Dynamic Load-Balancing Press-Pack IGBT for Robustness, Reliability and Ease of Use

For optimum performance of press-pack IGBT devices, it is critical that contact pressure is applied uniformly across the device. Dynex's dynamic load balancing press-pack IGBTs make this easy, ensuring robust and reliable device performance.

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Introduction

Press-pack IGBTs are an alternative to isolated-base wire-bonded plastic modules, relying instead on pressure contacts. The ease with which press-packs can be stacked makes them the device of choice for applications that require series operation. Their ratings typically extend to higher currents than modules and, by using pressure contacts instead of wire bonds and solder joints, they typically benefit from higher reliability. In contrast to wire bonds, which typically fuse and render modules open-circuit in the event of failure, the use of pressure contacts ensures press-packs fail to short circuit. In the event of a high energy failure, their robust housings offer greater rupture resistance than modules [1].

Dynex's press-pack IGBT products employ a number of novel and cutting edge technologies:

- Dynamic load-balancing (DLB) technology maximises safe operating area, gives high reliability and improves ease of use compared to conventional press-pack IGBT designs.
- Silver-sinter bonding applied between the chip and adjacent molybdenum platelets ensures outstanding reliability and improved thermal performance.
- Silicone edge passivation applied to Dynex's press-pack chips and a hermetically sealed housing give robust high voltage blocking performance.
- A dedicated auxiliary emitter connection ensures synchronisation of gate drive signals between chips, mitigating the effects of power circuit di/dt on the driver circuit.

This article will focus on Dynex's DLB technology, how it differs from conventional press-pack IGBT technology and the benefits this offers users in terms of robustness, reliability and ease of use.

Importance of contact pressure uniformity

Uniform distribution of contact pressure is vital to ensure optimum sharing of electrical, thermal and mechanical stresses between the chips in press-pack IGBTs to give the largest safe operating area and the highest reliability. Conventional press-pack IGBTs, comprising a hermetic ceramic capsule housing an array of chip assemblies between rigid copper electrodes, have shortcomings in this respect.

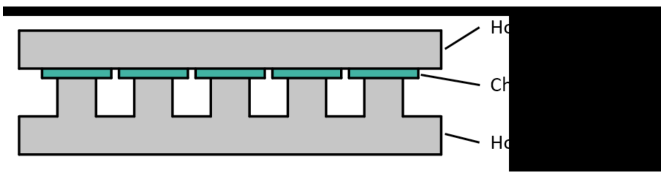

Figure 1: Cross-section of a conventional, rigid press- pack IGBT.

Figure 1 illustrates the basic construction of a conventional press-pack IGBT.

The temperature distribution that exists from chip to case within an operating press-pack IGBT drives differential expansion of the housing electrodes, causing them to distort, as shown in Figure 2. This unbalances the distribution of contact pressure and therefore thermal and electrical contact resistances, across the chips [2], [3], significantly reducing the safe operating area and reliability of conventional press-pack IGBTs. It is impossible to avoid electrode distortion, as a temperature distribution will always exist whilst the device is in operation, therefore, a press-pack IGBT design should employ a mechanism to compensate for electrode distortion.

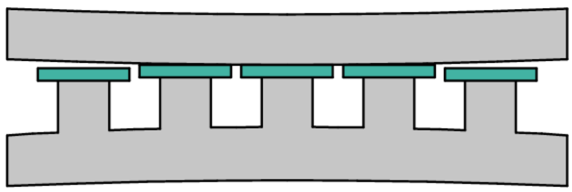

Figure 2: Thermomechanical distortion of a conventional, rigid press-pack IGBT device.

Dynex's dynamic load balancing mechanism (DLB)

Dynex's DLB mechanism replaces the rigid pillars of conventional designs with spring assemblies having far greater compliance. The springs are too resistive to form the primary load current path by themselves, so the DLB mechanism incorporates a novel current bypass mechanism, achieved using a flexible conductive diaphragm, as shown in Figure 3a.

When the device is clamped, the spring assemblies compress to the height of the spring locator plate at a pre-determined force – the threshold force - shown by label 1 in Fig. 3b. The clamping force specified in the product datasheet exceeds the threshold force, with the excess force applied to the support frame. This forces pressure contacts between the diaphragm, spring locator and housing electrode - shown by label 2 in Figure 3b – creating a low resistance current path – shown by label 3 in Figure 3c.

The DLB mechanism compensates for any thermomechanical distortion that occurs, ensuring chips are uniformly pressurised, enabling Dynex press- pack IGBTs to maintain their large safe operating area and outstanding reliability, under all operating conditions.

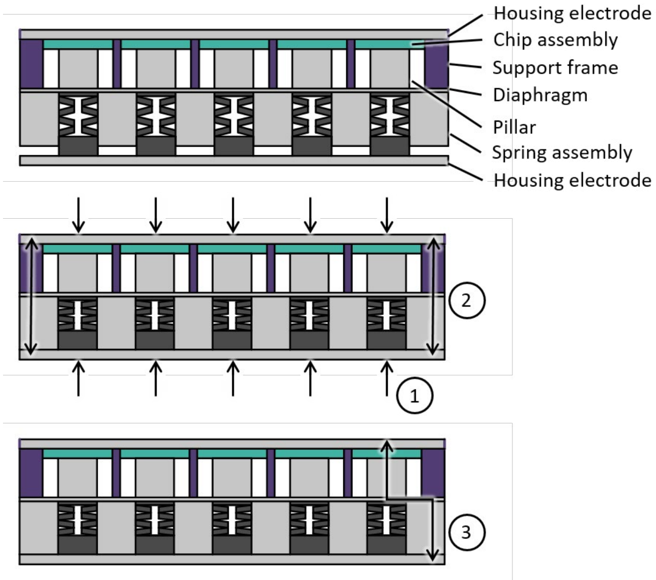

Figure 3: Illustration of the DLB (a) unclamped state, (b) clamped state, (c) current path.

In addition, the DLB mechanism gives users two further advantages. First, the enhanced mechanical compliance of the device means that heatsinks typically used with thyristors can be used and that onerous flatness tolerances required when using conventional, rigid press-pack do not need to be applied, reducing assembly costs. Second, chips in a Dynex DLB press-pack are protected from over-pressurisation – a risk with conventional press-pack IGBTs - providing extra flexibility in stack assembly procedures, where short-term over-clamping may be required.

Safe operating area robustness

Safe-operating area ratings for Dynex's 4.5kV press-pack IGBT range permit operation with line voltages up to 3.4kV and guarantee the capability of the IGBT to turn off over-currents of up to twice the product's rated current.

The products have ultimate capabilities far exceeding their datasheet ratings. To illustrate the robustness of Dynex's press-pack IGBTs, the following examples are given. Figure 4 shows a Dynex 2.1kA, 4.5kV press-pack IGBT (DPI2100P45A5200) turning off 7.4kA – 3.5 times its rated current - at a line voltage of 3.4kV and a junction temperature of 125°C. Figure 5 shows the same product withstanding a type-1 short-circuit test performed at a line voltage of 3.4kV and a junction temperature of 125°C for a duration of 40µs – 4 times industry standard. Figure 6 shows a Dynex 1.6kA, 4.5kV press-pack IGBT (DPI1600P45C3616) withstanding a type-1 short-circuit test with a gate-emitter voltage of 18V, at a line voltage of 3.4kV and junction temperature of 125°C.

Dynex press-pack IGBT product range

Dynex is able to supply press-pack IGBTs with a range of industry-standard contact diameters from 34mm to 150mm and current ratings from 120A up to 3000A at 4500V. An integrated research and development and manufacturing facility enables chips and devices to be tailored to customers' applications. Their ease of use, high reliability and robustness has made Dynex press-packs the product of choice

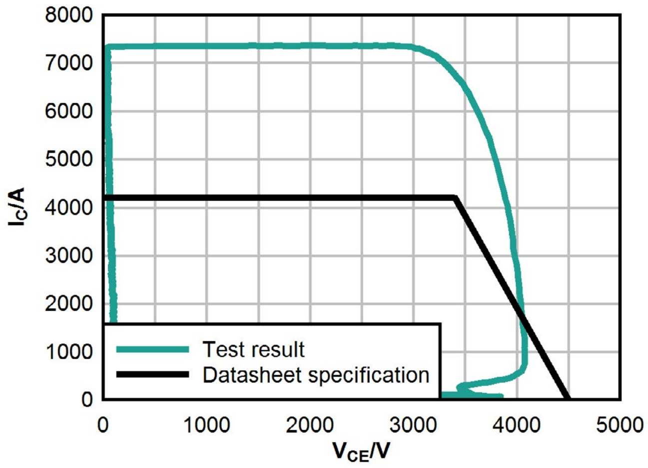

Figure 4: IGBT RBSOA robustness - successful turn-off of 7.4kA by a 2.1kA, 4.5kV device.

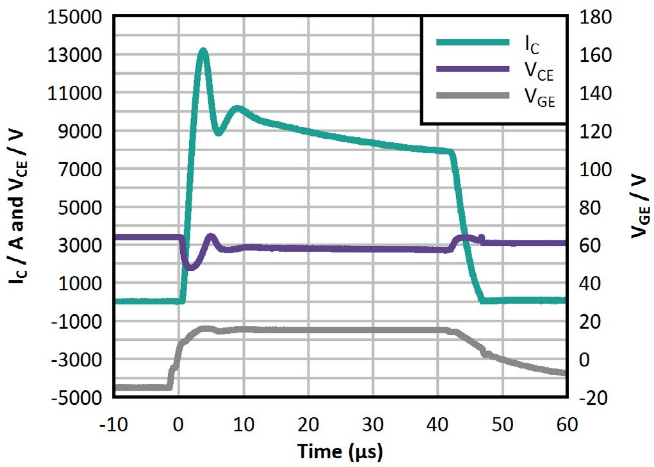

Figure 5: IGBT SCSOA robustness – a 4.5kV, 2.1kA device surviving a 3.4kV, 40µs short-circuit test.

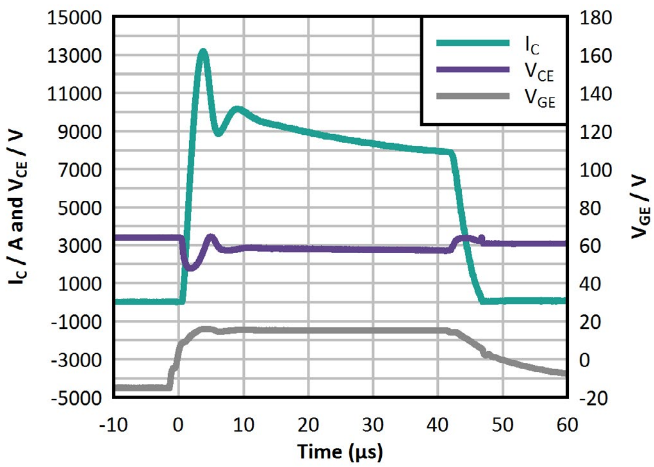

Figure 6: IGBT SCSOA robustness – a 4.5kV, 1.6kA device surviving a 3.4kV short-circuit test with a gate-emitter voltage of 18V.

for a variety of applications, including HVDC and medium voltage drives. Interested parties should contact the factory with their requirements.

Conclusion

Press-pack IGBTs are an enabling technology for high current, high reliability applications. Dynex's dynamic load balancing technology elegantly overcomes the challenges in ensuring the application of uniform contact pressure, giving Dynex's press-pack IGBTs outstanding robustness and reliability and making them easier to use than conventional designs.

References

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