

## Application Note

## Do's and Don'ts with SCALE™-2 Gate Drivers

### SCALE™-2 IGBT Driver Cores and Plug-and-Play Drivers

#### Introduction and Overview

This Application Note highlights important points that must be considered when using SCALE™-2 driver cores as well as plug-and-play drivers. It complements Application Note AN-1101 /1/.



Fig. 1 Examples of SCALE-2 gate drivers

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### Fast SCALE-2 Technology

SCALE-2 has been developed as a fast, precise and reliable technology to enable – among other features – high switching frequency and low jitter.

However, these advanced properties can have drawbacks in some applications if basic measures are not considered. If excessive magnetic fields are injected into the primary-side electrical cable or into the transformer interface, random IGBT/MOSFET switching may be generated, as the driver will respond quickly to these signals.

Some measures must therefore be taken to avoid such problems:

- The signal integrity of the driver's input signals must be checked properly. The signals must not contain high noise levels or strong oscillations. The signal edges must be fast if low jitter is required (refer to the respective product data sheets for more information /3/).
- The primary-side driver cable must be placed in locations free from strong magnetic fields. See also the section "Use of Electrical Cables in Front of Driver Cores or Plug-and-Play Drivers" for recommended cable types.
- The driver placement, especially in case of driver cores, must be selected properly. Strong magnetic fields must be avoided close to several products. Please refer to Application Note AN-1101 /1/, section "Driver placement on top of 17mm IGBT modules or close to high magnetic fields" for more information.
- The fiber-optic links must be free from contaminations and be properly connected to their connectors. Otherwise, weak light signals or natural light may lead to random driver switching. If driver channels using fiber-optic inputs are powered, but not used, their fiber-optic receivers must be properly closed to avoid random IGBT/MOSFET switching due to natural light.

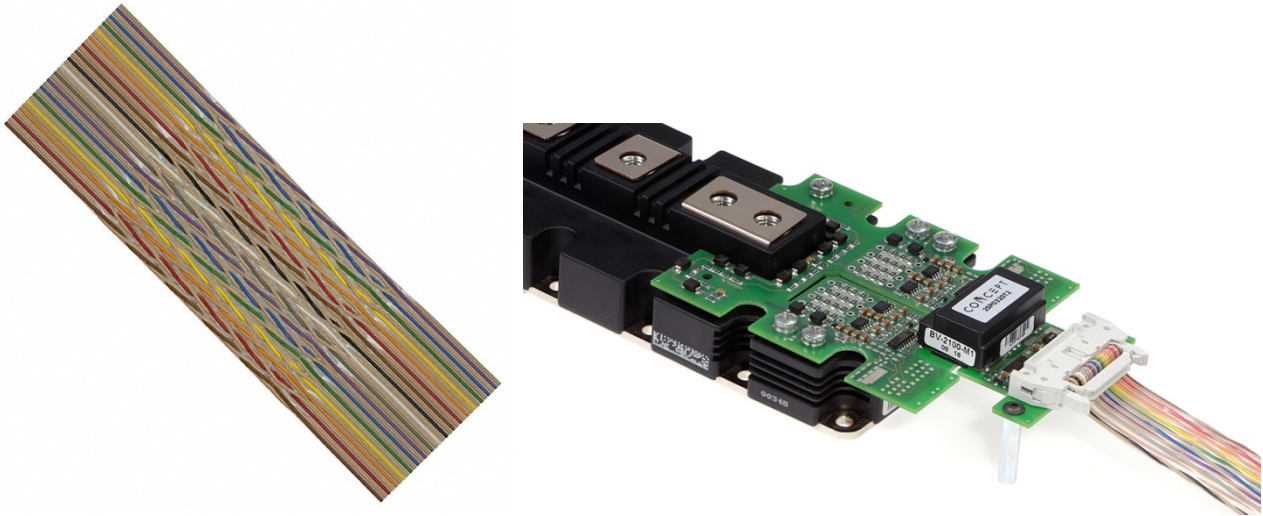
### Use of Electrical Cables in Front of Driver Cores or Plug-and-Play Drivers

In many applications, the primary side of driver cores or plug-and-play drivers is connected via electrical cables to the host controller. SCALE-2 gate drivers with an electrical interface usually feature a low-voltage input threshold (2.6V for turn-on, 1.3V for turn-off, refer to the corresponding product data sheets /3/) to allow the use of 5V or even 3.3V logic circuits. Moreover, no short-pulse suppression is usually implemented to allow high switching frequencies and low jitter.

It is recommended in general to place the cables at locations free from strong magnetic fields to limit their influence.

Moreover, CONCEPT recommends using pairwise twisted flat cables (e.g. 1700/20 or 2100/20 from 3M™) according to Fig. 2. The use of non-pairwise twisted cables is NOT recommended; otherwise random switching of the gate drivers may occur, possibly leading to IGBT and/or driver damage. A minimum distance of typically 2cm is recommended from the cabling to any conductor subject to high-voltage or high-current switching. It may be necessary to increase this distance depending on the actual magnetic field strength.

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*Fig. 2 Recommended use of pairwise twisted flat cables*

The driver cables may also be shielded against magnetic fields by using an additional metal shield around the cable. Pre-assembled cables according to Fig. 3 with shielding (e.g. 1785 series from 3M™) may be purchased.



*Fig. 3 Use of shielded flat cables with pairwise twisted wires*

Note, however, that additional shielding as shown in Fig. 3 is usually not required.

Moreover, if gate driver cores are used and long cables are required, it is additionally recommended to place a voltage divider and/or a short-pulse suppression circuit directly in front of the gate driver. Please refer to Application Note AN-1101 /1/, sections “Increase of the noise immunity at inputs INA and INB (excluding 2SC0635T)” and “Minimum pulse suppression for inputs INA and INB”.

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### Active Clamping Activity

Most SCALE-2 plug-and-play drivers use the CONCEPT Advanced Active Clamping scheme in order to limit turn-off overvoltages at IGBT turn-off. Advanced Active Clamping can also be used with most of the SCALE-2 gate driver cores.

Advanced Active Clamping is a highly efficient method to limit turn-off overvoltages during IGBT turn-off /4/. However, the active clamping activity must be limited in order not to overload the components involved, such as the transient voltage suppressor (TVS) diodes or the secondary-side driver ASIC. Therefore, the following points have to be considered:

- The maximum permissible DC-link voltage must never be exceeded. For plug-and-play drivers, this value is given in the absolute maximum ratings of the driver data sheets /3/. For gate driver cores, the following rule must be considered: the maximum DC-link voltage must not be higher than 0.9 times the typical TVS diode breakdown voltages at 25°C/1mA when using TVS with  $\pm 5\%$  breakdown voltage tolerance. This consideration is usually sufficient for designs with ambient temperatures from -40°C to 85°C.
- The active clamping activity depends on the IGBT power module used as well as on several other parameters such as DC-link voltage, collector current, DC-link stray inductance, selection and manufacturer of the TVS diodes, IGBT and TVS diode junction temperatures. The active clamping activity must be limited to a reasonable level, especially if it is applied repeatedly. Excessive activity may thermally overload the TVS diodes and/or other driver components. It may also lead to a secondary-side undervoltage lockout, as the Vee regulator of the driver's secondary side may be overloaded. See also AN-1101 /1/, section "VEx terminal characteristics".
- A constant DC voltage must not be applied to the driver's active clamping pin ACLx, e.g. for functional testing. The resulting high power losses may lead to destruction of the driver.

### ESD handling of IGBT gate drivers

CONCEPT SCALE-2 gate drivers are based on highly integrated CMOS technology. They provide only limited protection against ESD. Appropriate ESD handling is therefore mandatory in order to guarantee correct operation and high reliability. Please refer to AN-0902 /2/.

### Use of Diodes

The applications circuits, especially for gate driver cores, contain several diodes. The required types of diodes are clearly specified in the Application Manuals or Application Notes. The types of diodes (e.g. using a Schottky diode instead of the low-leakage diode BAS416) must not be changed, as this may lead to incorrect driver operation.

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### Conformal Coating

Most CONCEPT SCALE-2 gate drivers are designed according to Pollution Degree 2 (PD2), Overvoltage Category II (OVII) and a maximum operating altitude of 2000m (refer also to AN-1101 /1/). None of these gate drivers requires a conformal coating to achieve the insulation coordination requirements.

If the application conditions (e.g. operation in polluted environments) demand a conformal coating, the following points need to be considered:

- Prior to the coating process, proper cleaning of the gate driver boards is required. The degree of cleaning depends on the selected coating material and expected application conditions.
- After the cleaning process, all moisture must be removed from the gate driver prior to applying the coating material.
- Several coating materials are silicon-based, i.e. show a tendency to let moisture diffuse over time through the coating layer. This moisture may accumulate between the board and the coating film, ultimately producing a conductive path within the circuitry of the gate driver and consequently leading to a malfunction or even destruction of the driver.
- CONCEPT will not assume any liability or warranty for gate driver failures as a result of the applied conformal coating and/or process to apply the conformal coating. It is within the responsibility of the end-user to qualify both the suitability of the coating material as well as the long-term effects of the application with respect to environmental conditions.

### Bibliography

- /1/ Application Note AN-1101: Application with SCALE™-2 Gate Driver Cores, CONCEPT
- /2/ Application Note AN-0902: Avoiding Electrostatic Discharge (ESD) when using CONCEPT IGBT Gate Drivers, CONCEPT
- /3/ Data sheets of SCALE™-2 drivers, CONCEPT
- /4/ Paper: Safe Driving of Multi-Level Converters Using Sophisticated Gate Driver Technology, PCIM Asia, June 2013

**Note:** The Application Notes are available on the Internet at [www.igbt-driver.com/go/app-note](http://www.igbt-driver.com/go/app-note) and the papers at [www.IGBT-Driver.com/go/paper](http://www.IGBT-Driver.com/go/paper)

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### Legal Disclaimer

The statements, technical information and recommendations contained herein are believed to be accurate as of the date hereof. All parameters, numbers, values and other technical data included in the technical information were calculated and determined to our best knowledge in accordance with the relevant technical norms (if any). They may base on assumptions or operational conditions that do not necessarily apply in general. We exclude any representation or warranty, express or implied, in relation to the accuracy or completeness of the statements, technical information and recommendations contained herein. No responsibility is accepted for the accuracy or sufficiency of any of the statements, technical information, recommendations or opinions communicated and any liability for any direct, indirect or consequential loss or damage suffered by any person arising therefrom is expressly disclaimed.

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