

The background of the entire page is a dark, atmospheric scene featuring three cars rendered as glowing blue wireframe models. The cars are positioned in a row, with the one in the foreground being a sedan, and the two behind it being SUVs. They are all reflected on a dark, glossy surface. A warm, yellow light source is visible in the background, creating a soft glow and highlighting the wireframe structures of the vehicles.

**ROHM**  
SEMICONDUCTOR

ROHM Products for  
Electric Vehicles

EV Solutions



# SiC Technology for Formula E

## SiC Power Devices Adopted for Inverters in Formula E – the Premier Racing Series for Electric Cars

### SiC Power Devices Accelerate Electric Vehicle Innovation

As an official technology partner of Formula E team Venturi, which participates in FIA's Formula E Championship series, ROHM supplies SiC (Silicon Carbide) power devices that contribute to increased efficiency in the power electronics system of state-of-the-art, all-electric race cars.



### Exploring the possibilities of SiC through Formula E

Integrated into the inverter that comprises the core of the drive system



Contributes to smaller lighter inverters



Season 2 2015  
Conventional Inverter  
(IGBT+FRD)

Season 3 2016  
SiC-Equipped Inverter  
(IGBT+SiC SBD)

Efficiency **Increased 1.7%**

Weight **Reduced 2kg**

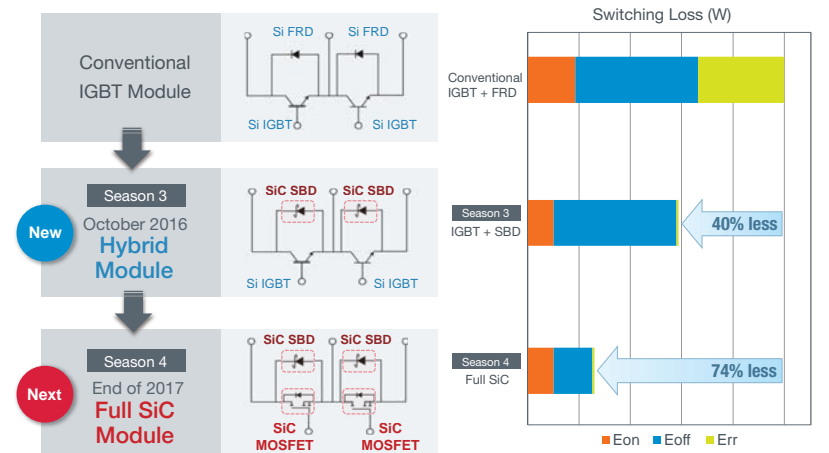
Volume **Decreased 30%**  
(Cooling System)

### ROHM SiC Technology Delivers Improved Performance

For battery-driven Formula E cars, power supply control is the most important factor, and making the most efficient use of electricity can often mean the difference between victory and defeat. ROHM SiC power devices were adopted in the main drive inverters for Season 3, achieving a significant reduction in energy loss.

In Season 3, hybrid IGBT+SiC SBD modules replaced conventional IGBT modules used in Season 2, and Season 4, which starts at the end of 2017, will see the adoption of full SiC power modules comprised of SiC MOSFETs and SiC SBDs that further reduce switching loss by 74% while at the same time significantly improve vehicle performance by dramatically reducing the size and weight of the inverter.

### Approach to Formula E



\*The above data are the results of evaluation conducted by ROHM and intended for reference purposes only. ROHM does not guarantee any of the characteristics shown here.

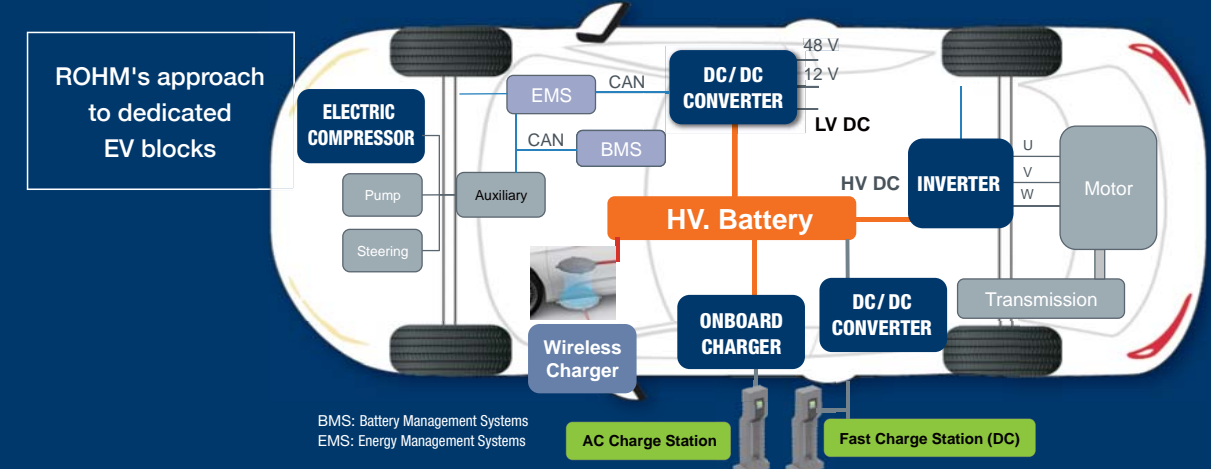
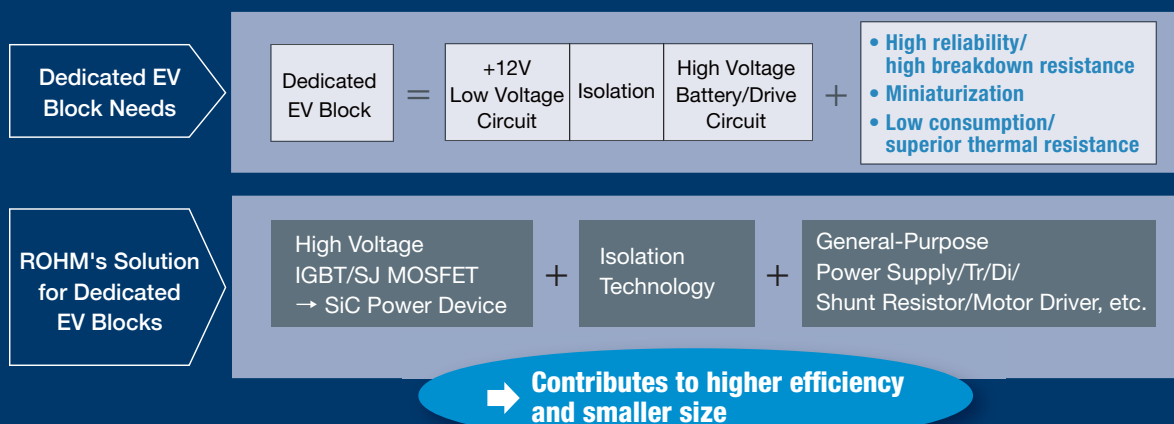
## ROHM's Approach to Dedicated EV Blocks

For specialized EV blocks, it is necessary to isolate the 12V low-voltage circuit from the high voltage battery/drive system while providing higher reliability, greater miniaturization, and lower power consumption. ROHM meets these needs with a variety of power devices, including SiC, IGBTs, and SJ MOSFETs.

We also offer products optimized for a variety of solutions, including shunt resistors for current detection, diodes, transistors, power supplies, and control ICs for power devices that contribute to lower power consumption, higher efficiency and greater miniaturization.

In the diagram below, showing dedicated EV blocks, ROHM is focusing its efforts on the main inverter, DC/DC converter, onboard charger, and electric compressor. Currently, integrating SiC SBDs in the onboard charger has become mainstream. Going forward, we believe that SiC MOSFETs will be increasingly adopted to

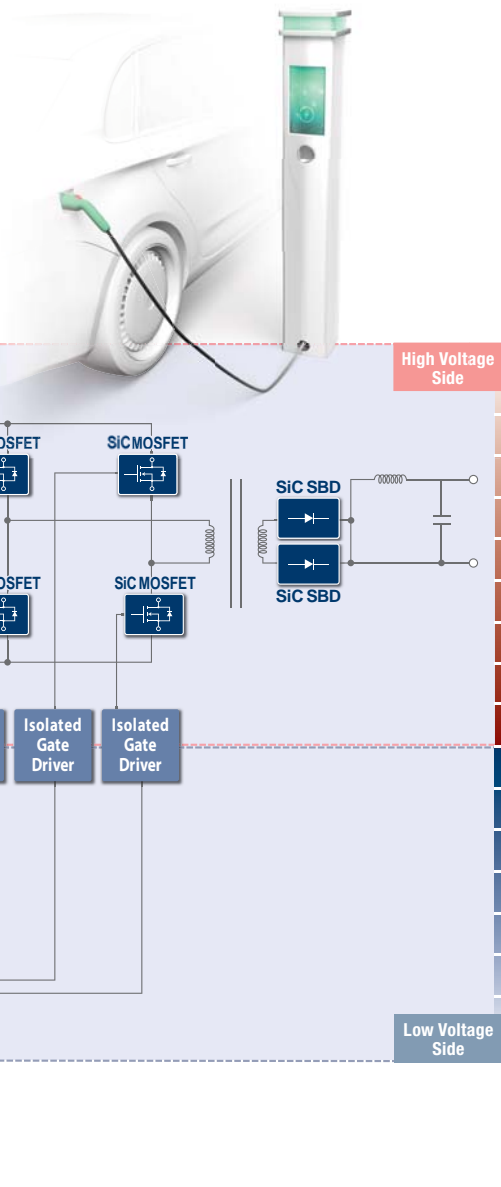
provide greater efficiency and withstand voltage that will translate to shorter charge times and increased charge efficiency. We ensure a stable supply of high quality products by leveraging our vertically integrated production system in which all processes, from materials to package, are carried out in-house.





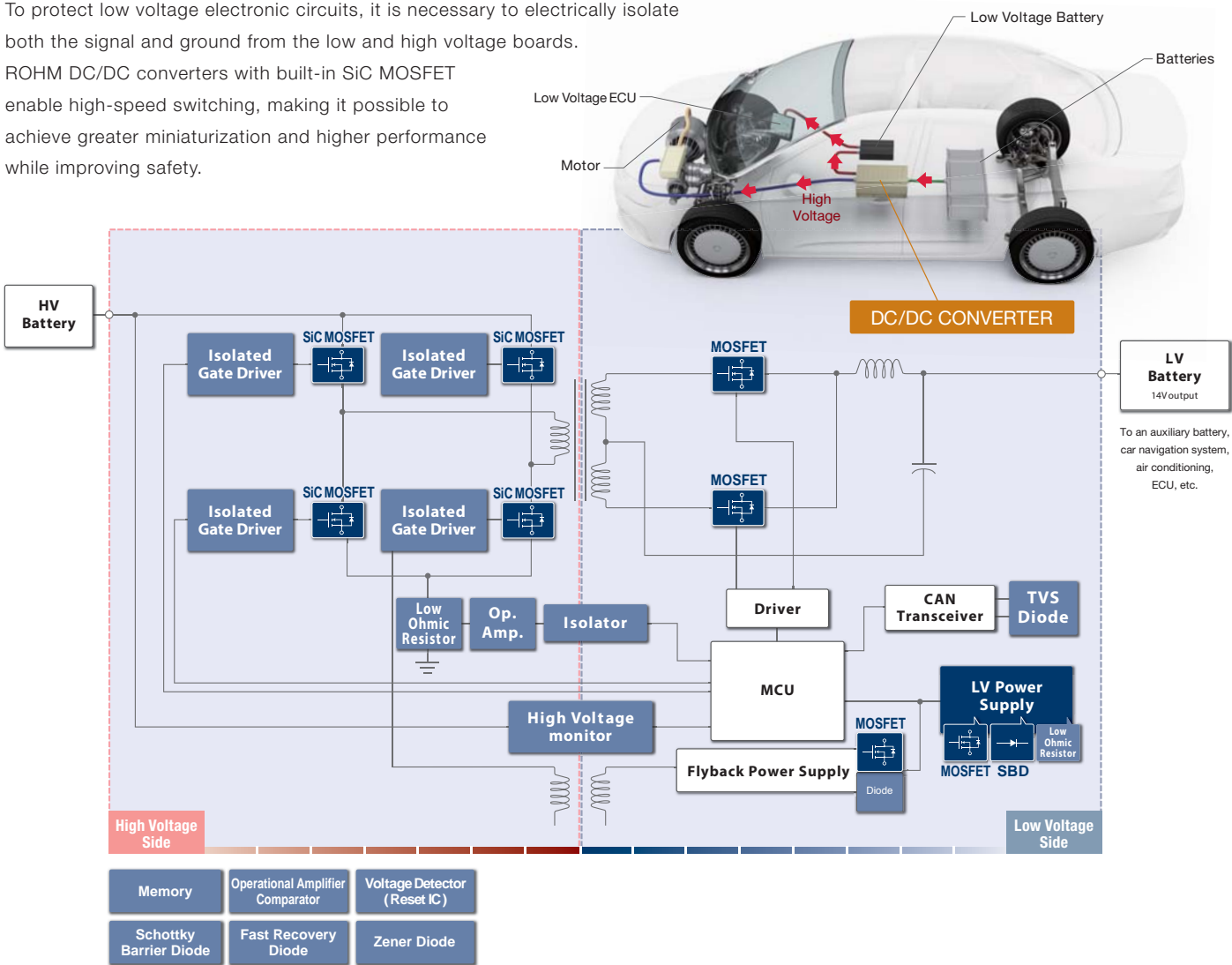
# ONBOARD CHARGER

Onboard chargers consist of AC/DC converters that convert an AC voltage (100V to 240V) to a DC voltage in order to charge the high voltage battery. To ensure worldwide compatibility, the permissible input voltage for many onboard chargers ranges from 85V to 265V. And to meet market needs for shorter charge times, the voltage specified under fast charging standards is increased, along with battery voltage. As a result, onboard chargers tend to have higher permissible input voltage, promoting the use of SiC not only for the internal diodes, but MOSFETs as well.



# DC/DC CONVERTER

In EVs the engine is replaced by a high voltage battery and motor. The DC/DC converter switches power elements and utilizes a transformer to convert the high battery voltage to a lower voltage. To protect low voltage electronic circuits, it is necessary to electrically isolate both the signal and ground from the low and high voltage boards. ROHM DC/DC converters with built-in SiC MOSFET enable high-speed switching, making it possible to achieve greater miniaturization and higher performance while improving safety.

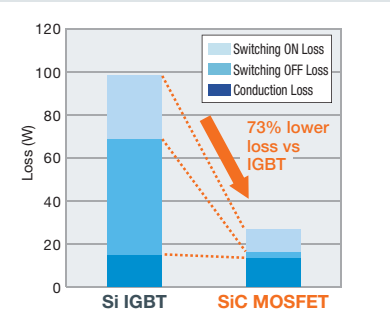


## ROHM Products for EV ECUs

### SiC POWER DEVICES



Utilizing SiC power devices makes it possible to reduce the size and power consumption of EV systems. Superior voltage and thermal resistance enable mounting under harsh environments and provide greater space savings through optimized thermal design. This contributes to higher efficiency in EVs while expanding interior cabin space.

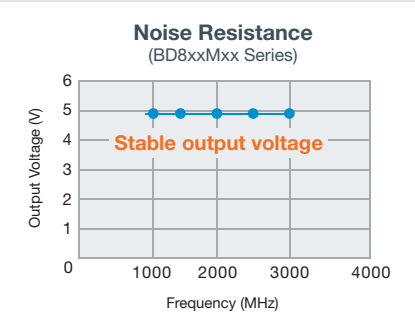
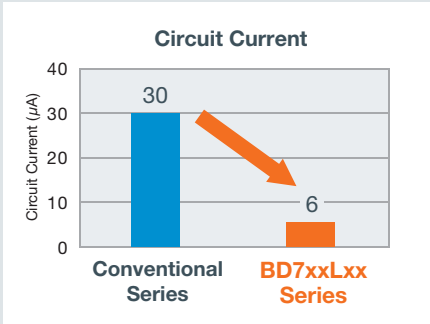


### LDOs



Single Output Low Saturation Regulators

Along with greater functionality and accuracy in automotive blocks, ICs that can supply stable power to MCUs and sensors are being increasingly demanded. In response, ROHM offers linear regulators strong against external noise and battery fluctuations. We also offer a broad lineup of class-leading automotive-grade quiescent current regulators that contributes to greater energy savings and enables users to select the ideal product based on application requirements.

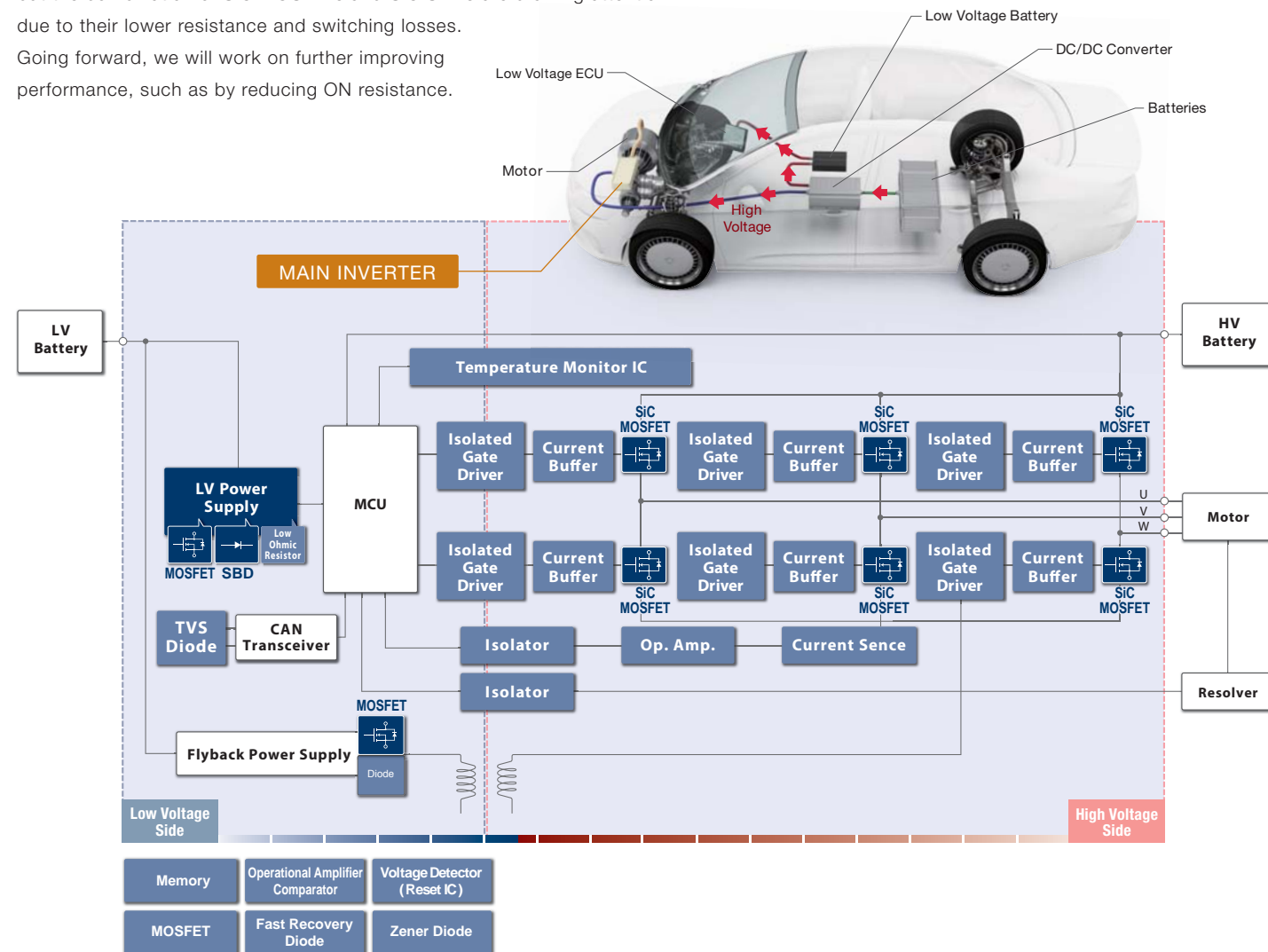


## MAIN INVERTER

The main inverter converts DC voltage provided by the battery into 3-phase AC voltage for driving the motor.

Many power devices used in inverters consist of IGBTs and diodes, but the combination of SiC MOSFETs and SiC SBDs are drawing attention due to their lower resistance and switching losses.

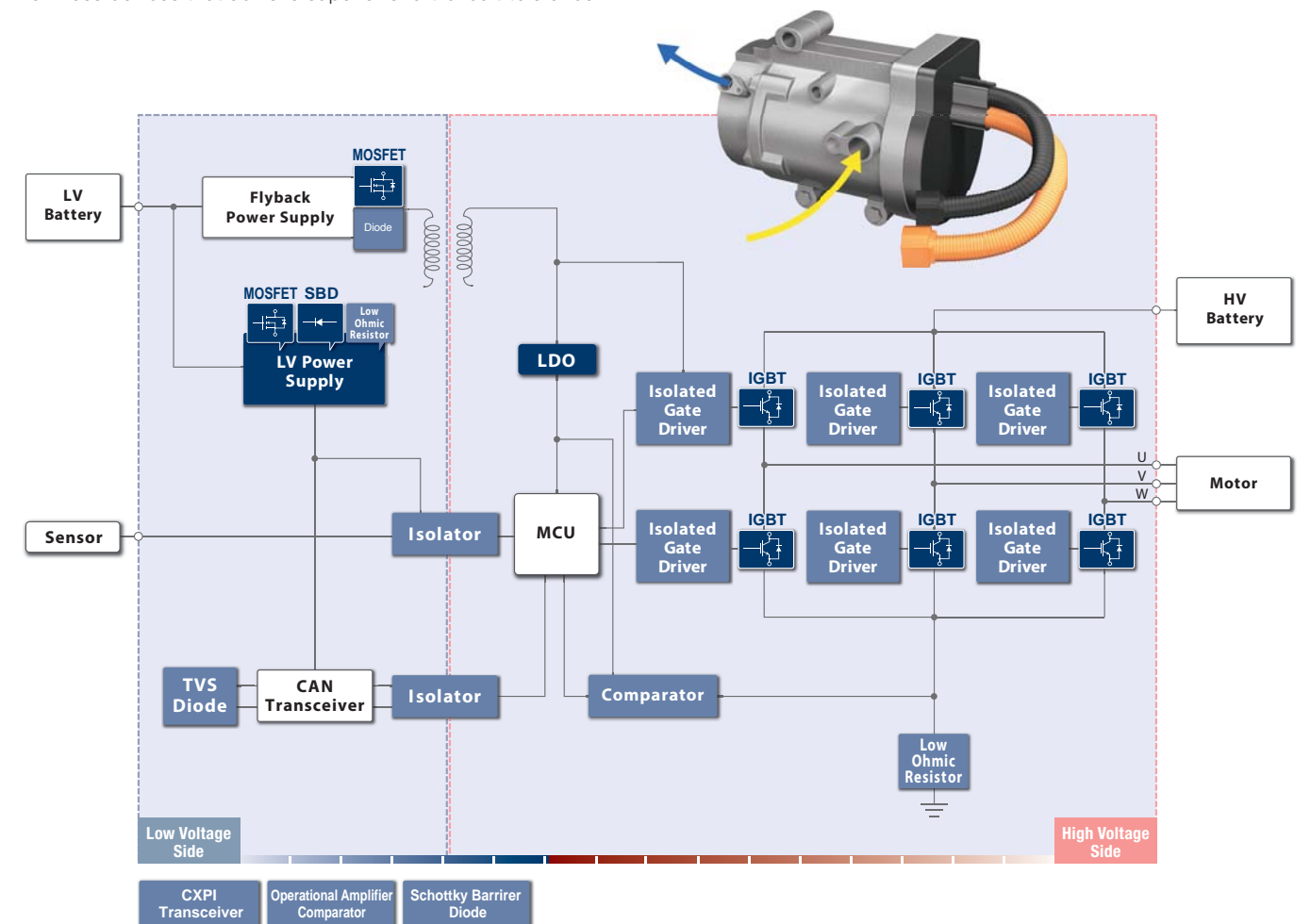
Going forward, we will work on further improving performance, such as by reducing ON resistance.



## ELECTRIC COMPRESSOR

In EVs, the AC compressor is electric.

High voltage is used to increase motor efficiency, and for inverters that control rotation as well, high voltage, along with high reliability and high efficiency, are important factors. ROHM IGBTs for electric compressors are low-loss devices that achieve superior short-circuit tolerance.



## ROHM Products for EV ECUs

### SHUNT RESISTORS

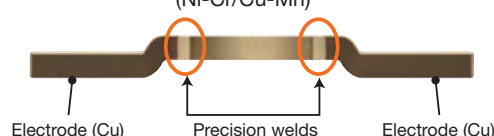
PSR Series



Features such as high power handling capability and ultra-low resistance are ideal for current detection in high power automotive blocks. High precision welding technology utilized between the resistive element and electrodes allows ROHM's PSR series to deliver excellent temperature coefficient of resistance (TCR) - even in the low-ohmic region.

High power achieved by combining precision welding technology with a high-performance alloy

High Performance Resistive Alloy (Ni-Cr/Cu-Mn)



### IGBTs

RGS Series



Isolated Gate Bipolar Transistor

ROHM IGBTs contribute to greater energy savings and efficiency in a wide range of high voltage high current applications. Original trench gate structure and thin wafer technology are used to achieve low switching loss and  $V_{CE(sat)}$ . This makes the AEC-Q101 qualified RGS series ideal for a variety of EV systems, including the electric compressor.

### SCHOTTKY BARRIER DIODES

Low  $V_F$  Series  
Ultra-Low  $I_R$  Series



The broad lineup consists of both low  $V_F$  and  $I_R$  types that allow users to select the ideal product based on set requirements.

### MOSFETs

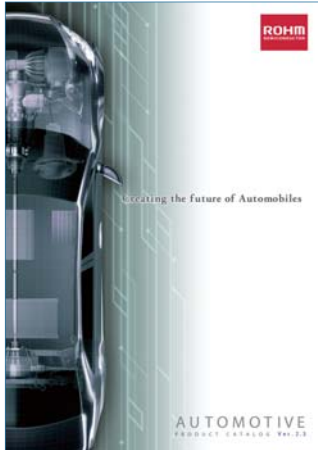
40V Series  
60V Series  
100V Series



ROHM offers a wide range of MOSFETs that support a variety of motor and drive applications, including low ON resistance models developed utilizing the latest processes.

# ROHM Automotive Catalogs

Automotive and Power Device Catalogs are available in addition to this brochure.



## Automotive Catalog

Includes detailed information on the ROHM Group's broad range of automotive products.

We offer an extensive lineup of automotive-grade products and solutions that support the continuing electrification and evolution of today's and next-generation vehicles.



## Power Device Catalog

Introduces ROHM's industry-leading products for power applications. Also included are high voltage, high efficiency devices utilizing SiC. Please refer to our next-generation Eco Devices that contribute to greater energy savings and reduced CO<sub>2</sub> emissions.

- 1) The information contained in this document is provided as of October 1st, 2017.
- 2) The information contained herein is subject to change without notice. Before you use our Products, please contact our sales representative (as listed below) and verify the latest specifications.
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