Benefits of SiC for Industrial Auxilliary Power Supply

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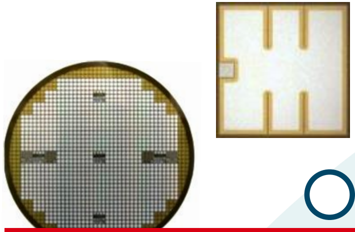
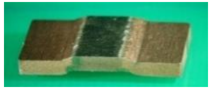
ROHM’s Power Devices

ROHM’s power item lineup covers wafers/bare dies, discrete packages, module, ICs and Intelligent Power Modules

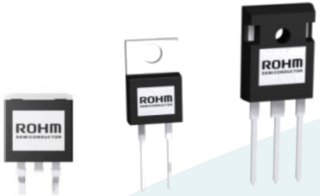


○ **Device**

FET
FRD
SBD
Shunt Resistor



Today we focus on an auxilliary supply solution around discrete SiC MOSFETs and driving/control IC



○ **Discrete**

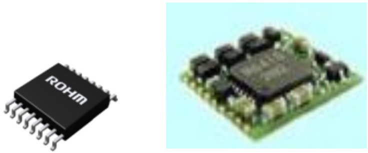
TO220
TO247/3PF
D-Pak / D2-Pak
etc···

○ **Power Module**

Case type
(Full SiC Module)
Mold type
IPM etc···

○ **ICs**

Gate driver
Temperature/High Voltage monitor
ACDC etc···



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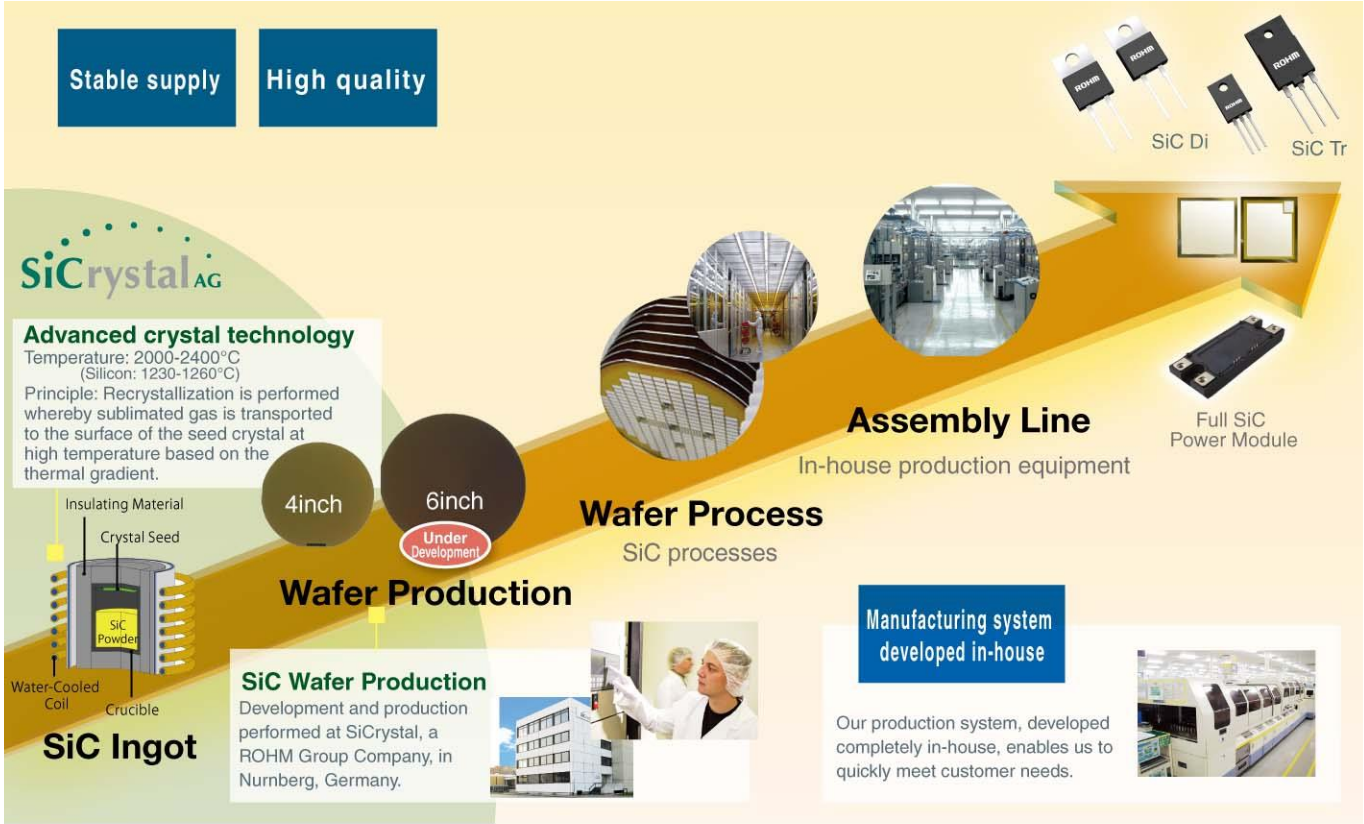
Integrated SiC Production



Advanced crystal technology

Temperature: 2000-2400°C
(Silicon: 1230-1260°C)

Principle: Recrystallization is performed whereby sublimated gas is transported to the surface of the seed crystal at high temperature based on the thermal gradient.

SiC Wafer Production

Development and production performed at SiCrystal, a ROHM Group Company, in Nurnberg, Germany.

Manufacturing system developed in-house

Our production system, developed completely in-house, enables us to quickly meet customer needs.

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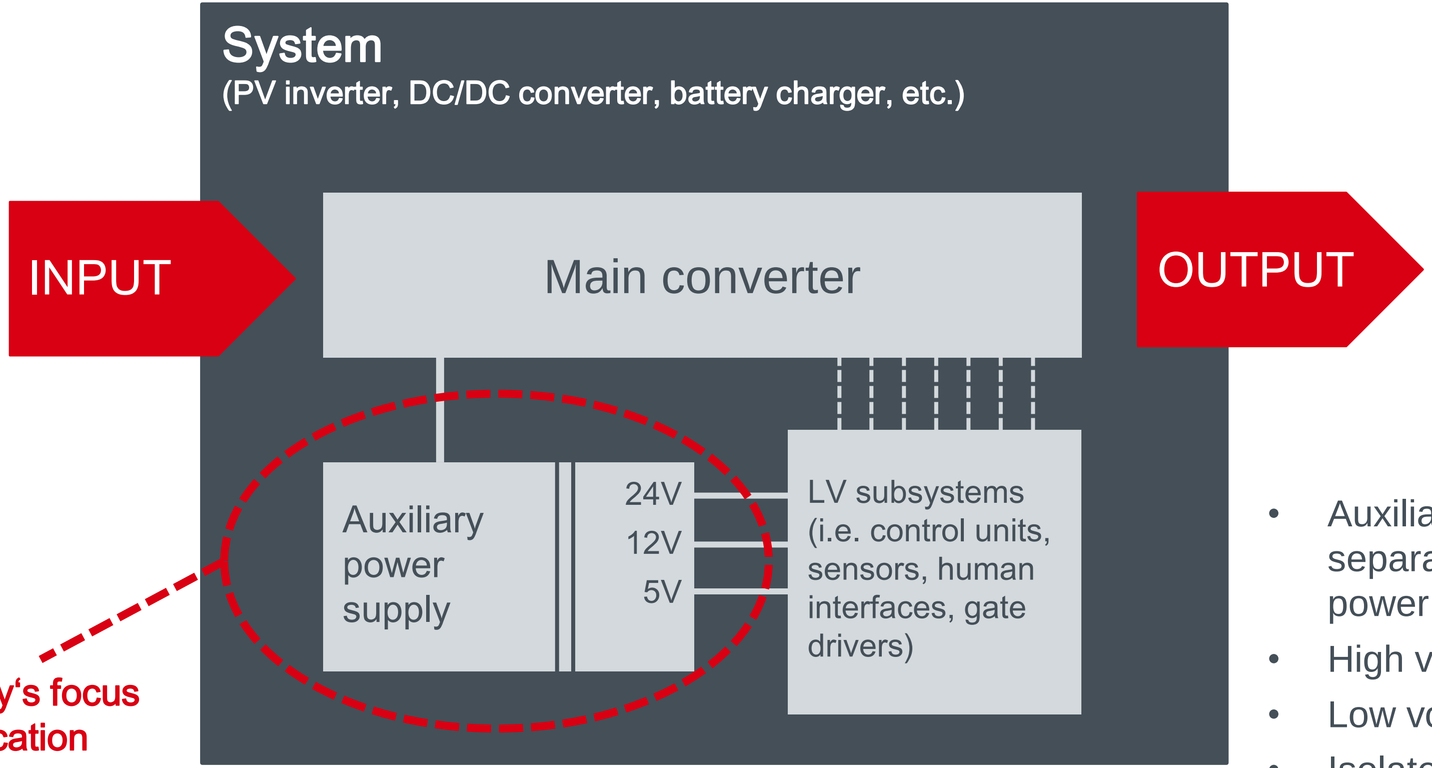
Auxiliary power supplies for industrial applications



System
(PV inverter, DC/DC converter, battery charger, etc.)

INPUT

Main converter

OUTPUT

Auxiliary power supply

24V
12V
5V

LV subsystems (i.e. control units, sensors, human interfaces, gate drivers)

Today‘s focus application

- Auxiliary supply is separated from the main power path
- High voltage input
- Low voltage output
- Isolated

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Myths of SiC MOSFET technology

Expensive

Device cost may be higher, but **overall system cost equal or lower**

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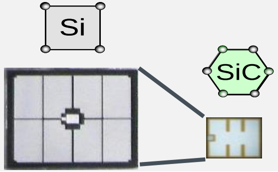
Application advantages vs. Si components

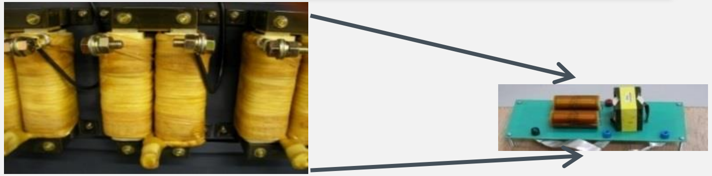
Lower Resistance



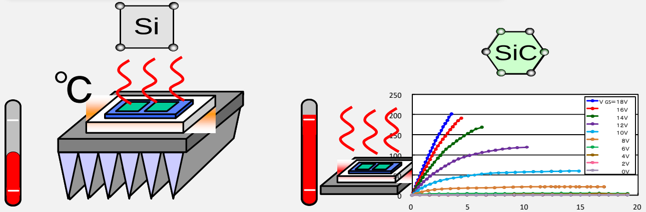
Smaller Size / Higher Efficiency

Higher Frequency Operation

Smaller Passive Components

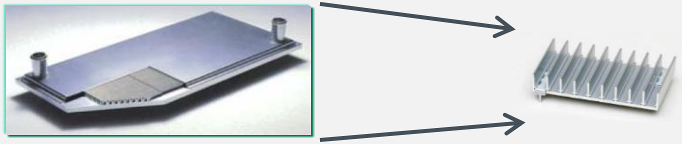


Higher Temp Operation



Simpler Cooling System

Down sizing



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Myths of SiC MOSFET technology

Expensive

SOLVED

Device cost may be higher, but **overall system cost equal or lower**

Not reliable

Extensive reliability testing done, comparable to Si-based devices

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Reliability aspects of SiC Trench MOSFETs

Reliability tests for ROHM Trench MOSFETs

Test	IEC Standard	Conditions	Si	SiC	Comments SiC
High Temperature Reverse Bias	60747	1000 h @ 95% $V_{ds,max}$, T_{amb}= 125..145°C	✓	✓	@ 100% $V_{ds,max}$ T_{amb}= $T_{j,max}$ =175°C
High Temperature Gate Bias	60747	1000 h @ ±$V_{GS,max}$,	✓	✓	
High Humidity High Temperature Reverse Bias	6				$V_{ds,max}$=100V
High Temperature Storage	6				
Low Temperature Storage	60068-2-1	1000 h @ $T_{STG,min}$	✓	✓	
Thermal Cycle	60068-2-14	100 cycles $T_{STG,max}$ - $T_{STG,min}$	✓	✓	

SiC 3 Gen. MOSFETs undergo reliability tests similar to those for Si MOSFETs and IGBTs

➔ Automotive qualification soon to be finished

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Myths of SiC MOSFET technology

Expensive

SOLVED

Device cost may be higher, but **overall system cost equal or lower**

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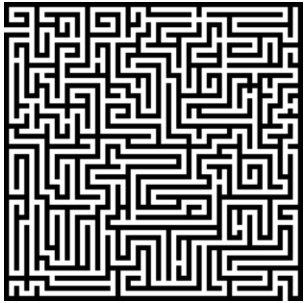
Complex



Use of SiC MOSFETs can simplify circuit design

Todays focus:
Simple solution for aux supply

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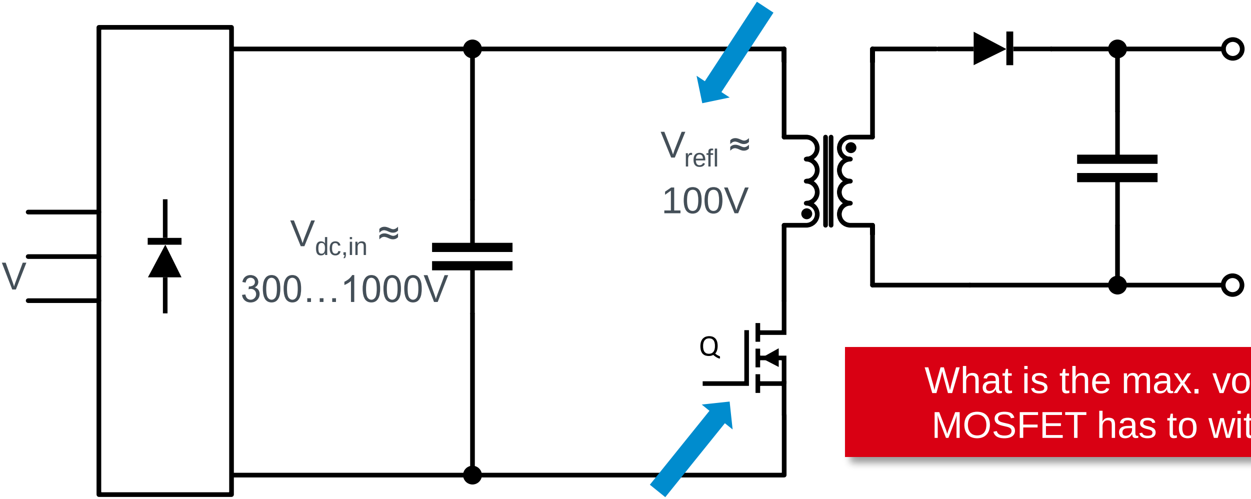
Typical circuit for industrial auxilliary supply

Flyback converter with 3-phase input



Reflected voltage from secondary side

$V_{refl} \approx$ 100V

AC mains 3ph

$V_{ac,in}$ = 210…690V

$V_{dc,in} \approx$ 300…1000V

$V_{surge} \approx$ 200V (turn-off overshoot)

What is the max. voltage the MOSFET has to withstand?

➔ $\mathbf{V_{dc,in} + V_{refl} + V_{surge} = 1300V}$

Device rated voltage: **≥ 1500 V**

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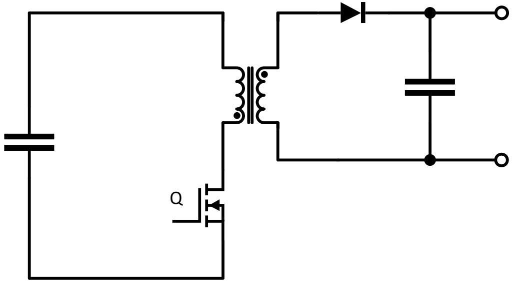
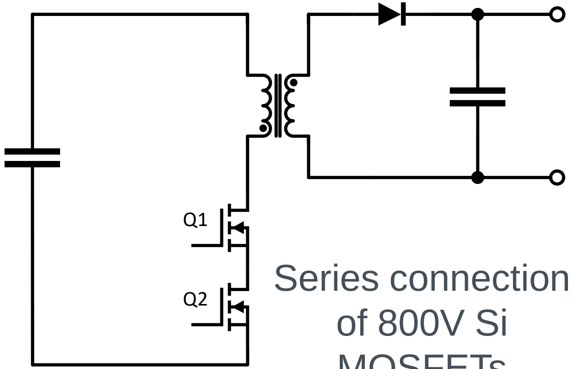
Typical Si-based solutions



1500V Si MOSFET

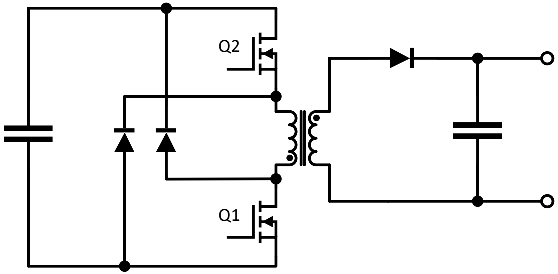
e.g. 1500V, 6Ω

- High gate charge Qg (high gate driving losses)
- High leakage current, especially at high temp.
- High conduction losses



Series connection of 800V Si MOSFETs

- Gate driving circuit more complex
- Static voltage balancing network
- Larger space for the heat sink



Two-switch flyback topology

- Higher complexity in design and assembly
- Isolated gate driver & power supply for high side
- Larger space for the heat sink

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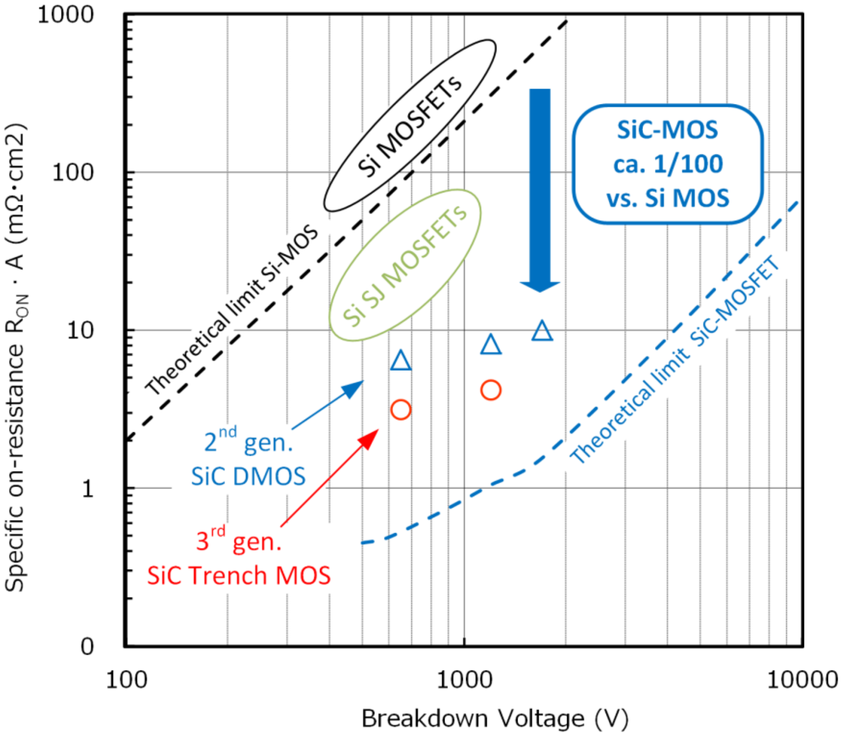
Why use a SiC-MOSFET in this application?



Technology advantage of SiC MOSFET:

→ Significantly reduced $R_{DS(on)}$·A

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Why use a SiC-MOSFET in this application?

Property	unit	SCT2H12NZ			Si-MOSFET-A			Si-MOSFET-B			Si-MOSFET-C		
		min	typ	max	min	typ	max	min	typ	max	min	typ	max
V(BR)DSS	V	1700			1500			1500			1500		
Id @ 25°C	A		3,7				2			2,5			6
Rds(on)@25°C	Ω		1,15	1,5		9	12		6	9		2,2	3
Idss@25°C	µA		0,1	10			500			10			1000
Ciss	pF		184			990			939			2025	
Rg	Ω		64						4				
Qg	nC		14						29,3			114	
Rth(j-c)	K/W		3,32	4,32						2			

- SiC MOSFET has lower $R_{DS(on)}$ · Area
- Also, Qg and capacitance are much reduced – for same $R_{DS(on)}$

- High gate resistance of SiC device demands a low-impedance gate drive

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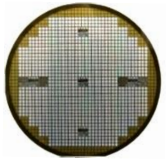
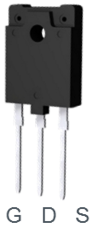
ROHM SiC-MOSFETs for Auxiliary Power Supplies

Lineup 1700V SiC MOSFET devices:

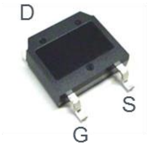
	Part No.	V_{DS}[V]	$R_{DSon\ typ}$[mΩ] @Vgs=18V	I_D[A] @T_C=25°C	I_D[A] @T_C=100°C	T_{jmax}[°C]	Package	Die Part No.
	SCT2H12NZ	1700	1150	3,7	2,6	175	TO-3PFM	-
NEW	SCT2H12NY	1700	1150	4,0	2,9	175	TO-268-2L	-
NEW	SCT2750NY	1700	750	5,9	4,0	175	TO-268-2L	-
		1700	100	34	-	175	bare die	S2409



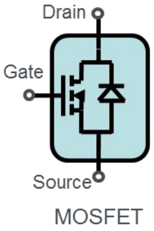
TO-3PFM



TO-268-2L



SCT series



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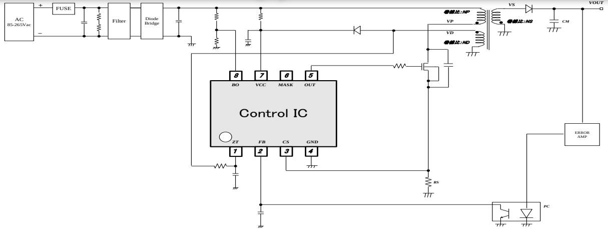
BD768xFJ-LB – Control IC for SiC Aux Supply

Feature

- Optimum System for driving SiC MOSFET
- Quasi – Resonant DC/DC convertor
- Low VCC current（19uA@VCC=18.5V）
- Burst function at light load
- Max Frequency Controlled（120kHz）
- VCC Over Voltage Protection
- VCC Under Voltage Locked Out
- Brown IN/OUT Function
- DC/DC Soft Start
- DC/DC Cycle by Cycle current limiter
- 250nsec Leading-Edge Blanking
- ZT Trigger mask function
- ZT Over Voltage Protection
- Over Load Protection (128ms Timer) ●MASK Function

Application circuit



Specification

●Operating VCC Range : 15.0V ~ 27.5V
●DCDC Max Frequency : 120kHz
●Operating current 800 uA
●Operating Temperature: - 40deg. to +105deg.

PIN place ／ Package

NO.	Pin	
1	ZT	Zero Current Detect pin
2	FB	Feedback pin
3	CS	Current Sense pin
4	GND	GND pin
5	OUT	MOSFET drive pin
6	MASK	External TR drive
7	VCC	Power Supply pin
8	BO	Broun IN/OUT monitor pin

SOP-J8S
6.0mm×4.9mm :
1.27mm pitch
<TYP>

Application

Factory Automation, PV Inverter, Battery Charger

Line up

	FBOLP	VCCOVP
BD7682FJ	AutoRestart	Latch
BD7683FJ	Latch	Latch
BD7684FJ	AutoRestart	AutoRestart
BD7685FJ	Latch	AutoRestart

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BD768xFJ-LB – Features for driving SiC MOSFETs

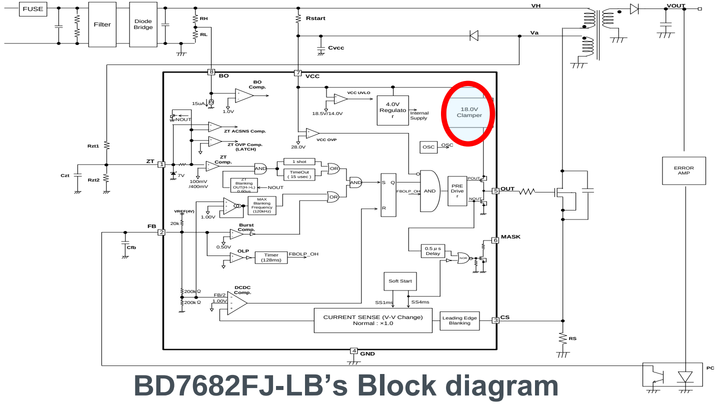
SiC MOSFET gate driving requirement

Compared to Si MOSFETs the **permissible gate-voltage** range is smaller.
Recommended gate drive voltage for SiC MOSFET: ca. 18V (max. rating: +22V, ensure min. level of ca. 14V to avoid thermal runaway)

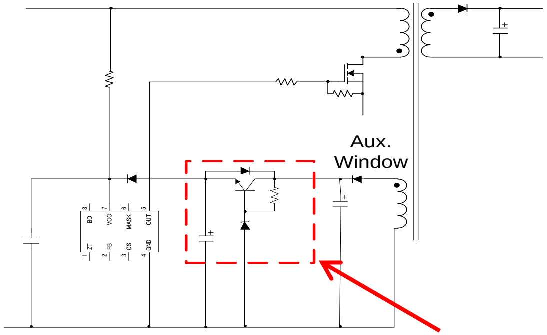
Suitable UVLO and gate-clamp circuit integrated in BD768xFJ-LB

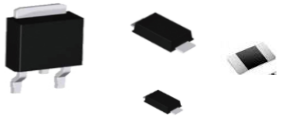
Gate-clamp limits the OUT terminal voltage, so as not to apply an **overvoltage** to the gate voltage of the SIC-MOSFET.
UVLO (14 V typ.) ensures no operation with **undervoltage** to avoid thermal problems.

Parameter	Specifications			Unit
	MIN	TYP	MAX	
OUT Pin Clamp Voltage	16	18	20	V
OUT pin Nch MOS Ron	2	5	10	Ω



BD7682FJ-LB's Block diagram





Over Voltage can be prevented, but still need to ensure correct UVLO to protect against too low gate voltages!

External Gate Clamp Circuit

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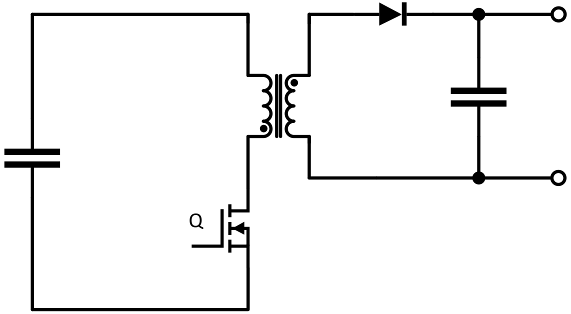
Auxiliary power supply solution

SiC-based solution with 1700V MOSFET and single-switch flyback topology

- Single switch
- Isolated package
- Control IC **BD768xFJ**
- Heat sink not mandatory if <40W



TO-268 2L

0.75Ω, 1.15Ω

TO-3PFM

1.15Ω

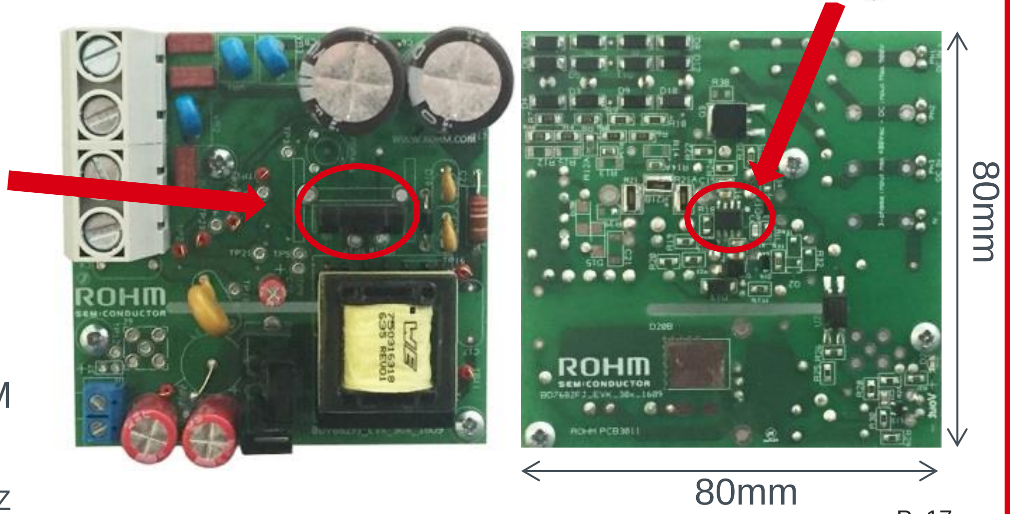
SCT2H12NZ

Input:	300-900 Vdc
Output:	12 Vdc
Power:	40 W (no heat sink)
Sw. freq.:	90…120 kHz
Efficiency:	85% (300 Vdc), 83% (700 Vdc)

ROHM evaluation board available

BD7682FJ_EVK_301

BD768xFJ



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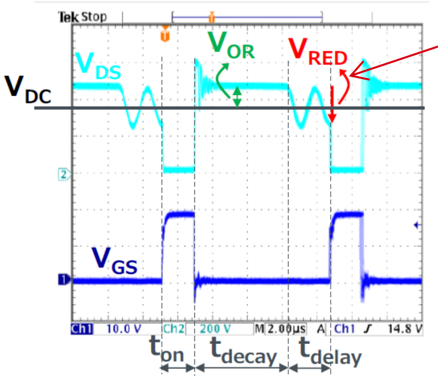
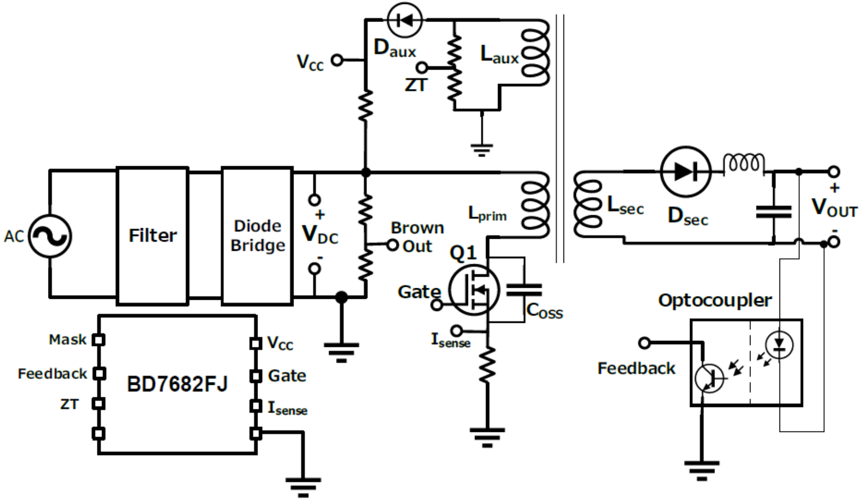
Auxiliary power supply solution

ROHM evaluation board
BD7682FJ_EVK_301



Reduced effective switching voltage leads to lower turn-on loss



Control IC for SiC based solution: **BD768xFJ**

- Implements quasi-resonant switching to minimise dynamic losses and achieve low noise
- Suitable drive voltage for SiC MOSFET

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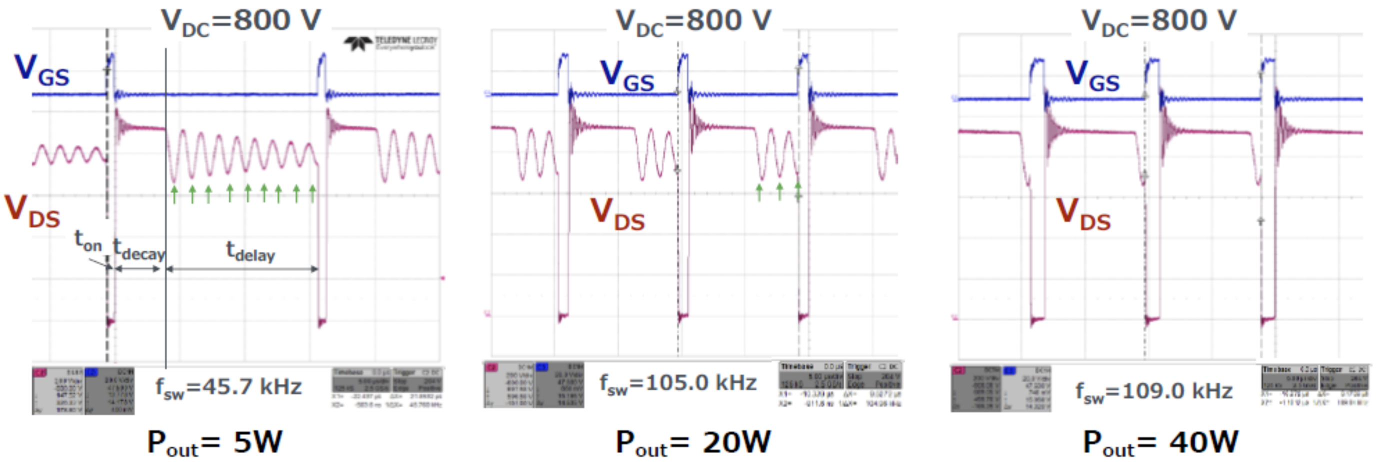
Auxiliary power supply solution

Waveforms of flyback switch for different operating contitions:



- Quasi-resonant operation is maintained across the output power range
- As the delay time decreases the effective switching frequency increases with increased load

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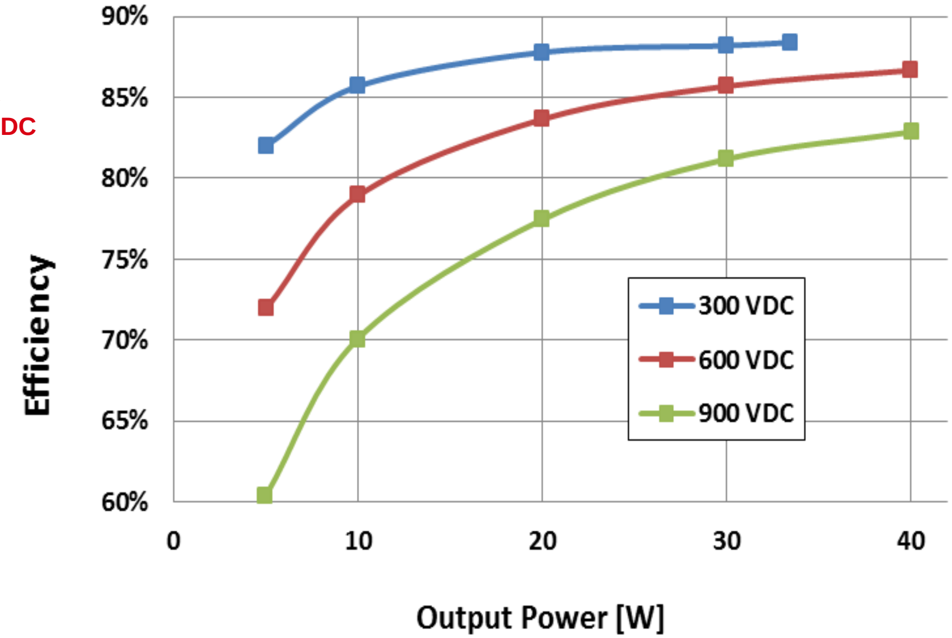
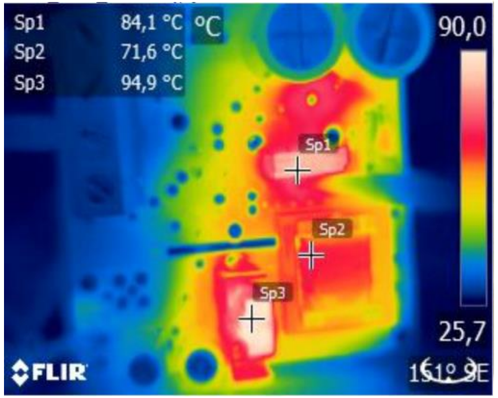
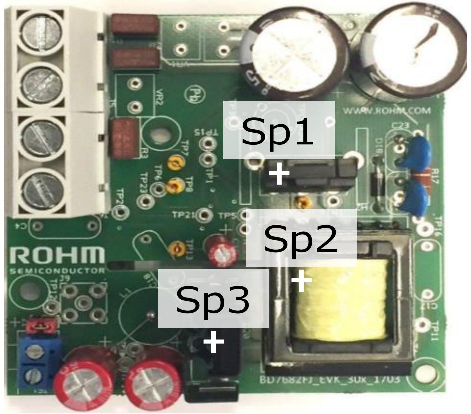
Auxiliary power supply solution

Operation at 40W without heat sink ➔
(with heat sink ca. 100W possible)

V_{out} = 12 V_{DC}







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Conclusions

- Combination of BD768xFJ and 1700V SiC MOSFET

  → **Simple** and **performant** auxilliary supply solution

- Great alternative to current solutions with series connection of Si MOSFETs or complex topologies.

- Auxilliary suply applications shows that cost advantages can be realised on system level if the SiC device benefits are fully utilised.

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Thank you for your attention!

In case of later questions please contact:

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