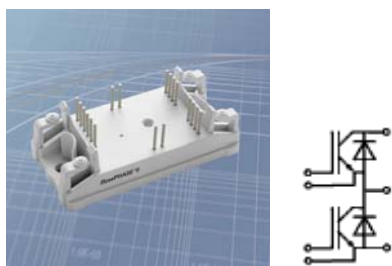


## Intelligent Structure of Power Modules - *flow*PHASE 0

Michael Frisch, Tyco Electronics / Power Systems, May 04

*Since IGBT's used for frequency control of 3 phase electro motors most motor drive applications are designed as printed circuit board (PCB) based systems where power components are soldered into the system board. For low power an ideal power flow is an advantage to achieve a compact and efficient solution. For high power the power flow is decisive whether a PCB based solution is still possible or expensive alternatives have to be used. PCB integration of drive applications in the power range 15.. 30kW facing the challenge of high current in the power tracks, compensation of line inductance, and to achieve a reliable but simple assembly process. The key component for this approach in most instances is the power module. An intelligent structure, and a reliable mechanic concept will reduce the expenditure for development and assembly.*

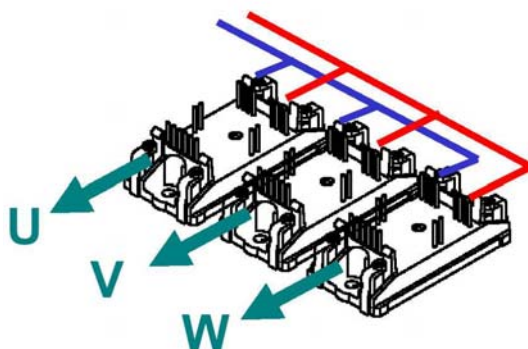
The PCB integration of high power applications is faced with problems as the limited current capabilities of the PCB-tracks, parasitic inductance, difficult mechanical interaction of PCB, module and heat sink, and an expensive assembly process. The new Tyco Electronics *flow*PHASE 0 module family is designed to reduce the expenditure for a solution and to make PCB based inverter design efficient and reliable. The module is structured as an IGBT half bridge with the opportunity to combine 3 modules to a 3-phase inverter bridge.



### PCB-Routing

Even more important than a compact module outline is the arrangement of the in- and outputs of those components. The following structure has been incorporated into the new module:

- ⇒ Power flow through the module
- ⇒ Concentration of high voltage in voltage islands to minimize isolation distances and the high current tracking on the PCB
- ⇒ Standoff between module and PCB for the placing of components (e.g. gate driver).
- ⇒ Meeting of UL-requirements



These features are generating advantages for the application as:

- ⇒ Minimal power tracking for easy routing
- ⇒ Only double sided board is needed
- ⇒ No Input – Output X-ing (EMC)
- ⇒ Short gate connection
- ⇒ Extreme compact application is possible

### Parasitic Inductance

Parasitic inductance in fast switching applications causes over voltage and increased switch off losses in the semiconductor.

#### Theory

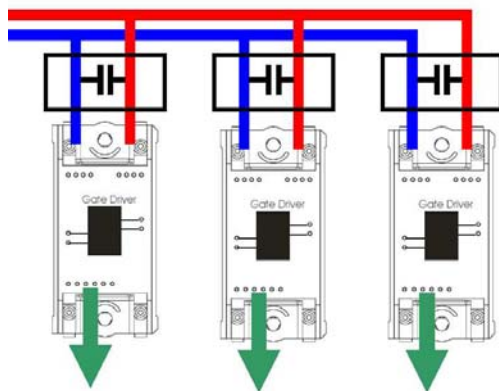
Switching-off the IGBT results in a current change and this causes an over voltage spike by the current change in the parasitic inductances according to

$$V_{CE}(\text{Peak}) = V_{CE} + L \times di/dt$$

To avoid parasitic inductance in the power circuit, the layout of the circuit becomes important. The parasitic inductance rises with the area encircled by the electric current. With overlap of the tracks of positive and negative voltage this area becomes minimal. Capacitors are used to shorten these loops in order to reduce the encircled area. The power module is a key component regarding the parasitic inductance. Lowest internal inductance of the module is required. But more important is also here how pinning and structure influence the inductance of the PCB layout. The target in bridge configurations is to avoid inductive loops in the DC-Link with a capacitive overlap of positive and negative DC-tracks, and to compensate the remaining inductance. A module structure and the pinning of modules have to be designed referring to the targets of parasitic inductance reduction. If this is considered prior to the module design, this goal is achievable without any disadvantage and additional cost.

The division of the 3-phase inverter bridge into 3 half-bridge modules offers the opportunity to

shorten the inductive loop individually for each module.

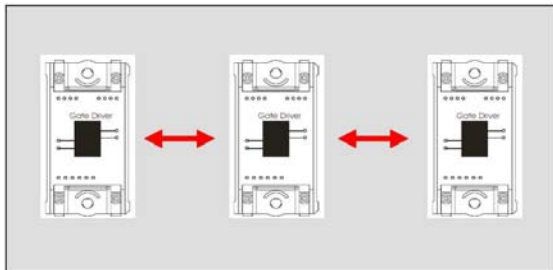


### Mechanical System Requirements

In addition to the electronic challenge in the system design, mechanical and thermal effects have to be covered. Here also the power module with its heat dissipating function has a key function in the application.

### Thermal Contact

The thermal contact of the direct pressed DBC solution is due to the high power density the critical function. On the other side due to the small substrate size of this solution, the thermal grease has to compensate only small tolerances of the contact surface. For a superior transfer of the dissipated power, AlN substrates used. The thermal conductivity of this material is ca. 5 times better than the standard  $Al_2O_3$  substrate technology. The half bridge concept offers the opportunity to reduce hot spots by distribution of the modules on the heat sink.



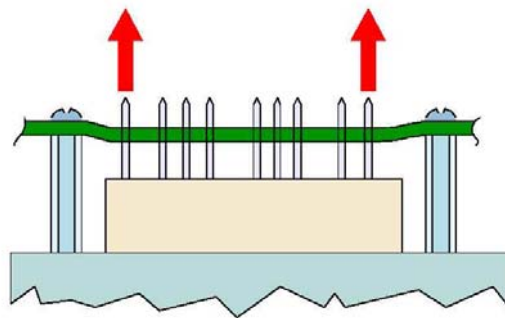
For a reduction of power losses at its origin the latest low loss, Trench and Fieldstop IGBT technology is used.

### Mechanical Stability

The weakest mechanical component is usually the pin for the TTH-soldering into the PCB. The aim is to get defined conditions for avoiding mechanic pull force or vibration at the pins for TTH soldering. The mechanic design of the power module and the assembly process has significant influence on this.

### External Module Fixing

In module concepts without built-in mechanic fixing with the PCB, the only direct connections are the pins. To prevent force from the pins at vibration, an external mechanic fixing between PCB and heat sink is necessary. This system only works well when small tolerances of the mechanic outline of the module and the dimensions of the external fixing point have been achieved.



Using wave soldering as an efficient assembly process, the module have to be assembled 1<sup>st</sup> into the PCB before mounting to the heat sink. The total avoidance of mechanic forces to the pins is here not possible! The only way is, to alter the assembly process and mount the module to the heat sink before soldering. But then wave soldering is impossible and the assembly costs will increase due to the additional process step.

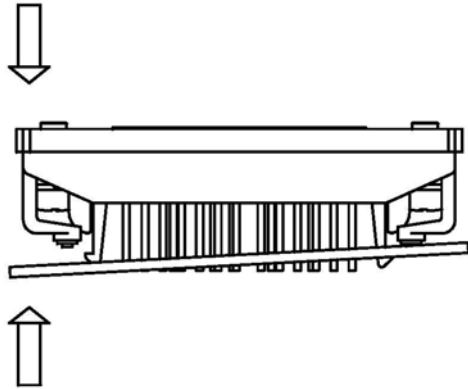
### Mechanical PCB – Module Connection

A direct connection between PCB and module avoids the problems with tolerances. The reason is that the electrical and the mechanic connection are done with the same component. The system is then connected to the heat sink together with the module. The Tyco Electronics flow0 package uses a Clip In system to provide this mechanic connection between module and PCB without the disadvantage of the additional screw process.

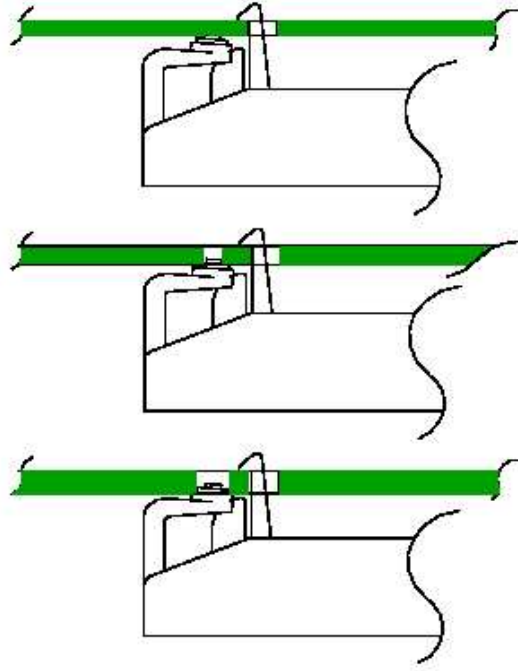


For Clip In systems a spring arrangement is necessary. Either the module provides a flexible component, or the PCB provides the spring effect. This PCB bending using the 1<sup>st</sup> solution is maximal during the assembly, and it

remains after. Sensitive components as SMD ceramic capacitors are endangered. This is the argument to prefer a concept with elastic parts at the module that do not require any bending of the PCB. A flexible plastic arm of the Tyco Electronics flow 0 housing provides the spring force needed during mounting, and compensation of PCB tolerances. With this technology the PCB remain flat during the clip in of the module into the PCB. The mechanism provides all the flexibility that is needed.



The clip mounting requires also some precautions. With external fixing elements placed too close at the clip, the system is over determined and either the PCB is bent or, if the fastening module to heat sink is too soft, the module is not pressed to the heat sink. The clip of the Tyco flow 0 package is qualified as a mechanical fixing element for the PCB. External fixing close to the module is needless. The flow 0 package adjusts different PCB thickness in 3 steps between 1 and 2 mm with cylinders with different diameters on top of the plastic arm. PCB tolerances are compensated with the flexible plastic arm.



### Summary

Modules are the ideal platform to improve the PCB-layout, dynamic and mechanic behavior of power systems with intelligent pinning and a module structure conforming to the needs. The Tyco flowPHASE 0 provides a real low inductive power section, a perfect thermal arrangement on the heat sink, coming along with the best mechanical module – PCB interconnection, given by the used flow 0 package. Tyco offers the flowPHASE 0 first of all in two versions: 100A and 140A @ 80°C T<sub>H</sub>, 1200V.