Title	***Reference Design Report for a General Purpose Base Board for Using SCALE™-iDriver SID1183K***
Specification	Up to 1200V DC-link Voltage
Applications	General Purpose Drives, UPS, Photo Voltaic and Others
Author	High-Power Application Engineering Department
Document Number	RDHP-1702
Date	May 16, 2017
Revision	1.0

Summary and Features

- Suitable for IGBT power modules in various housings
- Up to 1200 V DC-link voltage
- Electrical interfaces
- Basic Active Clamping
- Short-circuit detection with Advanced Soft Shut Down

PATENT INFORMATION
The design proposal, products and applications illustrated herein (including transformer construction and circuits external to the products) may be covered by one or more U.S. and foreign patents, or potentially by pending U.S. and foreign patent applications assigned to Power Integrations. A complete list of Power Integrations patents may be found at https://www.power.com/. Power Integrations grants its customers a license under certain patent rights as set forth at https://www.power.com/company/intellectual-property-licensing/.

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Important Note:
Although this board is designed to satisfy safety isolation requirements, the engineering prototype has not been agency approved. Therefore, all testing should be performed using an isolation transformer to provide the AC input to the prototype board.

1 Introduction

This application proposal provides a circuit design for a general purpose base board for driving various IGBTpower modules.
The main features of the design are:

- Suitable for IGBT power modules in various housings such as 17 mm dual, 17 mm six-pack,
- 62 mm, PrimePACK™, etc. with a maximum blocking voltage of 1700 V
- Short-circuit detection with Advanced Soft Shut Down (ASSD)
- Electrical command inputs and status outputs
- 0 V / 5 V command input logic
- 0 V / 5 V status output logic
- Minimum pulse suppression
- Interlock of command inputs
- 5 V supply voltage
- Single PCB solution with soldered-in gate driver IC

The set of CAD data, which includes the circuit schematics, Gerber files, assembly drawing, BOM and pick-and-place file are available at www.power.com.

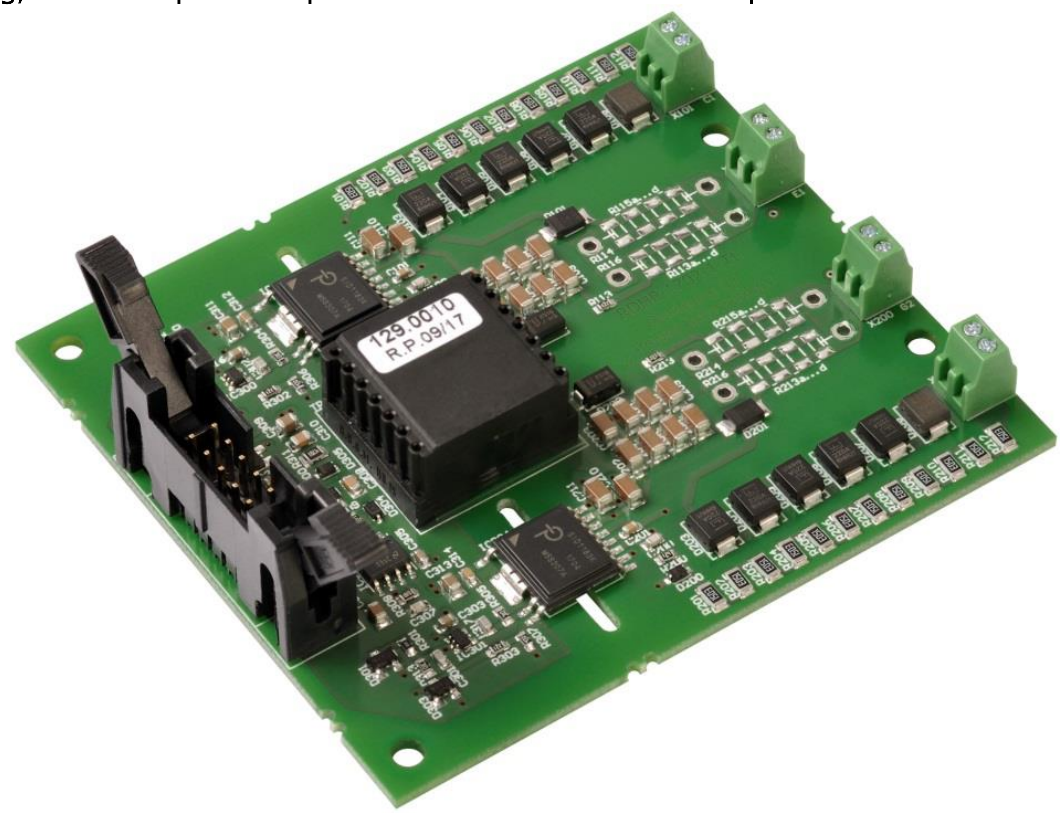

Figure 1 – Populated Circuit Board Photograph, Top.

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2 Power Supply Specification

2.1 *Application Conditions*

The design is proposed for the following application conditions:

- General purpose applications and IGBT power modules
- Adaptations such as adjustment of gate resistors can easily be done
- Up to 8 A peak gate current
- Up to 1 W per channel

3 Circuit Description

In addition to the following design description, reference to the datasheet of the gate driver IC family is recommended.

3.1 *Gate Resistors*

Gate resistor values are not explicitly given as they depend on the IGBT power module used and on theapplication. Gate resistors of either SMD (size 1206) or THT (size PR02) package can be selected.

Turn-on gate resistors

Channel	SMD Package	THT Package
1	R117a … R117d	R116
2	R217a … R217d	R216

Turn-off gate resistors

Channel	SMD Package	THT Package
1	R115a … R115d	R114
2	R215a … R215d	R214

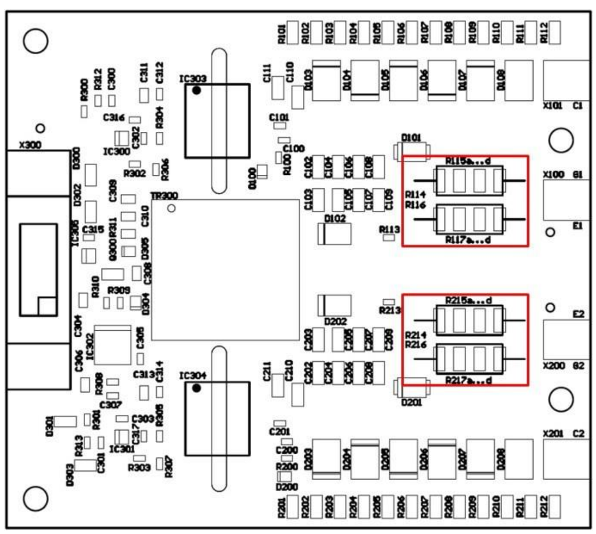

Figure 2 – The Gate Resistors Must be Determined and Assembled by the User.

3.2 *V_{CEsat} Monitoring*

SID1183K gate driver ICs from Power Integrations provide sense inputs for monitoring IGBT short-circuit conditions. The details of the V_{CEsat} monitoring function are described in the corresponding datasheet of the gate driver.

3.3 *Advanced Soft Shut Down (ASSD)*

The driver ICs SID1183K of the SCALE-iDriver family feature an Advanced Soft Shut Down (ASSD) function, which reduces the turn-off di/dt to limit VCE overvoltage spikes as soon as a short-circuit condition is detected. An excessive turn-off overvoltage is therefore avoided and the IGBT is turned off within its safe operating area.

3.4 *Basic Active Clamping*

Active clamping is a technique designed to partially turn on the IGBT in case the collector-emitter voltage exceeds a predefined threshold. The IGBT is then kept in linear operation. Basic Active Clamping topologies implement a single feedback path from the IGBT's collector through transient voltage suppressor (TVS) diodes to the IGBT gate. Basic Active Clamping is recommended as an option in addition to the Advanced Soft Shut Down (ASSD) function in the following cases depending on actual application conditions:

- High DC-link voltage and/or high commutation loop stray inductances
- Turning-off overcurrents and/or high commutation loop stray inductances

3.5 *Minimum Pulse Suppression*

This design possesses a minimum pulse suppression with a time constant τ of typically 99 ns. If required the setting can be changed by adjusting C300 and C301. The time constant τ is given by the following equations:

$\tau_1 = 99\ \Omega \cdot C300$

$\tau_2 = 99\ \Omega \cdot C301$

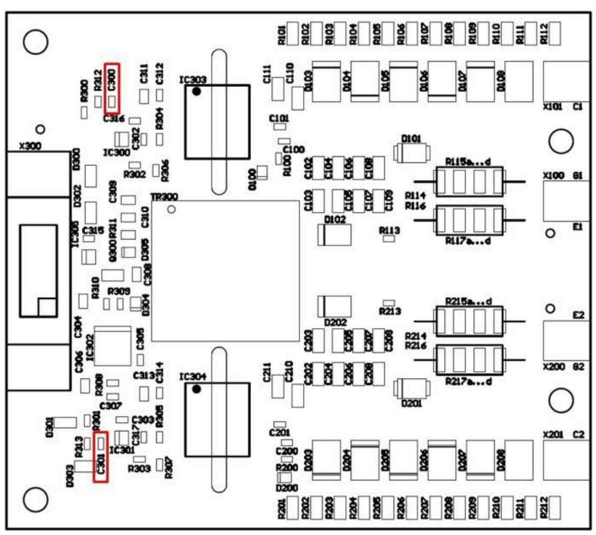

Figure 3 – Recommended Values of C300 and C301 are in the Range of 1 nF (τ_x = 99 ns) to 3.3 nF (τ_x = 327 ns), Depending on Actual Application Conditions.

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3.6 *Blocking Time*

During the blocking time, which is set to typically 10 µs, the gate driver IC ignores incoming command signals. The blocking time starts once a fault was detected by the gate driver IC's secondary side (undervoltage lockout or a short-circuit event) or when an undervoltage condition ends on the primary side. For further details refer to the datasheet of the gate driver SID1183K.

3.7 *Interlock*

To prevent synchronous switching of the gate driver channels 1 and 2 an interlock circuitry is implemented.

3.8 *Interfaces*

3.8.1 Electrical Interfaces

Pin	Designation	Description
1	V5	5V supply (referenced to GND)
3	SO2	Status output channel 2
5	INB	Command input channel 2
7	SO1	Status output channel 1
9	INA	Command input channel 1

Pin	Designation	Description
2	GND	Ground
4	GND	Ground
6	GND	Ground
8	GND	Ground
10	GND	Ground

X100		
Pin	**Designation**	**Description**
1	E1	Emitter channel 1
2	G1	Gate channel 1

X101		
Pin	**Designation**	**Description**
1	C1	Collector channel 1
2	C1	Collector channel 1

X200		
Pin	**Designation**	**Description**
1	G2	Gate channel 2
2	E2	Emitter channel 2

X201		
Pin	**Designation**	**Description**
1	C2	Collector channel 2
2	C2	Collector channel 2

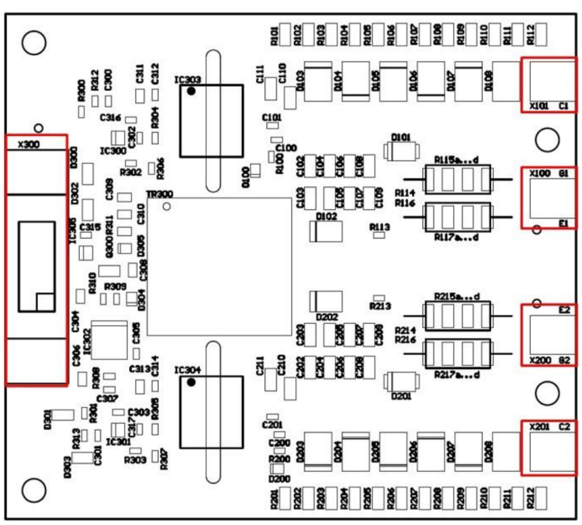

Figure 4 – Printed Circuit Layout Silkscreen, Highlighted Interfaces.

4 PCB Layout

An example for a suitable layout is shown in the following picture. The recommended PCB thickness is 1.55 mm.

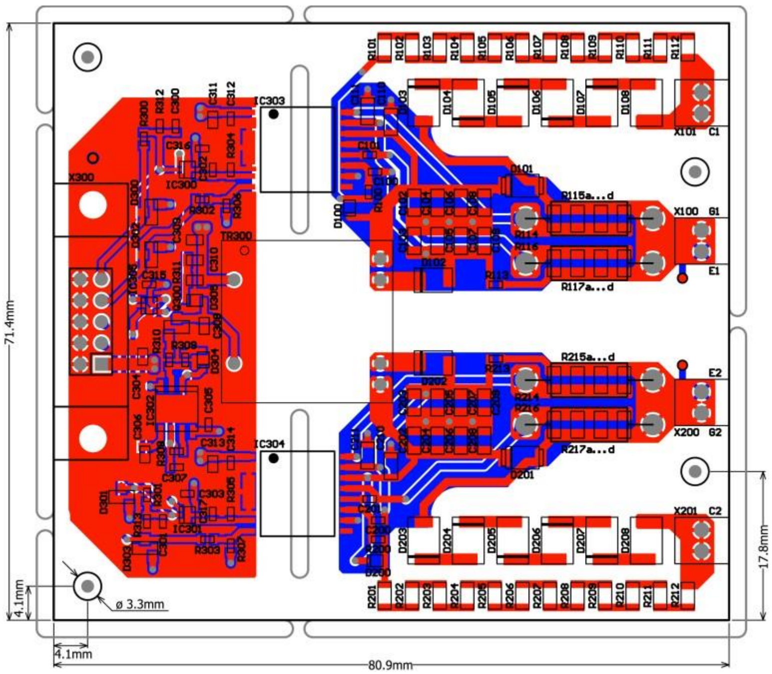

Figure 5 – Printed Circuit Layout, Top.

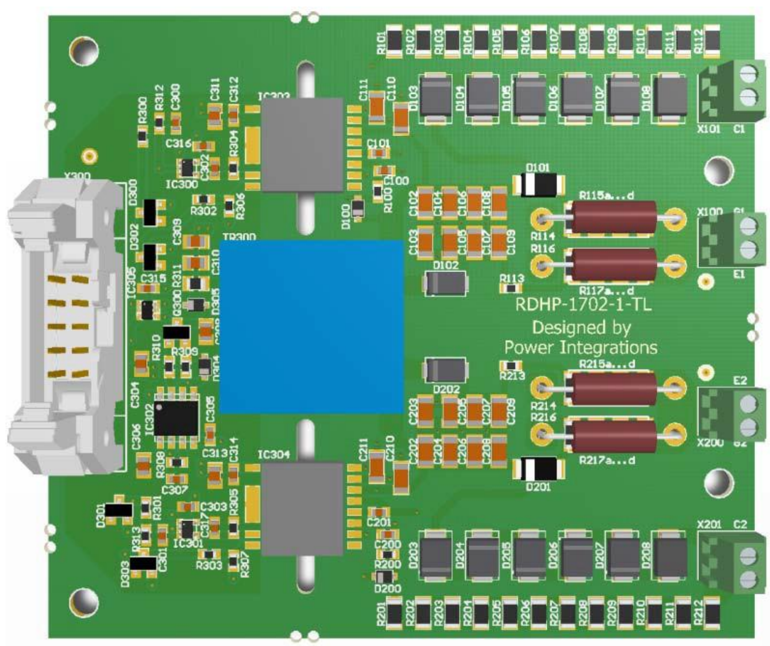

Figure 6 – Assembled Image.

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5 Bill of Materials

Value	Qty	Ref Des	Part Description	Parameters	Package	Temperature Range	MFG 1	Type Designation 1
33p	2	C100, C200	Ceramic Chip Capacitor	NP0,C0G/50V/5%	0603	-55 to +125°C		
10n	2	C101, C201	Ceramic Chip Capacitor	X7R/25V/10%	0603	-55 to +125°C		
4u7	20	C102, C103, C104, C105, C106, C107, C108, C109, C110, C111, C202, C203, C204, C205, C206, C207, C208, C209, C210, C211	Ceramic Chip Capacitor	X7R/25V/10%	1206	-55 to +125°C		
1n	4	C300, C301, C316, C317	Ceramic Chip Capacitor	NP0,C0G/25V/5%	0603	-55 to +125°C		
100n	4	C302, C303, C305, C315	Ceramic Chip Capacitor	X7R/25V/10%	0603	-55 to +125°C		
4u7	5	C304, C306, C309, C311, C313	Ceramic Chip Capacitor	X7R/16V/10%	0805	-55 to +125°C		
220p	1	C307	Ceramic Chip Capacitor	NP0,C0G/16V/10%	0603	-55 to +125°C		
1n	1	C308	Ceramic Chip Capacitor	X7R/50V/5%	0805	-55 to +125°C		
100n	1	C310	Ceramic Chip Capacitor	X7R/100V/10%	0805	-55 to +125°C		
470n	2	C312, C314	Ceramic Chip Capacitor	X7R/16V/10%	0603	-55 to +125°C		
BAS416	2	D100, D200	Low Leakage Diode	75V/200mA/250mW	SOD323	-65 to +150°C	NXP	BAS416
PMEG4050ETP	2	D101, D201	Schottky Diode	40V/5A/750mW	SOD128	-55 to +175°C	NXP	PMEG4050ETP
ES1B	2	D102, D202	Rectifier Diode	100V/1A/1.47W	SMA	-50 to +150°C	FAIRCHILD	ES1B
220V	10	D103, D104, D105, D106, D107, D203, D204, D205, D206, D207	Transient Voltage Suppressor	600W/5%	SMB	-65 to -150°C	Littelfuse	P6SMB220A-E3
220V	2	D108, D208	Transient Voltage Suppressor	600W/5%	SMB	-65 to +150°C	Littelfuse	P6SMB220CA
BAT54S	4	D300, D301, D302, D303	Dual High Speed Diode 30V, Connected in Series	30V/200mA/230mW	SOT23	-65 to +125°C	NXP	BAT54S
1N4148WS	1	D304	Low Leakage Diode	75V/150mA/200mW	SOD323	-55 to +150°C	Vishay	1N4148WS
PMEG4010CEJ	1	D305	Schottky Diode	40V/1A/350mW	SOD323F	-65 to +150°C	NXP	PMEG4010CEJ
SN74AHC1G08	2	IC300, IC301	2-Input AND Gate	2.0V to 5.5V/20mA	SC70-5	-40 to +125°C (Ta)	Texas Instruments	SN74AHC1G08QDCKRQ1
LMC555IM	1	IC302	Precision Timer	4.5V to 16V/200mA	SOIC-D	-40 to +105°C (Ta)	Texas Instruments	LMC555IM
SID1183K	2	IC303, IC304	SCALE-iDRIVER	4.75V to 5.25V/250kHz/1790mW/8.0A	eSOP-R16B	-40 to +125°C	Power Integrations	SID1183K
NC7WZ14	1	IC305	UHS Inverter	1.65V to 5.5V/100mA	SC70-6	-40 to +125°C	Fairchild	NC7WZ14EP6X

			Schmitt Trigger			(Ta)		
PMV45EN2	1	Q300	Logic level N-Channel MOSFET	30V/4.1A/510mW/35mOhm	SOT23	-55 to +150°C	NXP	PMV45EN2
120k	2	R100, R200	Thick Film Chip Resistor	1%/0.1W/50V	0603	-55 to +155°C		
150k	24	R101, R102, R103, R104, R105, R106, R107,R108, R109, R110, R111, R112, R201, R202, R203, R204, R205, R206, R207, R208, R209, R210, R211, R212	Thick Film Chip Resistor	1%/0.25W/200V	1206	-55 to +155°C		
22k	2	R113, R213	Thick Film Chip Resistor	1%/0.1W/50V	0603	-55 to +155°C		
N.A.	4	R114, R116, R214, R216	Power Metal Film Resistor	5%/2W/500V/PR02	Axial-0.6	-55 to +155°C	VISHAY	
N.A.	16	R115a, R115b, R115c, R115d, R117a, R117b, R117c, R117d, R215a, R215b, R215c, R215d, R217a, R217b, R217c, R217d	Thick Film Chip Resistor	1%/0.25W/200V/CRCWe3	1206	-55 to +155°C	Vishay	
100R	2	R300, R301	Thick Film Chip Resistor	1%/0.1W/75V/CRCWe3	0603	-55 to +155°C	Vishay	CRCW0603100RFKE
220R	2	R302, R303	Thick Film Chip Resistor	1%/0.1W/50V	0603	-55 to +155°C		
10k	4	R304, R305, R312, R313	Thick Film Chip Resistor	1%/0.1W/50V	0603	-55 to +155°C		
4k7	2	R306, R307	Thick Film Chip Resistor	1%/0.1W/50V	0603	-55 to +155°C		
4k22	1	R308	Thick Film Chip Resistor	1%/0.1W/50V	0603	-55 to +155°C		
1k2	1	R309	Thick Film Chip Resistor	1%/0.1W/50V	0603	-55 to +155°C		
100R	1	R310	Thick Film Chip Resistor	1%/0.1W/50V	0603	-55 to +155°C		
4k7	1	R311	Thick Film Chip Resistor	1%/0.125W/150V	0805	-55 to +155°C		
BV129.0010	1	TR300					Contact PI Sales	
2Pin Header	4	X100, X101, X200, X201	Terminal Block	150V/6A/2Pin/2.54mm	1x2Pin, Pitch 2.54	-40 to +105°C	Wuerth Electronic	691210910002
10Pin Male Box Header	1	X300	Eject Latch Header	500V/3A/10Pin/2.54mm/180°	2x5Pin, Pitch 2.54	-55 to +125°C	Wuerth Elektronik	61201022821
RDHP-1702-1	1	Z1	Printed Circuit Board		N			

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6 Performance Data - Switching Characteristic Waveforms

6.1 ***Turn-On/Off***

The measurement examples shown with the IGBT power module FF450R17ME4 from Infineon Technologies (R_{Gon} = 3.3 Ω and R_{Goff} = 3.3 Ω) were carried out in a double-pulse test using a half-bridge topology setup at room temperature with an initial DC-link voltage of 1200 V_{DC}. The adjusted load current is either 450A (I_{nom}) or 900 A (2x I_{nom}).

Channel assignment:

Channel C2: Collector current [1 V ≙ 1 A]

Channel C3: Collector-emitter voltage

Channel C4: Gate-emitter voltage

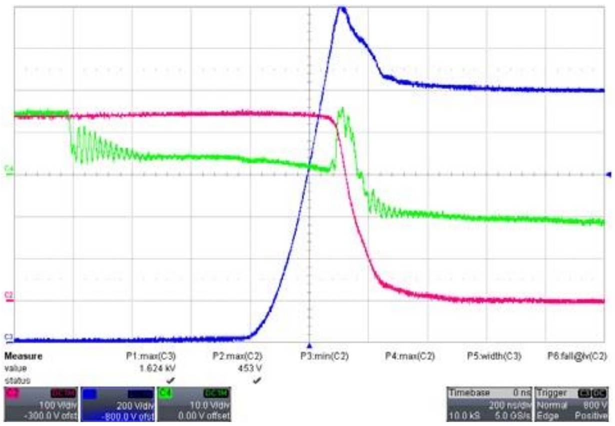

Figure 7 – Turn-off Top Side (I_{nom}).

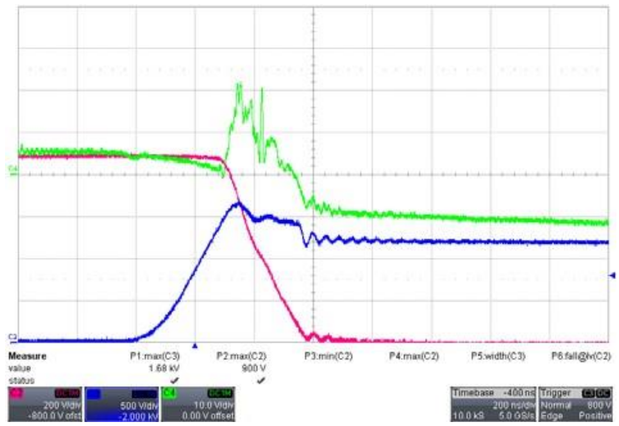

Figure 8 – Turn-off Top Side (2x I_{nom}).

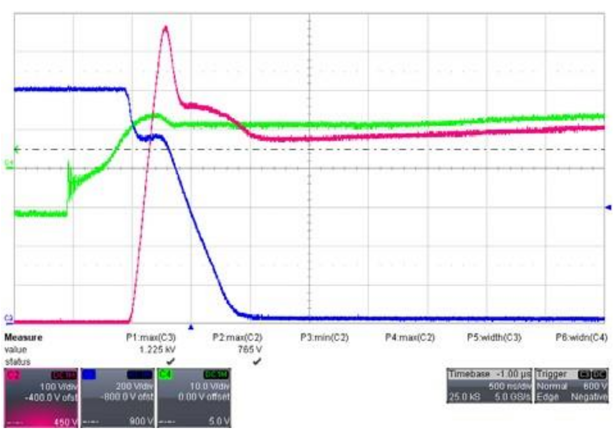

Figure 9 – Turn-on Bottom Side (I_{nom}).

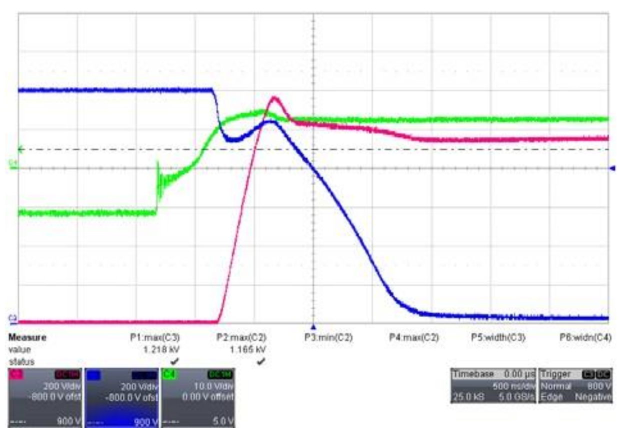

Figure 10 – Turn-on Bottom Side (2x I_{nom}).

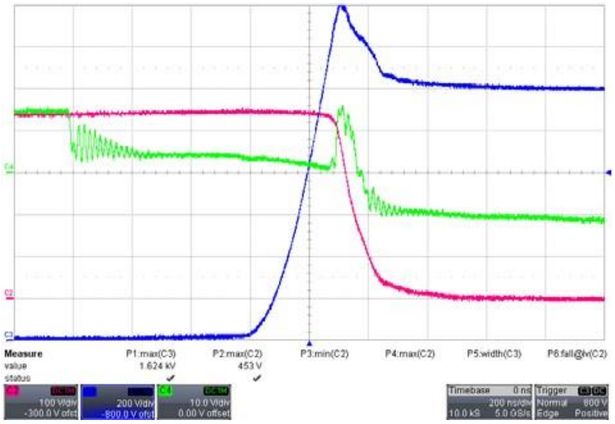

Figure 11 – Turn-off Top Side (I_{nom}).

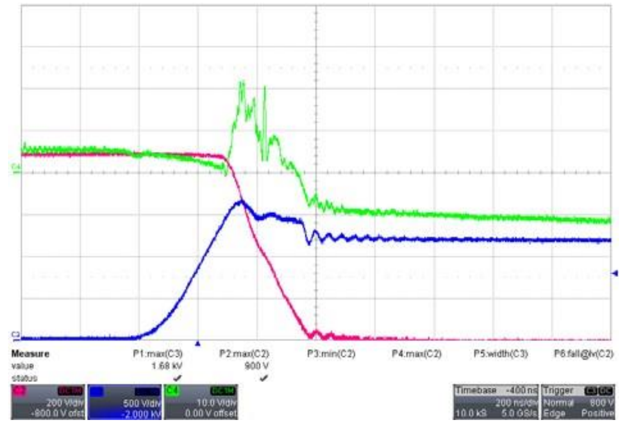

Figure 12 – Turn-off Top Side (2x I_{nom}).

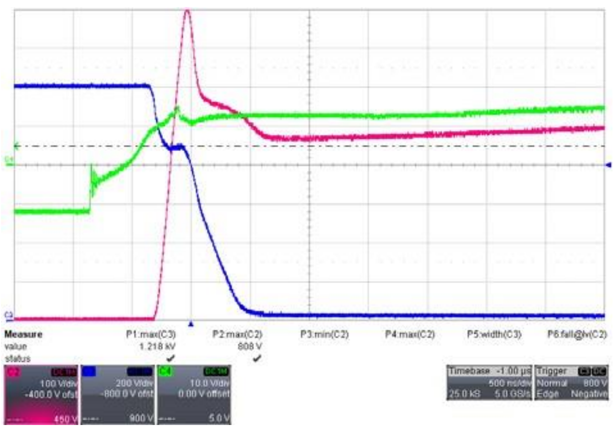

Figure 13 – Turn-on Top Side (I_{nom}).

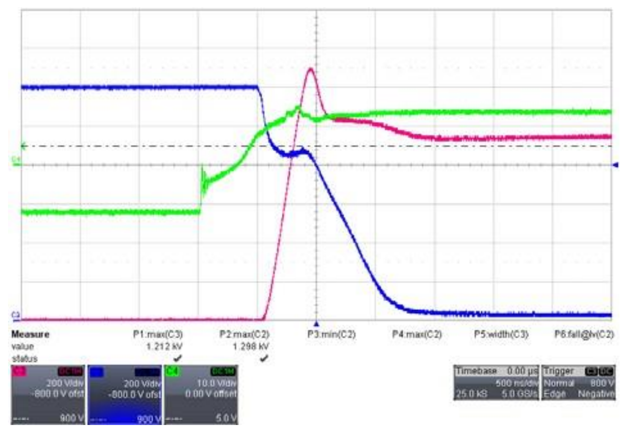

Figure 14 – Turn-on Top Side (2x I_{nom}).

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7 Short-Circuit

The measurement example shown with the IGBT power module FF450R17ME4 from Infineon Technologies (R_{Gon} = 3.3 Ω and R_{Goff} = 3.3 Ω) was carried out at room temperature with an initial DC-link voltage of 1200 V_{DC}.

Channel assignment:
Channel C1: Status output
Channel C2: Collector current (1 V ≙ 1 A)
Channel C3: Collector-emitter voltage
Channel C4: Gate-emitter voltage

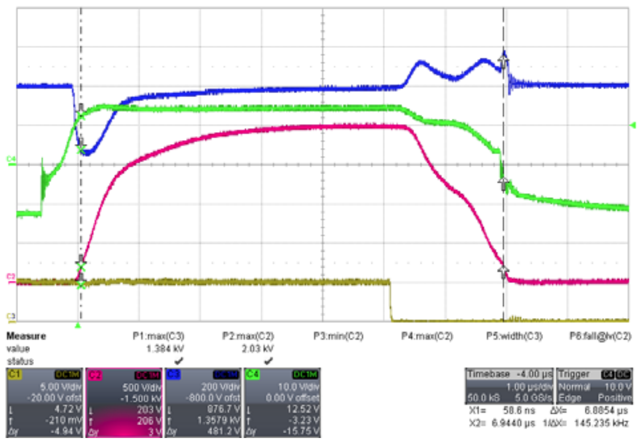

Figure 15 – Bottom Side.

8 Handling

To avoid possible failures caused by ESD, a handling- and assembly-process with persistent ESD protection is necessary /2/.

9 References

/1/ SID1183K SCALE-iDriver Family Data Sheet, Power Integrations
/2/ Application Note AN-0902, "Avoiding ESD with CONCEPT Drivers", Power Integrations

10 Technical Support

Power Integrations provides expert help with your questions and problems:

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11 Quality

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12 Revision History

Date	Author	Revision	Description & Changes	Reviewed
16-May-17	MH	1.0	Initial Release.	Apps & Mktg

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