Battery Main Switch

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Agenda

- System Overview and Requirements
- Relay = ideal Component?
- Semiconductor Selection
- Reference Design development
- Precharging
- Conclusion

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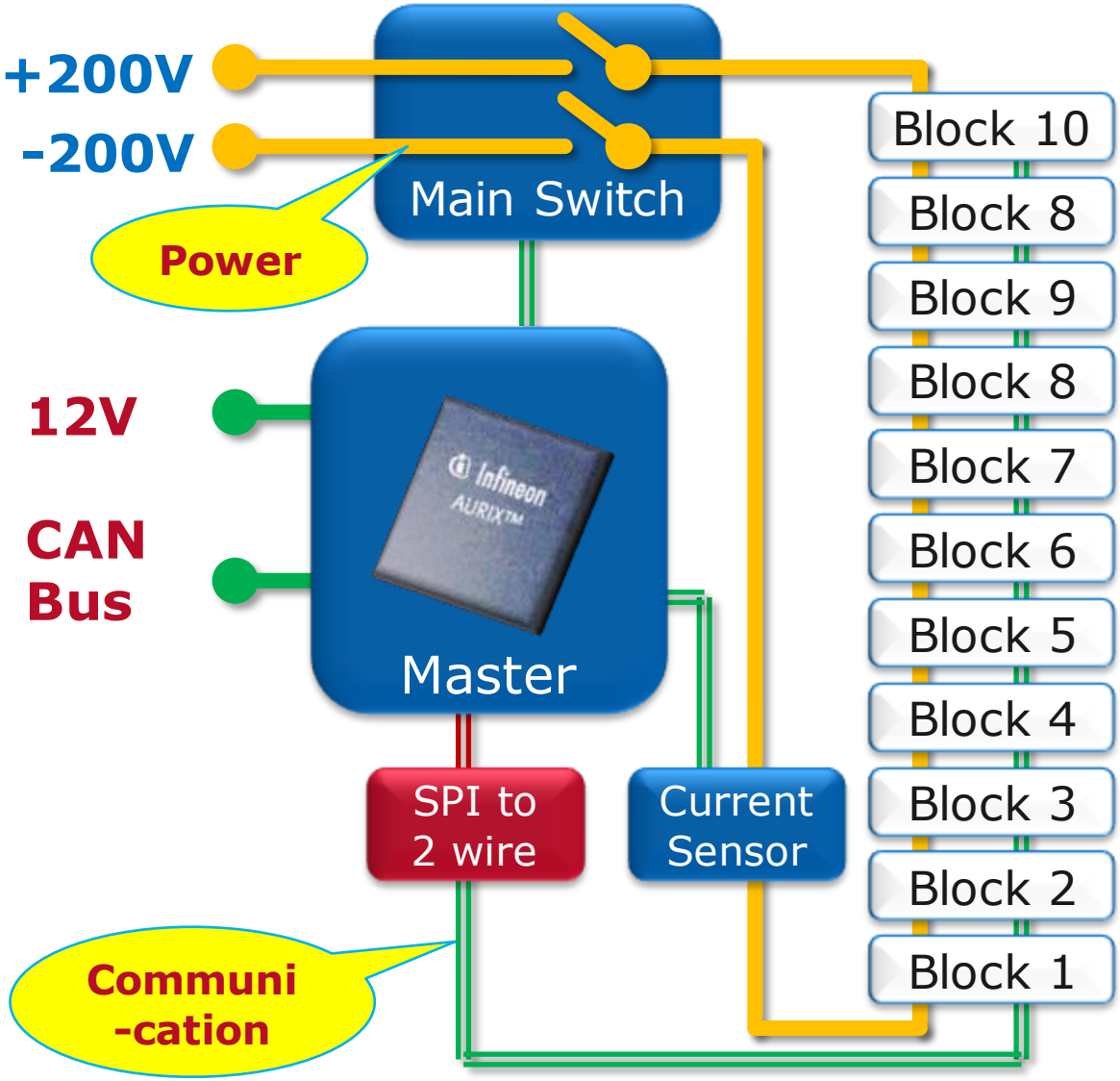
Battery System



Main Switch Requirements

- Safe Disconnection
- Voltage: 200 – 500V
- Charge Current:
  - Continuous 100A
  - Peak (10s): 250A
- Load Current:
  - Continuous 150A
  - Peak (10s) 350A

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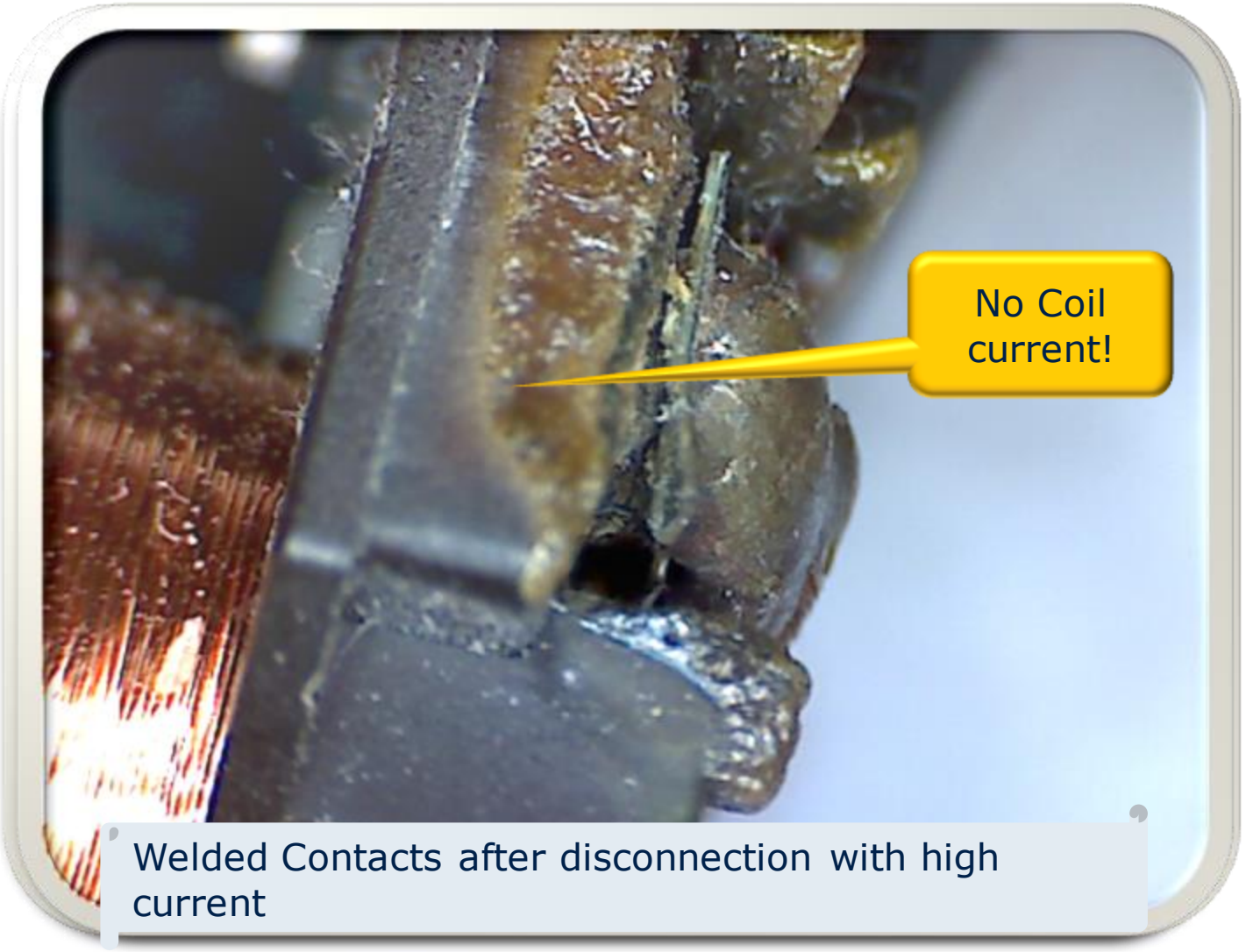
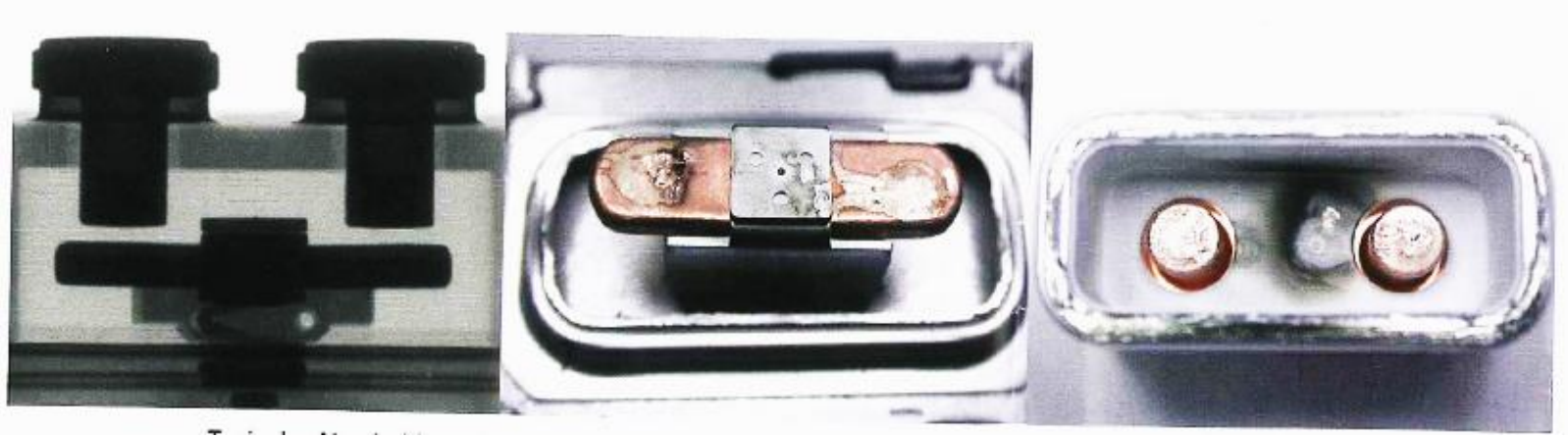
Relay Arcing



Welded Contacts after disconnection with high current

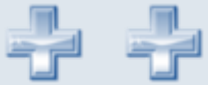
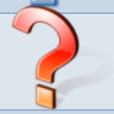
Relay – a real ideal switch?

- Contact aging after switch-off (210V / 205A)
  - R_{on} = really 0Ω ?
- Condensation of vaporized metal parts at the wall
  - Isolation resistance really ∞ ?

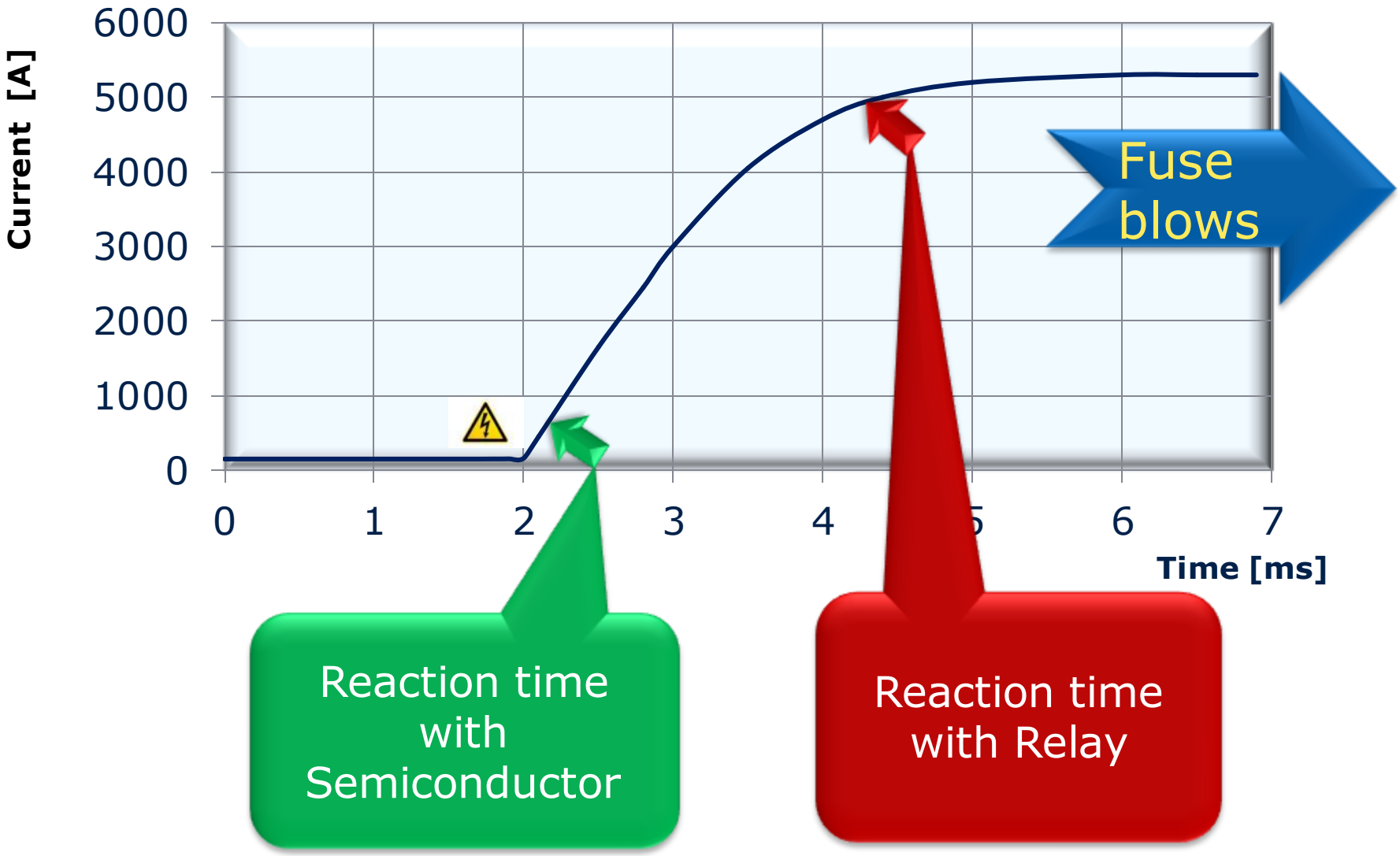


Source: Panasonic

Relay or Semiconductor- What is better?

	Relay	Semiconductor
Lifetime		
Reaction time		
Efficiency		
Module weight		
Module height		
Component Cost		
System Cost		
Experience		
Vibration robustness		
Noise		

Main Switch
Current rise after Short Circuit



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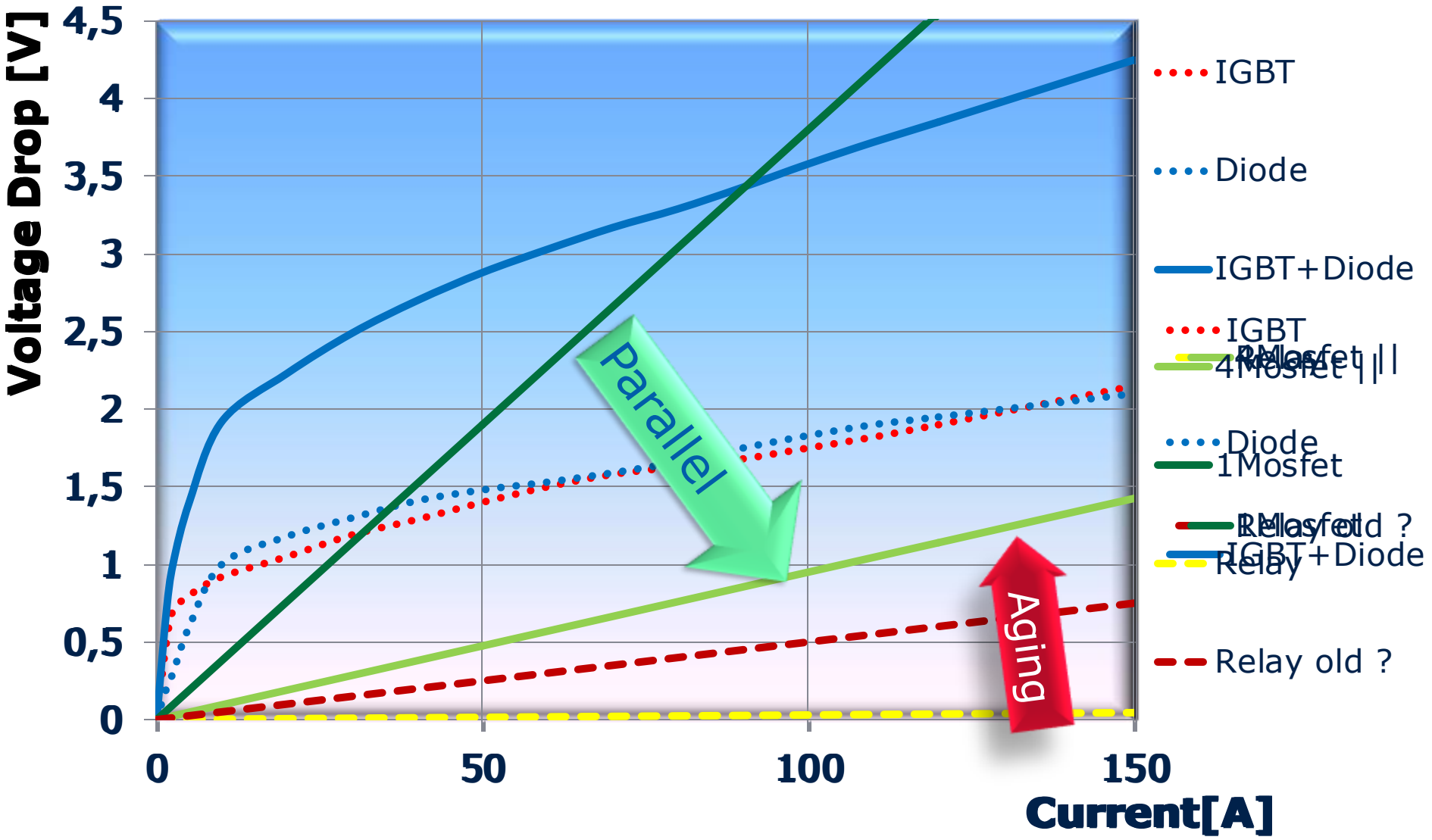
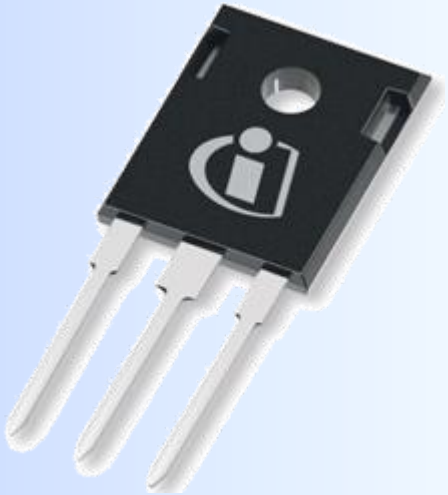
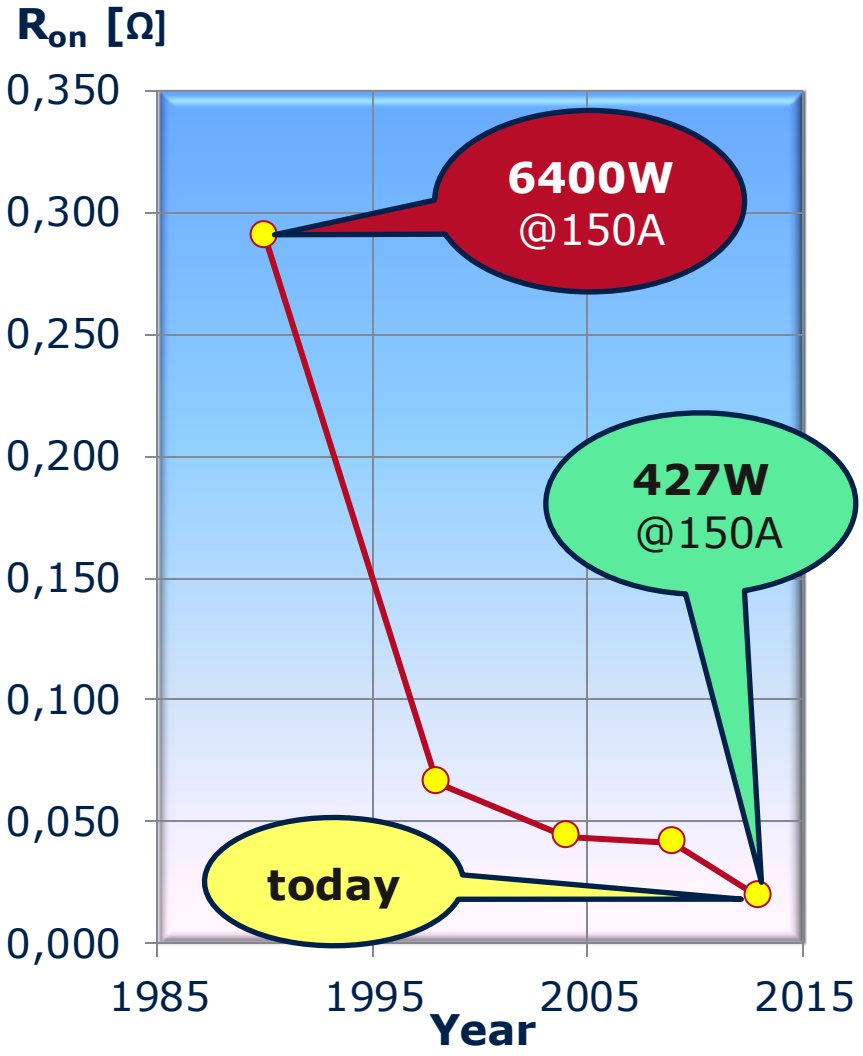
Switching Elements
Voltage Drop over Current



MosFET Evolution
Better Ron Resistance

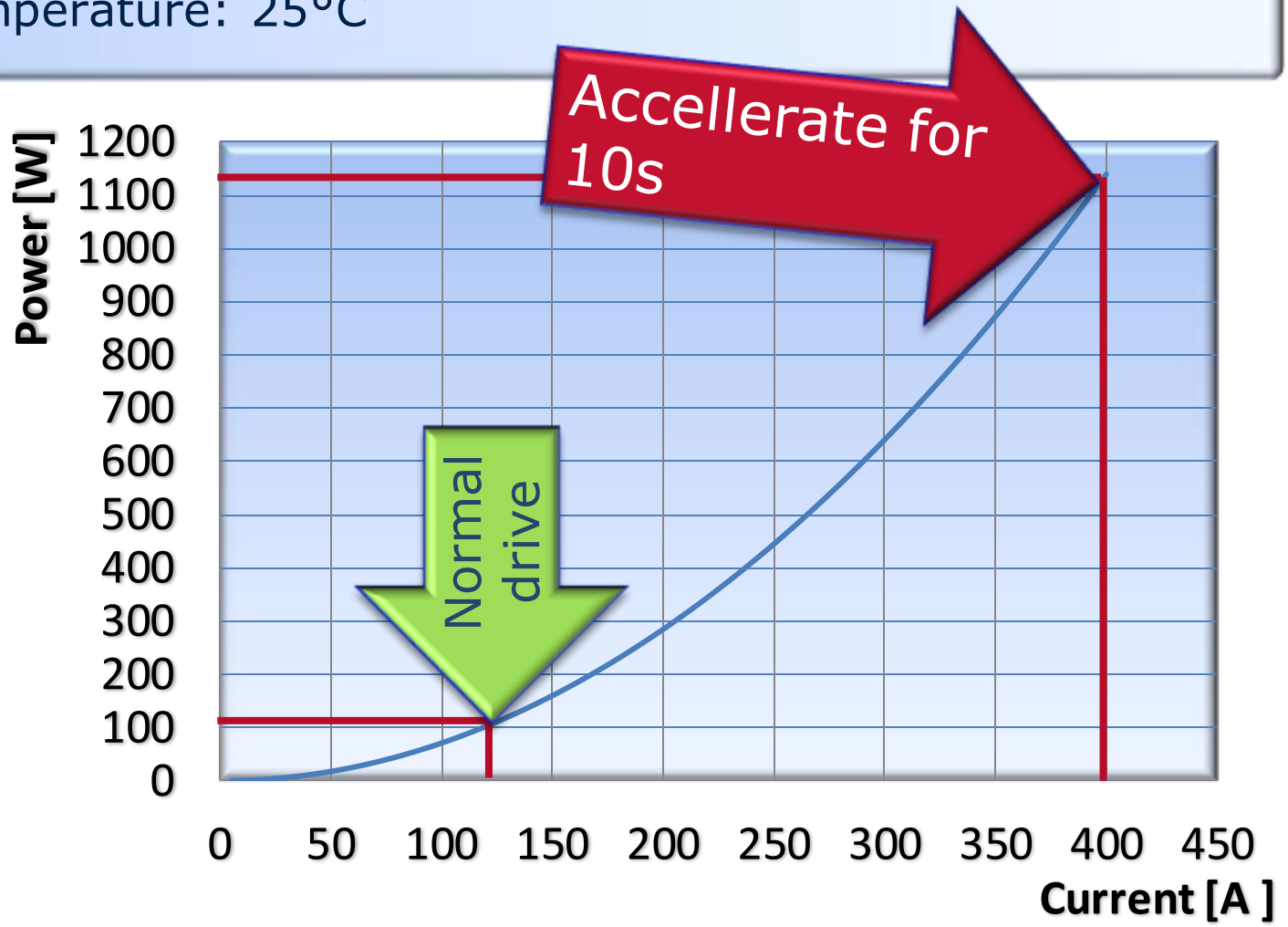
- Improvement factor 15 within 20 years
- Assumption: available silicon chip technology in the actual *TO247* package device





Power Dissipation

- Configuration 8P/3S (8 MosFets parallel and 3 in series)
- Temperature: 25°C



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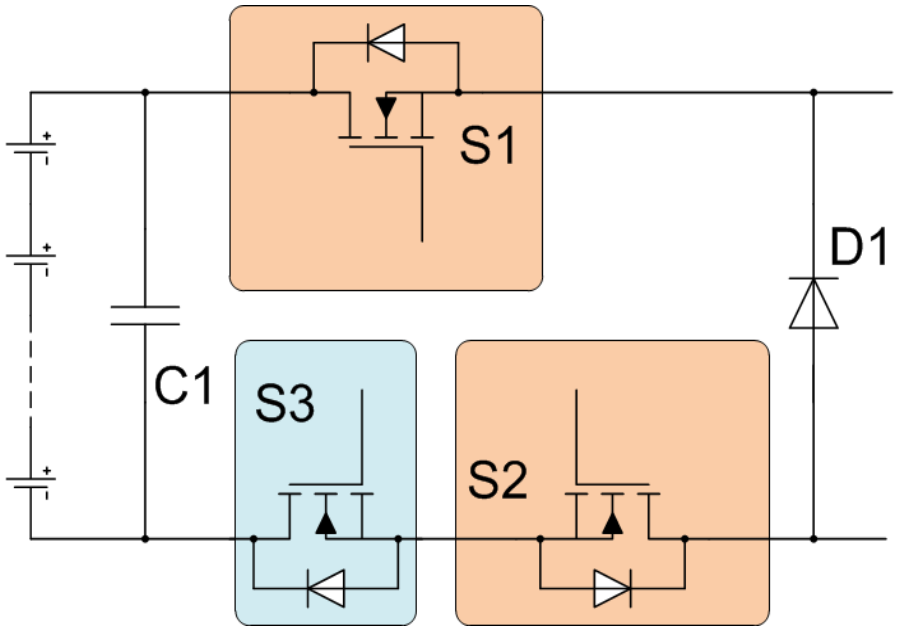
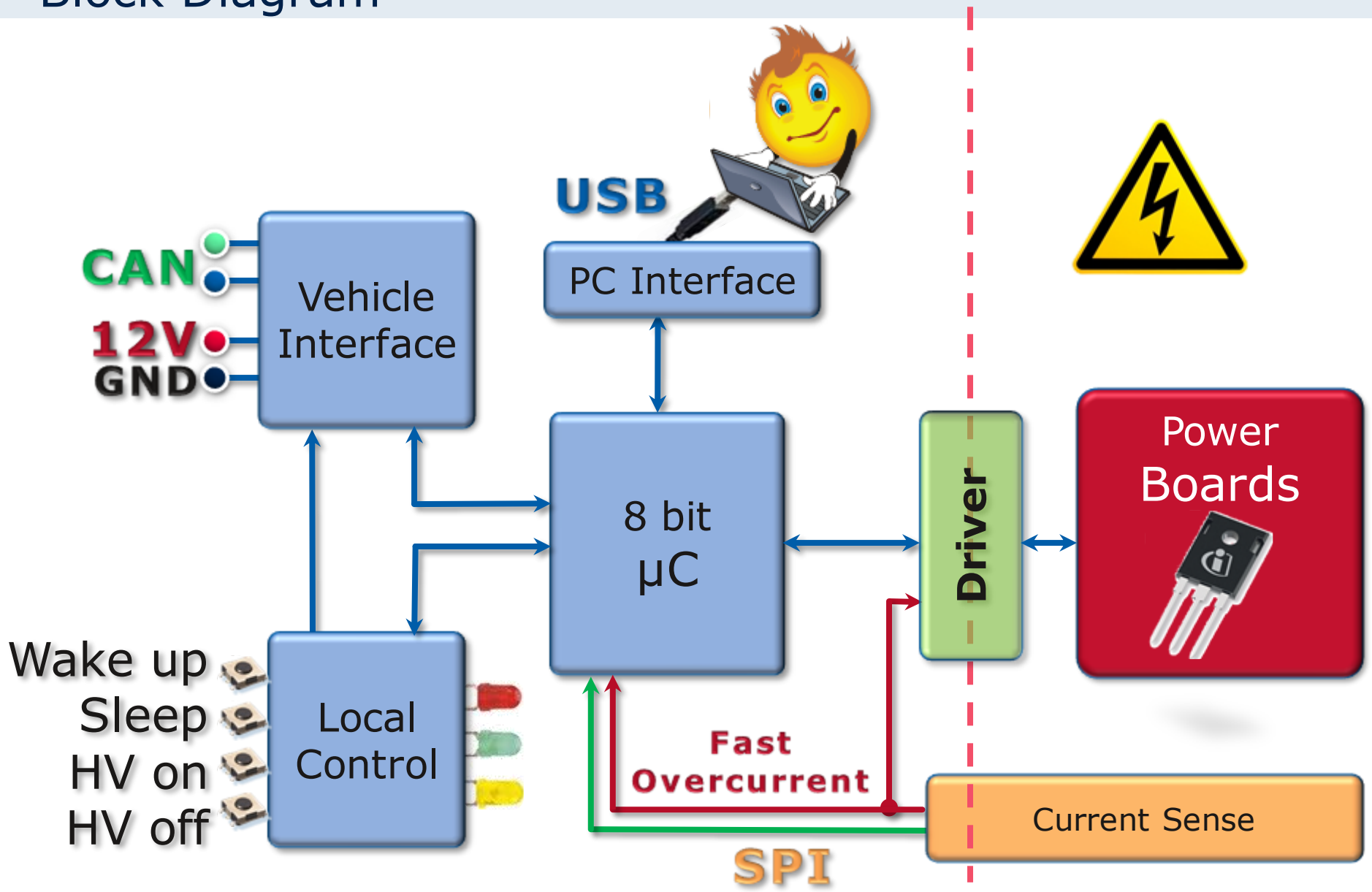
Block Circuit

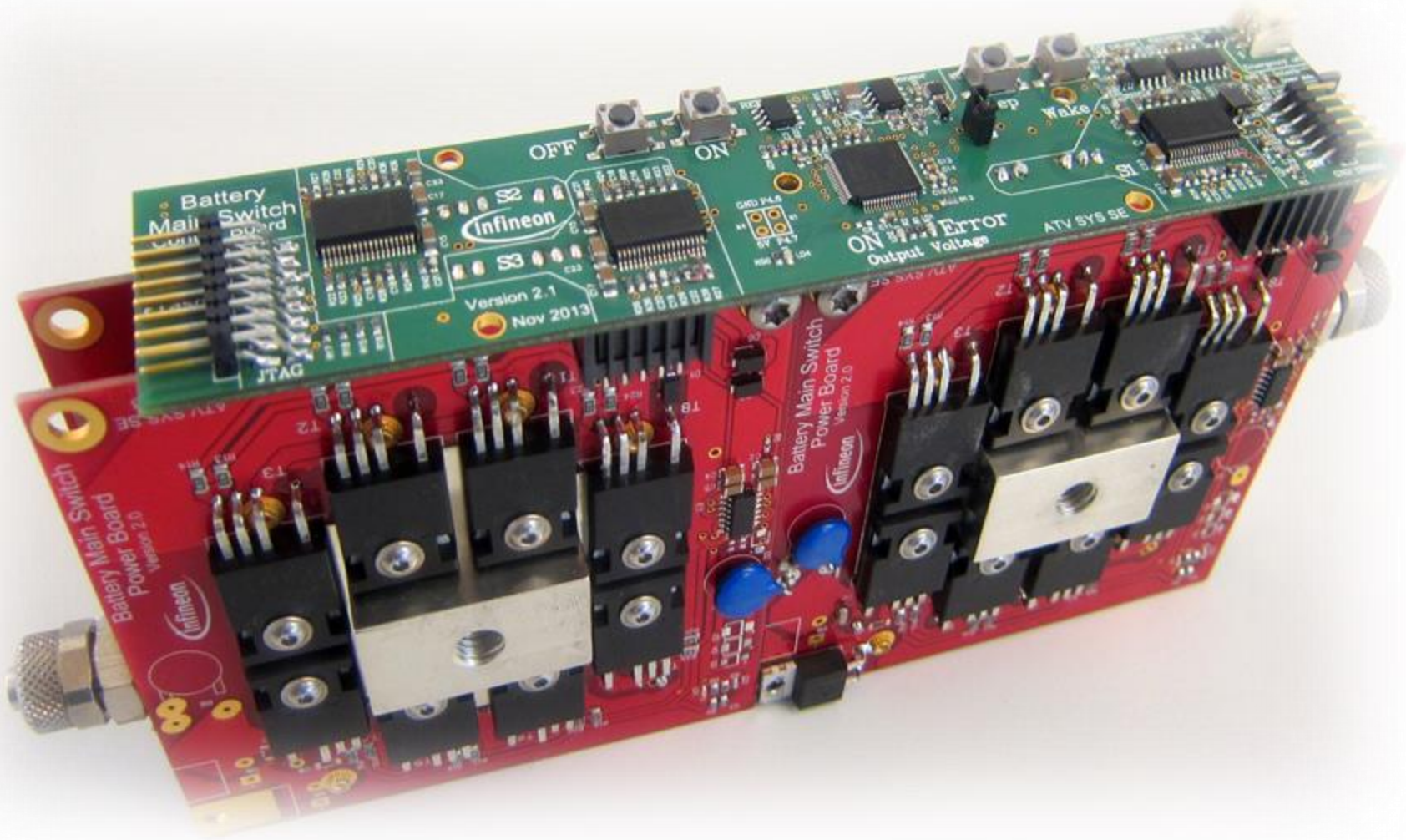
- **S1**
  - Voltage disconnect
- **S2**
  - Voltage disconnect (redundant)
- **S3**
  - Prevent from overcharge (only in charger fail mode)
- **D1**
  - Free Wheel diode for emergency switch-off
- **C1**
  - Input Buffer



Version 2.0
Block Diagram



Reference Design



Overload Handling

- Normal Operation (<400A):
  - 8 equal independent paths via Hall sensor
    - Check of current distribution possible
  - Board Temperature Measurement

Software Controlled

- Overload Condition:
  - Fast Overcurrent in Hall Sensors
    - 3µs delay
    - 55A Threshold each > 440A in total
    - Interrupt in µC
    - Hardware Reset of Driver
  - Voltage drop over RDSon
    - Hardware switch-off
    - Threshold:
      - 650A @ 25°C
      - 400A @ 120°C

Hardware Controlled

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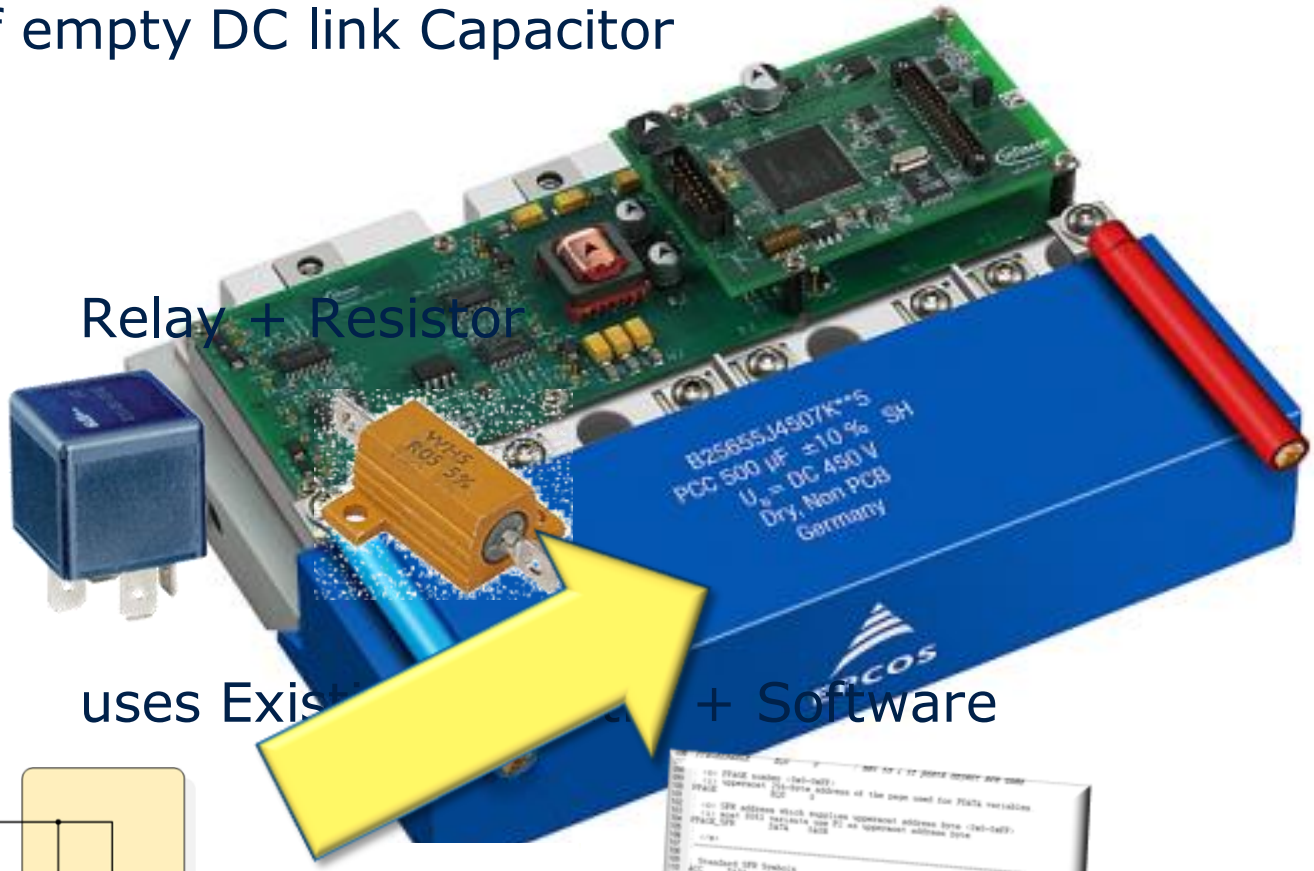
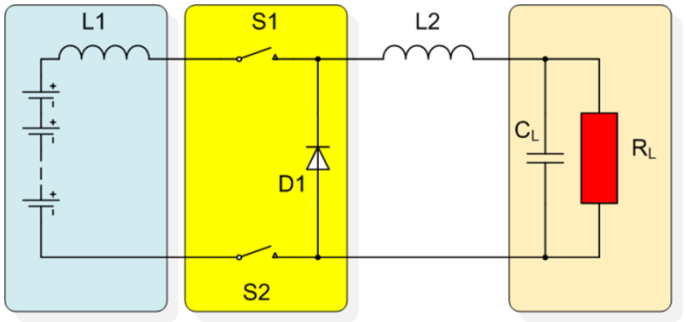
Precharge Function

- **Task:** Charge of empty DC link Capacitor

- **Conventional :** Relay + Resistor

- **Solid State :** uses Exist[illegible] + Software





Precharge Features

- Detection of
  - Short Circuit
  - Open Load
- Measurement of
  - Load current
  - Capacitance value of DC link

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Legal Situation
LV123

- **Past**: Two Relays mandatory as safety part;
  No semiconductors allowed
- **Actual proposal**: One Relay for final interruption necessary
- **Future**: Complete solid state solution under discussion

Savings in the System

- Mechanical Parameters
  - Size
  - Weight
- Parts
  - Relays
  - Fuse
  - Precharge Circuit
- Wiring diameter
- Noise Cancellation
- Replacement of Switchbox (and Batteries ?) after Crash

ENERGY EFFICIENCY
MOBILITY
SECURITY

Innovative semiconductor solutions for energy efficiency, mobility and security.