英飞凌为AI数据中心提供先进的高能效电源解决方案

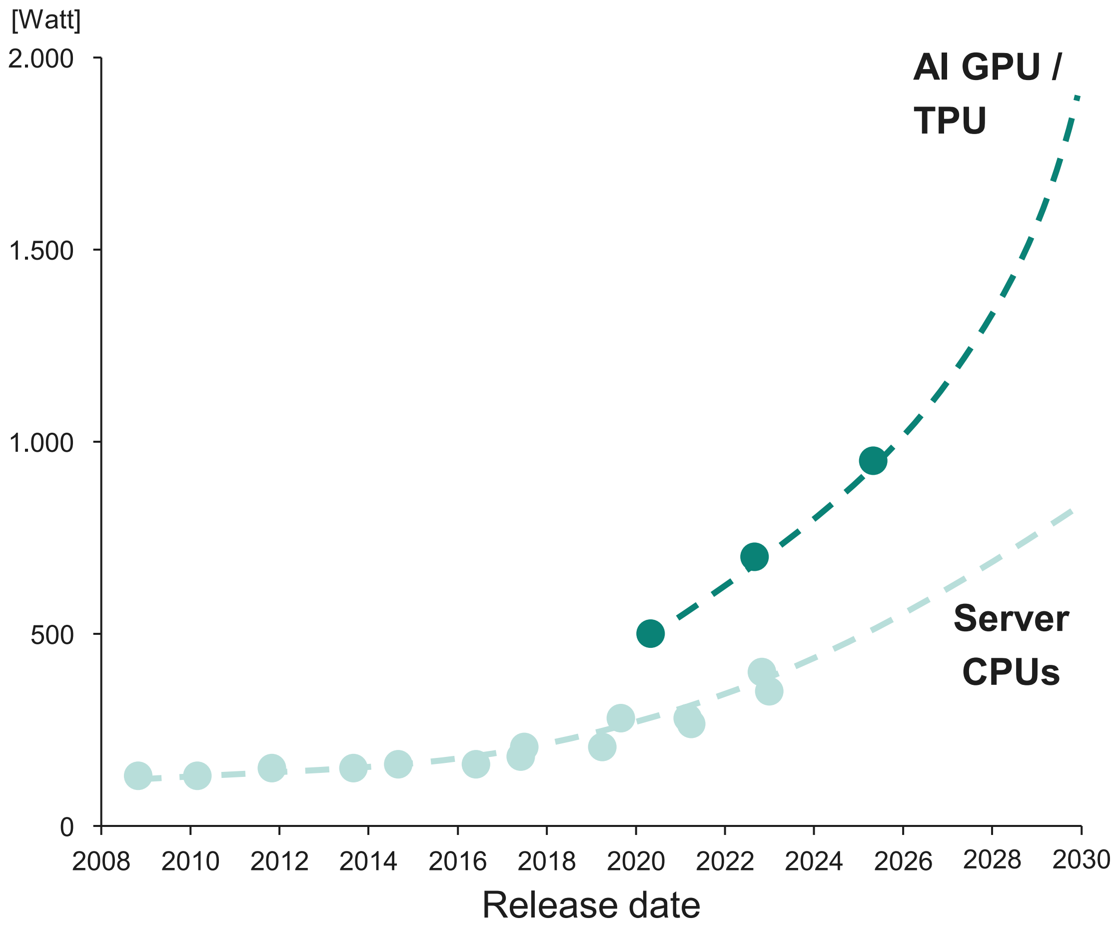
Aug 2024

Table of contents

Table of contents

AI systems demand higher power that further increases semiconductor content

x86 and ARM-based processor electricity demand



Source: Company information; Infineon analysis
[1] CAGR 2023-2027 in Infineon relevant market
[2] Incl. AI inference

Semiconductor SAM CAGR[1]

AI Training GPU / TPU Unit CAGR[1] **>40%** Avg. BOM CAGR[1] **>10 %**	**>50%**
Other Servers Unit CAGR[1,2] **6%** BOM CAGR[1,2] **<10%**	**~15%**

Power evolution for AI Server PSU and Rack - Power and Density

ORv3 PSU ➔ 3kW 32W/in³

*73.5*40*520 mm*

	Rack power
1 shelf 5+1	15 kW
2 shelves 11+1	33 kW

Gen 1 ~2024

ORv3-HPR PSU ➔ 5.5kW 48W/in³

*73.5*40*640 mm*

	Rack power
1 shelf 5+1	27.5 kW
2 shelves 11+1	60.5 kW
3 shelves 17+1	93.5 kW

Gen 1/2 ~ 2025

1-ph AI PSU ➔ ~8kW 62W/in³

*73.5*40*720 mm*

	Rack power
1 shelf 5+1	40 kW
2 shelves 11+1	88 kW
3 shelves 17+1	136 kW
….	….
8 shelves 47+1	376 kW

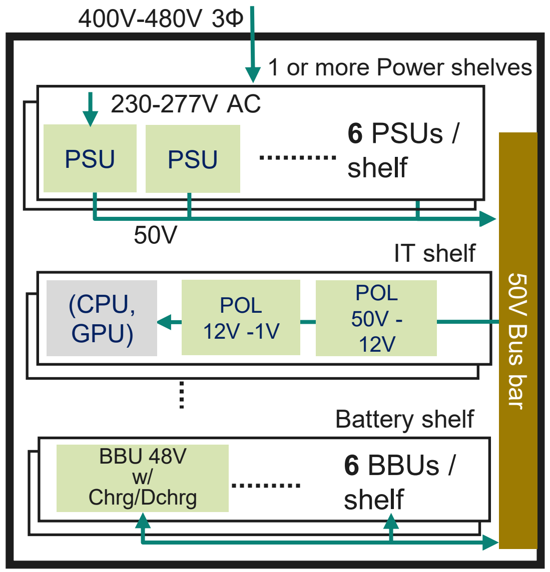
Gen 3 ~ 2026/7

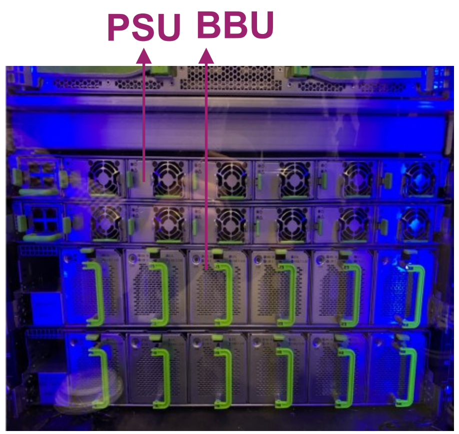
3-ph AI PSU ➔ ~22kW 85W/in³

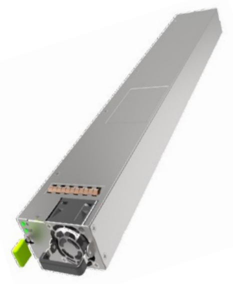
*147*40*720 mm*

	Rack power
1 shelf 2+1	40 kW
2 shelves 5+1	110 kW
3 shelves 8+1	176 kW
….	….
6 shelves 17+1	374 kW

Hyperscale Rack







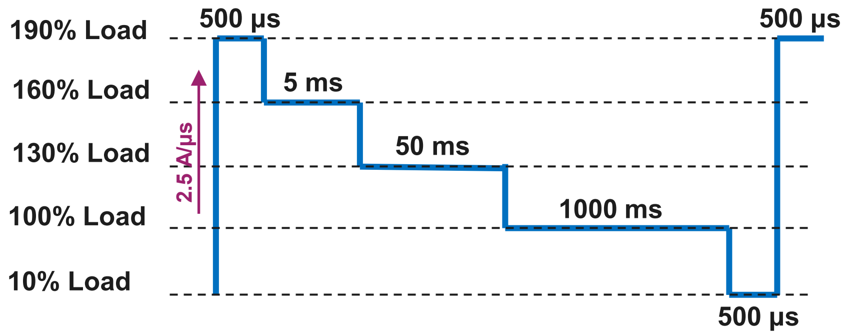
restricted

AI demands PSU higher peak power and transient dynamics

- GPU draws high peak power and high load transient ➔ LLC stage must deliver
- **Higher LLC switching frequency** needed to increase the control loop bandwidth

➔ **CoolGaN™ are enablers for high switching frequency**

Spec of EDPP load for AC/DC AI power



- EDPP= Electrical Data Peak Process

ORv3-HPR

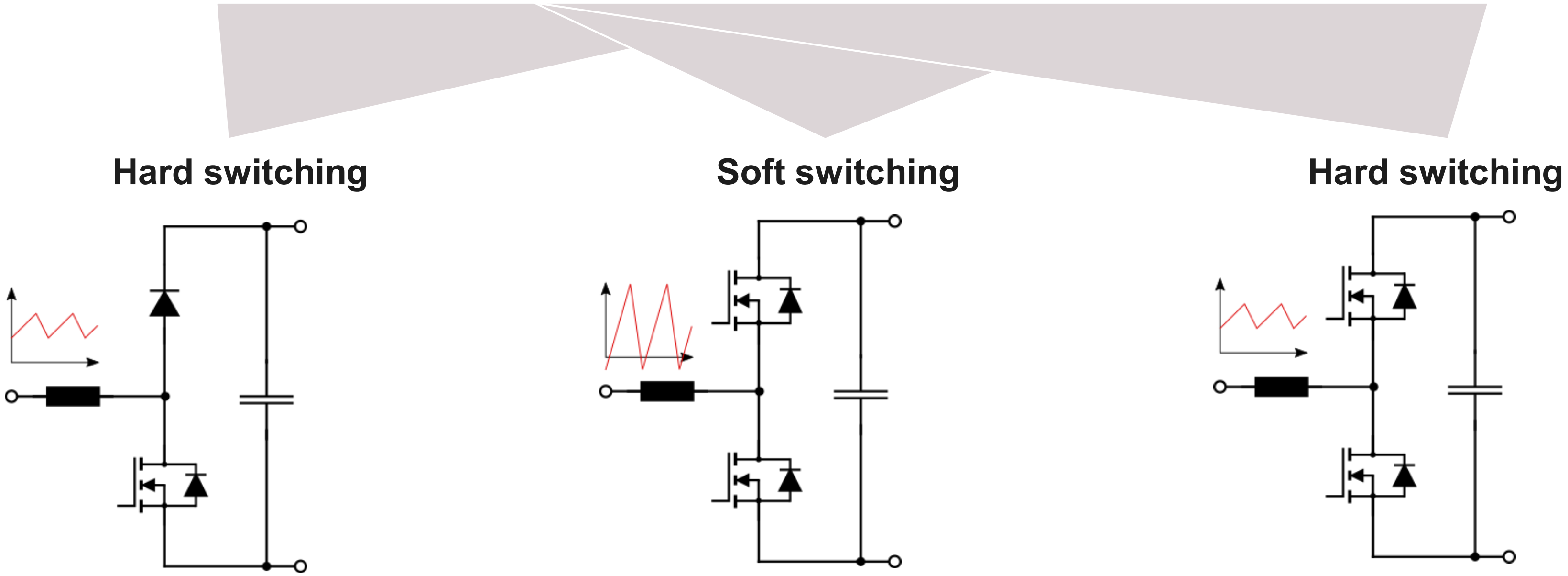
Peak power specs according to GPU spec

50ms	400µs
136%	160%

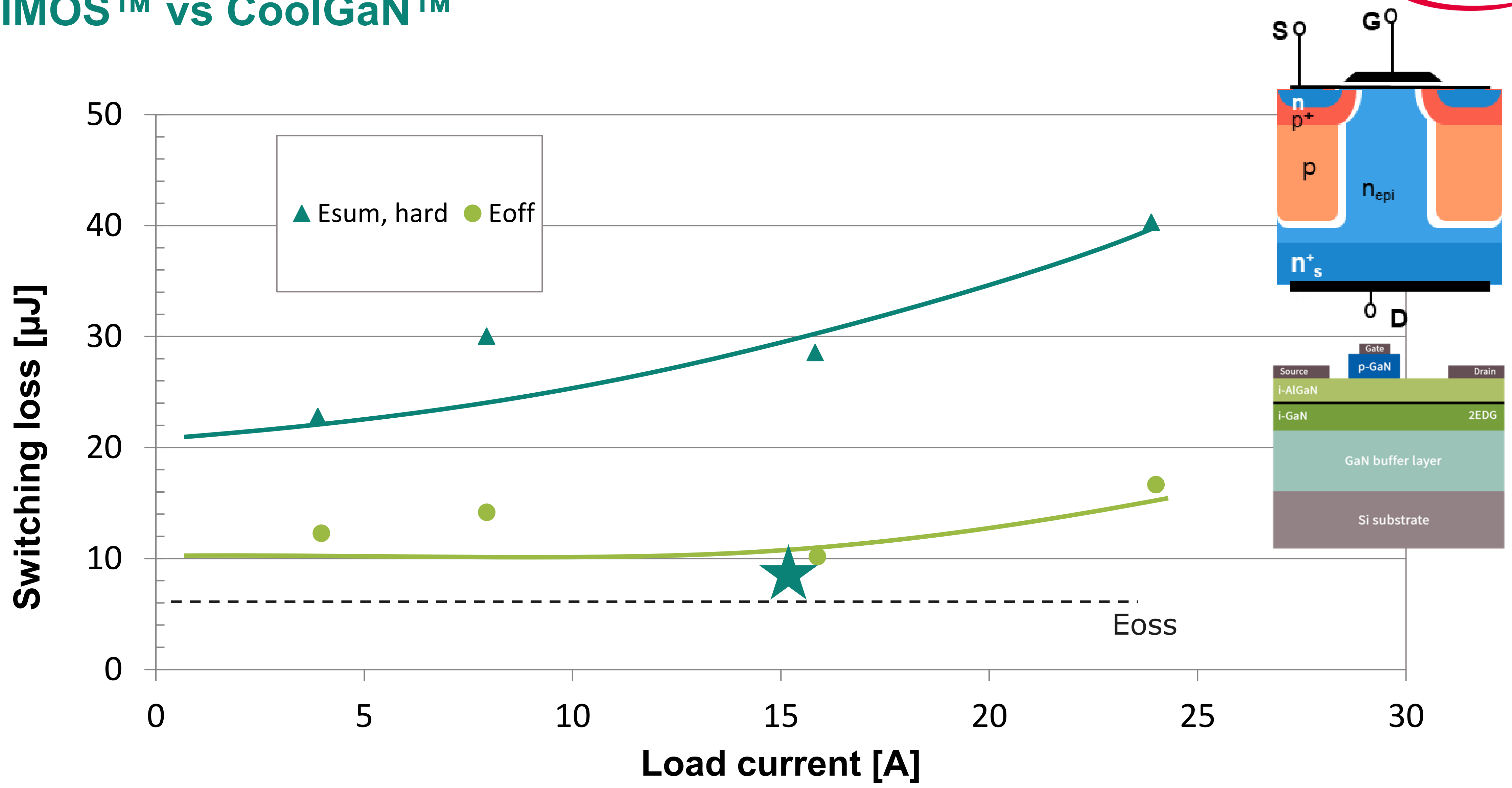
Table of contents

Summary of Technology Comparison: Si vs. SiC vs. GaN

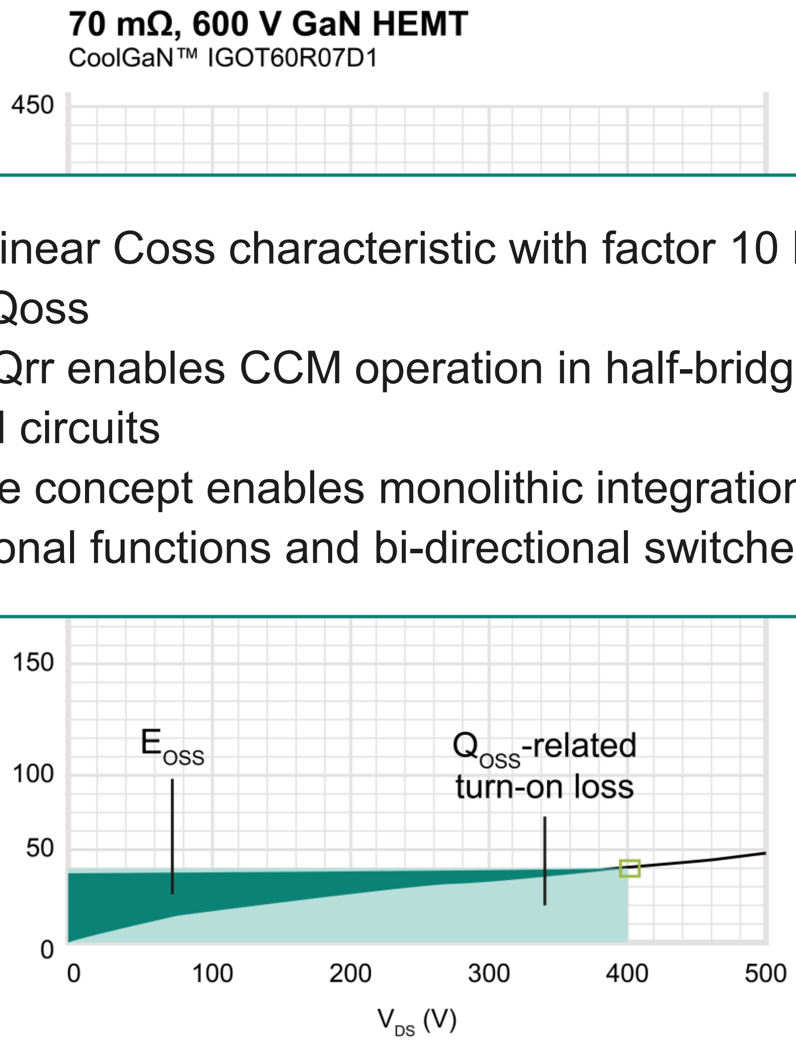
Device	$V_{(BR)DSS}$ [V]	$R_{DS(on)}*E_{oss}$	$R_{DS(on)}*Q_g$	$R_{DS(on)}*Q_{oss}$	$R_{DS(on)}*Q_{rr}$
CoolMOS™ C7	600	100%	100%	100%	100%
CoolGaN™	600	84%	6%	13%	0%
CoolSiC™	650	133%	41%	21%	2%



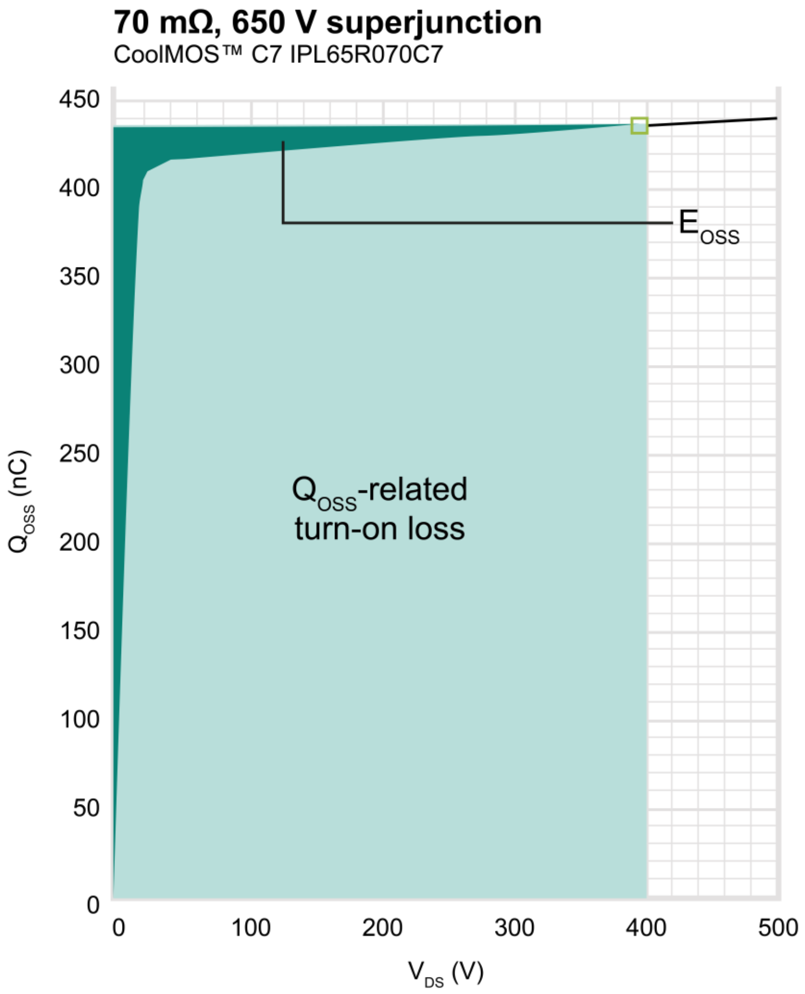
Approaching the Nakajima limit for switching losses: CoolMOS™ vs CoolGaN™



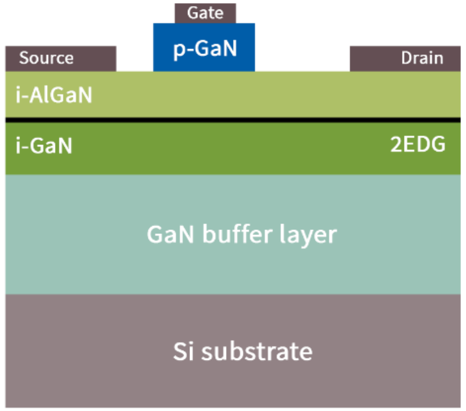
Q_{oss} & true Zero Q_{rr} are the key benefits of GaN HEMTs



- Very linear Coss characteristic with factor 10 lower Ron*Qoss
- Zero Qrr enables CCM operation in half-bridge based circuits
- Device concept enables monolithic integration of additional functions and bi-directional switches



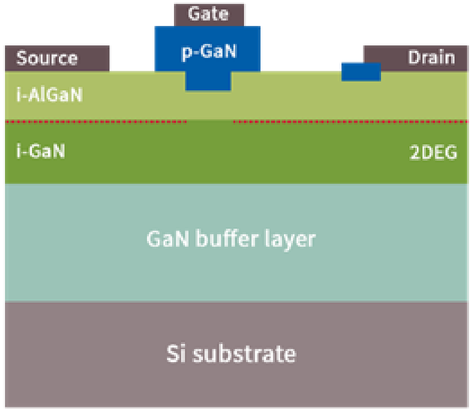
While Si SJ prevails at low switching frequencies, SiC and GaN will conquer novel topologies and the high-frequency space



CoolGaN™ SG HEMT

- Zero reverse recovery charge
- Ultra-low gate charge
- Integrated power stages
- Available in voltage classes 100V/200 V and 650V

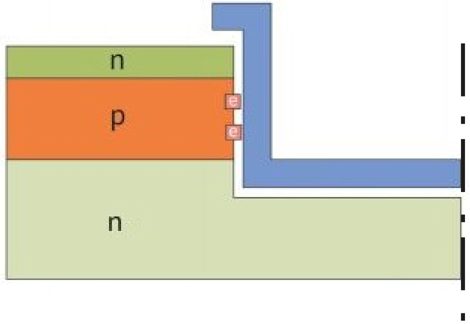
➡ Best option for high-density and high-frequency applications



CoolGaN™ GIT HEMT

- Zero reverse recovery charge
- Lowest Q_{oss} and gate charge
- More complex driving
- 600 V rated

➡ Best option for high-density and high-frequency applications



CoolSiC™

- Low reverse recovery charge
- Low temperature dependence of $R_{DS(on)}$
- Easy driving, 400 V to 2 kV rating

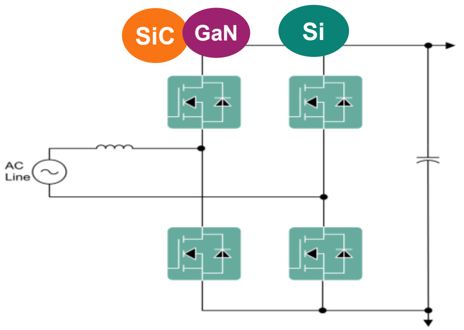
➡ Best option for CCM totem-pole PFC and high-power automotive applications

Infineon’s 3 power technologies offers flexible and hybrid approach for AI Server SMPS PFC and DCDC topologies

PFC

Mainstream (today)

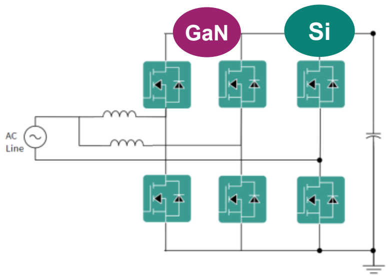
CCM Totem Pole



- η= ~99%
- Low system cost

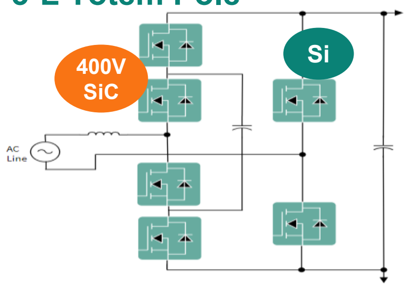
In development (future)

Interleaved TCM Totem Pole



- η= ~99.2%
- Low system cost

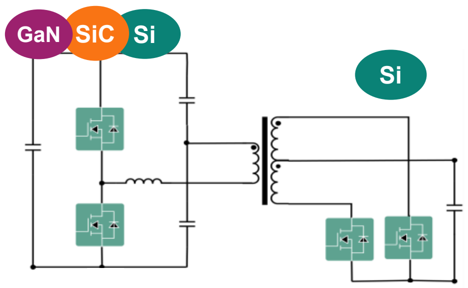
3-L Totem Pole



- η= ~99.2%
- Low system cost

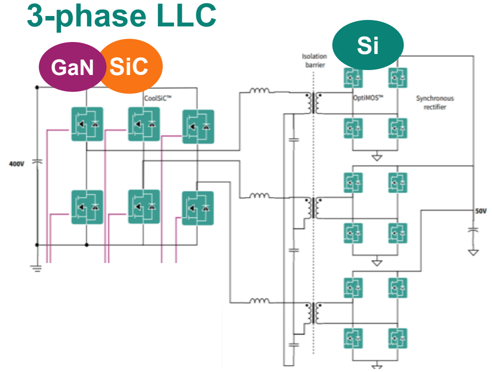
DC-DC

LLC



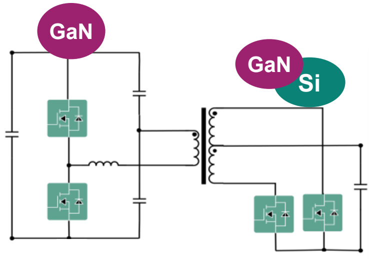
- η= ~98.5%
- Full resonant ➔ less EMI
- Full soft switching ➔ highest efficiency
- Half/Full Bridge / Interleaved ➔ scalable

3-phase LLC



- η= ~98.5%
- Natural current sharing

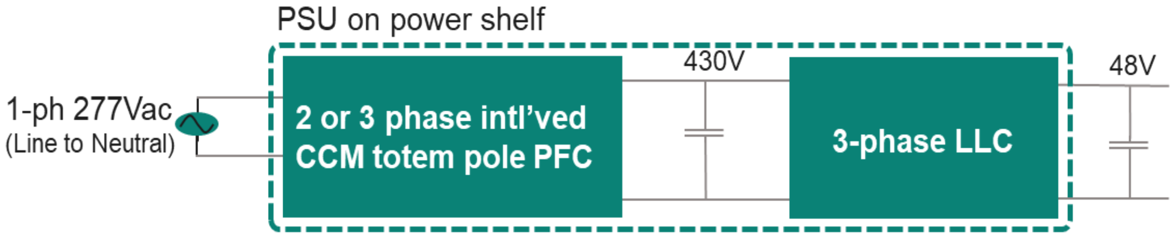
High frequency LLC f_{sw} > 300kHz

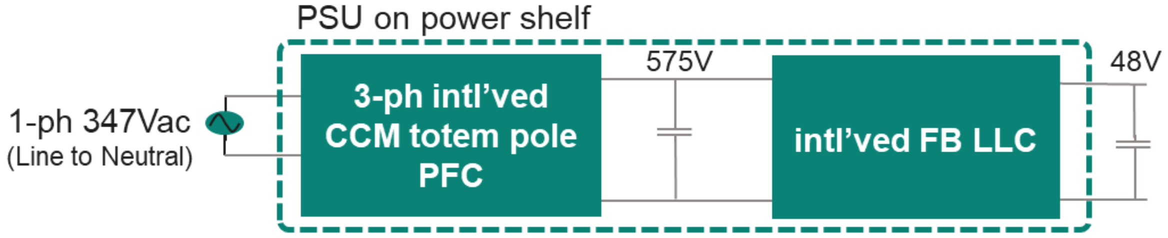


- η= ~98.5%
- Highest density

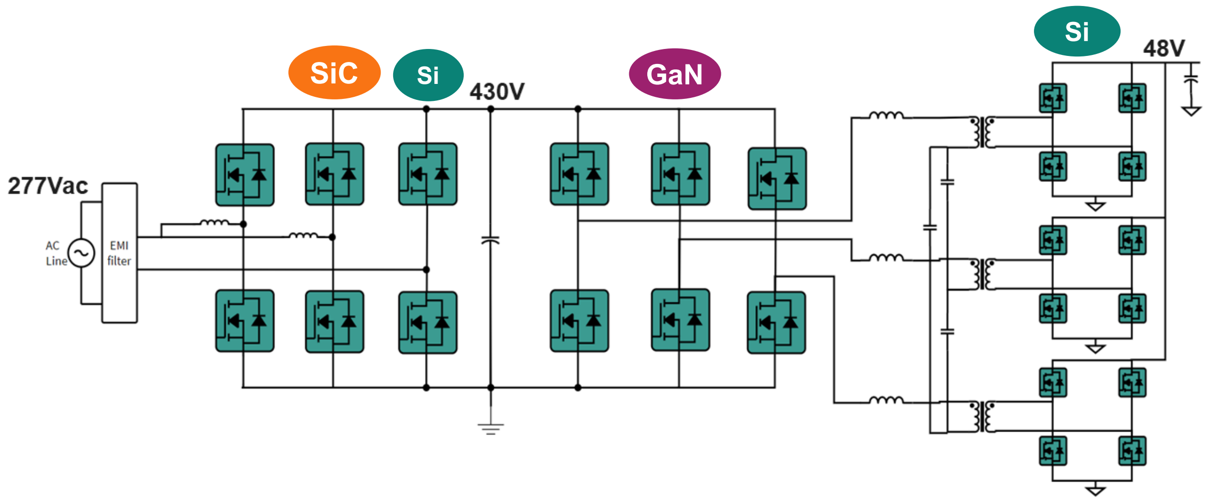
Gen 1/2 AI PSU: 1-ph 277 Vac or 347 Vac to extend power to 5.5 kW and 8kW

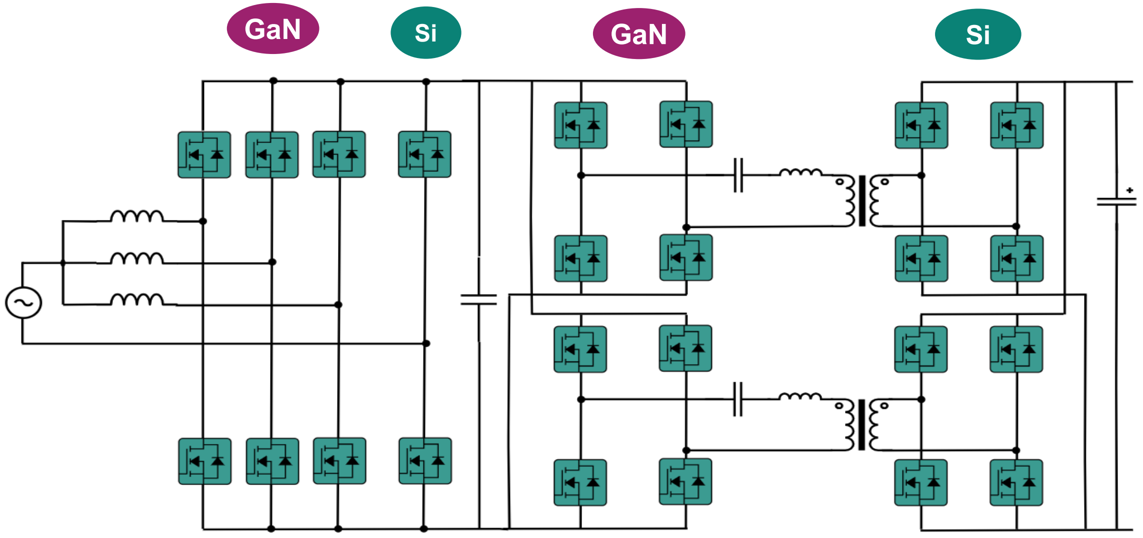
PSU Block Diagram	PSU Block Diagram





Schematic of Power Topology	Schematic of Power Topology

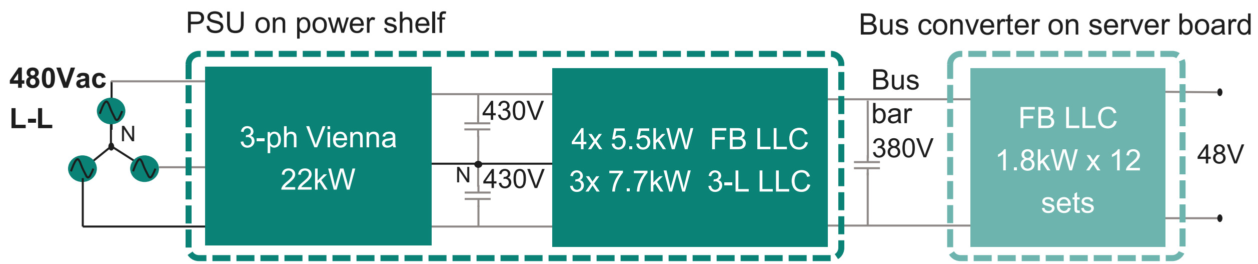




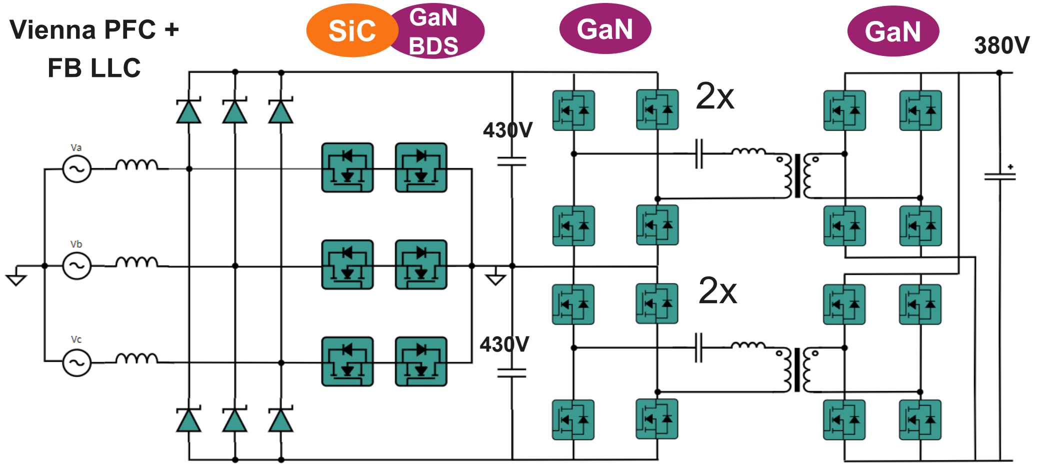
- ❑ SiC for CCM TP PFC, GaN for LLC
- ❑ GaN for TCM TP PFC, GaN for LLC

Gen 3 AI PSU: 3-Ph 480Vac architecture and 380V distribution for 22kW

PSU Block Diagram

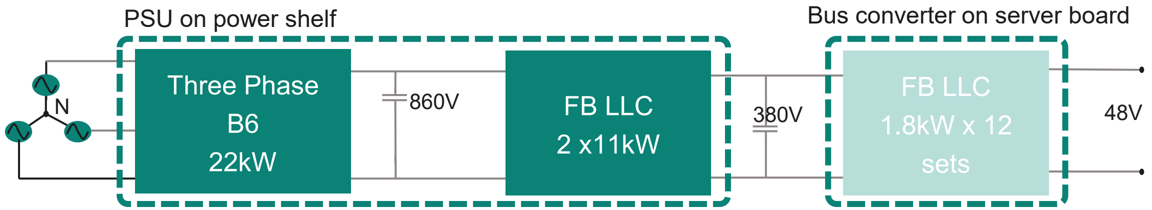


Schematic of Power Topology

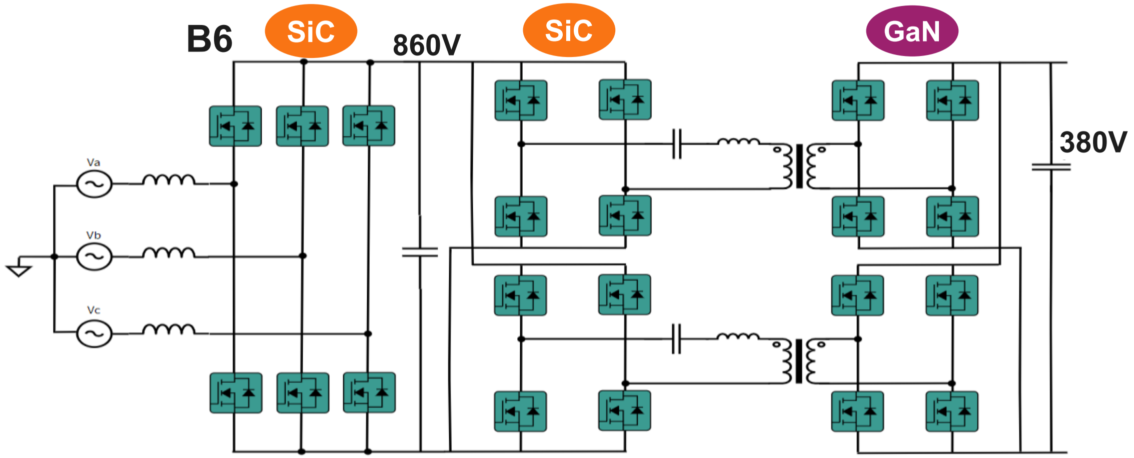


- ❑ SiC or GaN BDS for CCM TP PFC, GaN for LLC

PSU Block Diagram

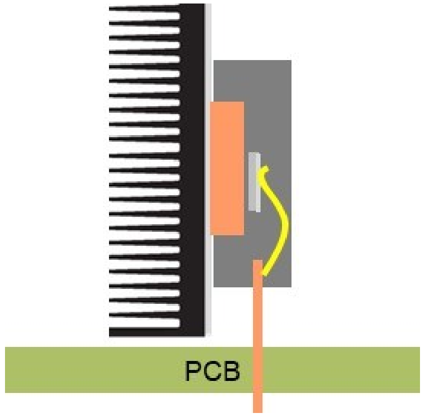


Schematic of Power Topology

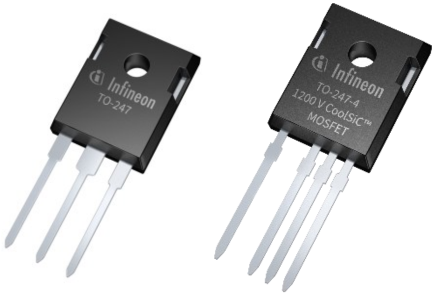


- ❑ SiC for B6 PFC, and LLC pri, GaN for LLC sec.

Infineon industrializes top-side cooling with the most robust roadmap in the market ➔ Enabler for high power and density

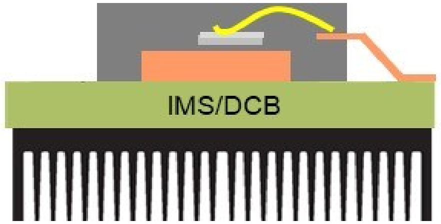


TO-247



THD – Through Hole Device

– Robust thermal performance
– **High package inductance**



ThinPAK 8x8 / 5x6

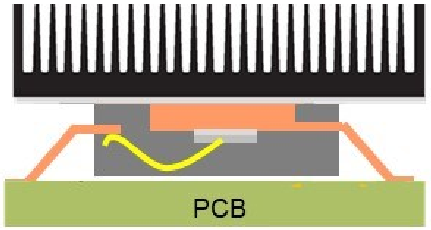
D2PAK

TOLL

DSO-20 BS

SMD Bottom-side cooling

– **Medium thermal performance**
– Low package inductance

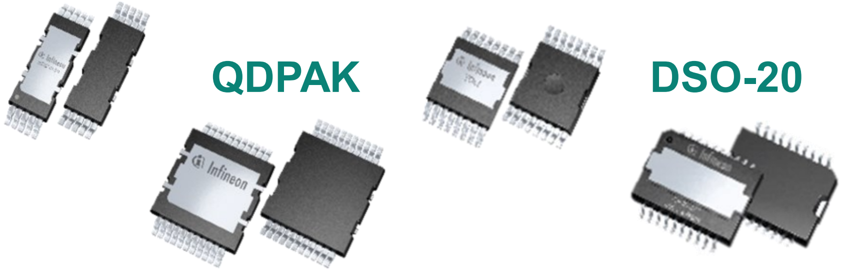


DDPAK

QDPAK

TOLT

DSO-20



SMD top-side cooling

– **Optimal** thermal performance
– **Optimal** loop inductance and PCB design

Table of contents

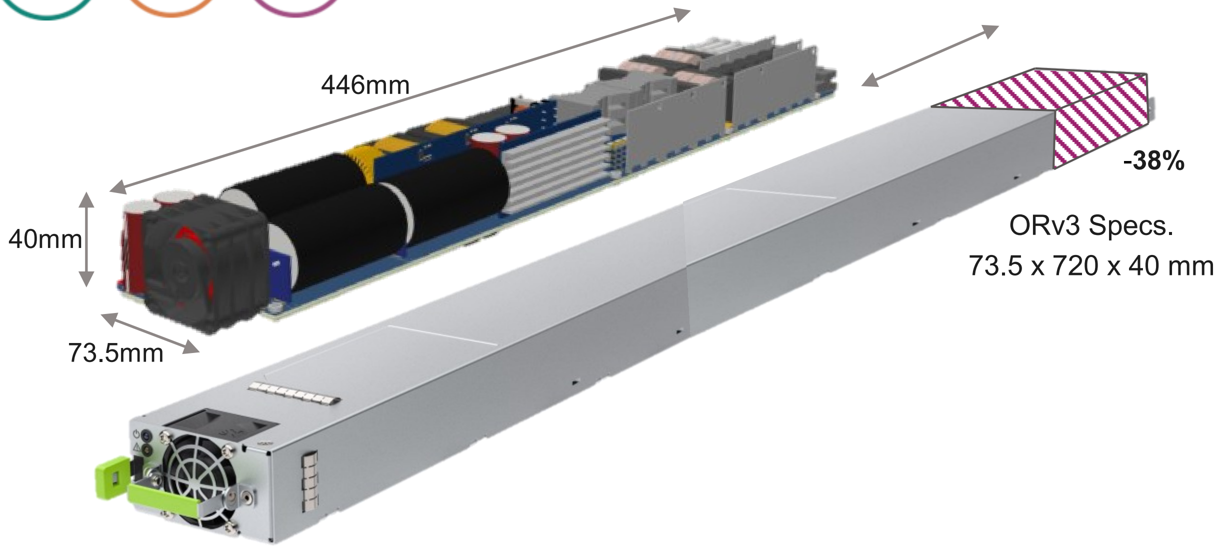
Reference Board 8 kW PSU

Showcasing CoolMOS™ and CoolSiC™ and CoolGaN™

upcoming

REF_8KW_HFHD_PSU

Si SiC GaN



Technical details

Input voltage range	180 V_{AC} ~ 275 V_{AC}	
Output voltage	50 V_{DC} nominal	
Output power max	8000 W	
Efficiency	~ 98%	
Power factor (load > 10%)	PF > 0.98, 20%→80% load iTHD < 10%, 20%→80% load	@ 180 ~ 275 V_{AC}
Temperature Ambient	0°C to 40°C	

Learn More

Infineon components	*8x IGT65R025D2, 8x IMT65R040M2H, 4x IMT65R010M2H, 4x IPT60R016CM8, 2x IPT60R050G7, 2x IDL12G65C5, 1x IPT60R022S7, 60x IQE03xN08LM6, 10x ISC018N08NM6* *1EDB8275F, 1EDN8511B, 2EDB9259Y, 1EDN8550B* *BAT46WJ, BAT165, BSS138N* *ICE2QR2280G,* *TLS4120D0EPV33, 4DIR1400H*
Controller	*XMC4200*

Features

- Full IFX BOM content including CoolMOS™, CoolSiC™, CoolGaN™ and OptiMOS™
- Novel integrated planar magnetic construction
- Hold-up time extension
- Full digital control (PFC and DCDC)
- Interleaved Totem-Pole PFC + Full-Bridge GaN LLC

Benefits

- Target 98% peak efficiency
- Power density 100W/in³ (**-38% volume vs ORv3 specification**)
- **Hold up time extension circuit for 20ms @100% Load**
- 400kHz LLC switching frequency enabled with GaN
- Based on 2x REF_3K3W_HDHF_PSU reference board

Table of contents

 restricted

Summary & Key take-aways

- AI servers show significant higher power trend, and possibly new rack architecture and cooling.
- AI server SMPS higher power is reached by scaling up the number of interleaved stages and using lower Rds_on devices.
- Further higher power requirement will push the SMPS to 3-Phase topologies (e.g.: Vienna) and higher DC voltage distribution (ex: 380V).
- Top side cooling packages can be an enabler for new cold plate liquid cooled SMPS.
- **Infineon CoolGaN™ Leads the Way in Next-Generation AI Server SMPS Together with Si and SiC Power Technologies**

infineon