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Electric vehicle (EV) ecosystem





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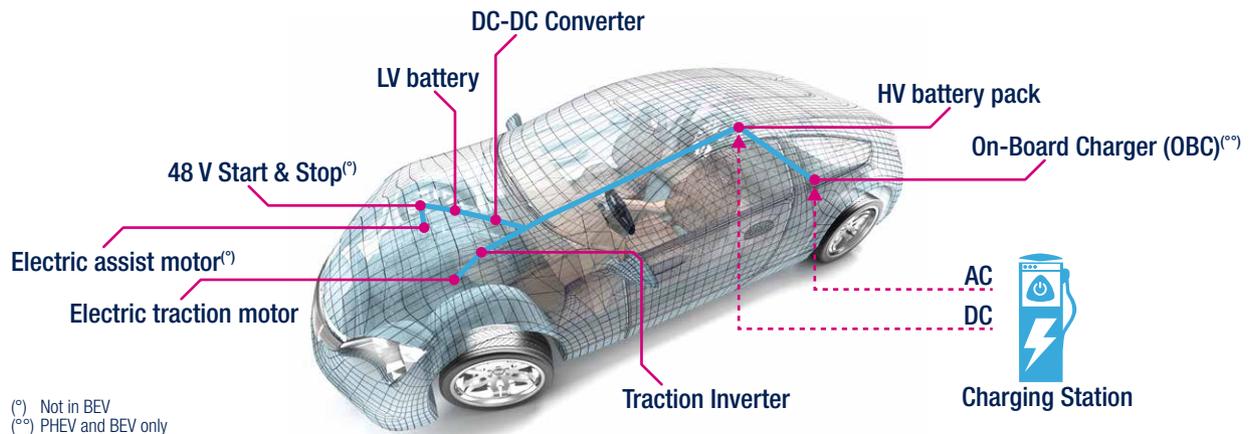
Introduction

The electrification of vehicles is increasing rapidly, driven by the availability of higher-performance, more cost-effective battery technologies, and improved mileage vehicles as well as ecological awareness, and government incentives and regulation.

Latest forecast shows sales of electric vehicles increasing from a record 1.1 million worldwide in 2017 to 11 million in 2025. (source bnaf.com)

The electric vehicle (EV) ecosystem is composed of:

1. Electric vehicle
2. Charging station



The Electric vehicles are classified by how electricity is used to power the vehicle:

- Hybrid Electric Vehicles (HEVs) are powered by an internal combustion engine (ICE) and electric power. Batteries are charged via regenerative braking and optionally by a generator connected to the ICE
- Plug-in Hybrid Electric vehicles (PHEVs) are HEVs, so they have an ICE, and they have an on-board charger (OBC) that allows the batteries to be charged from an external electric power source
- Battery electric vehicles (BEVs) 100% use of electric power. Batteries charged from external electric power source and regenerative braking

The charging infrastructure plays a pivotal role on electric vehicles deployment. The charging infrastructure includes all of the hardware and software that ensures energy is transferred from the electric grid to the vehicle. It can be categorized in different ways but the most common one is based on the provided voltage type:

- AC charging station transmits power from a single phase/poly phase at home or at public/private outlet to an electric vehicle. The max common power charging level are 7.2 kW (single phase), 22 kW (three phase). The charging time takes several hours
- DC charging station (fast charging) are suited for electric vehicles needing a lot of charge during a short stop. The common power charging is ≥ 50 kW. The charging time usually takes 30-60min for 80% charge

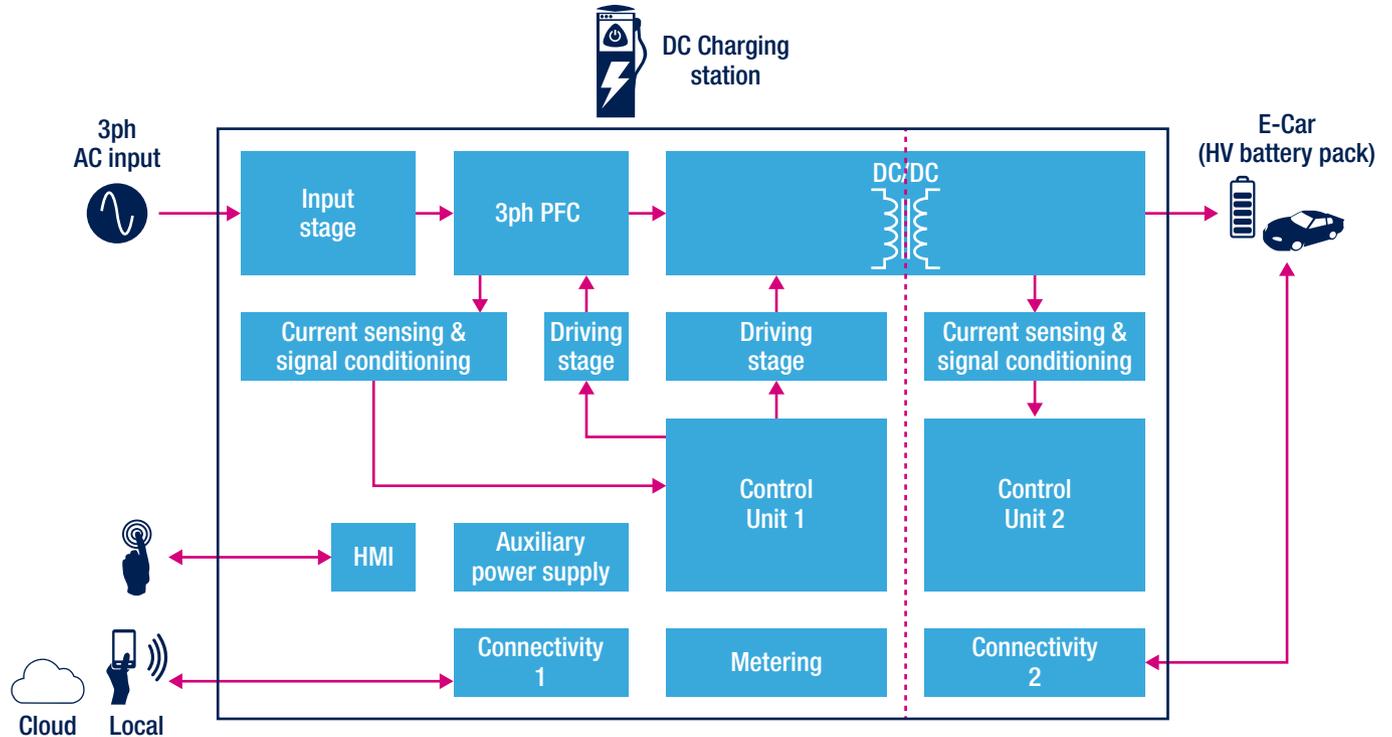
ST provides leading-edge solutions for electric vehicles and charging stations based upon proven and innovative technologies and backed up with our extensive power management experience.

Silicon and SiC (Silicon Carbide) MOSFETs and diodes, IGBTs, protection components, isolated gate drivers and microcontrollers make up an unrivalled offer for electric vehicle power management. They are available as discrete components, or as part of dedicated system solutions, all in accordance with the AEC-Q100 and AEC-Q101 standards.



DC Charging Station

Charging infrastructure also plays a pivotal role on Electric vehicles deployment. The charging infrastructure includes all of the hardware and software that ensures energy is transferred from the electric grid to the vehicle. Household AC chargers generally work with limited power and long charging times. Charging electric vehicles quickly (up to 1h) requires a DC charging station (200-800 V_{DC}) with power rates about ≥50 kW. ST is able to offer a complete product portfolio including silicon and SiC power MOSFETs, IGBTs, silicon and SiC diodes, SCR thyristors, protections, gate drivers, microcontrollers, connectivity and metering ICs and microcontrollers.



ST's product mapping for the DC Charging Station is reported in table 1.



Tab. 1 - ST's products mapping for DC Charging Station

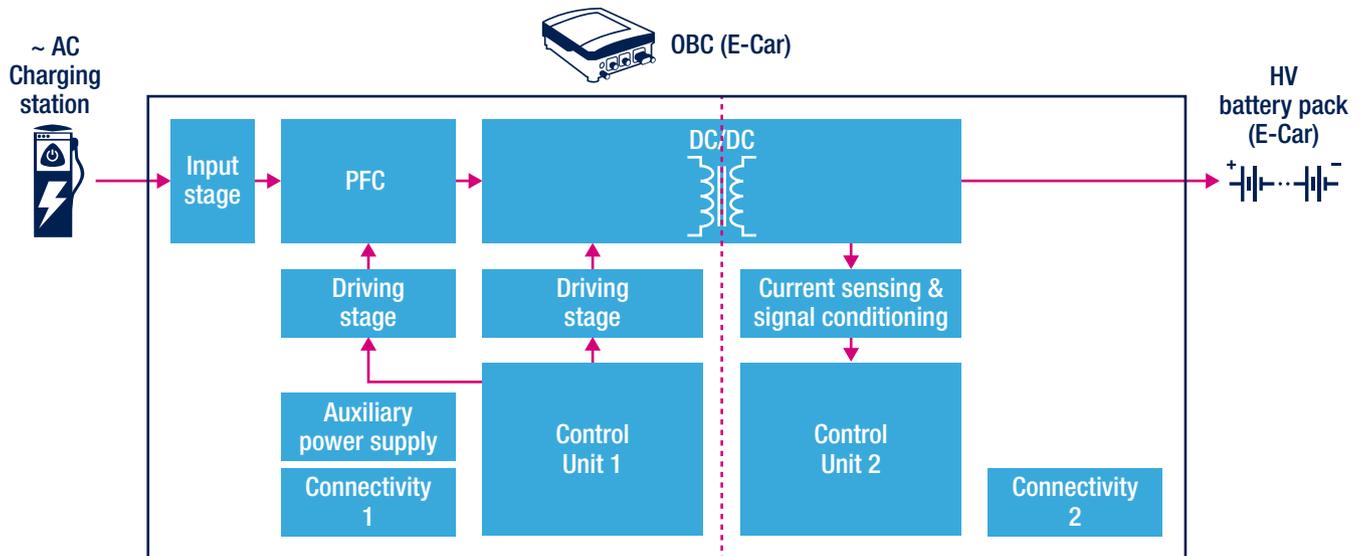
		Input stage	3ph PFC	DC/DC		Control units		Driving stage	Current sensing & signal conditioning	Aux SMPS	HMI	Metering	Connectivity	
				1^ side	2^ side	1^ side	2^ side						1^ side	2^ side
Rectifiers	SiC series - 600/650 V		•		•									
	SiC series - 1200 V		•		•									
	Ultrafast RQ series - 600 V		•	•	•									
	Ultrafast R series - 600 V		•	•						•				
	STBR series - 1200 V	•	•											
	Schottky series - 40/45/60/100 V									•				
Thyristors	BTW series - 1200 V	•												
	TYN series - 1200 V	•												
	TM8050H series - 800 V	•												
	TN3050H, TN5050H series -1200 V	•												
TVS protections	SM4TY, SM6TY, SM15TY, SM30TY		•	•	•					•				
Power MOSFETs	SiC series - 1200 V		•											
	M5 series - 650 V		•											
	M6 series - 600/650 V		•	•										
	DM6 series - 600/650 V			•										
	DM2 series - 600/650 V			•										
	K5 series - 1200 V		•							•				
IGBTs	H series - 1200 V		•											
	HB series - 650 V		•	•										
MCUs (32bit)	STM32F334		•	•		•								
	STM32F0, STM32F1				•		•							
Gate drivers	L6491							•						
	STGAP1AS							•						
Memories (EEPROM)	M24**, M95**					•								
Current sense amplifiers	TSC102		•						•					
Offline converters	VIPer06, VIPer16, VIPer26									•				
Offline controllers	L6566BH, STCH02									•				
Voltage regulators	L5963, L5964 L798*, L698*									•				
CAN transceivers	L9616													•
CAN ESD protections	ESDCAN01, ESDCAN03, ESDCAN05													•
Power line transceivers	ST2100												•	•
	ST7540, ST7580, ST8500												•	
Bluetooth Low Energy Transceiver	ICs	BlueNRG-MS, BlueNRG-1, BlueNRG-2												•
	Modules	SPBTLE-1S, SPBTLE-RF, SPBTLE-RF0												•
NFC/RFID	Dynamic tags	M24SR, ST25DV-I2C												•
	Readers	ST25R												•
Metering ICs	STPM32, STPM33, STPM34										•			
LED array drivers	LED1642, STP08, STP16									•				

Note: * is used as a wildcard character for related part number



On-Board Charger (OBC)

One of the key elements of battery electric (BEVs) or plug-in hybrid (PHEVs) vehicles is the traction high voltage battery ($200 V_{DC} - 800 V_{DC}$). In the car the on-board charger (OBC) allows the charging of the battery from home AC mains plug or private/public outlets (AC charging station); typical AC power charging level goes from 3.6 kW (single phase) to 22 kW (three phase). The key success factors of on-board charging are efficiency and high power density for a small form factor. ST provides a complete product portfolio including silicon and SiC power MOSFETs, IGBTs, silicon and SiC diodes, protections, SCR thyristors, MEMS, connectivity ICs, gate drivers, and microcontrollers, in accordance to AEC-Q100 and AEC-Q101 standards.



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ST's product mapping for On-Board Charger (OBC) is reported in table 2.



Tab. 2 - ST's products mapping for On-Board Charger (OBC)

		Input stage	PFC	DC/DC		Control units		Driving stage	Current sensing & signal conditioning	Aux SMPS	Connectivity	
				1^ side	2^ side	1^ side	2^ side				1^ side	2^ side
Rectifiers Automotive grade	SiC series - 600/650 V		•		•							
	SiC series - 1200 V				•							
	Ultrafast RQ series - 600 V				•							
	Ultrafast R series - 600 V		•	•						•		
	STBR series - 1200 V	•										
	Schottky series - 40/45/60/100 V									•		
Thyristors Automotive grade	TN3050H, TN5050H series - 1200 V	•										
TVS protections Automotive grade	SM4TY, SM6TY, SM15TY, SM30TY		•	•	•					•		
Power MOSFETs Automotive grade	SiC series - 650/1200 V		•	•								
	M2 series - 650 V		•									
	M5 series - 650 V		•									
	M6 series - 600/650 V		•									
	DM2 series - 600/650 V				•							
	DM6 series - 600/650 V				•							
IGBTs Automotive grade	H series - 1200 V		•	•								
	HB series - 650 V		•	•								
MCUs (32bit) Automotive grade	SPC58NE E-LINE, SPC58NN, SPC560D, SPC560P, SPC582B/4B B-LINE, SPC56EL, SPC570S					•	•					
Gate drivers Automotive grade	A6387							•				
	STGAP1AS							•				
Voltage regulators Automotive grade	A798*, A698*, L5963, L5964									•		
Memories (EEPROM) Automotive grade	M24**, M95**, M93**					•	•					
MEMS Automotive grade	AIS2120SX, AIS1120SX, AIS3624DQ	•										
Current sense amplifiers	TSC102								•			
CAN transceivers Automotive grade	L9616										•	•
CAN ESD protections Automotive grade	ESDCAN01, ESDCAN03, ESDCAN05										•	•
K-line transceivers Automotive grade	L9637											•

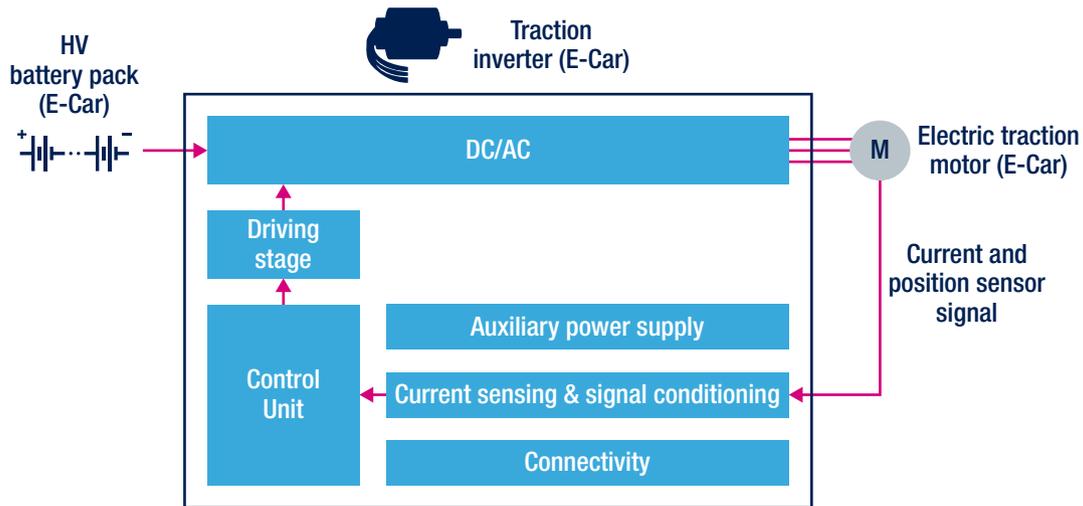
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Traction Inverter

Within an electric drivetrain, the inverter controls the electric motor. This is a key component in the car as it determines driving behavior. The main requirements for automotive inverters include control performance that extends from low to high motor speeds, robustness to withstand a harsh environment (heat and vibration), to minimize switching losses and maximize thermal efficiency, electromagnetic compatibility (EMC) performance to minimize the radiation of electromagnetic noise due to heavy current switching, ease of installation (small size and light weight), high level of insulation, the ability to withstand high voltage, and failsafe functions in the event of a fault.

ST provides a complete product portfolio including silicon and SiC power MOSFETs, IGBTs, silicon and SiC diodes, protections, connectivity ICs, isolated gate drivers, and microcontrollers, in accordance to AEC-Q100 and AEC-Q101 standards.



Tab. 3 - ST's products mapping for Traction Inverter

		DC/AC	Driving stage	Control unit	Current sensing & signal conditioning	Aux SMPS	Connectivity
Rectifiers Automotive grade	SiC series - 650/1200 V	•					
	Ultrafast R series - 600 V		•			•	
	Schottky series - 40/45/60/100 V		•			•	
	MC series - 650/1200 V	•					
TVS protections Automotive grade	SM4TY, SM6TY, SM15TY, SM30TY	•				•	
Power MOSFETs Automotive grade	SiC series - 650/1200 V	•					
IGBTs Automotive grade	H series - 1200 V	•					
	M series - 650 V	•					
MCUs (32bit) Automotive grade	SPC58NE E-LINE, SPC58NN, SPC570S, SPC56EL, SPC582B/4B B-LINE			•			
Gate drivers Automotive grade	STGAP1AS		•				
Voltage regulators Automotive grade	L5963, L5964 A798*, A698*					•	
Memories (EEPROM) Automotive grade	M24**, M95**, M93**			•			
Current sense amplifiers	TSC102				•		
CAN transceivers Automotive grade	L9616						•
CAN ESD protections Automotive grade	ESDCAN01, ESDCAN03, ESDCAN05						•

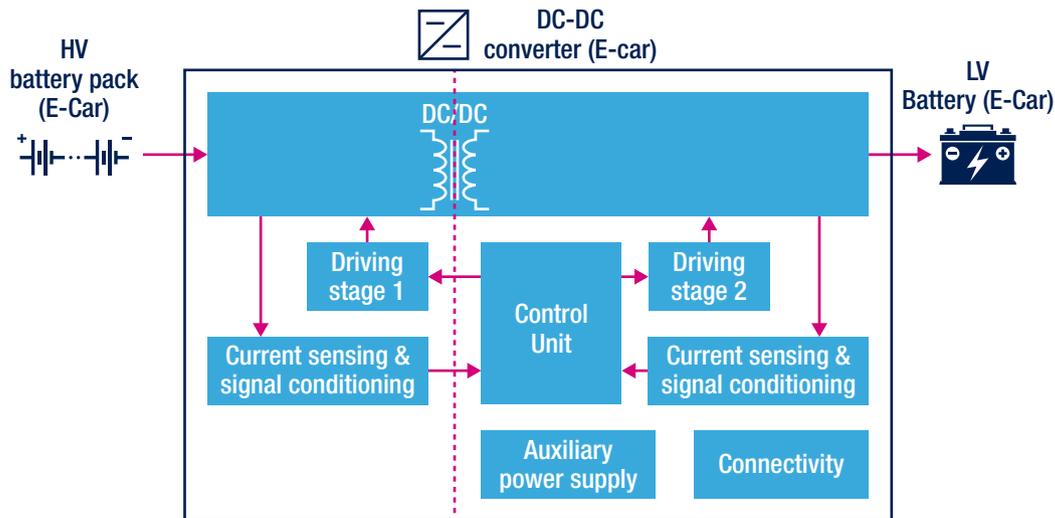
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DC-DC Converter

Electric vehicles usually have two kinds of battery, a standard low voltage (12/48 V) for the general electric appliances, and a high-voltage battery pack to provide the power for the electric traction motors. There is an energy exchange between them.

The low battery is no longer recharged by the alternator, but is charged from the high-voltage battery pack. For this purpose, a standard DC-DC converter is used. However, in some cases it could be necessary to reverse operation, and to recharge the high-voltage battery pack from the low-voltage battery to crank the car. ST provides a complete product portfolio including silicon and SiC power MOSFETs, silicon and SiC diodes, protections, connectivity ICs, isolated gate drivers, and microcontrollers, in accordance to AEC-Q100 and AEC-Q101 standards.



Tab. 4 - ST's products mapping for DC-DC Converter

		DC/DC		Driving stage		Control unit	Current sensing & signal conditioning	Aux SMPS	Connectivity
		1^ side	2^ side	1^ side	2^ side				
Rectifiers Automotive grade	SiC series - 650/1200 V	•							
	Ultrafast R series - 600 V	•		•				•	
	Schottky series - 40/45/60/100/150/170 V		•	•				•	
TVS protections Automotive grade	SM4TY, SM6TY, SM15TY, SM30TY, LDP01	•	•					•	
Power MOSFETs Automotive grade	SiC series - 650 V	•							
	M2 series - 650 V	•							
	M6 series - 600/650 V	•							
	DM2 series - 600/650 V	•							
	DM6 series - 600/650 V	•							
F7 series - 80/100 V			•						
MCUs (32bit) Automotive grade	SPC58NE E-LINE, SPC58NN, SPC560P, SPC56EL				•				
Gate drivers Automotive grade	AG387				•				
	STGAP1AS			•					
Voltage regulators Automotive grade	L5963, L5964 A798*, A698*							•	
Memories (EEPROM) Automotive grade	M24**, M95**, M93**					•			
Current sense amplifiers	TSC102						•		
CAN transceivers Automotive grade	L9616								•
CAN ESD protections Automotive grade	ESDCAN05								•

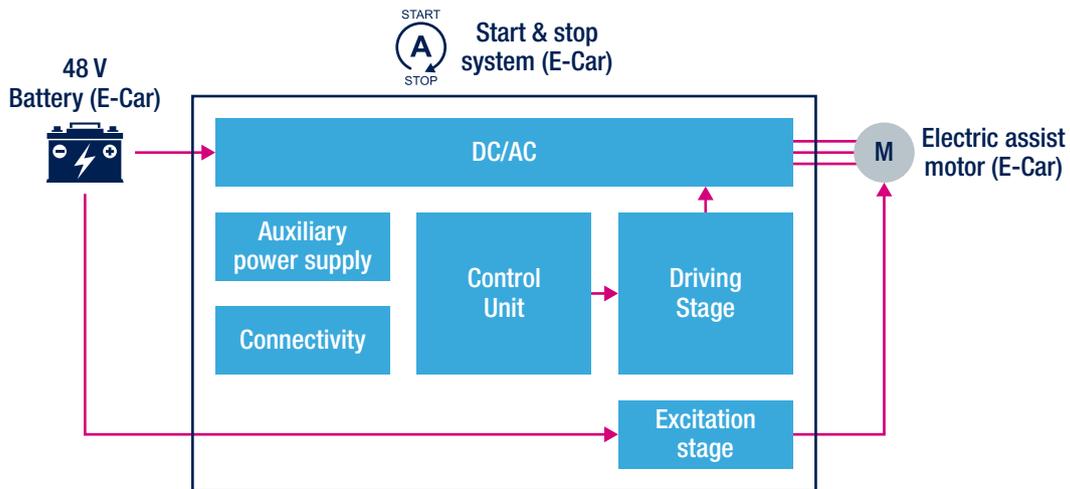
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48 V Start & Stop

A start/stop system automatically shuts down and restarts an automobile's internal combustion engine to reduce the amount of time the engine spends idling, thereby improving fuel economy. This is most advantageous for vehicles that spend significant amounts of time waiting at traffic lights or that frequently come to a stop in traffic jams. This requires power electronics that can handle high current during cranking and ensure reliability during engine cycles operating on/off at high temperatures.

ST provides a complete product portfolio including silicon power MOSFETs, diodes, connectivity ICs, protections, gate drivers, and microcontrollers, in accordance to AEC-Q100 and AEC-Q101 standards.



Tab. 5 - ST's products mapping for 48 V Start & Stop

		DC/AC	Driving stage	Excitation stage	Control unit	Aux SMPS	Connectivity
Rectifiers Automotive grade	Schottky series - 45/60/100 V					•	
TVS protections Automotive grade	SM4TY, SM6TY, SM15TY, SM30TY, LDPO1	•		•		•	
Power MOSFETs Automotive grade	F7 series - 80/100 V	•		•			
MCUs (32bit) Automotive grade	SPC58NE E-LINE, SPC58NN, SPC56EL, SPC584B/EC				•		
Gate drivers Automotive grade	L9907 - 3ph motor driver		•				
Voltage regulators Automotive grade	L5963, L5964 A798*, A698*					•	
CAN transceivers Automotive grade	L9616						•
CAN ESD protections Automotive grade	ESDCAN01, ESDCAN03, ESDCAN05						•

Note: * is used as a wildcard character for related part number



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