation, in particular in combination with low temperatures. Some remarks are made about radiation issues, but primarily in the low temperature article.

II. Applications of Extreme Environment Electronics

Energy is clearly critical to economic and national security. With the rapid economic development in other parts of the world, the worldwide demand for energy will continue to rise. According to Department of Energy (DoE) projections, twenty years from now petroleum will still be the dominant source of energy despite advances in alternate energy sources (Figs. 1 - 2) [7]. However, the easily recoverable oil and gas will be diminishing in supply. In fact, during the next decade, the largest growth in natural gas (US and Canadian) will be from deep wells, defined as greater than 15,000 ft. To increase oil and gas recovery, instrumentation is required in the well during drilling and throughout the production life. The well temperatures vary from 150 ∞C to over 300 ∞C and pressures can reach 25,000 psi. The well also contains steam and corrosive gases and naturally occurring radiation. During drilling, the drill and associated logging instrumentation are subjected to high levels of shock and vibration.

When drilling at depths in excess of 20,000 ft, the driller on the surface has little control or even an understanding of drill bit-rock interaction. Drilling tools with electronics and sensors are needed to monitor and steer the drill bit. In the future, electronic control systems will monitor and correct drilling problems. Formation sensors are used during drilling to gather geological information to identify production zones.

Only about 20% of any oil reservoir is ever recovered. As such, there is an increasing use of horizontal “lateral” drilling that is pushing 20,000 ft. In the more distant future, ‘robotic’ tractors with electric drilling motors combined with formation sensors will drill new production zones while the well continues to produce oil and natural gas, thereby increasing the production rate and total reservoir recovery.

While limited in functionality, the state-of-the-art in high temperature downhole oil and gas monitoring tools is the Pressure-Temperature tool recently demonstrated by Sandia National Laboratories [8]. This tool utilizes the Honeywell high temperature silicon-on-insulator (SOI) device technology, rated for continuous service at 225 oC for 5 years. Honeywell offers a limited standard product line of high temperature devices (12 components). The DoE has funded the Deep Trek Program to expand the Honeywell product offering. These efforts address limited aspects and immediate needs, not the needs 5-20 years from now.

Alternative energy sources such as geo-thermal power will also benefit from high temperature electronics. The Iceland Deep Drilling Project, a member of the International Continental Scientific Drilling Program (ICDP), is preparing a 4-5 km deep drillhole into a hydrothermal system to reach 400-600 °C supercritical hydrous fluid on a mid-ocean ridge. Here, the energy density is up to 8 times higher than that available from non-supercritical hydrothermal vents, but will require extreme environment electronics if it is to be fully exploited.

Scientific discovery in the field of Earth Sciences also benefits from extreme environment electronics. The drilling and instrumentation technological advances will enhance earth science projects such as the USGS and NSF-funded Earthscope Project that includes the San Andreas Fault Observatory at Depth (SAFOD). A 5 km well will be drilled into the San Andreas Fault and instrumented to collect scientific information.

Transportation is both an important manufacturing segment in the US economy as well as critical infrastructure for moving goods, services and people. In the automotive industry, the system design trends are toward mechatronics (integration of electronics and mechanical systems, i.e. electronics in transmissions) and X-by-wire (X = throttle, steer, shift, brake) [9-12]. The goals are distributed electronic architectures, replacing mechanical and hydraulic systems with electromechanical systems to simplify assembly, improve fuel efficiency and increase safety. Table 1 lists the maximum ambient operating temperatures associated with different automotive locations. Hybrid electric and future fuel cell vehicles will further increase the electronics content. The power and control electronics for these vehicles will require either elaborate cooling systems (size, weight, and cost) or electronics capable of reliable operation at high temperatures. In addition to temperature, automotive electronics are exposed to other extreme conditions including wide thermal cycles, shock, vibration, fluids and corrosive gases. Finally, many next generation mechatronics systems will employ MEMs devices for miniature sensor applications. The packaging of these devices for extreme environment applications will be critical to the success of these new systems.

Table 1. Automotive Maximum Ambient Temperatures

Under-hood	100-125 °C	On Wheel	150 – 250 °C
On-Engine	150 – 200 °C	Cylinder	200 – 300 °C
In-Transmission	150 – 175 °C	Exhaust	Up to 850 °C, ambient 300 °C

High temperature, radiation tolerant electronics are needed by the commercial aircraft industry. To meet global, high speed transportation needs twenty years from now, high altitude, hypersonic passenger planes will fly between the US and Australia in 3 hours. The January 2004 issue of IEEE Spectrum describes hypersonic passenger flight as the holy grail of transportation [13]. To accomplish this feat, engines and new airframe designs will be required with complex computer control to maintain flight stability and control dynamic aeroelastic wings. The hydraulic systems of today will be replaced by distributed electromechanical systems, to decrease maintenance cost, improve performance, decrease weight and decrease fuel consumption. These distributed electronics and sensors will be located in high temperature locations including on-engine where temperatures can reach 500 ∞C. In addition, the high altitude flight will expose the electronics to increased radiation levels.

III. Status of High Temperature Electronics Technologies

Active Electronics – High and Low power

Most commercially available electronic devices have rated temperature limits of operation (125 ºC) far below those required for an extreme situation such as engine electronics (under the hood) and geothermal applications (300ºC). Conventional silicon (Si) devices cannot be used above 200 ºC, due to problems with leakage and latch-up at reverse bias junctions. For functionality to 300 ºC, these problems may be managed using Si on insulator (SOI) technology, where devices are isolated on the integrated circuit dielectrically. Beyond this temperature, however, SOI also becomes unusable due to leakage. At temperatures above 300 ºC, alternatives such as wide bandgap semiconductors are needed. The most highly developed of these are SiC and GaN. An alternative set of devices capable of operating at 500 ºC are thermionic vacuum microelectronics. In addition to the aforementioned active devices, the development of passive components has had mixed success. Currently, thick film ruthenium oxide resistors are capable of operating for long periods of time at 500 ºC; however, general-purpose ceramic capacitors, the best candidate technology for high temperature operation, often tend to exhibit wide variations in capacitance with increases in temperature, particularly as the dielectric constant is increased. Finally, the packaging of high temperature devices requires the careful selection and evaluation of substrate, die attach and interconnect materials that are capable of withstanding high temperatures, without decomposing, forming excessive, brittle intermetallics, Kuykendall voiding, or breaking due to mismatched coefficients of thermal expansion.

The theoretical temperature limits of various solid-state semiconductors, which are governed by their bandgaps and carrier mobilities, are summarized in Tables 2 and 3, along with their maximum service temperatures. These practical limits are determined by the metallurgical contacts of the devices, electromigration within metal traces, time dependent breakdown of gate dielectrics, and defects within the semiconductors. SiC and GaN are the most highly developed wide bandgap semiconductors. Currently, discrete SiC diodes and Metal Semiconductor Field Effect Transistors (MESFETs) are available commercially, and Junction Field Effect Transistors (JFETs), Bipolar Junction Transistors (BJTs) and Metal Oxide Semiconductor Field Effect Transistors (MOSFETs) are currently being developed [14]-[17]. Even thyristors have been demonstrated [18]. Since high power circuits are the commercial applications that can make best use of the inherent properties of SiC, only discrete, high voltage transistors are currently available. In addition, normally-on JFETs are the most widely available for high temperature applications [19]-[21], but development of normally off JFETs and BJTs is ongoing. MOSFETs are unable to withstand high temperatures due to breakdown of the gate dielectric, while thyristor development is relatively immature. Evaluations of currently available commercial SiC devices indicate that they can survive operation within a 500 ºC ambient environment for at least tens of hours, a limit determined by the degree of electromigration within the metal traces and oxidation of the ohmic contacts. Commercial GaN devices, on the other hand, have been developed for high speed and microwave applications. They are currently available at the small scale integrated levels for military and defense applications; however, their operation at 500 ºC has not yet been demonstrated even at the discrete transistor level.

Table 2. Capability of High Temperature Technologies.

Electronics Technologies	Theoretical Temperature Limit of Semiconductor (°C)	Practical Device Temperature Limit (°C)
Bulk Si	400	225
SOI	400	300
GaN	900	600
SiC	900	600
Thermionic Vacuum Devices	1000	600

Table 3. Summary of the Status of High Temperature Transistor Technologies.

Technology	Transistor type	Operating Voltage	Freq limit	Demonstrated Temperature	Power Consumption	Integration Scale
SiC	Normally on	>200V	200 MHz	500 °C	High	Discrete
GaN	Normally on	>15V	100 GHz	300 °C	Medium	SSI
Vacuum Transistors	Normally on	>200V	2 GHz	500 °C	High	Discrete
SOI CMOS	Normally off	5V	20 MHz	300 °C	Low	MSI

Passive Elements

Passive elements for high temperature applications depend not only on the survivability of resistive elements, dielectrics or magnetic core materials, but also on the component packaging or contact technology, which is the most common site of failure for devices that have not been designed for high temperature operation. With respect to resistors, thin film and thick film resistors deposited on ceramic substrates provide the best performance and miniaturization of currently available resistor technologies. Potential problems include oxidation of thin film resistive elements with time at temperature and drift in thick film resistors. Thick film resistors have been characterized at 500 ∞C and both thick film and wire wound resistors have been characterized at 300 ∞C [22, 23]. Degradation of other potential candidate resistors must be characterized in detail, in order to make use of them in 500 ºC circuits.

Capacitors are particularly challenging devices for high temperature operation, since they tend to vary in capacitance with increasing temperature, particularly as the dielectric constant is increased. At elevated temperatures, the leakage currents of these capacitors become very high, making it difficult for the capacitor to hold a charge. The most promising candidates for high temperature (500 ºC) capacitors are NP0 ceramic capacitors (for low capacitance values) and piezoelectric based capacitors. NP0 capacitors have minimal variation in capacitance with temperature, but unfortunately they exhibit a significant increase in dissipation above 300 ºC. Piezoelectric capacitors are designed for operation at a specific temperature, and therefore exhibit optimum properties at the desired temperature. Unfortunately, this peak in behavior is very narrow, with respect to temperature, and these capacitors change significantly with increasing temperature. Various capacitor technologies, such as diamond capacitors and other alternative dielectric materials, are currently under development and may offer superior properties throughout the entire temperature range from 23 to 500 ºC. Large value (>1mF) capacitors and high voltage (>100V) present a significant challenge for operation at 300 ∞C and above.

Packaging

Electronic packaging for high temperatures is distinguished from that within conventional temperature ranges due to the following issues: decomposition or melting of materials, coefficient of thermal expansion (CTE) mismatch, interdiffusion of different metal layers or interconnects, and electromigration. For example, the maximum use temperature for most polymers is less than 300 ºC. Therefore, above 300 ºC, there are no available polymers for circuit boards, underfills, encapsulants, cable/wire insulation, die attach or a variety of other applications used in conventional electronic packaging. Regarding melting, various solders and die attach materials used at lower temperatures are not applicable at higher temperatures. To further complicate matters, solders are usually selected to have reflow temperatures at least 50 ºC higher than their use temperature. Increasing processing temperatures of solid state electronics to 550 ºC rather than 500 ºC could significantly reduce the survivability of the active circuitry. Liquid phase transient (LTP) bonding has been used with eutectic Au-Sn. By dissolving excess Au into the eutectic Au-Sn from either the substrate or the die metallization, the melting point can be raised to ~450 ∞C at a composition of Sn <10wt.%. This die attach process can be performed at 400 ∞C [24].

Assuming that all of the materials used in the packaged assembly survive exposure to the required temperatures, careful selection of materials to minimize mismatch in coefficients of thermal expansion (CTE) is critical, due to the significant temperature range of operation and the stiffness of die attach materials that are capable of withstanding such temperatures. Differences in CTE between the substrate and the die could lead to die fracture and fatigue. In addition, stresses at the die edge can cause horizontal crack propagation and die lifting. For power modules, the CTE mismatch between the ceramic substrate and the thick copper foils can lead to delamination and cracking of the ceramic during thermal cycling over wide temperature ranges. Finally, diffusion and electromigration are both significantly influenced by increasing temperature. Interdiffusion of different metals at the die bondpad can result in failure of the electrical interconnect. The example most often used for this phenomenon is the Au-Al system, in which the diffusion of Au into Al leads to the formation of intermetallics in the Al side and voiding in the Au side of the interface. A summary of the maximum service temperatures and limiting properties for a selection of die bondpad wire bond combinations is provided in Table 4.

Considerations for 300 °C Neighborhood

At temperatures in the 300 °C range, it becomes feasible to exploit traditional Si-based electronics. Currently available SOI circuits that have been qualified for 225 °C operation (demonstrated to work at 300 °C) include gate arrays, microcontrollers, 256K SRAM and operational amplifiers. Once again the wide bandgap technologies hold the most promise for the power devices. This temperature range brings GaN technology into play along with SiC – depending upon the application. With respect to passive components, similar resistors to those used at 500 °C would be used at 300 °C. Capacitors are significantly less problematic at this temperature, and currently available NP0 should function well for low value capacitor needs. Electronic packaging for 300 °C would be similar to that used at 500 °C.

Table 4. Maximum Use Temperatures and Limiting Properties for Select Bondpad-wire Metallurgical Combinations.

Metals: Pad-Wire	Max. Temp. (°C)	Properties/Comments
Al-Au	175	Forms brittle intermetallic phases which reduce bond strength and conductivity.
Ni-Al	300	Interdiffusion creates excessive voids that decrease bond area and strength.
Al-Al	660	Melting temperature of Al.
Au-Au	1064	Melting temperature of Au.

IV. Technological Needs

Although the operation of various devices has been proven at elevated temperatures, the technological improvements outlined in Table 5 are necessary to develop systems with the needed capabilities. As mentioned previously, current SiC devices are available as discrete, normally-on, high voltage devices. In order to use SiC for the development of 500 ºC instrument amplifiers and other small-signal circuits, having transistors capable of working at low voltages is critical. In addition, the availability of complementary devices (normally on and normally off) as well as the resulting integrated circuits allows device matching and the capability to tailor device properties to the application. For power electronic circuits, normally off devices would allow power switches to default to the off position in the case of failure. For logic circuits, complementary devices reduce required power. Low voltage small-scale integrated circuits are already available in GaN; however, the high temperature survivability of this technology has not been established. Modification of metal layers may need to be pursued in order to enable 500 ºC operation. Similar to the development required for SiC devices, thermionic vacuum devices are available as discrete, normally-on, high voltage devices, and their use in small-signal circuits would greatly benefit from the availability of low voltage, complementary devices and small scale integrated circuits. With this technology, a 500 ºC S-band telecom system, actuator drivers, sensor amplifiers, and power converters can be developed.

Table 5. Improvements needed and technical direction

Technology	Critical improvements
SiC	500 °C normally off transistors that can operate at low voltages Reliable 500 °C SSI level of integration
GaN	500 °C normally off low voltage transistors Reliable 500 °C SSI integration technology
Vacuum Transistors	500 °C normally off low voltage transistors Reliable 500 °C SSI integration technology
SOI CMOS	Ultra low power (0.2 µW/gate/MHz) 300 °C LSI technology 40MHz min operating frequency

As with any modern electronics design process, the most fundamental need for extreme environment circuit and system design is accurate models of the semiconductor devices and passive elements that are valid over the conditions to which the circuit is being targeted. These models are used to repeatedly analyze the system as it is being designed. If they are unavailable, the designer is merely guessing as to whether the circuit will work at all at extreme temperatures. If the reliability of the circuit is to be predicted, then both custom designed components as well as commercial-off-the-shelf (COTS) components must have lifetime assessment effects included in their models. Models, modeling methodologies for including end-of-life predictability, and modeling tools to expedite this process are solid requirements for extreme environment electronic design [25].

With respect to passive devices, capacitors that have a low temperature coefficient of capacitance and low dissipation factor over the entire temperature range are greatly needed for a full range of capacitance values.

Potential solutions to several of the current challenges with elevated temperature packaging exist. Ceramic substrates with high temperature metallizations and relatively close CTE matching with SiC or GaN active elements are available, as well as potential high temperature die attach solutions. In addition, the use of Au wirebonds with Au bondpads on active circuitry will reduce the formation of intermetallics at the interface. Options may exist for coating of finished assemblies with ceramics. Unfortunately, negligible work has been done to clearly determine whether these solutions will meet the needs for high temperature electronic systems. Finally, high temperature electronic packaging for high frequency applications must be developed and evaluated in detail.

V. Summary

This article has presented the current state-of-the-art along with many of the high temperature issues for realizing extreme environment electronics. The presentation covered equally all the aspects of an integrated power electronic-based solution including passives, active power devices, low voltage control electronics (integrated circuits), and packaging. While it was not specifically stated, the ultimate miniaturization aim is to fully integrate all of these constitutive parts into a single package or module.

This survey provided a routinely one-dimensional view in that only extreme temperatures were considered, while some combination of temperature, radiation, shock, vibration and corrosiveness often factor into the overall environmental picture. The Extreme Environments Consortium sponsored by the Jet Propulsion Laboratory consists of a number of universities partnered with industry and some national laboratories for investigating new design methodologies, tools and basic physics and materials research for the next generation of extreme environment electronics systems. Member universities include (alphabetically) Arizona State, Arkansas, Auburn, Georgia Tech, Maryland, Purdue, Tennessee, and Vanderbilt.

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Biographies

Alan Mantooth

H. Alan Mantooth (S'83 - M'90 - SM'97) received the B.S. (summa cum laude) and M. S. degrees in electrical engineering from the University of Arkansas in 1985 and 1987, respectively, and the Ph.D. degree from the Georgia Institute of Technology in 1990. He joined Analogy in 1990 where he focused on semiconductor device modeling and the research and development of HDL-based modeling tools and techniques. In 1996, Dr. Mantooth was named Distinguished Member of Technical Staff at Analogy (now owned by Synopsys). In 1998, he joined the faculty of the Department of Electrical Engineering at the University of Arkansas, Fayetteville, as an Associate Professor. In 2003, he co-founded Lynguent, an EDA company focused on modeling and simulation tools. Dr. Mantooth has published numerous articles on models, modeling techniques, and modeling strategies. He holds patents on software architecture and algorithms for modeling tools and has others pending. He is co-author of the book Modeling with an Analog Hardware Description Language by Kluwer Academic Publishers and has served on several technical program committees for IEEE conferences. He served as Guest Editor for a Special Issue on Behavioral Modeling and Simulation for the IEEE Transactions on Computer-Aided Design in February 2003 and as an IEEE Circuits and Systems Society Distinguished Lecturer in 2003-2004. He is currently serving the profession in the following roles: 1) Past-Chairman of the Computer-Aided Network Design (CANDE) committee, the technical committee for CAD for the Circuits and Systems Society, 2) IEEE CAS representative on the Design Automation Conference Executive Committee, 3) Member of the IEEE Council on Electronic Design Automation, and 4) Member of the Power Electronics Society Advisory Committee. Dr. Mantooth is a senior member of IEEE and a member of Tau Beta Pi and Eta Kappa Nu.

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Dr. Mohammad Mojarradi is an integrated circuit design specialist and Chair, Extreme Environment Electronics Consortium, Jet Propulsion Laboratory/California Institute of Technology, and Principal Engineer in Power and Sensor Electronics. Specifically he is an expert in developing mixed-signal/mixed-voltage electronic circuits for smart power systems, sensors and micro-machined electromechanical interface applications for space. He leads a consortium of universities developing electronics for NASA's extreme environments and manages the development of "thermal cycle resistant electronics" for NASA's Mars Science Laboratory. Dr. Mojarradi has over 20 years of technical, management and academic experience. He received his Ph.D. in electrical engineering from the University of California, Los Angeles (UCLA) in 1986. He has twenty-two patents, forty publications and is a member of IEEE. Prior to joining Jet Propulsion Laboratory, Pasadena, CA, he was an Associate Professor at Washington State University and the Manager of the mixed-voltage/specialty integrated circuit group at the Xerox Microelectronics Center, El Segundo, CA.

R. Wayne Johnson

Dr. Johnson is a Ginn Distinguished Professor of Electrical Engineering at Auburn University and Director of the Laboratory for Electronics Assembly and Packaging (LEAP). Dr. Johnson received the B.E. and M.Sc. degrees in 1979 and 1982 from Vanderbilt University, Nashville, TN, and the Ph.D. degree in 1987 from Auburn University, Auburn, AL, all in electrical engineering. He has worked in the microelectronics industry for DuPont, Eaton, and Amperex. At Auburn, he has established teaching and research laboratories for advanced packaging and electronics assembly. He is Editor of the IEEE Transactions on Electronics Packaging Manufacturing. He received the 1997 Auburn Alumni Engineering Council Senior Faculty Research Award for his work in electronics packaging and assembly. Dr. Johnson was the 1991 President of the International Society for Hybrid Microelectronics (ISHM). He received the 1993 John A. Wagnon, Jr. Technical Achievement Award from ISHM, was named a Fellow of the Society in 1994 and received the Daniel C. Hughes Memorial Award in 1997. He is a Fellow of IEEE, and a member SMTA, and IPC.

40th International Universities Power Engineering Conference (UPEC 2005)

7-9 September 2005, University College Cork, Cork, Ireland

T. J. Hammons, Chair, International Practices for Energy Development and Power Generation, University of Glasgow, UK

The 40th International Universities Power Engineering Conference (UPEC 2005) was held 7-9 September 2005 at University College Cork, Cork, Ireland. It excelled earlier conferences by the exceedingly high quality of the presentations, the technical content of the papers, and the number of delegates attending. As in the past, it had a broad theme, covering all aspects of electrical power engineering, and was attended by academics, research workers, and members of the power service and manufacturing organizations.

This year the technical co-sponsors included IEEE/PES/PELS, IEE, CIGRE, and IEI (the Irish body). Industrial co-sponsors included ESBI, University College Cork, and Cork Institute of Technology. The conference was hosted in the historical campus of University College Cork. It provided engineers and academia with the opportunity to explore recent developments, current practices and future trends in power engineering. Young engineers and research students were particularly invited to contribute.

OPENING SESSION

Dr Noel Barry, Chairman of the Organizing Committee, welcomed delegates and accompanying persons to the conference, Cork, and Ireland. He said the International Universities Power Engineering Conference or UPEC as it is more commonly known, with a history of close on 40 years, has provided and still provides engineers and academia with an opportunity to find and explore the newest trends in the development of Power Engineering and scientific methodology that is connected with it.

PLENARY SESSIONS

The first Plenary Lecture was given by Thomas G. Habetler, School of Electrical and Computer Engineering, Georgia Institute of Technology, USA. It was entitled On-Line Condition Monitoring and Diagnostics of Electric Machines. Dean Paterson, Nebraska University Lincoln, USA, who talked on Renewable Energy Engineering—Sustainable-Alternative Energy Engineering, followed this. On the second day Charles Elachi, Director of the NASA Jet Propulsion Laboratory at Pasadena, California Institute of Technology, USA discussed the future of the electrical industry in space exploration (the full presentations can be accessed at http://pei.ucc.ie/UPEC2005/index.htm (editor note: not available at press time)

On-Line Condition Monitoring and Diagnostics of Electric Machines

On-Line Condition Monitoring and Diagnostics of Electric Machines by Prof. Thomas G. Habetler. Traditional monitoring of motors has consisted only of protection. This means that typically, a motor is protected from an overload condition (i.e., misuse) by an overload relay that monitors the current and estimates, usually in a very crude way, the temperature of the machine windings. It is only inexpensive, or sensitive load applications that condition monitoring is extended to include fault prediction. Traditionally, sensors are added to motors to detect specific faults. These include thermal and proximity sensors for bearing faults, accelerometers for vibrations, etc. Fault prediction implies that an impending failure is sensed in the monitored device prior to shutdown, so that maintenance can be performed without incurring unscheduled downtime. Protection and fault prediction, therefore, are philosophically quite different. When both are used with sensible preventative maintenance, low operating costs AND high availability rates can both be achieved.

The work done at Georgia Institute of Technology, and many other research laboratories, has led to monitoring schemes that greatly increase the availability rate of system components without requiring changes to the system configuration or hardware. Such incipient fault detection devices will no doubt become common in the industrial marketplace.

Renewable Energy Engineering—Sustainable-Alternative Energy Engineering.

Prof. Dean Paterson discussed many of the issues of renewable-sustainable energy use in light of the second law of thermodynamics. The proposition was put that no energy is renewable, and budget was presented for energy use in the globe. Several technologies currently experiencing substantial research attention were discussed. The case was made that efficiency of use is a fundamental part of energy considerations, and several topical issues in energy efficiency were discussed. The issue of matching entropy of the load to entropy of the source was introduced. The good news is that the law of conservation of energy holds, that is, there is a finite and unchangeable amount of energy in the Universe, and while it can be changed from one form to another, energy can neither be created nor destroyed The bad news is that the second law of thermodynamics also holds. Whilst in its simplest form it states that heat flows from a hot body to a cold one, in its more complex formulation it discusses the level of disorder, or entropy in the universe, which is continually increasing. Energy in its most organized form continuously and uni-directionally is changing into its least ordered form that of low grade heat, where the energy exists as random molecular or atomic motion.

General opinion is that our solar system is about 5 billion years old and has about another 5 billion years to go, so it seems reasonable to consider a "half time report" on our management of the globe and its resources. Rather than try and estimate the life of the universe, contracting our view to the much shorter "life of the solar system" will still provide a challenge, with some worthwhile insights. The significant and important reality of the second law discussion above is that no energy is renewable. It is all being continuously degraded from its low entropy highly ordered form to its most disordered form, as low grade heat.

AN ENERGY BUDGET MODEL

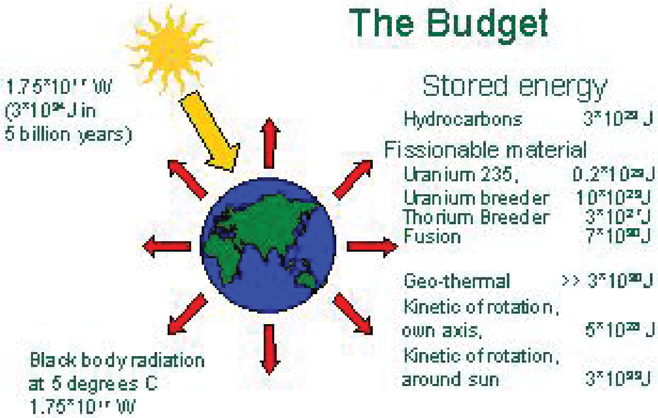

Figure 1. An Energy Budget Model for the Globe

Paterson then viewed the problem in light (of) income, expenditure, and capital accumulation, or energy stored "In the bank", as shown in Fig. 1. It is worth noting however that this particular bank pays no interest. The energy in the bank is shown on the right, and includes energy stored chemically in hydrocarbons, that obtainable through nuclear fission and fusion, and the thermal energy in the core of the earth. The income and expenditure statement however are particularly interesting seen against this "bank balance". Note that incomes and expenditures are in rates, i.e., joules per second or watts, rather than in absolute joules. The figure for insolation over the notional 5 billion years is however instructive. Further, the incoming energy in some 20 days is equal to the total stored in hydrocarbon form.

Storage

The budget model highlights the issue of adding to the bank balance, or storing energy in some way. Since many of our alternative sources such as wind and solar are highly variable, high levels of penetration imply storage to match the unrelated demand profiles of consumers. Thermal storage is under consideration, however storage at very high temperatures and hence high entropy becomes progressively more difficult. Unfortunately electrochemical storage on a large scale is currently a long way from being viable. Potential energy storage via pumped hydro is used where available. The work on Ammonia dissociation is perhaps the most promising of the technologies being researched today to store e.g., solar energy directly.

"RENEWABLE ENERGY" SOURCES

Photovoltaics

are indeed a sustainable source of energy, however from mono and poly- crystalline solar cells the cost is high, and much of this cost is representative of the very high levels of embodied energy in the pure crystalline silicon, indeed a very low entropy state for silicon atoms. While the future may reveal a range of less expensive photovoltaic generators, whether by concentration - focussing techniques or a range of variations on crystalline and amorphous structures, or indeed other materials, the reality is that the niche markets will grow, particularly for remote area power supplies, but large scale adoption in the short term is unlikely. Fig. 2 shows a remote community power supply in the Northern Territory.

Figure 2. Photovoltaic array as part of a Hybrid Remote Area Power Supply at Jilkminggan in the Northern Territory of Australia. - Designed Constructed and Operated by the NT Power and Water

Solar Thermal

This is perhaps the only way in which large scale energy needs can be supplied from direct sunlight. The technology exists today in close to economic form. Very serious attention should be paid to this in the absence of any other conversion techniques or new technologies. The 400 square metre aperture dish at the Australian National University, Canberra is shown in Fig 3.

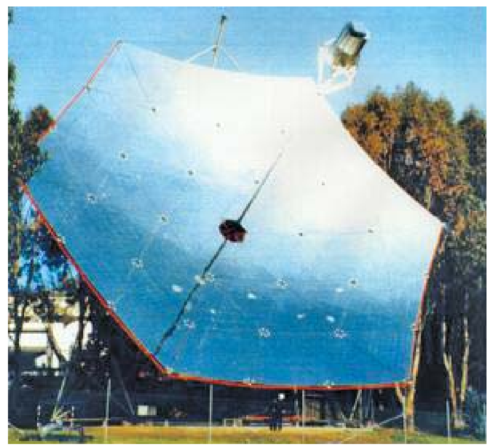

Figure 3. The 400 m2 Parabolic Solar Collector at the Australian National University, Canberra

Wind Power

The commercial viability of wind power has altered dramatically in the last decade, primarily because of the application of solid engineering development, and the rewards of economies of scale. The resource is however limited to certain geographic locations, and has a high degree of variability and unpredictability. There are also concerns for visual and acoustic pollution as wind farms proliferate. Fig. 4 shows the ENERCON E112 to indicate the state of the art, at a rating of 4.5 MW.

Tidal Power

It should be clear that this is not renewable, nor even sustainable. All we do when using tidal power is use the kinetic energy of the moon and the kinetic energy of rotation of the earth, hastening the departure of the moon from orbit, and slowing down the globe's rotation rate. A few calculations however are revealing if one looks for some time scale arguments. The friction of tides flowing over the ocean floor and against land masses naturally absorbs some of this kinetic energy. It has been estimated that this effect has retarded the rotation of the earth so

Figure 4. The ENERCON E112, a 114 metre diameter wind Turbine, hub height 124 metre, with a direct drive variable speed generator rated at 4.5 MW.

Figure5 The NTU – NT PAWA Kinetic tidal energy converter, on shore for maintenance

that a solar year is about one second longer than it was a century ago.

The kinetic energy of rotation of the earth is as shown in the budget 5.3 * 1028 joules. An estimate of all the tidal power units of the earth both existing and proposed (including La Rance at 240 MW, and the proposed Severn development in the UK at 8 GW) might result in a total capacity of some 30 GW. Converting energy at this rate, it would take 200,000 years to make a solar year one second longer. Thus this again illustrates the difficulty of sustainability or renewability arguments, and indicates the need to take time scale into account.

Thus it is believed that there is a future for tidal power, both in its large scale potential energy form, and also the free flowing kinetic energy conversion for application in very small systems for remote communities. Fig. 5 shows the Northern Territory University – NT Power and Water Authority Kinetic tidal energy converter, with the "outboard leg" raised for maintenance, on shore. When deployed, the propeller is lowered in exactly the same way that an outboard motor would be angled into the water. The pontoon is tethered, and at a water flow rate of 2 metres per second, the 2 metre diameter turbine produces 2 kW. of electrical power.

Geothermal

Very similar arguments apply to Geothermal energy as do to tidal power. The resource is neither renewable nor sustainable, however the resource is in current terms, vast. Also as it makes its way to the surface and contributes to black body radiation, attempting to get it to do useful work on its way there should be seen in the light of sustainability.

Biomass

This is perhaps the most sustainable of all. Photosynthesis and the carbon cycle provide solar energy conversion, and short term storage. The overall efficiency of conversion of the sun's energy has been estimated to be around 3%. The balance of the world's forest reserves, and their depletion in some developing countries, are serious concerns. However in the long run Biomass can substantially contribute to our energy management strategies.

CONFERENCE PROCEEDINGS

All technical papers were incorporated in the UPEC 2005 1259-page Proceedings in Hard Copy and CD-ROM (with 251-page book of conference abstracts) that was distributed to delegates at the conference. UPEC 2005 Proceedings may be purchased (Hard Copy and CD-ROM) for 200 Euro (Hardcopy) (plus postage) and 40 Euro (CD ROM) plus postage, until supplies are exhausted, from Dr Noel Barry, UPEC 2005 Conference Organizer, School of Electrical and Electronic Engineering, Cork Institute of Technology, Bishopstown, Cork, Ireland, Tel: +353 21 432 6384, Fax: +353 21 432 6625, E-mail: nbarry@cit.ie

T. J. Hammons
October 18, 2005

Co-Sponsored By:
IEEE Vehicular Technology Society (VTS) and Power Electronics Society (PELS).

Call for Papers

The 2006 IEEE Vehicle Power and Propulsion (VPP) Conference is located in Windsor UK. VPP conference will conduct sessions in different technical tracks and paper offers are being invited on the following or related topics.

VPP Track 1: Vehicular Electric Power Systems and Loads
Power system architectures, power management and distribution, 42V PowerNet, higher voltage power systems, military vehicular power systems and loads, harmonics and power quality, conventional vehicle electrical loads, advanced vehicle electrical loads, drive-by-wire, brake-by-wire, X-by-wire, electric power steering, active suspension, automatic cruise controls, engine electrical controls, remote sensing and fault tolerance, wireless sensors and controls.

VPP Track 2: Vehicular Power Electronics and Motor Drives
Converters, rectifiers, inverters, power electronic systems, electric machines, motor drives, motion control, applications in land, air, space, sea, and undersea vehicles, power semiconductors, EMI/EMC, starters, generators, integrated starter/alternators, novel power modules, auxiliary motor drives, drive trains.

VPP Track 3: Advanced Vehicles
Advanced land, sea, air, and space vehicles, electric and hybrid electric vehicles, lightly hybridized vehicles, diesel hybrid vehicles, hybrid sport utility vehicles, more electric vehicles, fuel cell vehicles, fuel cell hybrid vehicles, military vehicles, multi-wheeled vehicles, heavy-duty vehicles, off-road vehicles, rail vehicles.

VPP Track 4: Energy Storage Components/Systems
Battery technology, advanced battery and management systems, charge/discharge units, new capacitor technology, ultra-capacitors, flywheels, hybrid energy storage systems, auxiliary power units.

VPP Track 5: Modeling, Analysis, Dynamics, and Control
Modeling, simulation, analysis, design, dynamics, stability, and control of vehicular systems/components, CAD/CAE, on-board power management, well-to-wheels and tank-to-wheels analysis, load control, control systems, hybrid control strategies, thermal analysis and management, packaging, educational approaches.

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.

Prospective authors of papers are asked to submit their paper proposals through the conference Web site www.vppc2006.com .

Richard G. Hoft 1926 - 2006

Richard G. Hoft, Ph.D., passed away on January 1st, 2006 at 11:10am, after a 10 year battle with Alzheimer's disease. He was enjoying the company of all of his children and grandchildren during the holidays when he suffered a stroke the evening of December 29th. He passed peacefully 3 days later.

Dick was born in Wall Lake, Iowa on December 4th, 1926 and was raised on a family farm. He was a devoted son and brother to 6 siblings, with ambition to go to college. He was the valedictorian of his one-room country school and signed up for NROTC duty in 1944. He attended DePauw University, then Purdue University, and graduated from Iowa State University with a Bachelor of Science in Electrical Engineering in 1948. During his university studies he married his high school sweetheart, Merna Collis. She survives.

After Dick received his B.S.E.E., the couple moved to Schenectady, New York where Dick was employed by General Electric for 17 years. During these years Dick completed his Master's degree in Electrical Engineering at Rensselaer Polytechnic Institute in Troy, New York. He was a major contributor in the field of power electronics. Among many other significant projects, he helped to develop circuitry for the first nuclear powered submarine. He co-authored one of the first books on power electronics, entitled Principles of Inverter Circuits. He served as a Unit Manager for 9 years at General Electric's Corporate Research and Development Center. In addition, during the Schenectady years Dick and Merna's 3 sons and 1 daughter were born. Dick was an active member of the First Methodist Church of Schenectady, serving as a Sunday school teacher and volunteer on several church boards.

In 1963, the family moved to Ames, Iowa where Dick completed his Ph.D. degree in Electrical Engineering in 1965. After receiving his Ph.D. (thesis entitled "Liapunov Stability Analysis of an SCR Brushless Motor Speed Control"), he was immediately hired as an Associate Professor at the University of Missouri in Columbia, and within his first 3 years with the University was promoted to full Professor with tenure. He gave 35 years of service to the University of Missouri, during which he taught and mentored more than 30 graduate students who have gone on to be leaders in their fields in industry and academia in the U.S., Japan, Taiwan, China and India. He directed an internationally recognized Power Electronics Center, conducted research, consulted for industry, and spent 8 years as the Editor-in-Chief of the IEEE Transactions on Power Electronics. His work in power electronics impacted the development of IBM computers, the most sophisticated mass transit trains built in the U.S., and the development of electric and hybrid automobiles. He received more than 30 grants and contracts providing more than $1 million for his research group. He authored more than 60 technical papers and textbooks translated into at least 3 languages. His many professional awards included the first IEEE William E. Newell Award for Outstanding Achievement in Power Electronics in 1977, the Byler Distinguished Professor Award from the University of Missouri in 1984, the Distinguished Service Award from the IEEE Power Electronics Society in 2000, and the IEEE Third Millennium Medal in 2000.

During his years in Columbia, Missouri, Dick was an active contributing member of the community. He served as Boy Scout Troop Scoutmaster for more than 8 years. He chaired multiple church committees and ultimately succeeded in implementing a local Hospital Chaplaincy program for both the University of Missouri and private hospitals. He tithed for 40 years to the Missouri United Methodist Church, where he served as Sunday school teacher, sang in the choir, and participated as a member of the Executive Board. He was an active member of the NAACP, as well as the Democratic Party, and volunteered for multiple local community relief programs. In addition, he was an avid runner, completing 13 marathons after the age of 50.

All who knew Dick were touched by his generosity, warm spirit and determination to make the world a better place. He will be greatly missed by family, friends, former students and professional colleagues. All were enriched by their interaction with Dick, and the world benefited from his wonderful life. He is survived by his wife, 4 children, 10 grandchildren, 2 brothers and 2 sisters. Dick's wish was to be cremated and laid to rest in the memorial garden at his church. Memorial services will be conducted at the Missouri United Methodist Church in Columbia, Missouri in January 2006. A broader service is planned for July 2006.

Call for Papers

41ST INTERNATIONAL UNIVERSITIES POWER ENGINEERING CONFERENCE (UPEC 2006) September 6-8, 2006 northumbria UNIVERSITY, newcastle-upon-tyne, uk

Abstract Deadline: February 10, 2006

The 41st International Universities Power Engineering Conference (UPEC 2006) will be organized by the School of Computing Engineering and Information Sciences, Northumbria University, Newcastle-upon-Tyne, September 6-8, 2006. It will be based at the main University campus that is located at the heart of Newcastle. It will be co-sponsored by IEEE, IEE, and CIGRE. Its aim will be to provide professional engineers from the universities, consultants, and in the manufacturing and supply industries opportunities to explore recent developments, current practices and future trends in Power Engineering and related fields. Young engineers and research students are especially invited to attend. The conference will cover all aspects of power engineering. It will be residential for three nights. The working language will be English. Accepted papers will be presented in oral and in interactive sessions.

UPEC 2006 seeks papers in all aspects of power engineering, including the following topics:

1) Power Generation
2) Renewable Energy Systems
3) Distributed Generation
4) Transmission and Distribution
5) Future Power Networks
6) Power System Operation and Control
7) Power Conversion
8) Power Electronics and Devices
9) Electrical Machines and Drives
10) FACTS: Power Electronic Applications
11) System Integrity and Protection
12) High Voltage Engineering
13) Power Utilization
14) Power Quality
15) Expert Systems
16) Power Engineering Education

Prospective Authors are invited to submit an abstract (max 2 A4 pages) in the relevant subject area to the UPEC 2006 Secretariat or to the Program Chair (Dr Ghanim Putrus), School of Computing Engineering and Information Sciences, Northumbria University, Ellison Building, Newcastle-upon-Tyne NE1 8ST, UK, E-mail eb.upec@northumbria.ac.uk, Tel: +44 191 227 3603, Fax: +44 191 227 3598 before February 10 2006. On the front page they should give the full name, address, affiliation, and e-mail of the author to communicate with, the number of the area the paper is from taken from the list above, the preference for presentation (oral or interactive), and title of the paper, Notification of acceptance will be by 24 March 2006. Final camera-ready papers are to be received by May 19, 2006 for final review. Style of submission is available on the conference web site (http://www.upec2006.org/) One of the authors will be required to register and attend the conference. Registration will be available at: http://www.upec2006.org/

For more information on UPEC 2006, contact: UPEC 2006 Secretariat, School of Computing Engineering and Information Sciences, Northumbria University, Ellison Building, Newcastle-upon-Tyne NE1 8ST, UK, E-mail eb.upec@northumbria.ac.uk, Tel: +44 191 227 3603, Fax: +44 191 227 3598, or the Conference Organizer, Dr Ghanim A. Putrus, E-mail: ghanim.putrus@northumbria.ac.uk Tel: +44 191 227 3107, Fax: +44 191 227 3598.

Book Review of: Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Fundamentals, Theory, and Design

CRC Press www.crcpress.com
ISBN 0-8493-3154-4
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Mr. Sebastien E. Gay, Texas A&M University
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This book is a remarkable achievement as it treats, at the college textbook level, the very contemporary subject of electric, hybrid electric and fuel cell vehicles. The scientific and engineering principles required, presented at the beginning of each chapter, allows the reader and students of modern vehicle design to identify, prioritize and perform the analysis necessary to establish the requirements of the subject vehicles performance and mission.

It is not often that a hard bound college level text is as up to date as this book. With this text, one could design at the 95% confidence level, a modern contemporary vehicle that would be commercial in our global competitiveness world.

This text allows the requirements definition to be written for a vehicle including tire, terrain, drag, drive train efficiencies, various traction motor efficiencies, electronic controller design and efficiencies, battery types and efficiencies, ultra capacitors and how the can be designed into the control schema, and all of the other myriads of details necessary for a successful vehicle design.

The authors are to be congratulated on this very complete design text, as it is at the cutting edge of vehicle design principles, and should be on the desk of US, European and Asian vehicle design engineers.

I highly recommend this book to any vehicle design engineer (electrical or mechanical) to bring him up to speed on this emerging hybrid vehicle design technology. With the growth of "Hybrid Vehicles" in our escalating fuel cost world, the 1st Principles of vehicle engineering taught in this book will be an excellent "Jump Start" for any engineer in the vehicular design field.

Joe Ziomek
IEEE VTS

Meetings of Interest

APEC 2006, The 21st Annual Applied Power Electronics Conference and Exposition. Now scheduled for 19-23 March 2006 at the Hyatt Regency Dallas. APEC is co-sponsored by IEEE PEL's and IAS societies and by Power Sources Manufacturers Association, PSMA. For more details see: www.apec-conf.org.

PEMD 2006, 2nd IEE International Conference on Power Electronics, Machines and Drives, will be held at Clontarf Castle, Dublin, Ireland on 4-6 April 2006. PEMD 2006 is organized by the IEE Power Conversion & Applications Professional Network and is technical co-sponsored by the IEEE IEMDC. For additional information please see: http://conferences.iee.org/pemd

18th International Symposium on Power Semiconductor Devices and Integrated Circuits (ISPSD'06), will be held 4-8 June, 2006 in Napoli, Italy. This edition of ISPSD will have a joint session on Power Integration with the Conference on Integrated Power Systems, CIPS, that will be held in Napoli, Italy on 8-9 June 2006. IEEE PEL's is technical co-sponsor of ISPSD'06. For more information visit www.ISPSD2006.it or contact the General Chairman, Prof. Paolo Spirito.

NORPIE 2006, the Nordic Workshop on Power and Industrial Electronics, takes place from 14 – 16 June 2006 at the Lund Institute of Technology, Department of Industrial Electrical Engineering and Automation, Lund, Sweden. The IEEE Power Electronics Society is a technical co-sponsor. Timetable is available at: http://www.iea.lth.se/norpie2006 and for additional information please visit: www.iea.lth.se/norpie2006/.

PESC 2006, the 37th Annual IEEE Power Electronics Specialists Conference, will be held June 18-22, 2006 at the International Convention Center Jeju, Jeju, Korea. PESC is sponsored by the IEEE Power Electronics Society. For more information on the PESC2006 program visit http://www.pesc06.org or contact the PESC06 Secretariat at +82 42 472 7460 or via email: pesc06@pesc06.org.

EPE-PEMC 2006, the 12th International Power Electronics and Motion Control Conference, will be held 30 August - 1 September 2006 at the Congress Centre Bernardin Portoroz, Slovenia. EPE-PEMC 2006 is technical co-sponsored by IEEE Power Electronics Society and Industrial Electronics Society. Visit http://www.ro.feri-uni.mb.si/epe-pemc2006 for more details. Prof. Dr. Karel Jezernik, University of Maribor is EPE-PEMC2006 General Chair and may be contacted at: karel.jezernik@uni-mb.si

The 41st International Universities Power Engineering Conference (UPEC 2006) will be organized by the School of Computing Engineering and Information Sciences, Northumbria University, Newcastle-upon-Tyne, September 6-8, 2006. UPEC2006 is co-sponsored by PEL's. Abstracts are due 10 February 2006. For more information visit the web site at: (http://www.upec2006.org/ and also see the announcement in this issue.

VPPC2006, Vehicle Power and Propulsion Conference, will be held 6-8 September 2006 at Windsor, England, UK. VPPC2006 is co-sponsored by IEEE Power Electronics Society and IEEE Vehicular Technology Society. For more information visit www.vppc2006.com or contact Prof. John T. Economou at J.T.Economou@cranfield.ac.uk

CIEP 2006, International Power Electronics Congress, to be held 16-18 October 2006 in Puebla, Mexico with venue Universidad de las Americas Puebla. CIEP is co-sponsored by IEEE Power Electronics Society. For more information visit the website at www.udlap.mx/electronica/ciep2006/ or contact Dr. Pedro Banuelos-Sanchez at pbanuelo@mail.udlap.mx for more information.

International Electric Machines and Drives Conference, EMDC 2007, is scheduled for 3-5 May 2007 in Antalya, Turkey. IEMDC 2007 is co-sponsored by IEEE PEL's, IAS, PES and IE. Conference details can be found at www.iemdc07.org or by contacting Prof. Okyay Kaynak, Bogazici University at o.kaynak@ieee.org

Proposals Invited for Special Issues of the Transactions

The AdCom of the IEEE Power Electronics Society has authorized its flagship technical publication, the IEEE Transactions on Power Electronics, to publish one Special Issue (SI) each year.

Proposals for a Special Issue must include the following: (1) Guest Editor, (2) list of potential Guest Associate Editors, (3) time line, and (4) topic and areas of specialization (scope of the issue).

The following is an example of the suggested time line for a SI. This time line should be used routinely, because the SI is scheduled for publication in May of each year. Once the proposed SI has been approved, the Transactions Editor-in-Chief (EIC) and the Guest Editor will determine specific dates.

- Approval by AdCom: February of the first year
- Paper submission deadline: February of the second year
- First reviews: June of the second year
- Revised paper deadline: August of the second year
- Second and final review: September of the second year
- Final manuscripts: December of the second year
- Published: May of the third year

The following special issues are presently planned:

Special Issue on Automotive Power Electronics & Motor Drives
Guest Editors: Dr. A. Emadi and Dr. J. Shen
Planned Publication: May 2006

Special Issue on Lighting Applications
Guest Editor: Dr. J. Marcos Alonso
Planned Publication: May 2007

The deadline for IEEE Transactions on Power Electronics Special Issue proposals for the May 2008 Special Issue is February 10, 2006. Proposals for a SI are to be emailed to the Transactions EIC at the address given below. The Transactions EIC presents the submitted SI proposals and his recommendations to the AdCom at the annual February meeting for a decision.

Daan van Wyk, Editor-in-Chief
IEEE Transactions on Power Electronics
peleditor@ieee.org

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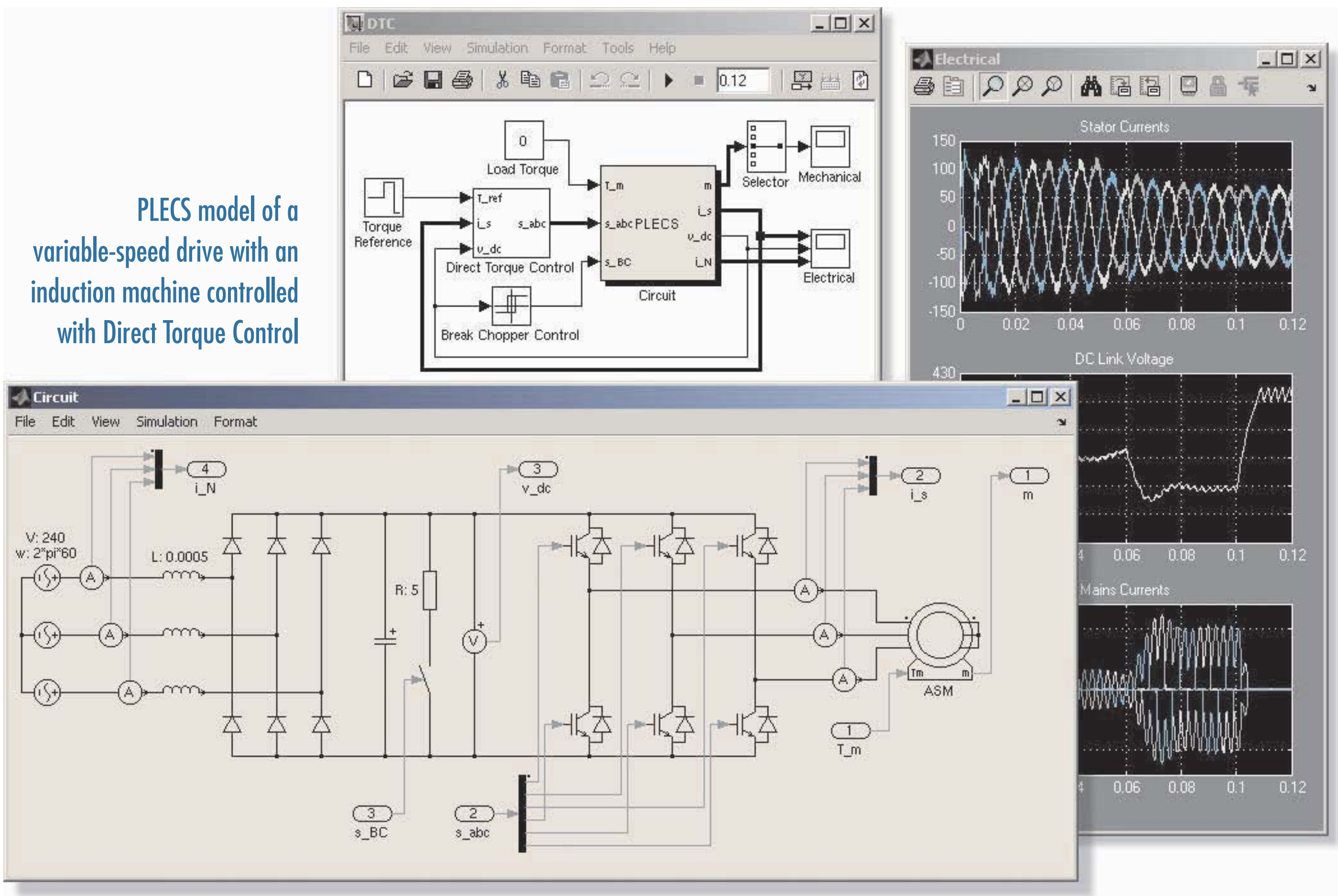

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