



Asia Pacific
Power Seminar 2022

Wide Bandgap Devices

for next generation of power electronics

Ravinder Pal Singh



Agenda

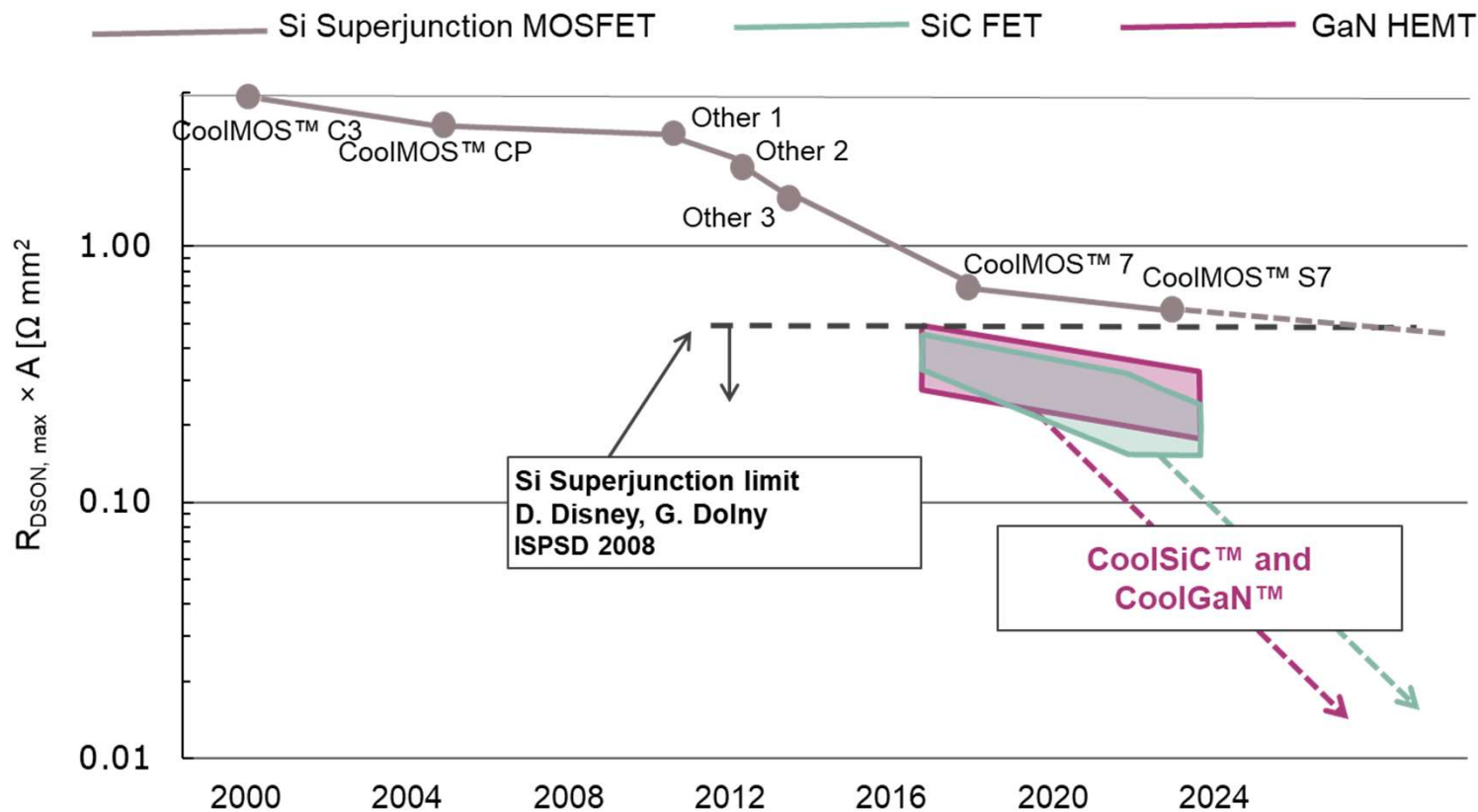
- › Wide Bandgap material properties
 - Infineon - a Si and WBG technology provider

- › CoolSiC™ MOSFETs
 - SiC Technology Differentiators
 - Driving CoolSiC MOSFETs
 - 650V/1200V/1700V Product Portfolio

- › 600V CoolGaN™ GIT HEMTs
 - GaN Technology Differentiators
 - Driving CoolGaN HEMTs
 - Integrated power stage (IPS)
 - 600V CoolGaN™ Product Portfolio

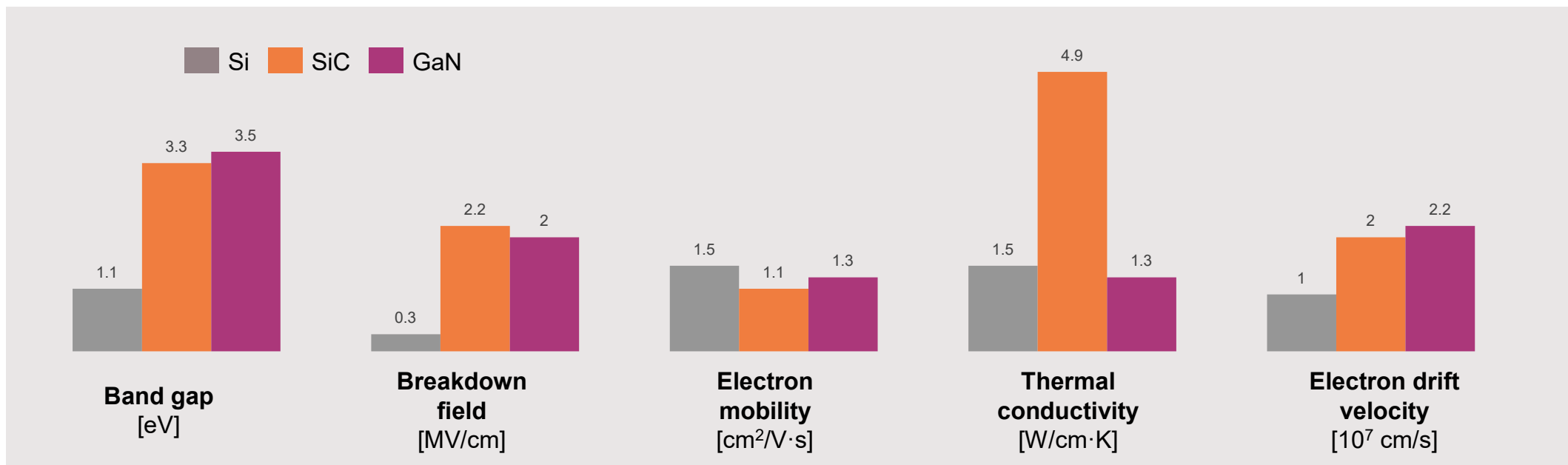
- › Summary
 - Si/SiC/GaN Value Proposition

Background: $R_{on} \times A$ “roadmap” of HV semiconductor devices



- ✓ Thanks to further improvement in manufacturing processes Si SJ limit potentially pushed lower than $0.5 \Omega \text{ mm}^2$
- ✓ New materials (e.g. GaN and SiC) continue to push the barriers lower.

Si, SiC, and GaN show different material properties



The wide band-gap of GaN and SiC...

...enables higher breakdown fields...

...allowing for strong minituarization of devices and significant improvements of figures of merit (FOM) for power switches...

Si, SiC, and GaN

Value proposition in the 600 V and 650 V segment



Silicon (Si)

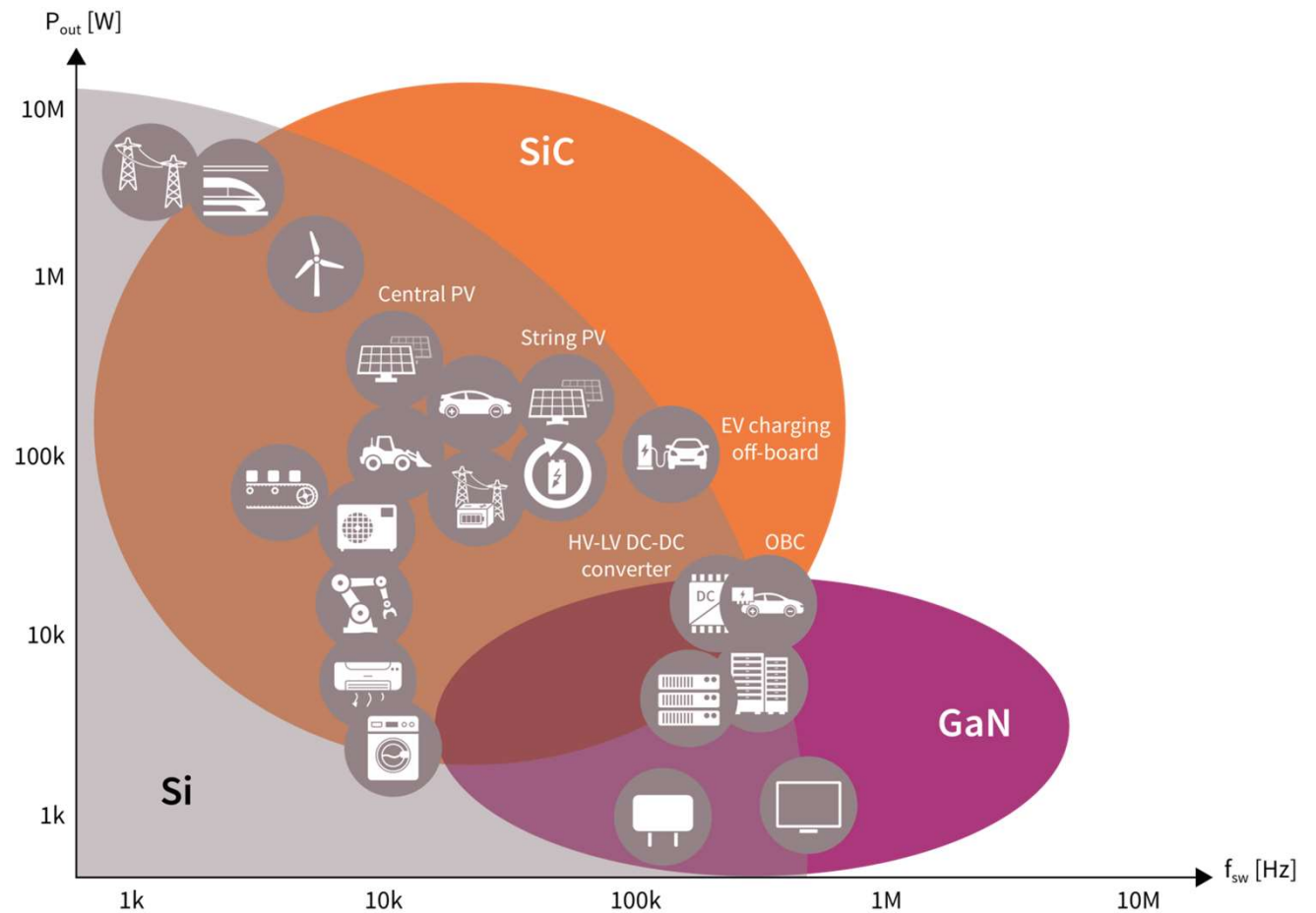
- › Targeting voltages ranging from 25 V – 1.7 kV
- › The mainstream technology
- › Suitable from low to high power

Silicon carbide (SiC)

- › Targeting voltages ranging from 650 V – 3.3 kV
- › High power from moderate to high switching frequency

Gallium nitride (GaN)

- › Targeting voltages ranging from 80 V – 650 V
- › Medium power at highest switching frequency



Si, SiC, and GaN

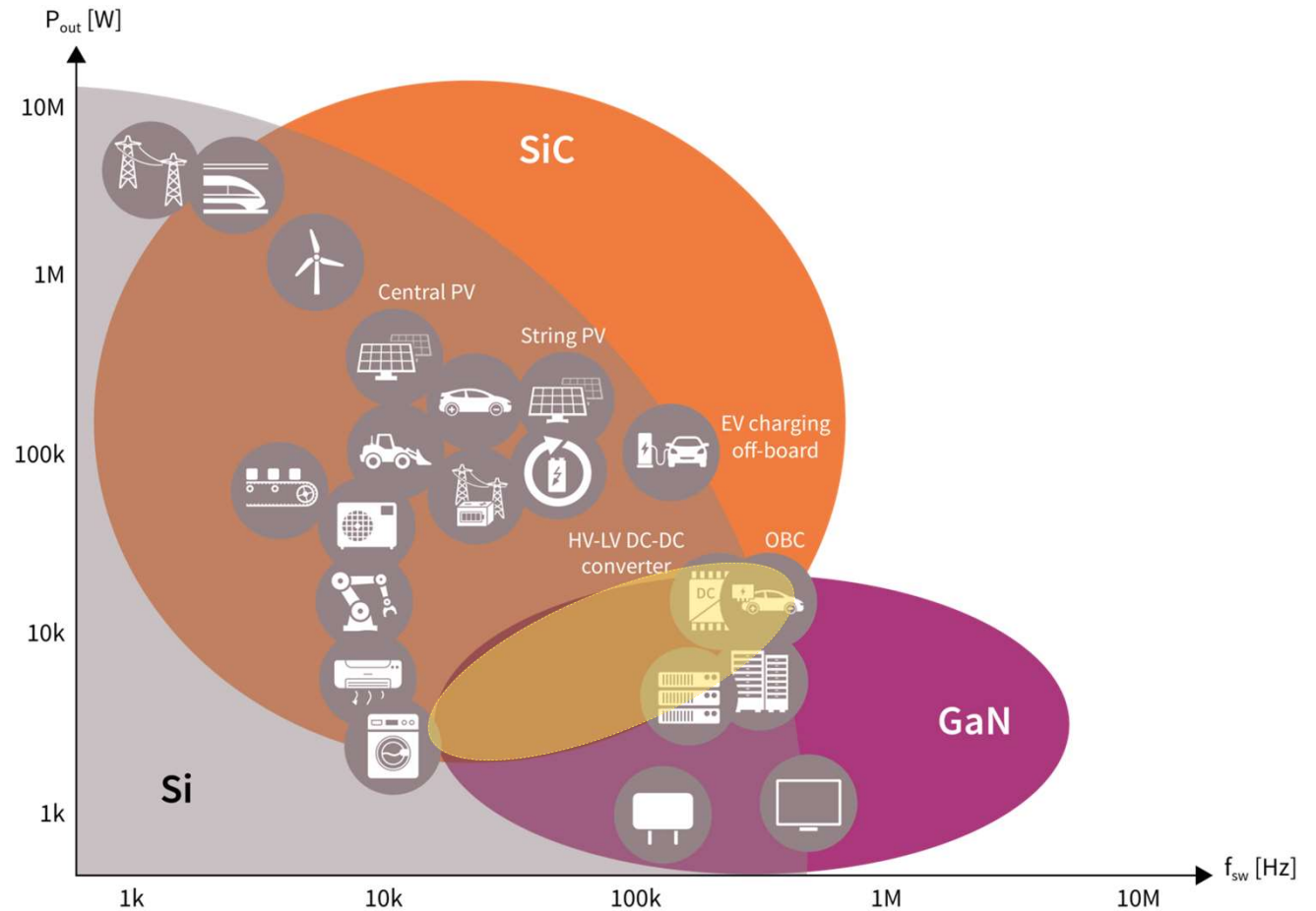
Value proposition in the 600 V and 650 V segment



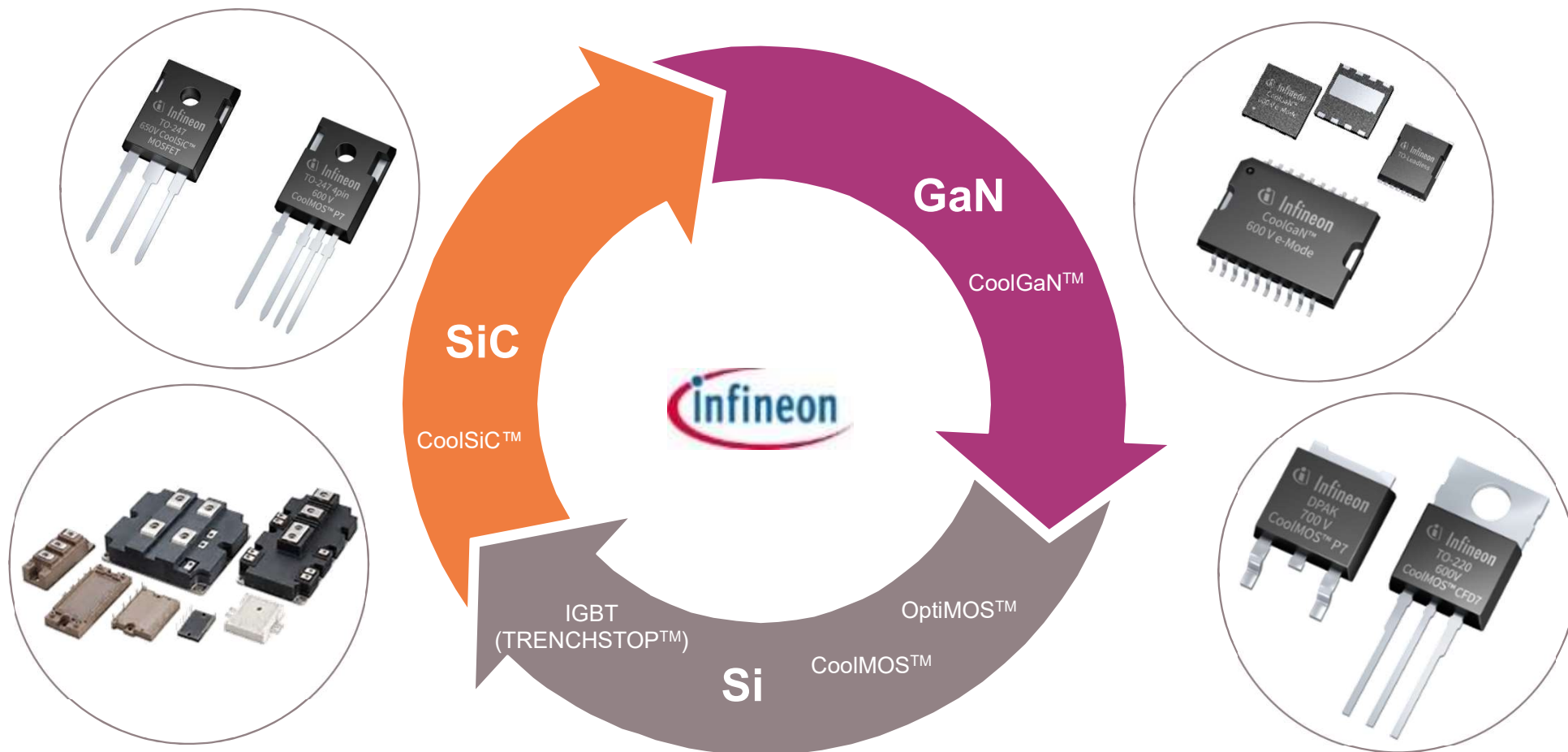
600 V / 650 V segment

CoolMOS™, CoolSiC™ and CoolGaN™ coexists, addressing applications such as:

Datacenter and telecom SMPS,
Industrial SMPS,
solar inverters,
energy storage, UPS,
battery formation, EV charging,
motor drives plus automotive applications
like OBC (on-board charger)



Si | SiC | GaN Positioning



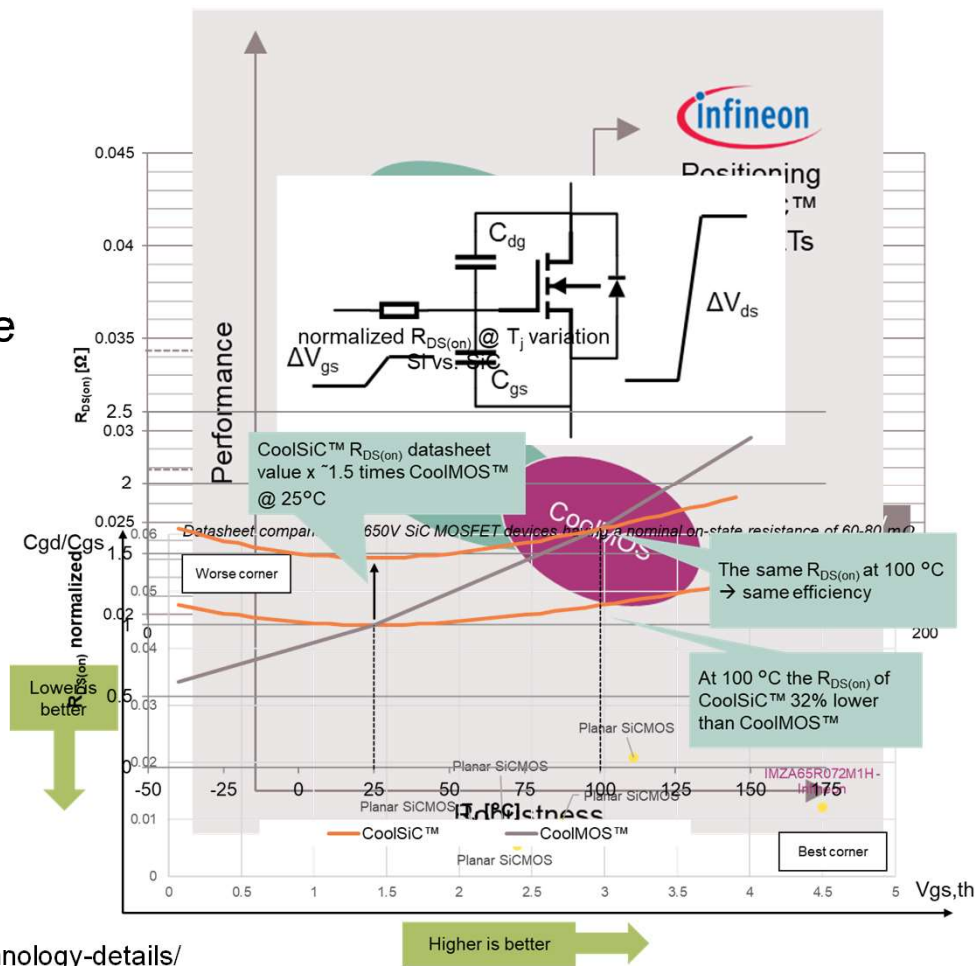
Infineon is mastering all base power technologies

650V CoolSiC™

A decorative graphic consisting of several thin, light green lines. One line starts from the top right, near the Infineon logo, and extends diagonally down to the right. Another line starts from the left edge and extends diagonally down to the right, meeting the first line. A third line starts from the left edge and extends diagonally down to the right, meeting the second line. A fourth line starts from the top right and extends diagonally down to the left, meeting the second line. A small dark green circle is located at the intersection of the second and third lines. A solid dark green shape, resembling a trapezoid or a wide triangle, is positioned at the bottom of the page, with its top edge following the path of the second and third lines.

Infineon's CoolSiC™

- › CoolSiC™ is a vertical device using trench gate.
- › Optimized for the operation of the body diode.
- › Matches the robustness that of silicon technology while having an advantage in terms of performance.
- › Recommended driving voltage levels of only $V_{GS} = 18\text{ V}$ (max 23V) combined with a sufficiently high gate-source threshold voltage of typically 4.5 V.
- › Unipolar driving is recommended.
- › Stable $R_{DS,ON}$ over operating range.
- › Susceptibility to unwanted turn-on effects-
 - $V_{GS(th)}$ of 4.5V and the smaller is the ratio C_{dg}/C_{gs}



For further reading: <https://www.infineon.com/cms/en/product/technology/silicon-carbide-sic/technology-details/>

Strong CoolSiC™ portfolio expansion: more than 130 catalogue products complemented by customized solutions



		Industrial					Automotive grade			
package options voltages	CoolSiC™ Diode	CoolSiC™ Hybrid		CoolSiC™ MOSFET			CoolSiC™ Diode	CoolSiC™ Hybrid	CoolSiC™ MOSFET	
	Discrete	Discrete	Module	Discrete	IPM	Module	Discrete	Discrete	Discrete	Module
600 V	Mass production									
650 V	Mass production	Mass production	Mass production	Mass production	Coming soon		Mass production	Expected in 2022		
1200 V	Mass production		Mass production	Mass production	Mass production	Mass production			Mass production	Exp. in 2022
1700 V				Mass production						

Continuous extension of portfolio

mass production




coming soon



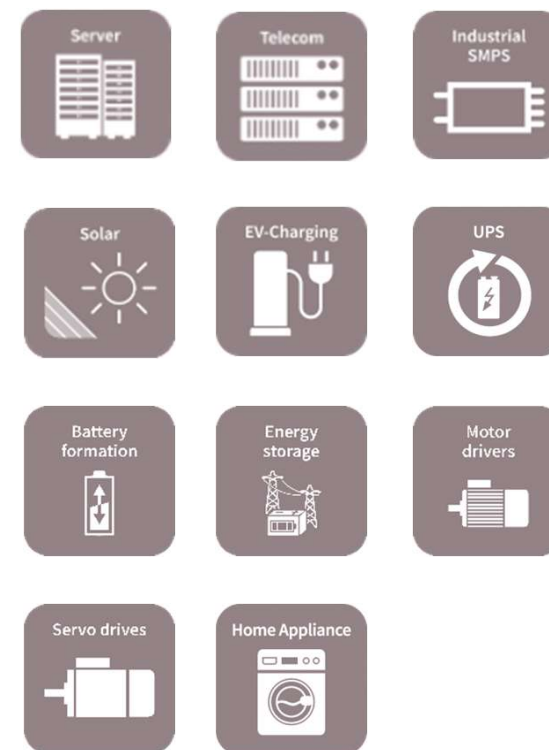
Complement the vast portfolio of CoolSiC™ MOSFETs with the EiceDRIVER™ gate driver ICs.

CoolSiC™ MOSFETs 650 V – industrial grade

Product portfolio

$R_{DS(on)}$ max [mΩ] 18 V	$R_{DS(on)}$ typ [mΩ] 18 V	TO-247-4	TO-247-3	D2PAK-7
				
346	260			IMBG65R260M1H
217	163			IMBG65R163M1H
141	107	IMZA65R107M1H	IMW65R107M1H	IMBG65R107M1H
111	83	IMZA65R083M1H	IMW65R083M1H	IMBG65R083M1H
94	72	IMZA65R072M1H	IMW65R072M1H	IMBG65R072M1H
74	57	IMZA65R057M1H	IMW65R057M1H	IMBG65R057M1H
64	48	IMZA65R048M1H	IMW65R048M1H	IMBG65R048M1H
50	39	IMZA65R039M1H	IMW65R039M1H	IMBG65R039M1H
42	30	IMZA65R030M1H	IMW65R030M1H	IMBG65R030M1H
34	27	IMZA65R027M1H	IMW65R027M1H	
30	22			IMBG65R022M1H
Available				

Target applications



Recommended Gate-Driver ICs for 650V CoolSiC™

1EDN9550B



1-channel **non-isolated differential** gate-driver IC

- > Source current: 4 A (0.85 Ω)
- > Sink current: 8 A (0.35 Ω)
- > Common robustness: +/- 150 V (w. CMR)
- > **UVLO_{VDD_on} (typ.): 14.9 V**
- > Prop. delay accuracy: + 10 ns / - 7 ns
- > Packages: SOT-23

www.infineon.com/1edn-tdi

1EDB6275F, 1EDB9275F



1-channel **galvanic isolated** gate-driver IC

- > Source current: 5.6 A (0.95 Ω)
- > Sink current: 10.2 A (0.48 Ω)
- > V_{IOTM} : 4242 V_{peak}
- > **CMTI: > 300 V/ns**
- > **UVLO_{VDD_on} (typ.): 12.2 V, 14.9 V (SiC)**
- > Prop. delay accuracy: + 5 ns / - 4 ns
- > Package: DSO 8-pin 150 mil



Every Switch needs a Driver



Every Switch needs a Driver

2EDF9275F



2-channel **galvanic isolated** gate-driver IC

- > Source current: 4 A (0.85 Ω)
- > Sink current: 8 A (0.35 Ω)
- > V_{IO} : 1500 V_{DC}
- > **CMTI: > 150 V/ns**
- > **UVLO_{VDD_on} (typ.): 13.7 V (SiC version)**
- > Prop. delay accuracy: + 7 ns / - 6 ns
- > Package: DSO 16-pin 150 mil

2EDS9265H



2-channel **galvanic isolated** gate-driver IC

- > Source current: 4 A (0.85 Ω)
- > Sink current: 8 A (0.35 Ω)
- > V_{IOTM} : 8000 V_{peak}
- > **CMTI: > 150 V/ns**
- > **UVLO_{VDD_on} (typ.): 13.7 V (SiC version)**
- > Prop. delay accuracy: + 7 ns / - 6 ns
- > Package: DSO 16-pin 300 mil

The new Infineon CoolSiC™ Schottky diode 650 V G6

The new silicon carbide diodes of generation 6 optimally leverage Infineon's leading technology for SiC Schottky barrier diodes

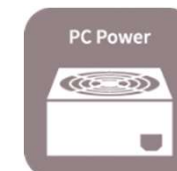
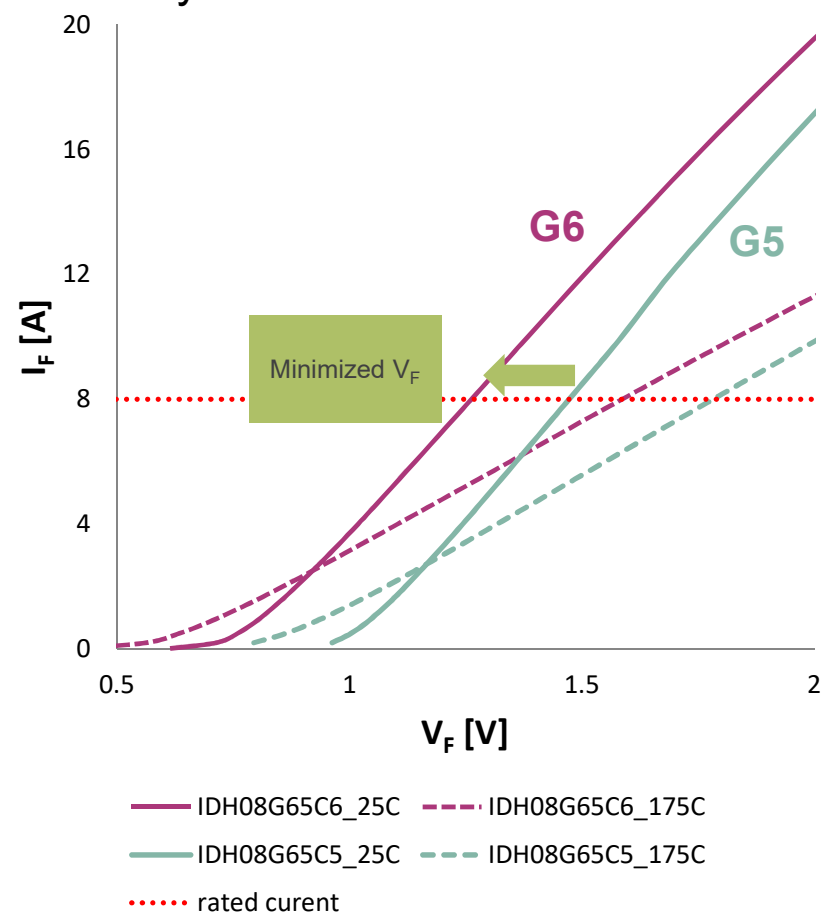
- > CoolSiC™ Schottky diode G5 attained a substantial reduction of Q_c with strong characteristics of reliability and high ruggedness
- > CoolSiC™ Schottky diode **G6 achieves the lowest V_F** on the market keeping intact the G5 characteristics

Features










- > Unmatched forward voltage V_F : **1.25 V**
 - Best-in-class figure of merit $Q_c \times V_F$ - **17% less than G5**
 - High switching performance

Benefits

- > Outstanding efficiency
- > Enables higher power density
- > Best price performance



CoolSiC™ Schottky Diode 600 V / 650 V

	650 V CoolSiC™ Gen6*		650 V CoolSiC™ Gen5**					600 V CoolSiC™ Gen3**	
Ampere [A]	 TO-220 R2L	 DDPAK	 TO-220 R2L	 TO-247	 D²PAK R2L	 ThinPAK 8x8	 TO-247 Dual Die*	 TO-220 R2L	 DPAK RTL
2A			IDH02G65C5		IDK02G65C5	IDL02G65C5			
3A			IDH03G65C5		IDK03G65C5			IDH03SG60C	IDD03SG60C
4A	IDH04G65C6	IDDD04G65C6	IDH04G65C5		IDK04G65C5	IDL04G65C5		IDH04SG60C	IDD04SG60C
5A			IDH05G65C5		IDK05G65C5			IDH05SG60C	IDD05SG60C
6A	IDH06G65C6	IDDD06G65C6	IDH06G65C5		IDK06G65C5	IDL06G65C5		IDH06SG60C	IDD06SG60C
8A	IDH08G65C6	IDDD08G65C6	IDH08G65C5		IDK08G65C5	IDL08G65C5		IDH08SG60C	IDD08SG60C
9A			IDH09G65C5		IDK09G65C5			IDH09SG60C	IDD09SG60C
10A	IDH10G65C6	IDDD10G65C6	IDH10G65C5	IDW10G65C5	IDK10G65C5	IDL10G65C5		IDH10SG60C	IDD10SG60C
12A	IDH12G65C6	IDDD12G65C6	IDH12G65C5	IDW12G65C5	IDK12G65C5	IDL12G65C5		IDH12SG60C	
16A	IDH16G65C6	IDDD16G65C6	IDH16G65C5	IDW16G65C5					
20A	IDH20G65C6	IDDD20G65C6	IDH20G65C5	IDW20G65C5			IDW20G65C5B		
24A							IDW24G65C5B		
30/32A				IDW30G65C5			IDW32G65C5B		
40A				IDW40G65C5			IDW40G65C5B		



***Active and Preferred**
****Active**

1200 V CoolSiC™ G5 Schottky Diode



1200 V CoolSiC™ Schottky diode generation 5:

Continuous Forward Current, I_F [A]	TO-252-2 (DPAK real 2-leg)	TO-263-2 (D ² PAK real 2-leg)	TO-220-2 (real 2-leg)	TO-247-3	TO-247-2
2	IDM02G120C5	IDK02G120C5	IDH02G120C5		
5	IDM05G120C5	IDK05G120C5	IDH05G120C5		
8	IDM08G120C5	IDK08G120C5	IDH08G120C5		
10	IDM10G120C5	IDK10G120C5	IDH10G120C5	IDW10G120C5B ¹⁾	IDWD10G120C5
15-16		IDK16G120C5	IDH16G120C5	IDW15G120C5B ¹⁾	IDWD15G120C5
20		IDK20G120C5	IDH20G120C5	IDW20G120C5B ¹⁾	IDWD20G120C5
30				IDW30G120C5B ¹⁾	IDWD30G120C5
40				IDW40G120C5B ¹⁾	IDWD40G120C5

- > **Low V_F with low temperature dependency** give low static losses over entire load range
- > **Zero reverse recovery charge**
- > **10 A CoolSiC™ diode matches V_F of 30 A rated Si ultrafast diode** thanks to its superior efficiency
- > **Up to 40 A diode rating**





1) „B“ = common-cathode configuration

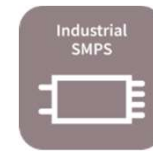


CoolSiC™ Discrete portfolio

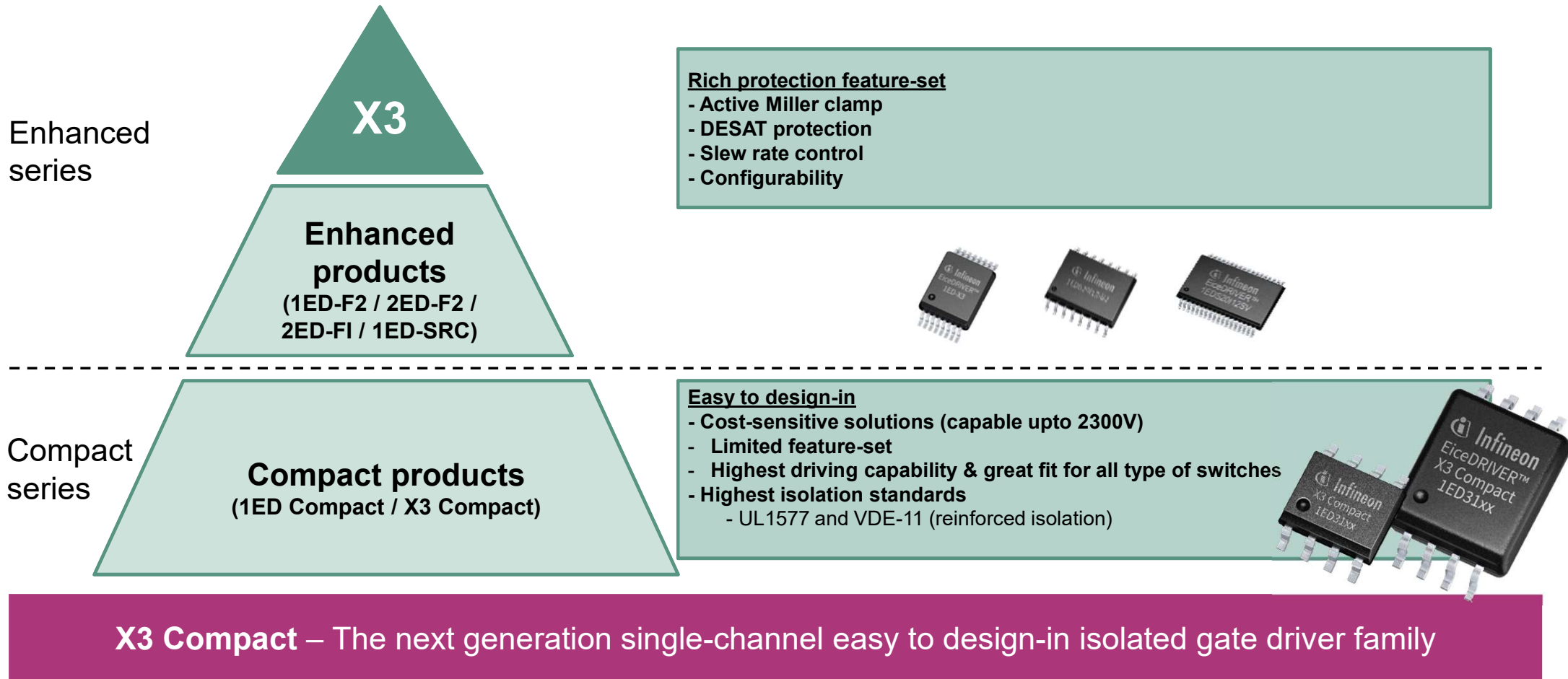
1200V and 1700V MOSFETs lineup



CoolSiC™	R _{DS(on)} [mΩ]	TO-247-3 	TO-247-4 *Optimized Pin-out 	D ² PAK-7L SMD 	D ² PAK-7L SMD *high creepage 
1200 V	7	IMW120R007M1H	IMZA120R007M1H*		
	14	IMW120R014M1H	IMZA120R014M1H*		
	20	IMW120R020M1H	IMZA120R020M1H*		
	30	IMW120R030M1H	IMZ120R030M1H	IMBG120R030M1H	
	40/45	IMW120R040M1H	IMZA120R040M1H*	IMBG120R045M1H	
	60	IMW120R060M1H	IMZ120R060M1H	IMBG120R060M1H	
	90	IMW120R90M1H	IMZ120R090M1H	IMBG120R090M1H	
	140	IMW120R140M1H	IMZ120R140M1H	IMBG120R140M1H	
	220	IMW120R220M1H	IMZ120R220M1H	IMBG120R220M1H	
	350	IMW120R350M1H	IMZ120R350M1H	IMBG120R350M1H	
1700 V	450				IMBF170R450M1
	650				IMBF170R650M1
	1000				IMBF170R1K0M1



EiceDRIVER™ isolated gate driver portfolio – X3 Compact (1ED31xx) positioning



3300 W CCM bi-directional totem pole with 650V CoolSiC™ and XMC™



Name: EVAL_3K3W_TP_PFC_SIC

Components:

- > 600 V CoolMOS™ C7 SJ MOSFET and 650 V CoolSiC™ silicon carbide MOSFET
- > 2EDF7275F isolated gate drivers (EiceDRIVER™)
- > XMC1404 microcontroller
- > ICE5QSAG CoolSET™ QR Flyback controller
- > 950 V CoolMOS™ P7 SJ MOSFET

Efficiency: > 99% @ 50% Load

Power Density: ~72W/in³

EMI Class B

THD < 10%, from 20% load

PF > 0.95, from 20% load

PLD compliant (line cycle drop out and voltage sag)

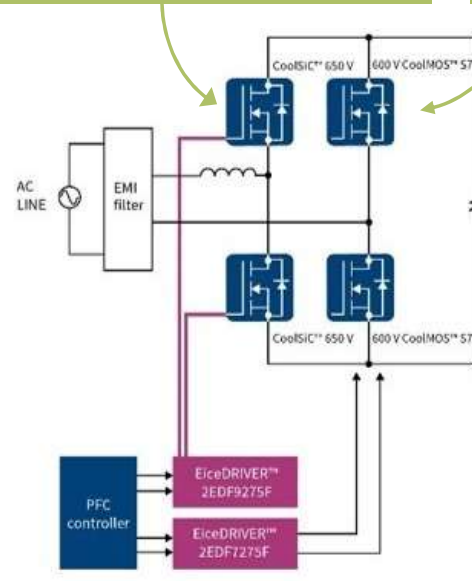
1U form factor

Applications

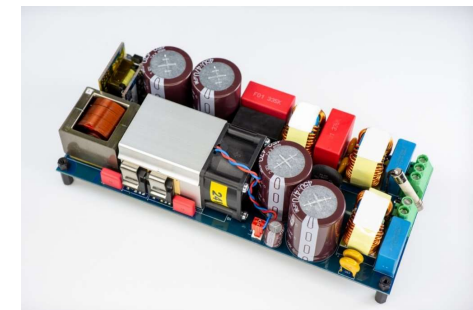
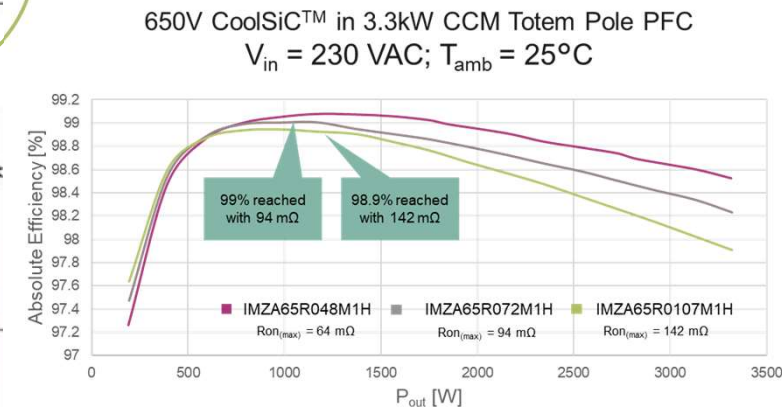
- > Server, Telecom, Energy Storage, Battery charger, Battery formation

CoolSiC™ 650V
 IMZA65R027M1H, IMW65R027M1H
 IMZA65R048M1H, IMW65R048M1H
 IMZA65R072M1H, IMW65R072M1H

CoolMOS™ S7
 IPT60R022S7
 IPT60R040S7



Gate Drivers
 2EDF9275F → CoolSiC™ MOSFET
 2EDF7275F → CoolMOS™ S7



Reference: https://www.infineon.com/cms/en/product/evaluation-boards/eval_3k3w_tp_pfc_sic/

CoolSiC™ MOSFETs Supporting Documents / Tools

Collaterals and brochures

- > Selection guides
- > Product brief
- > Solution brief
- > Presentations

Support & tools

- > PCB design data
- > Simulation models

Technical materials

- > Application notes
- > White papers
- > Datasheets
- > Training & Support



Videos

- > Product information videos

Internet

- > Webpage: www.infineon.com/coolbic-mosfet-discretes



Ask for technical support



Call us toll-free
or request a call back

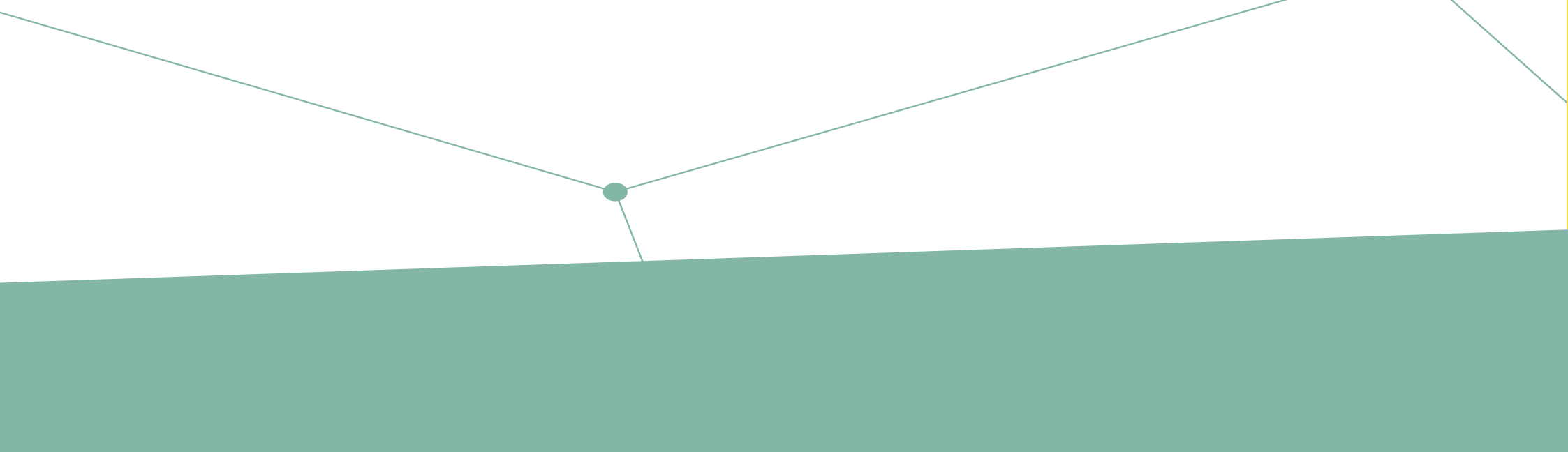


Live chat
with our Support Center



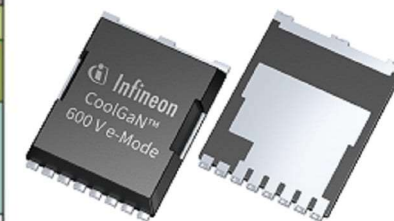
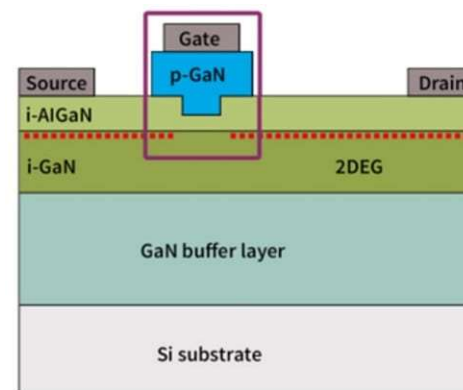
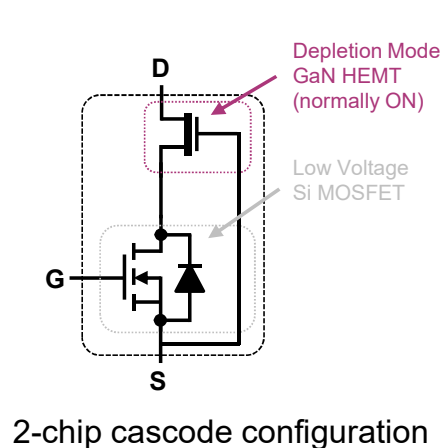
Ask our community
for support

600V CoolGaN™ GIT HEMTs



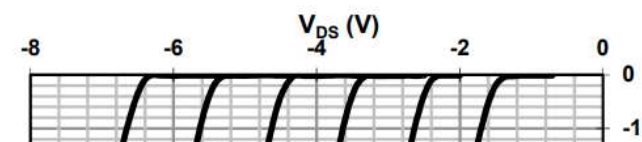
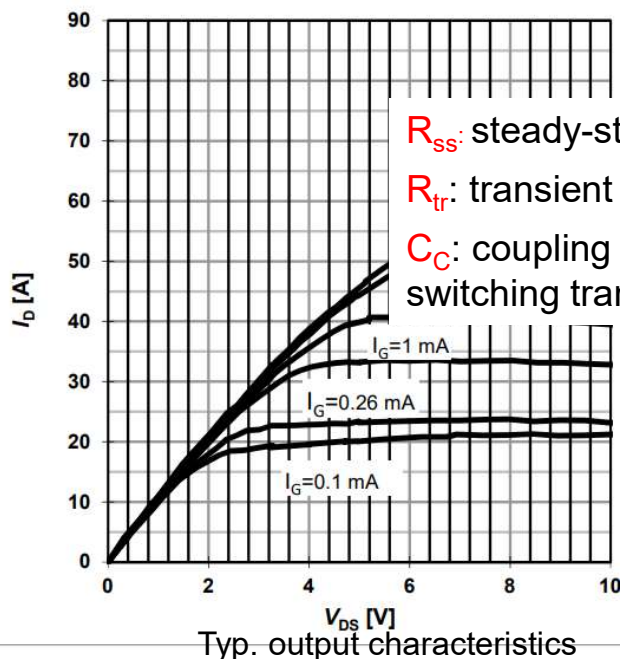
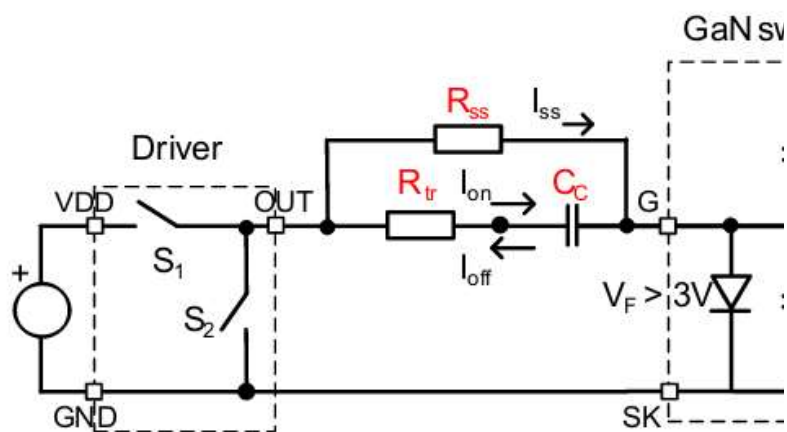
Infineon's CoolGaN™ GIT HEMT

- > Most engineers prefer to work with naturally 'off' devices in switching applications due to safety and acceptability considerations.
- > Two ways to deliver naturally "off" operation – single-chip enhancement mode (e-mode) or two-chip cascode configuration.
- > Infineon technology is based on ohmic p-GaN gate structure (e-mode, normally off).

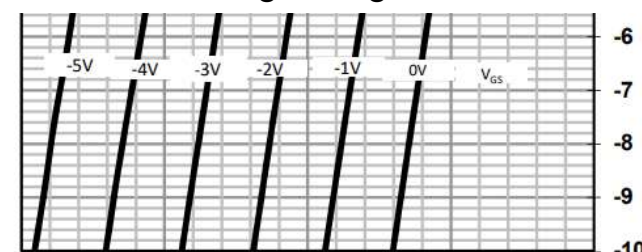


Driving 600V CoolGaN™ GIT HEMTs

- > CoolGaN™ GIT HEMTs have diode-like input characteristics. This provides voltage clamp and helps avoid any overvoltage damage to the transistor gate.
- > A continuous gate current I_{ss} of a few mA is needed during the steady on-state, self-commutates in off-state.
- > The RC interface is the gate drive circuit recommended with standard gate drivers. Dedicated gate drivers for minimizing reverse conduction losses.

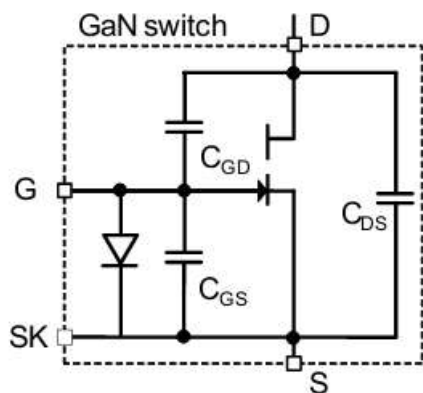
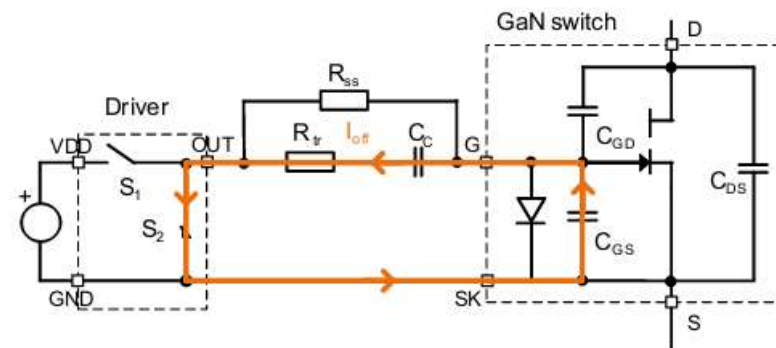
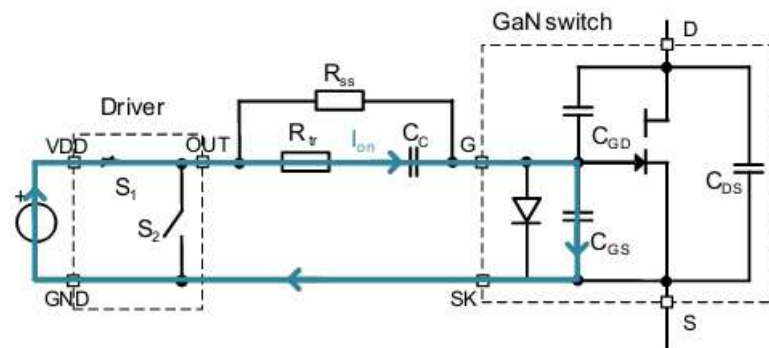
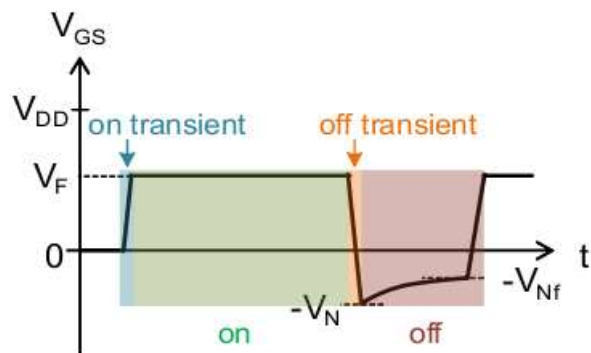


R_{ss} : steady-state gate current tuning resistor
 R_{tr} : transient switching speed dv/dt tuning resistor
 C_C : coupling capacitor as charge pump to provide fast-switching transient as well as negative gate bias

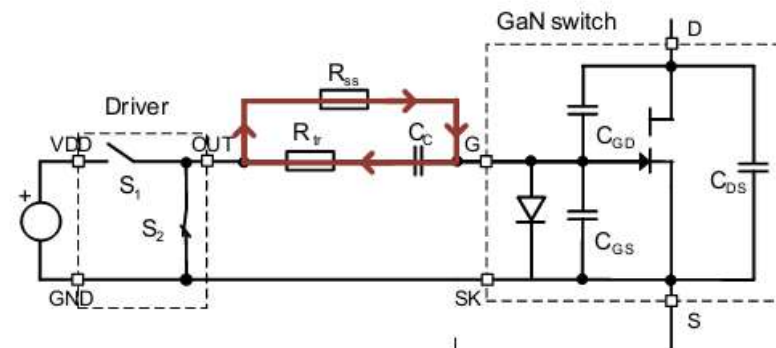
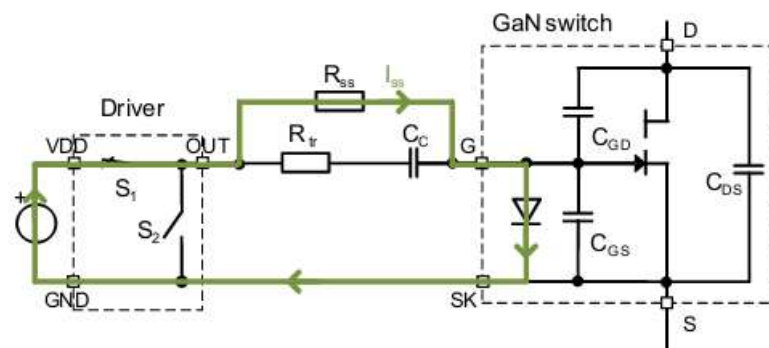


Typ. channel reverse characteristics

Driving 600V CoolGaN™ GIT HEMTs



CoolGaN™ GIT HEMT equivalent circuit



Typical gating procedure of CoolGaN™ GIT HEMT

Standard Gate Driver ICs for CoolGaN™ GIT HEMTs

from the EiceDRIVER™ 2EDi, 1EDB and 1EDN-TDI product families



Family name	Product	Package	Input-to-output isolation		Output UVLO *	Output peak source / sink current	CMTI (min.)	Propagation delay (typ.)	Propagation delay accuracy
			Isolation class	Rating					
2EDi	2EDS7165H	DSO-16 300mil	Reinforced	$V_{IO} = 5.7 \text{ kV}_{\text{rms}}$ $V_{IOTM} = 8 \text{ kV}_{\text{pk}}$	4 V	1A / 2 A	150 V/ns	37 ns	-6 ns / +7 ns
	2EDS8165H				8 V				
	2EDS8265H				8 V				
	2EDF7275F	DSO-16 150mil	Functional	$V_{IO} = 1.5 \text{ kV}_{\text{DC}}$	4 V	5A / 9 A			
	2EDF8275F				8 V				
		2EDF7275K	LGA 13-pin 5x5 mm ²	Functional	$V_{IO} = 1.5 \text{ kV}_{\text{DC}}$	4 V			
1EDB	1EDB7275F	DSO-8 150mil	Functional/ Single protection	$V_{ISO} = 3 \text{ kV}_{\text{rms}}$ (UL 1577)	4 V	5A / 9 A	300 V/ns	45 ns	-4 ns / +6 ns
	1EDB8275F				8 V				
1EDN-TDI	1EDN7550B	SOT23 6-pin	Non-isolated	n.a.	4 V	5A / 9 A	n.a.	45 ns	-7 ns / +10 ns
	1EDN8550B				8 V				

* 8 V UVLO parts recommended for bipolar driving or for unipolar driving with $V_{DD} \geq 10\text{V}$



DSO-16 300mil
2EDSxx65H



DSO-16 150mil
2EDFx275F



LGA-13 5x5 mm²
2EDF7275K



DSO-8 150mil
1EDBx275F

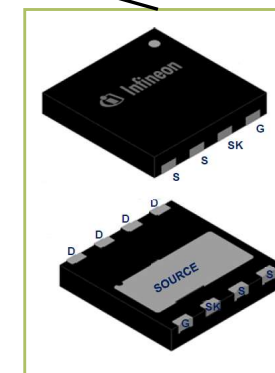
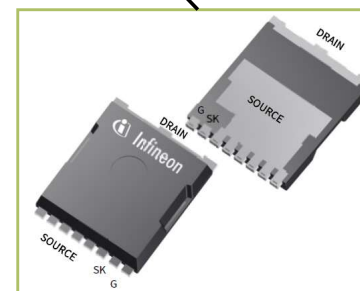


SOT23 6-pin
1EDNx550B

Dedicated gate drivers for CoolGaN™ are also available. Minimize reverse conduction losses.

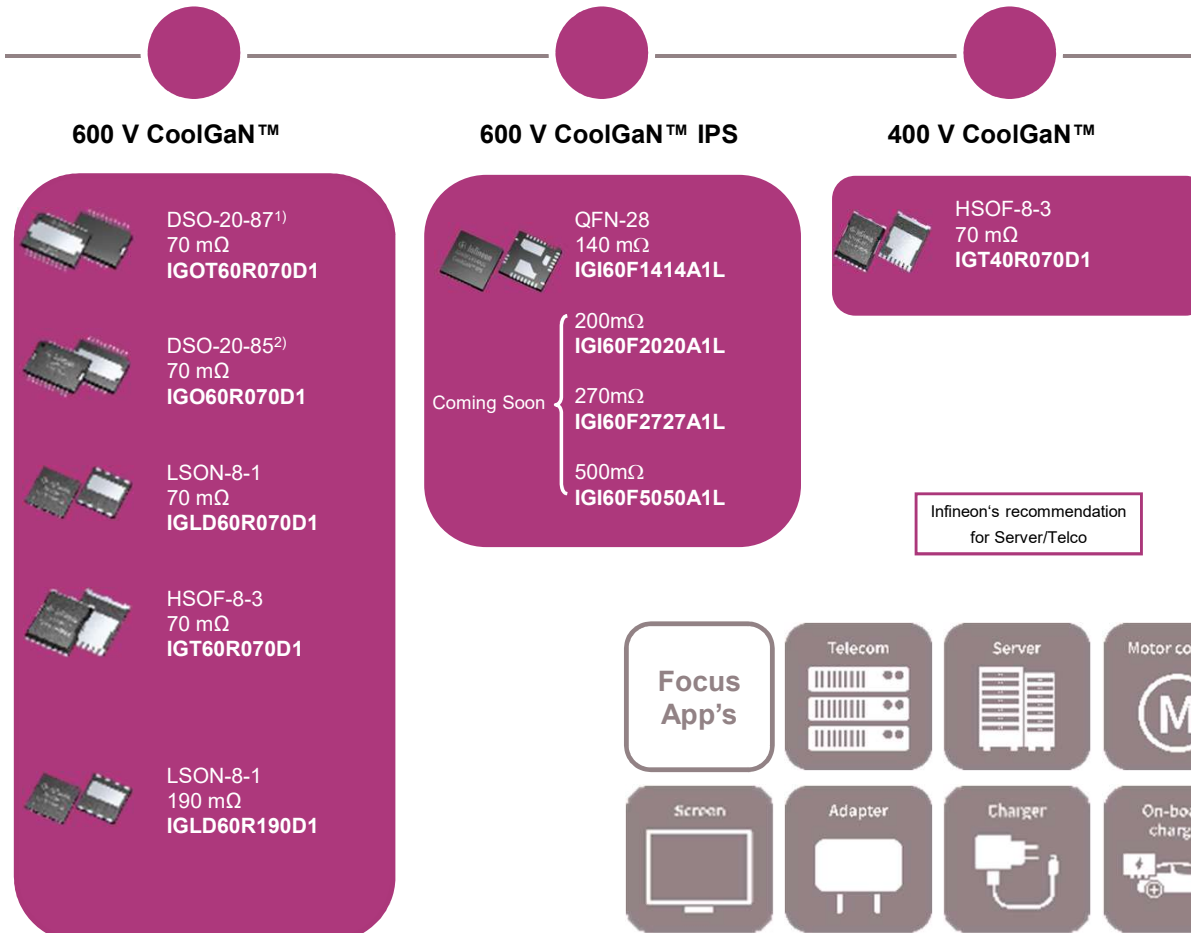
SMD packages for CoolGaN™ cooling concepts

Package	DSO BSC PG-DSO-20-85	DSO TSC PG-DSO-20-87	TOLL PG-HSOF-8-3	DFN 8x8 PG-LSO-8-1
Cooling				
Thermal performance	++	+++	+	0



CoolGaN™ 400 V & 600 V + CoolGaN™ IPS + GaN EiceDRIVER™

In volume production now



1) Top-Side-Cooling 2) Bottom-Side-Cooling (Coming soon)

CoolGaN™ The new power paradigm: Ultimate efficiency and reliability

- > The most **reliable** GaN solution delivering **highest performance** amongst all available GaN devices
- > **Manufacturing expertise** throughout the entire supply chain
- > Global application design **support**
- > Broad **portfolio** including drivers.
- > 600V and 400V CoolGaN™ HEMTs, 600V CoolGaN™ Integrated Power Stage (IPS) and EiceDRIVER™ family



CoolGaN™ IPS



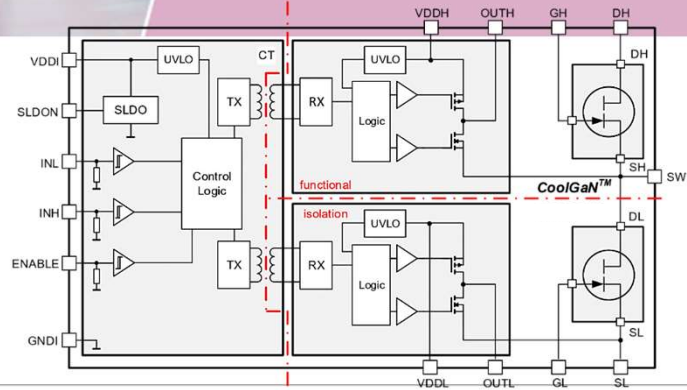
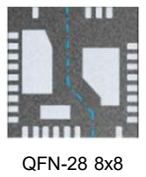
- > Infineon as the quality leader in GaN is complementing its discrete **CoolGaN™** portfolio with IPS Products
- > **Integrated Power Stages** are products containing one or more GaN switches combined with customized gate drivers
- > IPS products and roadmap are targeted to deliver increasingly **easy-to-use GaN** based products, with Infineon trademark **quality and reliability**, which will enable **ultra high density and lighter weight** end-products
- > Initial product portfolio targets chargers, adapters and low to medium power SMPS applications



IGI60F1414A1L 2x 140 mΩ - Available

Half Bridge with GaN switches

- > Robust isolated gate-drive with 2x digital PWM inputs
- > Application configurable switching behavior
- > Highly accurate and stable timing allows short dead-time setting in order to maximize system efficiency
- > 2x 140mΩ



Wider portfolio - coming soon.

CoolGaN™ demonstrators

PFC for server SMPS and telecom rectifiers – 99.3% peak efficiency (Ordercode: EVAL_2500_PFC_GAN_A)

2.5 kW totem pole PFC: IGO60R070D1 **70 mΩ/600 V** in DSO-20-85 bottom-side cooling
 Input: 90 to 265 V_{AC}, to 390 VDC; 65kHz switching; auxiliary supply for bias.



Buy online

On display

Lab evaluation board – high frequency (>1 MHz) half-bridge platform (Ordercode: EVAL_1EDF_G1_HB_GAN)

Functional board with 2x GaN EiceDRIVER™ in LGA package
 70 mΩ/600 V in **DSO-20-87 top-side cooling**



Buy online

LLC for telecom rectifiers – ~160 W/in³ @ >98% peak efficiency (Ordercode: EVAL_3K6W_LLC_GAN)

3.6 kW LLC: IGT60R070D1 **70 mΩ/600 V** in **HSOF-8-3 (TOLL)** on primary side
 360~400V_{DC} to 52V V_{out}; Switching at 350 kHz; bias board & cooling included in demo board.



Available to order

On display

Dual Channel - 200 W + 200 W class D audio amplifier (Ordercode: EVAL_AUDAMP24)

Functional board with 70 mΩ/400 V in HSOF-8-3 (TOLL)
 + IRS20957SPBF MERUS™ discrete audio amplifier driver IC



Buy online

IPS chipset evaluation board (Ordercode: EVAL_HB_GANIPS_G1)

High-frequency CoolGaN™ IPS half-bridge 600V evaluation board featuring **IGI60F1414A1L**



CoolGaN™ MOSFETs Supporting Documents/ Tools

Collaterals and brochures

- › Selection guides
- › Product brief
- › Solution brief
- › Presentations

Support & tools

- › PCB design data
- › Simulation models

Technical materials

- › Application notes
- › White papers
- › Datasheets
- › Training & Support



Videos

- › Product information videos

Internet

- › Webpage: www.infineon.com/gan



Ask for technical support



Call us toll-free
or request a call back

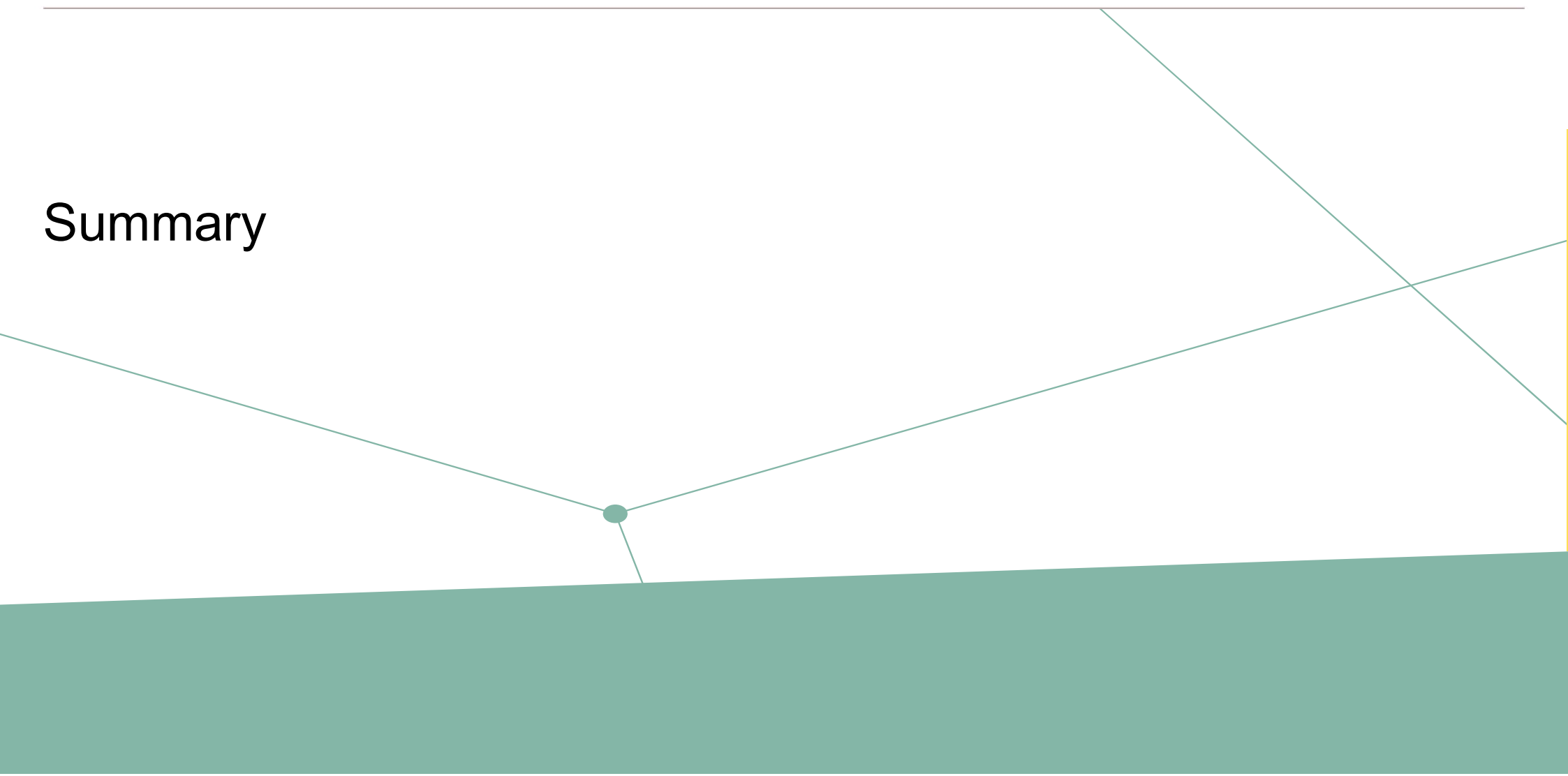


Live chat
with our Support Center



Ask our community
for support

Summary



Value proposition - 650V CoolSiC™ & 600V CoolGaN™

WBG Technology – leveraging material properties, and delivering improved performance:

CoolSiC™



High performance



Reduced system size



Simplification

CoolGaN™



High power density



System and TCO cost reduction



High robustness and reliability

SiC, GaN and Si Positioning – Summary

	CoolMOS™	CoolSiC™	CoolGaN™
Efficiency	★★★★☆	★★★★★	★★★★★
Frequency	★★★★☆	★★★★★	★★★★★
Power Density	★★★★☆	★★★★★	★★★★★
Efficiency at max power density	★★★☆☆	★★★★☆	★★★★★
Robustness	★★★★☆	★★★★★	★★★☆☆
High temperature operations	★★★★☆	★★★★★	★★★★☆
Fit for bi-directional topologies	★★★☆☆	★★★★★	★★★★★
Ease of use	★★★★☆	★★★★★	★★★★☆
Price performance(1)	★★★★★	★★★☆☆	★★★☆☆
Portfolio granularity	★★★★★	★★★☆☆	★★★☆☆

(1) Price performance depends largely on application and efficiency targets

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- User Groups
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Welcome to the Infineon Developer Community

All Community

🔍

Ask a question

61560 Discussions
 35339 Members
 33195 Solved

Product

Microcontrollers (MCUs), PSoC, Memory, Automotive, USB, Wire...

Software

Software including ModusToolbox, PSoC Creator, WICED Studios...

General

Community Information, Technical Blogs, Community Member Pro...

Home > Products > Power

Silicon Carbide
 46435
 63

CoolGaN™
 4546
 8

Gate Driver IC's
 321167
 138

And others too ...



Thank you
See you soon!





Part of your life. Part of tomorrow.



Extras

