HybridPACK™ Drive

HybridPACK™ Drive FLAT Baseplate Direct Cooled

About this document

This application note describes a cooler example for HybridPACK™ Drive with flat baseplate (e.g. FS660R08A6P2Fxx). These power modules can be directly fluid cooled. Customer can use same assembly process for all HybridPACK Drive product variants, which accelerate the inverter design for different power classes.

Scope and purpose

General information about the assembly process can be found under the application note **AN-HPD-ASSEMBLY**, which describe assembly processes of the HybridPACK Drive family. This application note shows one possible cooler design for the HybridPACK Drive with flat baseplate. The cooler drawing example as well as experimental results are included in the application note.

Intended audience

Engineers involved in inverter concept and design for HybridPACK™ Drive Flat Baseplate products (e.g. FS660R08A6P2Fxx).

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1 General Information

The **HybridPACK™** Drive power module family is designed to meet the high volume production, high robustness, high power density, and low cost requirements of the automotive market. Different product derivate with e.g. different power tab sizes and different baseplates are available within the HybridPACK Drive product family.

This application note describes a cooler example for the HybridPACK™ Drive flat baseplate product. The design of HybridPACK Drive flat baseplate considered direct fluid cooling and therefore this cooling method is explicitly allowed in the assembly instructions of the power module family [1]. The cooler example avoids an application of thermal grease. The flat baseplate power module can be assembled with same as process as the PinFin or WAVE product types and due to missing thermal grease the thermal path into the cooling fluid is well defined and also stable over application lifetime. With the direct fluid cooling approach customer can use same assembly line for all HybridPACK™ Drive products. This simplifies and accelerate the inverter design for different power levels.

It has to be noted that the cooler drawing should be understood as a non-binding example. Several designs were tested at Infineon and the described design in this application note had shown a good performance. But is should not be understood as most optimal cooler design in general. The cooling structure can be further optimized for project specific needs and provide a good starting point for coolant system design. It is generally recommended to test the thermal performance on product and inverter level after finalization of the cooing structure.

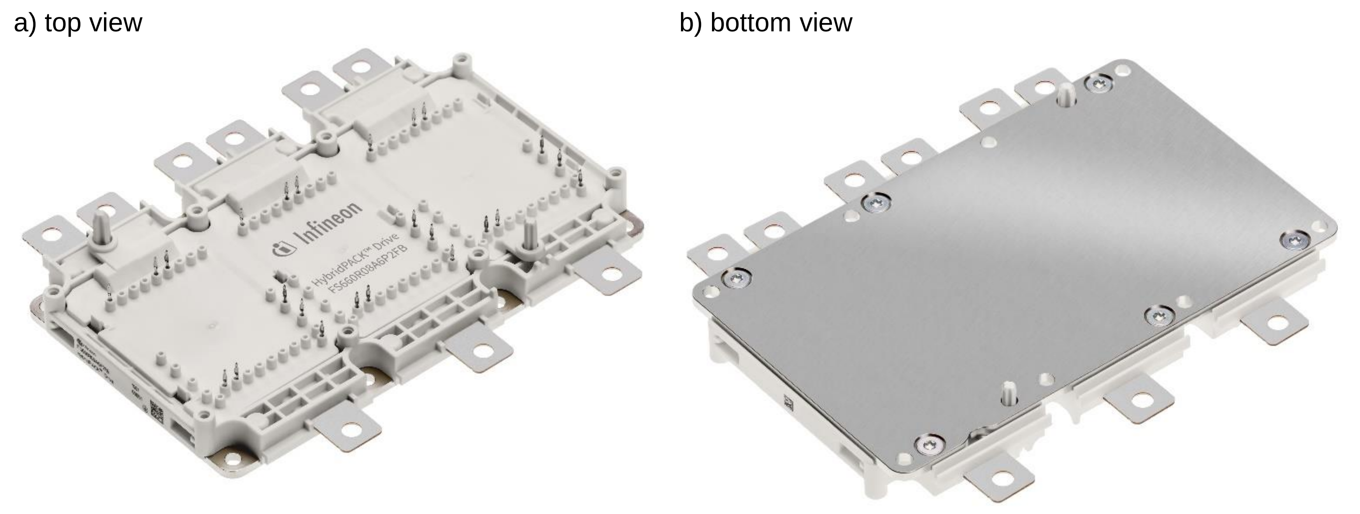


Figure 1 HybridPACK™ Drive Power Module with flat baseplate (typical appearance FS660R08A6P2FB).

1.1 HybridPACK™ Drive product list in scope of this application note

The scope of the application note is for the following products:

Type Designation	SP order number	Status
FS660R08A6P2FB	SP001632426	in production
FS660R08A6P2FLB	SP001850450	in production

2 Cooler Drawing Example

Figure 2 show an example of a cooler for HybridPACK Drive flat baseplate, which can be direct fluid cooled. The sealing ring area as well as inlet/outlet is designed identical to the standard reference cooler for PinFin. The difference is the design of the cooler grove, see also zoom E where a “bubble” like structure is designed in the aluminum cooler. This structure provide smooth barriers for the fluid flow and generates a turbulent flow. Despite the flat baseplate surface, the thermal dissipation is quite high. Next chapter show experimental results on the thermal performance using the proposed cooler structure.

Figure 3 show a 3D picture of the proposed cooler including a standard sealing ring for HybridPACK Drive power module family as well as a HybridPACK Drive product with flat baseplate (FS660R08A6P2B).

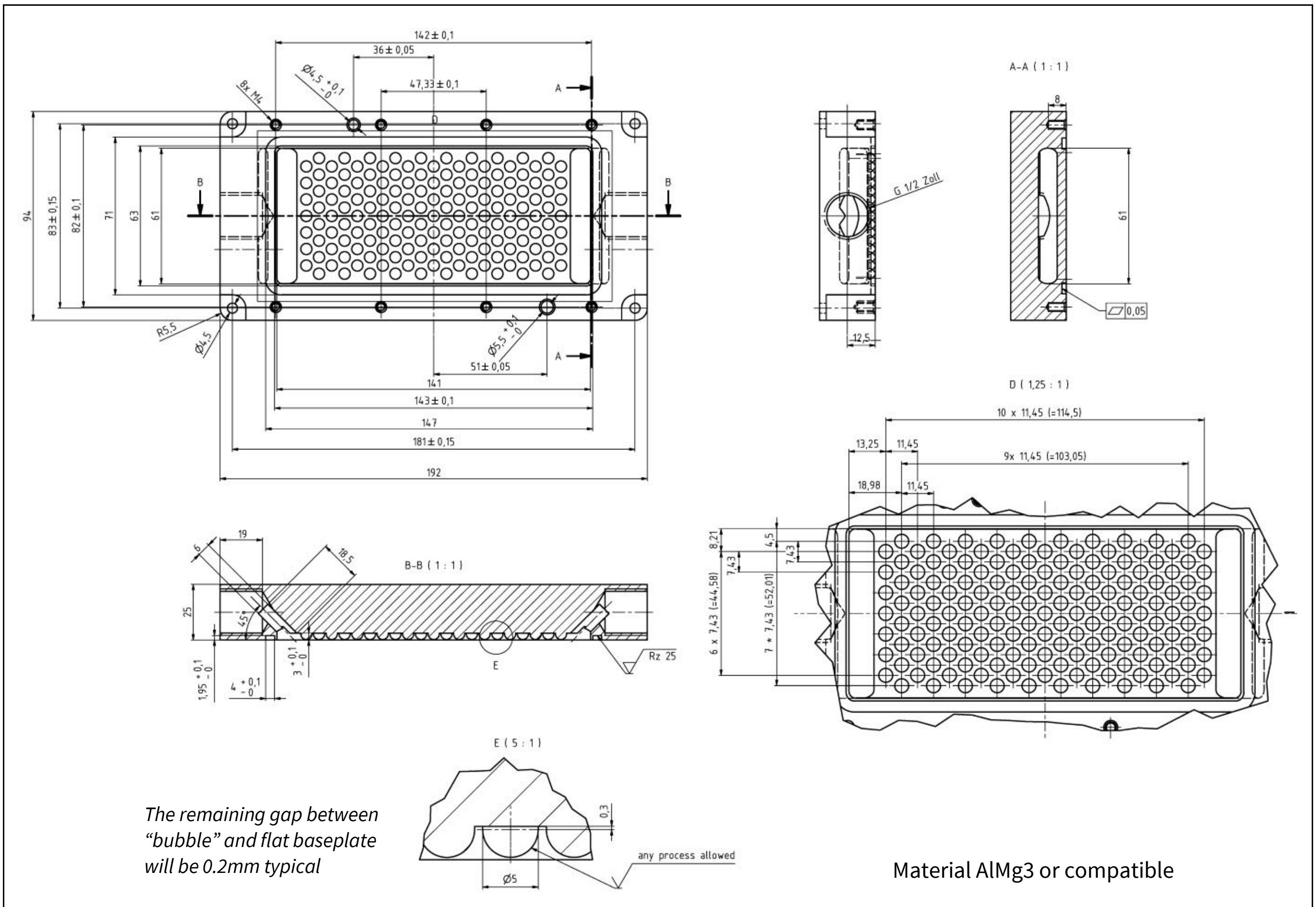


Figure 2 Cooler drawing example for HybridPACK Drive Flat Baseplate direct fluid cooled. The simple “bubble” structure in the cooler can be made with any process. It can be realized during aluminum die casting for example and does not need a post process rework.

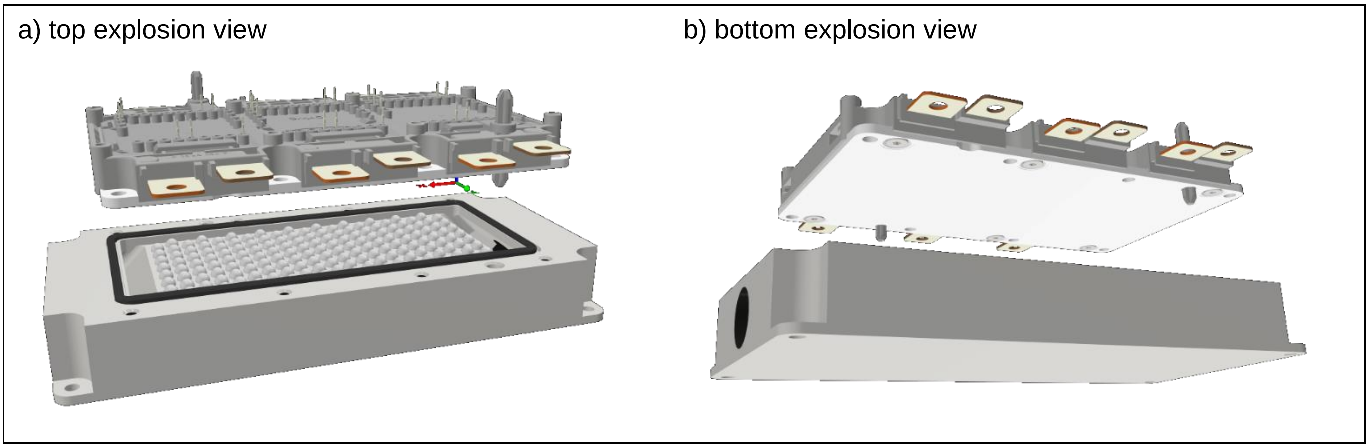


Figure 3 Explosion view of the sample cooler with standard sealing ring and HybridPACK Drive flat baseplate. The aluminum cooler has a simple “bubble” structure for appropriate direct fluid cooling of the flat baseplate.

3 Experimental Results and Thermal Model

The proposed cooler structure of Figure 2 was experimentally tested with the HybridPACK Drive flat baseplate product FS660R08A6P2B. The measured transient thermal impedance (Zth) for IGBT, Diode and also the coupling from antiparallel IGBT/Diode is shown in Figure 4. The experiments were performed at a flowrate of 10 L/min with 50% water / 50% ethylenglycol mixture at an inlet temperature of 75°C. Measured was the low side switch in the center of the module (i.e. system 4). Based on the measured results a thermal foster model was created. The curve fitting for the thermal model was done in similar way like maximum Zth curve for a direct fluid cooled module. With this thermal model it is possible to compare the thermal performance with datasheet values of other HybridPACK Drive products (see Table 2).

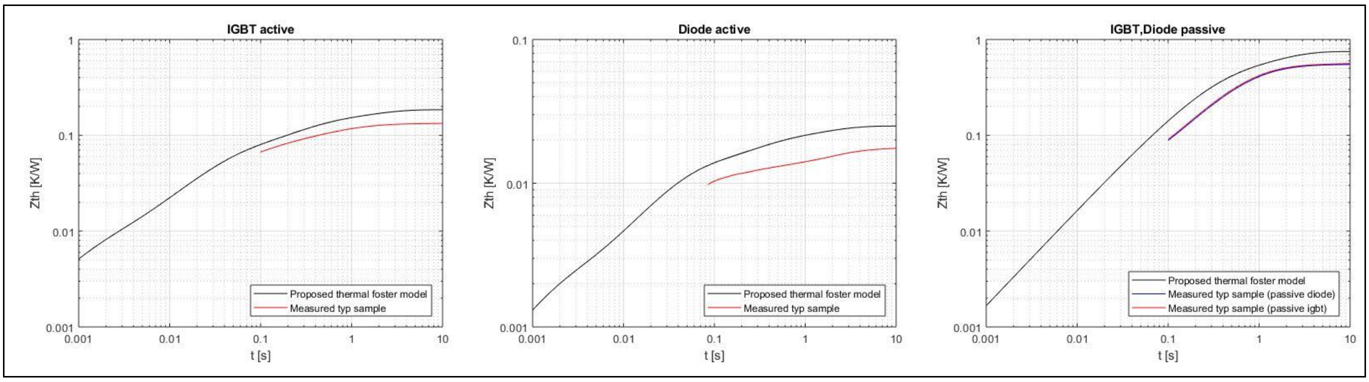
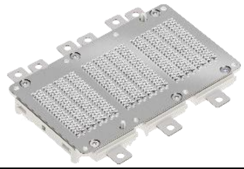
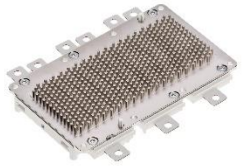
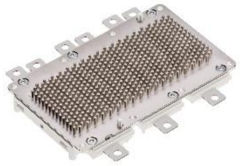


Figure 4 Measured results with prototype cooler and a typical HybridPACK Drive Flat baseplate module FS660R08A6P2FB at 10L/min (red curves). Based on measured results a thermal foster model was created (black curves). Foster model parameters are noted in Table 1.

Table 1 Proposed Thermal Foster Model Parameters for 10L/min.

i	1	2	3	4
IGBT r_i [K/W]	0.005	0.050	0.070	0.060
Diode r_i [K/W]	0.015	0.100	0.070	0.065
Passive r_i [K/W]	0	0	0.035	0.04
Applied for IGBT, Diode and passive τ_i [s]	0.001	0.030	0.250	1.500

Table 2 Comparison of thermal resistance (Rth) junction to fluid for different HybridPACK Drive modules.

Power Module	FS660R08A6P2Fxx	FS770R08A6P2xx	FS820R08A6P2xx	FS950R08A6P2xx
Short Description	FLAT baseplate with direct cooling (see Figure 2)	WAVE baseplate cooling with reference cooler [1]	PinFin baseplate cooling with reference cooler [1]	High Performance ceramic with PinFin baseplate cooling with reference cooler [1]
Picture				
IGBT Rth [K/W]	0,185	0,153	0,140	0,115
Diode Rth [K/W]	0,250	0,217	0,200	0,160

4 Hints for experiments and cooler optimization

The proposed simple “bubble” structure in the cooler can be easily manufactured in an aluminum die casting process for the final high volume product. However, the structure can be quite complex for prototype coolers, which are often NC drilled. In order to overcome this problem in early design phase it is possible to use a standard reference cooler for the PinFin power modules and to use a 3D printed plastic inlay. In 3D printing, the “bubble” structure can be easily realized. For these inlays it is recommended to use some distance keepers at the edge of the inlay. The distance keeper are in contact with both, the cooler groove and the power module baseplate. It clamps the inlay in a correct height position. With such 3D printed inlays it is possible to test the target cooler design before starting the design of serial tools of the final inverter housing. The Figure 5 show an example of a 3D printed inlay, which was also used at Infineon for testing the proposed coolant structure on thermal test bench.

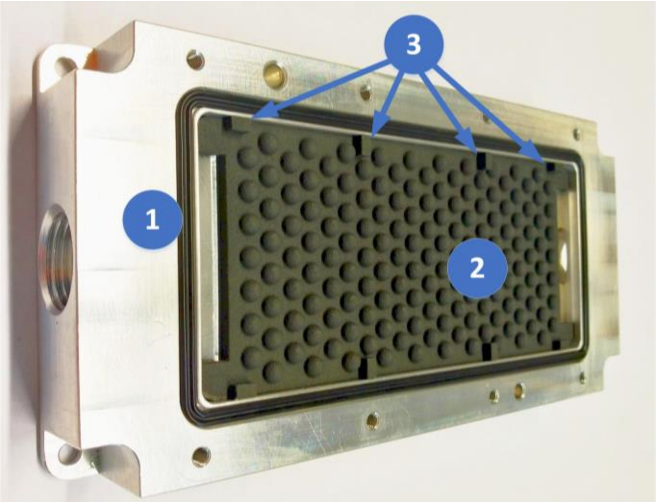


Figure 5 For rapid prototypes it is possible to use a 3D printed plastic inlay in the standard PinFin cooler. (1) shows standard cooler and standard sealing ring for PinFin. (2) show the 3D printed plastic inlay. (3) highlight the distance keeper at the edge of the inlet to ensure stable position in the cooler during testing.

5 Coolant fluid type

A general recommendation for a specific cooling fluid cannot be provided, as the power module is only one single part in the entire cooling system. Following items have to be considered at the system supplier to find appropriate coolant fluid:

- Coolant fluid with its corrosion protection has to be compatible with the aluminium of the cooler material and the nickel overplated Cu module baseplate.
- Also other parts in the coolant system has to be compatible to the fluid type (e.g. Zn screws and chrome parts are typically not allowed in the cooling system).
- The fluid mixture has to provide enough anti-freeze for the application conditions. Freezing events of the fluid has to be strictly avoided. Freezing fluid will lead to plastic deformation of the power module baseplate and may lead to fluid leakage and/or isolation failure consequently.

For power module tests at Infineon where cooling is required (e.g. thermal characterization, power cycling tests) typically BASF Glysantin™ G30™ with an organic-acid-technologie (OAT) silicate-free corrosion protection is applied.

6 References and Revision History

The referenced application notes can be found at http://www.infineon.com

[1] Infineon Technologies AG, Application Note, "Mounting Instructions HybridPACK Drive Module", AN-HPD-ASSEMBLY

Revision History

Date	Version	Changed By	Change Description
2020-02	1.0	T. Reiter, E. Keli, (IFAG ATV HP HMD AE) Ki S. Lee (IFKOR ATV HPC)	Initial Version for HybridPACK Drive Flat Baseplate direct cooled.

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