MIT/Industry Consortium on Advanced Automotive Electrical/Electronic Components and Systems

Current Research Units and MAESTrO Deliverable

Research Unit Description

One of the primary benefits of Consortium membership is the opportunity to oversee and participate in MIT research projects funded by Consortium membership fees, and, ultimately, to take advantage of project results. Project topics are chosen on the basis of their merit as well as their interest to as many Consortium members as possible. The number and sizes of these projects is evolving as the Consortium grows, with ten approved projects being pursued during 1998.

A Research Unit Subcommittee is organized to guide and oversee each project. Members include the principals of the investigation at MIT and volunteer representatives of member companies who have particular interest or expertise in the research topic. Subcommittee meetings are scheduled as appropriate for each project, sometimes taking the form of telephone conference calls or face-to-face meetings. Consortium member representatives are encouraged to become actively involved in project activities whenever possible.

Research Units

Title/Objective	Technical Approach
1. DC/DC Converters for Dual-Voltage Electrical Systems Investigate the design of dc/dc converters for dual-voltage systems and develop fundamental technologies which facilitate their use in this application	▪ Design, build, and evaluate the performance of a prototype dc/dc converter intended for centralized power conversion in a 42/14V architecture ▪ Investigate active filtering techniques for reduction of ripple and EMI components in dc/dc converter input and output ▪ Develop a CAD software tool to assist in the optimized design of dc/dc converters for dual-voltage systems ▪ Investigate the impact of key system variations such as bidirectional power flow on dc/dc converter design
2. High-Power Generation and Starting Determine the benefits and limitations of high-power alternator and combined starter/alternator designs to meet the requirements of the proposed 42/14-Volt system	▪ For the combined starter/alternator project: design, build, and test a prototype in a direct-drive configuration capable of delivering 6 kW at 6000 rpm engine speed using an interior permanent-magnet (IPM) synchronous machine ▪ For the alternator project: investigate alternative electric machines with simplified power electronics for providing high-power generation in future vehicles without the starting function
3. MAESTrO Develop a knowledge-based software tool to assist users in the design and evaluation of advanced automotive electrical power system architectures	▪ Project completed in June 1998 ▪ See below for MAESTrO deliverable

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Title/Objective	Technical Approach
4. Electrical System Transient Investigation Investigate the generation and control of high-power electrical transients in dual/higher-voltage power supply architectures	▪ Evaluate the transient characteristics of candidate dual/higher-voltage power supply architectures selected for investigation in RU#5 ▪ Investigate the impact of these transients on semiconductor voltage requirements for the different architectures as well as compatibility with proposed voltage specifications ▪ Explore approaches for transient control and suppression to minimize system cost ▪ Experimentally demonstrate the effectiveness of promising approaches, where practical
5. Comparative Power Supply Architecture Evaluation Develop comparative evaluations of candidate dual/higher-voltage power supply architectures to provide insight into their desirability for different vehicle applications	▪ Develop models for key components and subsystems in candidate power supply architectures ▪ Use MAESTrO to evaluate and compare the key attributes (weight, cost, reliability, etc.) of the candidate architectures ▪ Investigate impact of key architecture variations, such as one vs. two batteries, tighter 14V voltage regulation, etc. ▪ Verify key results experimentally using Body-in-White (BIW) test facility
6. Load-Flow Study of Dual-Voltage System Evaluate power and energy flows in dual-voltage electrical systems during vehicle drive cycles in order to provide insights into the sizing of key power supply component	▪ Develop Saber simulation models of candidate power supply architectures appropriate for long time-scale simulations ▪ Develop meaningful vehicle load cycles for future vehicles for use in combination with appropriate drive cycles ▪ Use simulation results to develop guidelines for sizing key system components including alternator and batteries ▪ Evaluate the impact of alternative inter-bus energy transfer strategies on component sizing requirements
7. Dual-Voltage System Protection and Fusing Investigate alternative strategies, configurations and components to provide fault protection in dual-voltage systems	▪ Work with suppliers to evaluate application of automotive semiconductor switches in dual-voltage architecture ▪ Investigate capabilities and limitations of fuses for protection of high-voltage 42V bus ▪ Propose and evaluate alternative fault protection configurations using combinations of semiconductors, fuses and characteristics of the system architectures ▪ Experimentally verify protection system characteristics

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8. 42-Volt PowerNet System Management Using Multiplexed Remote Switching Explore techniques for using multiplexed remote switching in dual-voltage systems to perform bus energy management and other useful system functions	▪ Propose and evaluate candidate algorithms for bus energy management in a dual-voltage electrical system with dc/dc converter power supply architecture as baseline ▪ Verify key results experimentally using CAN network installed in breadboard and/or Body-in-White test facility ▪ Investigate other opportunities (e.g., diagnostics) for gaining significant system advantages from multiplexed switching network
9. EMI/EMC in Dual-Voltage Electrical Systems Investigate EMI/EMC issues and suppression techniques associated with the introduction of higher voltages and increased accessory power levels	▪ Evaluate transient waveforms expected in future 42V systems caused by inductive loads and compare to 14V transient waveforms document in SAE J1113/42 ▪ Investigate EMI emissions from future 42V dc motors and from PWM drives that will be used to control them ▪ Participate in the development of recommended di/dt limits for future 42/14V systems ▪ Experimentally characterize the EMI characteristics of key components including the dc/dc converter
10. Economic Analysis of Dual-Voltage Automobile Electrical System System-level economic analysis of the dual-voltage automobile electrical system, including manufacturing costs of critical new components and the process of transition	▪ Develop manufacturing cost models for DC/DC converter and combined starter/alternator that can be used to evaluate the impact of various design specifications ▪ Develop a system-level cost model capable of providing "point-estimate" and sensitivity analysis results for baseline 14-V and proposed 42/14-V systems ▪ Evaluate the economic and competitive impact of various transition strategies

MAESTrO Deliverable

Another important benefit of Consortium membership is access to the PC-based program MAESTrO (Multi-Attribute Automotive Electrical System Trade-Off) developed at MIT during the past four years. MAESTrO is a knowledge-based software tool to assist users in the design and evaluation of advanced automotive electrical power system architectures. New architectures are entered in a convenient schematic form in order to calculate key system "attributes" such as cost, weight, size, and reliability. Version 3.5 of MAESTrO, completed in June 1998, allows the software tool to import and export large vehicle electrical system schematics in EDIF format.

Each Consortium member company is licensed to use MAESTrO for their own internal investigations. Documentation and training is provided to new members.

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