Interview with
Volvo E/E VP,
Thomas Müller

I spoke last month with Thomas Müller, vice president, electrical and electronic systems engineering at Volvo Car in Göteborg, Sweden, about the carmaker’s new EE architecture, the standards he favors, software development and Volvo innovation. Dr. Müller, who has a Ph.D. in nuclear physics, joined Volvo from BMW, where he most recently worked on connectivity, HMI and driver assistance system development. At Volvo he is responsible for developing Volvo Group’s electrical architecture, infotainment systems, connectivity, HMI, body and security electronics, cable harnesses and the electrical integration of ECUs into the vehicle.

Volvo’s New Domain Architecture

Faced with rising complexity and a big increase in functionality, Dr. Müller’s organization has developed a new electrical and electronics architecture that is both future-proof and flexible. The domain architecture will first be applied to the new XC90, Volvo’s big SUV due to go into production at the end of 2014, and then to all new Volvo models as they are launched.

Based around a number of domain controllers, e.g. powertrain, chassis or active safety, which are connected to each other by means of a central FlexRay backbone, the new architecture is expected to reduce data traffic to 40% of today’s volume. Each domain controller will have different levels of support capability for entry-level, mid-level and high-end feature sets.

High-end, fully featured Volvos will have as many as 100 ECUs. “As we looked at all the innovations and new features planned for future vehicles, the rise in software, the demand for processing power and the number of signals interchanged on the buses, we decided it was time for a completely new architecture,” said Dr. Müller.

Self-Driving Car Development Faces Huge Hurdles

Google’s self-driving vehicle development program came to light in October 2010 followed by a flood of publicity. What quickly followed was the realization by the general public that cars will, in the not very distant future, be able to drive themselves, probably better than people can. Since then carmakers have stepped up their own publicity to inform consumers that they too have been experimenting with cars that drive themselves.

Now a number of carmakers and suppliers have fully embraced automated driving as a long-range objective worth serious investment. This fall, Mercedes will begin shipping the 2014 S Class with Stop&Go Pilot, an optional feature that automates acceleration, braking and steering in stop and go driving at speeds up to 60 kph (37 mph). But while the vehicle can steer itself, the driver is required to keep his hands on the wheel or the feature is deactivated.

Other carmakers have signaled that they will soon bring automated driving features to the market. Cadillac could in the next couple of years introduce Super Cruise, a feature that lets the vehicle drive itself on freeways and in stop-and-go traffic without the driver’s hands on the wheel. “While the driver will be able to do other things with his hands, he won’t be able to disengage from the driving task,” noted John Capp, director of electronics and controls research and active safety strategy at General Motors. “He will be monitored to be sure he stays alert so he can immediately take the wheel back when needed.”

Continental refers to features such as Stop&Go Pilot and Super Cruise as partially automated driving, because the driver cannot be permitted to disengage from his driving responsibility. He must continually monitor what the vehicle is doing and quickly take over should something go wrong.

According to Continental, partially automated systems will be the rule at least until 2020. In the meantime, the industry will tackle many daunting legal, technical and driver interface challenges before it can offer systems that allow the driver to take his mind off the driving while the control system is engaged.

The driver interface challenge includes answering some basic questions. What is the benefit of automatic driving if the driver must be fully in charge? Will a consumer pay extra for a car that can steer itself in stop-and-go traffic if his hands have to be on the steering wheel anyway? Even if a carmaker has enough confidence in the feature to let the driver take his hands off the wheel, what will he be able to do with his hands if he must keep his eyes and attention on the road ahead?

One of the promises of partially automated vehicles is safety. “Safety will be a prerequisite for these cars,” said Alfred Eckert, head of advanced engineering for Continental’s Chassis and Safety division. “They will automatically brake and keep to their lane.”

But as driving becomes more automated, will it become even more boring than it already often is? The driver will be more likely to turn to his smartphone or even a book, or he could doze off. If the driver must be responsible, how do we keep him in the loop as driving requires less and less of him? Partially automated driving could make him less safe.

Letting the Driver Disengage

Carmakers aren’t about to take responsibility for a fully automated vehicle’s performance until everyone is 100% convinced that cars are able to drive themselves more safely than people can. Of all the challenges that must be overcome before cars can drive themselves without a human driver even temporarily in the loop, the legal and regulatory obstacles are probably the greatest. Insurance companies will step in to underwrite the liabilities once the technology is proven safe, but the
“That will give us a lot of headroom on the bus. ... Most of our competitors are living with a star architecture, which will have one or several gateways that become bottlenecks and lead to point-to-point connections all over the place. Instead, we want to encapsulate systems within clear domains.”

With the architecture compartmentalized into domains, it is easier to add features. For example, integrating new sensors or actuators into the chassis domain will have little effect on the other domains. Problems that may occur during development will be easier to diagnose, since they can often be isolated within a domain.

In a few years, the FlexRay backbone will likely be changed to Ethernet. “Once Ethernet gives a cost benefit, and once there is an advantage from a technology and bandwidth point of view, we can easily switch to Ethernet,” Dr. Müller noted. “Our logical architecture makes that possible. Ethernet could reach that point by 2015 or 2016,” he said. Volvo already uses Ethernet to download software to the car.

Volvo’s new architecture is based on Autosar 4. “We are the world’s first carmaker to convert an entire network and tool chain to Autosar 4,” said Dr. Müller. “Standards are important to us. We don’t want to make Volvo unique in areas where it makes no difference to the customer. We would rather focus on being unique in the parts of the vehicle where we can differentiate.” Volvo uses a MOST 150 bus in its infotainment system.

Back End Developed with Ericsson
Volvo is working with the Swedish telecommunications company Ericsson to develop its cloud-connected back end, capable of delivering infotainment, apps and communications services to Volvo cars. The first head unit to make use of the new back end will come to market at the end of 2013 in a refreshed vehicle. Development of the new back end will be complete at the end of 2014 in time for the new XC90.

According to Dr. Müller, Volvo reached out to Ericsson because the telecommunications industry is already doing many of the things the carmaker aims to do. “They remotely control mobile devices, they do firmware updates over the air, they manage devices remotely. We have similar requirements. We need to know which car in which configuration is connected to which customer in which market. Ericsson adapted their tool suite to our needs.”

The back-end servers will run at Volvo’s trusted IT centers. “We need to have control of the back end so we can protect the vehicle from cyber-attacks. In the future, when you connect to the Internet from a Volvo it will not be a direct link from the car to just any server somewhere in the world; it will always go via our trusted back end. Used correctly, servers in the back end can create a lot of value for our customers.”

More In-House Software Development
Volvo already develops quite a bit of its software in house. The carmaker handles its own powertrain calibration and develops much of its chassis and central body controller software. The algorithm and much of the software that defines City Safety, Volvo’s active safety system that brakes automatically for pedestrians and cyclists at speeds up to 50 kph, is developed by Volvo.

In the future Volvo will also develop Volvo-specific service apps and HMI software. “HMI is an important domain for us because it uniquely defines Volvo’s identity. HMI software should be a longliving part that can port from one hardware platform to another,” Dr. Müller noted. That strategy aligns with a trend in the industry to decouple hardware from software as is done with Genivi and Linux and possibly in the future with a QNX or Windows platform. “Today if you switch from one headunit supplier to another, the only thing you carry over to the new supplier is the specification. Then they have to develop everything all over again from scratch, including the look and feel. This is a big waste.”

Most Volvo software is developed at the company’s headquarters in Göteborg. However, apps and CE device integration software is developed closer to the markets where Volvo cars are sold. The company has software development teams in California, Shanghai and Copenhagen.

Navigation Data Standard
Another standard advocated by Dr. Müller is the Navigation Data Standard. “With NDS-compliant navigation systems you can do partial map updates over the air and even exchange compiled map artifacts from one supplier to another. You don’t need to buy a complete DVD and copy all the map data to your head unit. The second advantage is that the map format is independent of the head unit supplier. That means you could buy NDS-compliant, compiled (machine readable) map data from a variety of suppliers.” Volvo is a member of NDS; Dr. Müller was its first chairman. Daimler, Volkswagen and BMW are NDS members, along with a number of infotainment, navigation systems and map data suppliers.

How Suppliers Can Help Volvo
I asked Dr. Müller what investments suppliers should be making to win business with Volvo. “On the infotainment side, I definitely want them to deliver systems that decouple the hardware from software so we can use our own HMI and install best of breed third-party applications. The same goes for suppliers of head-up-displays and clusters. Outside of infotainment, our suppliers must also have Autosar experience. And they must be very good software developers, especially good at controlling and managing software projects. A number of suppliers out there are quite good at software, but others are still too hardware oriented.”

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Automated Driving...

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2014 Features Update

Fuel Economy

As the U.S. economy recovered in 2013, so did sales of large pickup trucks, but with gasoline selling at roughly $3.60 per gallon in the U.S. and more than $8.00 per gallon (€1.6 per liter) in Europe, fuel economy remains an important factor for at least some new car buyers. J.D. Power and Associates’ 2013 Automotive Emerging Technologies Study found that of the 22 technology features presented, vehicle owners showed the most interest in fuel economy indicators and, oddly, active shutter grille vents, which carmakers have installed on many different models over the past few years to gain a slight boost in miles per gallon.

The average sales-weighted fuel economy of new vehicles purchased in the United States was 24.8 miles per gallon, a 5% improvement from a year ago. In addition to developing more electric vehicles, plug-in hybrids and attractive subcompacts, carmakers are downsizing and turbocharging engines, removing weight and working to improve combustion efficiency in preparation for stricter CAFÉ requirements in the U.S. and tougher CO2 emissions targets looming in Europe and other regions.

More carmakers are adding an “eco mode” option for drivers, which adjusts the electronic throttle response and transmission shifting points to save fuel. Gasoline direct injection (GDI) engines will find their way to 18% of global car production in 2015, according to Bosch. Combined with an exhaust-gas turbocharger, Bosch claims its GDI can achieve a reduction in fuel consumption and carbon dioxide emissions of roughly 15%.

By 2015, according to TRW, 75% of new vehicles in North America and 80% in Europe will come with electric power steering, which consumes less than 7% of the energy required by conventional hydraulic rack and pinion power steering systems.

According to Johnson Controls, penetration of start stop systems, which reduce fuel consumption by 5% to 8%, will reach 70% of new vehicles in Europe in three years.

In tests by the European Union, LED headlights on an Audi A6 consumed far less energy than halogen bulbs: 80 watts vs. 135 for halogen. Audi was first to intro-

Turn to Features, page 8
The Company Profile... Denso Corp.

**Headquarters**: Kariya, Aichi, Japan; telephone: 81-566-25-5511; www.globaldenso.com

**FY 2013 Net Sales**: ¥3,580.9 billion ($36.2 billion)

**R&D**: 9.4%

**Capital Expenditures**: 6.4% of sales

**Operating Margin**: 7.3%

**Net Cash Provided by Operating Activities**: ¥374.8 billion ($3.8 billion)

**Working Capital**: ¥1,308.4 billion ($13.2 billion)

**Long Term Debt**: ¥351.2 billion ($3.5 billion)

**Stockholders’ Equity**: ¥2,164.1 billion ($21.9 billion)

**Market Capitalization**: ¥4,110.9 billion ($41.5 billion) as of September 4, 2013

**Employees**: 132,276

**Sales per Employee**: ¥27.1 million ($273,876)

**Main Customer**: Toyota Group carmakers accounted for 51% of Denso’s sales.

**Main Products**: Thermal systems and powertrain control systems account for more than half of sales.

**Ownership**: Toyota Motor Company, 24.8%

Denso’s 2013 fiscal year ended March 31, 2013.

**Background**

In 1949, Toyota spun off its radiator and electrical operations to form an independent company, which operated as Nippondenso until the name was changed to Denso in 1996. Toyota still owns 24.8% of the company and is by far Denso’s largest customer, accounting for 47% of FY 2013 sales. According to Denso, the amount of business the company gets from Toyota is not mandated, rather it competes for Toyota business on an even playing field.

Denso sales have grown 3.3% per year between FY 2009 and FY 2013. During the same period Toyota unit production increased annually at the rate of 5.4%. Denso expects business to be up in FY 2014 as well, with sales up 8.6% over the prior year’s. Powertrain control systems are the company’s largest product segment, contributing just over one-third of annual revenue.

Over the long term, Denso plans to strengthen its relationships with major automakers, expand business in emerging markets and develop systems that make vehicles more appealing. It also plans to expand its aftermarket business and develop new businesses beyond automotive. As part of its strategy for the near-term period ending in the 2015 fiscal year, Denso plans to focus its investments toward developing more world’s-first technologies.

Software is a crucial automotive electronics ingredient. To keep development costs low, some years ago Denso established two software development companies in low labor cost countries, one in Makati City, Philippines (near Manila), and the other in Shanghai, China. Both are subsidiaries of Denso Techno, Denso’s software development subsidiary, which has 2,209 employees. Denso also develops software at its technical facility in Delhi, India.

**Why Denso**

Suppliers are defined by the carmakers they serve and Denso serves Toyota, one of the world’s best in terms of value, reliability and profitability.

The world’s second-largest auto parts supplier, after Bosch, Denso’s competencies in thermal management, powertrain control, electrical/electronics parts and information and safety systems account for a significant percentage of the vehicle’s value. Denso says it develops systems from a vehicle perspective as opposed to a component perspective. For example, for stop-start systems, Denso can provide the starters, the battery packs and the cold storage evaporators, which combine to make stop-start systems that are especially efficient.

As a global company with more than 200 operations and seven technical centers worldwide, Denso can develop and manufacture products that meet the needs of each region and its broad customer base.
Denso is well positioned with technology and capability to respond to two of the automotive industry’s biggest trends: the universal drive to produce vehicles that have less impact on the environment and the universal drive to make them safer.

**Environmentally Beneficial Products**

- **Stop-Start Systems**

  Denso anticipates a fast rise globally for stop-start systems, which turn off the engine at idle. In 2010 just 5% of passenger and commercial vehicles weighing six tons or less were fitted with stop-start capability. By 2018, 35% of new vehicles globally will have the feature, according to Denso. In the future, stop-start systems will even shut down the engine when the vehicle is coasting. Passive coating, which will require a 48-volt battery, can reduce fuel consumption up to 15%, compared with 3% to 5% for conventional stop-start systems based on 12 volts.

  Denso’s Tandem Solenoid starter, lithium-ion battery pack and cold storage evaporator are aimed at this fast-growing market. According to Denso its Tandem Solenoid starter reduces engine restart time by 1.5 seconds.

  Last year the company introduced a lithium-ion battery pack that further increases the fuel efficiency of vehicles with stop-start systems. The battery pack allows the stop-start system to use more regenerative power than conventional systems that use a single lead-acid battery. The pack consists of a battery management unit and power supply control switch, as well as battery cells. The cells are produced by Toshiba.

  Denso’s cold storage evaporator limits the increase in vehicle cabin temperature during an idle stop when stop-start technology is employed. Developed in 2012, the evaporator is equipped with a cold insulator, located in the heat exchanger, which stores cold energy to cool cabin air while the engine and air conditioner are off.

  The Li-ion battery pack, the cold storage evaporator and the quick starting Tandem Solenoid starter are currently supplied to Suzuki in a stop-start application.

- **Smaller, More Efficient Radiator and Condenser**

  Two other relatively new environmentally friendly products are showing promise, according to Denso: a line of radiators that are 40% smaller compared to previous radiators and the Global Inner-Fin Condenser, which is 30% smaller.

- **48-Volt Power Supply**

  Denso is developing technologies for 48-volt systems. The company expects demand for such products to start in 2016 and reach significant volume after 2020 once the 95 g/km CO2 emission standard is in place in Europe.

**Distinctions Claimed by Denso**

- World’s second-largest automotive parts supplier
- First to commercialize diesel common rail systems. In 2013 Denso developed a diesel common rail system featuring 250 MPa (2,500 bar) injection pressure. Denso is working on a 3,000 bar system.
- In collaboration with Philips and Lite-On Digital Solutions, Denso developed the world’s first integrated, in-vehicle wireless cell phone charger, which debuted on the 2013 Toyota Avalon.
- Developed the world’s first motor-driven electric variable cam-timing control system for the Lexus LS460, launched in September 2006.
- In 2003, Denso invented the world’s first electric powered compressor for hybrids, allowing the vehicle’s AC to cool the car even while the engine is off.
- Invented QR (Quick Response) code, the machine-readable, two-dimensional barcode consisting of an array of black and white squares, typically used for storing URLs or other information for reading by the camera on a smartphone.

**Safety-Related Products**

According to Denso, most accidents are caused by driver error or driver behavior related to delayed recognition of potential risks, judgment and operation. So the company is focused on developing products for active safety, such as adaptive cruise control. Denso expects greater demand for autonomous emergency braking (AEB) systems and lane departure warning systems, especially in Europe, where carmakers will try to achieve five-star ratings in the European New Car Assessment program. Safety regulations in the U.S. and Japan will also stimulate demand for AEB systems.

The company is also investing in head-up display technology, which projects information onto the windshield and helps to keep drivers’ eyes on the road. The demand for HUDs is expected to grow, says Denso.

Denso continues to invest in vision sensors, millimeter-wave radar and laser-radar sensors and in systems that fuse sensor outputs. According to Denso, the following
### Thermal Systems
**Thermal Systems Products**
- Air conditioning systems for cars
- Radiators
- Cooling fans
- Inter coolers
- Engine cooling modules
- Reserve tanks

**Climate Cooling and Heating Products**
- Air conditioning systems for buses and construction equipment
- Truck refrigeration units
- Air purifiers

### Powertrain Control Systems
**Engine Control Components**
- Ignition coils
- Magnetos
- Spark plugs
- Glow plugs
- Exhaust gas sensors
- Ceramic substrates
- Diesel particulate filters
- Engine ECUs for motorcycles
- Exhaust gas temperature sensors

**System control components**
- Exhaust gas circulation valves
- Automatic transmission (AT) control valves
- AT solenoid valves
- Oil flow control valves
- Vacuum switching valves
- Knock sensors
- Variable cam timing components
- Throttle bodies
- Air flow meters
- Oil filters
- Air cleaners
- Integrated air-fuel modules
- Shift-by-wire actuators
- Horns
- Accelerator pedal modules

### Electronic Systems
**Electronics Products**
- Engine ECUs
- Transmission ECUs
- Power management ECUs

**Electronic Devices**
- Sensors
- Manifold absolute pressure sensors
- Fuel tank pressure sensors
- Fuel pressure sensors
- Oxygen sensors
- Air-fuel ratio sensors
- Exhaust gas pressure sensors
- Speed sensors
- Ambient sensors
- Evaporator temperature sensors
- Humidity sensors
- Sonar sensors
- Rain sensors
- Vision sensors
- Inertia sensors
- ICs
- Power modules
- Relays

**Small Motors**
- Windshield wiper systems
- Windshield washer systems
- Power window motors
- Seat motors
- Power sliding door motors
- Power steering motors
- Motors for engine control systems
- Other automotive motors

### Denso Corp.
- Evaporative leak check pump modules
- Diesel Injection Products
- Common rail systems
- In-line fuel injection pumps
- Rotary fuel injection pumps
- Nozzles
- Fuel filters
- Gasoline Injection Products
- Fuel pumps
- Fuel pump modules
- Fuel injectors
- Engine Electrical Systems
- Starters
- Alternators
- Electric Hybrid Vehicle Components
- Inverters
- DC-DC converters
- Battery monitoring units

### Information and Safety Systems
**Information and Communications**
- Instrument clusters
- Integrated climate control panels
- Smart keys
- Remote keyless entry controllers
- Rear and corner sonars
- Car security systems
- Body ECUs
- Tire pressure monitoring systems
- Remote touch controllers
- Car navigation systems
- Electronic toll collection on-board equipment
- Data communications modules
- Advanced vehicle operation systems

**Driving Assist and Safety Products**
- Airbag sensors and ECUs
- ABS/ESC actuators and ECUs
- Millimeter wave radar
- ECUs for pre-crash safety systems
- ECUs for adaptive cruise control systems
- Laser radar and ECUs for ACC systems

**Cameras and ECUs for lane keeping assist**
- ECUs for adaptive lighting systems

**Electric Control Components**
- Sensors
- Manifold absolute pressure sensors
- Fuel tank pressure sensors
- Fuel pressure sensors
- Oxygen sensors
- Air-fuel ratio sensors
- Exhaust gas pressure sensors
- Speed sensors
- Ambient sensors
- Evaporator temperature sensors
- Humidity sensors
- Sonar sensors
- Rain sensors
- Vision sensors
- Inertia sensors

**Autonomous Emergency Braking**
Denso’s autonomous emergency braking system uses a vision sensor to identify a potential risk, whether it is a vehicle, pedestrian or stationary object, and millimeter-wave radar to determine the obstacle’s position, distance and the vehicle’s relative velocity approaching it. Combining data from both sources improves reliability and insures an accurate assessment before activating emergency brake assist.

Denso’s newest millimeter-wave radar has a detection distance of 205 meters and a +/- 18-degree detection radius within a distance of 35 meters from the vehicle.

are some of the company's most promising new or relatively new safety products where those technologies will be applied.

**Lane Keeping Assist**
Denso’s latest generation high resolution vision sensor, introduced in 2012, is 50% smaller than its predecessor, performs at higher operating temperatures and is equipped with a full color camera, which enables it to detect different color lane markings that might be used in different regions of the world as well as raised dot lane markings. The new vision sensor is used in active safety systems that include an automatic high beam control feature. The camera allows it to distinguish red tail lights on a vehicle ahead from other light sources.

**Driver Status Monitor**
Denso also applies its camera technology in a driver status monitor. The sensor detects position and movement of the driver’s face and eyelids and Denso’s image processing technology determines if the driver is sleepy or inattentive. Denso has not booked any orders yet for the driver monitor.

The Company Profile Continued

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<th>Sales by Customer in ¥ billion</th>
<th>FY 2013</th>
<th>% of Total</th>
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According to the company, the longer detection range enables adaptive cruise control to maintain a safe and constant distance to the vehicle ahead, even at higher speeds. The wider detection angle, achieved by better positioning the receiving antenna, improves ACC responsiveness. Denso’s ACC is available as a factory option on the new Maz6.

**Low-Speed Collision Avoidance**

This year, Denso announced it had developed a smaller and more cost-effective laser radar sensor that is applied in the Smart Assist low-speed collision avoidance system available on the Daihatsu Move compact. To reduce package size, Denso developed a simpler laser beam generation mechanism and integrated the ECU into the signal processing boards. Using a smaller lens also saves space.

**Pedestrian Collision Detection Sensor for the Pop-Up Hood**

The new sensor more precisely detects frontal collisions between vehicles and pedestrians. Instead of using the more common configuration of three acceleration sensors installed in the front bumper, Denso’s new approach uses two pressure sensors affixed to a hollow polyethylene housing installed across the front bumper conforming to the bumper’s shape. If the front of the vehicle strikes a pedestrian, the pressure sensors detect the increase in pressure as the housing deforms. The sensor is installed in the Pop-up Hood of the Toyota Crown Hybrid launched in Japan. The Pop-up Hood feature is designed to create a larger buffer space between the hood and the engine in the event of a collision with a pedestrian.

**Key Electronics Alliances**

In February 2012, Denso signed a memorandum of understanding with Intel to collaborate on next-generation infotainment systems research. The two companies will develop a platform that connects to the vehicle bus and to mobile devices. The platform will allow for infotainment system and app updates.

In July 2010 Microsoft and Denso signed a cross licensing agreement covering automotive infotainment and embedded navigation intellectual property.

In 2003 Bosch and Denso founded Advanced Driver Information Technology (ADIT), a 50-50 joint development partnership to develop infotainment system platforms in Kariya, Japan, and Hildesheim, Germany. ADIT’s latest platform is based on Genivi 4.0, the open source infotainment platform based on Linux. It will be brought to market by Bosch in 2014.

Denso is considering developing a multi-media system based on Genivi; it will make a final decision based on customer requirements.

**Bosch Sold Its Denso Stock**

In November 2012 Bosch sold its 5% stake in Denso, roughly 4.6 million shares, for €1.1 billion euros. The deal valued Denso at €2.2 billion ($2.9 billion) or 0.9 times sales. Bosch has held a significant position in Denso equity since the mid-1950s, which it took in return for granting licenses to Denso to manufacture and sell automotive parts such as generators, starters and spark plugs. According to a Bosch statement, the deal will not alter the “long-standing successful relationship between Bosch and Denzo.” In addition to ADIT, Bosch and Denso still jointly own the U.S. fuel pump maker AFCO.

**Denso-Made Semiconductors**

Denso produces a variety of semiconductor devices in house, including diodes, power transistors, microcontrollers and sensors, at two semiconductor facilities located in Aichi, Japan. Citing demand for a more diverse selection of semiconductors, in October 2012 Denso added a third semiconductor facility when it purchased the 1.2 million square-foot Iwate plant from Fujitsu Semiconductor. Besides serving Denso’s in-house needs, the facility will continue to supply Fujitsu customers with output from the plant until 2016.

In February 2013, Denso announced a licensing agreement with Tokyo-based New Japan Radio Co. for its 600 V super junction metal-oxide semiconductor (SJ MOS) transistor manufacturing technology, which realizes a power semiconductor device with an on-resistance of 13.5 mΩ per unit area, the world’s lowest, according to Denso.◆
Features...

duce LED headlights, in 2008. The new 2014 Mercedes S Class uses LED lighting throughout the vehicle. LED headlights, while still in very limited use, are beginning to show up in non-luxury vehicles. For example, even at the lowest trim level the 2014 Toyota Corolla has standard LED low beams and daytime running lights.

LED headlights will likely be adopted more quickly in Europe following a decision by the European Union in March 2013 to recognize LEDs as an eco-innovation that improves fuel economy and reduces CO2 emissions by at least one gram per kilometer.

Audi’s Matrix LED headlights, fitted on the 2014 A8, can automatically adjust their illumination to avoid blinding drivers in oncoming cars by switching off or dimming the appropriate LED segments. Using information from the car’s navigation system and an onboard camera, they can also provide maximum illumination on curving roads without using motors to swivel the beams as the car corners.

The S Class’ LED headlights employ a motorized shield that masks the high beams as needed to avoid blinding oncoming drivers or drivers in cars it approaches from the rear. Introduction of these and other types of intelligent lighting systems in the U.S. is being delayed by outdated regulations that require a switch to dim high beams. Several carmakers and the SAE are working with NHTSA to revise the requirements.

Safety

Most major carmakers currently offer vehicles with some kind of head-up display (HUD), which projects an image that appears to be above the vehicle’s hood, in the driver’s direct line of sight, helping to keep his eyes on the road. Information such as speed, speed limits and navigation directions are usually displayed. According to Nippon Seiki, the market leader in HUDs, all carmakers are either in production or in the process of launching a head-up display program. The global market for the feature is expected to grow at more than 14% per year over the next three or four years. Garmin offers an aftermarket HUD that fits any vehicle and works with the user’s smartphone, for example, projecting driving directions from a navigation app.

Cars that can almost drive themselves, such as the new Mercedes S Class and BMW X5, are here. BMW has demonstrated cars that can pass other vehicles autonomously. (See the feature article on autonomous driving, page one.) Volvo plans to introduce its Traffic Jam Assist feature in 2014. The vehicle will be able to steer, brake and accelerate on its own at speeds below 31 mph.

Advanced driver assistance features such as radar adaptive cruise control with automatic braking are becoming available in more mainstream cars, for example the 2014 Mazda3 compact. Volvo’s City Safety autonomous emergency braking system will be standard on most Volvo models in 2014. Beginning in 2014, autonomous emergency braking is required for a car to earn a five star Euro NCAP rating.

Chrysler’s 2014 Jeep Cherokee can sense road conditions and automatically select either four-wheel drive or front-wheel drive as needed to maintain traction.

Connectivity/Convenience

eCall, the emergency assistance communications link mandated for new model cars in Europe beginning in October 2015, will drive further use of embedded cellular connectivity. Customers’ brought-in smartphones do not meet eCall requirements. According to a report by the market research firm IHS, 25% of cars sold in the U.S. in 2012 had embedded cellular modems as standard equipment, enabling services like OnStar, Chrysler’s UConnect, BMW Assist, Mercedes mbrace and the new Volkswagen Car-Net subscription service, similar to OnStar.

Working with AT&T, GM plans to roll out embedded 4G mobile Internet access in most of its 2015 models. Audi was first to offer 4G LTE service, in Europe this summer on the S3; 4G will be available in the U.S. on the A3 in the spring of 2014. Many carmakers offer connectivity through both embedded (3G) and smartphone connections and will likely continue to do so. Safety related features such as automatic emergency notification when airbags deploy, vehicle diagnostics and software updates are better done through embedded connections.

According to J.D. Power and Associates, 67% of vehicle owners also own smartphones. Wireless charging for Qi-enabled devices (such as the Samsung Galaxy S4, HTC Droid DNA, Nokia Lumia 920, Nexus devices, but not the iPhone) is available in the 2013 Toyota Avalon, some 2013 Dodge Darts, the 2014 Jeep Cherokee and the 2014 Toyota Prius. According to the Wireless Power Consortium, its Qi standard is the only wireless charging solution integrated into vehicles at present. Following its $5 million investment in Powermat Technologies, which offers a competing wireless charging standard, GM plans to offer the feature in future models but has not announced any specifics.

Touchscreen displays are swiftly moving down market to vehicles including the 2014 Honda Fit/Jazz and 2014 Toyota Corolla. Toyota’s touchscreen Display Audio System is standard in all 2014 Scion models and 2013 xBs produced since August 2013.

Every carmaker looks for attractive new features that will pull new buyers to its brand. Infiniti’s brand new Q50 model, in addition to offering a full suite of apps, can identify up to four drivers by means of a smart key. After delivering a personal greeting on the display screen, the system also automatically brings up the driver’s preferred settings in music, steering (the Q50 has an adjustable steer-by-wire system), temperature setting and seat position. The system can also display the driver’s preferred Android and iPhone apps.

Automotive TFT LCD Forecast

NPD DisplaySearch forecasts global unit shipments of automotive TFT LCDs will grow by more than 8% per year from 2013 through 2016. Japan Display Inc., with 32.8% market share, is the largest supplier.