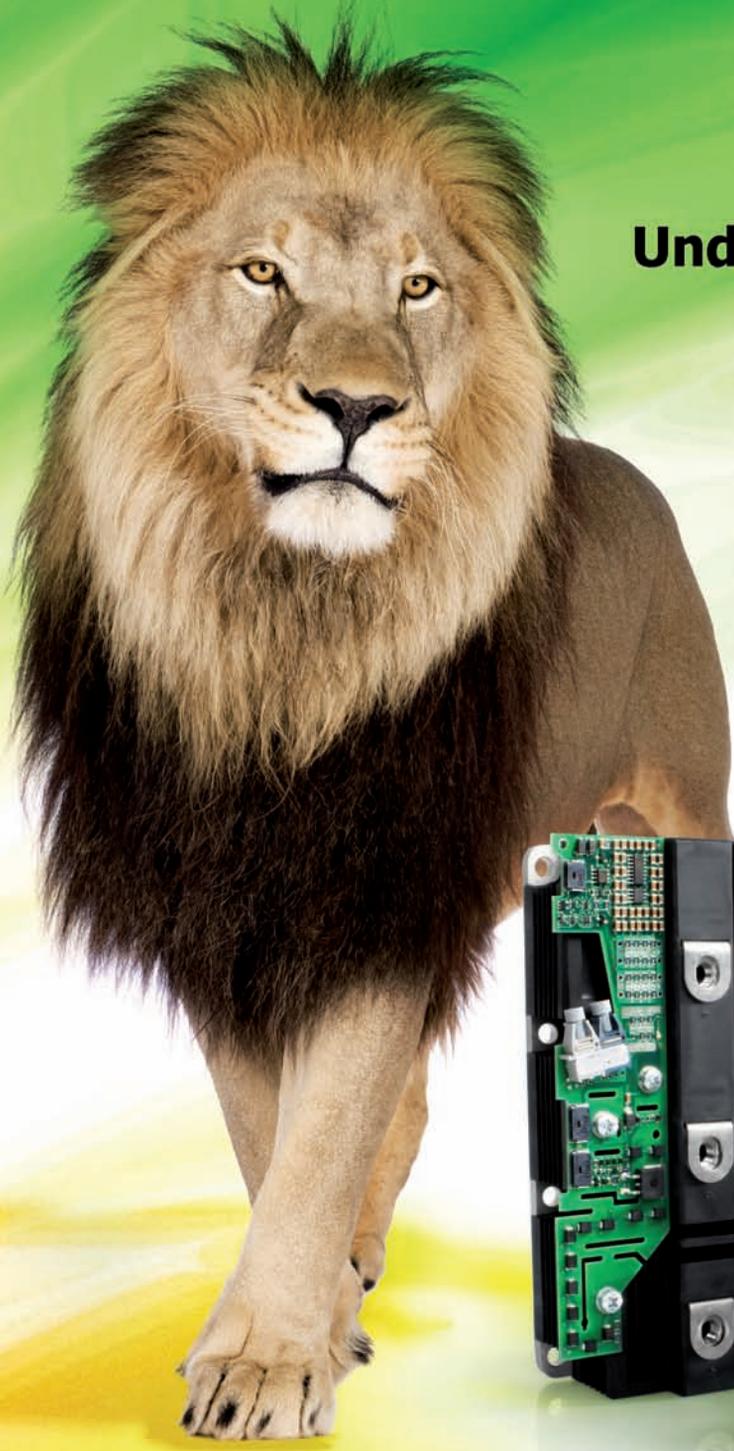


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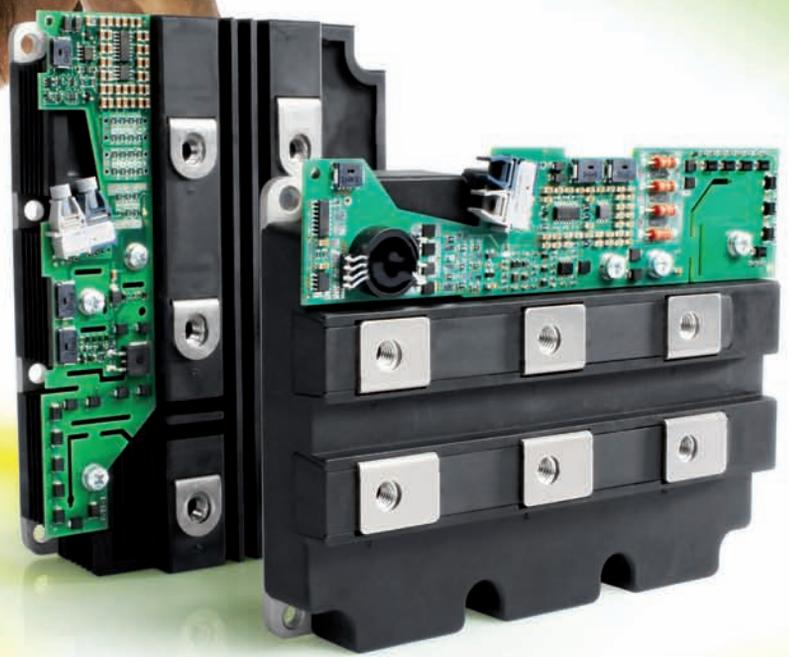
Electronics in Motion and Conversion

May 2010



Undisputed Competence

SCALE-2 Driver
for High Power IGBTs



Easy Parallel Connection of IGBT Modules at the Next SCALE Level

A Unified Direct Paralleling Approach Applied to IGBT Voltage Classes 1.2 to 6.5kV

The SCALE-2 implementation of high-voltage and high-power IGBT gate drivers offers competitive advantages such as a dramatically reduced component count, exceptional cost performance and wide application and topology diversity: from single-switch to parallel connection within multi-level converters for industry and traction applications, renewable energy and HVDC power transmission.

*By Jan Thalheim, Olivier Garcia, Sascha Pawel, Heinz Rüedi,
CT-Concept Technologie AG, Switzerland*

The goal of high efficiency drives modern power converters to greatly increased complexity and highly optimized solutions at different power levels. Reuse or re-targeting of building blocks can increase design productivity and offers a solution to decreasing time-to-market while in particular meeting increasing diversity and complexity. As a consequence, the SCALE-2 driver chipset [1] offers the option of easily scaling the converter power by direct parallel operation of standardized subsystems composed of IGBTs and dedicated gate drivers [2].

Plug-and-Play Drivers for High-Power and High-Voltage IGBTs

Thanks to SCALE-2 technology, the new 1SP0635 and 1SP0335 families comprise highly integrated, high-performance, complete and extremely compact single-channel

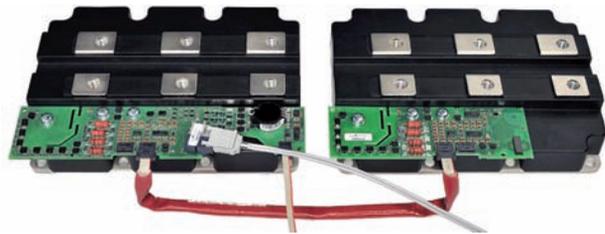


Figure 1: SCALE-2 Plug-and-Play driver 1SP0635 for 1200V to 3300V IGBTs

IGBT drivers equipped with DC/DC converters, short-circuit protection, Advanced Active Clamping, regulated turn-on gate driving voltage, and supply-voltage monitoring. Users need only mount them onto the corresponding IGBT module. The system can then be put into immediate operation with no further development or matching effort.

These new drivers are perfectly matched to 130 x 140mm and 190 x 140mm IGBT modules from various manufacturers. The 1SP0635 is designed for a voltage class of 1200 to 3300V and a current range up to 3600A. See Fig. 1.

The similar 1SP0335 gate driver (Fig. 3) focuses on 3300V modules with 10.2kV isolation voltage as well as 4.5kV and 6.5kV modules and uses the ISO5125I new dedicated external DC/DC converter for up to 5W gate power.

Direct Paralleling by Means of a Master-Slave Architecture

Furthermore, these drivers offer a master-slave architecture allowing direct paralleling of IGBTs by simple means, see Fig. 2. The master is equipped with a fiber-optic interface and global fault management.

The slaves are connected to the master by a bus cable which distributes the common command signal and the secondary-side supply voltages for the DC-DC converter.

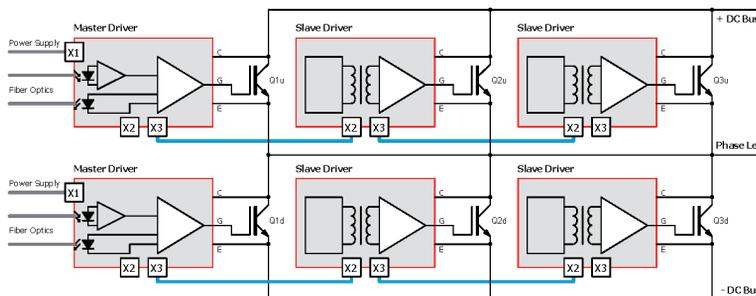


Figure 2: Driving parallel-operating IGBTs with individual drivers

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Thanks to the extremely low jitter and negligible variance of propagation delay of the SCALE-2 chipset, all IGBTs operate at virtually the same gate-driving voltage. The main advantage over the use of a central gate driver is the unlimited and easy scalability for a wide range of applications and power levels at optimum performance.

High Performance at Lowest Cost

A particular advantage is the optimum scaling of the Advanced Active Clamping function which enables full utilization of single-switch performance within a parallel connection of IGBTs. Application specific integrated circuits (ASICs) are used here because they reduce system complexity and therefore lower manufacturing costs while increasing reliability and system performance. It is the strength of CONCEPT as an independent and highly experienced gate-driver supplier for medium and high-power applications to overcome the obstacles of monolithic integration in this highly specific market by means of broad application coverage and a large combined quantity of drivers delivered to a wide variety of customers.

Combined with the inherently correct scaling of driver output stages and supply capacitors, the master-slave architecture offers

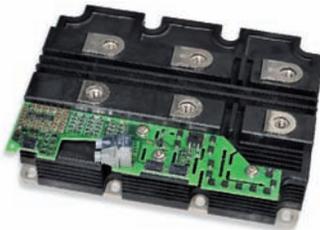


Figure 3: SCALE-2 Plug-and-Play driver 1SP0335 for 3300V to 6500V IGBTs

superior total-cost-performance ratio of the overall system.

Relevant cost reduction also results from a dramatic reduction of time-to-market, development effort and production cost compared to custom-specific low-volume IGBT drivers.

Maximum Utilization and Extended Safe Operation by Advanced Signal Processing

The architecture of the master and slave gate drivers is shown in Fig. 4. The new plug-and-play drivers introduce the following application advantages:

- Dynamic Advanced Active Clamping DA²C temporarily allows extremely high DC-link voltages. This is a particular advantage for traction, windmill and solar converters.
- Dynamic short-circuit detection to protect the IGBTs fully from any kind of short-circuit at any level of DC-link voltages while fully utilizing the collector current capability of both slow conduction-loss optimized and fast-switching IGBTs.
- Centralized monitoring of gate-emitter voltages of all individual drivers by the master to ensure correct parallel operation.

A Reliable and Long-Term Available Component

The SCALE-2 implementation offers competitive advantages such as exceptional cost performance, long-term availability and tried-and-tested SCALE technology. The chipset has been developed on the basis of two independent semiconductor processes (true second source) while retaining full functional and parametric compatibility.

In spite of increased functional complexity compared to the similar 1SD536F2 SCALE driver, the overall component count and the estimated failure rate are reduced through an exceptional level of integration achieved with the SCALE-2 chipset.

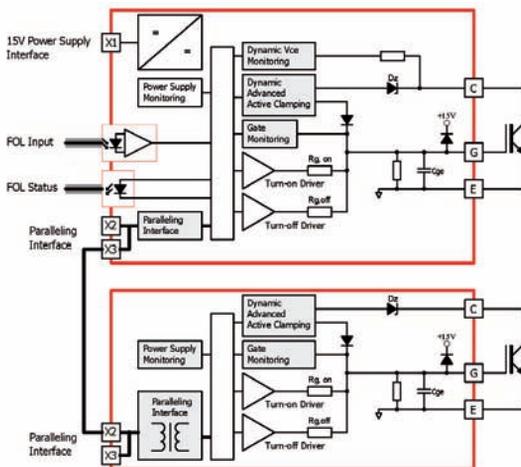


Figure 4: Master slave architecture of SCALE-2 Plug-and-Play driver 1SP0635

Beyond that, a long service life and safe operation are achieved thanks to increased thermal and gate current capability at high ambient temperatures and superior EMI immunity.

Outstanding signal integrity has been achieved by using PCB-integrated inductances within the power supply buses and differential 15V CMOS logic signal processing using planar transformers [3] to decouple the individual IGBT gate and emitter potentials during collector current redistribution. This decoupling ensures safe signal transfer even under extreme conditions such as severely asymmetric operation (e.g. as a consequence of failure), extremely high dV/dt and di/dt or dH/dt , or a command change during a switching transition.

Clearance and creepage distances comply with both IEC 60077-1 and EN 50178 for pollution degree 2 and overvoltage category 2. The paralleling bus interface is realized by a miniaturized high-reliability connector system which is used in the widest range of applications in automotive, industrial and medical sectors to achieve high vibration and shock-load capability as well as broad temperature capability.

To satisfy the requirements of multi-level converter topologies, the external ISO5125I DC/DC converter is available in different versions up to a specified operating voltage of 12kV (partial discharge extinction voltage above 9.4kV AC to IEC 61287).

Experimental verifications and field data gathered from products shipped in large item numbers since 1999 have shown no critical impact of the IGBT baseplate and junction temperature on gate-driver reliability for typical industrial and traction applications.

Assuming that the degradation of optical output power is the main failure criterion, the estimated lifetime of the fiber optic transmitter for a surface temperature of 85°C is above 208'000 hours, which is more than 23 years of permanent operation. (Based on time performance according to manufacturer data).

Superior Switching Behavior

The easy adaptation of the drivers permits an optimum setup to handle the special demands of a wide range of applications.

Synchronous switching of two parallel operating FZ1500R33HE3 IGBT modules from Infineon is shown in Figs. 5 to 6.

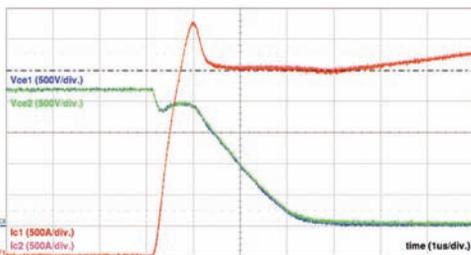


Figure 5: Turn-on of two parallel-operating IGBTs with 1SP0635

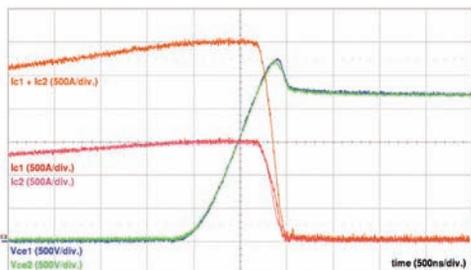


Figure 6: Turn-off of two parallel-operating IGBTs with 1SP0635

The SOA compliance has been verified for a collector current of up to twice the nominal current, and under short-circuit conditions for a junction temperature up to 150°C and a maximum permitted DC link voltage VDC of 2200V.

Worst-case conditions for the active clamping effect have been verified by setting the temperature of the active clamping circuitry to 125°C, but the IGBT junction temperature to 25°C. Thanks to the advanced driver architecture with integrated active clamping, IGBT operation is kept within the safe operating area with a sufficient margin up to a total DC link inductance of 180nH.

For 1700V IGBTs, the maximum DC-link voltage is specified to 1200V and may be increased up to 1450V and beyond in the off-state by DA°C to enhance the safety margin for traction, wind and solar power applications.

For the 6.5kV version of the 1SP0335, the maximum permitted DC link voltage for permanent switching is 4450V. In the off-state, the DC link voltage may approach 5240V.

This exceptional performance is made possible by keeping the MOS channel conducting during turn-off. The feedback signal is applied to both the driver input and the IGBT gate to improve the efficiency of the active clamping devices. This tried-and-tested architecture has become a virtual standard ever since CONCEPT presented a plug-and-play driver solution for a high-voltage IGBT for the first time ten years ago [4].

A total gate drive capability of 6W is available for the 1SP0635, which allows the parallel operation of three 3.3kV / 1500A modules connected in parallel operating at more than 1500Hz. The single IGBT gate drive capability is limited to 3W and 35A. The 1SP0335 also allows the connection of more than one external ISO5125I DC/DC converter to increase the available total gate power. The operating ambient temperature range of the driver is defined as -40°C to 85°C.

Customized Solutions

Plug-and-play drivers are also offered in customized versions for applications produced in volume quantities.

For example, an option will be available to separate the master from the IGBT module. This will allow the system lifetime to be further increased by reducing the ambient temperature of the fiber-optic transmitter, which may be advantageous for ambient temperatures above 60°C (depending on the mission profile). Customizing of dynamic short-circuit detection is also available upon request.

Pricing and Availability

The pricing of the drivers is very competitive, thanks to the exceptional level of integration achieved with the SCALE-2 chipset. In spite of increased functionality compared to the similar SCALE driver 1SD536F2, the price level is 40% lower.

The drivers are now being shipped in sample quantities.

Volume production is planned to start in Q3 and Q4 2010 for the 1SP0635 and 1SP0335 respectively.

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