Networking Reception in Exhibit

**Session Code:** ESVPR

**Room Peninsula Grand Ballroom (DEFGH) Session Time:** 5:30 p.m.

Day one concludes with an exhibition of leading companies in electronic technologies hosting a reception for all attendees of this symposium. Take advantage of having all these companies in one place to address your electronic control system issues and technology development questions or just relax and network with your fellow attendees and speakers in a social environment of drinks and appetizers.

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**Tuesday, November 8**

**Day 1**

**Session Code:** ESV100

**Room Salons ABC Session Time:** ALL DAY

The focus of day one will be on engine control, control & aftertreatment, as well as development methods & calibration. The day begins with a plenary keynote by a leading OEM on the future of propulsion electronics. Throughout the rest of the day speakers will address control of engines for both ICE and HEV technology, areas of concerns for advancements, exploring the enablers for better propulsion systems, and the current and future developments of this technology. The day concludes with an exhibition of leading companies in electronic technologies hosting a reception for you to come and network with industry experts in a relaxed environment.

**Organizers** - Bernard J. Challen, Shoreham Services; Magdi Khair; Patrick Leteinturier, Infineon Technologies

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<th>Time</th>
<th>Paper No.</th>
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<tr>
<td>8:00 a.m.</td>
<td>ORAL ONLY</td>
<td><strong>Plenary Keynote: Challenges of the OEM/Supplier Relationship with Respect to Powertrain Integration</strong></td>
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<td>This presentation discusses how electronic testing and validation of software and fur. requirements need to be raised to a different level. It also emphasizes on integration features that is required by the OEM and need to be integrated (sometimes) in the su. product.</td>
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<td>Mircea Gradu, Hussein Dourra, Chrysler Group LLC</td>
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<td>9:00 a.m.</td>
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<td><strong>Networking Refreshment Break w/Exhibits</strong></td>
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Thermal Dynamics and Combustion Systems

The efficiency of energy conversion of chemical energy stored in the fuel to mechanical energy is strongly affected by the peak temperature and pressure within the combustion chamber. Efficiency is also controlled by the phasing of the combustion event relative to the piston motion. Cylinder temperature and preparation of the fuel-air mixture also significantly affect the formation of pollutants within the cylinder. Raising cylinder temperatures can have positive effects on thermal efficiency and particulate matter emissions, but detrimental effects on NOx emissions. Typically, the recent interest in advanced combustion strategies has sought to combine modulation of combustion phasing, cylinder temperature, and mixture preparation to dramatically reduce engine-out emissions. Such combustion strategies as partially-premixed charge compression ignition (PCCI) can lead to reduced emissions of NOx, PM, CO and THC but do not typically lead to improved thermal efficiency relative to conventional diesel combustion because they rely on substantial amounts of exhaust gas recirculation. Moving toward combustion strategies that simultaneously achieve clean burning and higher efficiency may require a re-envisioning of the thermal dynamics and substantial alteration of current combustion systems. For instance, RCCI (reactive controlled compression ignition) combustion and PPC (partially premixed charge) combustion modes, which have been shown to achieve higher than diesel baseline efficiency in cylinder engine testing, can include fumigation of gasoline into the intake air of a diesel and use of high volatility and low T90 fuels, respectively, and as such serve as exam envisioning of both the fuel delivery system and the nature of diesel fuel itself.

André Boehman, Pennsylvania State University

Future of Internal Combustion Engine

The change in powertrain and vehicle technologies due to environmental concerns, fuel economy regulations over the past years has been tremendous. New technologies for drivability, performance, fuel cost, NVH, and residual value have been explored, developed, and ultimately implemented in production. While cost remains as one of the major concerns, all engine and vehicle manufacturers as well as the supply base attempt to optimize their products based on entire system solutions in order to take advantage of potential synergy effects.

The combustion engine as a prime power source or as a back-up solution in case of an extended range extender, now more than ever requires further optimization to cope with the current requirements. This includes measures such as downsizing, turbo- or supercharging, combustion system adjustments, aftertreatment solutions, etc. Furthermore, an efficient integration of the engine into the vehicle to optimize functionality, minimize space claims and leveraging synergy effects have become a must. In addition, a new generation of fuels of interest for future applications as well as bi-fuel applications need to be considered for future fuel economy regulations.

The presentation will outline different options and technology tendencies for future engine applications including a variety of fuels, their associated challenges, as well as benefic customer and society.

Dean Tomazic, FEV Inc.

Control of Engine for Hybrid Vehicle Emission

Michael Duoba, Argonne National Laboratory
There are many technical challenges facing the engineering community responsible for developing robust efficient engine control systems for both current and future internal combustion engine applications. The challenges arise as the modern automotive engine must satisfy an ever increasing number of difficult and often conflicting requirements, with ultimate burden being placed on the control system to achieve the objectives. The primary drivers continue to be generated by globally tightening legislation for fuel efficiency and emission reduction, combined with ever increasing customer demand for performance. However, the challenges in meeting these requirements is further compounded by the increasing complexities in emerging technologies such as; hybridization and electric range extension, vehicle architectures & systems, and alternative fuel types, thereby additional challenges, as well as opportunities, for enhancing the controls through system integration and optimization. Also as complexity and scope of the systems and their increasing, so does the challenge for the controls to maintain and meet functional, safety and reliability requirements, in particular during transient operation.

The increasing requirements and technical challenges driving the controls development shall be discussed broadly, and then in more detail with a specific focus on emerging technologies that shall become increasingly more dominant in the future. This, in particular, shall include hybridization, downsizing, boosting, combustion optimization and alternative fuels, with examples of R&D activities being undertaken in these areas and associated challenges facing the controls development.

Matti Vint, Ricardo Inc.

The Compression Ignition engine faces some specific challenges and opportunities as we contemplate a future that demands ever improved fuel efficiency with lower CO2 emissions. Starting from a position of relative high efficiency, it is being asked to make significant improvements while also adapting to low carbon fuels and an Industry-wide trend towards electrified vehicle. This presentation discusses some of the likely Industry responses related issues, and projects a future in which the diesel engine will still play a very key role.

Philip Dingle, Delphi Corp.
Particle emissions from highway diesel engines and vehicles have been reduced dramatically over the last two decades. The recent introduction of high efficiency exhaust particle filters on model year 2007 has led to a reduction in particle emissions from modern diesel engines to near zero-level, well below the stringent 2007 regulatory limit. The use of high efficiency filters will continue to propagate forward into the nonroad sector leading to a significant environmental benefit for a long time to come as long as the exhaust filter technology remains in good working condition. One key technology that insures the environmental benefit of exhaust particle filters is the use of particle sensors for onboard diagnostics. Progress in this area in this decade will be essential.

Conventional multi-port (fuel) injection (MPI) stoichiometric gasoline engines that are widely used in the market place already enjoy very low par emissions. Particle emissions from modern gasoline engines using MPI are also well below the regulatory limit, similar to modern diesel, but without the use of any exhaust particle filter. Gasoline engines, however, are going into some transformation during this decade due to stringent fuel economy and greenhouse gas emission requirement. Gasoline direct injection (GDI) engines are gaining more momentum and are expected to represent 50% of modern vehicles sold in the US in 2016. Recent work with gasoline vehicles using GDI engine technology show higher particle emissions, compared to conventional gasoline and modern diesel. LEV III regulations introduced by the California Air Resources Board (CARB) need to force this engine technology to reduce particle emissions in stages between 2017 and 2025. European Union (EU) solid particle number regulations, however, if enforced in 2014 will likely force a particle filter in the exhaust of GDI engines.

This presentation covers the topic of particle emissions from diesel and gasoline engines. It highlights the significant progress made and the issues that need to be addressed moving forward.

Imad A. Khalek, Southwest Research Institute
Catalytic Diesel Emissions Control

A diverse spectrum of highly capable diesel catalytic emission control technologies has emerged in the recent years, in response to stringent environmental regulations in leading world markets. Importantly, in many cases, these highly effective systems took the brunt of the emission reduction, which allowed the engines to be designed and tuned for maximum fuel efficiency.

A number of fundamental challenges are inherent to these systems, due to the necessity to selectively reduce NOx in the net oxidizing environment, as well as poor reactivity of diesel soot towards oxidation under typical exhaust conditions. Furthermore, such systems need actively controlled, either continuously or in a periodic manner, based on their short-term history, long-term degradation factors, and driving conditions. This effectively leads to sophisticated, often kinetic model-based control algorithms. Implementation of such systems requires a detailed quantitative understanding of their performance and degradation. As a result, every such system represents a mobile chemical plant, including several catalysts, a catalyzed diesel particulate filter (DPF), reactant delivery units (urea solution and/or supplementary fuel), and sophisticated electronic control and diagnostics.

Despite these impressive developments, many challenges and opportunities lie ahead, for example:

- Undoubtedly, the first generation of NOx reduction and DPF systems can be further improved and optimized through better catalysts, and especially better integration based on the expanded understanding of the underlying chemical processes.
- The regulations for traditional criteria pollutants, such as NOx, PM, and HC continue to rapidly evolve and expand. The leading emission zones keep lowering the limits and new regulatory aspects, such as PM count. An increasing number of trailing markets adopting diesel emission standards, albeit often with local variations and additional problems, such as the prevalence of fuel with high sulfur content. Finally, the emerging road standards are bound to drive very different technical solutions, owing to the sheer number of such applications, from power generation to marine engines.
- A new set of chemical species is subject to emission control through the emerging greenhouse gas (GHG) regulations worldwide. Besides CO2, which is also inextricably linked to the fossil fuel efficiency, N2O and CH4 will need to be controlled as species with a large warming potential.
- Alternative fuels for lean-burn engines, such as natural gas, biodiesel, gasified biogas, and landfill gas, are becoming increasingly important both economically and environmentally. These technologies entail their own set of catalytic challenges, ranging from poor methane at the temperatures typically found in the exhaust of a lean-burn engine, to the set of catalytic poisons endemic to landfill gas or biodiesel.
- Finally, on-board diagnostics (OBD) regulatory requirements in the US and Euro-regulatory zones continue to present both scientific and application challenges. These regulations require that OBD not only detect excess emissions of criteria pollutants, pinpoint their source down to a specific catalyst device and a specific function. This demand unparalleled understanding of the relationships between various catalysts in a complex system, and their tie to any parameters which could be reliably measured by on-board sensors.

Aleksey Yezerets, Cummins Inc.

Model Based Powertrain Tests for EPA Regulation Compliance

The presentation focuses on the emission law requirements for using model based test environments, such as HIL. Specific ASM Diesel models are introduced, based on different technologies for emission control in engine air and exhaust paths. These test relevant models and their core functionality are detailed. Some application projects where the test models support exhaust related controller function development are shown.

Jace Allen, dSPACE Inc.

Networking Refreshment Break w/Exhibits
3:30 p.m.  ORAL ONLY  How will Alternative Fuels Affect Powertrain Electronics?
Ethanol and biodiesel are being added to gasoline and diesel fuel in increasing amounts. National Renewable Fuel Standards guarantee that this trend will continue and that these fuels will come from increasingly diverse feedstocks. In addition, processes that produce transportation fuels from natural gas, biomass, and municipal waste are introducing new options into the marketplace. This presentation will discuss the impact of these fuels on powertrain electronics including material compatibility effects, stoichiometry changes impacts on power, emissions and efficiency.

Jon H. Van Gerpen, Univ. of Idaho

3:55 p.m.  ORAL ONLY  Simulation Assists Vehicle and Powertrain Optimization and Component Selection
The trend in vehicle development is steadily toward a stronger focus on energy efficiency. OEMs are seeking contributions toward improved efficiency from many different directions, and there are an ever-increasing number of proposed innovative solutions. Many of these solutions are enabled by the expanding power of electronic systems. These solutions concern, among others, major subsystems such as engine combustion, electrification and transmissions, but important contributions can be made by a wide range of other devices and components. Vehicle designers face a myriad of possible combinations, and it has become difficult to examine these possibilities and properly design the overall system for a maximum benefit and optimum cost/benefit ratio. New simulation methodologies are being applied directly in selection of specific components. Use of integrated simulations eases collaboration between different departments and disciplines and can thus move important design decisions to earlier stage of product development. It does so, for example, by accounting for full two-way interactions between the various subsystems.

Thomas Morel, Gamma Technologies Inc.

4:20 p.m.  ORAL ONLY  Safety Integrity
The advent of electrification of powertrain has brought with it many advances in efficiency also new potential hazards and hazardous situations. This paper will outline the new functional safety standard for passenger vehicles, describe some of the scenarios where electrification creates new potential hazards, and describe some of the assessment and mitigation techniques required at system, hardware, software, process and organisational levels.

Simon P. Brewerton, Infineon Technologies

4:45 p.m.  ORAL ONLY  Development of the OSU EcoCAR dedicated E-85 engine control unit using SIL and HIL tools
Model-based design is a collection of practices in which a system model is at the center of the development process from requirements definition and system design to implementation testing [1]. This approach provides a number of benefits such as reducing development costs, improving product quality, and generating a more reliable final product through use of computer models for system verification and testing. Model-based design is particularly useful in automotive control applications where ease of calibration and reliability are parameters. This presentation describes the complete development cycle carried out using software-in-the-loop and hardware-in-the-loop methods, leading to the develop an engine control unit for a dedicated E-85 engine. The presentation outlines the use of various modeling tools, from GT-Power to Simulink, and of SIL and HIL methods leading to systematic development of air, fuel, and emissions controllers for the engine used in EcoCAR hybrid vehicles.

Giorgio Rizzoni, Katherine Bovee, Ryan Everett, Shawn W. Midlam-Mohler, Ohio State Univ.

5:10 p.m.  ORAL ONLY  Calibration
Craig Carlson, Delphi Energy and Chassis
Wednesday, November 9

Day 2

Session Code: ESV200

Room Salons ABC  Session Time: ALL DAY

The focus of day two is on transmission electronics and current and future powertrain electronics technology issues. The day begins with a plenary keynote from a government representative addressing their view on the future of electronics. The rest of the morning is dedicated to all the developments surrounding transmission control. The afternoon is a unique opportunity to ask questions and hear from leaders of electronic controls systems the complexities of bridging the engine and transmission as well as the challenges of electronics, vehicle electrification and energy usage via two panel discussions.

Organizers - Magdi Khair; Patrick Leteinturier, Infineon Technologies; Bernard J. Challen, Shoreham Services

Time  Paper No.  Title
8:00 a.m.  ORAL ONLY  **Plenary Keynote - Automotive Thermoelectric Generators and Air Conditioner/Heaters**

The US Department of Energy initiated the application of thermoelectric generators (TEG’s) to vehicles in 1994. This TEG was built by Hi-Z Technologies evaluated on a dynamometer test stand then tested successfully installed on a fully loaded Heavy Duty Diesel truck on PACCAR test track for the equivalence of 550,000 miles. Today every major automo manufacturer is investigating thermoelectric applications. The US Department of En supporting the development of production prototype TEG’s with teams headed by BS GM to integrate TEG’s to directly convert engine waste heat directly to electricity in t X6, the Ford Fusion and the Chevy Suburban. These first generation TEG’s will provide a nominal 5 percent improvement in on-highway fuel economy by allowing the alternator downsized by at least 1/3. The 2nd generation TEG is planned to replace the alternator providing a nominal 10 percent improvement in fuel economy.<p>

DOE/NETL conducted a competitive procurement for automotive thermoelectric air conditioners/heaters (TE HVAC) development and selected teams headed by Ford to develop this technology. Current air conditioners use the R134a refrigerant gas, which is 1300 times the “Greenhouse Gas Effect” as carbon dioxide (CO2), the primary “Gre Gas”. Approximately 41 Million Metric tons of CO2 equivalent (CO2e) are released t atmosphere in the US annually from air conditioner compressor seal leakage and frontal collisions wherein the R134a refrigerant gas containment was ruptured. The TE HVAC candidates to eliminate refrigerant gases from vehicles. A problem with maintaining comfort in an electrically assisted vehicle was illustrated by Bob Lutz, Vice Chairman Motors, who drove a Chevy Volt in January in Detroit and to obtain occupant comfort turn on the 5 kW resistive heater which reduced the battery only propulsion mileage to 28. Preliminary analysis indicates that with TE HVAC a single occupant can be made comfortable using about 630 Watts. Whereas current compressed refrigerant gas air conditioners typically use 3500 to 4,500 Watts. The TE HVAC uses design advan, afforded by Thermoelectrics as a dispersed or zonal system wherein only the occupants cooled/heated, not the whole cabin. As TE HVAC is a DC electrical system it only requires a switch to go from the cooling mode to heating. The Zonal System will consist of a thermoelectric seat, thermoelectric units in the overhead and dashboard, A&B pillars on each occupant. There will be a cooling loop with a dedicated radiator. TE HVAC is vehicle specific. In this program they are the Cadillac SRX, the Chevy Volt and the Fusion. The latter 2 also will have TEG’s.<p>

The Department of Energy has initiated a jointly funded program with the National Sc Foundation (NSF) to fund university and industrial teams to develop advanced comm viable Thermoelectrics for 2nd generation automotive thermoelectric applications. Awards were made to 9 of the 48 universities who, with their industrial partners, responded to the DOE/NSF announcement. In early 2011 the Department of Energy conducted a competitive procurement to accelerate scale up and manufacture of advanced automotive TEG’s. Teams selected and their approaches will be presented.

John Warren Fairbanks, US Dept. of Energy

8:30 a.m.  ORAL ONLY  **Plenary Keynote - Leveraging Intelligent Vehicle Technologies to Maximize Fuel Economy**

Advancements in vehicle electronics, along with communication and sensing technol have led to a growing propensity of intelligent vehicle applications. Example systems: those for advanced driver information, route planning and prediction, driver assistanc crash avoidance. As the U.S. Department of Energy (DOE) national laboratory excl dedicated to renewable energy and energy efficiency research, NREL is exploring wa leverage intelligent vehicle systems to achieve fuel savings. This presentation will di several potential applications, such as providing intelligent feedback to drivers on sp to improve their driving efficiency, and using information about upcoming driving to energized vehicle control strategies for maximum energy efficiency and battery life. I will also cover the potential of Advanced Driver Assistance Systems (ADAS) and relat technologies to deliver significant fuel savings in addition to providing safety and con benefits.

Jeffrey D. Gonder, National Renewable Energy Laboratory
Correct Transmission for E-mobility Vehicles

Some generic needs for transmissions in E-mobility vehicles are described. Which transmission attributes that will be prioritized in the end is very dependent on the purpose of electrification (efficiency, performance, drivability, etc) and the type of concept.<p>

The trend to electrified vehicles will create new types of operating conditions for the transmission and thereby new needs. It is important to optimize each source of propulsion as well as the interaction between them..<p>

Electrification with low power levels opens new possibilities to optimize the use of the combustion engine. Today it is difficult to fully utilize the ICE efficiency potential. The optimum for low power demand is at low engine speed and high torques. These operating points are in most cases not possible to utilize due to the lack of surplus power for acceleration, response and torsional vibrations. Electrification opens new possibilities since an electric motor can contribute with both low speed torque and response. This will increase the need for torsional vibration insulation and wider span for the transmission..<p>

With a higher degree of electrification the interaction between the two powertrains becomes even more important. Seamless interaction is a demand where the transmission has a key role. At the same time the complexity is increased with double powertrains implemented. The importance of transmission attributes such as weight, volume, standby losses and thermal mass increases..<p>

For vehicles with a high degree of electrification it is important to optimize the electric powertrain. This will most likely drive an increased number of gears for the electric powertrain to improve efficiency, top speed and take off performance. For those cases where a combustion engine still is implemented it will mainly be optimized to work in the optimum point and work primarily as a range extender.<p>

Mikael Ingemarson, Volvo Car Corporation
Due to the nature of the torque/speed characteristic of typical electric vehicle traction which usually exhibit a high constant torque from zero to base speed then entering an constant power region for higher angular velocities, electric vehicles are usually equipped with only a single-speed gearbox in order to minimize the drivetrain mass, volume, losses and cost. Despite the wide operational speed range of such traction motors (e.g. from 8,000-12,000 rpm), a 2-speed gearbox may be employed in order to increase the wheel torque at low vehicle velocity and, therefore, increase the maximum road gradient the vehicle can ascend when transporting heavy payloads, for example, whilst also facilitating a reasonable top speed. Moreover, as in some cases the efficiency of the electric motor/inverter may vary significantly as a function of the operating torque and speed, the adoption of a 2-speed gearbox can also facilitate significant benefits in terms of the energy consumption by optimizing the distribution of the operating points of the electric motor/inverter over the driving schedule; the selection of the gear ratio being as important as in the case of a conventional vehicle driven by an internal combustion engine. The efficiency of a multi-speed transmission system is generally lower than the efficiency of the single-speed transmission for the same vehicle; however this variation, for conventional transmission systems based on helical gears, is usually marginal in comparison with the potential from the viewpoint of the overall powertrain efficiency.

This contribution deals with a novel 2-speed transmission system specifically designed for electric axle applications. The design of this transmission permits seamless gearshifts and is characterized by a simple mechanical layout. The principles of the control system for the seamless gearshifts achievable by transmission prototype are currently under experimental testing at the University of Surrey and on a prototype vehicle are analytically demonstrated and detailed through advanced simulation tools. The simulation results and sensitivity analyses for the main parameters affecting the overall system dynamics are presented and discussed. The potential energy savings achievable through the adoption of the 2-speed transmission are shown in detail for a couple of case study vehicles.

Fabio Viotto, Oerlikon Graziano Drive Systems

Although the concept of a one-motor, two-clutch parallel system is, in and of itself, recognized for its simple and efficient architecture, application to the passenger vehicle segment has been thwarted by the challenge of suppressing vibration and fluctuating acceleration at switching operations. This is made more difficult by the elimination of a torque converter.

Nissan resolved these issues by developing breakthrough technologies. These breakthroughs culminated in the introduction of a new hybrid system into the luxury passenger vehicle segment, providing the following advantages:

- Simple and lightweight architecture
- Highly efficient system with significant improvement in fuel economy in both city and highway modes
- Direct and rhythmic feeling with high responsiveness

This presentation will cover the system outline, differences from a conventional 7-speed automatic transmission, and the following examples of breakthrough technologies:

- Innovative wet clutch start control method using robust motor controls
- Unique control strategies for engine start-up and gear shift
Panel Discussion: How to Bridge Conventional Engine & Transmission to Electrified Propulsion System: A Technical and Economical View

This panel will address the issues of complexity on bridging these two systems together, discuss the future of consumer response and its effect on development of technology.

**Panelists:**
- Philip Benjamin, Chrysler Group LLC
- Robert Gruszczynski, Volkswagen of America
- Linos Jacovides, Delphi Corp. (Retired)
- Peter Savagian, General Motors Education Relations
- Yukata Takamura, Nissan Motor Company, Ltd.
- Joachim Wolschendorf, FEV Inc.
- Martin Zimmerman, Univ. of Michigan

**Moderators:**
- Thomas Reinhart, Southwest Research Institute

Networking Refreshment Break w/Exhibits

Panel Discussion: Energizing the Future Mobility

A new chapter of the individual mobility is being written. Indeed, individual mobility could use, in the near future, a significant share of electric energy. The overall challenge of this issue is beginning to touch our Industry and it will only become larger as we move more towards electrification. This panel will address these issues as well as discuss opportunities for a proactive approach on energy usage.

**Panelists:**
- Gary Cameron, Delphi Corp.
- Frank Klegon, Fokus Associates LLC
- Patrick Leteinturier, Infineon Technologies
- Ravi Pandit, KPIT Cummins Infosystems, Ltd.

**Moderators:**
- Andrew Brown, Delphi Corp.