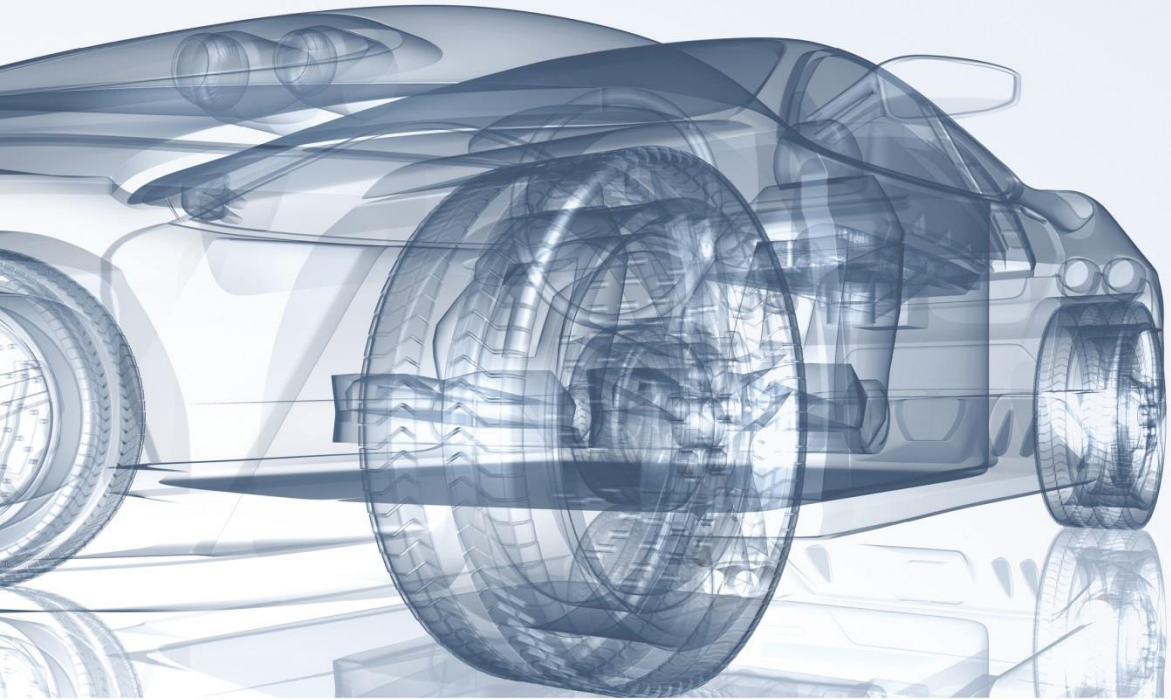
evs 30



The 30th International
Electric Vehicle
Symposium & Exhibition

October 9–11, 2017

Messe Stuttgart, Germany

www.evs30.org

Sponsored by

DAIMLER BOSCH Invented for life GROUPE RENAULT MAHLE EnBW PORSCHE swarco

Dimensioning of Power Net for Automated Driving

M.Sc. Tunan Shen,
Dr.-Ing. Ahmet Kilic,
Dipl.-Ing. Kirill Gorelik

Agenda

- Motivation
- Requirements
- Topology and Simulation-Based Method
- Voltage Stability Simulation
- Fault Injection Simulation
- Summary

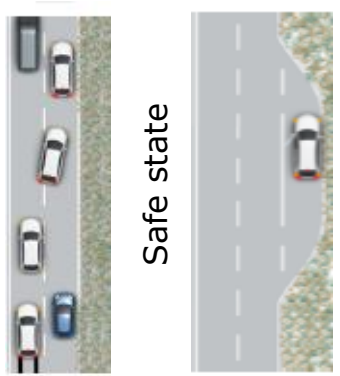
Dimensioning of Power Net for Automated Driving

Motivation

- Automated driving is coming

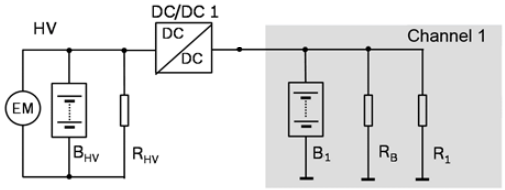
Source: Bosch

- New requirements on safety related subsystems and components (e.g. braking and steering system):
  - Today: Driver is fallback in case of failure
  - Automated driving: "*be capable of restoring the vehicle to a minimal risk condition automatically in case of failure*" (SAE Level 4 and 5) [1]



Source: Bosch

- The state of the art power supply system (power net) with one energy source and energy storage cannot fulfill this requirements.



- New design for a fail-operational power net is required.

Agenda

- Motivation
- Requirements
- Topology and Simulation-Based Method
- Voltage Stability Simulation
- Fault Injection Simulation
- Summary

Legislations and standards:

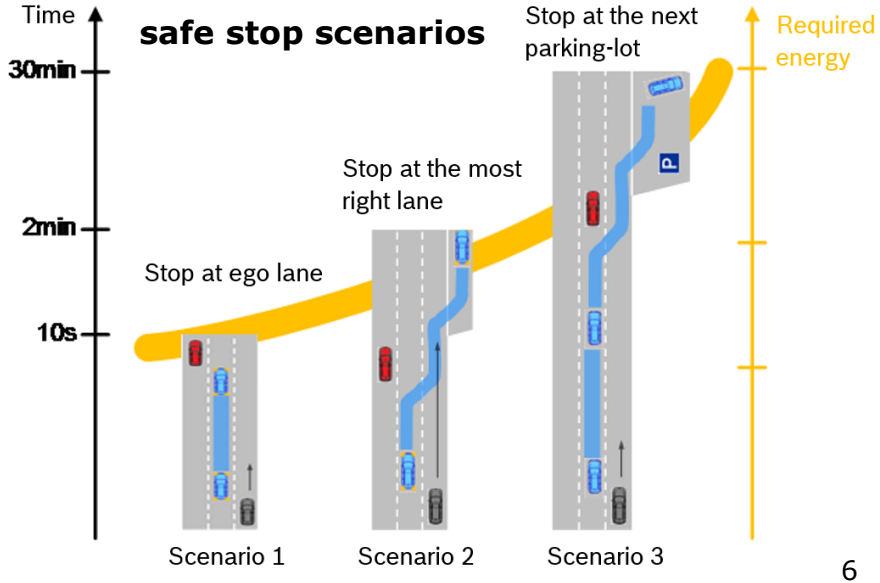
- Braking (UN R13-H §5.2.2.8): „… ***there shall be at least two completely independent energy reserves, each provided with its own transmission*, ...**“[4]
- Steering (UN R79 §5.3.3.3): “In the event of **a failure of the energy source of the control transmission**, it shall be possible to carry out at least 24 ‘figure of eight’ maneuvers, …”[6]

Two energy sources in two independent power supply channels

Requirements of OEMs[1]:

- In case of failure, the vehicle shall be transitioned to a **safe state**.
- Different requirements on subsystems and components depend on safe stop scenario

Dimensioning of power net is dependent on safe stop scenarios

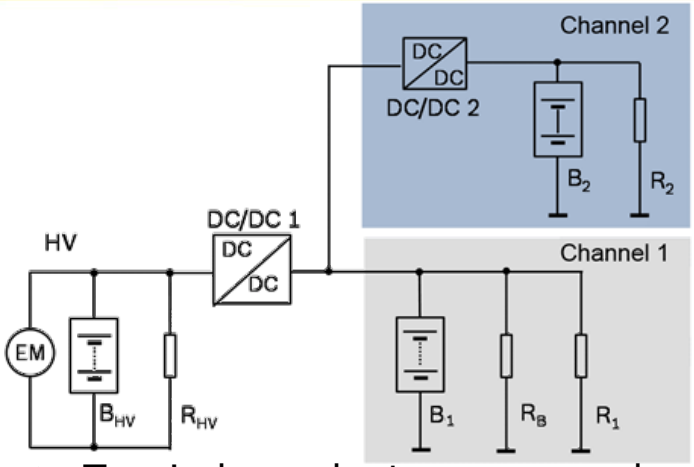


1: OEM: Original Equipment Manufacturer

Agenda

- Motivation
- Requirements
- Topology and Simulation-Based Method
- Voltage Stability Simulation
- Fault Injection Simulation
- Summary

Dimensioning of Power Net for Automated Driving
Topology and Simulation-Based Method



- Two independent power supply channels
- Safety related components are divided into two channels (R_1 und R_2)
- Add-on solution to the state of the art topology
- Scalable topology

Driving Cycle Simulation | **Voltage Stability Simulation** | **Failure Injection Simulation**

By varying: Temperature, basic load, battery capacities and the power of DC/DC converters(HV/12V, 12V/12V)

Dimensioning the power net components

- Electrical characteristics
- Functional and safety features
- Life cycle
- Random hardware failures
- Failure mode coverage

Agenda

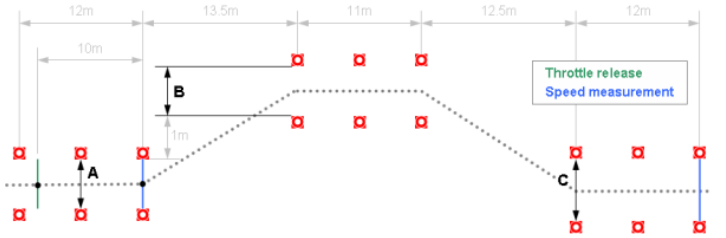
- Motivation
- Requirements
- Topology and Simulation-Based Method
- Voltage Stability Simulation
- Fault Injection Simulation
- Summary

Dimensioning of Power Net for Automated Driving

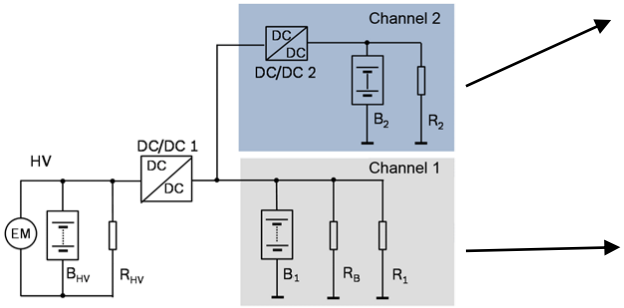
Simulation: Voltage Stability (1/2)

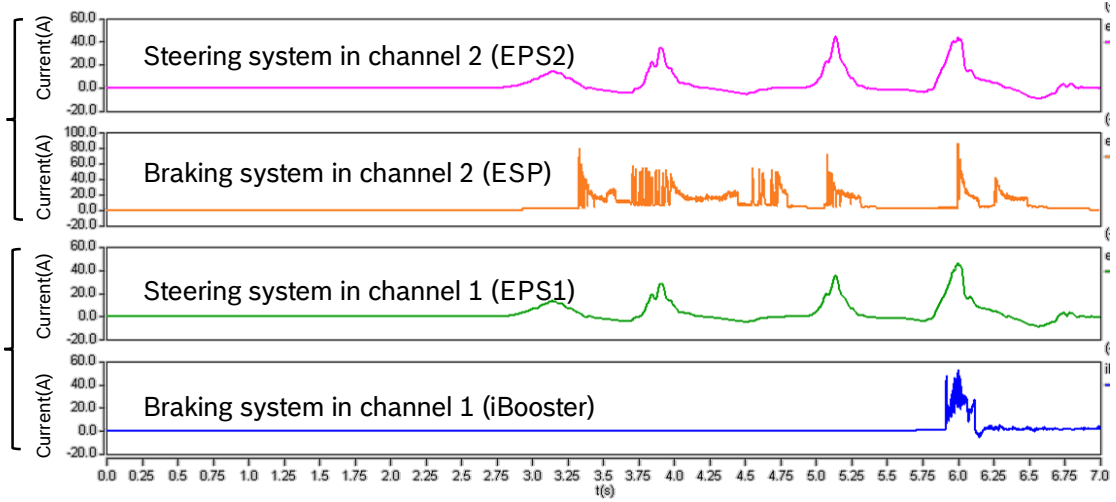
Condition:

- Critical environment scenario (season, weather, etc.)
- Highly dynamic driving situation (Worst case: double lane change test ISO 3888-2)



Source: [9]





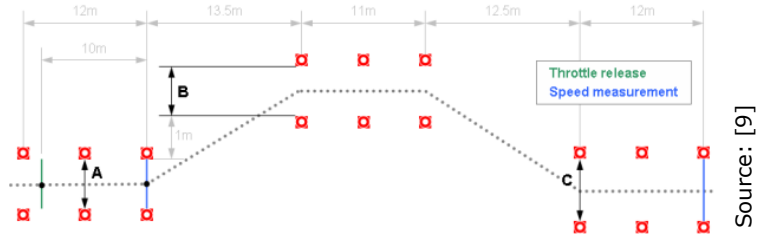
Dimensioning of Power Net for Automated Driving
Simulation: Voltage Stability (2/2)

Criteria:

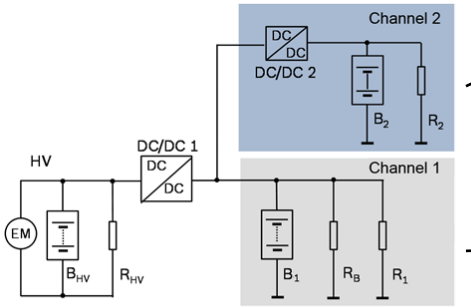
- Avoid over- & under voltage

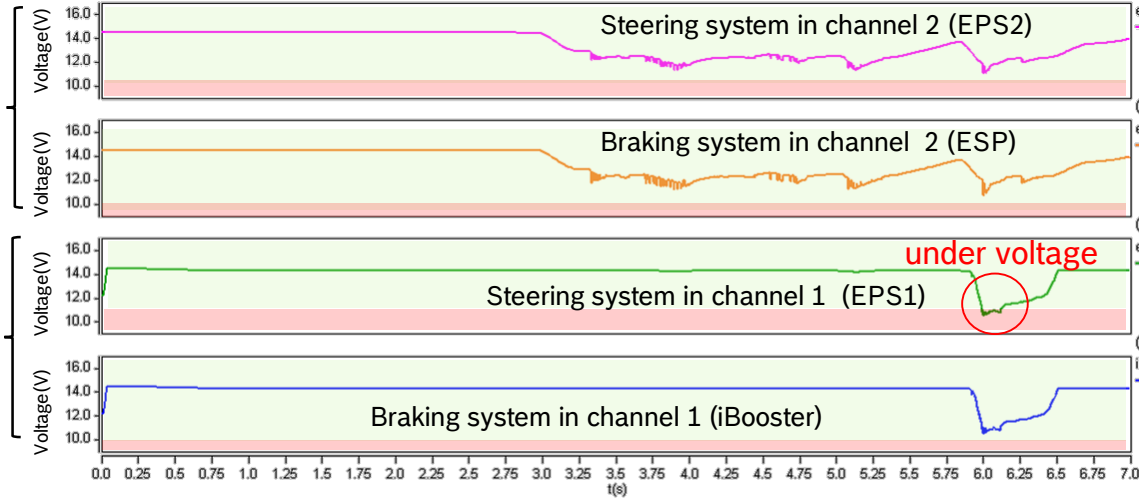
Methods:

- Increase the battery capacity
- Increase the power of DC/DC converter 1



Source: [9]





Agenda

- Motivation
- Requirements
- Topology and Simulation-Based Method
- Voltage Stability Simulation
- Fault Injection Simulation
- Summary

Dimensioning of Power Net for Automated Driving
Fault Injection Simulation

Goal:

- Quantitative analysis of power net failure rate
- Proving that the safety requirements are fulfilled in accordance with ISO26262.

Challenge:

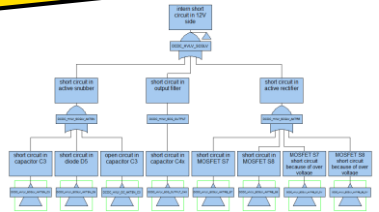
- A high number of failures in the power net have to be analyzed
- Dual-point failures have to be evaluated

Method:

- Step 1: failure analysis at component level
- Step 2: fault injection simulation of power net system
- Step 3: failure rate calculation

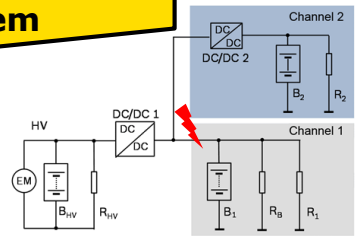
Failure analysis at component level

Reduce the quantity of failure by defining failure classes



Fault injection simulation of power net system

Simulative analysis of system behavior with automated fault injection

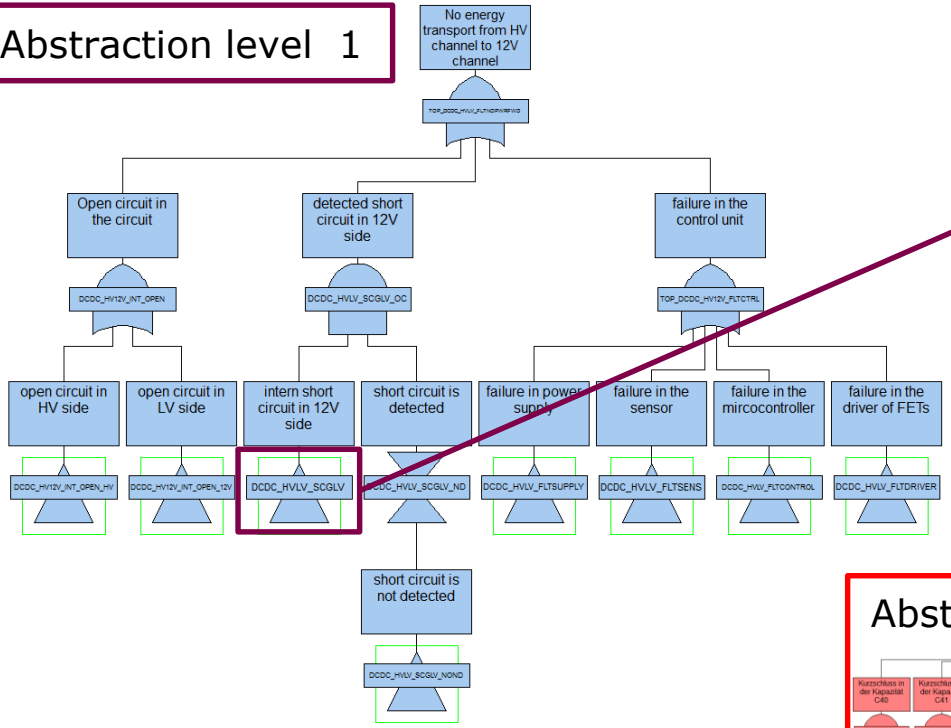


Failure rate calculation

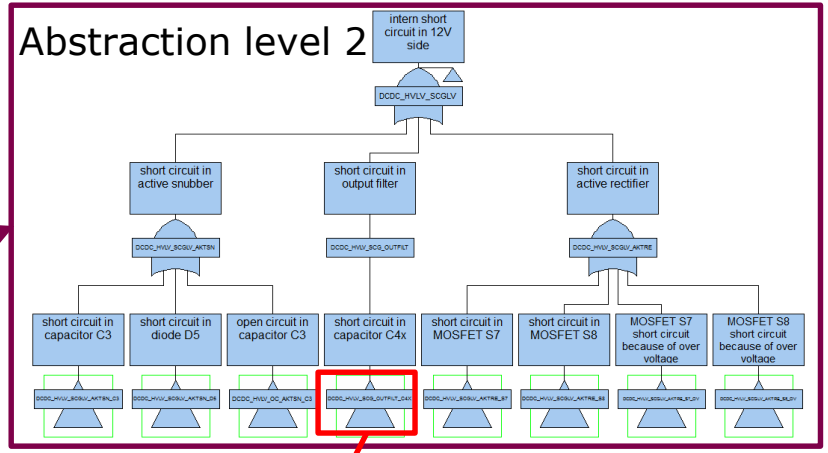
Iterative system design for fulfilling the requirements

Component failure class: no energy transport from HV channel to 12V channel

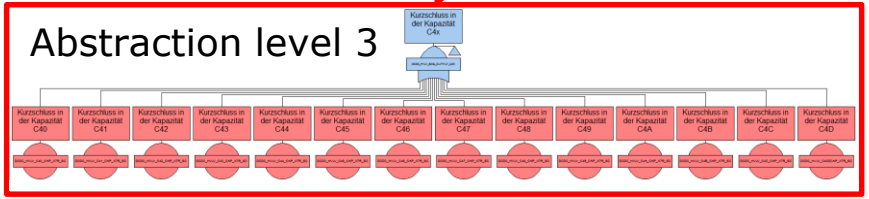
Abstraction level 1



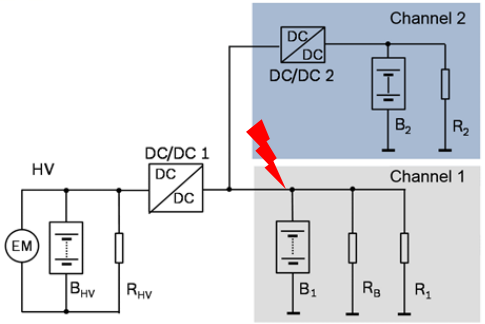
Abstraction level 2



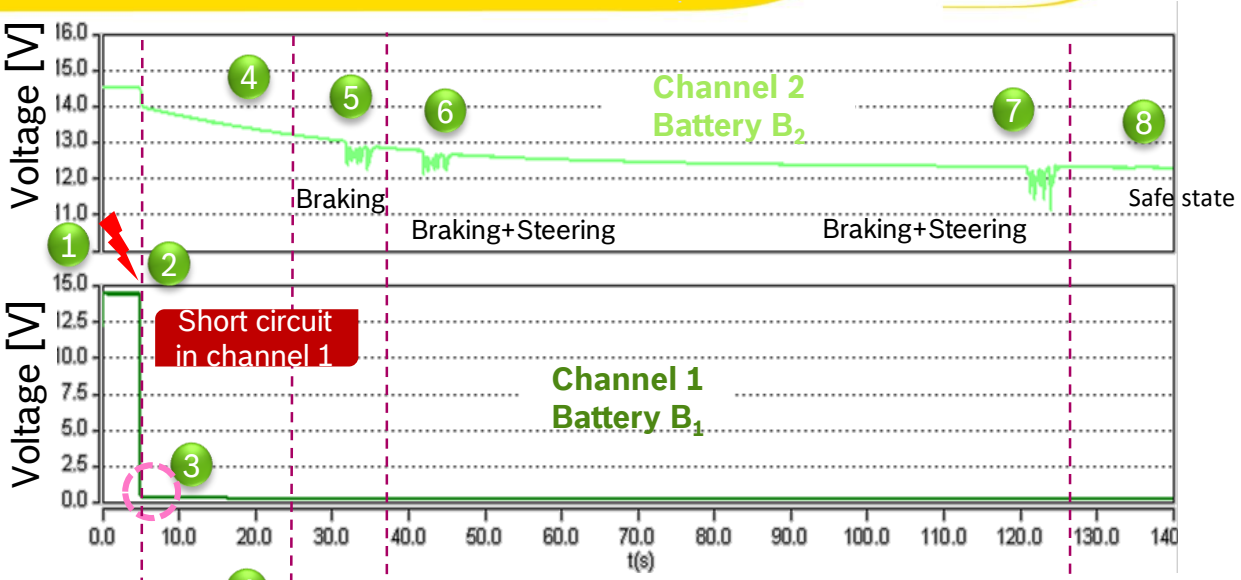
Abstraction level 3

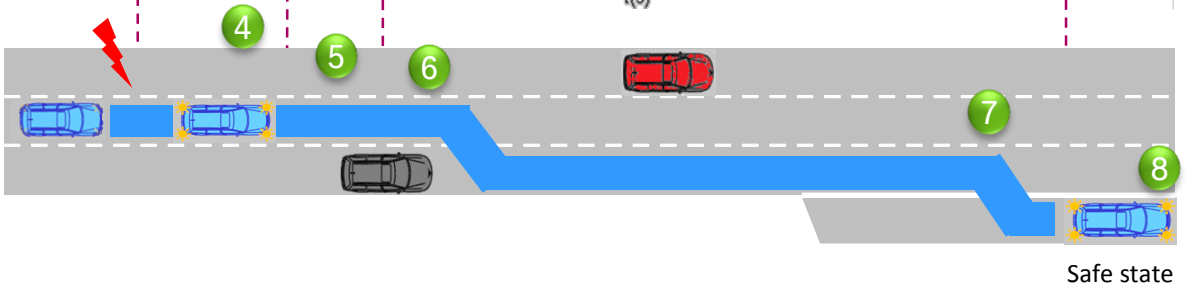


Dimensioning of Power Net for Automated Driving
Step 2: fault injection simulation of power net system



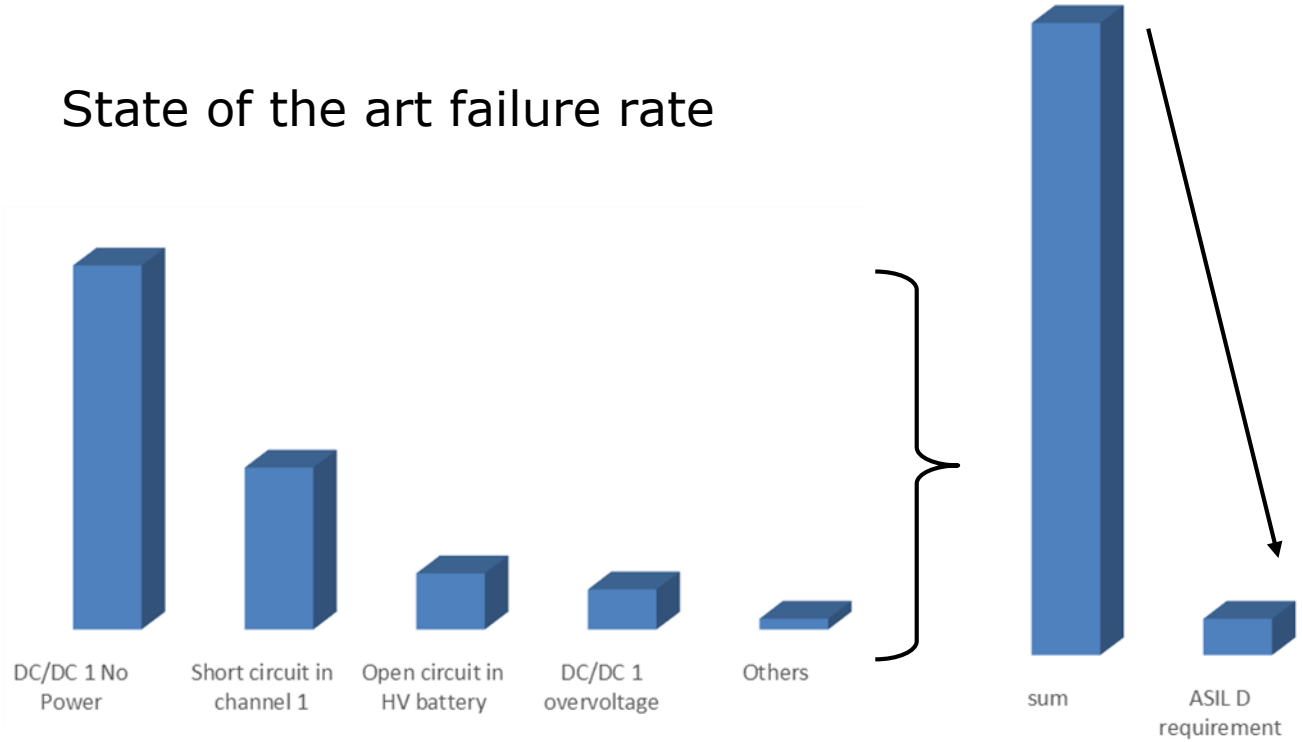
1. Failure free
2. Failure injected
3. Failure diagnostic
4. Driver take over?
5 6 7. Safe stop maneuver
8. Safe state





Dimensioning of Power Net for Automated Driving
Step 3: failure rate calculation

State of the art failure rate



Additional safety mechanisms are required!

Agenda

- Motivation
- Requirements
- Topology and Simulation-Based Method
- Voltage Stability Simulation
- Fault Injection Simulation
- Summary

Summary

- A new power net topology fulfilling the new functional and safety requirements for automated driving was presented

- A simulation-based method for dimensioning the power net components was developed. It consists of
  - Driving cycle simulation
  - Voltage stability simulation
  - Fault injection simulation and failure rate calculation

- New functional and safety requirements for power net components are derived

Thank you for your attention!

M.Sc. Tunan Shen,
Dr.-Ing. Ahmet Kilic,
Dipl.-Ing. Kirill Gorelik

Dimensioning of Power Net for Automated Driving

References

[1] SAE International, J3016 SEP2016: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles, United States: SAE International, 2016.

[4] United Nations Economic Commission for Europe, „Regulation No 13-H of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the approval of passenger cars with regard to braking [2015/2364],“ Official Journal of the European Union, European Union, 2010.

[6] UN/ECE, Regulation No. 79 UNIFORM PROVISIONS CONCERNING THE APPROVAL OF VEHICLES WITH REGARD TO STEERING EQUIPMENT, EU, 2005.

[9] Vehico, “ISO Double Lane Change Test,” [Online]. Available: http://www.vehico.com/index.php/en/applications/iso-lane-change-test. [Accessed 19 6 2017].