

# Mechanic Interacton of Module, PCB and Heat Sink in Power Applications

Ralf Ehler, Michael Frisch, Tyco Electronics / Power Systems, Oct. 04

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

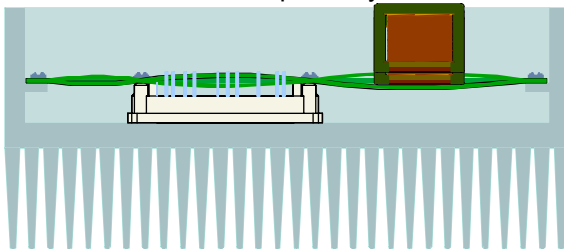
## Introduction

This report introduces application requirements in module features that were recognized in many cases only after the problems occurred as vibration stress and the assembly process at the PCB integration. Here is the special focus on the interaction between module, PCB and heat sink.

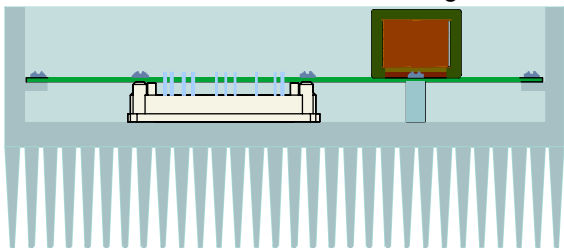
## Vibration

Ruggedness at vibration stress is required in most industrial applications and it is a must for motor integrated electronic.

To avoid pin stress caused by vibration a defined mechanical connection of PCB, power module and heat sink is required. During vibration, mechanic waves will spread out over the PCB, also in areas were the mechanical interconnection is done perfectly.



This problem has to be covered by placing the mechanic interconnection close to the big and heavy components soldered on the PCB. This will avoid the mechanic wave at its origin.



## Mechanic Stability

The weakest component is usually the pin for the TTH-soldering into the PCB. The targets are defined conditions for avoiding mechanic pull force or vibration at the pins for TTH soldering. Further critical process is the thermal contact of the power module with the heat sink. The mechanic design of the power module and the assembly process have significant influence on these sensitive

processes.

The usual process for assembling TTH-power components is as follows:

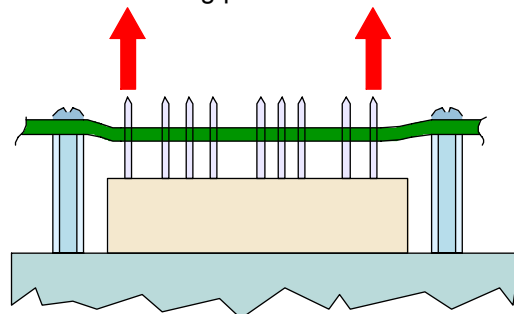
- ⇒ Assembly of all TTH-components
- ⇒ Soldering in solder wave
- ⇒ Apply thermal grease on the heat sink or on the thermal contact area of the power module
- ⇒ Assembly of the PCB on the system heat sink with thermal connection between module and heat sink.

With this assembly process the module is assembled into the PCB before mounting to the heat sink. Due to this fact the assembly process module – heat sink have to include the influence of this. Following side effects have to be considered:

- ⇒ Tolerances cause forces at pins
- ⇒ Insufficient thermal contact to the heat sink
- ⇒ Pre bent heat contact without fixing between module and PCB causes pull forces at pins.

## Mechanic Interconnection

In module concepts without mechanic fixing with the PCB, the only direct connections are the pins. To prevent pull force from the pins 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.



Here total avoidance of mechanic forces to the pins is not possible!

The only way is, to alter the assembly process and mount the module to the heat sink before soldering. Wave soldering is impossible here and the assembly costs will increase due to the additional process step.

## Tolerance Example

A module uses direct pressed DBC (without

base plate) soldered into the PCB, for the mechanic stability, external fixing points close to the module are used.

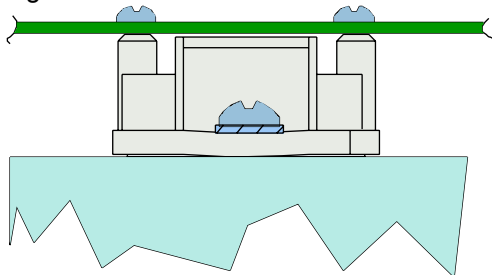
Dimensions:

- ⇒ Distance Module PCB =  $17\text{mm} \pm 0,35\text{mm}$
- ⇒ Mechanic fixing:  $17\text{mm} \pm 0,1\text{mm}$

In the worst case the PCB will be bent 0,45mm. This will cause pull force at the pins and there will be an influence in the thermal connection to the heat sink because the external fixing and the pull force at the pins will reduce the pressure of the module heat contact area to the heat sink. To shorten the length of the external fixing to the minimal tolerance (e.g.  $17\text{mm} - 0.45\text{mm}$ ) of the module will not solve the problem, especially if pins are placed in the middle of the module area. The length difference will result in bending of the PCB of max. 0.9mm. The pull force will remain in the middle of the circuit for pins and it will also not prevent from the disadvantage of reduced thermal contact to the heat sink, in addition sensitive components are endangered due to the PCB bending.

#### Mechanic PCB – Module Connection

A direct connection between PCB and module avoids the problems with tolerances, the reason is, that the Pins and the mechanic connection are done at the same component. The system is then connected to the heat sink together with the module.



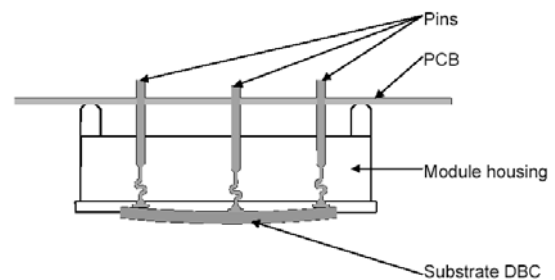
#### Modules with Pre Bent Heat Contact

A convex bending of the contact area improves the thermal connection between heat sink and module. For modules with base plate a convex shape of the heat contact area is a must, here the base plate is the only mechanic force between module and heat sink. Modules with direct pressed DBC are using the package to press the heat contact area to the heat sink. But here also a convex shape is superior. The reason is as follows:

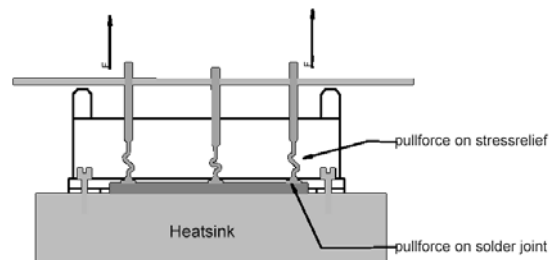
After soldering of the power semiconductors on the DBC substrate, the substrate gets a slight concave shape. The pins in the centre of the substrate will be loaded with pull force when soldered into a PCB and pressed down by the housing. This pull force will also reduce the

pressure between DBC substrate and the heat sink at the centre!

Module soldered into PCB

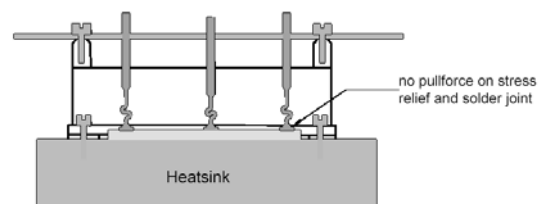


The advantage of a convex heat contact area requires some precautions in the mechanic setup. Without direct connection PCB and module, the pins next to the heat sink fixing points of the module will experience some pull force after the heat sink assembly.



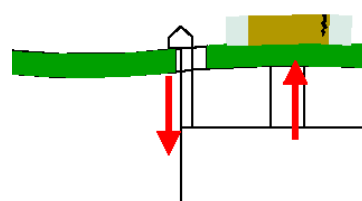
By fixing the PCB on the module pull force is avoided and the pins in the middle will be loaded with some pressure. This pressure can be compensated with a plastic deformation of a dedicated stress relief section in the pins.

Module soldered into PCB  
Mounted on heatsink  
Screwed onto PCB



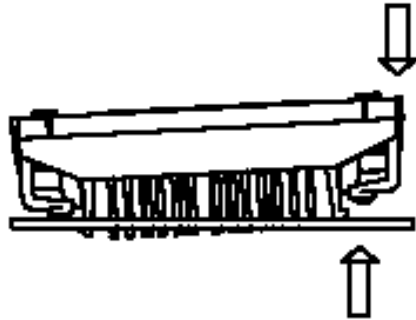
#### Clip In

Clip In is able to provide the same mechanic connection between module and PCB without the disadvantage of the additional screw process. For Clip In a spring arrangement is necessary, either the module provides a flexible component or the PCB provides the spring effect.



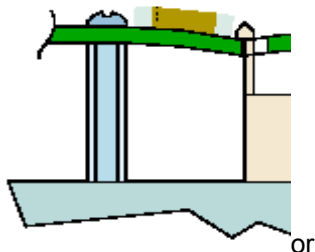
This PCB bending is maximal during the assembly and it remains after. Sensitive components as SMD ceramic capacitors are endangered, this is the argument to prefer a concept with elastic parts at the module that do not require any bending of the PCB.

A solution with integrated spring element is in the plastic housing, is the Tyco Electronics *flow0* housing.

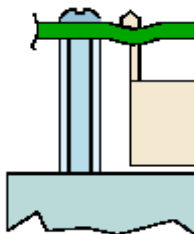


A flexible plastic arm provides the spring force needed during mounting and compensation of PCB tolerances. With this technology, the PCB might remain flat during the clip in of the module into the PCB; the mechanism provides all the flexibility that is needed.

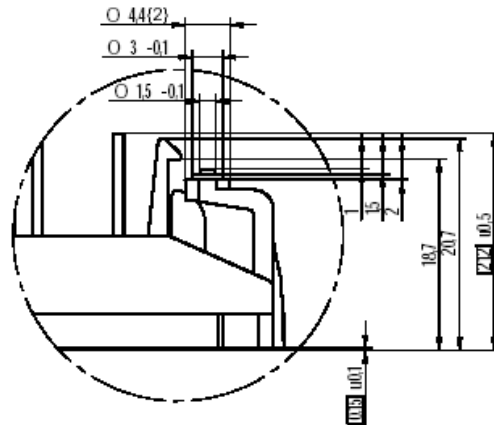
The clip mounting requires also some precautions. With external fixing points placed too close at the clip, the system is over defined and either the PCB is bent



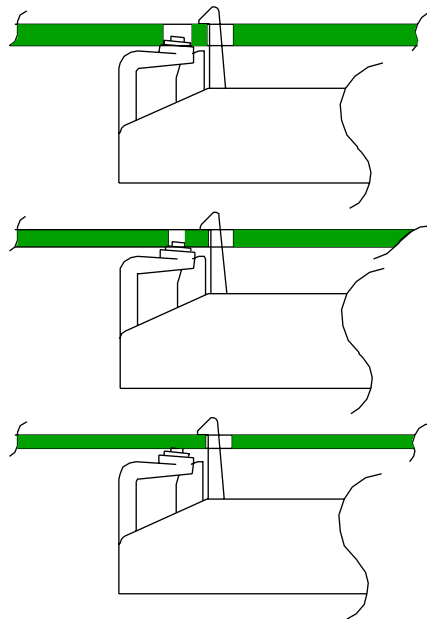
or  
if the module to heat sink is too soft the module is not pressed to the heat sink.



The clip of the Tyco Flow0 package is qualified as a mechanic fixing point for the PCB and external fixing close to the module is useless.



In difference to the screw mounting for adaptation to different PCB thickness some constructive actions have to be taken. In this example of "flow0" package, cylinders with different diameters on top of the plastic arm adjust different PCB thickness in 3 steps between 1 and 2 mm. PCB tolerances were compensated with the flexible plastic arm.



### Conclusion

In the selection of the components for power applications the main parameters to decide are voltage, current and price, but this is only true if the solutions are comparable in the mechanical setup introduced in this report. These features are cost and time relevant and have to be included in the system cost calculation comparing different solutions.