Trends in Automotive Electronics Challenges for IC Development
Dr. Tim Gutheit
06-Oct-2015
Table of contents

1. About Infineon
2. A view on the future of automotive
3. Challenges and upcoming requirements
4. Implications for Development of Semiconductor Components
Infineon plus International Rectifier: A Powerful Combination

As of **January 2015**, International Rectifier is an Infineon Technologies company

- Combined **pro-forma revenue of ~€5,150m** (~$6,950m) in Infineon 2014 fiscal year
- About **35,000 employees worldwide** (as of June 2015)
- Strong technology portfolio with more than **22,800 patents and patent applications** (as of September 2014)
- **33 R&D locations; 20 manufacturing locations**

*non-audited figures
Infineon’s Revenue split by segment

Q3 FY 2015 Revenue: € 1,586m

Automotive

ATV € 621m

Chip Card & Security

CCS € 172m

Power Management & Multimarket

PMM € 517m

Industrial Power Control

IPC € 269m

OOS+C&E* € 7m

*Other Operating Segments; Corporate & Eliminations

2015-10-06

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**Infineon Automotive Makes Cars: Clean, Safe and Smart**

<table>
<thead>
<tr>
<th>Clean</th>
<th>Safe</th>
<th>Smart</th>
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</table>
| › Clean Combustion Engines  
› Efficient Energy Management  
› Electrified Drivetrain | › Occupant and Pedestrian Protection  
› Collision Avoidance  
› Advanced driver assistance | › Individual Convenience  
› Secure Connectivity, Data Integrity and Privacy  
› Autonomous Driving |

*With innovative products for the highest growth applications in:*

<table>
<thead>
<tr>
<th>Powertrain</th>
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<th>Safety</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Body</th>
</tr>
</thead>
</table>
Table of contents

1. About Infineon
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Let us take a look into the future of the automobile...

a 1957’s view on 1967...
What will become reality?

Sources: Die ZEIT, HS Pforzheim
The most likely scenario ...
OEM are working on the concepts – who will be their partners?
Silicon Valley - Motown 2.0!

- NVIDIA – Santa Clara
- Qualcomm – Santa Clara
- Broadcom – Santa Clara, San Jose
- Intel – Santa Clara
- Apple – Cupertino
- Ford – Palo Alto
- GM – Palo Alto
- BMW – Mountain View
- VW – Belmont
- Daimler – Sunnyvale
- Tesla – Palo Alto, Fremont
- Google – Mountain View
- Toyota – Sunnyvale
- Renault-Nissan – Sunnyvale
- Honda – Mountain View
- Bosch – Palo Alto
- Delphi – Mountain View
4 Megatrends Are Shaping ATV Market, Significantly Increasing the Semiconductor Content of Vehicles

**ADAS/Autonomous Driving**
- From ADAS to Automated and finally Autonomous Driving
- Every World Region is striving for “0-accident”
- Advanced Connectivity is driven by making the car part of the internet
- The car will be fully connected (V2I, V2V, in-vehicle)

**xEV/eMobility**
- Mandated CO2 reductions make electrification of powertrain inevitable
- Increased connectivity & SW content increase risk exposure to hackers
- Internal/External connectivity must be secured
Semiconductor Content of EV/HEV Vehicles Falls Right into Infineon's Core Competence

Table of contents

1. About Infineon
2. A view on the future of automotive
3. Challenges and upcoming requirements
4. Implications for Development of Semiconductor Components
Everbody is working on self driving cars ..... also new players

- New vehicle concepts \(\rightarrow\) new possibilities, new behaviours, new players, new paradigms

**Convenience:**
- Time for calls, emails, entertainment
- Relax and get where you want

**Safety:**
- Avoid human errors
- Less traffic jam, less CO2
- Drowsiness & distraction detection

*It is worth to fight the challenges for a safer and comfortable mobility!*
Call for innovation – an example: "Smarter" cars lead to safer roads

ADAS for „Vision 0“
- Collision Warning / Mitigation
- Night vision
- Adaptive Cruise control
- Lane departure warning
- Adaptive light control
- ...

* In Germany, Source: Statistisches Bundesamt
Where do we come from?

Yesterday (the 1967 reality) ...

The first electronically controlled fuel injection device worldwide in a car built in mass production. The D-Jetronic from Bosch was introduced to the public 48 years ago at the IAA 1967 in a Volkswagen 1600 LE/TLE.

D-Jetronic (produced only with discretes devices)

Courtesy: Bosch
And here we are now.
Board Net Architecture in 2022 ???
Security Drivers

1. Network and Data Integrity
2. Privacy

Source: CAR 2 CAR Communication Konsortium
Security for sustainable user trust and added-value services – Press reports & publications

Fraud & Theft

Breach of privacy

Cyber Attacks
The connected car will come - with new requirements

- Software Update
- Car Repair Shop
- Remote Diagnostics
- Payment Systems
- eCall
- Tablet & Smartphone
- Traffic Information
- Apps
- Infotainment
- Internet Services
- Onboard Safety & Security
- Consumer Device Integration
- Car2Cloud
- Car2Car
- Car2Infrastructure

Hacker Attack
Unauthorized access must be denied

- Toll Control
- Prioritization of Emergency Services
- Traffic Jam Detection
- Accident Avoidance
- Tablet & Smartphone
- Traffic Information
- Infotainment Apps
- Remote Diagnostics
- Software Update
- Car Repair Shop
- Payment Systems
- eCall
- Internet Services
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- Car2Car
- Car2Infrastructure

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Basic security considerations

- Secure On-board communication
- Basic protection of single ECUs (Immobilizer & Access)
- Firewall & Gateway
- Sandboxing

Diagram:
- Driving Domain
  - Torque Control
  - Dynamics Control
  - Energy Management

- ADAS Domain
  - Radar
  - Camera
  - Lidar

- Body & Comfort Domain
  - HVAC
  - Lighting
  - Theft protection

- Infotainment Domain
  - Navigation
  - HMI
  - Entertainment
Example: Electrical Power Steering
A Safety Critical Application
For mission critical functions we have to come from fail safe to **Fail Operational**

Customers request functional safety acc. ISO26262

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**Electrical Power Steering**

- Redundancy
- Diversification
- Fault tolerant >10sec
- Self-monitoring device
- Multicore µC
- Watchdog sensing
- Secure communication
- ASIL D capable OS
- Redundant Power Supply
- ...

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2015-10-06
Fail Operational Actuators: BOM to Grow by Factor 1.3

EPS System

Torque Sensor
E-Motor
Gear
Pinion

EPS E-Motor

Steuergerät
Motorwelle
Gebemagnet
Sensor-Element

EPS Electronic Control Unit

© ZF Lenksysteme

Sense

Compute

Actuate

Safe Power Supply
System engineering opens up new optimization paths

Joint research project **EMiLE**

„Elektro-Maschinen integrierte LeistungsElektronik“

Highest integration of power electronics into a traction motor and research of the required technologies

- Reduction of interfaces
- Increase of system power density
- Cost reduction
- Increase of system efficiency
- Test of demonstrator on testbench
- Additional safety functionality
- Transfer of the results to industrial application
The 5 levels of increased automation (VDA/SAE definition)

- **Level 0-1**
  - Permanent monitoring by the driver
  - No Automation or Assisted
  - Driver only
  
  E. g.: Lane Departure Warning, Blind spot Detection

- **Level 2**
  - Partial Automation
  - Driver monitors the automated functions
  - E. g.: Traffic Jam Assist, Parking Assistant, Lane Keep Assist

- **Level 3**
  - System is driving, with more or less backup by the driver. In case of failure the system must run for a certain time on a backup.
  - High Automation
  - System monitors the car environment and gives control to driver beyond defined parameter values
  - E. g.: Traffic Jam Chauffeur, Highway Chauffeur, Garage Parking

- **Level 4**
  - Full Automation
  - System can take full control beyond defined limits of a specific application
  - E. g.: Automated Driving (Highway Pilot, Valet Parking)

- **Level 5**
  - Autonomous Driving/Driverless
  - System can tackle all driving situations. No Driver necessary from start to destination.
  
  E. g.: Google Car, Robot Taxi

Amendments of current regulations are necessary (e.g. Vienna StVO, ECE-R79)

Source: BASt und VDA
The road to Self Driving Cars requires:

- New architecture in vehicles with domain structure
- High speed internal data bus systems
- Redundancy in technologies and systems → fail operational
- Multiple signal collection and diversity in Sensor Systems
- Considerably increased computing performance
- External connectivity with secure gateways
- Driver observing technologies
- In-field upgradeability
- ...

... and more deep learnings!
Table of contents

1. About Infineon
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## Autonomous Driving
System complexity increases drastically

<table>
<thead>
<tr>
<th></th>
<th><strong>Object based fusion</strong></th>
<th><strong>Grid based fusion</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Addressable device</td>
<td>high end Multicore µC architecture</td>
<td>Matrix GPUs with safety guards µC</td>
</tr>
<tr>
<td>Representation of car</td>
<td>Limited. Lanes + object list.</td>
<td>Comprehensive. Grid/map of 200x80m, 0,1x0,1m resolution</td>
</tr>
<tr>
<td>environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usage</td>
<td>L1/L2 automated drive</td>
<td>L3/L4 autonomous drive</td>
</tr>
<tr>
<td>Computation types</td>
<td>Collision avoidance</td>
<td>Driving commands</td>
</tr>
<tr>
<td>Computation outputs</td>
<td>Object list</td>
<td>Grid, grid history</td>
</tr>
<tr>
<td>Memory for operands</td>
<td>Few MB</td>
<td>2020: 200 to 500MB for grid history</td>
</tr>
<tr>
<td>Memory for SW</td>
<td>Few MB</td>
<td>2020: 80 to 160MB</td>
</tr>
<tr>
<td>Computing performance</td>
<td>2022: up to 3000 DMIPs</td>
<td>2022: more than 8000 DMIPs</td>
</tr>
<tr>
<td>SW algorithms</td>
<td>Matrix based and Floating point</td>
<td>Matrix based and Floating point</td>
</tr>
</tbody>
</table>
The challenge for IC Design:
Escaping from the complexity trap

› Increase design productivity
› Contain complexity

**Cycle time**

**R&D effort**

- Faster platform cycles
- Project budget targets

The IC design methodology challenge!
Three Key Elements in Requirements-Driven IC Development

The three Key Fields

A. Traceability of Requirements
B. Quality of Requirements
C. Process Compliance

System Development following the ISO 26262
across the system value chain
Requirements Driven IC Development Flow
Requirements Graph by Layers

- Stakeholders
- Stakeholder requirements
- Product Requirements
  - Stringent configuration management
  - Automated documentation
- Design Requirements
- Verification / validation / testing items

Functional Safety Management acc. ISO 26262

1. Glossary
2. Management of functional safety
   - 2.4 Management during complete safety lifecycle
   - 2.5 Safety management during development lifecycle
   - 2.6 Safety management activities after SOP
3. Concept phase
   - 3.4 Item definition
   - 3.5 Initiation of safety lifecycle (modification and derivates)
4. Product development system
   - 4.5 Specification of technical safety content
5. Product development S/W
   - 5.4 Product release
   - 6.5 SW safety requirement specification
6. Product development S/W
   - 6.6 SW architecture and design
   - 6.7 SW implementation
   - 6.8 SW unit test
   - 6.9 SW integration and test
   - 6.10 SW qualification and release
7. Production and operation
   - 7.4 Production
   - 7.5 Operation, upkeep and decommissioning
8. Supporting processes
   - 8.4 Interfaces within distributed developments
   - 8.5 Overall management of safety requirements
   - 8.6 Configuration management
   - 8.7 Change management
   - 8.8 Safety analysis
   - 8.9 Analysis of COTS/CRM cascade failures
   - 8.10 Verification activities
   - 8.11 Documentation
   - 8.12 Overall quality management
   - 8.13 Qualification of software tools
   - 8.14 Qualification of software hardware
   - 8.15 Packaging / configuration

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Good Sets of Requirements are ...

› ... complete
  - Impossible to prove, but still a goal

› ... consistent
  - No contradictions between requirements

› ... irredundant
  - Non "atomic" requirements easily lead to inconsistencies upon changes

› ... maintainable
  - Unique labeling allows for automated configuration management

› ... structured
  - Introduce classification, e.g. following the function (squib driver, sensor interface, supply, MCU interface etc.)

› ... hierarchical
  - Continuous breakdown of requirements

› ... traceable
  - Upstream: every requirement is linked to a higher level requirement or a stakeholder
  - Downstream: every requirement is linked to a lower level requirement or a coverage point (verification experiment, test routine, ...)

It’s not just a new set of tools

... but a new working mode
Self Driving Cars are enabled by Semiconductors ...

... and set new demanding requirements!

Source: Rinspeed