MathWorks Automotive Conference (MAC):

**Higher efficiency with scalability in semiconductor and mixed EV architecture**

Hans Adlkofer, SVP Automotive System
12th July 2023
The future car is fully connected and always online. It requires an end-to-end solution and SW-defined architecture.

The future car links the real world with the digital world and ensures safer and more efficient roads.

- This transformation requires enormous **computational horsepower, fail operational and security** as well as...
- …a SW ecosystem which allows **reuse, fast T2M, SW update of all important function & units and modern design tools** e.g. Model-Based Design and automatic code generation.
Customer value is the critical ingredient to innovation
EV market will be diverse, efficient use of energy remains a common goal

Efficiency is the new currency

Vehicle dynamic
Range
Charging time
Operating hours
Operating cost
Cost of purchase
Energy efficiency improvements are key to extend driving range. Therefore, Infineon defined 10 kW/100km as its vision for the future.
Transition to WBG will vastly differ by application with Si expected to remain technology of choice for many of them

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<th>Key automotive applications</th>
<th>2020</th>
<th>2030</th>
<th>Technologies</th>
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<td>xEV traction inverter</td>
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<td>SiC</td>
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<td>with advantage in <strong>high power</strong> switching performance and <strong>power density</strong></td>
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<td>DCDC HV-HV</td>
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<td>GaN</td>
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<td>superior switching performance results in <strong>higher efficiency</strong> and <strong>lower system cost</strong></td>
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<td>On-board charger</td>
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<td>Si</td>
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<td>is 3-4 times <strong>cheaper than WBG</strong>, will remain competitive in many applications where top performance and form factor are secondary</td>
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### Key automotive applications
- DCDC HV-HV
- DCDC HV-LV
- On-board charger
- xEV traction inverter
- Power distribution
- DC motor control
- LED lighting
- Smart Power Switching

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SiC will be main material for traction inverter, complemented by Si-IGBTs wherever focus on cost is key
On-board charger will move from SiC to GaN as high-power. With MDB we provide easy switch from Si to SiC to GaN.

Today ~ 2kW/l

Moving to >10kW/l in the size of less than 2 milk packs.

Functionality integration

Topology enhancement

Model based development

DCDC + OBC + Power distribution

Hybrid Totem pole SiC + Si 650/750/1200V

650/750V based Multi-Level

Model based development

2020

Si

SiC

GaN

2030
E/E architecture evolution towards SW defined architecture
This architectural transformation and not Revolution!

**Domain Architecture**

- Central Gateway
- Powerful domain controllers
- Separate function domains

**Mixed Domain/Zone Architecture**

- ADAS, Infotainment, Vehicle motion (powertrain, chassis) remain in own, separated domains
- One central ECU mainly controls Body-zones:
  - Direct control of local body loads and their diagnostics
  - In charge of power distribution & management

**Full Car Computer**

- Single or multiple Central Car computer(s)
- Most advanced zones
- Improved sharing of wiring
- full function agnostic network
- Lowest weight and cost of wiring harness
Zonal architectures will replace domain based in the upcoming years. However, a full zonal concept for all functions will take time to come.
Infineon Market Model 2023 - The majority of top16 OEMs will have introduced a mixed domain/zone architecture in 2026

<table>
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<th>Selected E/E Architecture Roadmaps (introduction date)</th>
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Few OEMs will introduce a full car computer architecture in the second half of the decade

Volume OEMs are assumed to remain longer on a distributed architecture and go directly to a mixed domain/zone architecture

Premium OEMs are going for advanced version of a domain architecture. The introduction of a mixed domain/zone architecture remains to be seen

Many Chinese OEMs are introducing a mixed domain/zone architecture earlier than other key OEMs
Evolution to the software defined car - Mindset change in the vehicle development process towards models & virtualization

- OEM takes the lead for centralized software
- Functional integration rather than ECU specification
- Security-by-design & Update-by-design
- Decoupling Hardware/Software & virtual development
- Essential reuse of software pieces & strong eco system
- Transformation from HW to Model-Based Design development
- Standardized actuators and sensors & virtual platforms

Source: How To Catch a Moving Target in the Digital World
www.europeanbusinessreview.com
Change from hardware defined to a software centric architecture
Hierarchical software concept in a zonal architecture concept

High performance computing cluster
› Service oriented, Application cores in MPUs + companion MCUs
› Virtualization of computing resources
› Application software decoupled from hardware
› Integration of various applications

Service to Signal transformation
› Bridge between central computing and real-time satellites
› Converging in-vehicle networking and power distribution
› Enable significant harness reduction
   (power distribution to local sensors & actuator ECUs)

Real-time, signal based
› Bus connection to agnostic network
› Smart mechatronic solutions
› Local legacy ECUs enabling a smooth transformation from given topologies
In reality, OEM architectures will be a mix of these scenarios. There is no standard architecture in the near future nor standard OS.

Complexity can be managed only by model based design plus strict virtualization and layer separation. → key challenge will be to manage SW complexity, validations and homologation.
The vehicle E/E Architecture includes two main functions: The In Vehicle Network (IVN) and the Power Distribution (PD)

Focus of this Application Roadmap Level II: Power Distribution
Power distribution is a critical aspect of the new software defined E/E architecture, driven by E-Mobility, Automated driving and Connectivity.

The Power Distribution System is transforming from a centralized to a decentralized zonal architecture.

Centralized power distribution

Partially decentralized power distribution

Decentralized power distribution

Solution with fuses and electromechanical relays for primary and secondary PDS

Replace fuses and relays and create flexibility for decentralization

PDS integrated into zone controller
Product to system: How do balance SW with right E/E architecture
We have to virtualize SW & develop HW in model based environment

Electric vehicle

Mobility as Service

Server infrastructure

- Microcontroller
- Analog/mixed signal chip
- Power switch

+ Software & Algorithms
+ Development Tools

Integrated ecosystem to achieve T2M and allow Innovation
Think Efficient Systems along the value chain

Transition to **WBG will vastly differ by application** with Si expected to remain technology of choice for many of them.

**SW defined E/E architecture** requires a new view on SW & HW components and requires more **virtualization and standardization**.

**Power distribution** becomes a critical aspect of the new E/E architecture and is **part of the SW-defined architecture**.

The **KEY to win the game of T2M and innovation** plus to manage the complexity of the new E/E Architecture will be **Virtualization & Model Based Design & Automatic Code Generation**.
Part of your life. Part of tomorrow.