

## Fast switching for welders of ever decreasing size and price

### **fastPACK 0 H 2<sup>nd</sup> gen & fastPHASE 0**

*In recent years welding equipment has become lighter and physically smaller. In the case of welders of higher power, size is becoming increasingly important as a cost factor, e.g. in determining the total surface of a production line. For handheld equipment, size and weight are critical. In both cases, the price pressure is high.*

*By Kuno Straub, Product Marketing Manager, Vincotech*

The fastPACK 0 H 2<sup>nd</sup> gen and fastPHASE 0 2<sup>nd</sup> gen families of power modules are Vincotech's answer to these requirements. The portfolio of CoolMOS and fast IGBT full-bridges and half-bridges, along with optional AlN substrate and/or integrated capacitors, enable the fast switching required to reduce the size of the transformer. Featuring chips of various sizes, these modules cater for almost every need in welding for up to approximately 30 kW as single modules. The compact flow0 housing and efficient layout design lead to a high power per area rating, thus satisfying the demands for both small size and low price.

#### **Overview of fastPACK 0 H 2<sup>nd</sup> gen and fastPHASE 0 2<sup>nd</sup> gen modules**

An overview of the modules in question can be seen in Table 1.

Part	Configuration	Voltage	Current	Technology	Substrate
V23990-P622-F64-PM*	H	600 V	30 A	CoolMOS	Al <sub>2</sub> O <sub>3</sub>
V23990-P622-F74-PM*	H	600 V	30 A	CoolMOS	AlN
V23990-P623-F04-PM*	H	600 V	60 A	High Speed IGBT2	Al <sub>2</sub> O <sub>3</sub>
V23990-P623-F14-PM*	H	600 V	60 A	High Speed IGBT2	AlN
V23990-P623-F24-PM*	H	600 V	50 A	IGBT3	Al <sub>2</sub> O <sub>3</sub>
V23990-P624-F24-PM*	H	600 V	75 A	IGBT3	Al <sub>2</sub> O <sub>3</sub>
V23990-P625-F24-PM*	H	600 V	100 A	IGBT3	Al <sub>2</sub> O <sub>3</sub>
V23990-P628-F64-PM*	H	900 V	26 A	CoolMOS	Al <sub>2</sub> O <sub>3</sub>
V23990-P629-F44-PM*	H	1200 V	25 A	IGBT2 phantom	Al <sub>2</sub> O <sub>3</sub>
V23990-P629-F64-PM*	H	1200 V	25 A	IGBT2 phantom	Al <sub>2</sub> O <sub>3</sub>
V23990-P629-F54-PM*	H	1200 V	25 A	IGBT2 phantom	AlN
V23990-P629-F56-PM*	H	1200 V	25 A	IGBT2 phantom	AlN
10-Fx122PA100FEx-P999F3x-PM**	Half bridge	1200 V	100 A	IGBT2 phantom	AlN
10-Fx122PA100FEx-P999F2x-PM**	Half bridge	1200 V	100 A	IGBT2 phantom	Al <sub>2</sub> O <sub>3</sub>
10-Fx122PA100FCx-P999F5x-PM**	Half bridge	1200 V	100 A	Fast IGBT2	AlN
10-Fx122PA100FCx-P999F4x-PM**	Half bridge	1200 V	100 A	Fast IGBT2	Al <sub>2</sub> O <sub>3</sub>

\*optionally available with internal DC link capacitors (V23990-P72x-PM family)

\*\*optionally available in 12mm /17mm / solder pin / Press-fit pin

Table 1: overview of fastPACK 0 H 2<sup>nd</sup> gen & fastPHASE 0 2<sup>nd</sup> gen modules for welding

The technologies used are

- 600 V: CoolMOS and High Speed IGBT2
- 1200 V: Fast IGBT2

Optionally available is an AlN substrate instead of the standard Al<sub>2</sub>O<sub>3</sub> substrate for better thermal performance. The V23990-P72x-PM modules feature the same layout and components as the V23990-P62x-PM family and additionally feature internal DC link capacitors for reduction of E<sub>off</sub> losses.

The simulation results shown throughout this document were generated using a linear interpolation model based on actual measurements. This tool allows the comparison of two modules under the same conditions. The cases simulated are for DC to DC conversion using Zero Voltage Switching, which is typical for welding. A more detailed simulation tool is *flowSIM*, the power module simulation tool by Vincotech.

### Component Technology

At 600V, CoolMOS is used for the V23990-P622-PM and V23990-P722-PM modules. It is ideal for applications requiring extremely fast switching without short circuit capability. High Speed IGBT2 at 600V and Fast IGBT2 at 1200V are IGBT platforms designed for extremely fast switching. A comparison between the different technologies based on an application example can be seen in Figure 1 (600 V) and Figure 2 (1200 V). The conditions chosen are typical for welding and can be found in Table 2 below.

600V	1200V
$U_{out} = U_{dc} = 230V$ $R_{gon} = 4 \text{ Ohm}$ $R_{goff} = 2 \text{ Ohm}$	$U_{out} = U_{dc} = 380V$ $R_{gon} = 6 \text{ Ohm}$ $R_{goff} = 6 \text{ Ohm}$
$T_j = 125 \text{ }^\circ\text{C}$ $I_{outpeak}/I_{out} = 1,3$ $T_{sink} = 60 \text{ }^\circ\text{C}$ to $100 \text{ }^\circ\text{C}$ in steps of $10 \text{ }^\circ\text{C}$ ZVS DC output	

Table 2: Parameters for application examples

As can be seen in Figure 1, for any frequency above 20 kHz to 25 kHz, the High Speed IGBT2 module V23990-P623-F04-PM provides a clear advantage over the IGBT3 module V23990-P625-F24-PM of the same chip size. At 1200 V, the Fast IGBT2 module P999F48/-F49 /-F58/ -F59 performs better than the similar (10% smaller size) sized standard IGBT4 module P999F08/ -F09 for any switching frequency above 20 kHz, depending on heat sink temperature (Figure 2).

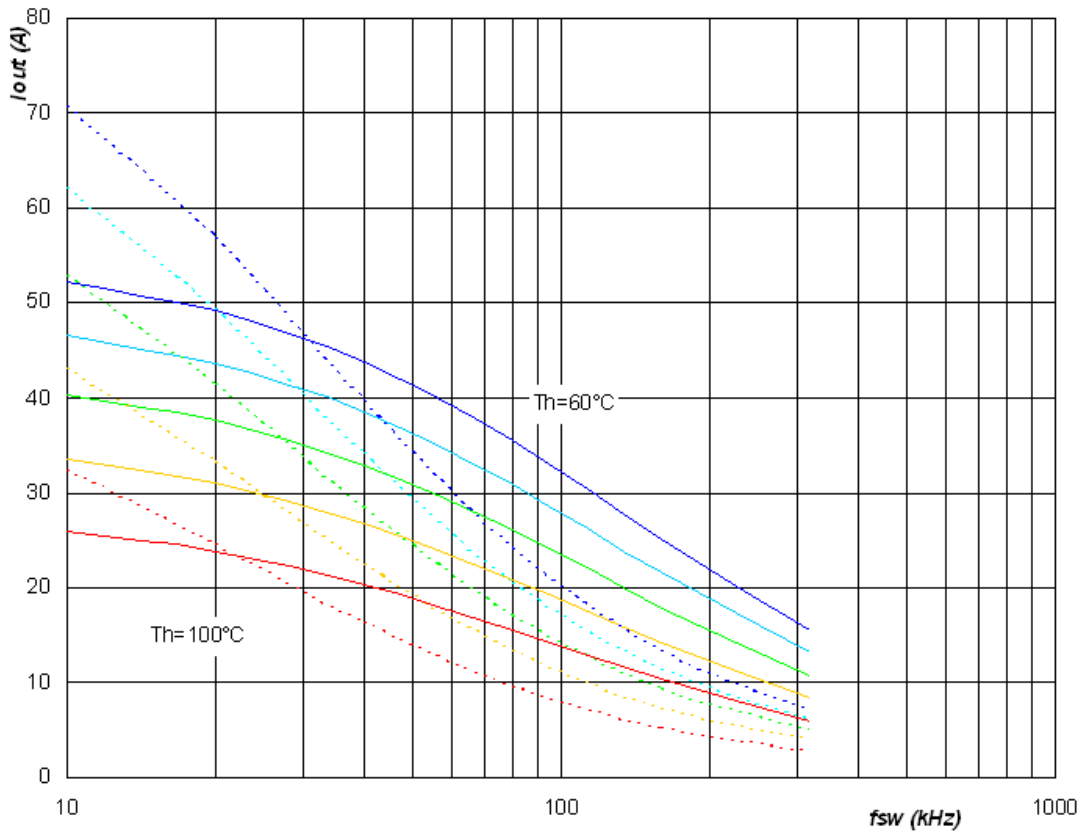
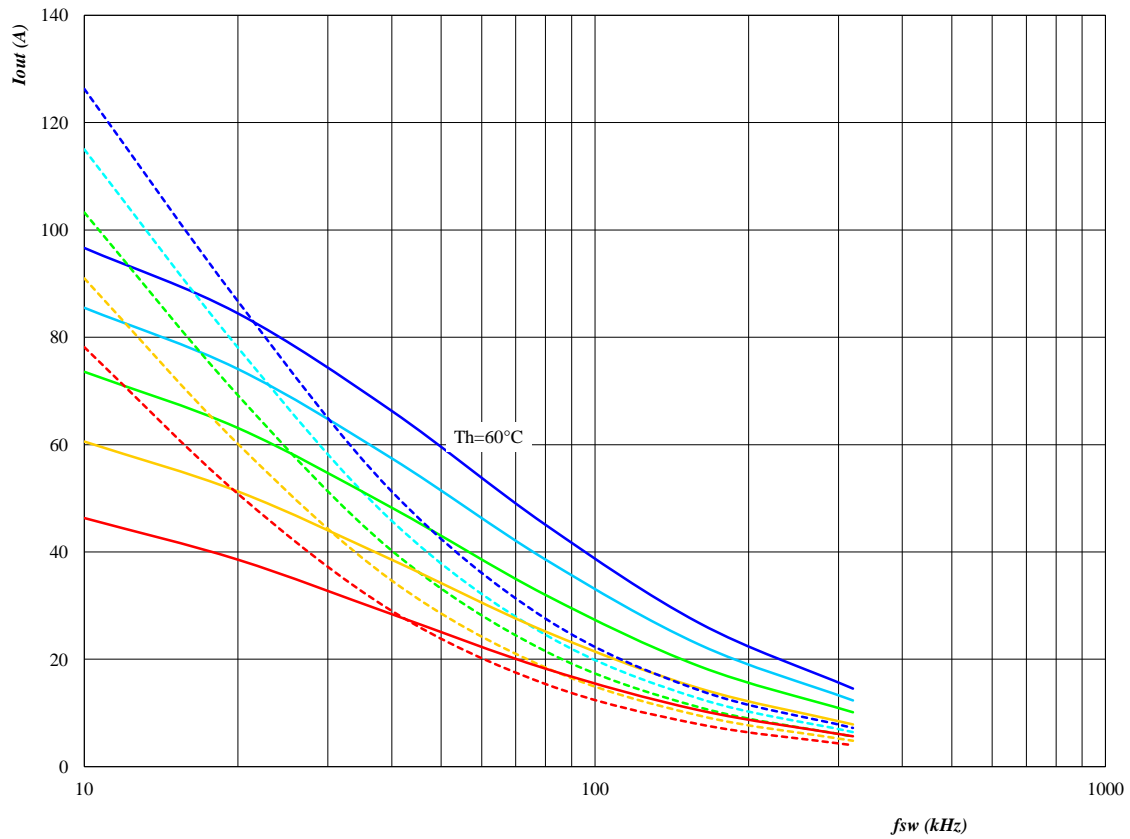


Figure 1: 600V High Speed IGBT2 vs std IGBT3 same chip size  
 Typical available current at  $T_j = 125^\circ\text{C}$  as function of frequency  
 (parameter: heat sink temperature)

- continuous lines: V23990-P623-F04-PM (60 A rating, High Speed IGBT2)
- dashed lines: V23990-P625-F24-PM (100 A rating, std IGBT3)



$T_h = 100^\circ\text{C}$

Figure 2: 1200V fast IGBT2 vs. std IGBT4 same chip size  
 Typical available current at  $T_j = 125^\circ\text{C}$  as function of frequency  
 (parameter: heat sink temperature)

- continuous lines: P999F58 (-F59) (100 A rating, Fast IGBT2)
- dashed lines: P990F18 / -F19 (150 A rating, std IGBT4, 10% smaller)

### DC link capacitors

The internal DC link capacitors of the V23990-P72x-PM family aim at reducing the parasitic inductance and the  $E_{off}$  losses during switching. The great advantage of capacitors inside the package is the extremely short current path. As can be seen in Figure 3, the switch-off overvoltage peak in a module with capacitors reaches 120% of the nominal DC voltage, as opposed to 138% in a module without capacitors. This 15% reduction in the turn-off voltage peak extends the lifetime of the module and increases its reliability. In some cases, it even makes the use of lower rated components possible.

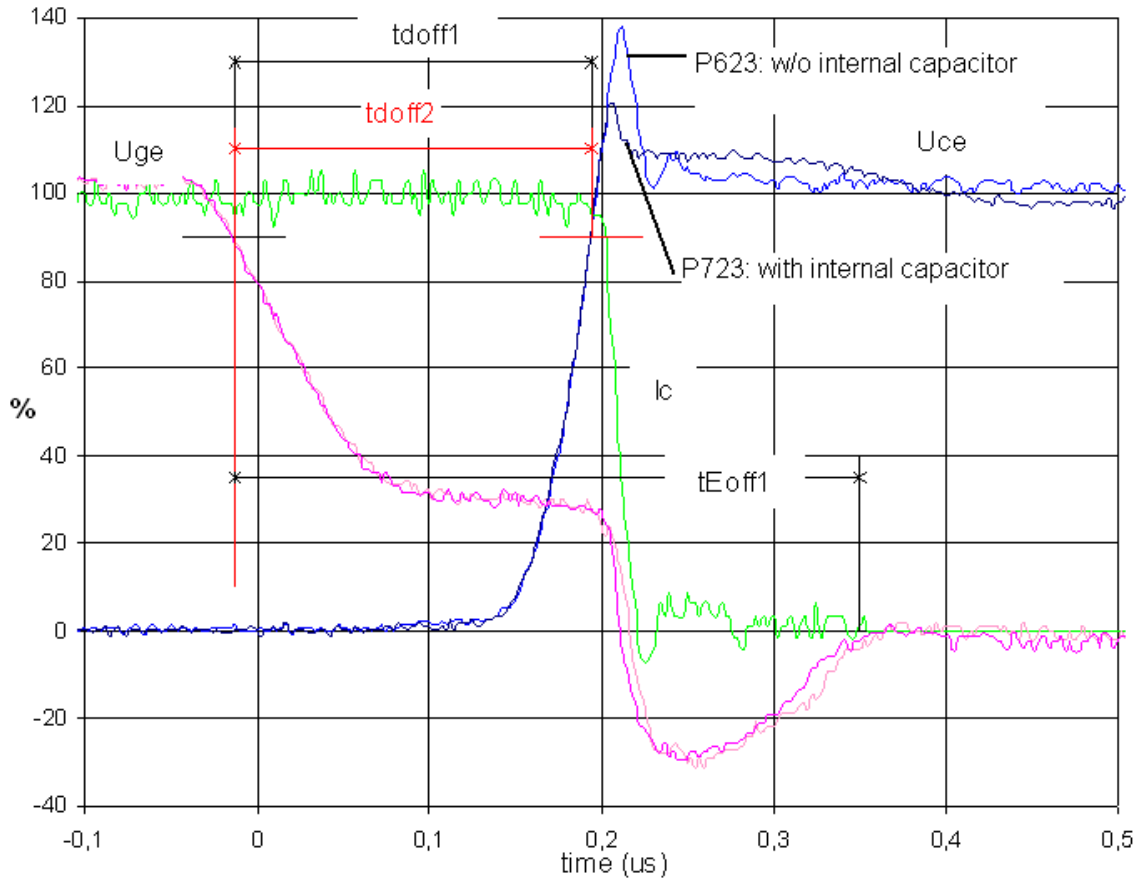


Figure 3: Turn-off characteristics w/o internal capacitors

- light colored lines: V23990-P623-F10-PM (no capacitors)
- dark colored lines: V23990-P723-F10-PM (with internal capacitors)

The conditions used for the example above were:

$$U_{ce} (100\%) = 400 \text{ V}$$

$$U_{ge} (100\%) = 15 \text{ V}$$

$$I_c (100\%) = 60 \text{ A}$$

$$R_{gon} = 4 \text{ Ohm}$$

$$R_{goff} = 2 \text{ Ohm}$$

### AlN substrate

The AlN substrate reduces the thermal resistance of the module by approximately 30% compared to a module with an Al<sub>2</sub>O<sub>3</sub> substrate. The lower temperature rise means that either smaller chips, and potentially smaller modules can be used, or that a higher switching frequency can be used, leading to an advantage in size and price. Figure 4 illustrates the advantage of a module with AlN (conditions in Table 2). The two modules used are identical, apart from the substrate.

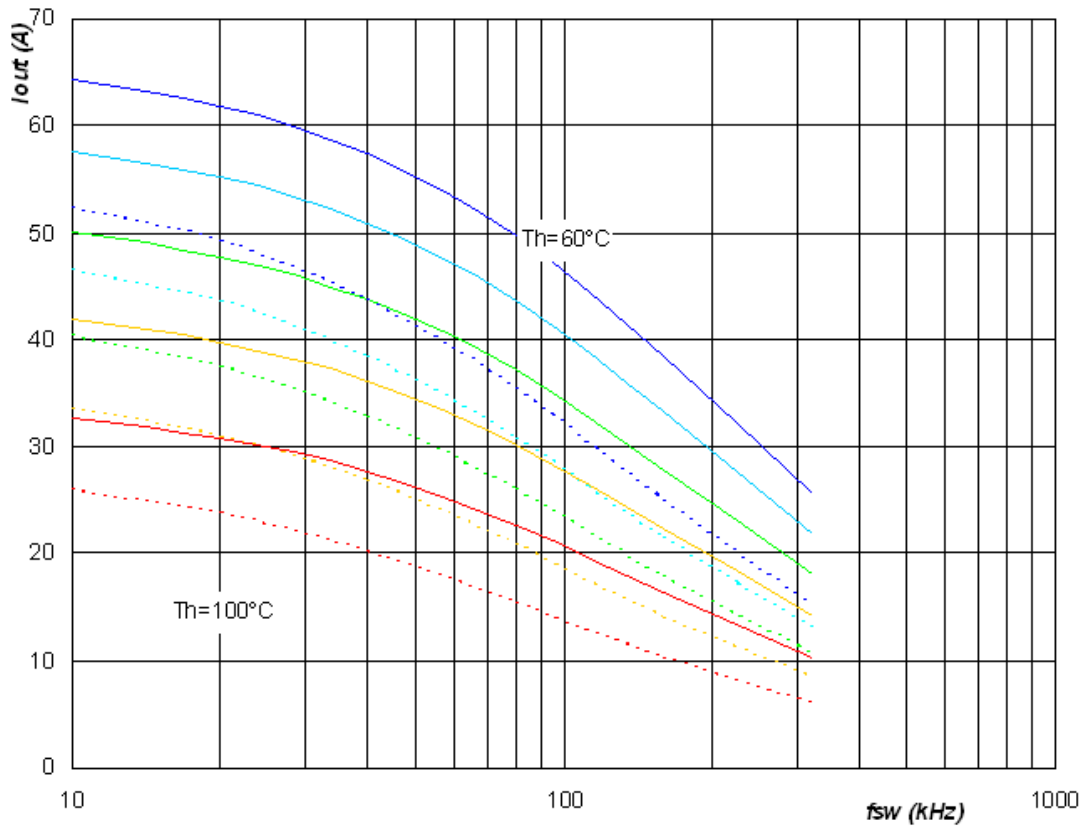


Figure 4: AlN vs. Al<sub>2</sub>O<sub>3</sub> substrate  
 Typical available current at T<sub>j</sub> = 125 °C as function of frequency  
 (parameter: heat sink temperature)

- continuous lines: V23990-P623-F10-PM (AlN substrate)
- dashed lines: V23990-P623-F04-PM (Al<sub>2</sub>O<sub>3</sub> substrate)

### flow0 housing

The flow0 housing features a number of advantages: it is compact (66 mm x 13 mm x 17 mm or 12mm), flexible in pin position and therefore with optimized DCB layout and pin out (DC+ and DC- side by side for low inductive supply) and easy to mount onto the PCB (via clip-in mechanism). For details see Figure 5.

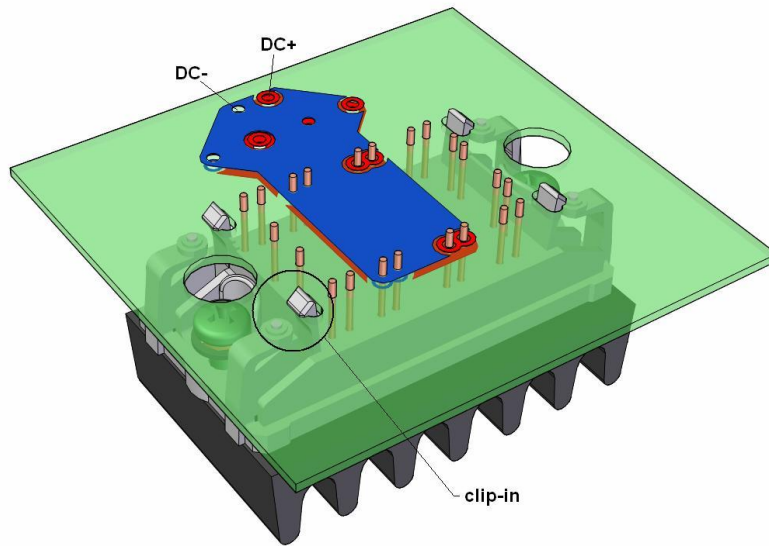


Figure 5: V23990-P62x-PM family with DC+ & DC- side by side in flow0 housing with easy clip-in mechanism

### Conclusion

The *fastPACK 0 H 2<sup>nd</sup> gen* and *fastPHASE 0* families are designed to meet the requirements of today's welding manufacturers: fast switching in a compact design. Single modules cover up to 30 kW; due to the positive thermal coefficient of the IGBTs, chips can also be paralleled in order to achieve higher power. Vincotech also offers the corresponding input rectifier stages in the *flowCON 0* family (V23990-P590-PM and V23990-P600-PM), as well as PFC stages (V23990-P980-PM family).

For more information please contact Vincotech directly.