ROHM Products for Electric Vehicles

EV Solutions
For battery-driven Formula E cars, making the most efficient use of electricity can often spell the difference between victory and defeat. In Season 3 (2016-17) we supplied SiC Schottky barrier diodes (SBD), but for Season 4 (2017-18) we are introducing full SiC power modules that integrate SiC SBDs and MOSFETs in order to further reduce energy loss and inverter size/weight, resulting in improved performance on the track.

*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.

**Approach to Formula E**

<table>
<thead>
<tr>
<th>Season 3</th>
<th>October 2016 Hybrid Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional IGBT Module</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Season 4</th>
<th>End of 2017 Full SiC Module</th>
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</thead>
<tbody>
<tr>
<td>New</td>
<td></td>
</tr>
</tbody>
</table>

**Conventional IGBT Module**

**Full SiC Module**

**Switching Loss (W)**

- **Eon**: 40% less
- **Ediff**: 74% less
- **Err**: 76% less

**ROHM’s Approach to Dedicated EV Blocks**

In the diagram below, showing dedicated EV blocks, ROHM is focusing its efforts on the main inverter, DC/DC converter, on-board charger, and electric compressor. Currently, integrating SiC SBDs in the on-board 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.
SiC Power Devices Adopted in Inverters for Formula E, the World's Premiere Racing Class 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.

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.

ROHM's Approach to

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 (Weight:15kg)

Season 4 2017
SiC-Equipped Inverter (Weight:9kg)

- Reduced 6kg
- Decreased 43%

SiC-Equipped Inverter

RoHM's Solution for Dedicated EV Blocks

- Dedicated EV Block Needs
  - Dedicated EV Block
  - +12V Low Voltage Circuit
  - Isolation
  - High Voltage Battery/Drive Circuit

- ROHM's Solution for Dedicated EV Blocks
  - High Voltage IGBT/SJ MOSFET
    → SiC Power Device
  - Isolation Technology
  - General-Purpose Power Supply/Transistor/Diode/ Shunt Resistor/Motor Driver, etc.

Contributes to higher efficiency and smaller size
ON-BOARD CHARGER

On-board 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 on-board 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, on-board chargers tend to have higher permissible input voltage, promoting the use of SiC not only for the internal diodes, but MOSFETs as well.

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.
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.

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.
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.

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.
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 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 $V_{CE(mos)}$. 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 CO₂ emissions.

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