

Considerations for Developing Custom Power Module Solutions

In the last years the power module market demand quickly changed due to the stringent power design constraints of cost saving and efficiency increase. R&D engineers are working for innovative solutions where high integration level and latest chip technologies are the driving factors in the design phase. Power modules suppliers are compelled to fulfill these requirements and to deliver solutions that are optimized to meet customers' wishes. This article outlines all the aspects to consider when offering a custom solution in order to fulfill the continuous change in market demand of power modules design and performances.

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Power electronic engineers are working to develop electrical topologies which are able to ensure the best efficiency performances, power consumption and space reduction. There are some markets that are very sensitive to these topics. UPS and solar market are the best examples - the layout complexity can be very different from customer to customer and there is a continuous research to find out the best electrical solution and the minimum number of power modules to be used to achieve high performance level. Electrical vehicle application is a new emerging market where the above topics will become the challenging point when offering a power module solution. Some other markets, like welding or motor drive, are not affected by these constraints and quite standard electrical configurations are required; just slight changes in the existing configurations and possible redesign based on the latest chip technologies are required. For such kind of market, the most

cost effective product is the winning factor for the power suppliers. Picture 1 shows how customer needs and power suppliers strategies are interconnected.

- Depending on the market there are different strategies implemented:
- a) non cost driven markets: the winning factor is the capability to offer solutions that meet customers specific needs. Differentiation is the key word in this case, so that customer can perceive the uniqueness of the solution that other competitors are not able to offer.
 - b) cost driven markets: it will be needed to offer quite standard solutions. This market is normally based on high quantities per year.

Semikron offers power module solutions to meet both market demands and recognizes that custom solution is an important market and with its subsidiary Italy it is to serve customers with special

type products focused to the application, fast time to market, and customer differentiation.

Focus to the application

Offering the right chip technology in the right power modules in order to meet customers' requests leads to the advantage of a high power integration level and space saving. Available are power modules with or without baseplate, featuring different power contact interfaces such as soldering or screws terminals. The platforms can integrate the latest chip technologies like SiC diodes, MOSFETs even for high voltage applications and IGBTs for high switching frequencies (Figure 2).

The application support team suggests the best combination between chipset and power module. The experience in different application markets such UPS, PV, electrical drives, welding and railway help together with thermal and electrical simulations support to choose the right housing and

	Customer requirements		Power suppliers strategy		
	High integration level due to complex layout	High efficiency	Compact solution offer	Cost	
UPS	o	o	++	+	o required x not required ++ Very important + Important - Not so important
Solar market	o	o	++	+	
Motor drive	x	x	-	++	
Welding	x	x	-	++	
Power supply	x	o	-	+	
EV applications	o	o	++	+	

Figure 1: Customer demand and power supplier offer matrix interconnection

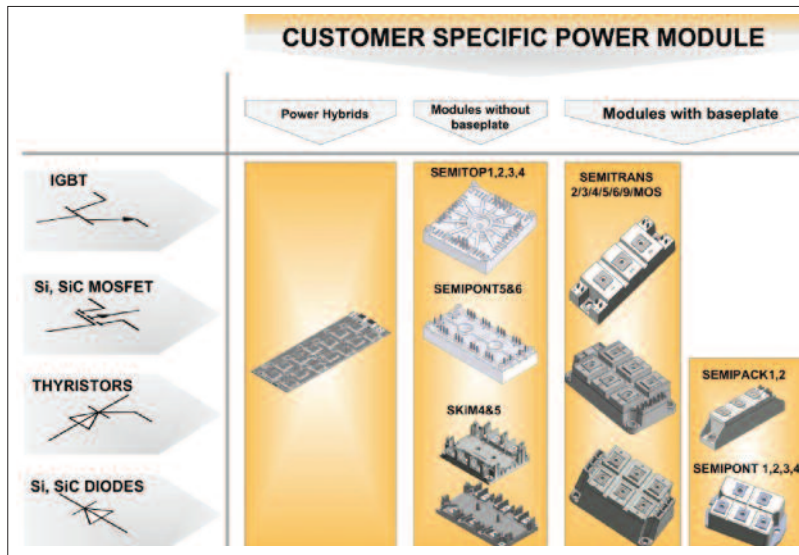


Figure 2: Available platforms and chips to offer custom solutions

the right number of modules to build up the required electrical configuration and thus ensuring the best thermal performances of the application.

The newest chip technologies are all qualified from reliability and dynamic perspective. Chip technologies that have passed more than 17 different reliability tests for more than 10,000 hours of tests are considered for a custom project.

Fast time to market

Power electronics is a dynamic market and

product development and introduction are particularly critical. How fast the first prototypes can be ready and how fast the mass production can be released are essential market success factors for a customer: to be first in the market means to capture market share respect to the competitors.

Any new project starts with the customer and ends to the customer passing through the power supplier project evaluation, defining the product life cycle process.

Time-to-market is measured as the time between project release and volume release. Each validation phase consists of a series of steps to be fulfilled; at the end of each validation phase some prototypes are produced and delivered to customer for final approval in order to proceed to the next step. This means collaboration in all project phases - the customer is involved during the project definition to ensure a quick definition of engineering specifications. Software support is used to minimize the engineering workload so to ensure that every product performs according to customer requirements. Also SEMIKRON has built up a flexible production: similar products are grouped into families that can be processed in one same equipment in the same sequence. This allows to shorten changeover time between products. The production lead time is therefore reduced, resulting in high quality manufacturing products, with lower manufacturing costs and on time delivery.

Customer advantages

The power module market is often based on standard electrical configurations. In most cases a custom solution is not available in the market and customer has to put in place a lot of efforts to achieve the desired configuration. More than one power module could be necessary to assemble the final configuration; the

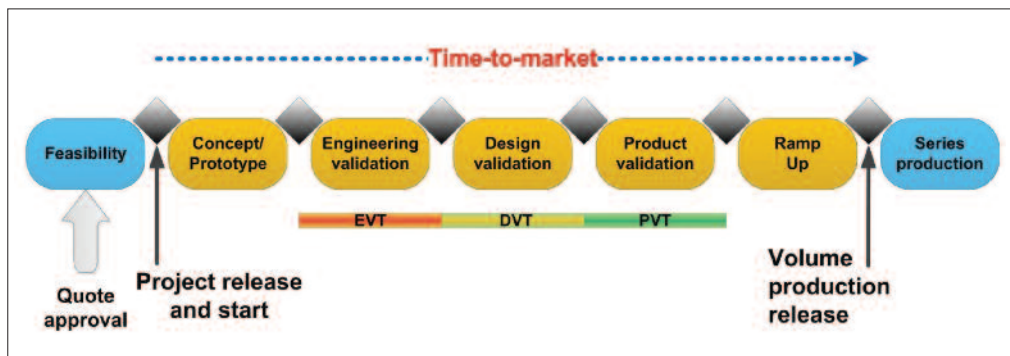


Figure 3: Product life cycle process

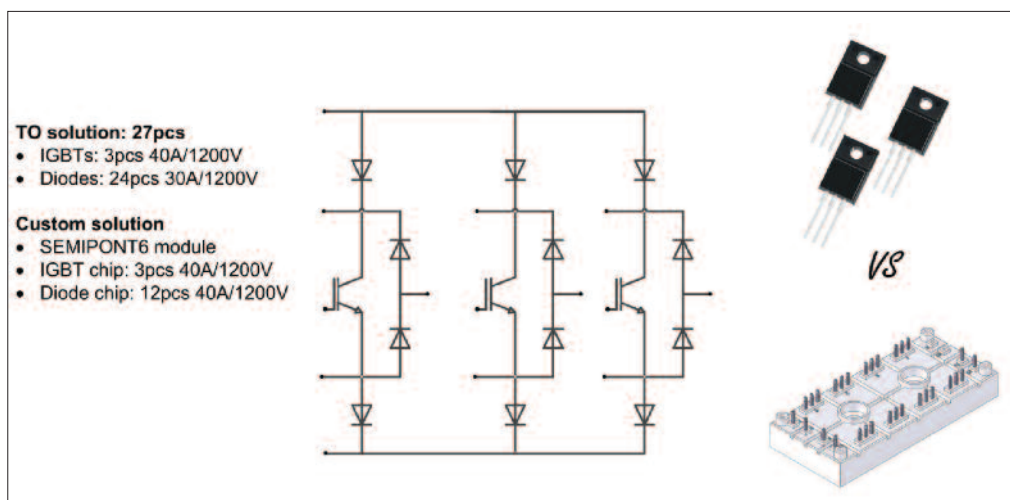


Figure 4: Three-phase PWM rectifier buck converter design

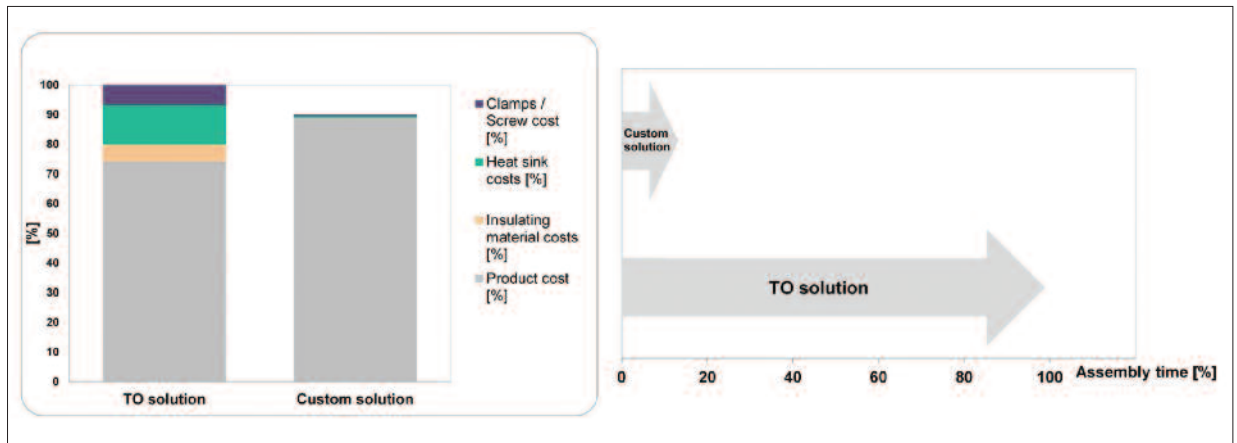


Figure 5: Material cost split and assembly time comparison

number of modules even increases with configuration complexity level. The required space for the application becomes relevant and PCB routing becomes more difficult, especially if the pinout is not optimized for this purpose. Customer is going therefore to face a huge bill of material management and a lot of efforts in the logistic. PCB routing issues enlarge the development time and the final application cost will increase. More time to enter the market is the result.

A custom-made solution becomes therefore the right solution to overcome the above issues. By using custom electrical configurations, the number of modules can be reduced and each power module will feature only the needed electrical requirements. PCB design efforts are reduced saving development time thanks to a match between module pinout and PCB routing needs. There is a significant reduction of bill of material and easier logistic and assembly process is achieved. Assembly error occurrence is reduced and manufacturing reliability is increased. As matter of fact a custom solution reduces the form factor of the final application with space saving and cost reduction respect to the use of standard

modules.

A case study has been carried out by considering the development of a three-phase PWM rectifier buck converter featuring IGBTs and diodes rated for 40A/1200V as per Figure 4. Comparison between a standard solution based on TO devices and a custom solution based on SEMIPONT™6 platform has been performed.

Due to the very complex layout, 27 pieces of TO devices are needed compared to one SEMIPONT™6 module integrating the whole three-phase configuration. One screw per TO device is needed for heatsink assembly, while the power module needs one assembly step with only two mounting screws. There is a clear benefit in the PCB routing, since the power module pinout has been designed according to customer requirements while TO devices do not feature flexible power pins position.

The investigations confirmed therefore the benefits in using a custom solution especially about material costs, assembly time and manufacturing process:

- A significant bill of material reduction leads to a 10 % lower material costs for the custom solution. The cost

breakdown is shown in Figure 5.

- Due to reduced parts to manage, the assembly time is reduced. Just one module against 27 pieces to handle, with an estimated assembly time reduction up to 85 %.
- Reduced parts to handle reduce the risk of assembly error occurrence. Manufacturing errors can be reduced up to 80%. Less parts to handle ensure higher manufacturing reliability and higher first-pass yield.

Conclusion

Besides volume driven standard configurations in power modules SEMIKRON offers also customer specific topologies in various housings addressing the market need for differentiation in dedicated applications. The company has established in its subsidiary Italy a support and production structure to handle specific customer demands in a short and effective way with dedicated application support team, experienced R&D team and a flexible module production. The benefits of a custom solution can be realized in terms of easy assembly process due to reduced material handling, form factor reduction due to high integration level and higher production reliability.



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