1.2kV and 1.7kV Dual 140x130mm IGBT Power Modules with Gate Driver Core 2SC0435T

Application	2-level topology for traction, solar power, general purpose drives and others
Specification	Suitable for dual 140x130mm IGBT power module package Up to 1200V/1500V DC-link voltage Electrical or optical interfaces Dynamic Advanced Active Clamping Short-circuit detection
Author	High-Power Application Engineering Department
Document Number	RDHP-1424
Revision[1]	A.1

[1] The letter refers to the hardware revision. The number refers to the documentation revision.

Scope

This application proposal provides a circuit design suitable for driving a 140x130mm dual IGBT power module.

The main features of the design are:

- Supports 1200V and 1700V IGBT power modules
- Dynamic Advanced Active Clamping
- Short-circuit detection
- Electrical or optical command inputs and status outputs
- 0V/15V command input logic (for variant with electrical interfaces)
- 0V/15V status output logic (for variant with electrical interfaces)
- Direct or Half-Bridge mode selection
- Adjustable blocking time
- 15V supply voltage
- Single PCB solution with soldered-in gate driver core
- Compatible to SCALE™-1 2SB315A and 2SB315B plug-and-play gate drivers

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Application Conditions

The design is proposed for the following application conditions:

- Maximum DC-link voltage of 1200V under switching conditions
- Maximum DC-link voltage of 1500V under non-switching conditions (limited to a duration of 60s)
- Typical total stray inductance of the commutation loop of 125nH

Design Description

In addition to the following design description, reference to the datasheet(s) and application manual of the 2SC0435T gate driver family is recommended.

Gate Resistors

Gate resistor values are not explicitly given as they depend on the IGBT power module used and on the application. Gate resistors of either SMD (size 1206) or THT (size PR03) package can be selected.

Turn-on gate resistors:

Channel	SMD Package	THT Package
1	R150a … R150l	R132, R133
2	R250a … R250l	R232, R233

Turn-off gate resistors:

Channel	SMD Package	THT Package
1	R140a … R140l	R130, R131
2	R240a … R240l	R230, R231

The gate resistors must be determined and assembled by the user. Minimum required gate resistor values are defined in the datasheet of the gate driver 2SC0435T.

V_{CEsat} Monitoring

In the schematic and bill of material, the resistor networks of the V_{CEsat} monitoring function are marked with "N.A." (not assembled), as their concrete value depends on the IGBT power module and applied DC-link voltage.

Recommended values are listed in the following table:

IGBT voltage	Max. DC-link voltage	R104	R110 to R123	R204	R210 to R223
1200V	800V/1000V	120kΩ	120kΩ	120kΩ	120kΩ
1700V	1200V/1500V	120kΩ	150kΩ	120kΩ	150kΩ

Recommended values of the blanking capacitors C100 and C200 as well as further details of the V_{CEsat} monitoring function are described in the corresponding application manual of the gate driver 2SC0435T.

Soft Shut Down (SSD)

For this design proposal no dedicated Soft Shut Down function is implemented. Instead, for over voltage protection Active Clamping is implemented.

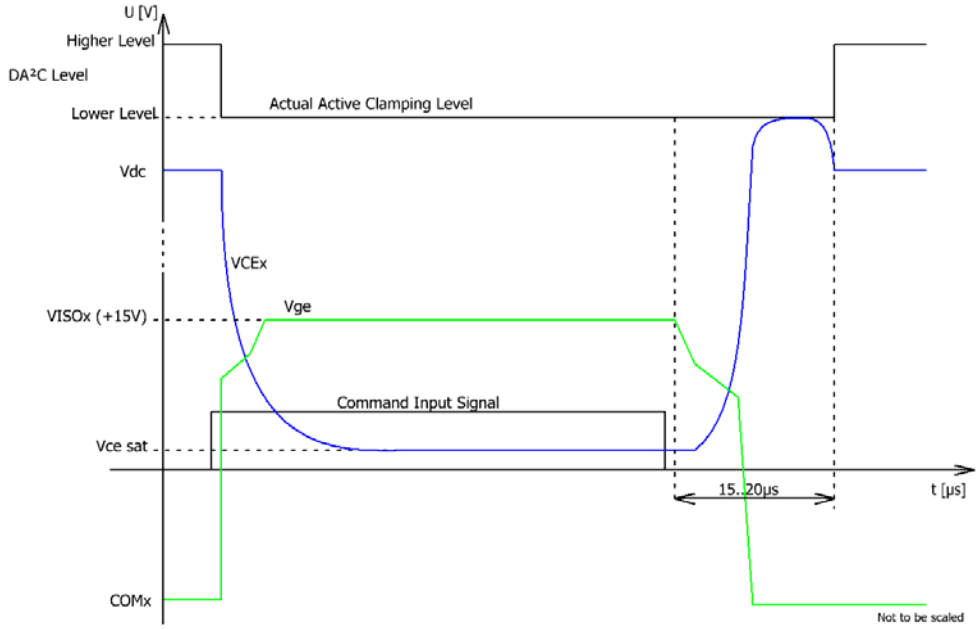
Dynamic Advanced Active Clamping

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. This design proposal supports Power Integrations' Dynamic Advanced Active Clamping (DA²C) based on this principle:

When active clamping is activated, the turn-off MOSFET of the gate driver 2SC0435T is switched off in order to improve the effectiveness of the active clamping and to reduce the losses in the TVS diodes. This feature – called Advanced Active Clamping – is mainly integrated in the secondary-side ASIC of gate driver core 2SC0435T.

Additional TVS diodes (D110, D111 and D210, D211) have been added in series to the TVS diodes required to withstand the maximum DC voltage under switching operation. These TVS diodes are short-circuited during the IGBT on state as well as for about 15…20µs after the turn-off command to guarantee efficient active clamping. After this delay, these additional TVS diodes are activated and allow the DC-link voltage to be increased to a higher value during the IGBT off-state. This feature – together with Advanced Active Clamping – is called Dynamic Advanced Active Clamping (DA²C). Note that the time during which the voltage can be applied above the value for switching operation should be limited to short periods (<60s).



In the schematic and bill of material, the TVS networks are marked with "N.A." (not assembled), as their specific value depends on the IGBT power module and applied DC-link voltage. Recommended values are listed in the following table.

IGBT voltage	Max. DC-link voltage	D101, D201	D112 … D116, D212 … D216	D117, D217	D110, D111, D210, D211
1200V	800V/1000V	SK34SMB	1.5SMC150A	1.5SMC150CA	SMAJ130A-E3
1700V	1200V/1500V	SK34SMB	1.5SMC220A	1.5SMC220CA	SMAJ188A-E3

For further details and alternative TVS diodes refer to the application manual of the gate driver core 2SC0435T.

Minimum Pulse Suppression

No minimum pulse suppression is implemented.

Blocking Time

During the blocking time the gate driver ignores incoming command signals. The blocking time starts once a fault was detected by the gate driver's secondary side (undervoltage lock-out or a short-circuit event) or when an undervoltage condition ends on the primary side.

The terminal TB allows the default blocking time of typically 99ms (R303) to be reduced by connecting an optional external resistor to GND. The external resistor R_b needs to be equal or larger than 129kΩ to fulfill the following formula:

$(R_b + 6.8k\Omega) \,||\, 150k\Omega \triangleq T_b + 51ms$ with $20ms < T_b < 99ms$

In case the terminal TB is directly shorted to GND ($R_b = 0\Omega$), the blocking time is set to its minimum value as descripted in the datasheet of the gate driver core 2SC0435T.

Mounting Instruction

The gate driver has to be mounted upside down onto the IGBT power module as shown in the following:

Interfaces

The design can be equipped using different variants either with electrical or optical interfaces for the command input and status output signals.

Electrical Interfaces

In case only electrical interfaces are equipped the connector X1 has to be used. Furthermore, it is highly recommended to use a pairwise twisted flat cable for the interconnection from the gate driver to the corresponding controller board.

X1		
Pin	Designation	Description
1	VDC	15V supply (referenced to GND)
3	VDC	15V supply (referenced to GND)
5	VCC	15V supply (referenced to GND)
7	VCC	15V supply (referenced to GND)
9	SO2	Status output top side
11	INB	Command input top switch
13	SO1	Status output bottom side
15	INA	Command input bottom switch
17	MOD	Mode selector
19	TB	Set blocking time

X1		
Pin	Designation	Description
2	GND	Ground
4	GND	Ground
6	GND	Ground
8	GND	Ground
10	GND	Ground
12	GND	Ground
14	GND	Ground
16	GND	Ground
18	GND	Ground
20	GND	Ground

In case optical interfaces are equipped connector X2 is required for the supply of the primary side.

X2		
Pin	Designation	Description
1	VDC	15V supply (referenced to GND)
3	VDC	15V supply (referenced to GND)
5	n.c.	Not connected
7	VCC	15V supply (referenced to GND)
9	VCC	15V supply (referenced to GND)

X2		
Pin	Designation	Description
2	GND	Ground
4	GND	Ground
6	GND	Ground
8	GND	Ground
10	GND	Ground

Optical Interfaces

IC302	
Pin	Designation
INA	Command input bottom switch

IC304	
Pin	Designation
INB	Command input top switch

D300	
Pin	Designation
SO1	Status output bottom side

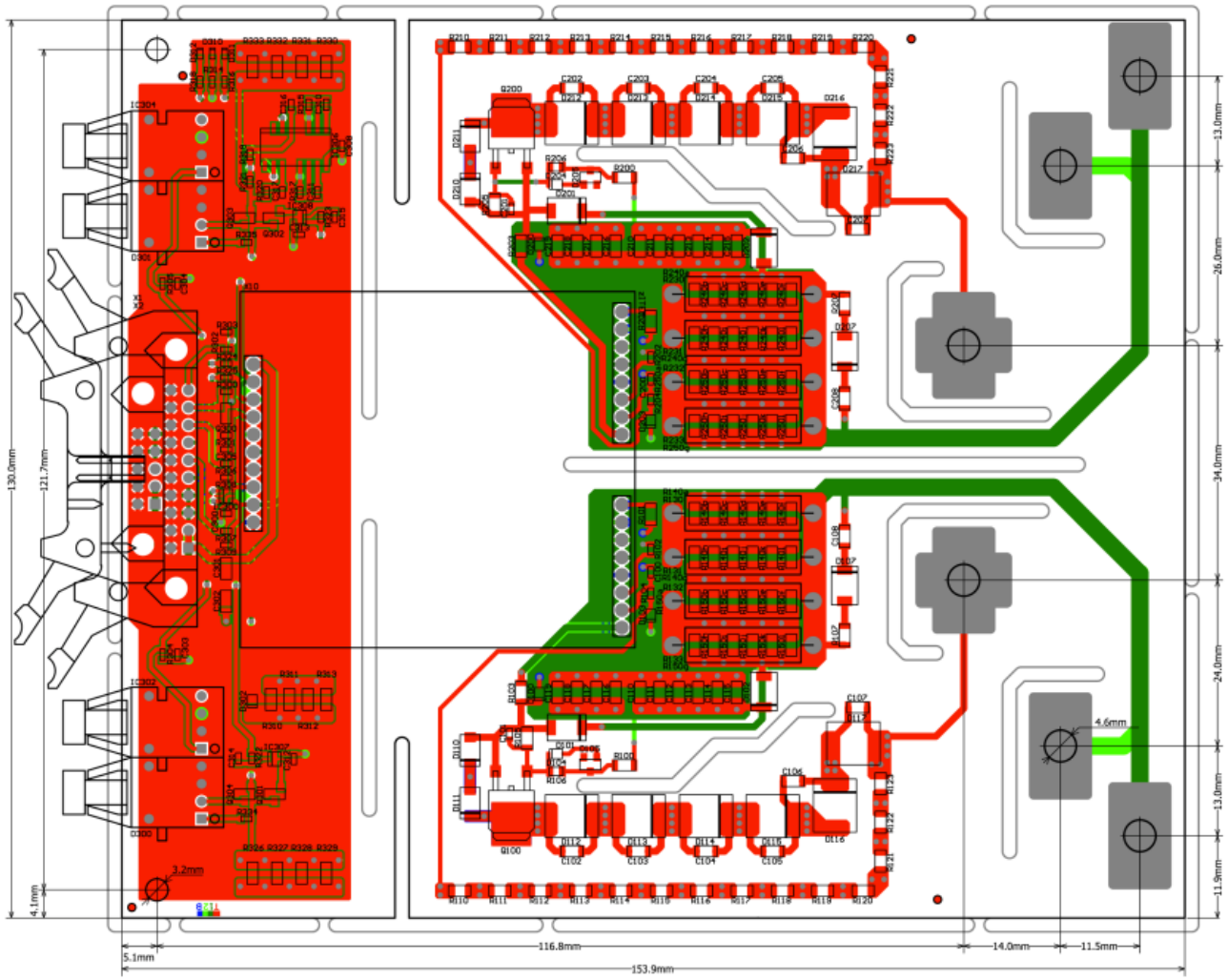
D301	
Pin	Designation
SO2	Status output top side

CAD Data

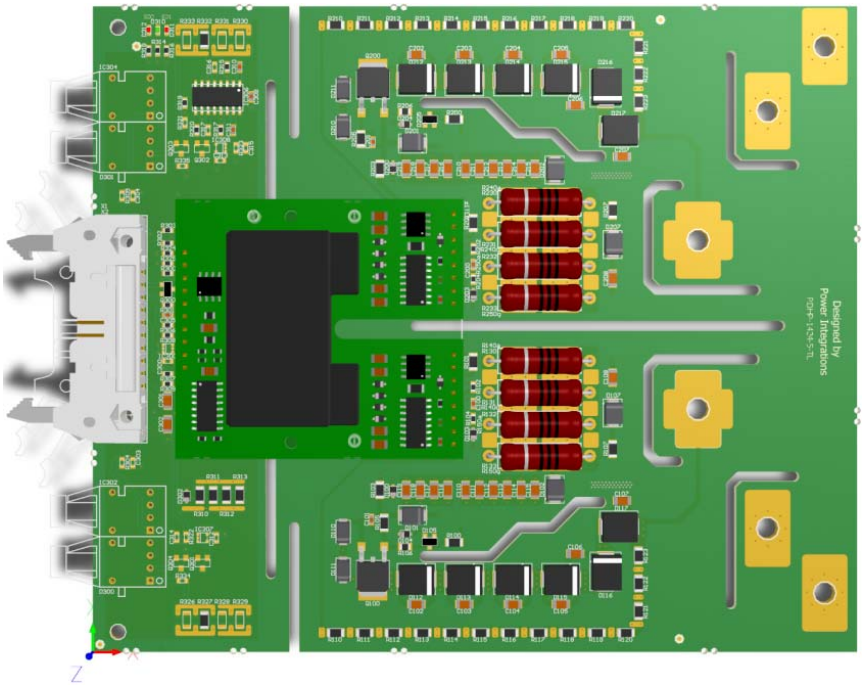
The set of CAD data, which includes the circuit schematics, Gerber files, BOM and Pick-and-Place file are available as separate documents bundled together with this documentation.

Layout Example

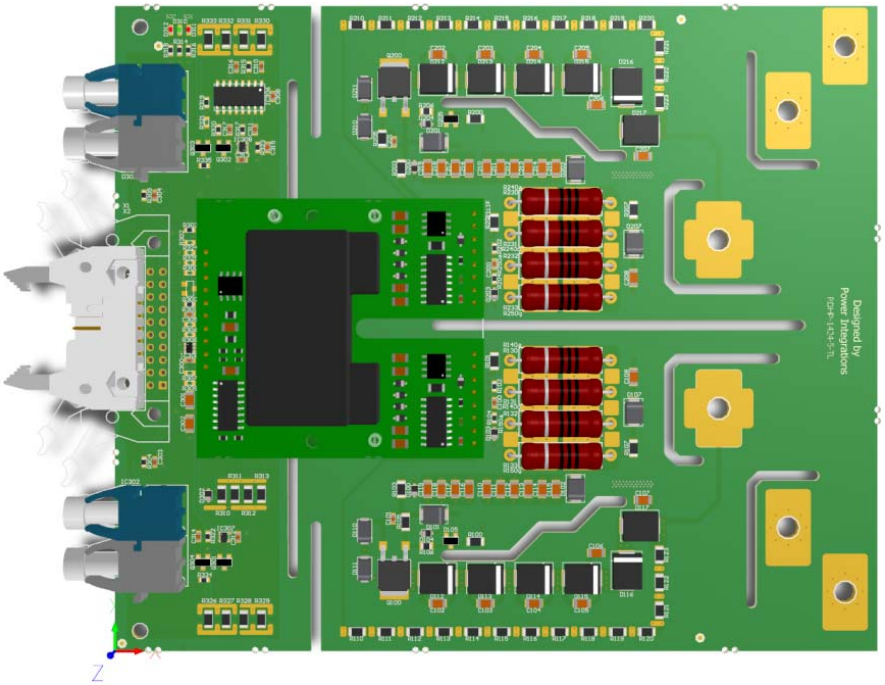
An example for a suitable layout is shown in the following picture. The recommended PCB thickness is 2.0mm.



Combined layout for electrical and optical assembly variants



Assembly variant with electrical interfaces



Assembly variant with optical interfaces

Switching Characteristic

Turn-On / Off

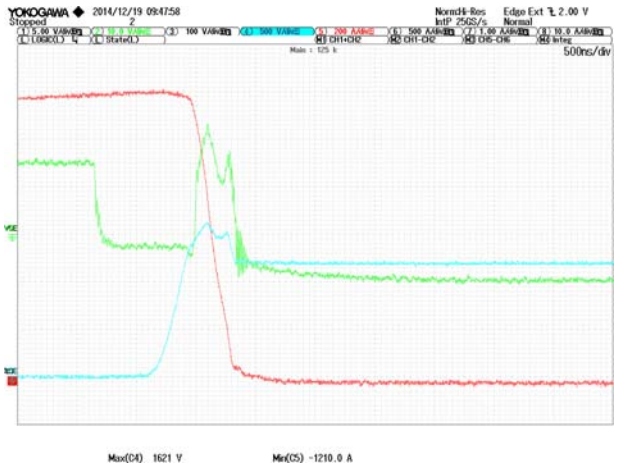
The measurement examples shown with the IGBT power module 2MBI1200U4G-170B from Fuji Electric (R_{Gon} = 4.7Ω and R_{Goff} = 1.2Ω) were carried out in a double-pulse test using a half-bridge topology setup at room temperature with an initial DC-link voltage of 1200V_{DC}. The adjusted load current is either 1200A (I_{nom}) or 2400A (2x I_{nom}).

Channel assignment:

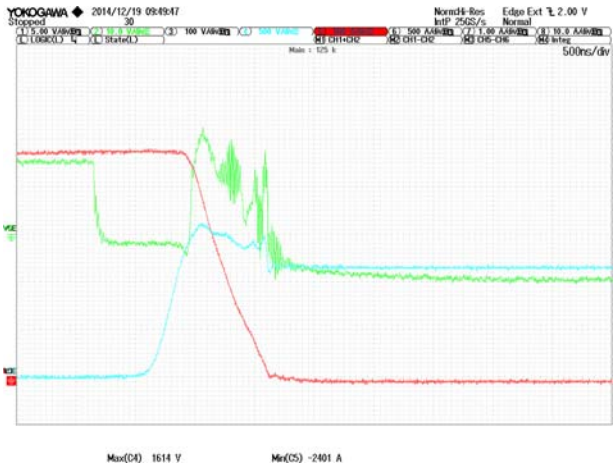
Channel C2: Gate-emitter voltage

Channel C4: Collector-emitter voltage

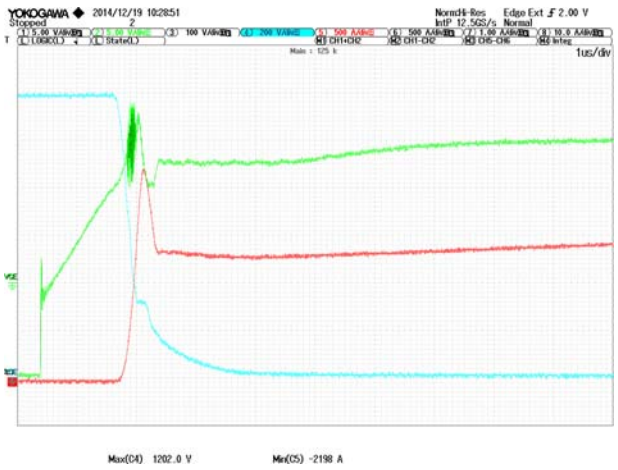
Channel C5: Collector current



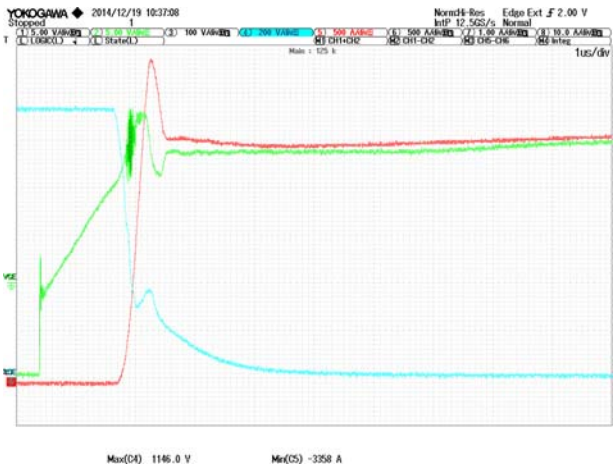
Turn-off bottom side (I_{nom})



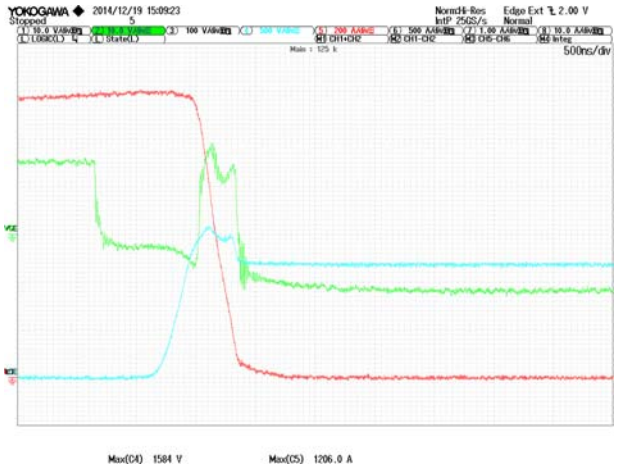
Turn-off bottom side (2x I_{nom})



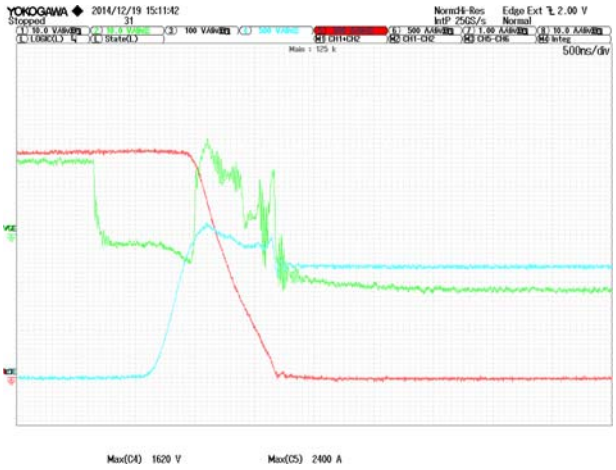
Turn-on bottom side (I_{nom})



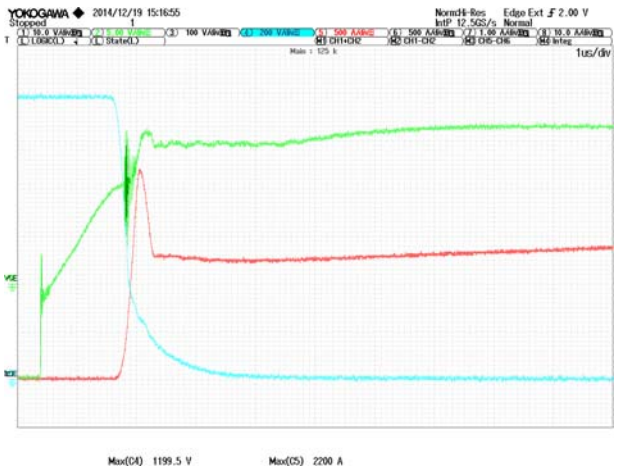
Turn-on bottom side (2x I_{nom})



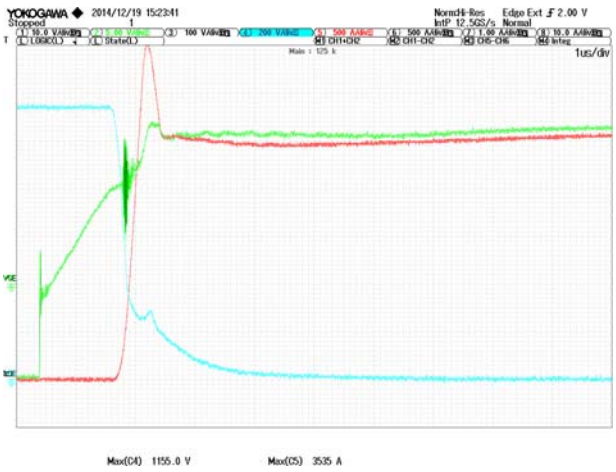
Turn-off top side (I_{nom})



Turn-off top side (2x I_{nom})



Turn-on top side (I_{nom})



Turn-on top side (2x I_{nom})

Short-Circuit

The measurement examples shown with the IGBT power module 2MBI1200U4G-170B from Fuji Electric (R_{Gon} = 4.7Ω and R_{Goff} = = 1.2Ω) were carried out at room temperature with an initial DC-link voltage of 1200V_{DC}.

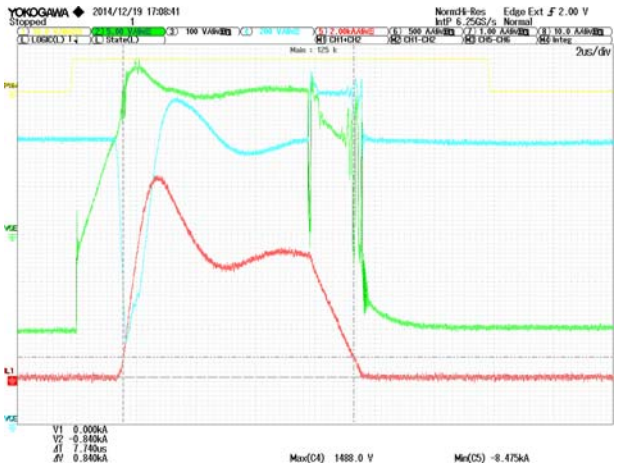
Channel assignment:

Channel C1: Command input signal

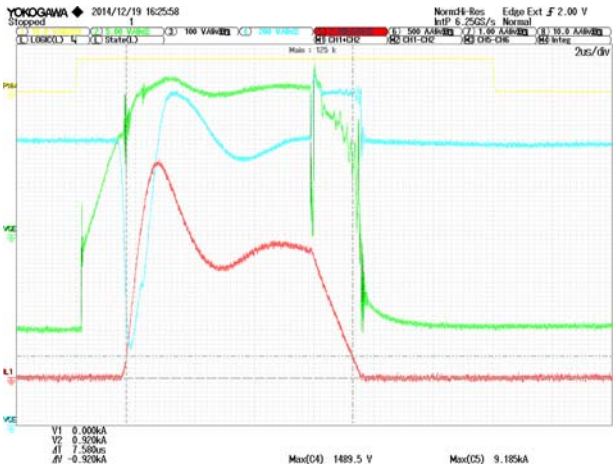
Channel C2: Gate-emitter voltage

Channel C4: Collector-emitter voltage

Channel C5: Collector current



Bottom side



Top side

Handling

To avoid possible failures caused by ESD, a handling- and assembly-process with persistent ESD protection is necessary /3/.

References

/1/ 2SC0435T2xx-17 Data Sheet, Power Integrations

/2/ 2SC0435T2xx-17 Description & Application Manual, Power Integrations

/3/ Application Note AN-0902, "Avoiding ESD with CONCEPT Drivers", Power Integrations

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