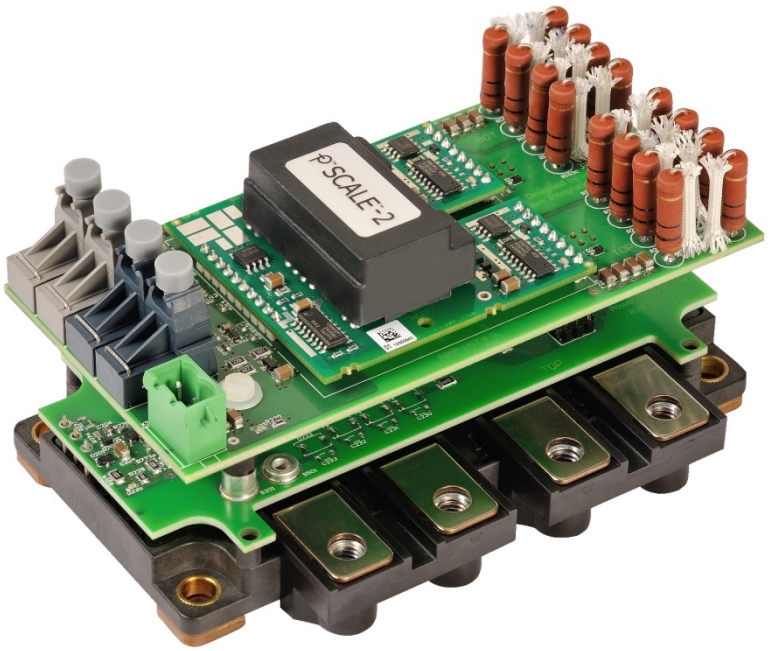
FMF800DX-24A with Gate Driver Core 2SC0435T

Application	2-level topology for general purpose drives, UPS, solar power and others
Specification	Suitable for 17mm dual full SiC MOSFET modules Up to 800V DC-link voltage Optical interfaces Advanced Active Clamping Adjustable overcurrent and short-circuit detection with Soft Shut Down (SSD)
Author	High-Power Application Engineering Department
Document Number	RDHP-1417
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 17mm dual full SiC MOSFET power module.

The main features of the design are:

- Advanced Active Clamping
- Adjustable overcurrent and short-circuit detection with Soft Shut Down (SSD)
- Optical command inputs and status outputs
- 15V supply voltage
- Dual PCB solution with soldered-in gate driver core

Intellectual Property Licensing

This design proposal contains an intellectual property of Power Integrations (PI), which provides a modular and adjustable circuitry for a soft shut down function for overcurrent and short-circuit events. Power Integrations offers this "External PI Value" with a royalty free license in conjunction with Power Integrations' parts in the same circuitry. No license is extended for use with non-PI parts.

Additional information can be obtained from the PI homepage at the following link:

https://igbt-driver.power.com/design-support/certificates-and-statements/

Application Conditions

The design is proposed for the following application conditions:

- Maximum DC-link voltage of 800V under switching conditions
- Typical total stray inductance of the commutation loop of 20nH
- Maximum switching frequency of 45kHz @ Ta = 85°C and 60kHz @ Ta < 70°C

Design Description

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

Gate Resistors

The gate resistor values are pre-selected and based on measurement results during the validation tests of the design. Depending on actual application conditions it may be required to modify the given gate resistor values.

V_{CEsat} Monitoring

2SC0435T gate drivers from Power Integrations provide sense inputs for monitoring IGBT or SiC MOSFET short-circuit conditions. The details of the V_{CEsat} monitoring function are described in the corresponding application manual of the gate driver.

The function of the V_{CEsat} monitoring is used in this design together with the sense outputs of the SiC MOSFET power module. The sense outputs act like a current-mirror to the main source terminal of the power module and provide a sense current i_{Sense}, which is proportional to the actual drain-current i_D. The sense current i_{Sense} is transformed via a shunt resistor (R127 and R227 of the bottom PCB) to a voltage signal. By adjusting the shunt resistor different overcurrent or short-circuit trip levels can be realized.

Soft Shut Down (SSD)

This design proposal possesses a dedicated SSD function, which is activated once an overcurrent or short-circuit event is detected through the sense output terminals of the power module. SSD reduces the turn-off $^{di}/_{dt}$ to limit overvoltage spikes as soon as an overcurrent or short-circuit condition is detected. An excessive turn-off overvoltage is therefore avoided and the SiC MOSFET is turned off within its safe operating area.

To provide also an effective overvoltage protection for switching events below the overcurrent threshold level Advanced Active Clamping is implemented.

Advanced Active Clamping

Active clamping is a technique designed to partially turn on the SiC MOSFET in case the drain-source voltage exceeds a predefined threshold. The SiC MOSFET is then kept in linear operation. Basic Active Clamping topologies implement a single feedback path from the SiC MOSFET's drain through transient voltage suppressor (TVS) diodes to the SiC MOSFET gate.

Advanced active clamping topologies implement the same structure as basic active clamping topologies, but in addition a fraction of the active clamping current is fed into the gate driver core at pins ACLx via 20Ω resistors. In this case, when active clamping is activated, the turn-off MOSFET of the 2SC0435T driver 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.

Minimum Pulse Suppression

No minimum pulse suppression is implemented.

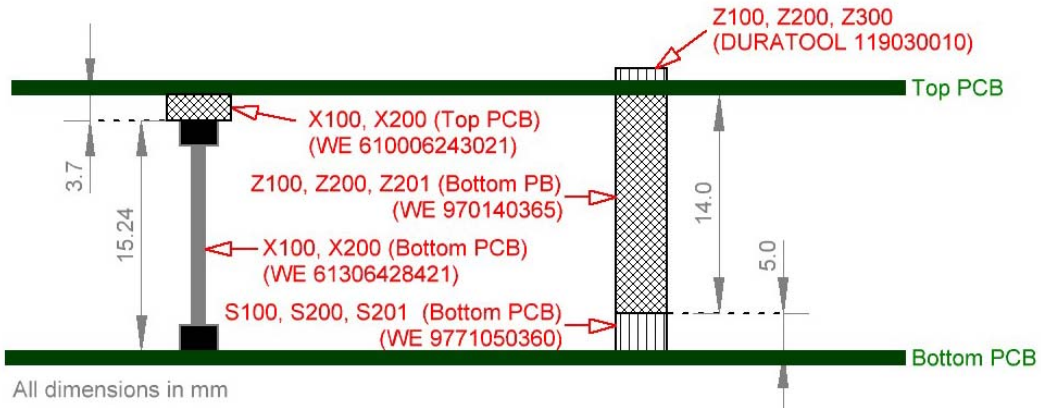
Blocking Time

During the blocking time, which is set to typically 99ms (R314), 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, overcurrent or a short-circuit event) or when an undervoltage condition ends on the primary side.

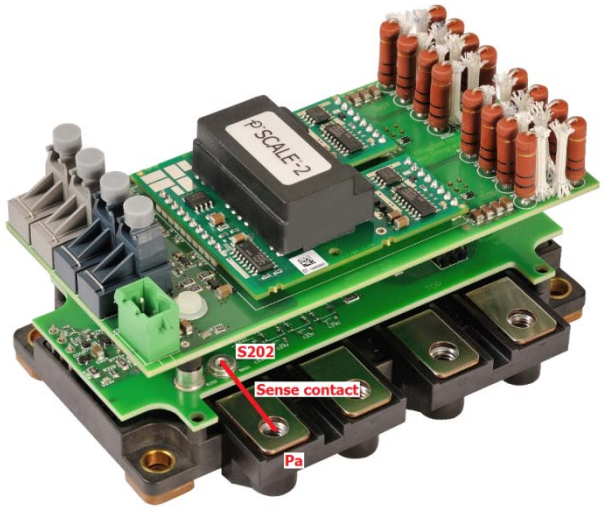
For further details refer to the application manual of the gate driver core 2SC0435T.

Mounting Instruction

This design proposal consists of two PCBs, which need to be mounted together according to the following drawing:



Furthermore, a conductive connection (sense contact) needs to be established from PCB terminal S202 to the power module terminal Pa:



Interfaces

Electrical Interfaces

X300		
Pin	Designation	Description
1	V15	15V supply (referenced to GND)
2	GND	Ground

S202		
Pin	Designation	Description
1	C2	Drain sense top switch

Optical Interfaces

IC300	
Pin	Designation
INA	Command input top switch

IC301	
Pin	Designation
INB	Command input bottom switch

D300	
Pin	Designation
SO1	Status output top side

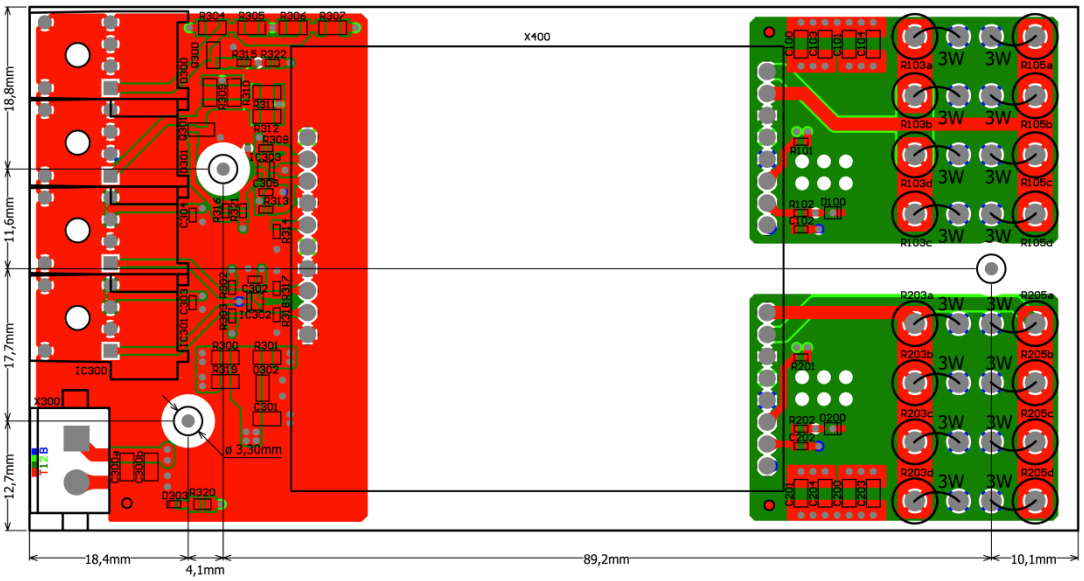
D301	
Pin	Designation
SO2	Status output bottom side

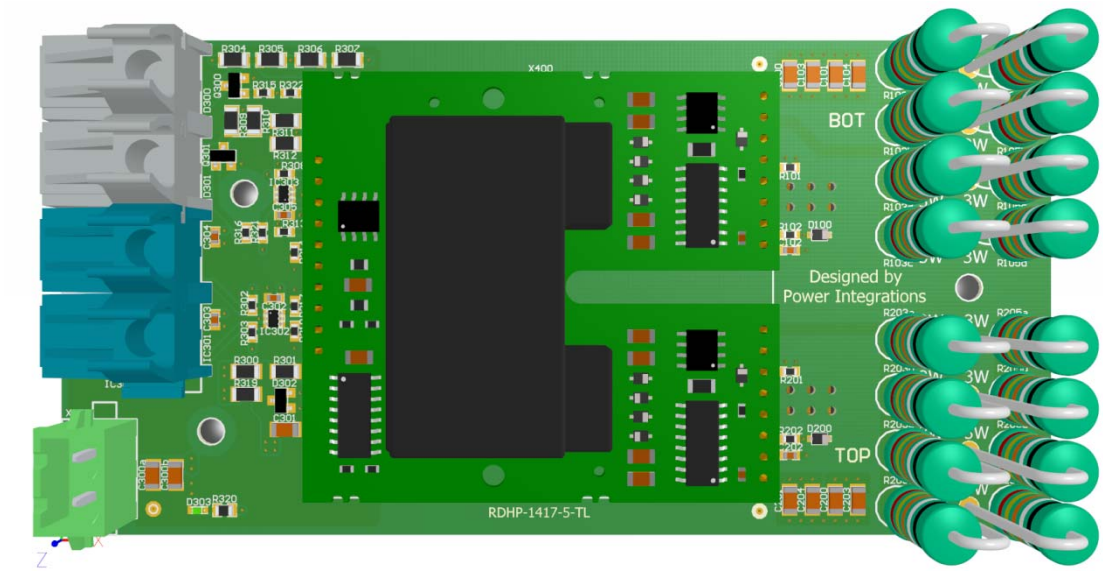
CAD Data

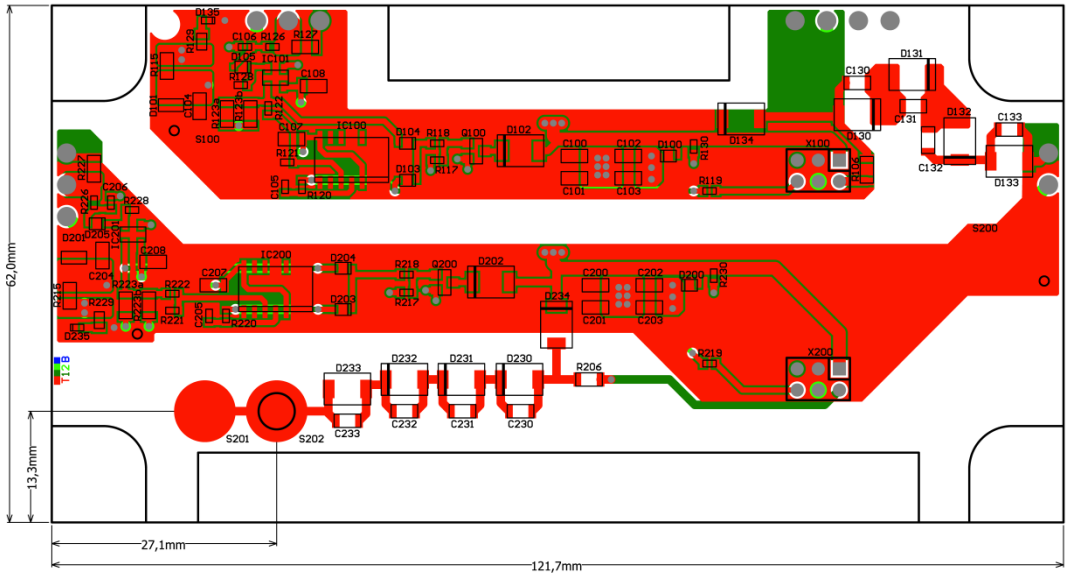
The set of CAD data, which includes the circuit schematics, Gerber files, BOM and Pick-and-Place file are available as separate documents bundled together with this documentation.

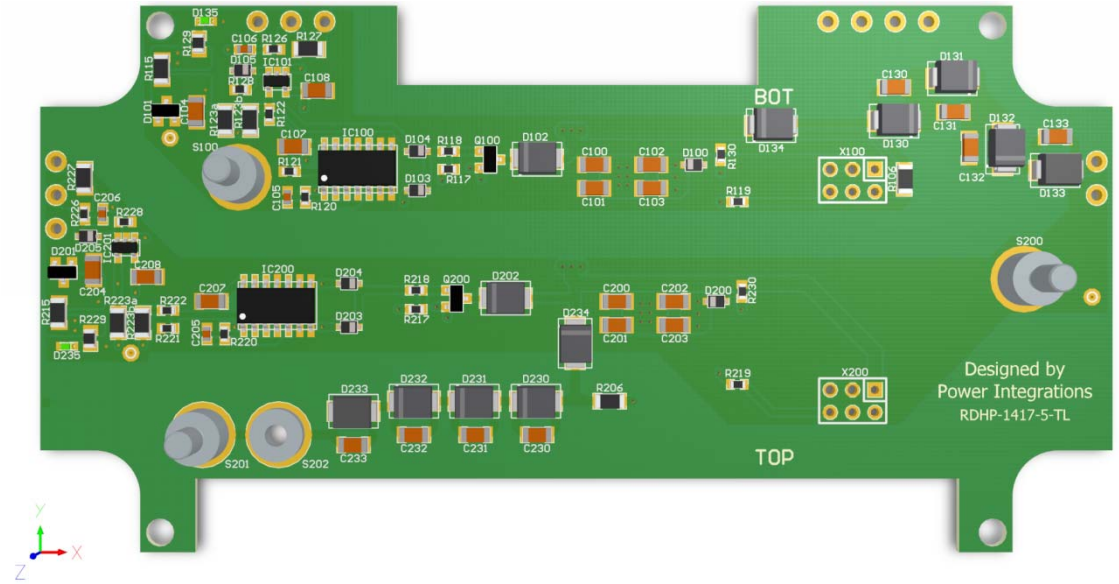
Layout Example

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






62,0mm
13,3mm
27,1mm
121,7mm


BOT
TOP
Designed by
Power Integrations
RDHP-1417-5-TL

Switching Characteristic

Turn-On / Off (without SSD)

The following measurement examples were carried out at room temperature with the SiC MOSFET power module FMF800DX-24A from Mitsubishi Electric (R_{Gon} = 2.5Ω and R_{Goff} = 2.5Ω) in a double-pulse test using a half-bridge topology setup with an initial DC-link voltage of 800V_{DC}. The total nominal load current corresponds to I_{nom} = 800A. The current measurement was conducted separately for the left and right part of the power module (two paralleled systems of a half-bridge topology).

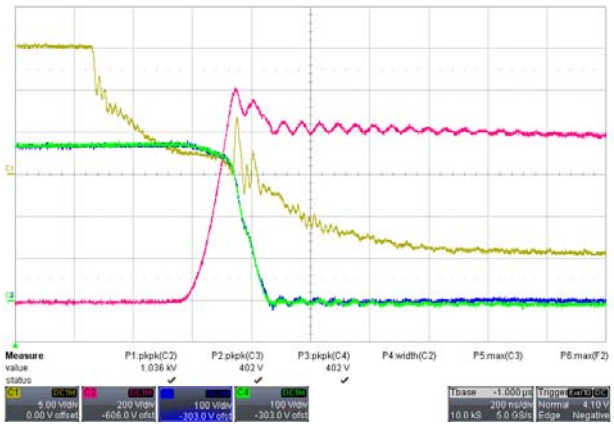
Channel assignment:

Channel C1: Gate-source voltage

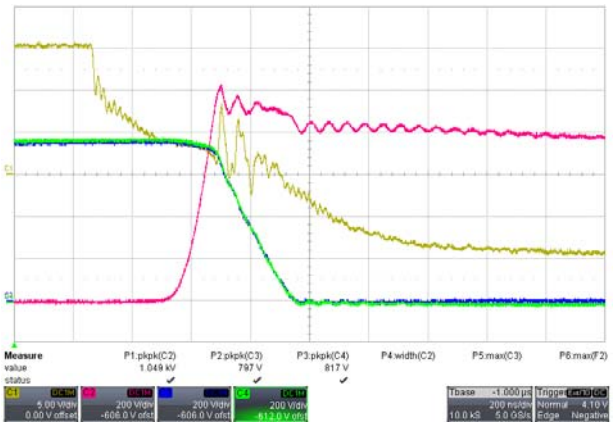
Channel C2: Drain-source voltage

Channel C3: Source current (left leg)

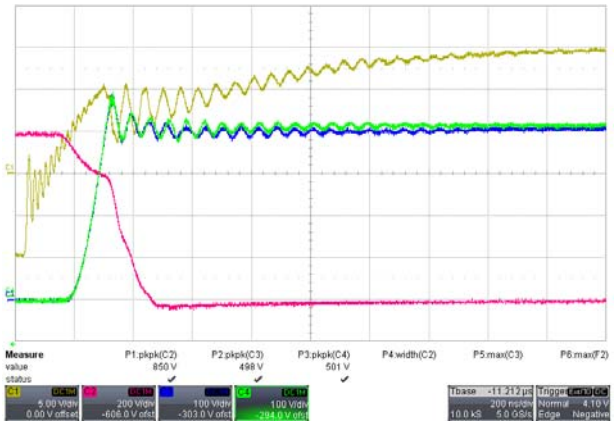
Channel C4: Source current (right leg)



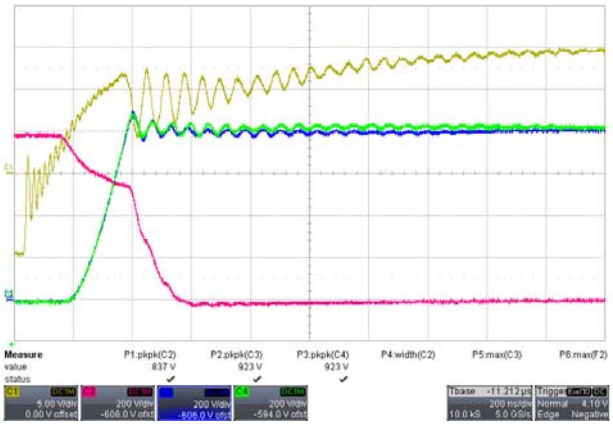
Turn-off bottom side (I_{nom})



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



Turn-on bottom side (I_{nom})



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

Turn- Off (with SSD)

The following measurement example was carried out at room temperature with the SiC MOSFET power module FMF800DX-24A from Mitsubishi Electric (R_{Gon} = 2.5Ω and R_{Goff} = 2.5Ω) in a double-pulse test using a half-bridge topology setup with an initial DC-link voltage of 800V_{DC}. The total nominal load current corresponds to I_{nom} = 800A. The current measurement was conducted separately for the left and right part of the power module (two paralleled systems of a half-bridge topology).

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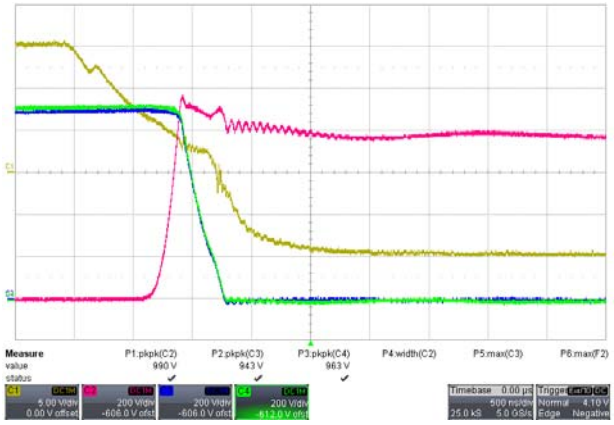
Channel C4: Source current (right leg)



Turn-off bottom side (2.4x I_{nom})

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

Technical Support

Power Integrations provides expert help with your questions and problems:

Website http://www.power.com/igbt-driver/go/support

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Quality

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Legal Disclaimer

Reference Designs are technical proposals concerning how to use Power Integrations' gate drivers in particular applications and/or with certain power modules. These proposals are "as is" and are not subject to any qualification process. The suitability, implementation and qualification are the sole responsibility of the end user.

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