Bodo´s Power Systems®

Trench XPT IGBT for Maximum Energy Delivery

With the introduction of the 650V Trench XPT IGBT technology IXYS sets a milestone in energy efficiency providing a best in class solution for IGBTs, by combining an innovative and unique trench gate architecture with well-established XPT (eXtreme light Punch Through) thin wafer technology. With its transparent emitter design and a newly applied technology of precisely controlling the injection efficiency IXYS has successfully developed this new IGBT technology resulting in measurable advantages to latest trench devices available on the market.

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In 2008 IXYS successfully introduced the 1200V XPT planar portfolio followed by the expansion to a broad 650V XPT planar product line in 2010. Continuous improvements of the device performance are targeted to follow the high efficiency demands in hard switching applications. The 650V range, rated to a maximum junction temperature of 175°C is selected as a carrier product portfolio for this new trench gated XPT IGBT because of the increased demand in the 650V market. This increased popularity is mainly caused by the popularity growth of the Neutral Point Clamped (NPC) configurations. In general customers are interested in the efficiency benefit of the NPC inverter topology.

For optimal usage the NPC configuration requires different switches which are optimized for different frequencies. Therefore the new Trench XPT IGBTs are available in medium and fast speed versions. XPT IGBTs are performing best when using a SONIC Free Wheeling Diode (FWD). The SONIC portfolio is also optimized to serve these different speed classes. A new edge termination design for the 650V SONIC, medium (low Vf) and fast (high speed), diodes has been introduced ensuring high thermal stability and reliability at 175°C. For extremely demanding applications an extra step in efficiency can be made using a Silicon Carbide (SiC) Free Wheeling Diode. The product Trench XPT IGBT portfolio will thus be offering both Silicon and SiC FWD options as standard products.

The new Trench XPT IGBTs offered by IXYS show a milestone improvement in trade off performance compared to the latest competitor trench IGBT devices available on the market. This is proven in comparative trade off measurements of the normalized turn off losses (Eoff) versus static losses (VCE(sat))as shown in figure 1. The Trench XPT devices with comparable Vcesat values to competitor parts show a significant reduction in turn off losses of approximately -25% leading to best in class devices. The medium speed class of Trench XPT devices show an even more drastic turn off loss reduction of almost -40% with only a marginal (4%) higher value in VCE(sat).

XPT Characteristics

IXYS' XPT IGBT was designed to provide low switching losses while retaining low on-state voltage. This was achieved with improved SOA and short circuit ruggedness ratings. The output characteristics at different temperatures are shown in Figure 2.

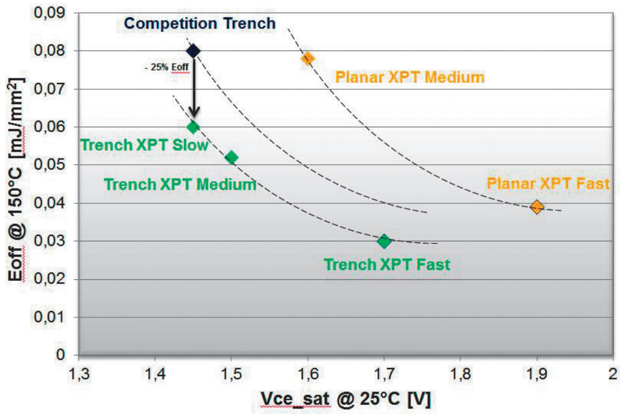

Figure 1: Trade off comparison, 650V IGBTs

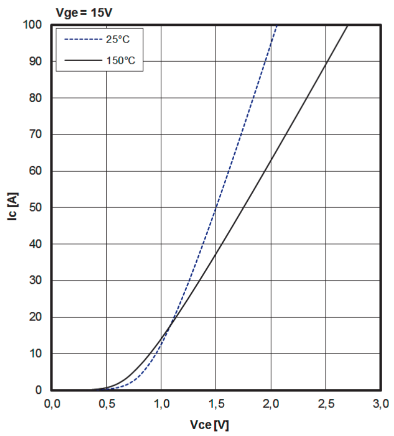

Figure 2: Trench XPT output characteristic

The Trench XPT has a low VCE(sat) (1.5V @Inom,25°C & 1.75V @Inom, 150°C). The positive temperature coefficient of the Trench XPT provides a negative feedback, making the XPT suitable for paralleling in modules or circuits. In addition to the low VCE(sat) the Trench XPT also has a low off-state leakage current at 150°C (<100µA @650V). The switching characteristics of the 50A, 650V Trench XPT are shown in figures 3 & 4.

As can be seen in figure 3 the current waveform has a smooth switching behaviour reducing EMI and resulting in small over voltage transients. The linear voltage rise and short tail current during turn-off, leads to reduced losses (Eoff = 1.2mJ). The Trench XPT has a low gate charge (Qg = 95nC @15V), requiring lower gate drive power when compared to other standard trench IGBTs.

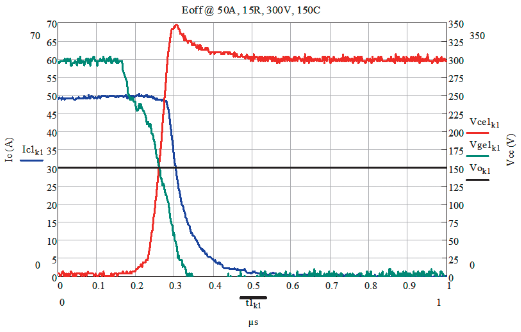

Figure 3: Trench XPT turn-off characteristic

XPT and SONIC – the perfect match

The latest 650V Trench XPT generation has a higher maximum junction temperature of Tjmax=175°C. Consequently an improved complimentary fast recovery diode design was developed utilizing p-doped guard rings, with new metal field plates and an optimized passivation layer termination structure; allowing for a higher junction temperature up to 175°C. The optimal match for reduced turn-on losses is achieved when the 650V Trench XPT with its higher current density is used alongside the metal field plate IXYS Sonic diode which also has a low on-state voltage with excellent temperature behaviour. The Sonic diode has soft recovery characteristics, which allows the Trench XPT to be turned on at very high di/dt's even at low current and temperature conditions where usually diode snappiness can occur. The Sonic diode retains soft switching behaviour during turn-off of freewheeling currents nullifying EMI problems.

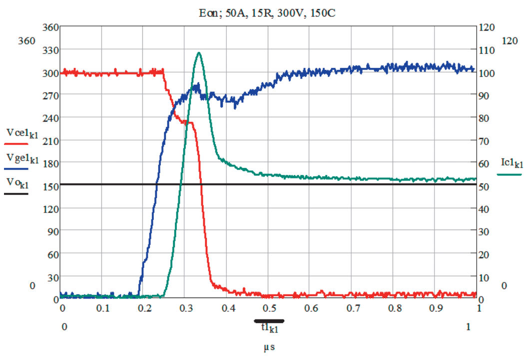

Figure 4: Trench IGBT turn-on characteristic

Sonic diodes combine a low reverse recovery current along with a short reverse recovery time, as shown in figure 4 to minimise the turn-on energy of the Trench XPT (Eon = 1.3mJ). The Sonic diode Vf is less sensitive to temperature resulting in better suitability for parallel operation of diodes and minimizing switching losses.

Rugged XPT Characteristics

The IGBT behaviour under short circuit conditions is a very important issue relating to motor drives applications and the IXYS XPT IGBT has shown extremely rugged performance during short circuit testing. The chip design was optimised with a low forward transconductance, therefore providing an approximate short circuit current of 4x nominal current to ensure robust short circuit performance.

Figure 5 shows the 50A, 650V Trench XPT during short circuit with a gate voltage of +/-15V at 150°C for 10µs. Characterisation of the Trench XPT technology showed extreme ruggedness during short circuit of the device at elevated voltages and temperatures for 10µs without any detriment to the IGBT characteristics. The Trench XPT has a square RBSOA at 650V up to two times nominal current at very high temperatures (150°C).

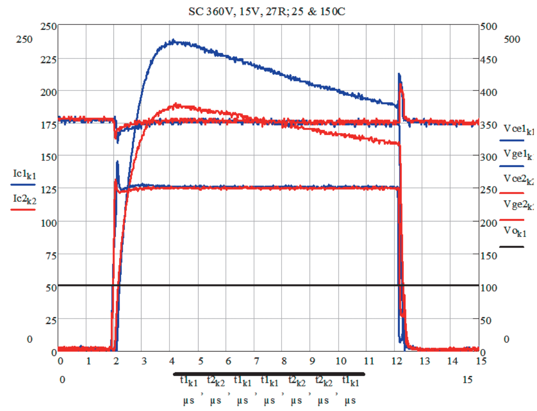

Figure 5: Trench XPT IGBT short circuit characteristic

Trench XPT & SONIC Reliability Assurance

Due to the increase in the maximum junction temperature (Tj max) of the 650V Trench XPT the following quality tests were accordingly verified; High Temperature Gate Bias (HTGB), High Temperature Reverse Bias (HTRB) and Humidity. Correspondingly the new improved metal field plate SONIC diode design was also verified according to increased HTRB and Humidity tests. Both of the new chip designs demonstrated outstanding stability and ruggedness with regard to elevated junction temperature and tough environmental conditions.

Product availability

More detailed information about the Trench IGBTs is displayed in the datasheet of the available devices. These are accessible under www.ixys.com. See figure 6 for an overview of a few selected Trench IGBT discrete and module products; please notes that the package and current specification influences the VCE(sat) value.

Part Number	V_{ces} [V]	$I_{c\_110/80°C}$ [A]	V_{ce_sat} [V]	E_{off} [mJ]	R_{th_jc} [K/W]	Conf.	Speed class	Package
IXXH30N65B4	650	30	1,66	0,60	0,65	Single	Medium	TO-247
IXXH60N65C4	650	60	1,80	0,93	0,33	Single	Fast	TO-247
IXXH60N65B4H1	650	60	1,70	1,34	0,33	Copack	Medium	TO-247
MIXD80PM650TMI	650	82	1,50	1,8	0,55	Multi Level	Medium	MiniPack2B
IXXN110N65B4H1	650	110	1,75	1,40	0,17	Copack	Medium	SOT-227B
IXXX160N65B4	650	160	1,54	2,36	0,16	Single	Medium	PLUS247
IXXK200N65B4	650	200	1,40	2,54	0,13	Single	Medium	TO-264

Figure 6: Selected overview of the Trench XPT Portfolio

Herewith the measurable advantage of the Trench XPT IGBT is shown compared to existing Trench and Planar technologies. Directly compared with the competitor Trench devices the Trench XPT IGBT gives a ~ 25% Eoff benefit. Therefore IXYS with its Trench XPT IGBT technology combined with the SONIC diode sets a new milestone in energy efficiency.

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