System Solution Guide - Preview

Solid-State Circuit Breaker

Table of Contents

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Overview
Application 03

System Implementation **04**
Market Information & Trends **05**

Solution Overview
Solid-State Circuit Breaker Block Diagram 06
Solid-State Switches 07
Silicon Carbide JFETs 08
SiC JFETs Characteristics and Advantages 09
onsemi EliteSiC JFETs 10
onsemi SiC Combo JFETs 11
onsemi SiC JFET Calculator and Simulator 12
onsemi EliteSiC MOSFETs 13
Gate Driver 14
Temperature Sensing 16
Current sensing 17
Ground Fault Circuit Interrupter 18
Wireless Communication 18

Recommended Products **19**

Complementary Prod **21**

Development Tools a **22**

Full Guide Preview

Get Latest Version

1


2


3

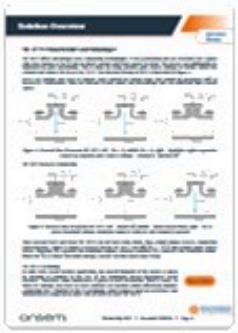

4


5

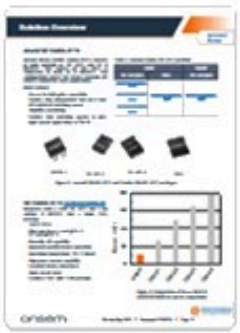

6


7


8


9


10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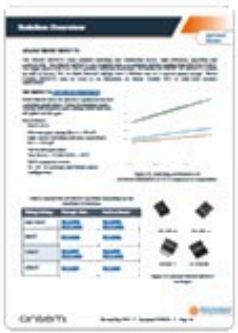
12


13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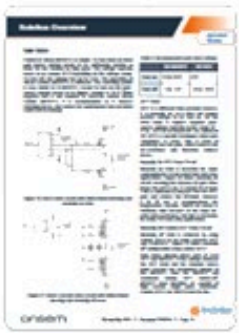
15

Block Diagram

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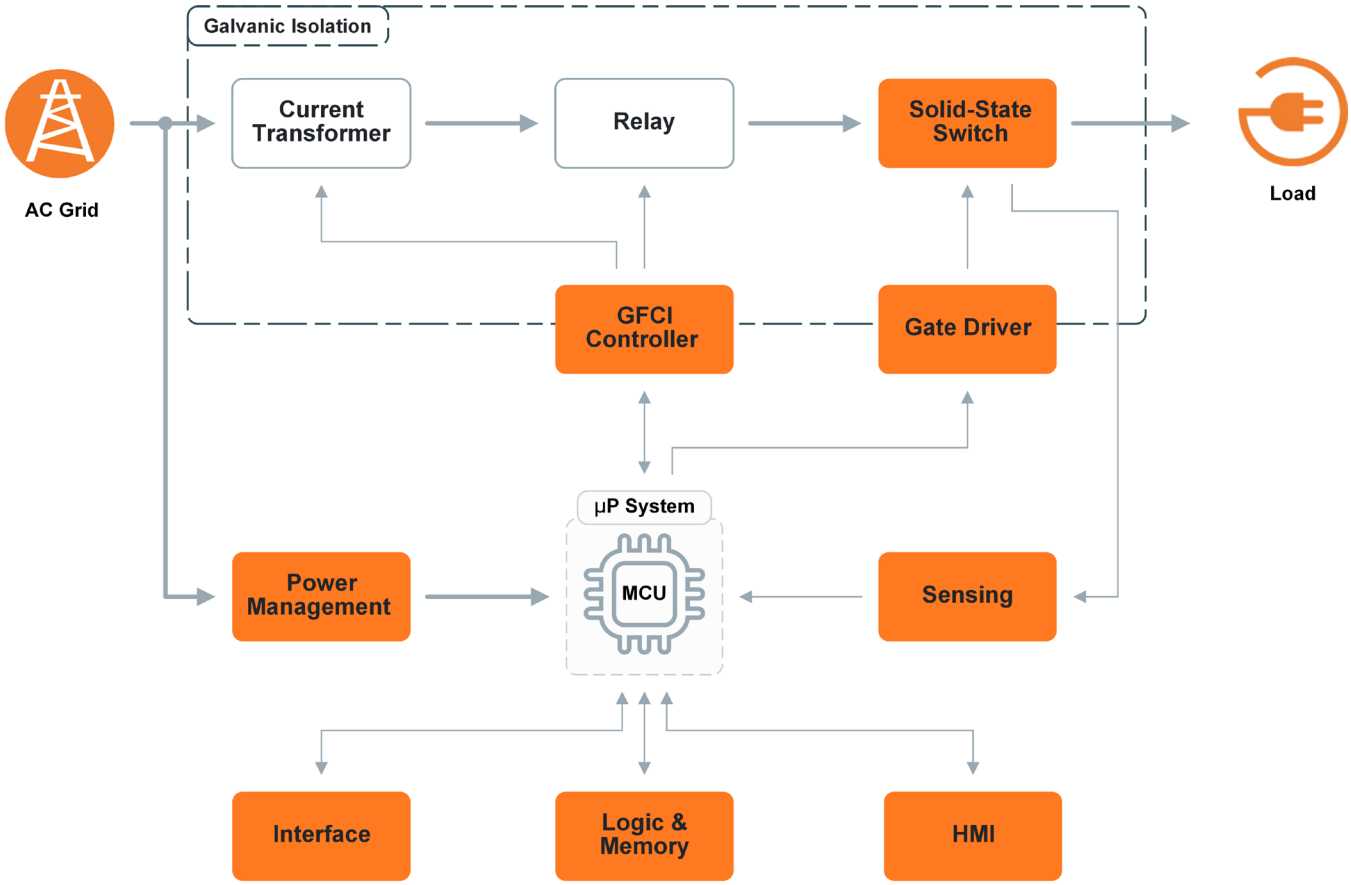
Solid-State Circuit Breaker Block Diagram

The block diagram below illustrates a solid-state circuit breaker solution featuring recommended products from **onsemi**. The most important building block is the switch which replaces traditional electro-mechanical relays. The Gate Driver controls the switch, and the Interface allows it to communicate with the device. Another important part is Sensing which includes both current and temperature sensing. For additional functionality, GFCI can be incorporated. Other components, including power management, logic, memory and many more, can be sourced from **onsemi's** comprehensive range of solutions.



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Silicon Carbide JFETs

Junction field effect transistor (JFET) is a type of unipolar transistor, so it only uses majority carrier type. It is similar to MOSFET as it is operated on the electric field principle, it is voltage controlled and does not require biasing current. The main difference between the two of them is that JFET is a depletion-mode device (normally on) and requires reverse bias to switch and remain off. While some semiconductor-relay applications benefit from this normally-on state, most require a default normally-off state. Addition of a few components can create a normally-off switch even without applied power.

Figure 3 shows a cross-section of SiC JFET with V_{GS} = 0 and drain-source voltage VDS nearly zero. This represents one of the thousands of parallel cells in a JFET chip. The **onsemi** SiC JFET has two PN junctions (diodes): drain-to-gate and gate-to-source. In this unbiased state, a highly conductive channel exists between the Drain and Source, allowing electrons to freely flow in either direction, yielding the distinctive low on-resistance of the **onsemi** SiC JFET.

onsemi offers SiC JFETs, SiC Cascode JFETs and SiC Combo JFETs, each type has its unique characteristics and is suitable to different application. SiC JFET allows the SSCB to operate at up to 175 °C, which is material limit for enclosure; SiC is able to withstand even higher temperatures.

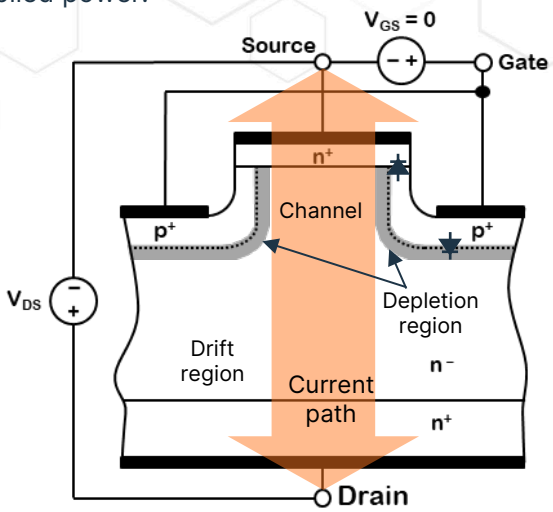

Figure 3: Vertical JFET structure with shown direct current path

SiC JFET

- Normally-on SiC JFET
- Lowest available Rds
- $R_{DS}(V_{GS}$ 2V) = 7 mΩ, $R_{DS}(V_{GS}$ 0V) = 8 mΩ
- Useful for circuit breaker and current limiting applications
- JFET V_{GS} in the on-state is a direct measure of device T_J, ideal for self-monitoring power devices

SiC Cascode JFET

- Co-packaged Si MOSFET
- Normally-off
- Standard gate drive
- Built-in JFET gate resistor
- Suitable for fast switching applications

SiC Combo JFET

- Separate access to MOS and JFET gates enables more control of switching dV/dt
- Enables direct drive of JFET gate for 10-15% lower $R_{DS(ON)}$ at @ V_{GS} =+2 V
- Simplifies paralleling of multiple JFETs
- Same gate drive as separate JFET + MOSFET
- Significant space savings

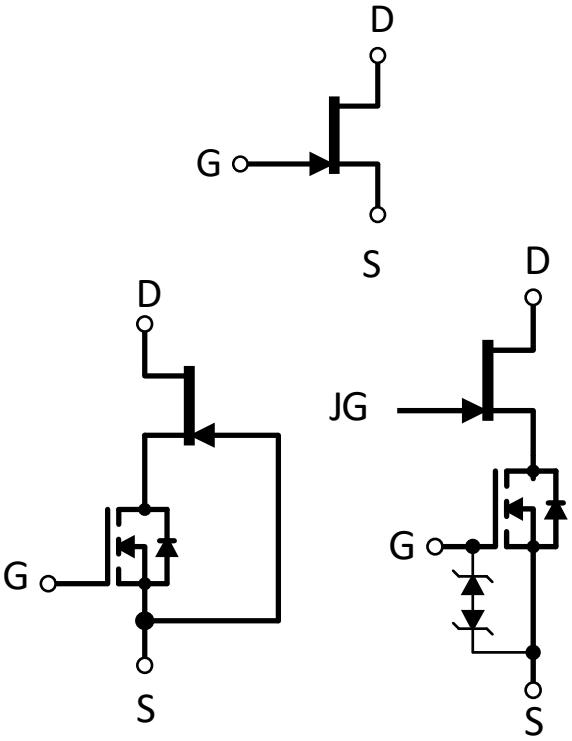

Figure 4: JFET (top), Cascode JFET (bottom left) and Combo-JFET (bottom right) schematic symbols

onsemi EliteSiC Combo JFETs

SiC Combo JFETs UG4SC075005L8S

Integrates both a 750V SiC JFET and a low voltage Si MOSFET into a single TOLL package

- 750 V, 120 A
- Ultra-low $R_{DS(on)}$: 5 mΩ @25 °C, 12.2 mΩ @175 °C
- Normally-off capability
- Improved parallel device operation
- Operating temperature: 175 °C (max)
- High pulse current capability
- Excellent device robustness
- Short circuit rated
- Leadless TOLL (MO-229) package

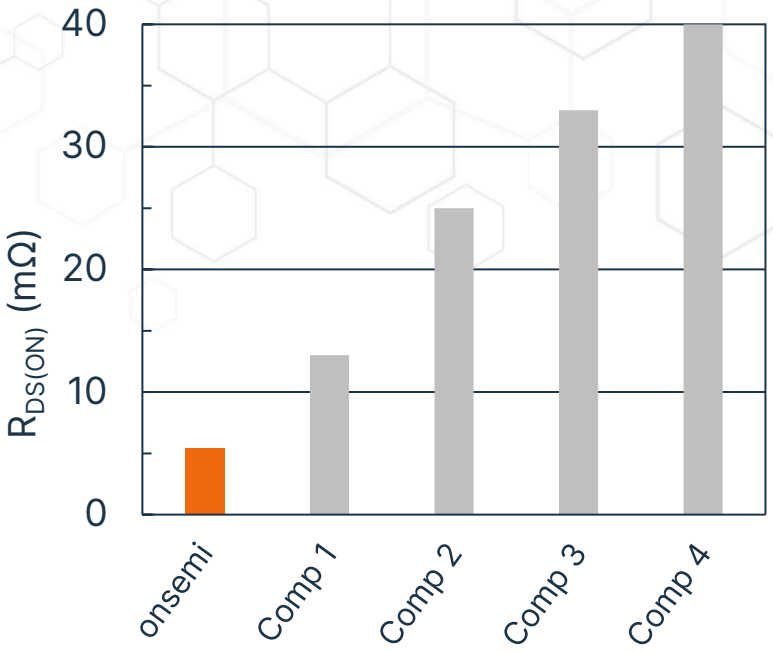

Figure 9: Comparison of $R_{DS(on)}$ (mΩ) of UG4SC075005L8S and its competition

Combo JFET Evaluation Board

The evaluation board demonstrates the design of solid-state circuit breaker with onsemi Combo JFET device UG4SC075005L8S.

SiC Combo JFETs are composite devices consisting of a low-voltage Si MOSFET and a high-voltage SiC normally on JFET. Both gates of SiC JFET and silicon MOSFET are accessible. Compared with standard cascode structure, the SiC Combo JFET has advantages of lower $R_{DS(ON)}$ by over-drive, full switching speed control and junction temperature sensing.

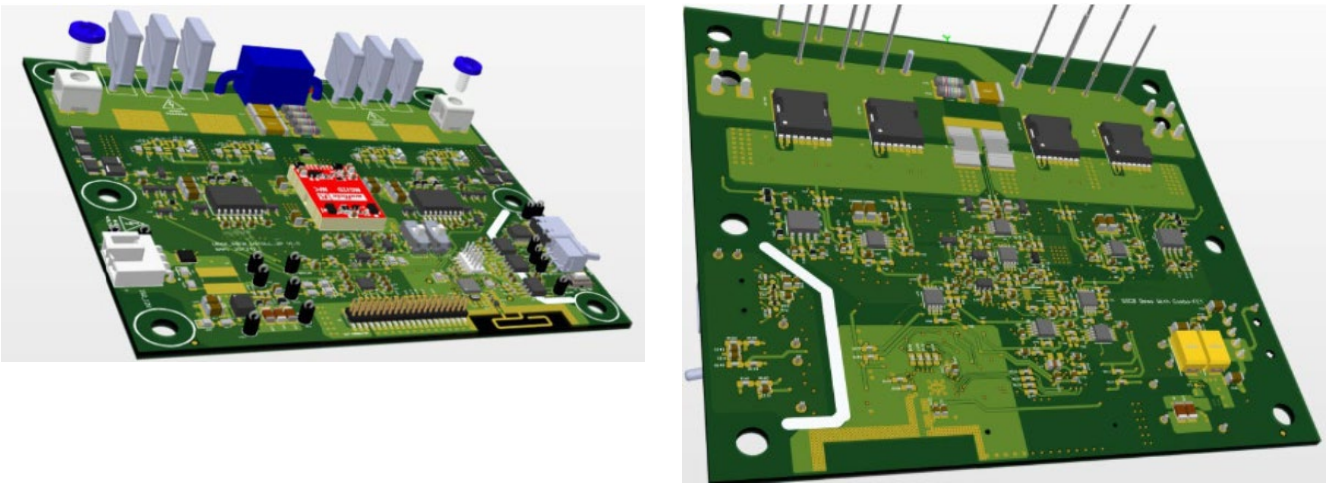

Figure 10: Combo JFET Evaluation Board top and bottom sides

Solid-State Circuit Breaker

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