focus on electronics

Siemens to unveil EIC at Convergence

An electromagnetically controlled valve in an engine's air-intake manifold can improve a vehicle's performance when it is going from slow to fast speed, bringing the added benefit of slightly improved fuel efficiency and lower emissions. **Siemens VDO Automotive** is developing a technique called electronic impulse charging (EIC), which eliminates engine air deficiencies to smooth performance during sudden acceleration. The EIC technology, which is being jointly developed with **Meta Motorentwicklung** GmbH, will be formally unveiled at Convergence in October. First discussed in Germany last year, the technology will debut in 2007, a spokesman said.

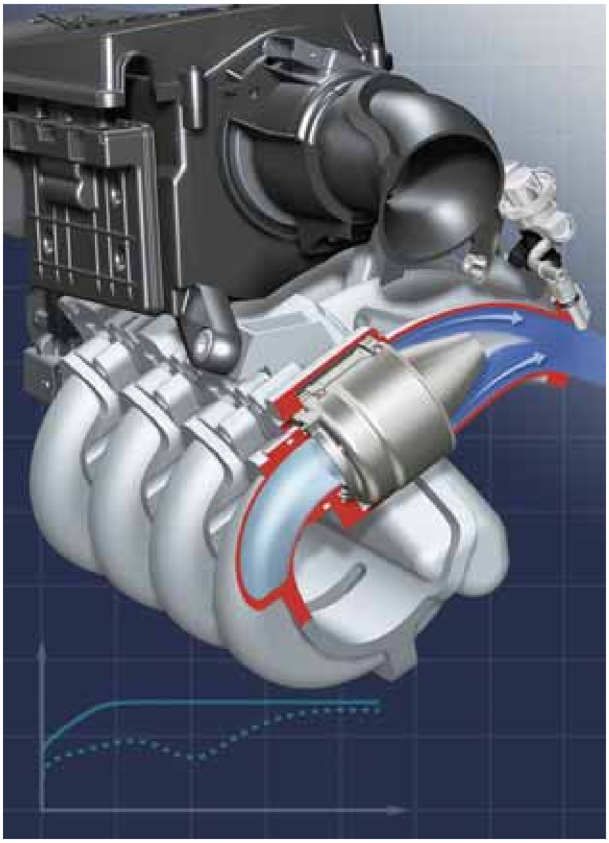
EIC's primary benefit comes when drivers want quick acceleration for passing and when vehicles must quickly go from low to high speed. Typically, internal combustion engines suffer from a lack of air in these conditions, causing a slight delay in acceleration.

Engines with EIC will respond instantly to acceleration demands, with a delay of only one engine cycle. That's accomplished by installing an electromagnetically controlled valve in each cylinder's air-intake manifold. As the piston moves downward, the valve closes to create a vacuum. Just before the piston reverses direction and compression begins, the valve opens quickly, causing air compression. This compressed air is captured, so the engine can deliver more torque during the next engine cycle. The technique works with any internal combustion, but the greatest performance benefits will be achieved on turbocharged engines. It can also be used on diesel engines, a spokesman added.

In addition to smoothing out response and providing more torque, the system helps reduce fuel consumption. In cold-start situations leaner fuel mixtures can be used, which has the added benefit of reducing hydrocarbon emissions by up to 50% during startup. Improvements in the way fuel and air are mixed makes it possible to use a leaner fuel mixture without sacrificing performance.

The development involves three Siemens VDO operations. The Electronics and Drive and Gasoline Systems Divisions have worked with the Engine Actuators Business Group, as well as Meta Motorentwicklung.

Terry Costlow

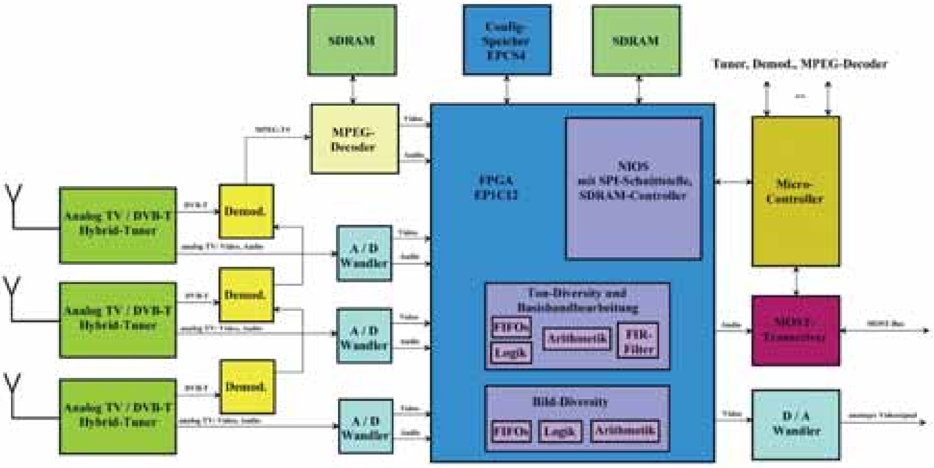


With Siemens' electronic impulse charging, valves compress air to help engines reduce acceleration delays.

Altera helps Hirschmann with mobile TV

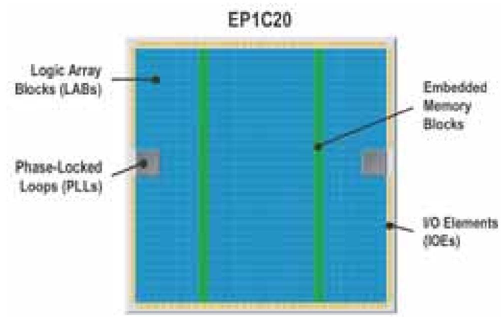
The introduction of DVB-T (digital video broadcast-terrestrial) television in Berlin has had a profound impact on television reception in automotive entertainment systems. In addition to being able to receive analog television signals, which will still be broadcast outside metropolitan areas for years to come, an automotive TV receiver must now be able to process DVB-T signals. **Hirschmann Electronics** has developed an FPGA (field programmable gate array)-based hybrid TV receiver—as well as improved diversity algorithms for better-quality analog reception—to meet this emerging need.

Hirschmann has developed a hybrid receiver for mobile TV reception in motor vehicles.



To ensure acceptable in-vehicle TV reception, "diversity" systems must make use of several antennas.

The DVB-T network in Berlin is designed for portable, not mobile, reception, so ensuring acceptable in-vehicle TV requires "diversity" systems using several antennas. The system switches between the various antennas it has at its disposal, selecting the one that delivers the best reception. For analog television, such switching is done separately for video and voice since the carrier waves for each are spaced more than 5 MHz apart and would suffer interference from different sources.



Cyclone FPGAs are optimized for processor-based applications.

Hirschmann's receiver features an improved proprietary procedure for analog television that constructively superimposes the received signals. The signals are first scanned and then synchronized for time alignment. The quality of each individual signal is then assessed. Using this assessment, weighting factors are used to multiply each of the received signals. The resulting sum of signals produced by this procedure delivers a better signal-to-noise ratio than is possible using only the best signal received.

MRC (maximum ratio combining) diversity is used for DVB-T receiver antennas. Using this approach, the output signal is formed by combining the best individual carrier signals, making it possible to ensure good reception when the vehicle is moving at speeds over 100 km/h (62 mph).

Although the Hirschmann system is scalable in terms of the number of reception paths, two to four are generally recommended. A greater number of reception paths not only improves reception, but also significantly increases system hardware and software complexity. The Hirschmann hybrid TV receiver uses three reception paths.

The tuner's RF (radio frequency) input signal is received from integrated disk antennas connected to tuners via controlled amplifiers. The hybrid tuners are configured to receive analog, regardless of standard, and DVB-T signals.

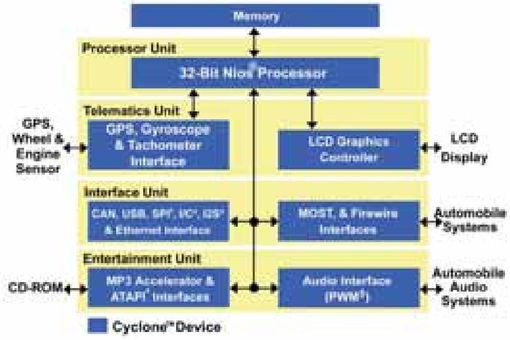
During DVB-T reception, coded orthogonal frequency division multiplexer (COFDM) demodulators, which deliver an MPEG (Moving Picture Experts Group) transport stream, are interconnected, establishing the required MRC diversity to optimize the MPEG transport stream. The video, audio, and data signals in the stream are then delivered to the FPGA.

All the digital signal processing is carried out in an **Altera** Cyclone FPGA, an example of which will be on display at Convergence 2004. In addition to logic and arithmetical functions, the RAM (random access memory) blocks in the FPGA

Briefs

Nissan and **Toyota** intend to pioneer the standardization and shared use of software and networks for electronic vehicle control systems by participating in non-profit Japan Automotive Software Platform and Architecture (**JASPAR**), established in September by Toyota Tsusho Corp. and its subsidiary Toyota Tsusho Electronics Corp. The new organization will help with the continuing advancement and sophistication of electronic vehicle control systems, which are drastically increasing the development costs of Japanese automakers and expected to keep on doing so to an even greater degree in the future. JASPAR, now joined by Nissan and Toyota, was specifically established to standardize specifications and evaluation methods for vehicle software, establish a common platform for onboard network specifications, and contribute technical support to international standardization organizations (such as those carried out by **AUTOSAR** and **FlexRay**. JASPAR is aiming for participation by automakers and suppliers of electronic parts, semiconductors, wire harnesses, and development tool makers. It intends to carry out its activities by setting up working groups to achieve its objectives.

One of the main attractions at this month's Convergence 2004, sponsored by the Convergence Transportation Electronics Association (**CTEA**), will be a spotlight on safety in three technical sessions on active safety, x-by-wire, and changing vehicle interiors. Advanced safety systems have received a boost from the **NHTSA** (National Highway Traffic Safety Administration), which has shifted its focus from occupants surviving auto crashes to accident avoidance, setting the stage for rapid growth in consumer awareness and demand for so-called active vehicle safety systems. The Convergence active safety session will address accident avoidance, impaired drivers, and intelligent vehicle systems. An interface challenge session examines the potential impact on safety from increasingly complex interiors. The x-by-wire session addresses the steps needed to further the promise of the developing technology and its impact on improved occupant safety features.



This telematics/entertainment controller example is based on a Cyclone FPGA with a Nios processor.

are used for functions such as FIFO (first in, first out) storage.

The designers of Hirschmann's diversity receiver leveraged Altera's development tools to create the complex units required to support system functions. The controller consists of the Nios embedded processor as well as RAM, a serial interface, and an SDRAM (synchronous dynamic RAM) controller. The FPGA's configuration data is located in the EPCS4 serial flash memory and is loaded onto the FPGA when the receiver is switched on. Graphical data processed in the FPGA is then sent to a digital-analog converter, which creates the analog output signal for the TV monitor. Audio signals from the FPGA are transferred digitally to a MOST (Media Oriented Systems Transport) transceiver, which sends them to the MOST bus. When a user enters control instructions via a multimedia interface, the instructions are also sent to the transceiver via the MOST bus.

The low-cost Cyclone EP1C12 device has more than 12,000 logic elements and 234 Kbits of embedded memory. Cyclone FPGAs are optimized for processor-based applications, especially those that benefit from the use of an embedded soft processor such as Altera's Nios processor.

Using Altera's SOPC Builder tool, designers can generate a system in a simple, step-by-step process. First, the CPU (central processing unit) is selected—in the mobile TV case a Nios architecture. The processor is then configured by establishing the variable architecture features, with the most important parameters including databus width, size of the register file, hardware support of arithmetic functions, and operating systems support. After the CPU has been tailored to match system requirements, the designer establishes the interfaces needed for the Nios controller system. With the aid of a graphical user interface, the desired system can be constructed from a library of completely different modules.

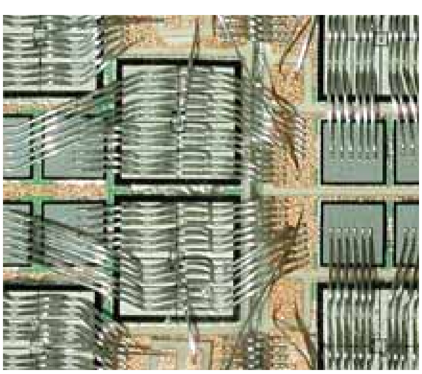
Hirschmann plans to integrate other digital standards, such as ISDB-T (Japan) and ATSC (USA) into its future systems. The company is also exploring the concept of a receiver located at the base of the antenna. This arrangement makes it possible to eliminate RF lines and amplifiers, and it promises to bring further improvement to the reception quality.

A receiver will be developed that can be configured for the various broadcast services via software rather than hardware. Such a software radio is based on a hardware platform upon which a whole series of receiver variants can be adjusted, configured, and used by software across a range of frequencies. The software radio concept calls for scanning of the broadcast signal directly at the antenna, and then performing all further processing in the digital domain.

A software radio based on this definition is not currently possible because the required system processing performance and the very high sampling frequencies needed for the analog-to-digital converter are not yet affordable. Nevertheless, a subset of software radios that work a few intermediate frequencies is definitely possible today. It is likely that such radios will soon find their way into new cars thanks to the attractive quality levels and convenience features that the technology offers.

This article was written for AEI by **Axel Zimmermann**, Altera Corp., and **Wolfgang Sautter**, Hirschmann Electronics.

Cost and thermal issues for power modules



Danfoss Silicon Power engineers designed this wire bond layout for an IGBT module for electrical traction systems with extreme power-density levels.

For each new vehicle generation, more functions previously realized mechanically are being solved electronically. Simultaneously, completely new application areas are being created that demand electronics also. Significant growth can be found in areas from advanced motor controllers to power electronics in electric power steering, electrical braking, advanced fan drives, electrical turbo generators, piezoelectric valve controllers, and starter generator designs.

The amount of silicon, especially in power modules, is also increasing dramatically, according to Convergence exhibitor **Danfoss Silicon Power**. For example, an integrated MOSFET (metal oxide semiconductor field effect transistor) module for a typical electrical power steering application in an SUV uses at least 180 mm^2 (0.28 in^2) of silicon or more depending on the power requested. In comparison, a Pentium 4 microprocessor manufactured by the latest process technologies from Intel uses 150 mm^2 (0.23 in^2) of silicon.

The increased amount of power electronics has put added demands on product developers regarding size and cost. More power and less space leads to rapidly increasing power densities, and the cost driver tends to reduce the amount of silicon that the designer is allowed to use, which again leads to increased power densities, because there is less space available for more heat dissipation.

Solutions to these challenges include using smaller dies and spreading the heat as much as possible. Consequently, engineers are not applying organic circuitry substrates such as epoxy boards (*e.g.*, FR4) as a thermal basis for dies. Instead, they are specifying more exotic solutions like ceramic substrates (*e.g.*, direct bonded copper or DBC) as platforms for power semiconductors, and a strong copper baseplate to spread the heat before it is conducted to a system heat sink that is typically aluminum.

When characterizing the thermal behavior of a power module, the "thermal stack" concept is useful. It defines the material composition and the geometries of the individual layers that the heat has to travel through on the journey from the junction of the power chip to the outside world.

A power module can be realized in several ways, with three typical examples using:

Module Thermal Stacks Power MOSFET							
6 x 4 x 0.175 mm (0.24 x 0.16 x 0.007 in)							
Material	k[A] [W/(m·K)]	Layer thickness (mm)			Rth junction to ambient (K/W)		
		TO200	Glue	Basepl.	TO200	Glue	Basepl.
Silicon	150	0.175	0.175	0.175			
Solder	55	0.1	0.1	0.1			
Copper	390	1	0.3	0.3			
Al_2O_3	24		0.380	0.38			
Copper	390		0.3	0.3	2.38	2.50	1.45
Solder	55			0.15			
Copper baseplate	390			3			
Interface[B]	1	0.25	0.1[C]	0.1			
Al heat sink	200	5	5	5			
Module size		25 cm^2	10 cm^2	10 cm^2			

[A] Thermal conductivity.
[B] The discrete component needs an electrical insulator as interface material thus the larger thickness than for the two other examples that only need the thermal conductivity. In the latter cases, the electrical insulation is established in the ceramic layer (Al_2O_3).
[C] The thermally conductive glue is assumed to have the same thermal conductance as the thermal interface.

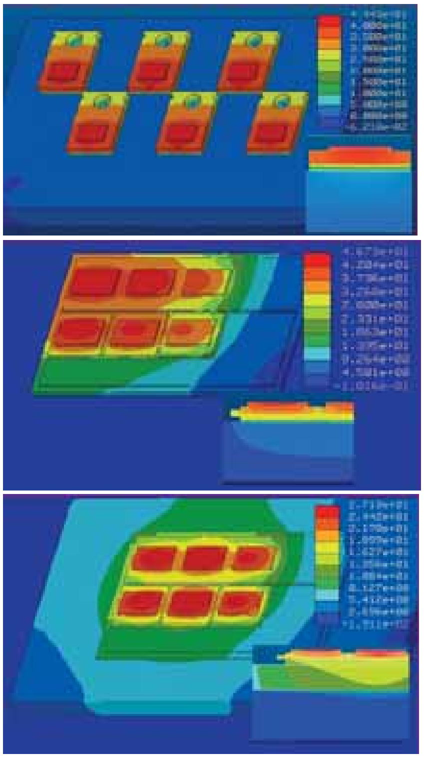
- Discrete components (*e.g.*, TO220s) that are mounted using screws
- Bare silicon chips on a DBC substrate that is glued to the aluminum heat sink
- Bare silicon chips on a DBC substrate, which again is soldered onto a copper baseplate, which then torque-mounted to the aluminum heat sink.

Assuming the power MOSFET measures 6 x 4 x 0.175 mm (0.24 x 0.16 x 0.007 in), the thermal stacks for these modules are shown in the table.

The discrete solution using TO220 offers about the same thermal performance as the bare die on DBC glue. The TO220 solution features extremely high heat spreading within the package due to the large copper lead frame, but the solution is hindered by the electrical insulation layer between the component and the heat sink.

The bare die types offer a much more compact solution than the discrete type, so the best solution, taking all considerations into account, is the bare die on DBC in which the DBC is soldered onto a copper baseplate. The thermal stack with copper baseplate must be soldered void free to provide optimal thermal and electrical conductivity.

To meet not only technical demands, but also an environmentally friendly solution, the solder layer should consist of a lead-free alloy. This is a real challenge for process engineers because void-free wetting requires lead. A sophisticated vacuum process was developed to guarantee solid connection without any lead in the solder joint of chip-to-DBC and DBC-to-baseplate connections. Process optimization now allows simultaneous soldering of chip-to-DBC and DBC-to-baseplate in one step. So competitive costs and best thermal properties are combined in the thermal stack building process.



Three typical power-module examples are a) TO220s mounted on a heat sink using an electrical insulator (Rth=2.38 K/W); b) a bare die on a DBC, glued to the heat sink (Rth=2.5 K/W); and a bare die on a DBC, which is soldered onto a copper baseplate.

This article was written for AEI by **Ronald Eisele** and **Klaus Olesen** of Danfoss Silicon Power GmbH.