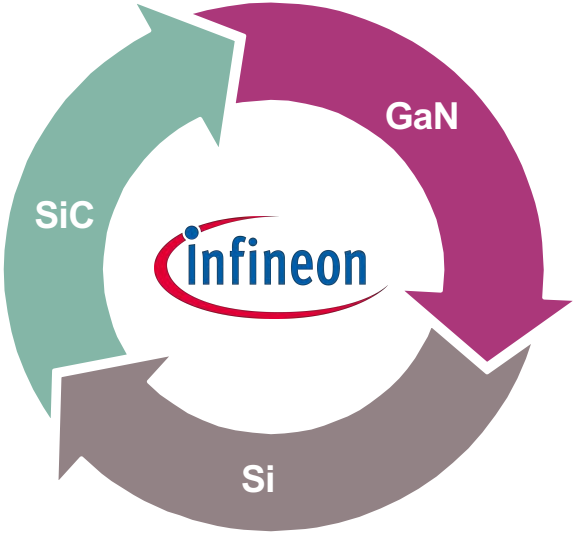
Your design consideration – our Si and WBG expertise

Infineon's virtual show 2020

Si, SiC and GaN
Infineon masters all power technologies...

…and is the trusted advisor for all of them



CoolSiC™

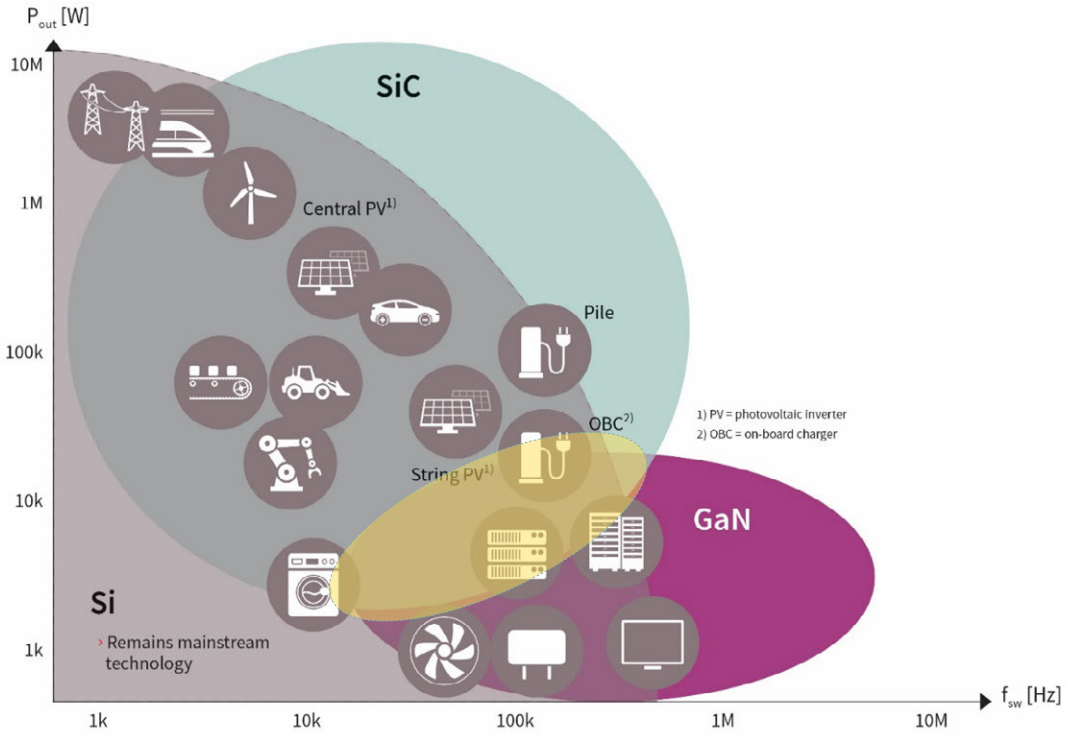
CoolGaN™

IGBT (TRENCHSTOP™)

CoolMOS™

OptiMOS™

Si, SiC and GaN
Overall positioning of the 3 thechnologies



Silicon (Si)
- Targeting around 25V – 1.7 kV
- Main stream technology
- Suitable across all power ranges

Silicon carbide (SiC)
- Targeting around 650V – 3.3 kV
- High power - high switching frequency

Gallium Nitride (GaN)
- Targeting around 80V – 650V
- Medium power – highest switching frequency

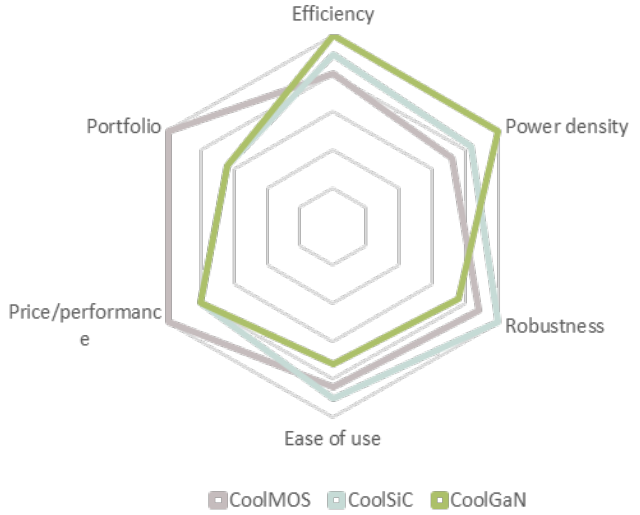
600 V/650 V segment
CoolMOS™, CoolSiC™ and CoolGaN™ coexists. Depending on requirements, they have different value proposition in applications such as:
Datacenter and telecom SMPS, Industrial SMPS, solar inverters, energy storage, UPS, battery formation, motor drives, EV charging plus automotive applications like OBC (on-board charger)

600 V/650 V CoolMOS™, CoolSiC™ and CoolGaN™
The key benefits positioning summary

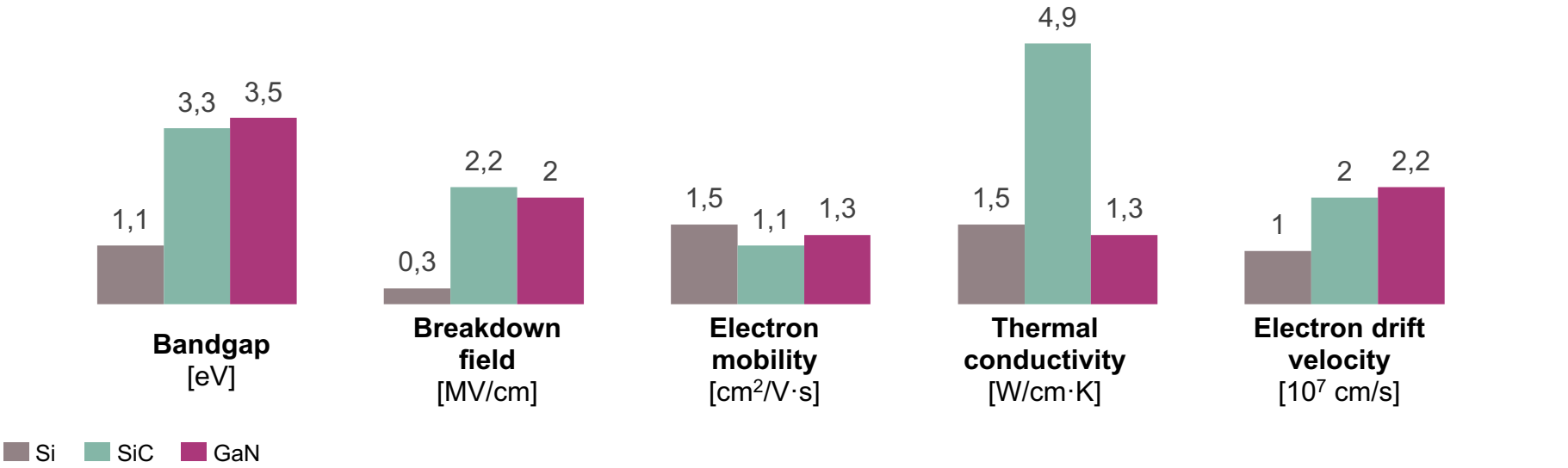
CoolSiC™
- High performance combined with ruggedness and ease of use
- High reliability especially with high temperature and in harsh environments
- Switching frequency: up to 300kHz with little efficiency deterioration
- Smaller system size
- Enable topologies with hard commutation
- Bi-directional topologies

CoolGaN™
- Highest efficiency at the highest frequency. Switching frequency: up to 1 Mhz with little efficiency deterioration
- Smallest system size
- Enables system integration
- Enable topologies with hard commutation
- Bi-directional topologies

CoolMOS™
- Meets most of application requirements, keeping cost/performance benefit
- Meets most of the density requirements
- Largest SJ MOSFET portfolio on the market
- Mature, stable, well established



Si, SiC and GaN show different material properties



The wide bandgap of GaN and SiC....

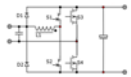
...enables higher breakdown fields...

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

600V/650V CoolMOS™, CoolSiC™ and CoolGaN™ FOMs analysis

DEVICE	$V_{(BR)DSS}$ [V]	$R_{DS(on)}*Q_{rr}$ [mΩ * µC]	$R_{DS(on)}*E_{oss}$ [mΩ * µJ]	$R_{DS(on)}*Q_g$ [mΩ * nC]	$R_{DS(on)}*Q_{os}$ [mΩ * µC]
CoolMOS™ 7	600	100%	100%	100%	100%
CoolMOS™ 7– fast diode	600	10%	104%	108%	104%
CoolGaN™ Gen 1	600	0%	84%	6%	13%
CoolSiC™ Gen 1	650	2%	133%	41%	21%

Allows WBG usage in topologies with repetitive hard commutation (e.g. CCM totem-pole PFC) → BOM savings for highest efficiency

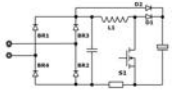


CCM PFC totem-pole

SiC/GaN in servers, OBC

Both SiC and Gan allow an easier way than Si to top efficiency

Minimum switching losses in hard switching topologies (e.g. classic boost PFC) → higher efficiency with GaN



Classic Boost PFC

Si for best cost – performance ratio

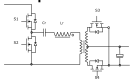
The 3 poducts have similar behaviour in hard switching topologies like classic PFC

Reduced driving losses especially at light-load conditions. Allows WBG to reach higher efficiency at increased frequency → power density increase (weight & size reduction).

high power density e.g. GaN for chargers

For power density, SiC is better than Si but the champion is GaN

Enables better soft-switching (e.g. half-bridge LLC), where WBG leads to higher efficiency combined with high frequencies



Half-Bridge LLC

SiC and GaN e.g. in telecom

SiC and GaN are both better than Si to reach both high efficiency and high density

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

Example of positioning in SMPS with 600 V / 650 V Si, SiC & GaN

Efficiency	94% (or less for < 600 W)		96% (12 V), < 97.5% (48 V)		98%	
Density	Low	High	Low	High	Low	High
> 3 kW	CoolMOS™		CoolMOS™ + CoolSiC™		CoolMOS™ + CoolSiC™ + CoolGaN™	
1.2 kW to 3.0 kW	CoolMOS™		CoolMOS™		CoolMOS™ + CoolSiC™ + CoolGaN™	
600 W to 1.2 kW	CoolMOS™		CoolMOS™ + CoolGaN™		CoolMOS™ + CoolGaN™	
75 W to 600 W	CoolMOS™	CoolMOS™ + CoolGaN™				
< 75W	CoolMOS™	CoolMOS™ + CoolGaN™				

6 kW

1W

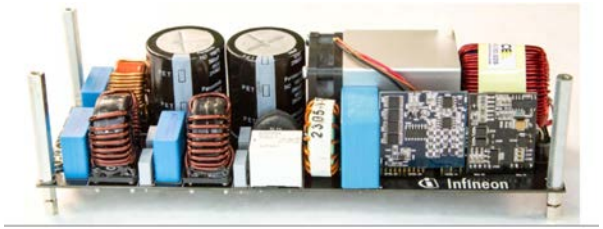
Applications and positioning per value drivers

	Energy efficiency	Power Density	BOM Savings	Bi-Directional Capability	Weight Reduction	OPEX reduction	Higher Reliability and/or Harsh Environments	High temperature	System Simplification Ease of Use	High Current Operations
SMPS Datacenter	GaN or SiC	GaN	GaN or SiC			GaN or SiC			SiC	
SMPS Telecom Rectifier	GaN or SiC	GaN	GaN or SiC		GaN	GaN or SiC	SiC	SiC	SiC	
SMPS 5G Small Cell Outdoor			GaN or SiC		GaN or SiC		SiC	SiC		
SMPS Industrial	GaN or SiC			GaN or SiC	GaN		SiC	SiC		
Solar PV inverters incl. ESS		GaN or SiC		GaN or SiC	GaN		SiC	SiC	SiC	
UPS				GaN or SiC			SiC		SiC	SiC
EV Charging	SiC[1]	SiC[1]		GaN or SiC			SiC	SiC	SiC	SiC
Ultra-High Density Chargers and Adpaters		GaN (int.)	GaN (int.)		GaN (int.)				GaN (int.)	
Automotive OBC	GaN or SiC	GaN or SiC		GaN or SiC	GaN or SiC		SiC		SiC	

2.5 kW totem pole PFC with CoolGaN™ HEMT EVAL_2500W_PFC_GAN_A

Demo Board Information

Input voltage:	85 – 265 VAC
Output Voltage:	390 V
Output power:	2500 W
Topology:	totem pole PFC
Sw. Frequency:	65 kHz
Efficiency:	Flat efficiency >99% over wide load range



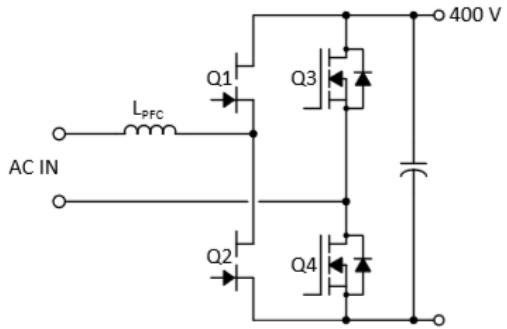
220 mm x 72 mm x 48 mm

www.infineon.com/ EVAL-2500W-PFC-GAN-A

IFX components

HV Devices:	2x IGO60R070D1 2xIPT60R033C7 2x IPW60R17C7
Driver:	2x 1EDI20N12AF 1x 2EDN7524F 2x 1EDI60N12AF
Schootky Diode:	1x BAT165, 1x Bat54C
Control IC:	1x ICE2QR2280G, 1x ICE3PCS01G
Voltage regulator:	1x TLE4264-2G
N-CH MOSFET:	1 x BSS138N

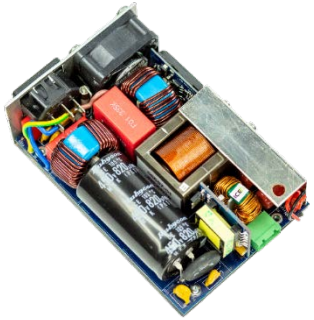
Schematic Overview



2400W Active Bridge PFC Demoboard EVAL_2K4W_ACT_BRD_S7

Demo Board Information

Input voltage:	90 – 265 VAC
Output Voltage:	390 VDC (nom)
Output power:	2400 W
Topology:	boost full bridge non-isolated PFC single phase
Sw. Frequency:	65 kHz
Efficiency:	98.6% (max)



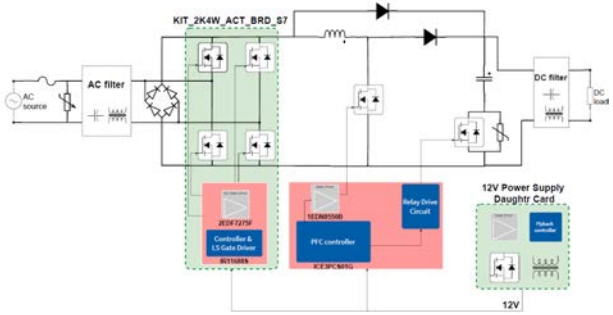
130 mm x 90 mm x 45 mm

www.infineon.com/EVAL-2K4W-ACT-BRD-S7

IFX components

HV Devices:	1x IPT60R022S7
	1x IPZ60R040C7
Diode:	1x IDH12G65C6
Driver:	1x 1EDN8550B
Voltage regulator:	1x BAT165
Controller:	1x ICE3PCS01G

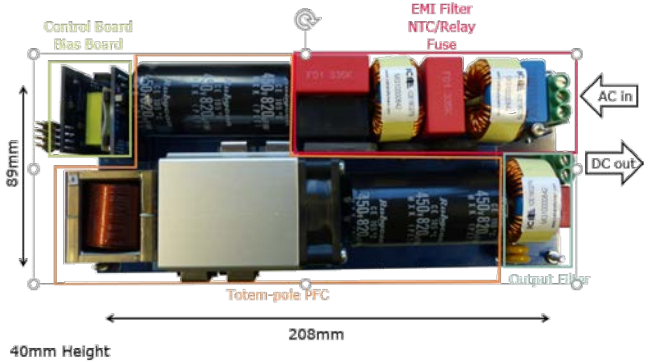
Schematic Overview



Bidirectional ACDC board with SiC MOSFET
3.3 kW BIDI CCM Totem Pole PFC

Demo Board Information

Input voltage:	176-265Vac
Output voltage:	400Vdc
Output power:	3300W
PF:	>0.95 from 20% load
Target Efficiency:	99% at 50% load
Power Density	~72W/inch³

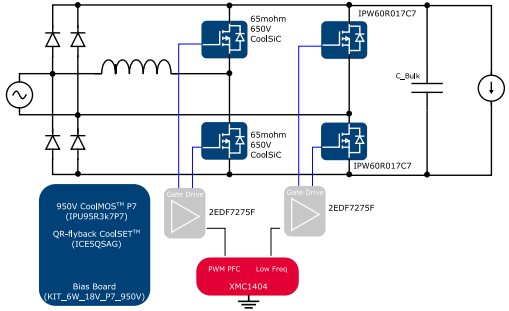


www.infineon.com/EVAL-3K3W-TP-PFC-SIC

IFX components

HV Devices:	2x 65mΩ 650V CoolSiC™ 2x IPW60R17C7
Driver:	2x 2EDF7275F
Controller:	1x XMC1404-F064X0200
QR-Flyback:	1x ICE5QSAG, 1x IPU95R3k7P7

Schematic Overview



1.6kW Titanium Efficiency HD AC/DC PSU for Server
EVAL_1K6W_PSU_G7_DD

Demo Board Information

Input voltage:	176 – 265 VAC
Output Voltage:	12.2 VDC
Output power:	1600 W
Topology:	CCM PFC bi-directional half-bridge
Sw. Frequency:	PFC: 65 kHz LLC: 160 kHz
Peak Efficiency:	96%

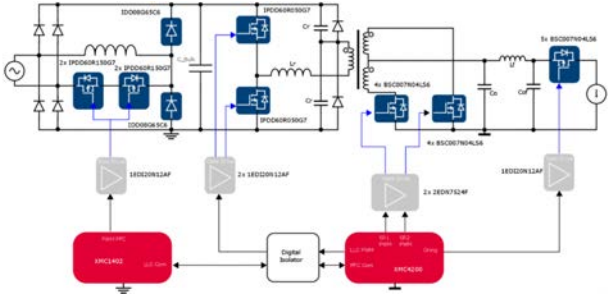
200 mm x 70 mm x 40 mm

www.infineon.com/EVAL-1K6W-PSU-G7-DD

IFX components

Driver:	2x 2EDN7524F, 5x 1EDI20N12AF
Controller:	1x ICE2QR2280G,
Microcontroller:	1x MC1402Q040X0128AAXUMA 1, 1x XMC4200-F64K256AB
Voltage regulator:	1x IFX1117ME V33
MOSFET:	13x BSC007N04LS6 2x IPDD60R050G7, 4x IPDD60R150G7, 2x IDDD08G65C6
Diode:	4x BAT165, 4x BAT54-04

Schematic Overview



3.3 kW bidirectional Full-bridge DCDC EVAL_3K3W_BIDI_PSFB

Demo Board Information

Input voltage:	350 V_{DC} ~ 415 V_{DC}
Output voltage:	40 V_{DC} ~ 60 V_{DC}
Output power:	3300 W
Efficiency:	98% peak

- Bidirectional mode
- Novel integrated magnetics concept
- Novel SMD cooling concept

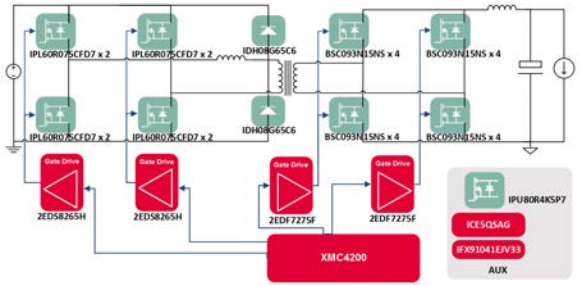
208 mm x 83 mm x 44 mm

www.infineon.com/EVAL-3K3W-BIDI-PSFB

IFX components

HV Devices:	8x IPL60R075CFD7 (75 mΩ, 600V)
LV Devices:	16x BSC093N15NS5 (9.3 mΩ, 150V)
Driver:	2x 2EDS8265H (4A/8A source/sink)
	2x 2EDF7275F (4A/8A source/sink)
Schottky Diode:	2x IDH08G65C6 (650V)
	4x BAT165 (40V)
Controller:	XMC4200-F64K256AB
AUX:	ICE5QSAG CoolSET™
	IPU80R4K5P7 (4.5Ω, 800V)

Schematic Overview



Part of your life. Part of tomorrow.