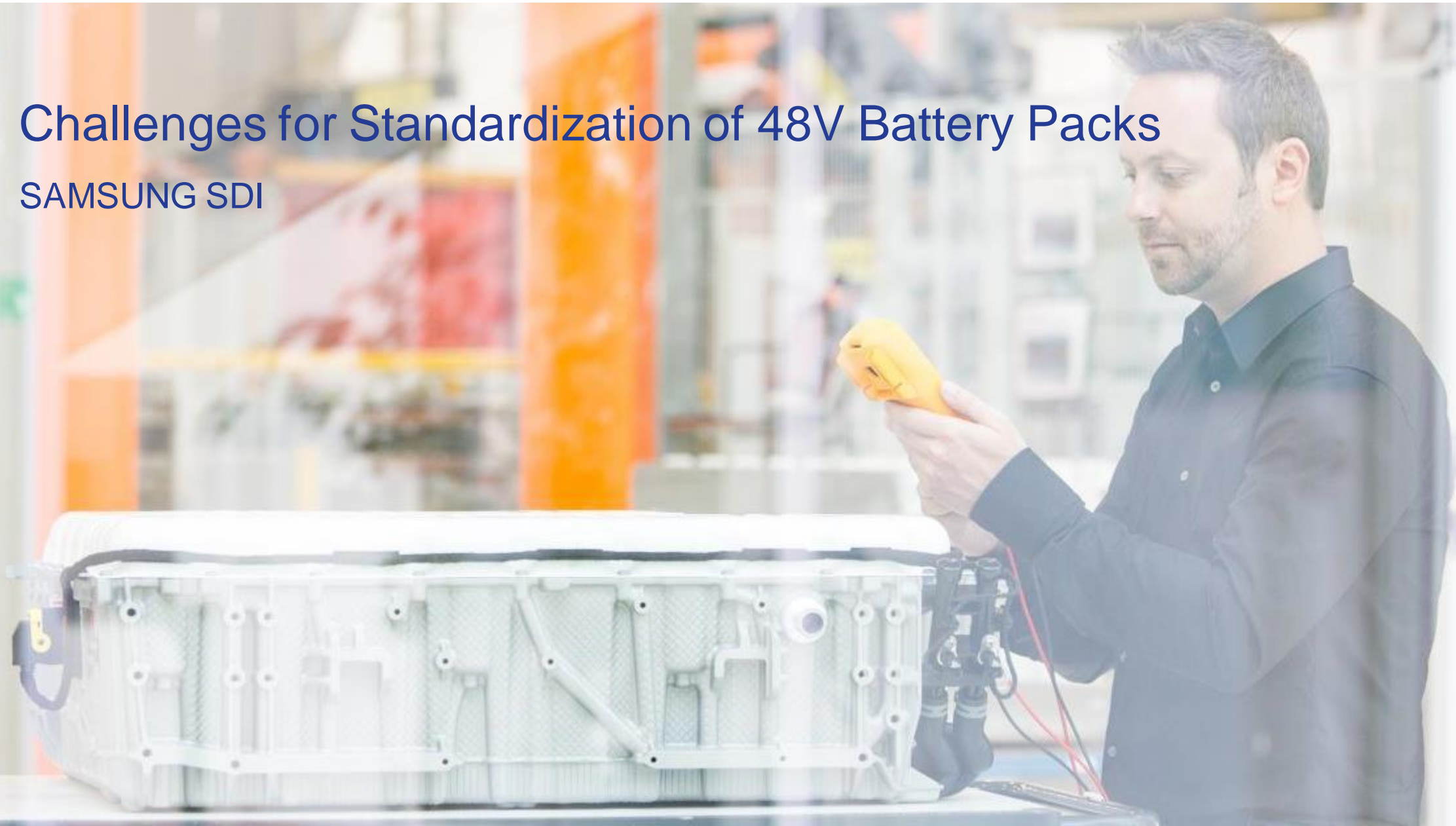


Challenges for Standardization of 48V Battery Packs

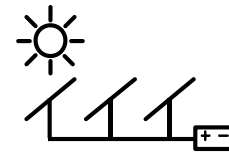
SAMSUNG SDI



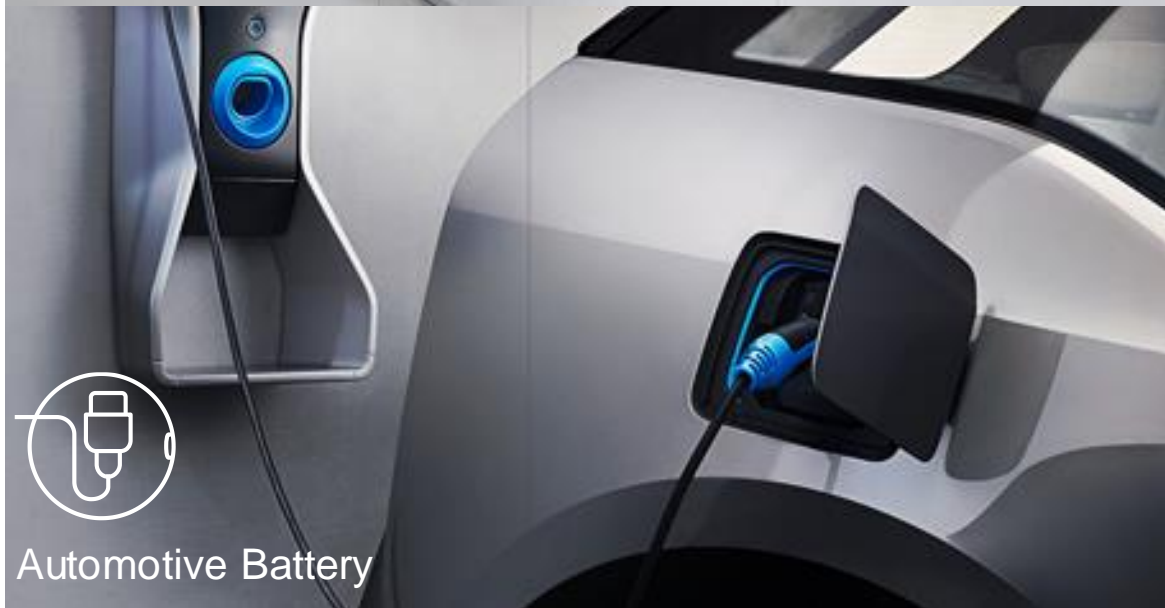
- SAMSUNG SDI - Overview
- Product Portfolio SAMSUNG SDI Battery Systems
- Overview of 48V battery packs
- Standardization potential of 48V battery pack
 - Cells
 - Mechanical design
 - Cooling
 - Electrics/electronics
- SAMSUNG SDI platform solutions
- Conclusion and outlook



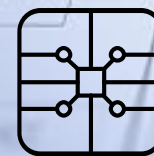
IT Battery



ESS

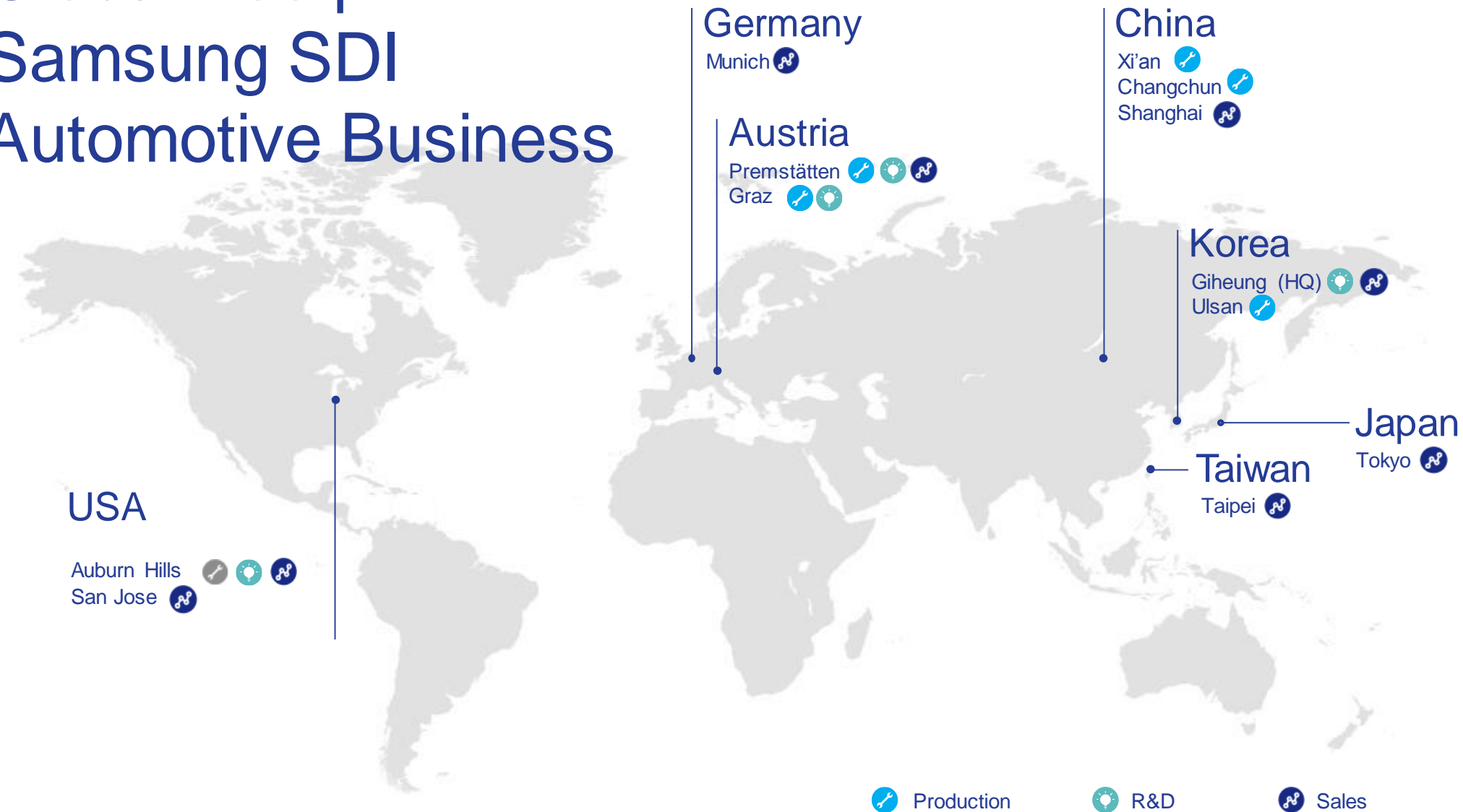


Automotive Battery



Electronic Material

Global Footprint Samsung SDI Automotive Business



Current Battery Packs & Portfolio

	12V	48V	PHEV	BEV Pack
				
	Serial Production	Serial Development	Serial Production	Serial Production (D/C)
Energy Content	0,15 – 0,5 kWh	0,2-3 kWh	6 – 18 kWh	36 – 100 kWh
Power	3 - 6 kW	12 - 25 kW	50 - 120 kW	100 – 500 kW
Voltage	12 V	48 V	400 V	400 V / 800 V
Weight	4 - 5 kg	< 10 kg	80 - 210 kg	400 - 600 kg
Cooling	passive	passive / air / liquid	liquid	passive / liquid
SOP	2013	2018	2013	2010

▪ Applications

- 48 V systems are designed to support cranking and restarting of the ICE, brake energy recuperation and electrical high power loads
- In premium vehicle segment additional energy content is requested to support comfort functions

▪ Performance - 3 classes of 48V applications

- Standard 48V pack
- High power 48V pack
- 48V pack with integrated DC/DC converter

▪ Packaging

- In 2020 current solutions specific to OEM's and application
- Vision for 2025+ for standardized 48V pack sizes

▪ Cooling

- Air cooling considered for 48V systems in most applications
- High performance: cooling media liquid / refrigerant
- Design target for next cell generations to omit active cooling

▪ Electronics/Battery management

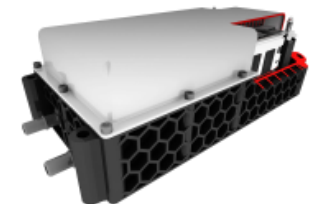
- Full integrated solutions: BMU, CSC, current sensor on one PCB
- “Down sized” with less functionality compared to PHEV/HEV electronics





Standard pack



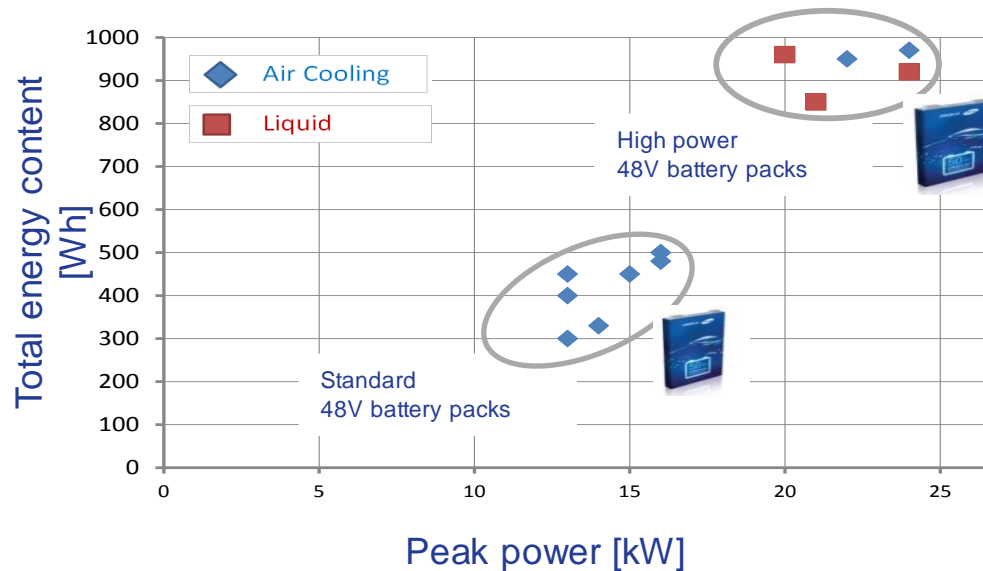
Power pack



48V pack with integrated DC/DC

	48V Standard Pack	48 V Performance Pack
		
Energy content [Wh]	500	1000
Voltage range [V]	36 - 52	36 - 52
Max. Current [A]	+/- 400	+/- 600
Charge Power BOL [kW] (50% SOC, 25°, 1 Sec)	12-16	20-25
Discharge Power BOL [kW] (50% SOC, 25°, 1 Sec)	12-16	20-25
Volume	< 8l	< 10l
Weight	< 10 kg	< 15kg
Cooling	No cooling / Air cooled	Air / liquid cooled
Housing Technology	Depending on crush requirements plastic or aluminum	Depending on crush requirements plastic or aluminum
Packaging	specific to OEM's and application	specific to OEM's and application

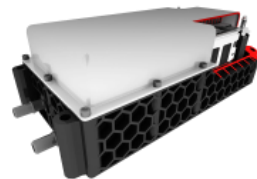
Energy / power requirements of different 48V programs worldwide



- Power / Energy performance requirements of different OEM's and applications can be covered with two classes of 48V battery packs
- “Standard” 48V battery pack applications satisfied with 15kW/500Wh-battery pack
- For high-power applications up to 25kW/1000Wh battery packs are requested
- Mostly active air-cooling required, liquid-cooling approach for specific applications.
- 48V pack with integrated DC/DC converter as option

Power/Energy requirements are very similar for different OEM's and applications → standardization of cell size

Samsung SDI offers standard cells for 48V applications

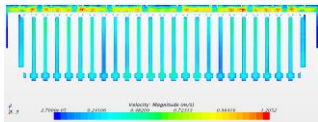
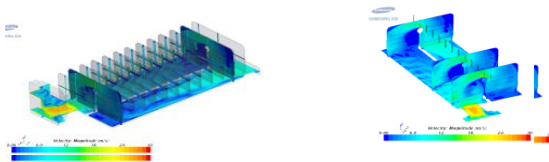
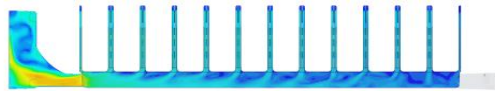
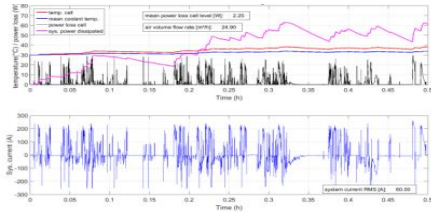


- Packaging for current 48V packs are specific depending on OEM and application.
- Interfaces for HV/LV, cooling and venting are diverging
- Installation area within vehicle are:
 - Engine compartment
 - Trunk area
 - Under front seat
- Crush/ crash requirements are between 20 and 200 kN result in different housing technologies:
 - Aluminum is used for higher crush/crash requirements
 - Plastic as low-cost approach
- Different packaging / cell integration concepts for air and liquid cooling are required

Due to different vehicle requirements mechanical designs are specific for different 48V applications

For harmonizing 48V battery packs OEM's will have to cooperate closely

Vision 2025+ → standardized 48 V battery systems ?



- Air cooling can be critical in matter of cooling capability and temperature gradient. Besides cooling performance, safety- (venting) and comfort (noise) aspects have to be considered.
- For high power 48V systems liquid cooling is the best solution. Cooling media has to be separated from HV path to avoid risk from leakage.
- Refrigerant cooling as an option to avoid separate liquid cooling circuit.
- Intelligent thermal management and specific pack design required to avoid aggressive cooling and condensation of humidity.
- Requirements for cooling are different depending on application
 - size and packaging of battery pack, safety and comfort aspects, cooling requirements, load cycles, power requirements, cell design and chemistry, after sales aspects...

**In general there is no optimal cooling concept and/or cooling medium!
Choice of cooling depends on vehicle requirements and architecture.
Standardization of cooling components is not feasible, but scalable cooling concept can be applied**



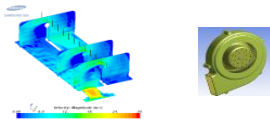
- **Battery management functions:**
 - Operation / Battery management function
 - Control & interface function
 - Safety function
 - Diagnose function
- **Specific electronics (BMU+CSC) and relays for 48V**
- **Modular software to be flexible for different pack requirements and cell technologies**
- **Safety requirements up to ASIL C requested.**
Conformity to safety standards (ISO 26262)

Platform components for electronics, sensors and relays

Cell

Electric,
Electronics

Cooling

Mechanics
design

Standardization

- Standard cells for 48V
- Platform for 48 V electronics, sensors and relays
- Adaptable cooling designs for air and liquid cooling
- Specific mechanical design

Samsung SDI has platform solutions for „standard“ and „high power“ packs.

12V		48V			
 11Ah Hi-Cap	 12.6Ah Hi-Cap (4.2Ah x 3p)				 Liquid Cooled Type  Air Cooled Type
Dual (Vertical)	Dual (Horizontal)	Standard	Power	DCDC integrated	
11Ah Hi-Cap	8.4Ah Hi-Cap (4.2Ah x 2)	5Ah HEV x 2p	Air Cooled Type 6.5Ah HEV x 3p	10Ah HEV (Gen2 : 19.5Ah HEV)	
SOP 2017	SOP 2020	SOP 2018	SOP 2019	SOP 2017	

- OEM's are currently targeting an additional 48V vehicle power supply, mainly to reduce CO₂ emission and fuel consumption and for supporting electrical high power loads
- Market introduction for 48V Systems for specific applications is ongoing. High volume approach is targeted for 2020+
- The main challenges for high volume market introductions are:
 - Development of specific cells in matter of design and size for 48V
 - Standardization of 48V systems overall OEM's
 - System cost reduction

**Platform approach for 48V applications is feasible.
Fully standardized 48 V battery systems needs close cooperation between OEM's**



SAMSUNG SDI

The Power behind Electromobility



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