Smart Solutions for the Next Generation of Power Electronics Systems

The XHP™ 2 package from Infineon Technologies AG is designed for future-oriented power electronics systems. It addresses the needs for scalable and low inductive inverter designs and can handle blocking voltages up to 3.3 kV.

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Technical concept

The existing XHP™ 3 has been designed for blocking voltages from 3.3 kV up to 6.5 kV addressing new designs in traction applications. As an additional member of the XHP™ package family, the 1700 V XHP™ 2 has recently been introduced. In Figure 1 the XHP™2 package and the half-bridge topology is depicted.

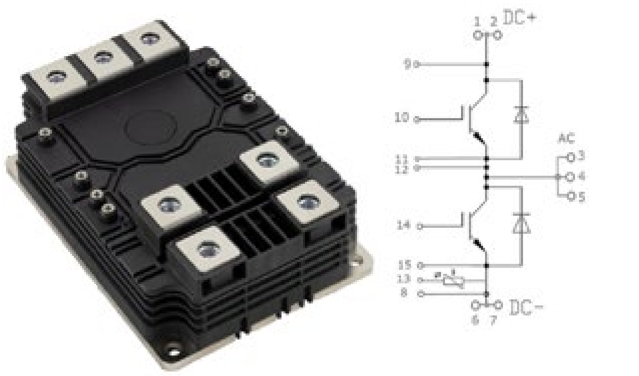

Figure 1: Typical appearance of XHP™2 from Infineon Technologies AG

The fleXible High power Platform XHP™ has been developed for applications like traction converters, renewable energy, and industrial drives [1]. To support this future orientation, three AC power terminals have been embedded to ensure high current carrying capabilities, and to minimize the losses in the power connection that are to be consumed by the application design.

The 1700 V XHP 2 module generation makes use of the latest and most rugged 5th generation IGBT and emitter-controlled diode from Infineon Technologies with its .XT joining technology [2, 3]. This combination makes the power device extremely robust against cycling loads [4].

Employing the state-of-the-art 5th generation IGBT and diode technologies from, the maximum module current for the 1700 V XHP 2 has now been further increased up to 1800 A / 1700 V with a continuous junction operating temperature $T_{vj,op}$, of 175°C. In addition to the 1800 A version, an XHP 2 with 1200 A / 1700 V will also be available.

The 5th generation of the IGBT and the diode have demonstrated their ruggedness in the PrimePACK™ module. In the XHP the size of the diode and the IGBT are well-balanced ensuring a sufficient lifetime of the diode in a traction mission profile. This provides optimal performance in traction but also in wind turbine applications.

Similar to the XHP 3, the XHP 2 features a strip line concept inside the module. This ensures very low inductivity in the DC bus bar. As the DC connection is located at the center of the module, a symmetrical design has been implemented. The resulting inductance of the power module of less than $L_s \leq 10nH$ in the commutation loop results in a small overvoltage peak. In Figure 2, an example of a turn-off event of the 1700 V XHP 2 with I_C=1800 A at U_{DC}=900 V and room temperature is depicted. The measurement shows an overvoltage of only ΔU_{CE_Peak}=320 V under these conditions.

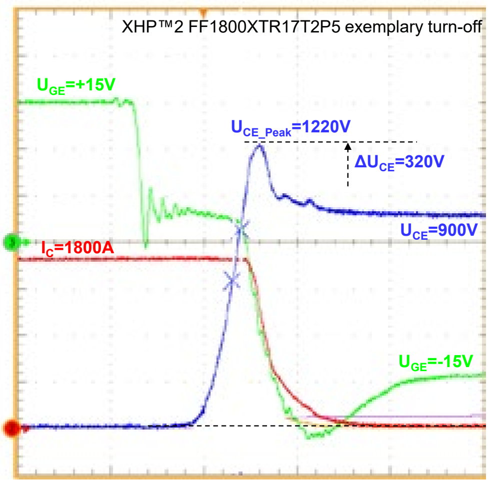

Figure 2: Example of turn-off event at IC=1800 A; 900 V and room temperature

With the smart combination of features such as package platform, highest power density, rugged .XT joining technology and excellent cycling capabilities as well as balanced 5th generation chip sizes, the XHP 2 package from Infineon Technologies AG addresses the needs of the next generation of propulsion converters in urban transportation systems [5].

Performance under heavy cycling conditions

While driving or accelerating the vehicle, the energy in the converter is conducted mainly by the IGBTs. When the vehicle brakes, the freewheeling diodes (FWD) of the converter have to conduct the generated reverse energy. A simple schematic of the electrical propulsion system is shown in Figure 3.

A typical tram stops after a few 100 meters, while a metro or subway stops at a typical distance of 1000 meters. These short distances in day-to-day operation result in an enormous stress. In particular, the power modules with their IGBTs and diodes in the electronics circuits of the converter have to withstand heavy electrical and mechanical stress and enormous cyclic thermal stress in daily operation. Figure 4 shows an example of the deployment profile of an electric drive system of a subway.

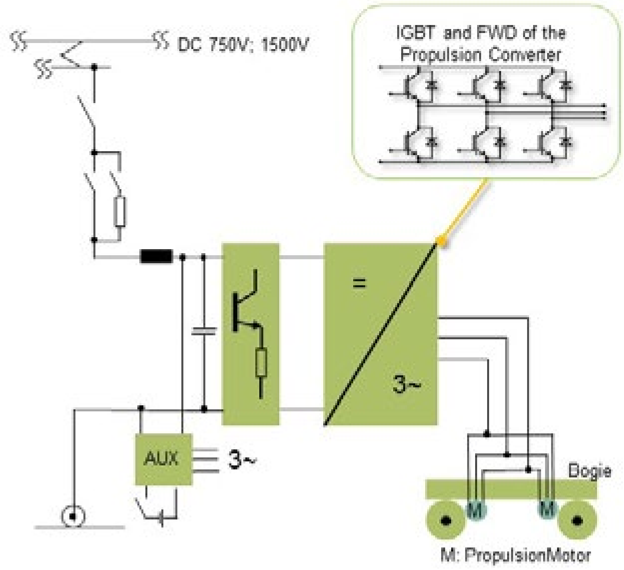

Figure 3: Schematic of electrical propulsion system

The major criterion for the long-term reliability or required lifetime of power modules is the capability to withstand these cycled thermal loads. The dominant end-of-life (EOL) mechanisms for standard joining technologies in such demanding applications include solder degradation and the lift-off of the aluminum-bond wires of the chip-joining connection. These die interconnections are highly stressed by the relative temperature swing ΔT at the resulting junction operating temperature $T_{vj,op}$ as well as by the duration of the thermal stress (ton).

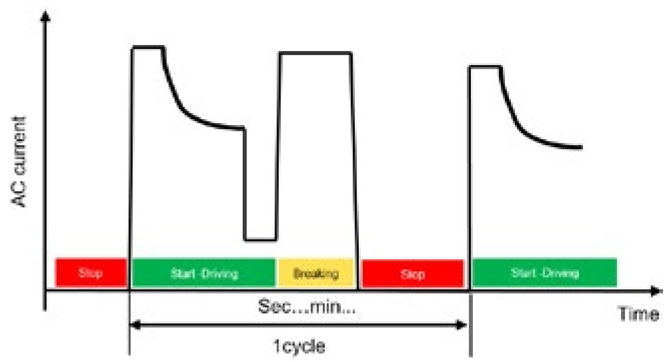

Figure 4: Generic metro mission profile

Owing to these challenging requirements, the power modules used nowadays are typically oversized. The modules are either bigger than required, or smaller ones are used in parallel to reduce the thermal loads and fulfill the high lifetime demands. As a consequence, IGBT modules in typical traction inverters are operated with junction temperatures significantly lower than the specified maximum temperatures. Thus, the full potential in terms of current density is not utilized.

To achieve smarter, tailor-made solutions in the power converter, the typical end of life mechanisms must be significantly improved or even eliminated to extend the running times. If the end of life can be extended, the current derating due to lifetime constraints can be reduced, and the RMS current can be increased. To quantify this effect, an XHP with IGBT5 and .XT has been compared to an IHM module with IGBT4 and standard joining technologies. Figure 5 depicts the simplified result of a lifetime comparison using a metro mission profile. For the implementation of a 30-year lifetime, two 1700 V IGBT4 IHM modules in parallel are required. Using IGBT5 and .XT in XHP 2, only one 1200 A/1800 A 1700 V XHP 2 module can achieve a similar lifetime.

Urban propulsion converter designs based on XHP 2 modules will benefit from the significant advantages of using Infineon Technologies AG new XHP 2 equipped with the 1700 V IGBT5/.XT. Among other things, power density can be increased drastically using the new technologies.

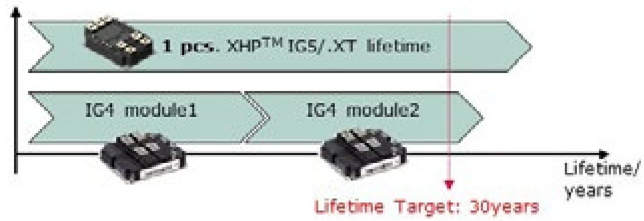

Figure 5: Simplified lifetime estimation based on a metro mission profile in an air-cooled propulsion system

Summary

Infineon Technologies AG has introduced a new XHP 2 with IGBT 5 and .XT. This combination provides system designers with the option of developing future-proof, scalable, low inductive systems with highest power density. Moreover, traction inverters can be harmonized with the XHP across various vehicle platforms and voltage classes. The field-proven IGBT5 and .XT technology is a key lever for increasing power density in applications, which demand long life cycles such as traction. The technology enables significant weight and volume reductions, and consequently, a reduction of system costs.

References

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