**Customized ICs reduce costs**

*In automotive electronics, there is a trend towards application-specific chips. OEMs and Tier-1s increasingly use FPGAs, ASICs, and other customized ICs, in order to make ECUs and system design more efficient.*

Nowadays, about one fourth to one third of the car production costs are related to electronics. More importantly, automotive electronics contribute 90% of the innovation. This includes safety systems, entertainment, and emission reduction as well as the upcoming autonomous driving functions. The annual average growth rate was about 7% in the last years. Market researchers predict 179 billion € worldwide turnover for automotive electronics for 2017. Radiant Insights (USA) expects in its "Global automotive electronic control unit (ECU) market size" report an annual growth rate of six percent. In 2022, the ECU market will exceed 45 billion US $.

**ECUs for passenger cars as well as for commercial and utility vehicles**

The automotive ECU market can be segmented based on type, application, and technology. Based on type, the market can be segmented as utility vehicles, commercial vehicles, and passenger cars. Of course, the requirements for ECUs are different. High-volumes are used in passenger cars, while ECUs for commercial and utility vehicles are produced in lower quantities.

Based on technology, the market can be further segmented as transmission control, engine management, anti-lock braking system, climate control, power steering, airbag restraint system, and body control system. On the basis of application, the market can be categorized in communication and navigation systems, entertainment systems, powertrain electronics, chassis electronics, and safety as well as security systems. The safety and security segment is anticipated to be the highest. Communication and navigation systems are likely to exhibit high growth owing to rising demand for comfort characteristics.

Nearly 100% of these ECUs are connected to in-vehicle networks. CAN is still the most used communication technology. CiA estimates for 2016 the installed number of CAN interfaces close to one billion. Most of the CAN-connectable ECUs are equipped with micro-controllers with...
on-chip CAN modules. CAN stand-alone controllers are used rarely, e.g. for some tools and some other low-volume applications. CAN is also implemented in several customized ICs (integrated circuit) such as System-on-Chip (SoC), application-specific standard product (ASSP), or application-specific integrated circuit (ASIC).

Customized circuitries become increasingly popular in ECU design. In order to simplify the design of ECUs with still increasing complexity, it is necessary to use application-optimized components. This keeps the chip costs tolerable. SoCs, ASSPs, and ASICs have a great future in automotive electronics. These products offer high-performance and low-power consumption, which is what the ECU makers like – and their customers as well. On the other hand, these chips are only partly programmable. This brings FPGAs (field-programmable gate arrays) into the game. For low-volume designs or for prototyping or for highly configurable devices, FPGAs are well suited. No surprise that after the CRC issue of the CAN FD standardization, it was quite easy for the FPGA vendors to update their silicon. Some of the micro-controller manufacturers are still working to migrate from the non-ISO to the ISO CAN FD protocol.

SoC-class FPGAs can comprise several processor cores including DSPs (digital signal processors), on-chip memory, dedicated logic circuitries, and CAN (FD) cores as well as transceiver blocks. There are also PSoCs (programmable system on chip) on the market: Cypress offers a hard-coded micro-controller core with programmable analog and digital parts. Altera and Xilinx provide similar solutions. The naming is not unified: some call those components CPLD (complex programmable logic device), PAL (programmable logic array), macrocell array, etc. The main players include Altera, Atmel, Cypress, Lattice, and Xilinx.

Automotive OEMs and Tier-1s use FPGAs and CLDPs to differentiate their ECUs and optimize them to their requirements on functionality and costs. Altera’s automotive-grade portfolio of highly integrated Empirion PowerSoC power management solutions features 45000 year mean-time between failures (MTBF) and delivers high efficiency in a tiny footprint to maximize power density, simplify design, reduce system cost, and minimize heat.

**Faster development cycles**

There are three challenges, automotive ECUs designers have to face: faster development cycles, cost-effective development as well as meeting quality and safety requirements. The gap between consumer and automotive technologies has narrowed significantly with automotive innovations keeping pace with consumer, or in some cases, leading. For example, video analytics for driver assist systems rely on ultra-low latency precision algorithms to analyze real-time video feeds from a vehicle’s cameras and make split-second decisions. System designers need to use the latest silicon to achieve these levels, but new ASIC/ASSP development schedules cannot keep up with the faster development cycles.

More and more system designers are using FPGAs for volume applications because of the following advantages they offer:

- **Shape-independent**
- **Network-independent**
- **Hierachy-independent**
- **Future proof**
- **Secures investment**

Future proof communication solution for CANopen, thanks to Hilscher Platform Strategy.
Shorter time to market compared to ASIC solution through re-programmability and reduced risk vs. an ASSP with the ability to fix bugs without a redesign;
- Do not go through the same time consuming physical design, design-rule closure, tape-out, and fabrication processes that ASICs do;
- Ability to make hardware changes available in FPGAs are not an option with ASSP and microcontroller unit (MCU) designs;
- Design software such as Altera’s Quartus Prime speeds-up system design and take advantage of FPGA in-system verification to reduce debugging effort.

Automotive OEMs are struggling with the economic and logistic realities of differentiating vehicles across hundreds of models and options. Many recognize the need for a modular system design approach based on flexible platforms that are customizable across several vehicle models or grades (entry, mid, high, or luxury). They like to scale the size of the FPGA within the same package so that they can increase logic resources using the same board design. They also appreciate the support of multiple types of image, radar and laser sensors, and various network connectivity options like CAN (FD), Flexray, MOST (media-oriented system transport), and Ethernet AVB (audio/video bridging). Altera provides different customized IC solutions: MAX II CPLDs, Cyclone and MAX 10 series FPGAs, and Cyclone V SoCs with ARM-based hard processor system (HPS). The company guarantees to support the developed hardware for a minimum of ten years after release. “Our average product cycle is 15 years, with many of our products having lifetimes in excess of 20 years so you can design in our products with confidence,” states the company on its website. “When change is absolutely mandatory, we take exceptional care to provide special product change notifications so you can manage the delicate roll-out of changes to your customers, the automakers, in a coordinated and well-orchestrated manner.”

Intel completed the acquisition of Altera

End of 2015, Intel announced that it has completed 16.7 billion US-$ acquisition of Altera. This means Intel is back in automotive electronics. Back in the mid ‘80s, Intel was one of the first companies implementing the CAN protocol in its legendary 82526 stand-alone controller. The successor 82257, also a CAN stand-alone controller, was quite successful. But Intel decided in the ‘90s to focus on the PC business and stop the production of CAN products. Nevertheless, the 82257 is still alive: Innovasic offers the IA82527 CAN controller. It is a form, fit, and function replacement for the original Intel 82527 chip. This allows users to retain existing board designs, software compilers/assemblers, and emulation tools, thereby avoiding expensive redesign efforts.

The Altera acquisition complements Intel’s product portfolio and enables new classes of products in the high-growth data center and Internet of Things (IoT) market segments as well as automotive electronics. “Altera is now part of Intel, and together we will make the next generation of semiconductors not only better but able to do more,” said Brian Krzanich, Intel CEO. “We will apply Moore’s Law to grow today’s FPGA business, and we’ll invent new products that make amazing experiences of the future possible – experiences like autonomous driving and machine learning.”

Altera will operate as an Intel business unit called the Programmable Solutions Group (PSG), led by Altera veteran Dan McNamara. Intel promised a smooth transition for Altera customers and will continue the support and future product development of Altera’s many products, including FPGA, ARM-based SoC, and power products.

Altera cooperates with IFI (engineering office for IC technology) in respect to CAN FD cores for its customized IC business. The CAN-FD Mega Core for the German company supports the protocol as standardized in ISO 11898-1:2015 standard, released at the end of 2015. The core provides message transmit and receive buffers with capacity of up to 64 KiB each. The FIFO (first-in, first-out) buffers can be assigned dynamically to the message size. The core features 256 message filters, time-stamp functionality (captured at EOF and SOF), and an Avalon memory-mapped interface. It comes with software drivers.

CAN Newsletter Online

The CAN Newsletter Online sister publication provides brief product-related information. For more details please visit www.can-newsletter.org.

**Cooperation**

**Verification of CAN FD cores**
Avery Design Systems, Rianta Solutions, and Cast have joined their forces to provide verified IP cores for CAN FD and other automotive networks. Read on

**IP core**

**Compliant with Arinc 825-1**
Silkan (France) provides the D002, Arinc825 core featuring the CAN protocol. It can be integrated into FPGAs and ASICs. Read on

**IP core**

**Supports ISO and non-ISO CAN FD**
IF1 (Germany) provides CAN FD silicon implemented in different FPGAs from Altera. The user can switch between ISO and non-ISO mode. Read on

**CAN FD products**

**Microchip goes automotive**
Microchip has pre-announced its CAN FD stand-alone controller and transceiver. Its daughter company, K2L has launched interface devices supporting CAN FD to be used with the company’s software tools. Read on

**IP solution**

**Non-ISO CAN FD core for automobiles**
Arasan’s Total IP Solution implements the Classical CAN protocol, as well as the non-ISO CAN FD protocol compliant to Bosch. The company plans the development of CAN FD transceivers, too. Read on
Xilinx supports the CAN FD core from Fraunhofer IMPS

Competitor Xilinx cooperates with Cast to provide a CAN FD core for its customized chips. Cast offers the CAN FD core developed by Fraunhofer IMPS (Institute for Photonic Micro-systems). The CAN-CTRL core features programmable interrupts and bit-rates. The number of independently programmable acceptance filters is configurable. The core has a generic processor interface or comes optionally with an AMBA-APB interface. It implements a flexible buffering scheme, allowing fine-tuning of the core size to the requirements of each specific application. The number of receive buffers is synthesis-time configurable. Two types of transmit buffers are implemented: a high-priority primary transmit buffer (PTB) and a lower-priority secondary transmit buffer (STB). The PTB can store one message, while the number of included buffer slots for the STB is synthesis-time configurable (0 slots to 16 slots). Moreover, an optional wrapper instantiating multiple CAN controller cores eases integration in cases where multiple bus-nodes need to be controlled by the same host processor. The core implements functionality similar to the Philips SJA1000 working with its Peli CAN mode extensions, providing error analysis, diagnosis, system maintenance and optimization features.

Xilinx sells the CAN FD core, the Logicore IP, under two license agreements: The XA class components implementing the core and the non-XA class components for low-volume applications with less than 20000 pieces cumulative. If the volume of 20000 is exceeded, licensees must contact Bosch for an additional license. Bosch holds IP rights on the CAN FD protocol. The Logicore IP compensates three data-phase bit-times when falling back to the arbitration bit-time after the CRC (cyclic redundancy check) field. The implementation features 32 receive FIFO buffers with 32 filter-mask pairs. Cancellation of messages not yet transmitted is supported. Messages with the highest priority (lowest ID number) are transmitted first.

Cast representing Fraunhofer IPMS has teamed up with Avery Design System and Rianta Solutions to verify the CAN FD core. “We are excited to work with Avery to help automotive engineers develop safer systems quicker through the industry's first integrated CAN FD soft IP (intellectual property) core and VIP package,” said Nikos Zervas, chief executive officer of Cast. The CAN FD core is available in synthesizable RTL for ASICs or FPGAs. A ready-to-run reference design board and other development aids are also available from Cast to further shorten the time-to-market for CAN FD based products. The Avery's Classical CAN and CAN FD verification tool complies with ISO 11898-1:2015. Models and compliance test-suites for all modes are supported. The verification tool is developed in native System Verilog UVM and includes traffic generation, protocol checking, and coverage.

Xilinx tests its automotive-grade components above and beyond the current AEC-Q100 automotive qualification requirements. The company has also completed design tool certification by a 3rd party for compliance to the ISO 26262 standard for functional safety. In today’s automotive...
market, governmental safety standards demand to implement safety systems, such as back-up cameras in the USA and Automated Electronic Braking (AEB) systems from Euro NCAP. Vehicle-based camera systems have become a key differentiator for OEM (original equipment manufacturer) production using ADAS (advanced driver assistance system) technologies. As a primary processing platform in ADAS, Xilinx’s customized ICs enable:

- Real-time analytics including object detection, recognition, classification, and tracking enable applications such as lane departure warning and pedestrian detection;
- Video processing and displays providing video frame capture, de-warp and stitching, along with 2D/2.5D/3D graphics and overlays allowing users to customize the look and feel of what is displayed to the vehicle driver and passengers;
- Programmable I/O blocks and solutions for various communication technologies such as CAN (FD) and Ethernet AVB featuring flexible and effective methods for distribution of video and control data;
- Fast-time-to-market with differentiated products avoiding “me too” ASSP solutions while supporting rapidly changing ADAS requirements through the use of the company’s programmable Smartcore IPs and comprehensive tools.

Xilinx automotive solutions also address the challenges of quickly adopting and migrating to the latest standards, interfaces, and IPs to handle real-time image processing from multiple cameras on a single device. Partial reconfiguration can dynamically swap-out components IP-based on system/vehicle state to minimize digital logic silicon footprint allowing the smallest possible component while providing custom processing functionality for a variety of ADAS feature bundles. With the high-levels of integration possible using Xilinx solutions, users can reduce the size, power consumption, and total cost of ADAS while meeting market windows ahead of the competition, claims the company.

More competitors appear on the market

Microsemi launched automotive-graded FPGAs for the first time. The Igloo family is AEC-Q100 qualified and is specified for temperatures up to +125 °C. These components are positioned as an alternative to ASICs, providing a low-power, cost-effective, and secure solution for automotive applications including ADAS applications, vehicle-to-vehicle/vehicle-to-everything (V2V/V2X) communication, and electric/hybrid engine control units. “In addition to providing the highest operating temperature, our FPGAs also provide the lowest total power in their class, enabling automotive designers to maximize their dynamic power budget in compact and high performance systems to deliver highly differentiated automotive solutions at the lowest total cost of ownership,” said Bruce Weyer from Microsemi. The products offer single event upset (SEU) immunity from neutron-induced firmware errors, helping them achieve the zero-defect rate essential for the automotive industry, as well as advanced security features and secure supply chain, stated the US-company.

Demand for high reliability in critical applications, ensuring zero-defect and tamper-free applications, continues to grow rapidly in the automotive industry. With an increase in security mandates amongst its customer base, Microsemi is the only vendor offering automotive-grade FPGAs at higher junction temperature, along with best-in-class security in low power and small footprint packages, claimed the company.

“The automotive market for semiconductors is forecast to grow to 32.3 billion US-$ in 2016, from 30.3 billion US-$ in 2015, an increase of almost seven percent,” commented Colin Barnden, principal analyst at Semicast Research. “In comparison, we see the market for semiconductors in vehicle connectivity and ADAS growing at more than 20 % in 2016. Microsemi’s Smart Fusion 2 and Igloo 2 products bring world class security features to the automotive industry and will address several challenges such as hacking, malicious tampering, and data theft faced by system designers in creating safe and secure systems for the connected automobiles of the future.” The Igloo 2 FPGAs will be available in March 2016 for mass production, the company said.

Customized ICs with CAN core are not just interesting for the automotive industry. Also in other CAN markets such as industrial machine control, medical devices, etc. FPGAs become more attractive. Kvaser (Sweden) and Peak (Germany) were early birds providing CAN FD cores on FPGAs. And there are more under development. Esd (Germany) and MEN (Germany) use in their board-level products their own FPGAs with Classical CAN cores. When they migrate to CAN FD, they may update their FPGAs.

And don’t forget the M_CAN IP and the M_TTCAN cores from Bosch, which are licensed by many micro-controller manufacturers. They can also be integrated into customized ICs. Bosch has implemented them already in an FPGA used for example on the evaluation board designed jointly by Bosch, Daimler, and NXP.

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