

fastPACK 0 H 2nd gen & fastPHASE 0

fast switching for welders of ever decreasing size and price

In recent years, size and weight have been playing an increasing role in the design of welding equipment. This is particularly true in the case of handheld equipment, which needs to be light and small enough for the operator to carry. For welders of higher power, size is becoming increasingly important as a cost factor, e.g. in determining the total surface of a production line.

In both cases, the price pressure is high.

By Simon Sidiropoulos, Product Marketing Manager, Tyco Electronics

The fastPACK 0 H 2nd gen and fastPHASE 0 families of power modules are Tyco Electronics' 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. Containing chips of various sizes, these modules cater for almost every need in welding for up to approximately 30 kW. 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.

Part	Configuration	Voltage	Current	Technology	Substrate
P623-F64*	H	600 V	30 A	CoolMOS	Al ₂ O ₃
P623-F74*	H	600 V	30 A	CoolMOS	AlN
P623-F04*	H	600 V	60 A	High Speed IGBT2	Al ₂ O ₃
P623-F14*	H	600 V	60 A	High Speed IGBT2	AlN
P569-F40	Half bridge	1200 V	100 A	Fast IGBT2	Al ₂ O ₃
P569-F50	Half bridge	1200 V	100 A	Fast IGBT2	AlN

*optionally available with internal DC link capacitors (P72x family)

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

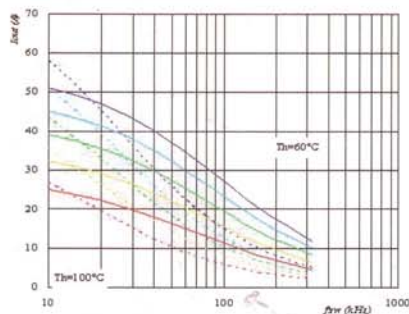


Figure 1: 600V High Speed IGBT2 vs std IGBT3

Typical available current at Tj = 125 °C as function of frequency

- continuous lines: P623-F04 (60 A rating, High Speed IGBT2)
- dashed lines: P624-F24 (75A rating, std IGBT3)

Overview of fastPACK 0 H 2nd gen and fastPHASE 0 modules for welding

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

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 Al₂O₃ substrate for better thermal performance. The P72x modules feature the same layout and components as the P62x family and additionally feature internal DC link capacitors for reduction of Eoff 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. A more detailed simulation for specific cases can be done using flowSIM, the power module simulation tool by Tyco Electronics.

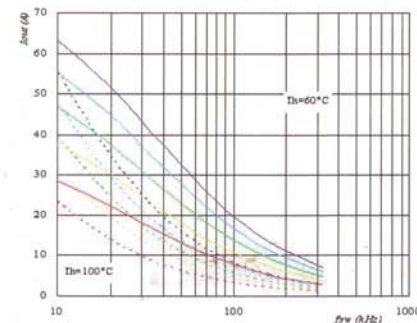


Figure 2: 1200V fast IGBT2 vs std IGBT3

Typical available current at Tj = 125 °C as function of frequency

- continuous lines: P569-F50 (100A rating, Fast IGBT2)
- dashed lines: P569-F30 (100 rating, std IGBT3)

For more information see Bodo's Power Systems, July 2007, pp. 16 – 20.

Component Technology

At 600V, CoolMOS is used for the P622 and P722 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, with less focus on conduction. 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 applications and can be found in Table 2.

600V	1200V
U _{dc} = 320 V	U _{dc} = 600 V
U _{out} = U _{dc} = 320V	U _{out} = U _{dc} = 600V
R _{on} = 4 Ohm	R _{on} = 6 Ohm
R _{off} = 2 Ohm	R _{off} = 6 Ohm
T _j = 125 °C	
I _{outpeak} /I _{out} = 1,3	
T _{amb} = 60 °C to 100 °C in steps of 10 °C	
ZVS	
DC output	

Table 2: Parameters for application examples

As can be seen in Figure 1, for any frequency above 13 kHz to 18 kHz (depending on the heatsink temperature), the High Speed IGBT2 module P623- F04 provides a clear advantage over the even higher rated IGBT3 module P624- F24. At 1200 V, the Fast IGBT2 module P569-F50 performs better than the equally rated standard IGBT3 module P569-F10 for any switching frequency above 10 kHz (Figure 2).

DC link capacitors

The internal DC link capacitors of the P72x family aim at reducing the parasitic inductance and the Eoff losses during switching. The great advantage of capacitors inside the package is the extremely short current path, which would be impossible to achieve with

an external capacitor. As can be seen in the example in Figure 3, the switch-off over-voltage 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 makes the use of lower rated components possible (eg when the peak would exceed 600V in a 600V rated module without capacitors).

The conditions used for the example in Figure 4 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 Al2O3 substrate. The lower temperature rise means that either smaller chips and potentially smaller modules can replace bigger ones, or

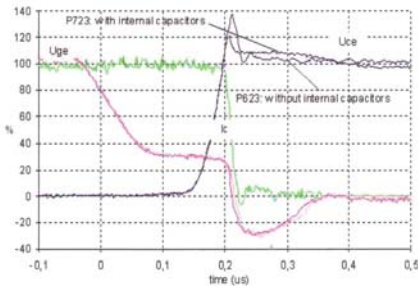


Figure 3: Turn-off characteristics w/o internal capacitors

- light coloured lines: P623-F10 (no capacitors)
- dark coloured lines: P723-F10 (with internal capacitors)

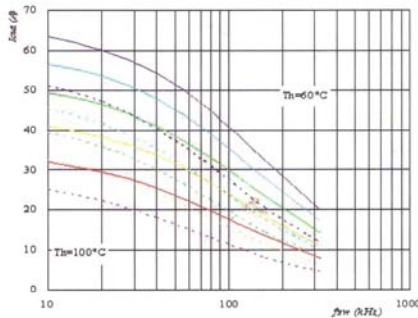


Figure 4: AlN vs Al2O3 substrate
 Typical available current at $T_j = 125\text{ °C}$ as function of frequency

- continuous lines: P623-F10 (AlN substrate)
- dashed lines: P623-F04 (Al2O3 substrate)

that the modules can be driven at a higher switching frequency, thus leading to an advantage in size and price. The 600 V example in Figure 4 illustrates the advantage of a module with AlN, using the conditions in Table 2. The two modules used were P623-F14 and P623-F04, which feature the exact same layout and components, apart from the substrate.

The losses for the two modules are almost identical, which is why the P623-F14 with the AlN substrate is superior to the P623-F04 (Al2O3 substrate) for all frequencies.

flow0 housing

The flow0 housing by Tyco Electronics features a number of advantages for circuit design and handling in production. At 66 mm x 13 mm x 17 mm, this is one of the most compact housings in the market. The flexibility in selecting the pin positions means that the DCB layout and the pinout itself are always optimized for the application in question. In this case, the DC+ and DC- are side by side for low inductive supply and hard switching, common to welding. Furthermore, mounting on the PCB is easy via the simple clip-in mechanism; screws are only needed for mounting onto the heatsink. For details see Figure 5.

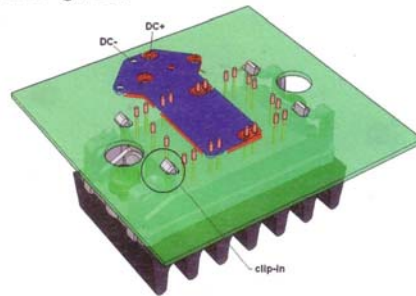


Figure 5: P62x family with DC+ & DC- side by side in flow0 housing with easy clip-in mechanism

Conclusion

The fastPACK 0 H 2nd gen and fastPHASE 0 families are designed to meet the requirements of today's welding manufacturers: fast switching in a compact design. The combination of H-bridge and half-bridge configurations, along with the optional AlN substrate and internal DC capacitors, cover the spectrum of up

to approximately 30 kW output power as single modules. Due to the positive thermal coefficient of the IGBTs used, complete modules or even the individual phases of the H-bridges inside the modules and the modules themselves can be used in parallel, thus supporting even higher power applications. Tyco

Electronics also offers the corresponding input rectifier stages in the flowCON 0 family (P590 and P600 modules), as well as PFC stages (P80x family), also designed for the area of welding.