Top Tips: Leverage SiC for Energy Efficient Power Electronics

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Introduction

As you are designing new power electronic products, your goals get tougher each passing year. High efficiency tops the list, but higher power is another feature that must be achieved in a smaller size at lower cost. SiC MOSFETs are a solution that will meet those goals. The following Top Tips are designed to help you create a switching supply based upon SiC semiconductors for application areas such as solar power systems, energy storage systems, and EV charging stations.

Why Choose SiC?

To justify your selection of SiC as the power semiconductor of choice for your switch−mode design, consider these standout characteristics. SiC devices can operate at higher voltages, higher frequencies, and higher temperatures than standard or super junction MOSFETs or even IGBTs. They can significantly eliminate most of the power losses of other devices, thereby providing better than 90% efficiency in most applications. Initially, SiC devices were more expensive than other MOSFETs or IGBTs. Today, those prices have dropped considerably, making SiC an attractive alternative.

Compare SiC vs. GaN

Both SiC and GaN devices are members of that wide band gap (WBG) category of devices that are steadily replacing standard Si MOSFETs. Because they can operate at much higher frequencies, the GaN devices are more widely used in RF power applications. The SiC devices can generally withstand more voltage, current, and power than the GaN devices. They switch faster and are more efficient, making them suited to switch−mode power supply applications. And, SiC MOSFETs do incorporate a body diode.

Consider Performance

A significant feature of SiC is that its thermal conductivity is more than three times that of Si or GaN. SiC based products operate at much higher temperatures, +175°C, while conduction loss stays relatively flat over temperature. Another performance factor is extremely low RDSon that can be in the range of 15 miliohms or less; it can achieve that specification even with high operating voltages. That greatly reduces power losses, thereby boosting efficiency.

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Select a Topology

In addition to the standard half−bridge and full bridge circuits, two other topologies are being widely adopted for use with SiC devices. These are bidirectional converters and Vienna rectifiers. The bidirectional configuration is essentially a DC−DC converter of the buck−boost type that can be configured to provide two different voltage buses that can exchange power as needed. This arrangement is ideal for vehicles with two battery buses as in all EV and mild−hybrid EVs. The two buses ideally can draw upon one another for charging. ICs implementing the bidirectional converter are available

Another topology being increasingly deployed is the Vienna rectifier. This is a three− phase, three−level PWM controlled bridge rectifier. Its primary application is power factor correction (PFC) in high power AC−to−DC power supplies.

Determine Voltage and Current Needs

In over 90% of current applications, a SiC device can replace an IGBT. Today, few if any new designs incorporate IGBTs. IGBTs can withstand high voltages up to about 1900 volts but are slow in switching. SiC devices can handle the high voltage and current levels but switch significantly faster. SiC transistors are available with upper voltage limits of 1800 volts so make a good IGBT replacement. They can not only boost performance and increase efficiency by being able to switch at higher frequencies but also result in a much smaller package.

Pay Attention to the Gate Drivers

SiC transistors require more gate drive voltage than other MOSFETs. The typical SiC transistor needs 15 to 20 volts on the gate to turn it on and −3 to −5 volts to turn off the device. However, most SiC vendors have addressed this need with special gate driver ICs, making it easy to design with SiC devices.

Use Modules Where Available

A module is a complete pre−wired MOSFET circuit in a package optimized for size and thermal capability. An example is a three−phase bridge module designed to drive a three−phase motor. Other configurations are connected to create DC−DC converters or three−phase rectifiers. Modules integrate both SiC MOSFETs and SiC diodes to ensure lower conduction and switching losses. This arrangement implements high efficiency and superior reliability in a power product.

Modules contain a temperature sensor like a thermistor to provide a way to monitor the heat level and provide some type of circuit protection or temperature control. Modules can significantly reduce your design time and enable smaller packaging. A desirable target for a new design is 90% modules and 10% other discrete components.

Find a Reliable Supplier

When working with sophisticated devices like SiC transistors and circuits, it is helpful to have a source that can not only supply the product but also provide design solutions, information, and assistance. **onsemi** is that kind of supplier since it is a full−service vendor of semiconductor devices and offers the advantage of a complete internal end−to−end supply chain.

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