

Hybrid Vehicles Drive New Demands for Power Electronics Expertise

by David G. Morrison, Editor, How2Power Today

Hybrid electric vehicle technology is changing the way automobiles are designed. It's also changing the mix of engineering skills that automakers and their suppliers need to design and build cars. While electronics content has been growing in vehicles for decades, the introduction of HEVs has greatly increased the need for power electronics as the technology requires inverters, dc-dc converters, battery chargers and battery management circuits, motion control circuits, and other power management circuitry.

If HEV technology was mature and if power conversion circuitry wasn't so critical to hybrid performance, then the automotive industry might not have such a critical need for power electronics (PE) expertise. However, the HEV is still in its infancy, and it requires highly customized power converters that have to operate over severe environmental conditions. Plus, every automotive product is cost sensitive, and new designs are scrutinized down to the penny. All of this means power electronics expertise is crucial to the development of HEVs, and a recent sampling of job postings by automotive companies attests to the fact that automakers and their suppliers are seeking out PE specialists (see the table).

Naturally, engineers who have both PE design skills and experience in the automotive industry would be considered strong candidates for these types of positions. But what do these listings mean to PE specialists who have been working in other segments of the electronics industry? Or to recent graduates of engineering programs? To get some answers I spoke with engineering managers and directors at a few automotive companies to get a broader picture of their requirements.

Are PE Specialists Hard To Find?

Whenever this question is raised in a public forum, it seems to generate vigorous debate, with some engineers and executives arguing there is a shortage and others saying there isn't. But when you ask engineers in the automotive industry, you get a more focused answer that helps explain what types of skills their companies are looking for.

Tom Goesch, managing director of Power Electronics at Delphi, responds that it is a problem finding engineers with a power electronics background. "High current, high power—it's not an area that all the universities have been training for. Most of the universities in the last 20 or 30 years [focused on] digital logic or controls for computer engineering circuits. Many universities actually dropped their power programs in EE." On top of that, automotive companies are looking for engineers with the knowledge to design for the automotive environment. This additional requirement makes the challenge of finding the right engineers doubly hard, says Goesch.

Ronn Jamieson, the director of Global Hybrid Battery Systems at General Motors, also notes that there has been limited availability of engineers with the required power electronics expertise, particularly with respect to the automotive environment.

Nancy Gioia, the director of Global Electrification at Ford Motor Company, elaborates on the difficulty of finding engineers with knowledge of power electronics, motor control, and battery management. "With the growth in electrified transportation and also the stationary storage equipment, solar and wind energy industries, there is currently a shortage of skilled engineers who understand both the applications and the chemistry and physics of the components and materials."

Although the scarcity of engineers with power electronics knowledge is an important issue, it's clear that the lack of experience or understanding of automotive application requirements are just as much of an issue in finding the right engineers to design power electronics for HEVs.

As Gary Cameron, director of Power Electronics Engineering at Delphi, and others point out, designing power converters for automotive is "just as much a mechanical engineering task as it is an electrical engineering task." The power stages are subjected to extreme temperatures and vibration. Cameron notes some of the specific challenges of power converter design, saying, "These aren't just standard IC packaging jobs laid out on FR4...the parts aren't standard anymore, each power inductor or transformer is different from the last one, [and we're] trying to pour it into the packaging space under the hood that the customer gave us...and have it keep working after a 50 g or 100 g shock load."

Cameron says that Delphi is looking for engineers with fundamental knowledge of power electronics. So what about engineers who have acquired that knowledge and gained experience as power supply designers in the commercial electronics industry, either at merchant power supply companies or OEM companies like server manufacturers? Those designers are candidates for positions at automotive companies according to Cameron and Jamieson. However, those designers must learn how to apply their skills in the automotive environment. "We're not designing for a stationary rack in a nice air conditioned room," says Cameron.

But while most engineers working in commercial applications haven't had to deal with extreme environments and requirements for high reliability, designers with backgrounds in military and aerospace applications certainly have. So PE specialists with a mil-aerospace background make especially good candidates for engineering positions in automotive companies. However, as Jim Wood, chief engineer for the Power Electronics Group at Delphi, says, engineers who make the transition from mil-aerospace to automotive must learn to deal with the extreme cost sensitivity of automotive design.

Ford's Nancy Goia provides a higher-level perspective in explaining what automotive companies may be expected to teach engineers who bring power electronics experience from other industries into the automotive design environment.

"Automotive applications have different user profiles—we spend a great deal of time understanding the actual user profiles and improving total system performance. System interactions are the key to the automotive environment and a systems engineering/thinking approach, in addition to the specifics of the technical areas a candidate has expertise in, is essential," says Goia.

Engineering Requirements Will Evolve

Because HEV technology is still so new, the automotive industry is focused very much on developing basic functionality and performance needed to build HEVs. However, as the technology matures, the focus will shift more to optimization of system designs and this may impact the requirements for engineers working on HEV technology.

Currently, the focus in developing HEV technology is "taking the current technology and applying it as efficiently and cost effectively as possible. Tomorrow, it is driving the technology on cost (including the manufacturing processes), size and efficiency with a total systems tradeoff and systems engineering approach," says Gioia. As the emphasis shifts from making HEV technology work to optimizing it for performance and cost, there will be increasing demand for engineers with system optimization skills. How do companies spot engineering candidates with such skills?

"We would typically ask them for specific examples of experiences they have had, where they've started with a design to deliver a function [but then optimized it]" says Jamieson. "What were the subsequent steps, processes or methodologies you applied that resulted in optimized designs to reduce costs, improve durability or reliability, and still maintain performance?"

Corporate Strategies For Satisfying Engineering Needs

While the automotive companies are seeking candidates outside their organizations, as evidenced by their job postings, they are also taking steps to fill these engineering positions from within their own organizations. Rather than laying off electrical engineers in other parts of their business, and then hiring power electronics specialists from the outside, companies such as Delphi are retraining some of their EEs to work on HEV designs, essentially converting them to power electronics engineers.

"I think you're going to see retraining and reskilling continuing in this industry. It's a natural phenomena since you've already got employees you know about, they're good performers, and they know the business you're in." says Delphi's Goesch. Goesch notes that the company's engineers are getting the training they need by enrolling in programs in hybrid vehicle electronics and systems, like those at University of Michigan and University of Detroit Mercy. Similarly, Ronn Jamieson says GM's engineers have been training in hybrid system programs at Michigan Technical University and Wayne State University.

Going forward, automotive companies will be looking to the universities to prepare new engineers for careers in the automotive industry by providing training in power electronics and other disciplines associated with HEV design. Jamieson notes that his company is working closely with the University of Michigan to support its [Energy Systems Engineering](#) program, which already has the participation of some GM employees. Jamieson

notes that students in other engineering programs can also gain valuable experience by participating in programs such as the SAE's Formula Hybrid competition.

Many automotive companies are also supporting the broader power electronics programs such as the Center for Power Electronics Systems (CPES) through their industry consortiums and partnerships. Over time, this support may encourage expansions of such power electronics programs, or perhaps simply create more competition for a relatively small number of graduates with power electronics training.

Table. Sampling of recently posted (01-15-2010) job listings at automotive companies for EEs with power electronics background.

Company	Job Title (location)	Description of position(s)	Qualifications sought
Ford Motor Company	Power Electronics Engineers (Michigan)several highly skilled and motivated candidates in the area of power electronic systems to support the development of current and future hybrid electric and battery electric vehicles in its Product Development and Research & Advanced Engineering organizations. There are several openings in the power electronics area and potential candidates with a strong background in the following fields are encouraged to apply: <ul style="list-style-type: none"> •power semiconductors •power module packaging, assembly and manufacture •electronics reliability, focused on detailed understanding of physical mechanisms for failure •power electronics topology and system design 	<ul style="list-style-type: none"> •M.S. or higher degree in Electrical Engineering with a specialty in power electronics, power semiconductors or power module packaging •At least 5-10 years of hands-on experience designing, manufacturing, developing or testing power electronic systems •Excellent teamwork and communication skills •Self-motivated with the ability to manage multiple tasks •Proficient computer skills.
Ford Motor Company	Electric Machine Engineers (Michigan)	...several highly skilled and motivated candidates in the area of electric machine drives to support the development of current and future hybrid electric and battery electric vehicles in its Product Development and Research & Advanced Engineering organizations. There are several openings in the electric machine design area and potential candidates with a strong background in the following fields are encouraged to apply: <ul style="list-style-type: none"> •electro-magnetic analysis and design of electric machines •mechanical design of electromechanical systems •magnetic material selection and evaluation, including permanent magnet materials •manufacturing of electric machines •electric machine development and integration •electric machine testing and high voltage laboratory operation 	<ul style="list-style-type: none"> •M.S. or higher degree in Electrical or Mechanical Engineering with a specialty in electric machine design •At least 5-10 years of hands-on experience manufacturing, developing or testing electric machines •Extensive experience in using finite element analysis in the design of electric machines •Excellent teamwork and communication skills •Self-motivated with the ability to manage multiple tasks •Proficient computer skills
Ford Motor Company	Electric Machine Drive Controls Engineers (Michigan)several highly skilled and motivated candidates in the area of electric machine drives to support the development of current and future hybrid electric and battery electric vehicles in its Product Development and Research & Advanced Engineering organizations. There are several openings in	<ul style="list-style-type: none"> •M.S. or higher degree in Electrical Engineering with a specialty in electric machine drive control systems •At least 5-10 years of experience developing control systems for electric machine drives, including hands-on experience

		<p>the electric machine drive controls area and potential candidates with a strong background in the following fields are encouraged to apply:</p> <ul style="list-style-type: none"> •electric machine drive torque control, current regulation, and PWM methods •electric machine drive algorithm and software development •electric machine drive system development and integration •electric machine testing and high voltage laboratory operation 	<p>testing and calibrating electric machine drive systems</p> <ul style="list-style-type: none"> •Excellent teamwork and communication skills •Self-motivated with the ability to manage multiple tasks •Proficient computer skills
Ford Motor Company	<p>Power Electronics Engineers, Hybrid Vehicle Team (Michigan)</p>	<p>Responsible for design and release of HV to LV DC/DC, charger, and 110V inverter for HEV. Develop specifications for HV to LV DC/DC, charger, and inverter. Lead engineer (with supplier) on the design and development of converter, control interface board, sensing, and protection Manage and coordinate HV to LV DC/DC, charger, and inverter FMEA process w/ robustness, SDS, and DVP&R Responsible for defining test methods and track testing Coordinate with EMC specialists and complete system level EMC requirements</p>	<p>M.S. or higher in Electrical Engineering with specialty in power electronics Strong background in power semiconductors, application of circuit theory, and design techniques Hands-on experience with designing, fabricating, and testing power modules Knowledgeable in CAE tools Excellent teamwork and communication skills Self motivated with the ability to manage multiple tasks</p>
Ford Motor Company	<p>Battery Controls Engineers – Electronics & Software Engineers - Hybrid Vehicle Team (Michigan)</p>	<p>Work with Battery Controls engineers in the development the requirements for the HV Battery H/W Lead the development of the HV Battery Electronics system architecture with the supplier.. Responsible for leading the design and development HV Battery Electronics Conduct failure mode analysis of the various hardware features and failure mode management strategies.. Review supplier analysis of hardware design, including WCCA. Coordinate with electronic/EMC specialists and complete development and validation of the electronic circuit development. Coordinate and conduct design verification testing at electronics and vehicle level. Job Description: (Software Engineer). Model Design and Development. Interpret requirements and implement in model-based design methods. Model-level validation of design using manual and automated testing . Integration of feature models to evaluate system interactions and performance . Contribute to the development of battery control software DVP&R . Software Development (For the rest of this description see link provided with job title.)</p>	<p>B.S. or higher in Electrical/Electronics Engineering with specialty in circuit design and Control Theory or Computer Science. Experience in Li-Ion cell balancing technology.. At least two years of hands-on experience with Automotive Electrical/Electronics Module design and testing. Good working knowledge of Microprocessor based controller design and testing. Good working knowledge of communication circuits and protocols (e.g. CAN, Serial, etc.). Electronic manufacturing experience is a plus. Excellent teamwork and communication skills. Self motivated with the ability to manage multiple tasks. Working knowledge of Control System software design including C Programming language . Working knowledge of Matlab/Simulink/Stateflow development environment. Working knowledge of various application build environments (compile, link, debug). Understanding of vehicle diagnostics and Network communications; Understanding of Industry Standard</p>

			Automotive Network Operating System (FNOS) desired. Understanding of Hybrid Battery & Hybrid Vehicle operations desired.
General Motors	Power Electronics Development Validation Engineer (DVE) (US-MI-Milford)	Responsible for development and specification of power electronic component and subsystem test plans. DVE's are responsible for the execution of the power electronic component and subsystem test plans. DVE's ensure that power electronic powertrain components will meet internal and external customer specifications for product reliability. DVE's must have highly developed system problem solving skills. DVE's will be required to aggressively root cause electric drive system vehicle incidents and work with design engineers to implement solutions in a timely manner. Generates technical requirements and plans for current, new and major programs Provides technical leadership for advanced technology development Performs complex design analysis Develops engineering designs (including subsystems) Implements/supports engineering changes Plans and implements testing for development programs Interface and support supplier component and subsystem development and testing Develop and critical review of DFMEA's (DRBFM/DRBTR) Communicates, coordinates, and consults with engineering departments and customers; Stays abreast of new technology and competitive products; Travels as required Specifies and balances system requirements Releases parts and subsystems for production	Basic Required: BSE, BS in Mechanical Engineering, Electrical Engineering or equivalent training Working knowledge of Power Electronic Inverter or Power Converter Design High level of oral and written communication skills Understanding of engineering theory and principles of operation of mechanical/electrical mechanisms Demonstrated technical and professional skills in job-related area; Exhibits appropriate interpersonal styles and communication methods to work effectively with business partners to meet mutual goals Specific knowledge of engineering discipline (e.g. mechanics, physics, metallurgy, manufacturing methods, electronics, software, control systems) within job-related area High level analytical ability where problems are unusual and complex; High level of interpersonal skills to wok independently and effectively with others Knowledge of engineering software and systems as it pertains to job-related area; Four or more years experience in job-related area (For the rest of this description see link provided with job title.)
General Motors	Hybrid & Electric Propulsion Calibration Engineer (U.S.)	Responsible for calibration of hybrid electric powertrain control systems for GM's World's Best Powertrains Develop calibrations that strike optimal balance between energy usage and noise & vibration attributes, to deliver world class fuel economy and drive quality Work with vehicle platform, powertrain, and controls engineers to develop requirements Show that requirements are met with dynamometer and vehicle tests at GM's proving grounds and other global locations Strong teamwork and collaborative development skills required. Join a strong technical team moving the frontier of powertrain technology Responsible for design, development, testing and control of engineering projects where decisions are made within the limits of general practices and standards Exercise technical direction over engineering	Basic Skills Required: Analysis and control of dynamic systems; BSE, BS in Mechanical Engineering, Electrical Engineering or equivalent training; Good written and oral communication skills High level of oral and written communication skills Understanding of engineering theory and principles of operation of mechanical/electrical mechanisms Demonstrated technical and professional skills in job-related area; Exhibits appropriate interpersonal styles and communication methods to work effectively with business partners to meet mutual goals Specific knowledge of engineering discipline (e.g. mechanics, physics, metallurgy, manufacturing methods, electronics, software, control

		<p>support personnel. Use independent judgment, but can receive some direct guidance from the supervisor Performs the design analysis Assists in developing engineering designs Participates in solution of engineering related product problems (Root Cause) Works with engineering functions, suppliers, plant personnel and others to implement cost reduction, methods improvement, product improvements, and to support build programs (For the rest of this description see link provided with job title.)</p>	<p>systems) within job-related area High level analytical ability where problems are unusual and complex; High level of interpersonal skills to work independently and effectively with others; Knowledge of engineering software and systems as it pertains to job-related area Four or more years experience in job-related area Basic Skills Preferred: M.S. or Ph.D in Mechanical or Electrical Engineering; Automotive control system experience for production programs; Hybrid or Transmission controls diagnostic development (For the rest of this description see link provided with job title.)</p>
Chrysler	<p>Electric Motors & Power Electronics Engineers/Specialists (Auburn Hills, MI)</p>	<p>...seeking multiple engineers and specialists in the area of Power Electronics and Electric Motors. A leadership position to manage both functions is also available. Engineers must be strong team players, systems focused with interdisciplinary experience & expertise and willing to work in fast paced environment. Responsibilities include: Develop system technical specification based on electric drive system requirements or vehicle level energy conversion and torque control requirements for HEV and EV applications Design, simulate, and test Power Electronics Unit per system specification; Evaluate electric machine electromagnetic design and follow technology advancements; Develop thermal analysis for modules and components; Provide technical support to packaging, mechanical design, cooling design, NVH and structural analysis activities; Develop and validate electric models and operating strategies for motor controls development and system optimization; Lead innovative power electronics concept development for vehicle applications; Lead motor or power electronics system failure mode analysis, EMC/EMI resolution, design fixes, and development testing; Follow electronics technology advancement regarding topology, modules, operating strategy, new design methods, manufacturing methods, and new control methods Assist sourcing activity regarding modules, components, and whole power electronics unit or electric machine Provide support for vehicle integration activities</p>	<p>Required Qualifications: Masters degree in Electrical, Mechanical, Controls, Automotive, Aerospace/Aeronautical Engineering, Engineering technology degrees from an ABET Accredited University Minimum 5 years experience (academic, training and industrial) in Power Electronics hardware or Electric machine design and analysis</p> <p>Other Requirements: Expertise in modern power electronics design and modeling of various converters Experience in digital and analog signal processing, integration of DSP and other microcontrollers or electric machine electromagnetic design and modeling of various machines Working knowledge in thermal and mechanical aspects of power electronics or motor design Working knowledge in power electronics or motor manufacturing processes Working knowledge in modern motor controls and techniques Good understanding of electric drive systems and vehicle applications</p>
Delphi Electronics	<p>Battery Applications Engineer</p>	<p>Support application of Lithium-Ion batteries into Hybrid and Electric Vehicle applications Lead and conduct structured problem solving</p>	<p>Minimum of two years of experience designing for military or automotive environment</p>

		<p>Provide input and guidance on battery safety considerations in engineering development labs, validation labs, vehicle applications, and other environmental situations</p> <p>Work with suppliers and application teams to define and implement energy storage control algorithms</p> <p>Lead research for application of new cell chemistries and verification of these new technologies to improve performance and reduce cost</p> <p>Coordinate status meetings and testing programs with existing and potential battery suppliers for Vehicle applications</p> <p>Work with academic and industry experts to keep abreast of development in energy storage applications and safety</p> <p>Disseminate technical information to the engineering organization</p>	<p>3-5 years of experience specializing in automotive battery applications, energy storage technologies, and control systems</p> <p>Good verbal and written communication skills (English); Experienced with customer technical interface/ presentation</p> <p>Training and demonstrated experience in use of structured problem solving</p> <p>Familiarity with automotive component design and application</p> <p>Preferred: 3-5 years of experience in application of Li-Ion batteries</p> <p>Experience with Li-Ion battery development</p> <p>Training and experience in structured design, simulation, and/or analysis tools</p> <p>Bachelor's degree in Chemical Engineering or Physics required</p> <p>Master's degree in Chemical Engineering, Physics or Electrical/Electronics Engineering preferred</p>
Delphi Electronics	Power Electronics Engineer (Kokomo, IN)	<p>Architect, design and develop power electronic products for HEV, PHEV, EV, and FCV applications including but not limited to DC-AC inverters, DC-DC converters and chargers</p> <p>Products will range in voltage levels from 14V-800V applications from 5-150kW systems</p> <p>Design responsibility will include power circuit design, component selection, thermal management, analysis and support for programs</p> <p>Design activity will be in a small group environment of a 3-10 person project team</p> <p>Experience and ability to lead projects and teams (preferred)</p>	<p>Minimum of 3-7 years of experience designing switched-mode power conversion products ranging from several watts to several kilowatts</p> <p>Strong background in all aspects of power conversion design especially DC-DC converter or DC-AC inverter topologies and application, component selection, thermal design, packaging and controls analysis, and simulation</p> <p>Motor control and application experience (preferred)</p> <p>Ability to work in a team environment</p> <p>Ability to multitask</p> <p>Ability to work with customers and suppliers during the product development cycle</p> <p>Proven track record of innovative design or power electronics hardware (preferred)</p> <p>Master's degree/ Ph.D. in Power Electronics required</p> <p>-Strong bachelor's degree in Electrical Engineering with qualifying experience may be considered</p>
Delphi Electronics	Power Electronics Electrical Design Engineer (Kokomo, IN)	<p>Design Power Electronics Electrical Hardware Products</p> <p>Motor Drive Inverters for propulsion systems</p> <p>Switched-Mode Power Conversion products</p> <p>Perform worst case analysis and simulations to ensure compliance to customer requirements</p> <p>Support product design reviews</p>	<p>Experience in designing Power Electronic systems consisting of inverters and DC-DC converters, electronics hardware involving Power Silicon/Converter Topologies/Thermal management/Magnetics Design/Control Systems</p> <p>Electrical Hardware design experience</p>

		<p>Create and maintain schematics Develop and maintain electrical DFMEA Generate electrical information to ECAD for PCB layout and support ECAD designer Create product verification plan and perform testing Support EMC and validation testing Utilize structured problem solving techniques for test failure resolution Present product design, analysis and testing with customer</p>	<p>in designing analog & digital circuits to support Power Electronic Circuits: power supplies, intelligent High side/Low side driver circuits, I/O signal conditioning and filtering circuits Preferred: Familiar with Free-Scale and/or Infineon 16/32-bit microprocessor products and their general use Familiar with MathCad Software and Saber simulation S/W to support design calculations and documentation Previous design experience with other automotive suppliers Bachelor's degree in Electrical Engineering is required -Master's degree/ Ph.D. in Electrical Engineering is preferred</p>
Delphi Electronics	<p>Magnetics Design Engineer (Kokomo, IN)</p>	<p>Design, Specify and Test Magnetics Components -Power Transformers and Chokes -Isolation Transformers -Current Sense Transformers -EMC Filters Modeling/Simulation -Magnetic -Electrical -Thermal Supply Management Team Member -Select and Develop Suppliers -Quality and Reliability Improvement Initiatives -Cost Reduction Initiatives Support Production, Advanced Development, Electrical Engineering and Mechanical Engineering Production Hardware Design Groups -Topology/Design Trade-Offs -Performance (Magnetic, Electrical, Thermal) Debug/Characterization</p>	<p>Minimum of 2 years of experience designing magnetic components Good verbal and written communication skills (English) Preferred: Minimum of 2 years of experience designing power (>1kW) magnetic components Minimum of 2 years of experience designing for military or automotive environment Experience designing power (>1kW) controllers Experience with ANSOFT modeling tool Experience with ANSYS modeling tool Experience with SABER modeling tool BS Electrical Engineering, Mechanical Engineering or related degree with equivalent experience</p>
Johnson Controls	<p>Senior Systems Engineer - Controls - Advanced Battery Technology (Milwaukee)</p>	<p>Responsibility Level: This position is responsible for the systems engineering and integration work activities related to the control and diagnosis of high voltage battery systems. Typical Duties: Lead the requirements analysis and validation planning activities specific to battery control and diagnostic functions across multiple programs; Establish core control and fault reaction strategies that can be reused among multiple programs; Coordinate control system planning between regional and functional engineering teams. Perform analysis and definition of battery control strategies leading to system level requirements; Establish engineering justification documents that demonstrate functional, safety, and regulatory</p>	<p>Requirements: BSEE or related field from accredited four-year college or university. 5 to 7 years of professional engineering experience in related field OE Automotive/Tier 1 powertrain systems and/or component experience is highly desired Experience with high voltage EV/HEV systems is desired Experience with NiMH and Li-Ion battery chemistries highly desired Experience with MATLAB and Saber is highly desired Good computer skills (Microsoft Office Suites) Solid communication and organizational skills Travel - up to 25%, including</p>

		<p>requirements are met. Participate in the specification and design of all battery components - mechanical, electrical, software, chemical and electronics; Play an integral role in leading the product design and technology roadmap for the global organization. Assist in the design for manufacturability (DFM) to ensure that the design of all components, sub-systems, and battery system optimizes the manufacturing process at the sub-assembly, battery system assembly, and vehicle level assembly. Assist in establishing a quality system - Support APOQ efforts to ensure the delivery of a quality finished product and process. Assist in the development and implementation of a control plan. Support safety analysis and creation of DFMEA documents. Assist the analysis of test data for battery systems; Manage or provide technical direction to designers, engineers, suppliers, and support personnel</p>	<p>international</p>
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