Mastering Power Modules

The advantages over discrete solutions

With the strong upsurge in the need for power electronics in applications such as solar, wind, industrial drives and UPS, system developers are becoming increasingly aware that the selection of the power devices for these often remotely-sited applications is critical. Such systems require the highest reliability and efficiency to minimize operating costs and build industry integrity for the developer.

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There is much discussion over what actually constitutes a Power Module. A typical example of a PIM Module for a drives application (see figure 1) would contain, in a single housing, a three-phase input rectifier, a brake chopper, a three-phase inverter plus the vital isolation material; the high prevalent voltages and levels of thermal stress are key to the ‘excellence factor’ encompassing the efficiency and most importantly, the long-term reliability, of a well designed PIM.

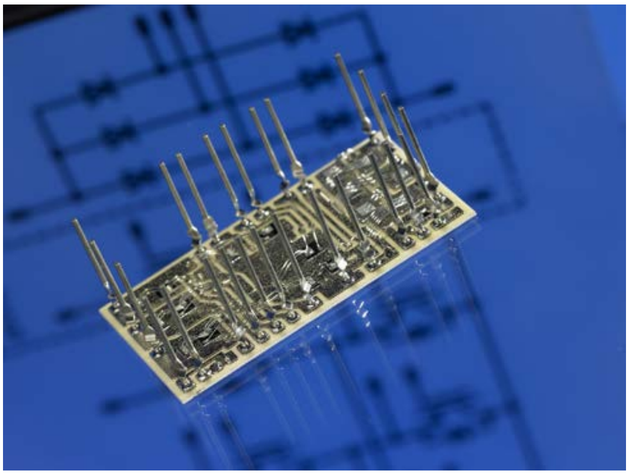



Figure 1: Typical power module showing the vital electrical and thermal connections (a), and the robust, maintenance-free housing (b).

Power Modules have become the most convenient way of building a cost effective power supply system. Everything is optimized within the constraints of the particular module manufacturer. The designer can rest assured that the module will do everything electrically and mechanically that is specified, is guaranteed to work to tight specifications such as EMI, efficiency, load cycling and reliability and it is virtually 'off-the-shelf' meaning that the all-important time to market pressure is minimized.

There is understandably a healthy debate on the various arguments on the topic of Module vs. Discrete component structure. Cost inevitably seems to be the driver in such arguments but then, what is meant by cost? If we simply take the sum of the costs of the individual discrete parts plus the cost of putting these parts together and shipping as the system cost, then we are deluding ourselves. We need to consider the impact of system reliability (load cycle / temperature cycles). The last thing a manufacturer wants in the field is an installed base of 'potential problems'. A system that looks good on the balance sheet and performs well in the lab, but after being deployed for some time in the field, suddenly fails. This escalates the cost of the original calculation significantly and can destroy the credibility that has been built by the manufacturer, perhaps over decades.

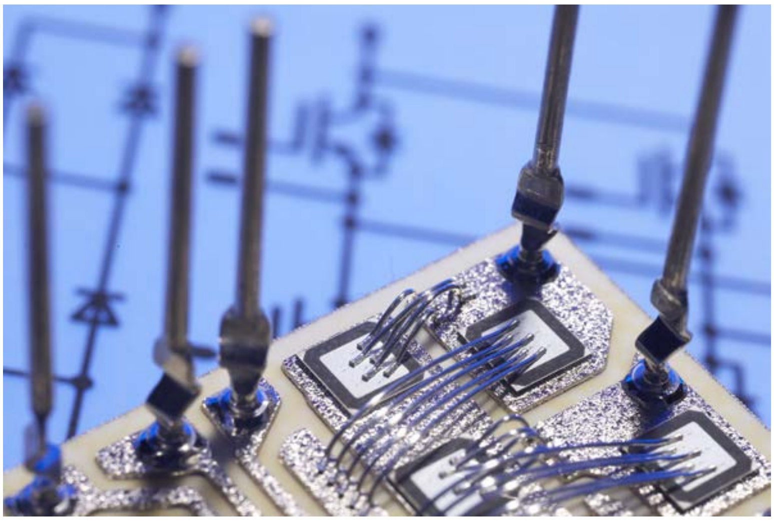
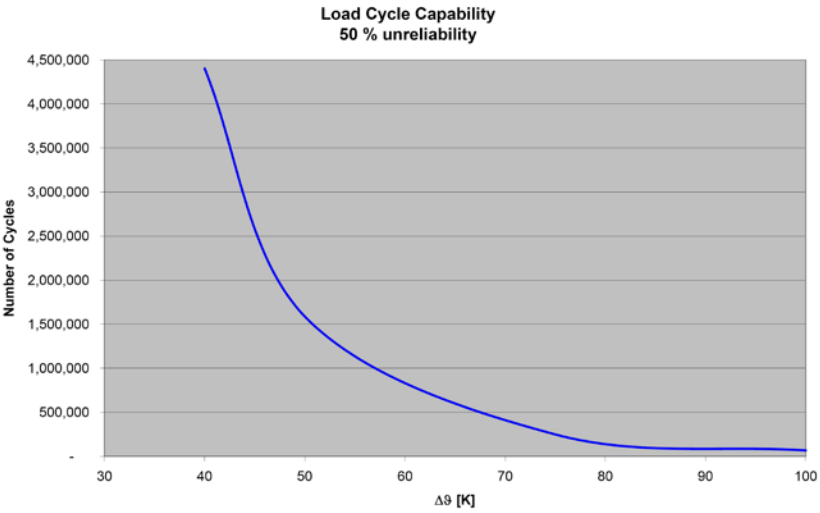


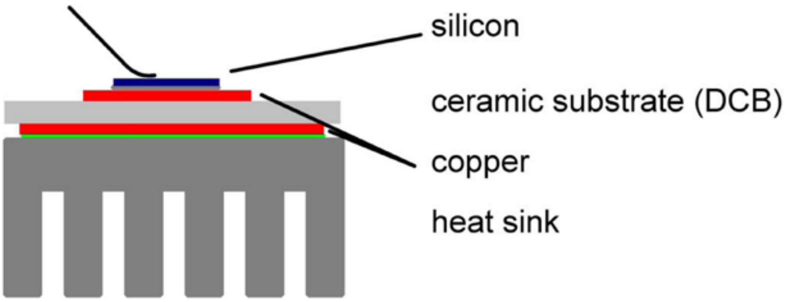
Figure 2: High quality, low inductance electrical and thermal connections are vital for high efficiency and field reliability.

There is also a high risk factor associated with developing a discrete solution. It can be readily appreciated by any designer that these projects never run smoothly; there are the inevitable design bugs to remedy requiring re-spins, tough specifications to achieve and regulations to adhere to and get verified. All this takes up valuable time as well as a significant financial burden.

With vital impact on system design, the PCB layout needs to be given special attention. Lead inductance and resistance play a great part in determining the losses and heat generation, all of which –unless skillfully compensated- can impact detrimentally the reliability of the system. Down time costs for an installation are painfully high and servicing faulty units in the field is difficult, expensive and in worst case, impossible. Reliability is therefore a premium priority.

One huge initial apparent cost saving which can result in failures further down the line is the use of a copper substrate. Naturally, it looks an ideal and simple choice due to its electrical and thermal conductivity. The problem can appear after field service and the normal in-service load and temperature cycling (see Figure 3). The thermal expansion of copper is not a good fit with silicon. A much more reliable solution is achieved with the use of ceramic. This is a solution that is initially more costly, but profoundly more reliable. One has to invest up-front to save costs and integrity in the longer term.





	ΔT [K]	α [10E-6 / K]	Free expansion
Silicon	100	4	0.04 %
Solder paste	93	27	0.25 %
Top copper	87	16.8	0.15 %
Substrate	69	7.1	0.05 %
Bottom copper	51	16.8	0.09 %

Figure 3: The layered construction of the PIM using highest quality materials (a), provides optimum long-term reliability with a high load cycling capability (b).

Apart from the electrical design, a vital part of the overall product ‘persona’ is the mechanical design and component layout. Power systems generally operate in extremes of the environment. Poor ventilation and hostile physical and environmental conditions are generally the norm in industrial drives and renewable energy installations such as solar or wind power.

A great impact on system cost is the assembly process. Discrete processes where soldering power semiconductors with heatsinks attached needs to be very precisely aligned requiring specialized alignment tooling and skilled operators in many cases or individual heatsinks for each semiconductor, using operators of similarly high skill levels.

Figure 4: Press-fit technology utilizes new pin technology (a), which eases assembly to the PCB (b), reducing time and cost of manufacturing.

Vincotech has introduced its new Press-fit technology to the market and is now shipping modules using this labour saving technology. The modules featuring this new pin technology are simply pressed in rather than soldered into the PCB, thus reducing PCB assembly time and costs.

The Vincotech Press-fit pin design is well established in the automotive industry and provides a reliable and gas-tight connection to the PCB. By eliminating the necessity of a solder process for the module, the customer reduces the PCB assembly time and thereby the production costs. A higher production output capacity is the direct consequence.

Further advantages of Press-fit technology include reuse of the PCB and design flexibility. The module can be removed without damaging the PCB, thus allowing for the reuse of the PCB with a new module. Design flexibility is guaranteed by the elimination of the need for soldering; the module can easily be mounted on either side of the PCB at no extra cost or effort.

Vincotech’s Press-fit Technology is DIN and IEC compliant and available upon request for all Vincotech proprietary module designs in pin-compatible versions to the current portfolio.

Of course, there are many module vendors in the marketplace and this can be a tough call to make the right selection. Most vendors are tied to their own proprietary brand in the choice of materials technology and semiconductors. Naturally it just would not be possible for module-maker ‘A’ to select MOSFETs from semiconductor-maker ’B’. Corporate rules would simply not allow it. But does this result in an optimum module? The answer is of course, no. To get the best of all worlds, one needs to go to an independent source such as Vincotech, where components and assembly can be truly optimized or even customized. Never has this been more important than in the power generation field where every percentage point in efficiency, reliability and therefore true cost of ownership adds to the customer’s profitability.

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