

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

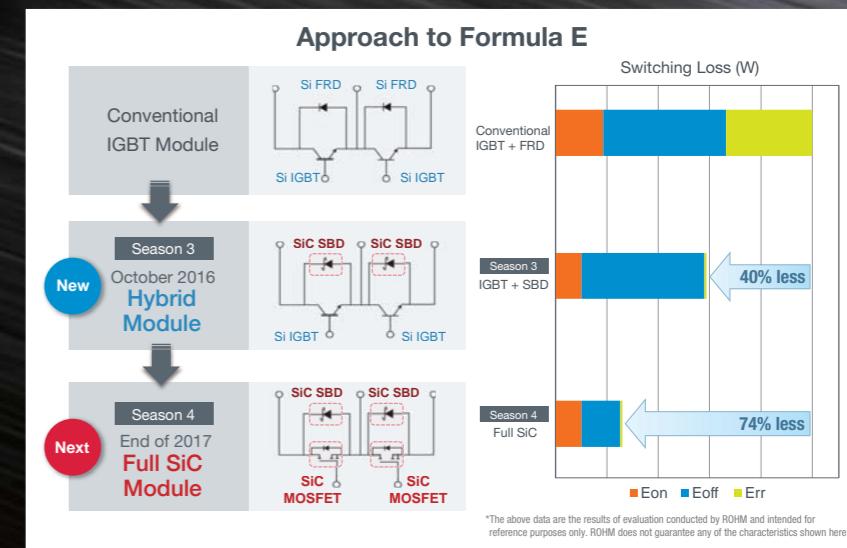


- Season 2 2015 Conventional Inverter (IGBT+FRD)
- Season 3 2016 SiC-Equipped Inverter (IGBT+SiC SBD)

Increased 1.7%
Reduced 2kg
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.



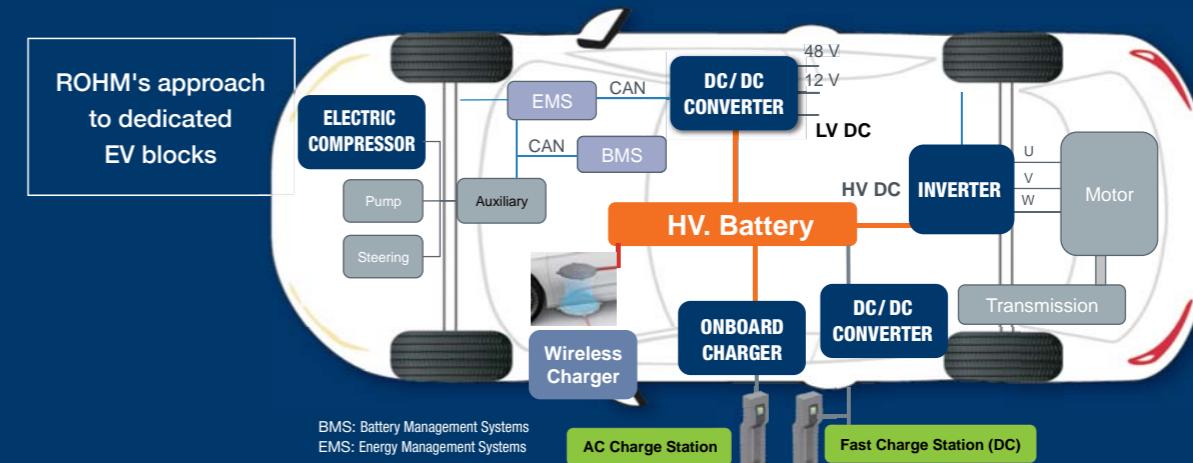
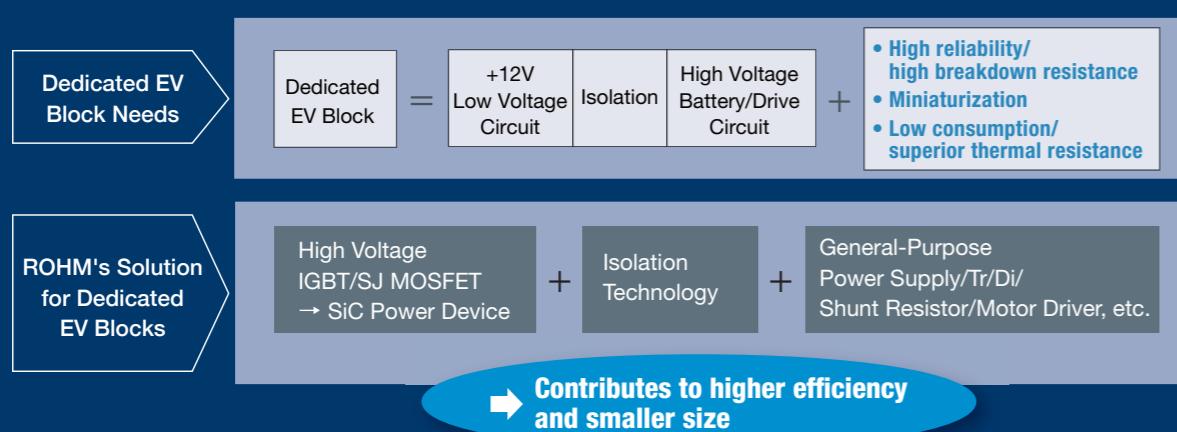
ROHM's Approach to Dedicated EV Blocks

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

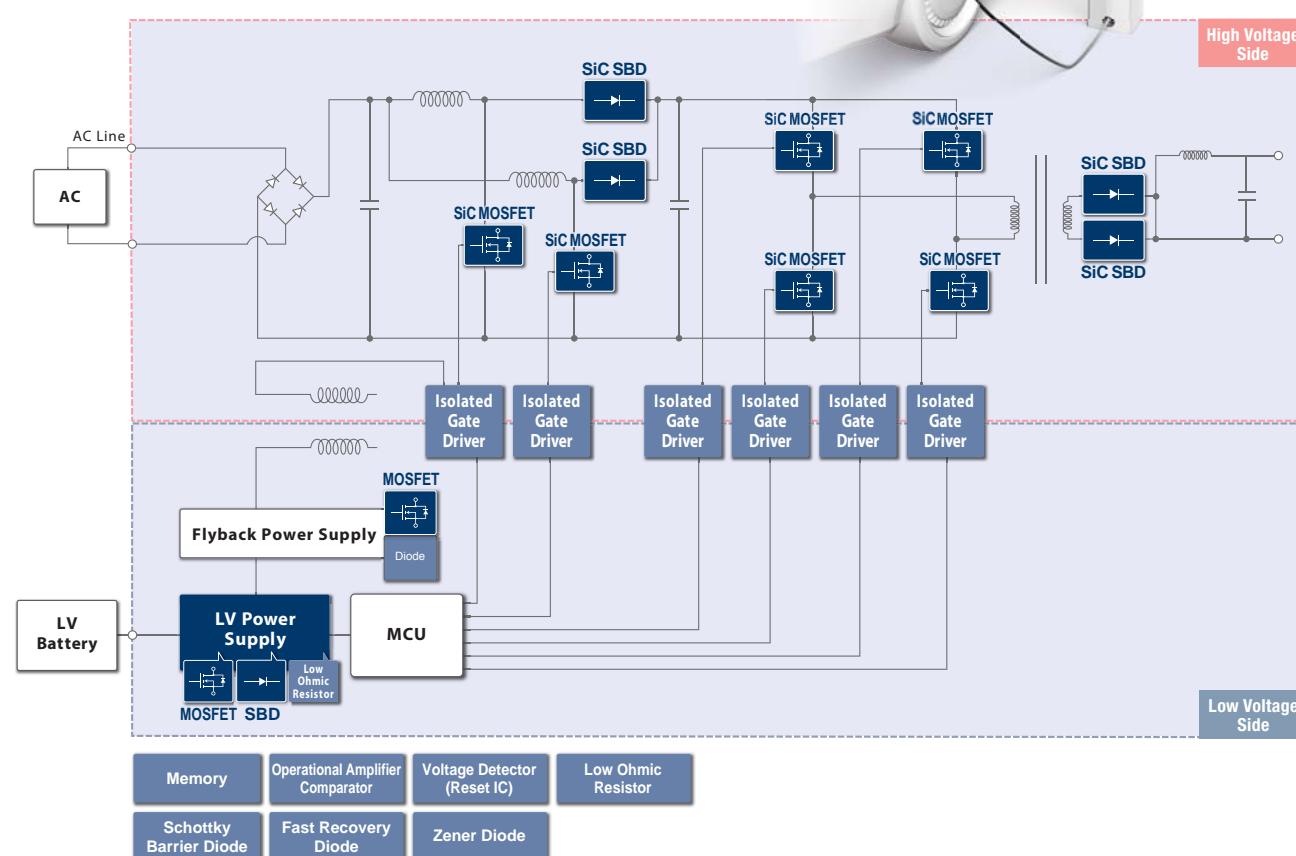
provide greater efficiency and withstand voltage that will translate to shorter charge times and increased charge efficiency. We ensure a stable supply of high quality products by leveraging our vertically integrated production system in which all processes, from materials to package, are carried out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



ROHM Initiatives for Dedicated EV Blocks

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.

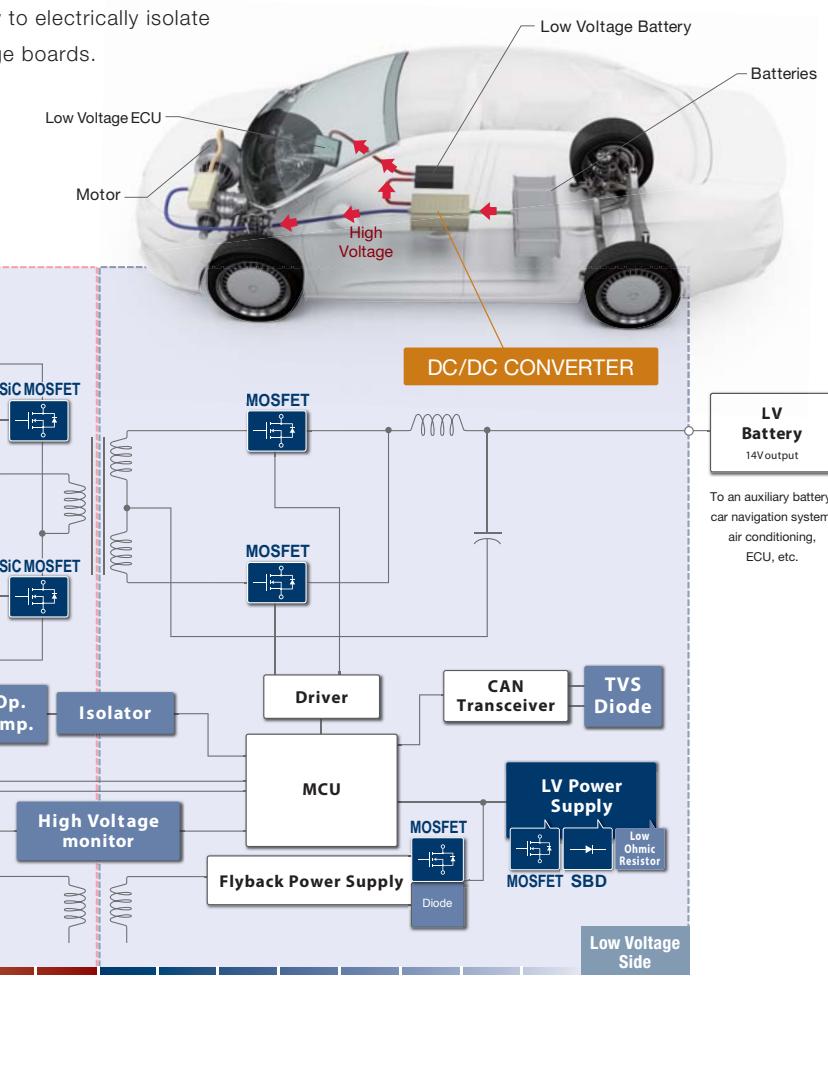


DC/DC CONVERTER

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

SCT2 Series

SCS2 Series



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.



LD0s

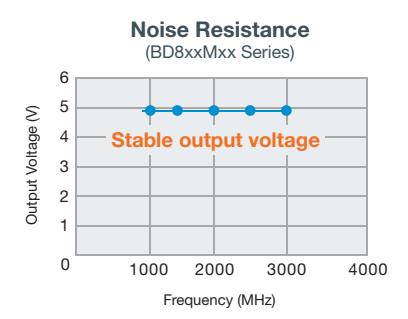
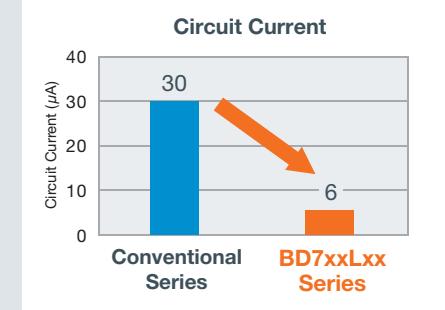
BD4xxMx Series

BD7xxLx Series



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.



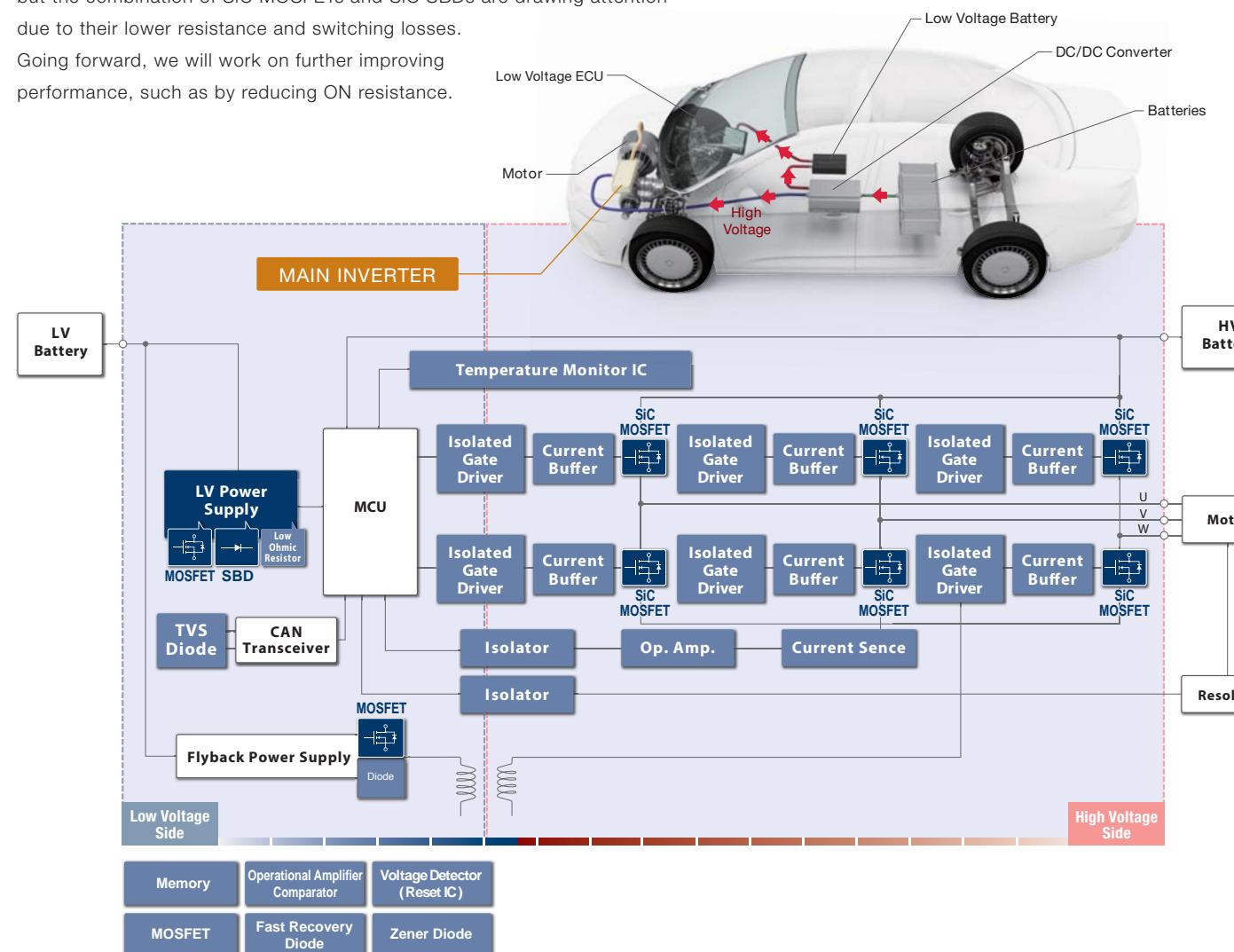
MAIN INVERTER

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.

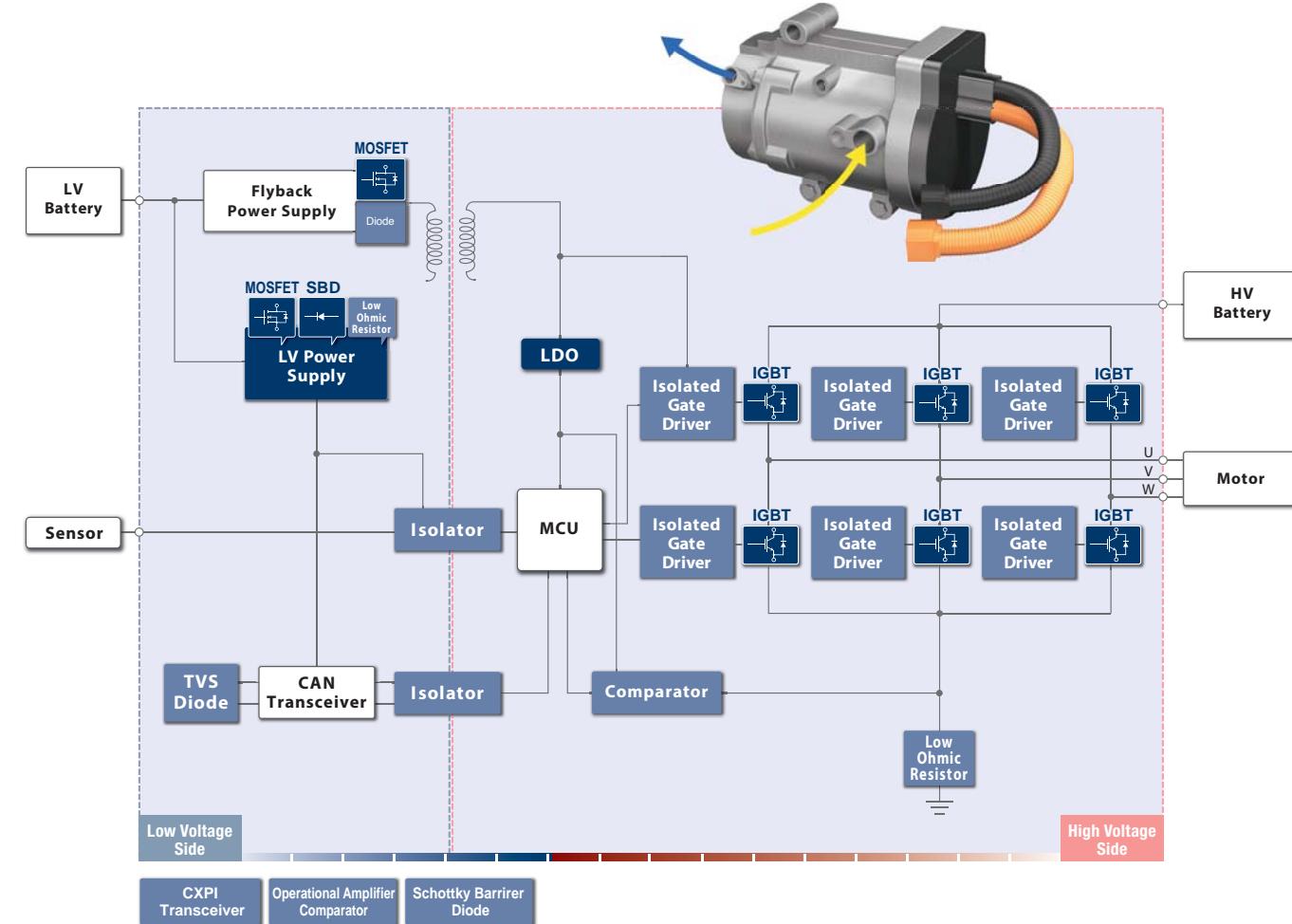
Going forward, we will work on further improving performance, such as by reducing ON resistance.



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

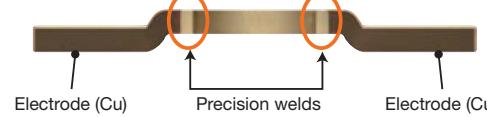
PSR Series



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

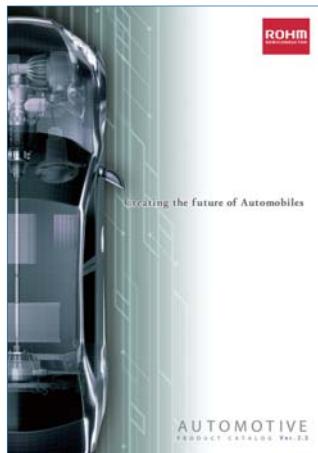
40V Series
60V Series
100V Series



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 electronification 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 CO₂ 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.
- 3) Although "ROHM group" (It is said here in after refers to ROHM) is continuously working to improve product reliability and quality, semiconductors can break down and malfunction due to various factors. Therefore, in order to prevent personal injury or fire arising from failure, please take safety measures such as complying with the derating characteristics, implementing redundant and fire prevention designs, and utilizing backups and fail-safe procedures. ROHM shall have no responsibility for any damages arising out of the use of our Products beyond the rating specified by ROHM.
- 4) Examples of application circuits, circuit constants and any other information contained herein are provided only to illustrate the standard usage and operations of the Products. The peripheral conditions must be taken into account when designing circuits for mass production.
- 5) The technical information specified herein is intended only to show the typical functions of and examples of application circuits for the Products. ROHM are not grant you, explicitly or implicitly, any license to use or exercise intellectual property or other rights held by ROHM or any other parties. ROHM shall have no responsibility whatsoever for any dispute arising out of the use of such technical information.
- 6) The Products are intended for use in general electronic equipment (i.e. AV/OA devices, communication, consumer systems, gaming/entertainment sets) as well as the applications indicated in this document.
- 7) The Products specified in this document are not designed to be radiation tolerant.
- 8) For use of our Products in applications requiring a high degree of reliability (as exemplified below), please contact and consult with a ROHM representative: transportation equipment (i.e. cars, ships, trains), primary communication equipment, traffic lights, fire/crime prevention, safety equipment, medical systems, servers, solar cells, and power transmission systems.
- 9) Do not use our Products in applications requiring extremely high reliability, such as aerospace equipment, nuclear power control systems, and submarine repeaters.
- 10) ROHM shall have no responsibility for any damages or injury arising from non-compliance with the recommended usage conditions and specifications contained herein.
- 11) ROHM have used reasonable care to ensure the accuracy of the information contained in this document. However, ROHM are not warrant that such information is error-free and ROHM shall have no responsibility for any damages arising from any inaccuracy or misprint of such information.
- 12) Please use the Products in accordance with any applicable environmental laws and regulations, such as the RoHS Directive. For more details, including RoHS compatibility, please contact a ROHM sales office as listed below. ROHM shall have no responsibility for any damages or losses resulting non-compliance with any applicable laws or regulations.
- 13) When providing our Products and technologies contained in this document to other countries, you must abide by the procedures and provisions stipulated in all applicable export laws and regulations, including without limitation the US Export Administration Regulations and the Foreign Exchange and Foreign Trade Act.
- 14) This document, in part or in whole, may not be reprinted or reproduced without prior consent of ROHM.

ROHM Sales Offices

Contact us for further information about the products.

Santa Clara	+1-408-720-1900	Germany	+49-2154-921-0	Dalian	+86-411-8230-8549	India	+91-80-4125-0811
Atlanta	+1-770-754-5972	Stuttgart	+49-711-7272370	Shanghai	+86-21-6072-8612	Kyoto	+81-75-365-1077
Boston	+1-978-371-0382	France	+33 (0) 1 40 60 87 30	Shenzhen	+86-755-8307-3008	Yokohama	+81-45-476-2121
Chicago	+1-847-368-1006	United Kingdom	+44-1-908-272400	Hong Kong	+852-2740-6262		
Denver	+1-303-708-0908	Oulu	+358-400-726124	Taiwan	+886-2-2500-6956		
Detroit	+1-248-348-9920	Spain	+34-9375-24320	Singapore	+65-6436-5100		
San Diego	+1-858-625-3600	Hungary	+36-1-950-5859	Philippines	+63-2-807-6872		
Mexico	+52-33-3123-2001	Russia	+74 95 739 4174	Thailand	+66-2-254-4890		
Brazil	+55-11-3539-6320	Seoul	+82-2-8182-700	Malaysia	+60-3-7931-8155		

Catalog No.60P7124E-B 11.2017 ROHM © PDF

R1017A

ROHM Co.,Ltd.

21 Saini Mizonaki-cho, Ukyo-ku,
Kyoto 615-8585 Japan

TEL : +81-75-311-2121 FAX : +81-75-315-0172

www.rohm.com

