As Solar and UPS companies start to discuss the next generation inverter products, many factors come into play. Competition from overseas and home, increased efficiency, size, cost and customer demands are all taken into consideration. Marketing, Sales, and Engineering all have input on key features, benefits, cost targets, and what is technically feasible to determine what the next inverter will be. Today’s power designers are challenged with these demands to meet the company’s goals.

As both higher efficiency and input voltage becomes key selling points, designers are leaving the two level designs in favor of three level topologies. Three level designs offer the benefits of better efficiency, higher switching frequencies and lower total harmonic distortion – resulting in lower filter cost. To make the decision even more difficult, the designer must choose amongst the vast array of three level topology power modules offered in the marketplace. The final factor the designer must consider is the use of Silicon Carbide (i.e. SiC) components within the module. For solar inverters SiC diodes are almost becoming the norm, since they have come down the price curve and offer the sought after additional efficiencies. However, this is not the case in the UPS world, where cost is considered over efficiency gains. Today’s semiconductor marketplace is making great strides in SiC MOSFETs – lower cost, improved electrical performance, better yields, and the availability from several leading suppliers. Thus as the solar inverter marketplace heats up from competitors offering these new benefits, designers must also consider using SiC MOSFETs to give them the needed performance edge to address this. The power designer faced with these challenges in inverter design must carefully choose the right power module to meet the company’s goals and competition.

**NPC TOPOLOGY**

In the beginning, solar inverters were based upon the tried and true classic two level topologies. Power modules such as the classic half-bridge were used in these designs which came directly from the standard motor drives marketplace. As the market matured with more solar inverter competitors vying for a piece of it, these inverters with the older two level topologies could not address the new demands brought by customers – higher input voltage and better efficiencies. Thus three level topologies came into play. The
earliest power modules offered in the marketplace were the classic Neutral Point Clamped Diode types as shown:

![Neutral Point Clamped Diode Diagram]

The Advantages of this circuit compared to usual 1200 V half-bridges are:

- 600 V devices are used – Low Switching Loss, Low Forward Voltage
- Higher Switching Frequency – use of smaller magnetic possible
- Higher Input Voltage because of low commutation inductance power modules
- Three levels of output voltage (DC+, DC-, Zero)
- Smaller Output Current Ripple – Reduced Output Filter and Cost
- High Efficiency design due to lower switching losses, especially at higher switching frequency.

The Disadvantages are:

- Increased Complexity
- Increased Part Count

Designers quickly started to recognize the advantages of this topology and several power module manufactures started to offer this in standard packages.

**ULTRA FAST NPC MODULE**

As the market for NPC modules became the norm, designers soon discovered the limitation they had. Power modules for lower power applications are in a smaller package, resulting in short commutation paths and low commutation inductances. In bigger applications such as large solar inverters above 100 kVA, the commutation paths become longer due to the increased package size needed. Power designers were still faced with having to switch these higher power modules at lower speeds – around 3 kHz, to obtain lower losses. The increased stray inductances created overvoltage spikes during turn-off, resulting in efficiency in the range of 97% ~ 98 %. If a designer wanted to use a higher switching frequency, let’s say 10 kHz ~ 15 kHz to reduce the magnetic content in the system, these modules would have high switching losses, reducing further
efficiency gains. Vincotech, a leader in power module design, “came to the rescue.” By using its proprietary low inductive technology (typical 5 nH) in its flowSCREW 4w modules, the ability to switch faster with low switching losses became a reality. This ultra low inductive technology also gave the designer better parallel module utilization, along with lower turn-off voltages. The flowSCREW 4w module is especially designed for high switching frequencies having the benefit of lower stray inductance. Therefore this package perfectly suits switching components that came along with very high switching speeds. Implementing a unique design approach, parallel technology – by replacing the fast recovery diode with a standard MOSFET or SiC MOSFET on the IGBT outer switches, very high switching frequency while maintain high efficiency is achievable. This gives the designer the needed performance sought after. In addition to this advanced topology, Vincotech can select “best-in-class” dies from multiple suppliers to further enhance the performance of the NPC module product line. No other module manufacture can offer the power designer these advanced technological advantages.

M400F & M800F flowSCREW 4w MODULES
Many utility companies are seeking ways to reduce the overall system costs. In the last couple of years, panel costs have significantly been reduced. Many panel manufacturers were heavily subsidize by their government to offset their true manufacturing costs. As this subsidy was eliminated, the steep decline in panel cost came to pass. This also reduced competition, since many panel manufacturers went out of business. Stability in the panel marketplace is now the norm. With other component costs in the solar system being stabilized, utility companies came to realize that using a higher panel array voltage would reduce costs through the reduction of less connections, smaller wire size, and inverter cost (i.e. eliminate the boost section). Inverter manufacturers quickly went back to their design team to address this higher voltage requirement in the next generation product.

Module manufacturers started to offer NPC modules using 1200 V IGBT dies within them. This "stacked approach" gave designers a module with much higher input voltage – typically blocking voltage capability of 2400 VDC. But this now presented another performance issue – higher losses over the previous generation NPC modules using 600 V components. This is because 1200 V IGBT’s are not as fast as 600 V devices. These higher input voltage modules lacking the ability to switch faster were stuck at the old switching speed resulting in high magnetic component content and associated costs. Vincotech’s idea of the using it’s parallel technology in the M400F (2400 V, 400 A), and M800F (2400 V, 800 A) – Figure 1, eliminates this issue. Although this technology does cost more than a competitor’s standard 2400 V NPC module, system costs are reduced with less magnetic content, less cooling (i.e. fans, heat sink area), buss bar utilization, and inverter housing (i.e. smaller size). Another key benefit of the flowSCREW 4w module is its Asymmetrical Inductance. This helps in further lower turn-on losses and reduced EMI. Designs
utilizing either the M400F or M800F will differentiate an inverter manufacture’s products by being smaller, lighter, and very high efficiency over their competitors which use competing power module technology. An efficiency of 99.1 % @ 10 kHz switching speed is quite achievable for inverters as large as 500 kVA using these ultra high performance power modules.

Vincotech’s unique flowSCREW 4w packaging also allows the designer ease of a parallel module layout, as seen below. The DC plus, DC minus, Neutral on one side, Power Out opposite side)
CONCLUSION
Every power designer has his or hers particular way of trying to achieve their company’s next generation inverter design goals. Utilizing Vincotech’s Wide Body products offers a technological advantage and performance not seen in competitor’s power modules. Companies that will make use of Vincotech’s flowSCREW 4w modules in their inverter design will have a clear advantage over two-level designs.