Solar Power Conversion – a System Solution to Alternative Energy Demand

Power electronics design plays a key role in the performance of a solar power system, as design engineers first look at maximum conversion. Since PV modules have very low conversion efficiency from solar to electrical energy (in the range of 20 percent), the efficiency of a power inverter is meaningful to minimize solar module area and volume of the entire system. Additionally, power loss of devices generates heat on silicon dies that causes temperature rise and must be effectively dissipated. These losses lead to a thermal stress that a high reliability design struggles with and heatsink is necessitated to address. Minimum power loss not only saves energy, but also enhances system reliability, making the system more compact and less costly.

Chang Qian, Applications Engineering Manager, Microsemi's Power Products Group, Bend, USA

With the ever-increasing demand for "green" energy, solar power has drawn a lot of attention by its rapid growth in recent years. It has been reported that worldwide solar system demand is predicted to continue to grow more than 30% annually for the next three years for the following reasons: excess manufacturing capacity has helped push down average photovoltaic (PV) system prices by more than 25%; the ongoing reduction of PV system installation cost; and the positive incentive movement in multiple regions.

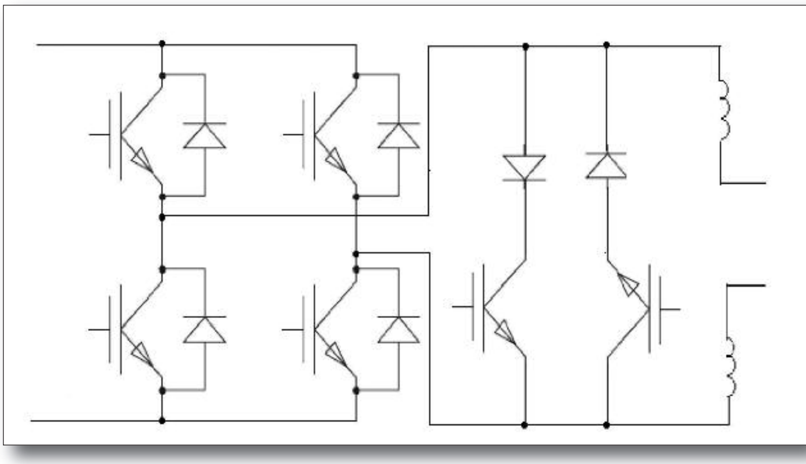


Figure 1: **Schematic of HERIC® inverter**

Converter topologies

To convert the fluctuating direct current (DC) output voltage from solar modules into a well- regulated sinusoidal alternating current (AC) voltage, the architecture of a typical solar power conversion system is either two-stage or single-stage, with or without, DC/DC converter. The existence of a DC/DC stage can maintain the input voltage of inverter at a constant and controlled level, and decouple the control of voltage and power flow. However, an extra conversion stage can have a negative effect on system efficiency. Because of this, more solar inverter manufacturers are evaluating and adopting single stage architecture, even when the inverter control is more complicated and voltage rating of power devices can increase. Among the recently introduced inverter topologies, two are considered to have the most potential for grid-tied centralised inverters in the future - HERIC® (Sunways) and multilevel inverters.

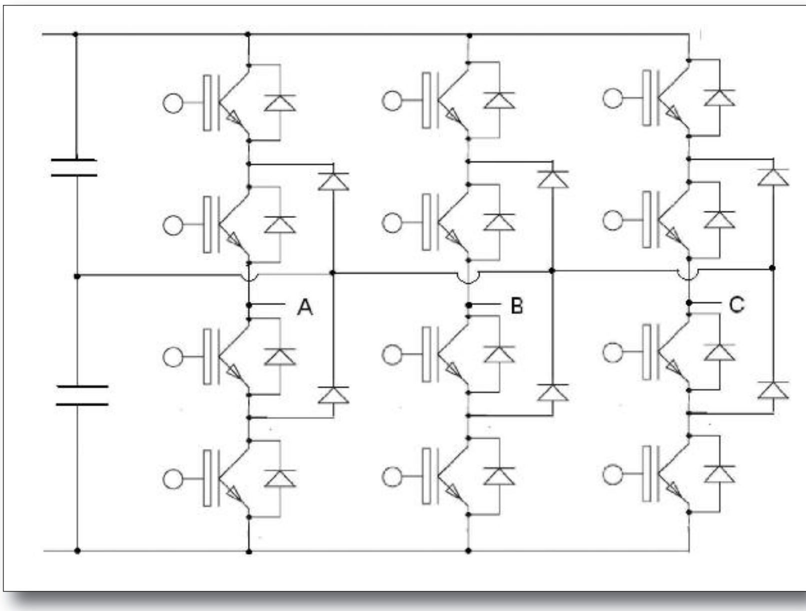


Figure 2: **Schematic of three-level inverter**

HERIC, shown in Figure 1, is structurally different than a conventional full-bridge

Device Technology		MOSFET	IGBT	Super Junction FET
600V/50A Devices	Conduction Loss	1	0.36	0.7
	Switching Loss	1	2.3	1.3
	Cost	1	0.5	0.86
1200V/25A Devices	Conduction Loss	1	0.17	X
	Switching Loss	1	2.2	X
	Cost	1	0.33	X

Table 1: Comparison of different device technologies (numbers normalised on MOSFETs)

inverter, incorporating an extra switch and diode pairs at the output. With these added devices and appropriate control, HERIC inverters are capable of boosting the system efficiency by effectively handling the reactive power flow.

Three level inverters, shown in Figure 2 is a specialised topology targeted at centralised solar power applications with higher voltages. Compared to its traditional counterpart, these inverters have only one-half of voltage stress on each switch so that devices with much lower voltage can be used. This leads to higher efficiency and lower device costs. In addition, the electromagnetic interference (EMI) level and output filter size can be reduced, thus lowering the overall cost of the system. It is important to note that this topology is more complex in its structure and control. Microsemi PPG offers a full line of three-level inverter modules in compact packages, which are extremely suitable for this application.

Power device selection

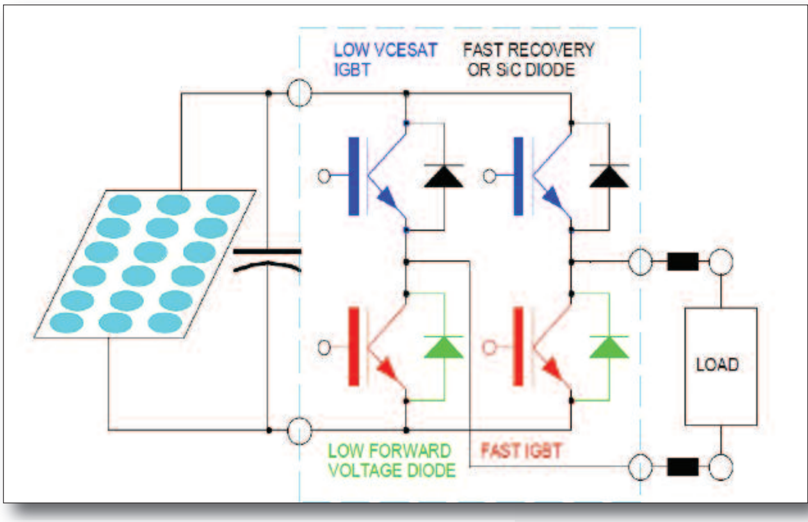
Selecting a MOSFET, Super Junction MOSFET or an IGBT) power device for solar inverters is decided by trade-offs between performance and cost. In general, IGBTs are a less expensive solution than MOSFETs, which are more efficient at higher frequencies. To select the best choice to meet the needs of the system designer, Table 1 lists a comparison of multiple devices regarding conduction loss, switching loss and cost. It is important to note that device selection ultimately depends on system performance requirements and cost structure.

Advantages of discrete power devices are:
- Lower cost at volume
- Flexibility in component selection
- Low power and simple topology applications.

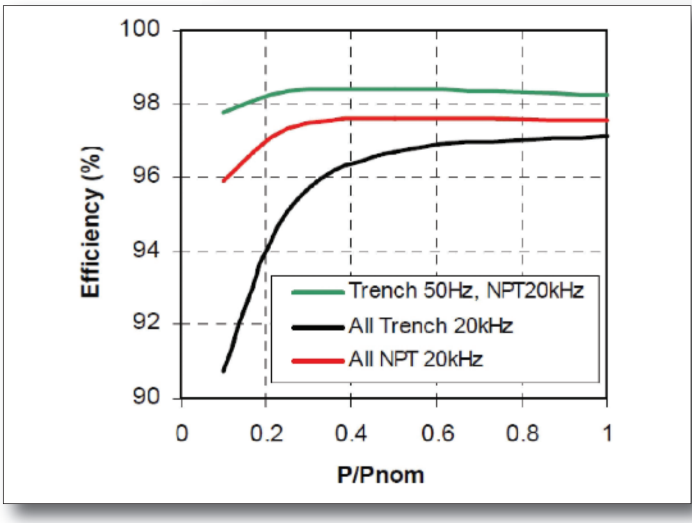
Advantages of modules are:
- Space savings
- Wide selection of topologies
- Ease of manufacturing
- Voltage isolation
- Short development time.

Control methods

Maximum Power Point Tracking (MPPT), has been used to optimise solar conversion for more than 20 years. Another instance is the application of unipolar PWM (Pulse Width Modulation) control for H-bridge inverter with mixed devices (Figure 3). The goal of unipolar PWM is to arrange faster devices and slower devices to switch at high frequency and low frequency, respectively, to maximise efficiency and reduce overall costs. Figure 4 demonstrates the increased efficiency of solar power modules that utilise PWM. The combination of slow IGBT (field stop trench) and fast IGBT (Non Punch Through) yields a 98% efficiency along light to full loads.



ABOVE Figure 3: H-bridge inverter module with mixed devices



LEFT Figure 4: Efficiency enhancement by mixed device inverter under unipolar PWM

Literature

1) Chang Qian, "Solar Power Conversion-a System Solution to Alternative Energy Deman", Alternative Energy Special Presentation, IEEE APEC Conference, February 21- 25, 2010

2) Tom Cheyney, "PV Cell Demand Should Surge 38% in 2010", www.pv-tech.org daily news December 07, 2009;

3) J.M.A. Myrzik and M. Calais, "String and Module Integrated Inverters for Single phase Grid Connected Photovoltaic Systems-a Review", IEEE Bologna Power Tech Conference, June 23th -26th, Bologna, Italy;

4) Serge Bontemps and Pierre-Laurent Doumergue, "A New Compact Power Modules Range for Efficient Solar Inverters", PCIM 2008

5)Weimin Wu, Xiaoli Wang, Pan Geng and Tianhao Tang, "Efficiency Analysis for Grid-tied Three Phase PV Inverter", IEEE ICIT 2008

6) Saraji V. Dohople, Ali Davoudi and Patrick L. Chapman, "Steady-state of Multiphase Interleaved DC-DC Converters for Photovoltaic Applications", IEEE ECCE Sept 20-24, 2009

7) Microsemi, Datasheet of APTCV60TLM45T3G, 2009