

A Wide Bandgap (WBG) Based Bidirectional LLC Converter for Energy Storage Systems (ESSs)

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Agenda

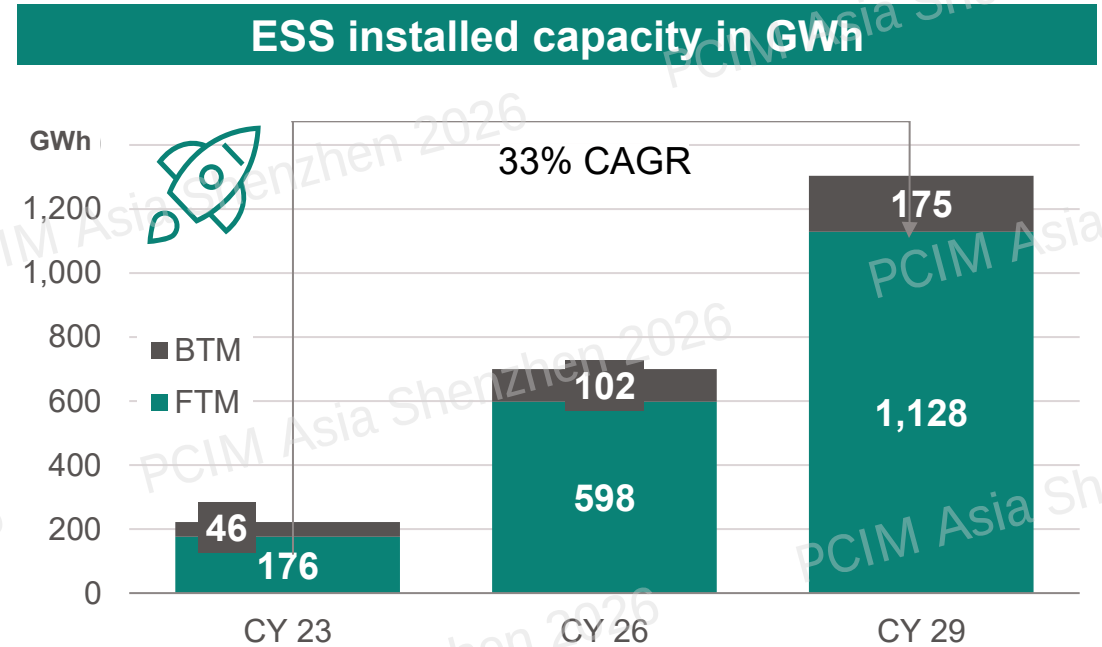
- 1 ESS Market, System Architecture & Topology Innovation
- 2 Infineon WBG Device Portfolio for LLC Converters
- 3 LLC Design & Efficiency Calculations
- 4 LLC Experimental Validation
- 5 Conclusion & Summary



ESS Market, System Architecture & Topology Innovation

Energy Storage – A Core Enabler for Renewable Integration

Global ESS Capacity Outlook & Advantages of BESS



Source: S&P Global commodity insights

Energy storage systems (ESS) are an essential enabler of renewable energy integration



BESS is the most promising of existing energy storage technologies

- Efficiency, modularity, fast response time
- T2M: built relatively quickly for less capital than many other energy projects
- High social acceptance
- Adaptability: variable storage times and power ratings

Classification of Energy Storage System by Application

Utility/C&I/Residential BESS Overview



Utility grid and generation (Grid forming capabilities)

- Frequency regulation: Maintains grid stability by quickly responding to frequency deviations with stored energy
- Voltage regulation: Stabilizes voltage fluctuation by injecting or absorbing power from grid, peak-shaving and load management
- Power factor correction: Ensuring and increasing grid efficiency
- Black start: provides back-up power for restarting the grid after blackout

Commercial and industrial

- Back-up power for EV charging, datacenter and critical infrastructure
- Optimization of PV-energy self-consumption
- Grid forming capabilities – frequency and voltage regulation

Residential storage

- Use for renewable integration from PVs, supporting microgrids and EV charging infrastructure
- Optimization: stores energy during off-peak periods and supplying during peak demand hours

Utility BESS



Commercial and industrial BESS



Residential BESS



Storage capacity

>1000 MWh

500 MWh

250 MWh

50MWh

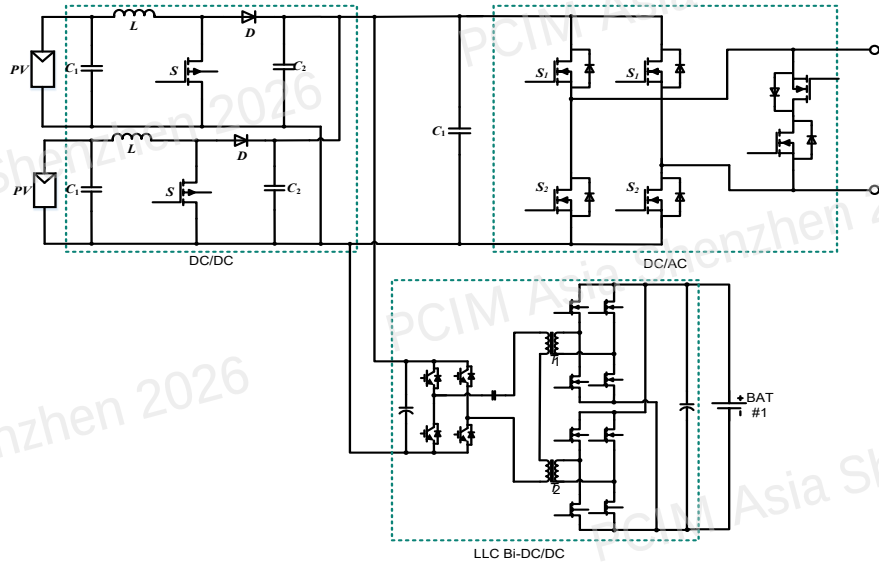
5 MWh

0.03 MWh

PV + ESS Power Conversion Architecture

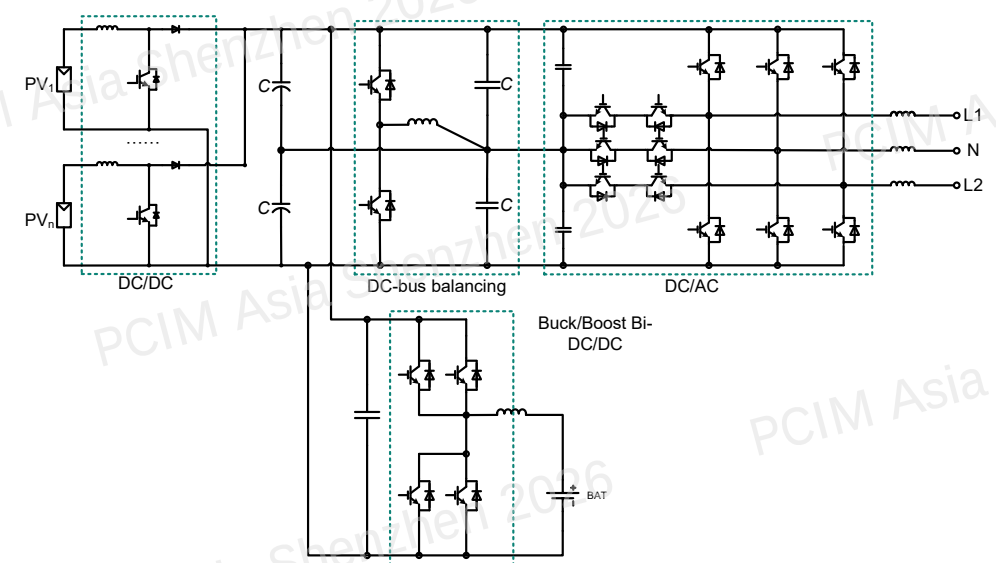
Single Phase vs Three Phase Topology Overview

Single Phase Architecture



- ⚡ **DC/DC Stage:** Boost topology for PV conditioning and MPPT
- ⚡ **DC/AC Stage:** HERIC topology to convert DC link to single-phase AC.
- ⚡ **Bi-DC/DC Stage:** LLC Resonant Topology for battery charging/discharging.

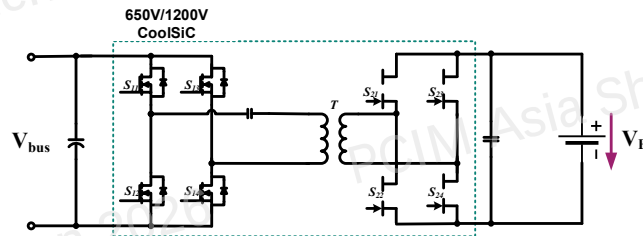
Three Phase Architecture



- ⚡ **DC/DC & Balancing:** Boost topology with MPPT; maintains DC link balance.
- ⚡ **DC/AC Stage:** Three-Level (3L) topology for high-power grid-tie.
- ⚡ **Bi-DC/DC Stage:** Buck/Boost topology for flexible battery energy management.

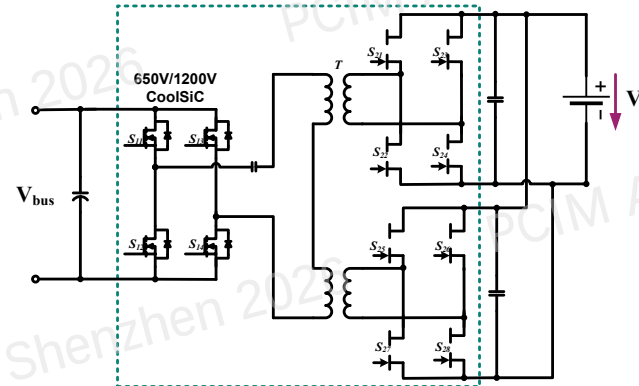
Scalable Bidirectional LLC Resonant Converter Solutions Topology Derivation for High-Current ESS Applications

Conventional LLC Topology



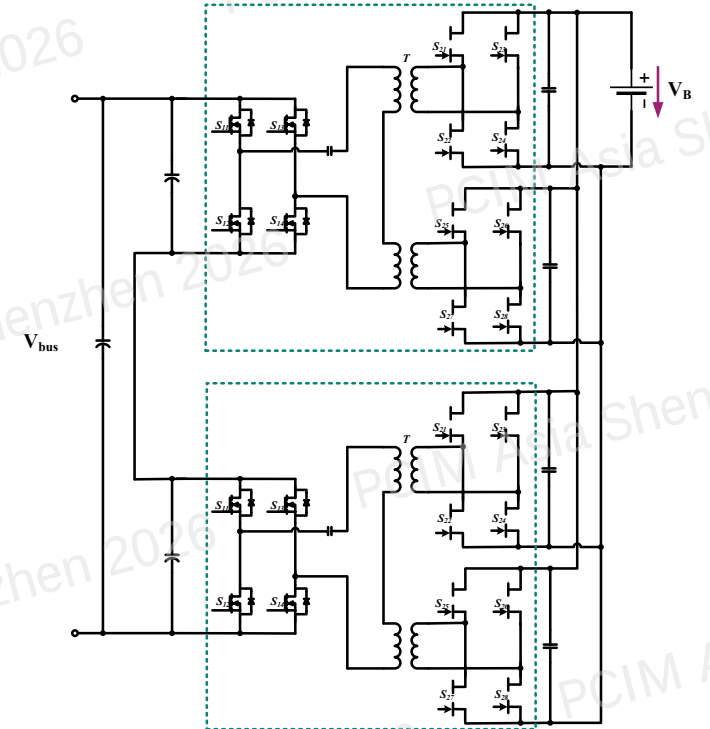
The starting point for topology evolution.

Scheme 1: Low-Side Paralleling



Directly increases current handling capability by paralleling on the low side.

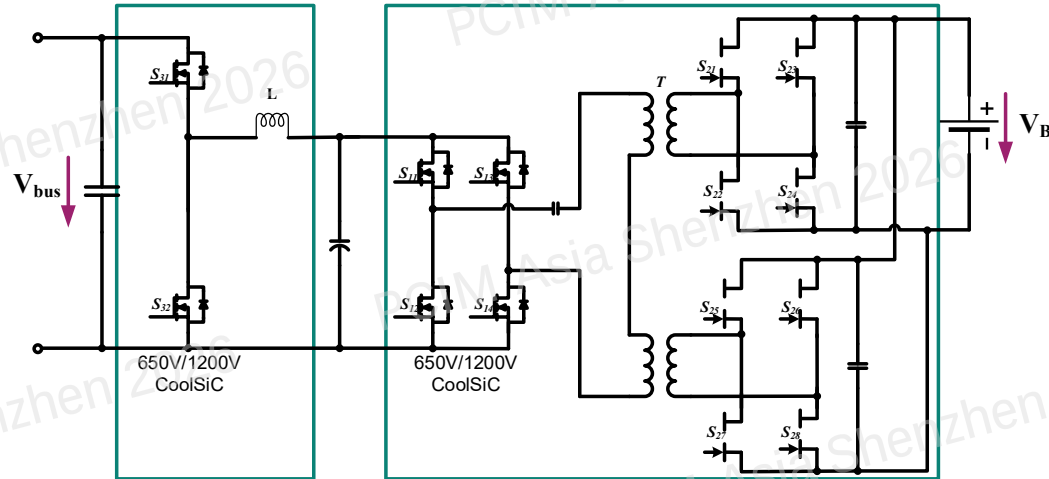
Scheme 2: Hybrid Configuration



Combines low-side paralleling with high-side series connection. Offers a flexible and scalable solution.

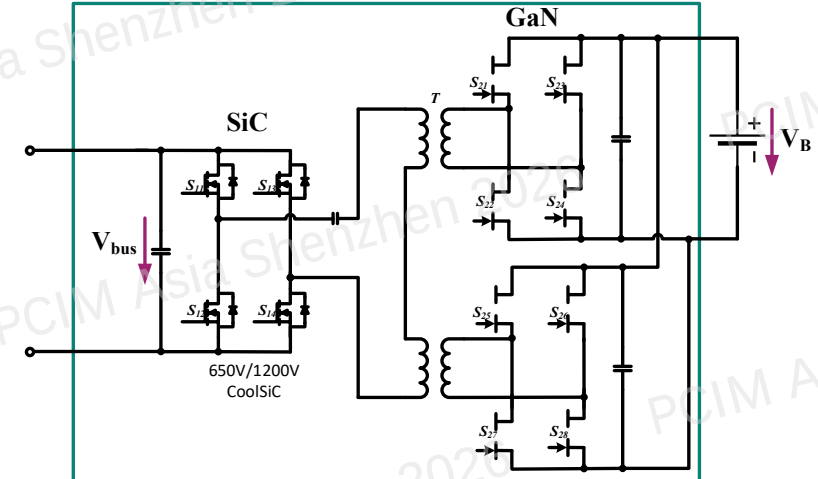
Innovation of Bidirectional Energy Storage DC/DC Topology From Two-Stage Buck-Boost+LLC to Single-Stage LLC

Conventional: Buck-Boost + LLC



- Bus voltage is tightly regulated by controlling the Buck-Boost stage.
- LLC stage operates at a fixed switching frequency for high efficiency.

Innovative: Single LLC Architecture



- Simplified single-stage solution; bus voltage naturally follows battery voltage.
- Maintains fixed LLC frequency while reducing component count and complexity.

5-in-One Integrated PV-ESS Platform

Architecture of Stackable Distributed Battery Modules

5-in-One



MPPT+ESS

For solar + energy storage system integration



EVDC

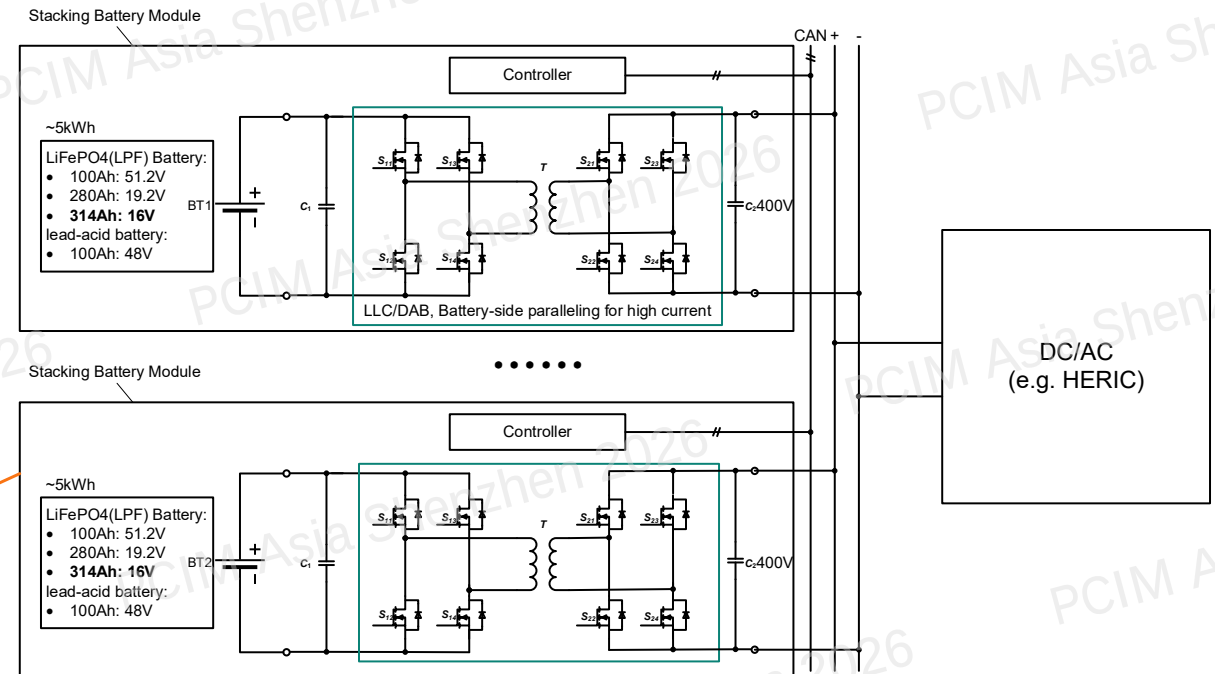
High-efficiency DC conversion module



BAT

Modular BESS (Battery Energy Storage System)

Stacking Module Diagram



Technology Shifts for Next-Generation Residential ESS WBG Device Rollout and Single-Stage Cycloconverter



Accelerated WBG Adoption

Trends: Switching frequency $\uparrow$, Passive Component $\downarrow$

- SiC MOS: 20kHz to 40–60kHz, ~30% smaller size, ~15% lower loss vs Si IGBT
- GaN HEMT: 20kHz to 100+kHz, ~50% smaller size, ~20% lower loss vs Si IGBT

Impact

- Cost competitive WBG products with broad package and voltage portfolio
- Transition from Si IGBT/Si MOS to WBG is still in full swing

System level example

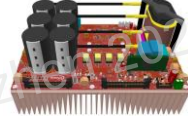


IGBT, 24kHz, Gen1



SiC MOS, 48kHz, Gen2

Infineon SiC Ref



- 30% size reduction
- 15% BoM cost reduction
- 2x switching freq.
- 0.3% higher CEC eff.

WBG – Wide BandGap (i.e. SiC and GaN)



Broader Cycloconverter adoption

Trends: High Efficiency at lowest BoM cost

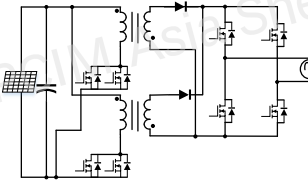
- Cycloconverter in 1- Φ /3- Φ microinverters will be adopted
- Expansion into Portable ESS applications

Impact

- Fast growing for 650V / 1200V low $R_{DS(on)}$ **GaN BDS**
- Increasing interest for low $R_{DS(on)}$ **MV GaN** for portable ESS
- HW accelerators for >500 kHz switching

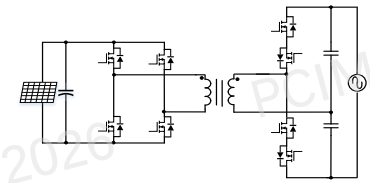


System level example



2-Stage Flyback + Unfolder

- Poorer efficiency (~96.5%)
- Smaller power density
- Lower & fixed f_{sw} (~100 kHz)
- No bidirectionality



1-Stage Cycloconverter

- Higher efficiency (~97.5%)
- Higher power density (>20%)
- Larger & variable f_{sw} (~100 kHz – 600 kHz)
- Bidirectionality (suitable for PF-adjustment and ESS application)

BoM – Bill of Materials
MV – Medium Voltage

BDS – BiDirectional Switch
PF – Power Factor

Next-Generation Residential Energy Storage Evolution

Modular Stacking, Grid-Forming Technology and AI-Driven

Multi-Source & Modular Stackable Architecture

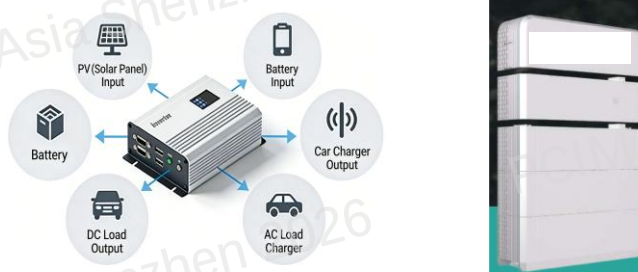
Customer Trends:

High Flexibility & Scalability

- Multi-Source, Multi-Port Energy Hub: PV + Battery + EV Charging + Generator + ...
- Modular Stacking as Universal Standard: Battery stacking + Inverter stacking + ...

Impact

- High-speed, reliable inter-module communication as system backbone
- Diversified voltage platforms & full product-line packaging consistency
- Shift from discrete components to integrated power devices



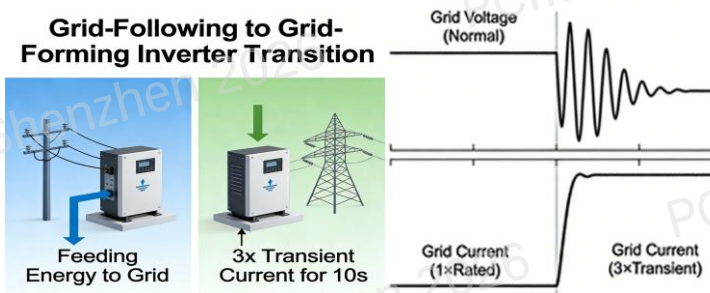
Grid-Forming Capability

Customer Trends: High Overload

- Revolution transformation from grid-following to grid-forming.
- Grid-forming inverter's requirement to support **3x transient current for 10s** presents a challenge to power devices.

Impact

- Devices optimized for high robustness & overload standards
- High computing MCUs with acceleration for complex grid-forming algorithm



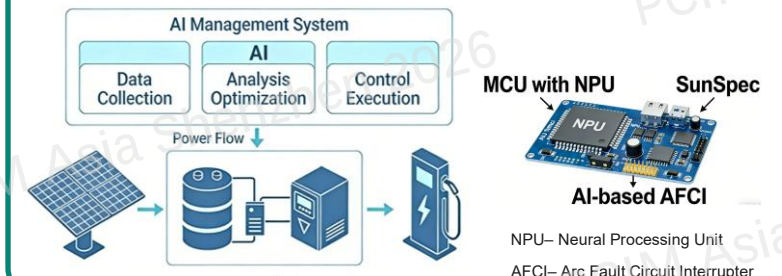
AI Energy Management

Customer Trends: Smart

- AI-powered planning for optimal energy cost
- AI migration from cloud to edge inverter
- Dual ecosystem interconnection for true smart home energy

Impact

- MCUs with NPU for real-time AI acceleration
- Open protocols (SunSpec, Matter) for cross-platform linkage
- AI-based AFCI mandatory; controller integrated into main unit; AFCI sensor merged with MPPT





Infineon WBG Device Portfolio for LLC Converters

Unlock Next-Gen Battery Bi-Directional DC/DC Performance WBG IPOS LLC Design

Challenges with Current Si-Solutions

Silicon-based designs hit a performance wall:

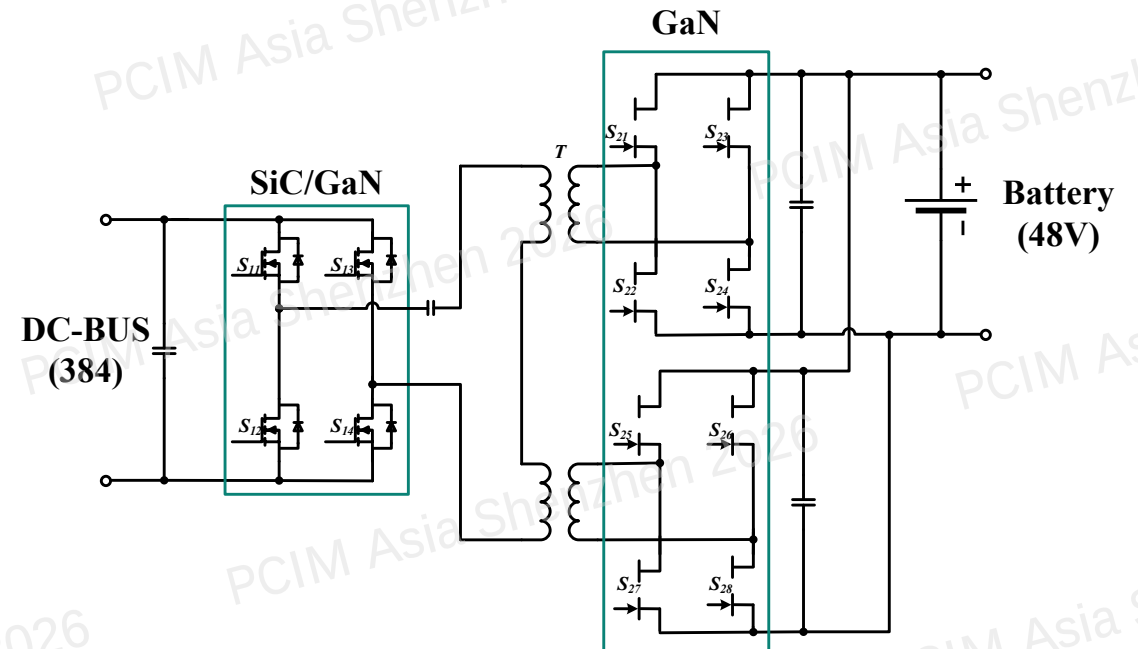
- Frequency-limited – switching losses prevent high frequency operation
- Thermally-constrained – limited to $\sim 150^{\circ}\text{C}$ junction temperatures
- Density-capped – magnetic size restricts power density
- Efficiency-plateaued – hard-switching losses limit to 96%

Key Value Proposition

- **Wide-Bandgap Core:** Employs GaN for low-voltage and SiC/GaN for high-voltage, unlocking the full value of WBG technology.
- **High-Frequency & High Density:** Drives increased switching frequency to achieve superior power density.
- **Advanced Thermal Management:** Implements a cutting-edge top-cooling concept for efficient heat dissipation.
- **Optimized Power Stage:** Features IPOS design for low-voltage, high-current battery applications and fast charging.
- **Key Performance Gains:** Delivers higher system efficiency despite elevated frequency and supports high-current operation.
- **Intelligent Firmware:** Developed specifically for Boy-X architecture, leveraging advanced hardware features.

Strategic Goal

- Establish a high-efficiency-density benchmark for residential ESS Bi-DCDC.
- System level comparison vs. today's mainstream Si solution
- Accelerate customer time-to-market with a scalable, platform-based architecture.



Infiniteon CoolGaN™ MV Product Portfolio

Medium-Voltage GaN HEMT Device Family for ESS

Sales Code	Voltage class	$R_{DS(on),typ}$	Package type (mm)	Package figure	Positioning
IGC033S101	100 V	2.4 mΩ	PQFN 3x5 BSC		– Lower $R_{DS(on)}$ → higher power rating – PQFN package – Smaller and lowest parasitic inductance – Bottom-side and dual-side cooling – RQFN package – Si footprint packages – Best thermals and TCoB
IGC033S10S1			PQFN 3x5 DSC		
IGB110S101		9.4 mΩ	PQFN 3x3 BSC		
IGB110S10S1			PQFN 3x3 DSC		
IGB070S10S1		5 mΩ	PQFN 3x3 DSC		
IGD015S10S1		1.1mΩ	RQFN 5x6 DD		
IGC019S06S1	60 V	1.3 mΩ	PQFN 3x5 DSC		
IGC025S08S1	80 V	1.8 mΩ	PQFN 3x5 DSC		
IGE033S08S1		2.3 mΩ	RQFN 3.3x3.3 SD		
IGC037S12S1	120 V	2.7 mΩ	PQFN 3x5 DSC		
IGC090S20S1	200 V	6.7 mΩ	PQFN 3x5 DSC		

- Voltage range spans 60 V ~ 200 V; 100 V devices are well suited for 48 V battery applications.
- Flexible PQFN & RQFN packaging.
- Rich $R_{DS(on)}$ selection to scale power capability for different system power levels.

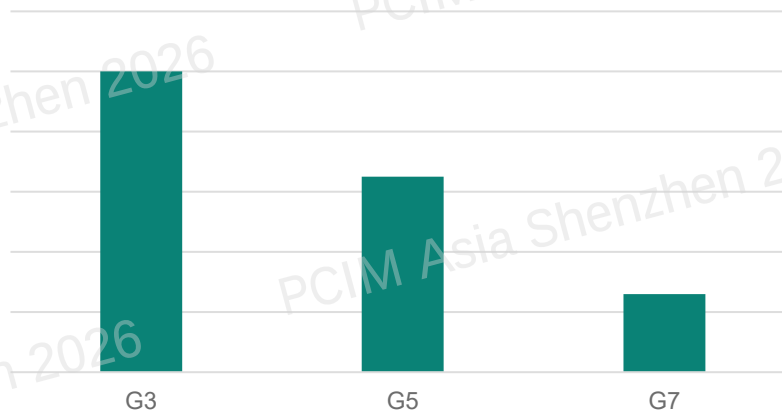
Relevance of MV CoolGaN™ Technology

Electrical Performance Benchmarking vs Silicon

Param.	100V G5 CoolGaN™	BiC Si
V_{ds}	100 V	100 V
Package	5x6	5x6
$R_{DS(on) max}$	1.1 mΩ	2.2 mΩ
$I_{d,con}$	43 A	25 A
Q_{oss}	90 nC	135 nC
Q_G	25 nC	73 nC
Q_{rr}	0 nC	70 nC
$V_{sd} @ 0.5A$	0.8 V	0.7 V

50% lower R_{on}
 35% lower Q_{oss}
 3x lower Q_g
 Zero Q_{rr} !

$R_{on} \cdot A$



Key Performance Metrics

1. Lower $R_{ds(on)}$: GaN (1.1mΩ) vs Si (2.1mΩ). Benefit: 35% lower $R_{ds(on)}$.
2. Zero Q_{rr} : GaN (0nC) vs Si (70nC). Benefit: Eliminates switching loss/EMI.
3. Lower Q_g : GaN (25nC) vs Si (73nC). Benefit: Faster switching.

Value Proposition

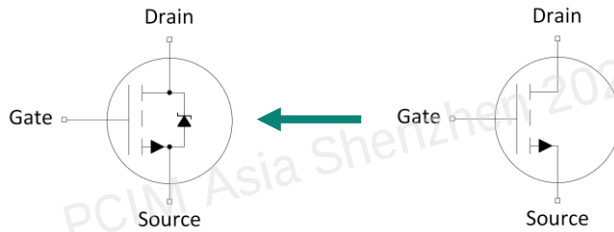
1. 50% lower $R_{on} \cdot A$: Key figure of merit.
2. 3x lower power loss: Superior switching.
3. Cost Target: GaN performance at Si cost.

Cost Reduction

1. Shifting production from 8" to 12",
2. Optimizing BEE & test costs,
3. Migrating to newer technology generations

MV CoolGaN™ G5 with Integrated Monolithic Schottky Diode Optimized Reverse Conduction Performance

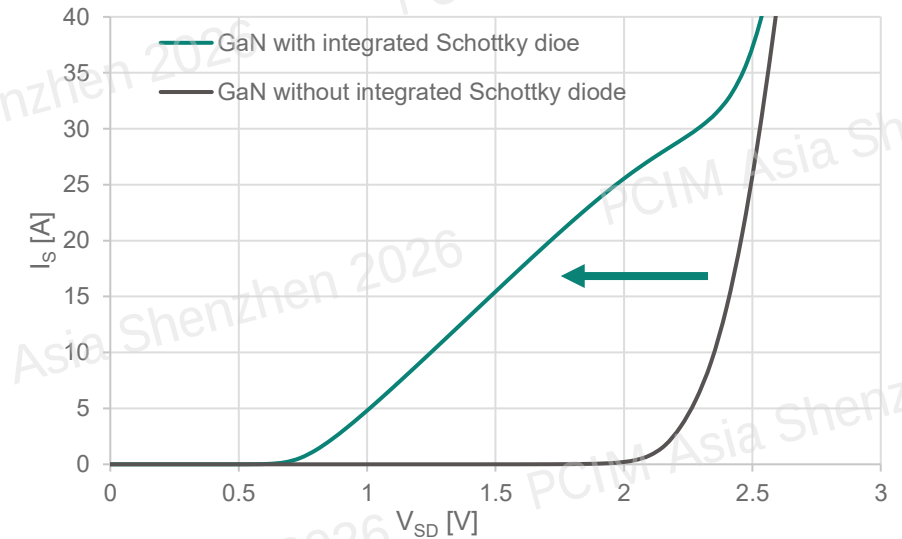
- Fully integrated monolithic GaN Schottky diode
 - No** reverse recovery as there is no p-n junction
 - No** need for external Schottky diode → cost & space savings



- Significant reduction of dead-time losses especially for applications with high switching frequencies, e.g., LLC converter

- Built-in monolithic GaN Schottky diode removes requirement for external freewheeling diode.
- Junction-free diode delivers zero Q_{rr} and cleaner switching behaviour.
- Reduced VSD reverse voltage significantly lowers dead-time losses.
- Well suited for high-frequency applications including LLC converters.

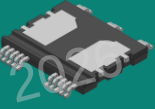
100V G5 3x5 PQFN



CoolSiC™ MOSFETs 750 V Generation 2

Industrial grade

Products in development stage - Portfolio and timelines subject to change.

Cooling		THD Package	SMD Bottom Side Cooling	SMD Top Side Cooling- 2,3mm height		
$R_{DS(on)}$ max [mΩ] 18 V	$R_{DS(on)}$ typ [mΩ] 18 V	 TO-247-4	 D2PAK-7	 Q-PAK	 Hex-DPAK Half-bridge Dual-switch	 Q-DPAK Bi-directional Dual-switch
75	60	IMZA65R060M2H	IMBG65R060M2H	IMDQ75R060M2H	IMSH75R060M2HH	
62	50	IMZA65R050M2H	IMBG65R050M2H	IMDQ75R050M2H	IMSH75R050M2HH	
49	40	IMZA65R040M2H	IMBG65R040M2H	IMDQ75R040M2H	IMSH75R040M2HH	IMDQ75R040M2HB
42	33	IMZA65R033M2H	IMBG65R033M2H	IMDQ75R033M2H	IMSH75R033M2HH	IMDQ75R032M2HB
33	26	IMZA65R026M2H	IMBG65R026M2H	IMDQ75R025M2H	IMSH75R025M2HH	
24	20	IMZA65R020M2H	IMBG65R020M2H	IMDQ75R020M2H	IMSH75R020M2HH	IMDQ75R022M2HB
18	15	IMZA65R015M2H	IMBG65R015M2H	IMDQ75R016M2H	IMSH75R016M2HH	
13	10	IMZA65R010M2H	IMBG65R010M2H	IMDQ75R011M2H	IMSH75R011M2HH	
8	7	IMZA65R007M2H	IMBG65R007M2H	IMDQ75R007M2H		
5	4			IMDQ75R004M2H		

Benefits

- ✓ Highly robust 750V technology + $T_{vj}=200^{\circ}\text{C}$ for 100h
- ✓ **100% avalanche tested**
- ✓ Superior energy efficiency and power system density
- ✓ **Dual-switch portfolio to enable innovation**
- ✓ **66% lower parasitics with Top Side Cooling**



Server



Humanoid charger



Storage



eScooter



HVAC compressor



Industrial robots



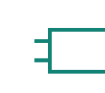
Telecom



DC wallbox



Solar



SMPS



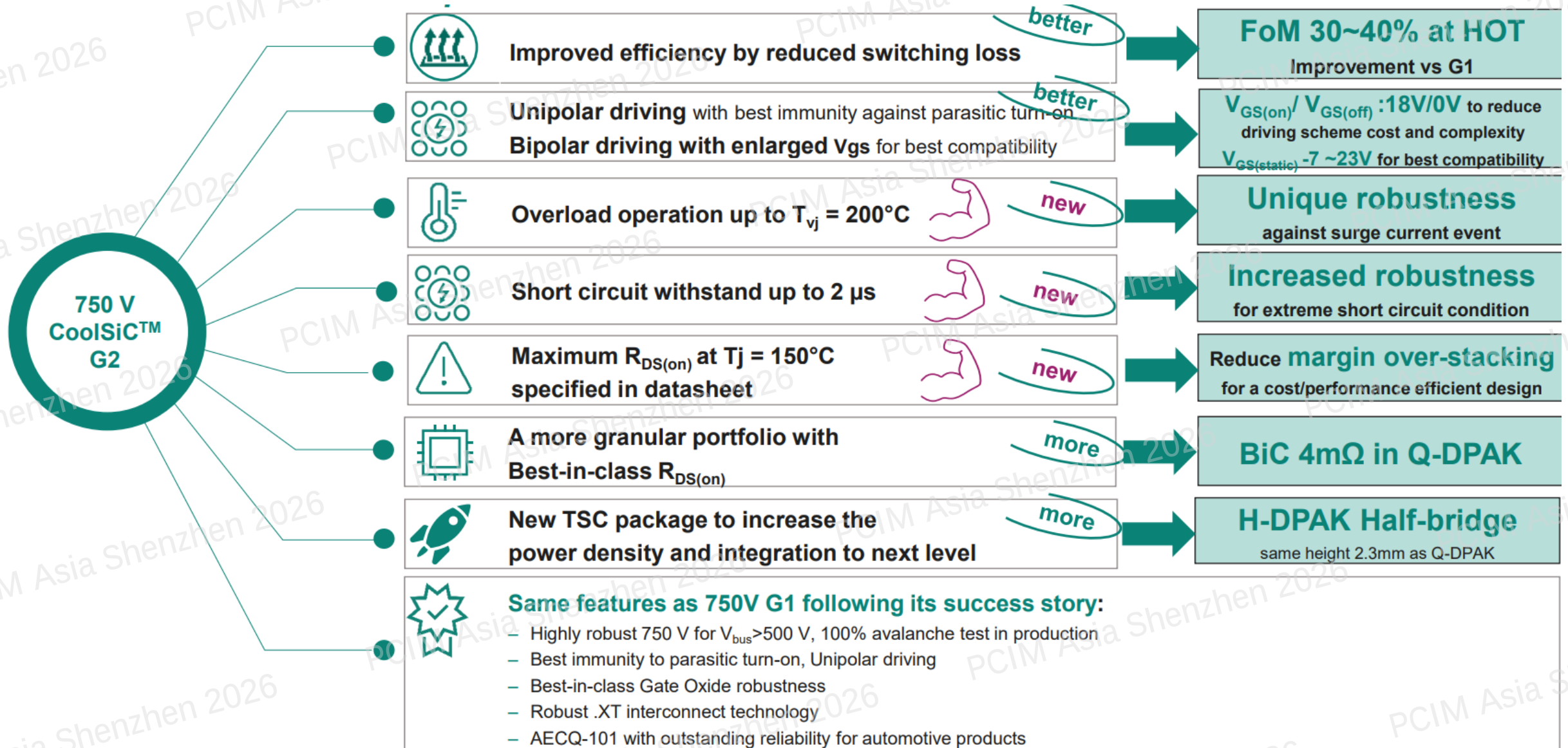
SSCB



Automated guided vehicles

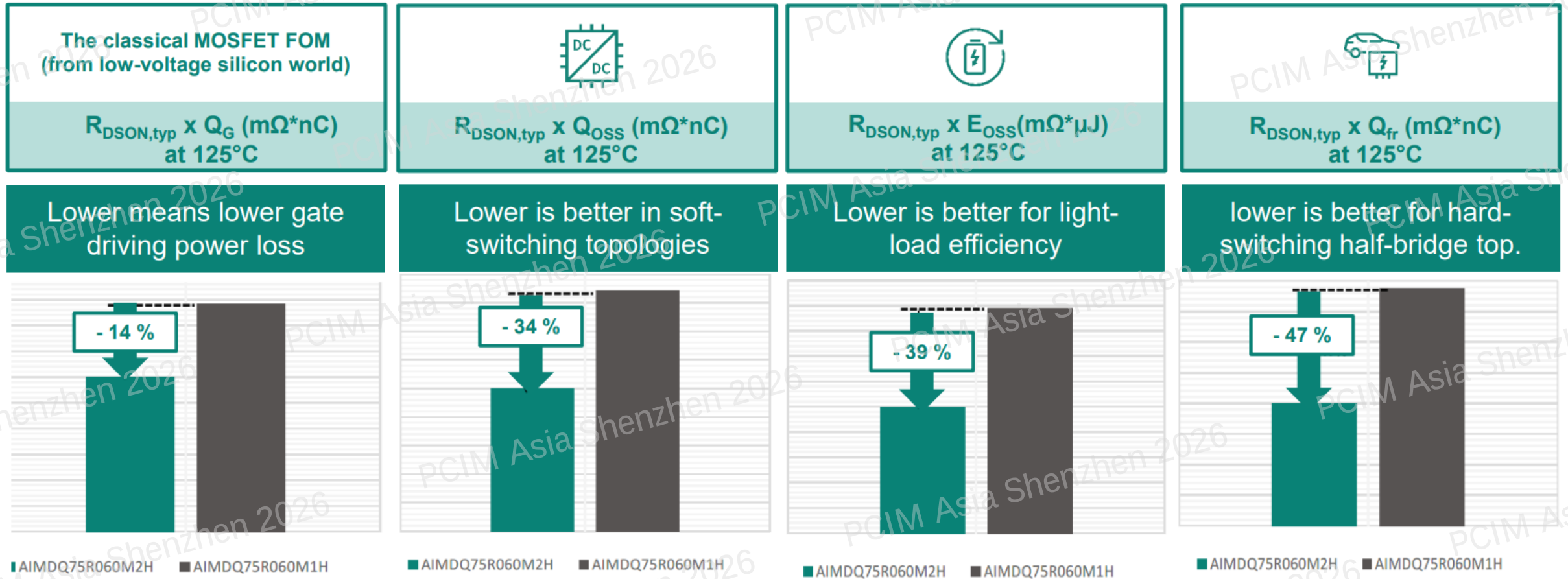
CoolSiC™ G2 Product Highlights

Performance, Robustness & Packaging Improvements vs. G1 Gen



CoolSiC™ Device Figure-of-Merit Benchmarking

Application-Oriented FoM Comparison of M2H vs M1H Platform



- -14% for $R_{DS(on)} \times Q_G$ (lower gate driving losses)
- -34% for $R_{DS(on)} \times Q_{OSS}$ (optimized for soft-switching)
- -39% for $R_{DS(on)} \times E_{OSS}$ (improved light-load efficiency)
- -47% for $R_{DS(on)} \times Q_{fr}$ (superior for hard-switching half-bridge circuits)

High-voltage CoolGaN™ Transistor G5 in-house portfolio

Broad portfolio enables optimized product selection

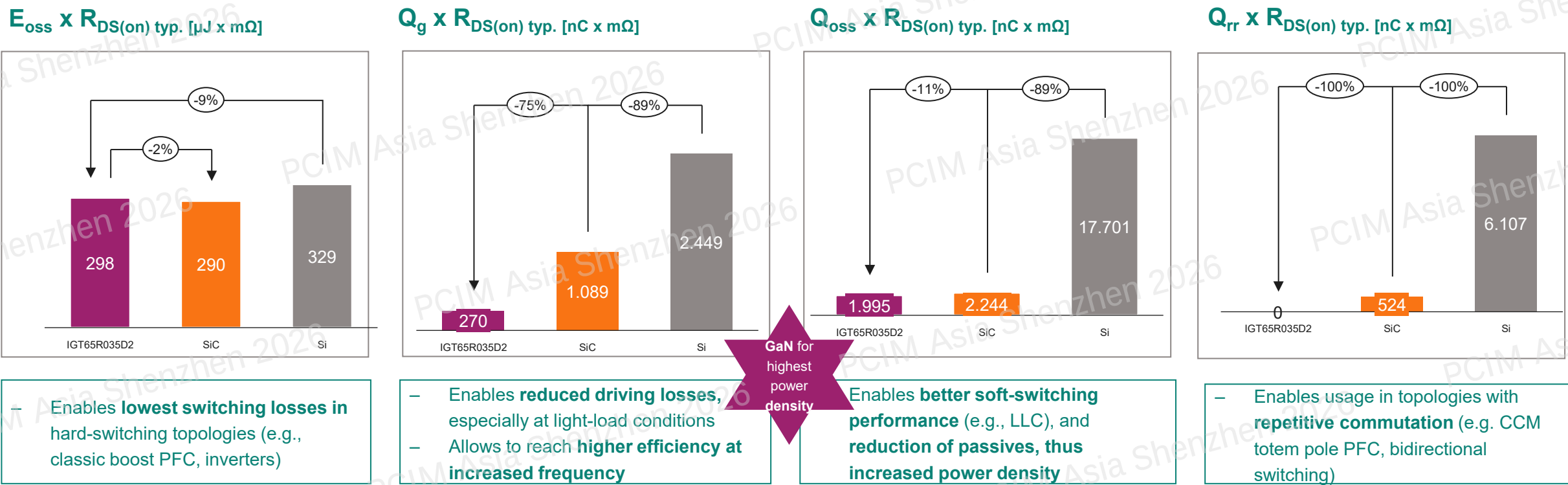


CoolGaN™ Transistor G5									
R _{DS(on, typ)} [mΩ]	650 V							700 V	
	ThinPAK 5x6	DFN 8x8	DSO TSC	ThinPAK 8x8	TOLL	TOLT	8x8 DSC	PAK	ThinPAK 5x6
									
500								IGD70R500D2S	
270	IGLR65R270D2							IGD70R270D2S	IGLR70R270D2S
200	IGLR65R200D2							IGD70R200D2S	IGLR70R200D2S
140	IGLR65R140D2	IGLD65R140D2		IGL65R140D2	IGT65R140D2			IGD70R140D2S	IGLR70R140D2S
100/110		IGLD65R110D2		IGL65R110D2		IGLT65R110D2	IGLC65R100D2		
80		IGLD65R080D2		IGL65R080D2					
50/55		IGLD65R055D2	IGOT65R055D2	IGL65R055D2	IGT65R055D2	IGLT65R055D2	IGLC65R050D2		
45			IGOT65R045D2		IGT65R045D2	IGLT65R045D2			
30/35			IGOT65R035D2		IGT65R035D2	IGLT65R035D2	IGLC65R030D2		
20/25			IGOT65R025D2		IGT65R025D2	IGLT65R025D2	IGLC65R020D2		
ES timeline	Released				Released	Released	Q2 CY26	Released	
QS timeline							Q3 CY26		
SOP							Q4 CY26		

CoolGaN™ Transistor 650 V G5 with best-in-class FOMs

Highest efficiency at increased switching frequencies

	Voltage	$R_{DS(on)} * E_{oss}$	$R_{DS(on)} * Q_g$	$R_{DS(on)} * Q_{oss}$	$R_{DS(on)} * Q_{rr}$
Silicon	600	100%	100%	100%	100%
SiC	650	88%	44%	13%	9%
GaN	650	91%	11%	11%	0%



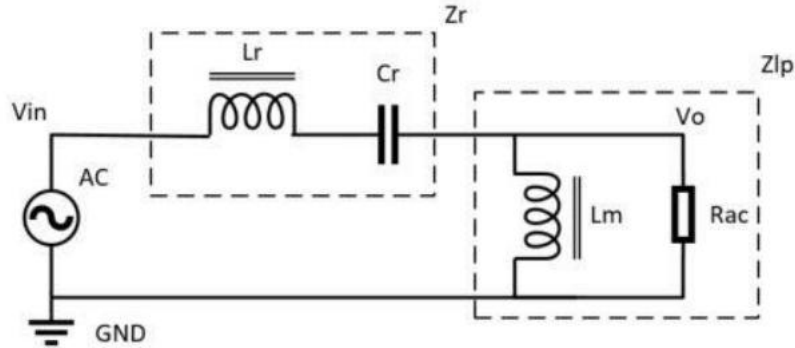
CoolGaN™ with outstanding FOM supports highly efficient fast switching operation & enables lowest switching and reduced driving losses

LLC Design & Efficiency Calculations

LLC Resonant Converter Tank Parameter Design

5kW 384V/48V Isolated DC-DC Design & Gain Analysis

01. Topology Principles



02. System Design Specifications

Parameter	Value	Description
Vin,nom	384 V	Nominal Input Voltage
Vout,nom	48 V	Nominal Output Voltage
Pout	5000 W	Rated Output Power
nratio	8	Np:Ns, Transformer Turns Ratio
fr	250kHz	Resonant Switching Frequency
[fo, fmax]	[150kHz, 500kHz]	Switching frequency range

03. Calculation Automation

$$L_m = \frac{1}{\sqrt{G(\omega_0)^2 - 1}} * \frac{R_{ac}}{\omega_o}$$

$$L_r = L_m * \frac{1 - \frac{1}{G(\omega_0)^2}}{\left(\frac{\omega_r}{\omega_o}\right)^2 - 1}$$

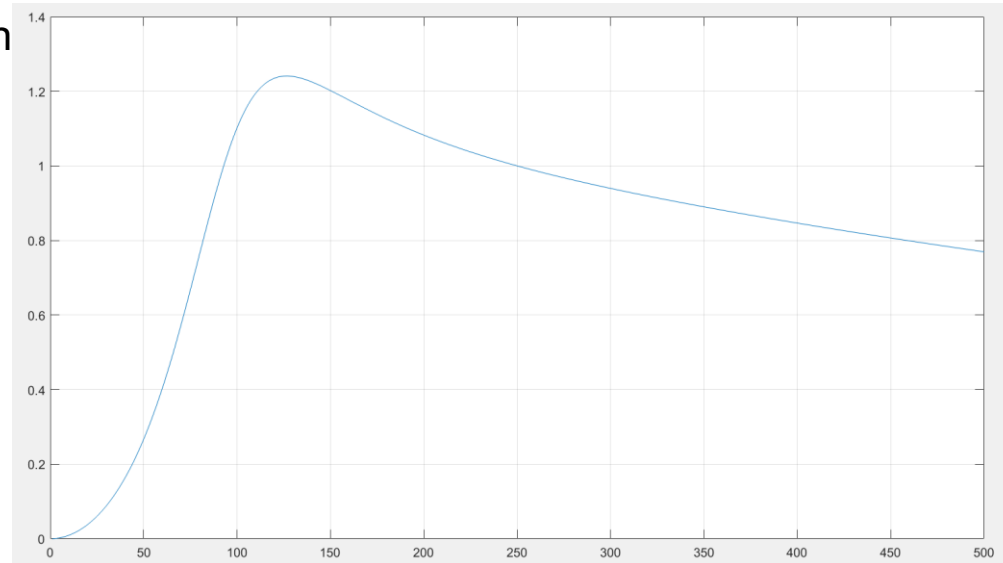
$$C_r = \frac{1}{\omega_r^2 * L_r}$$



- $L_m = 38\mu\text{H}$
- $L_r = 6.5\mu\text{H}$
- $C_r = 62\text{nF}$

04. Gain-Frequency Response

Gain



f/kHz

- Final tank parameters: $L_m = 38\mu\text{H}$, $L_r = 6.5\mu\text{H}$, $C_r = 62\text{nF}$.
- Operating frequency range: 150kHz–500kHz, sufficient gain margin for regulation.

Efficiency Analysis of LLC Resonant Converter Battery Discharging Operation (Battery to DC-Bus)

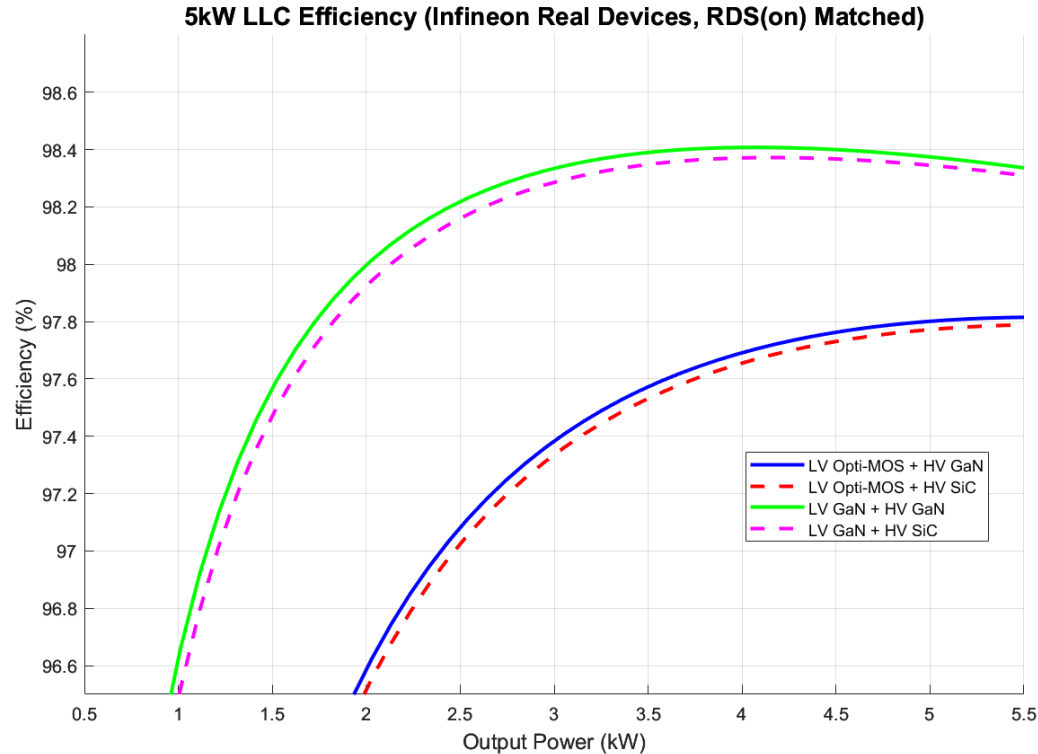


Figure: LLC Battery Discharging Efficiency. The graph illustrates efficiency performance across varying load conditions (0-5kW) for different semiconductor configurations, highlighting the impact of device technology on system-level efficiency.

01 Key Conclusions

- **LV GaN vs. Opti-MOS:** LV GaN outperforms LV Opti-MOS by ~0.5–0.6% due to lower primary-side turn-off loss.
- **HV GaN vs. SiC:** HV GaN shows a slight efficiency edge over HV SiC, even with matched Rds(on).
- The LV device type is the dominant factor determining efficiency performance.

02 Root Cause Analysis

- **LV turn-off loss:** LV turn-off loss is the main differentiator.
- **LLC Resonant Soft Switching:** Secondary ZCS rectification minimizes switching loss.
- **Minimized Device Gaps:** Low switching frequency (250 kHz) limits the impact of secondary device differences.

Efficiency Analysis of LLC Resonant Converter Battery Charging Operation (DC-Bus to Battery)

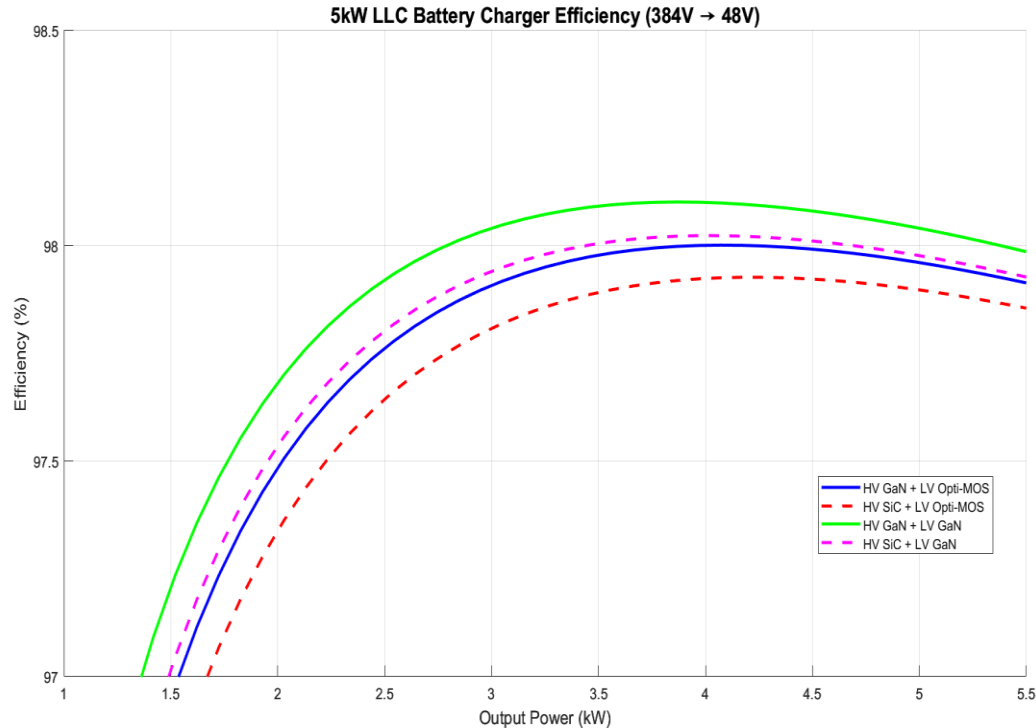


Figure: LLC Battery Charging Efficiency. The graph illustrates efficiency performance across varying load conditions (0-5kW) for different semiconductor configurations, highlighting the impact of device technology on system-level efficiency.

01 Key Conclusions

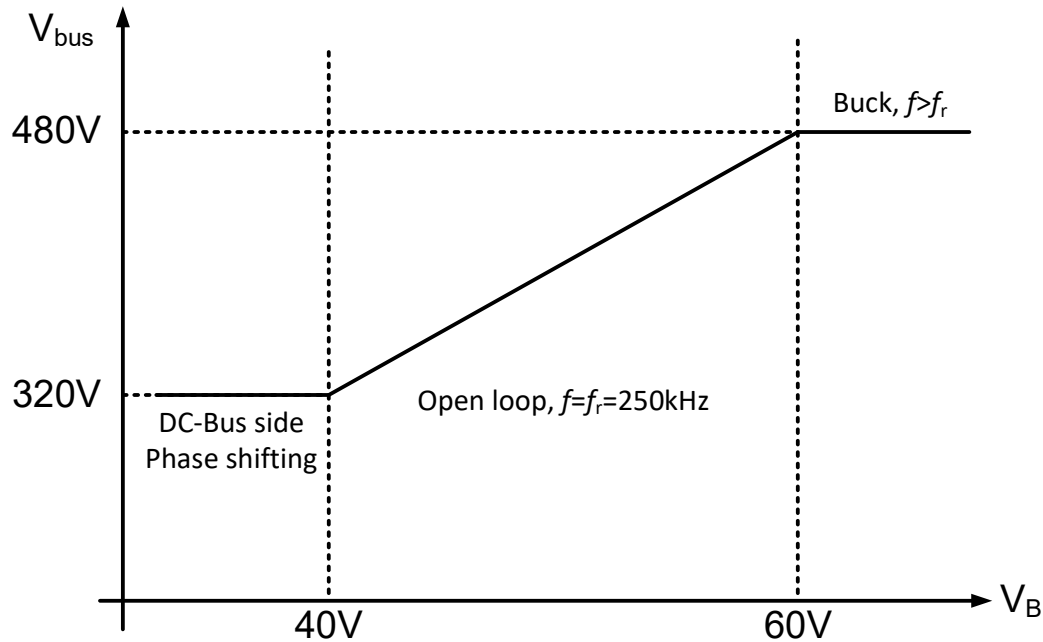
- **LV GaN vs. Opti-MOS:** Low-Voltage GaN delivers a slight efficiency advantage of ~0.1% over the optimized LV MOSFET baseline.
- **HV GaN vs. SiC:** High-Voltage GaN offers a marginal-0.07% improvement compared to HV SiC devices.
- **Peak Performance:** **HV GaN + LV GaN** hybrid achieves a class-leading 98.1% peak efficiency.

02 Root Cause Analysis

- **Equalized Conduction Loss:** Identical RDS(on) values across devices ensure conduction losses are uniform, isolating switching performance differences.
- **LLC Resonant Soft Switching:** Quasi-ZVS/ZCS operation eliminates hard-switching losses, a major contributor to high overall efficiency.
- **Minimized Device Gaps:** ZCS operation on the secondary side significantly reduces performance variations between different LV semiconductor technologies.

Control Strategy of LLC Resonant Converter

Battery Discharging Operation (Battery to DC-Bus)



Key Thresholds: The linear curve represents the open-loop gain ($G=8$) at resonance (250kHz). Vertical thresholds at 40V/60V trigger phase-shift boost and buck mode adjustments to maintain DC-bus stability across varying battery conditions.

01. Open-Loop Resonant Mode

Operates at 250kHz resonant frequency for 42–60V battery input, delivering a fixed gain of 8. This maps to a stable 336–480V DC-bus output, directly compatible with grid-tie requirements.

02. Buck Mode (Over-Frequency)

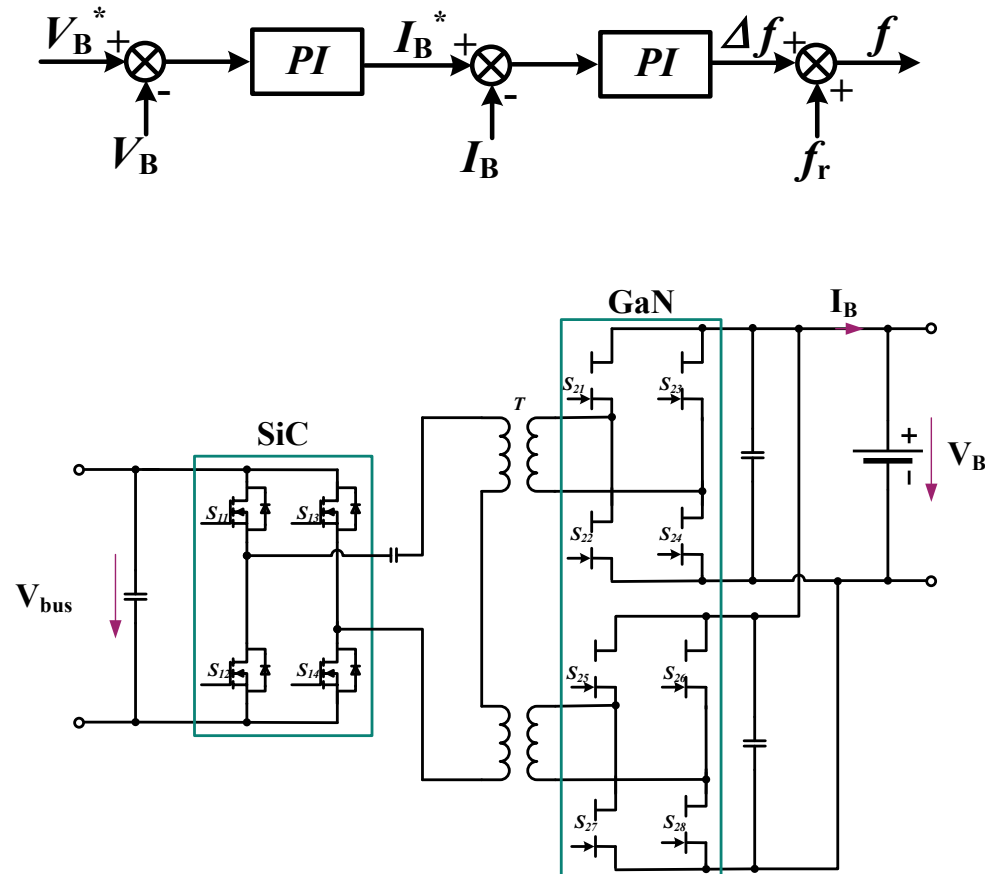
Activated when V_{bus} exceeds 480V ($V_B > 60V$). The switching frequency is increased above resonance, reducing the effective gain to clamp the output voltage and prevent overvoltage.

03. Phase-Shift Boost Control

Engages for $V_B < 42V$ ($V_{bus} < 336V$). Phase-shift modulation on the DC-side H-bridge actively boosts the voltage to meet the minimum grid connection threshold, ensuring uninterrupted power flow.

Control Strategy of LLC Resonant Converter Battery Charging Operation (DC-Bus to Battery)

01. Control Loop



Operational Mechanism

01. Frequency-Driven Voltage Regulation

The system modulates the switching frequency (f) around the resonant frequency (f_r) to adjust the voltage gain. This allows precise control of the output voltage to match the battery's charging profile without dissipative regulation.

02. Dynamic Response & Stability

The dual-loop design (outer voltage, inner current) provides both steady-state accuracy and rapid transient response. It quickly rejects disturbances from DC bus voltage fluctuations or sudden load changes.

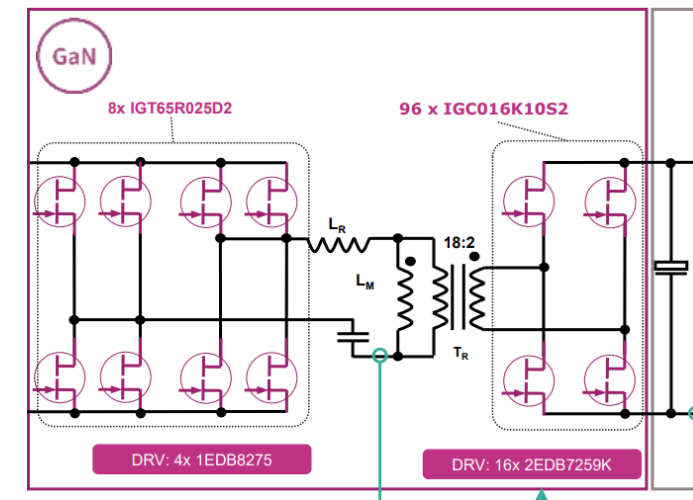
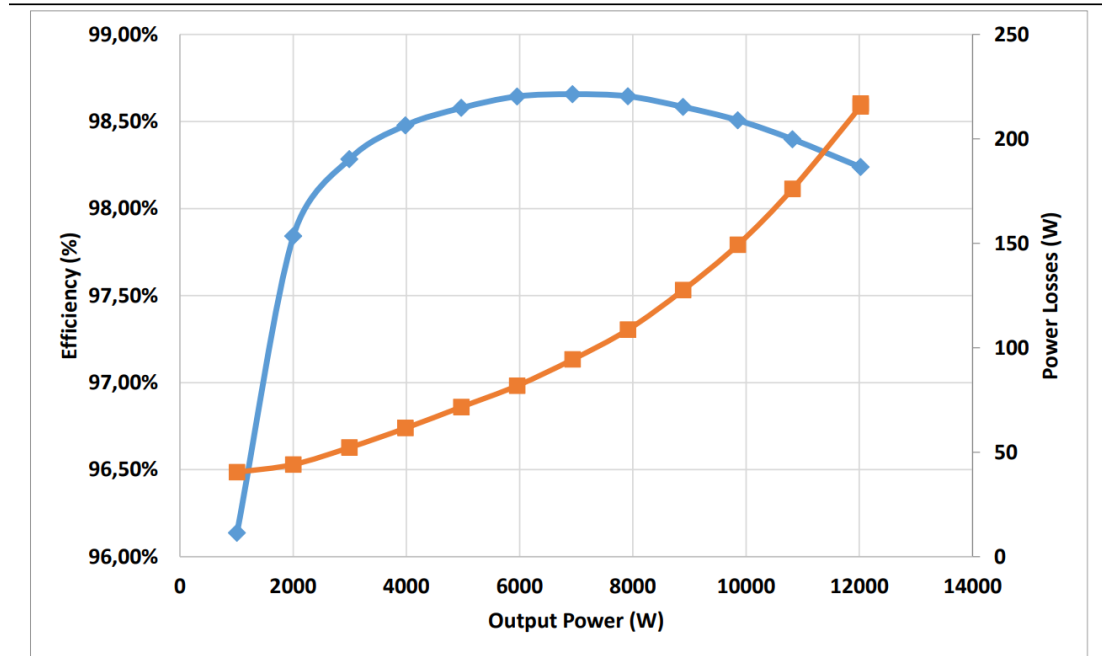
03. Synergy with Wide Bandgap

Combining this strategy with SiC/GaN devices achieves >98% peak efficiency, critical for reducing thermal management complexity and maximizing energy transfer efficiency.

LLC Experimental Validation

Infinion Full GaN Bidirectional LLC Reference Design

High-Efficiency Power Conversion



Performance Highlights

1. Efficiency: Peaks at 98.65% (50% load).
2. High Eff. Range: >98.2% (25-100% load).
3. Full GaN: GaN on both sides for optimal performance.

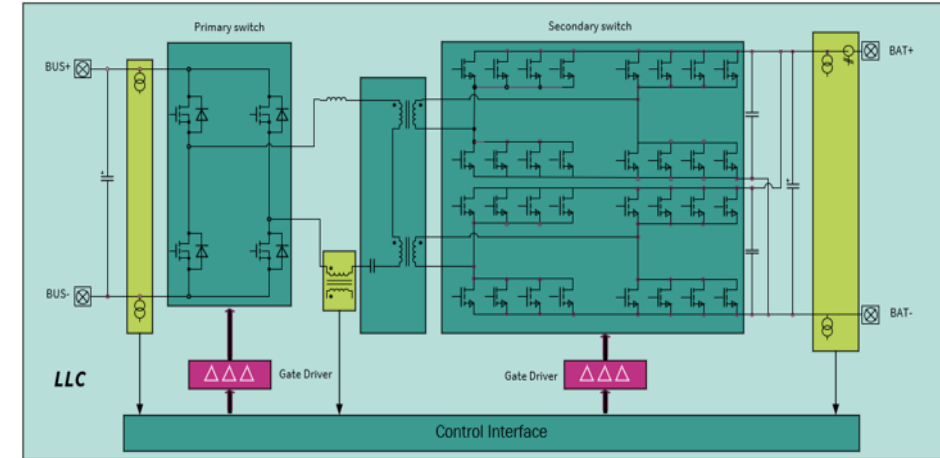
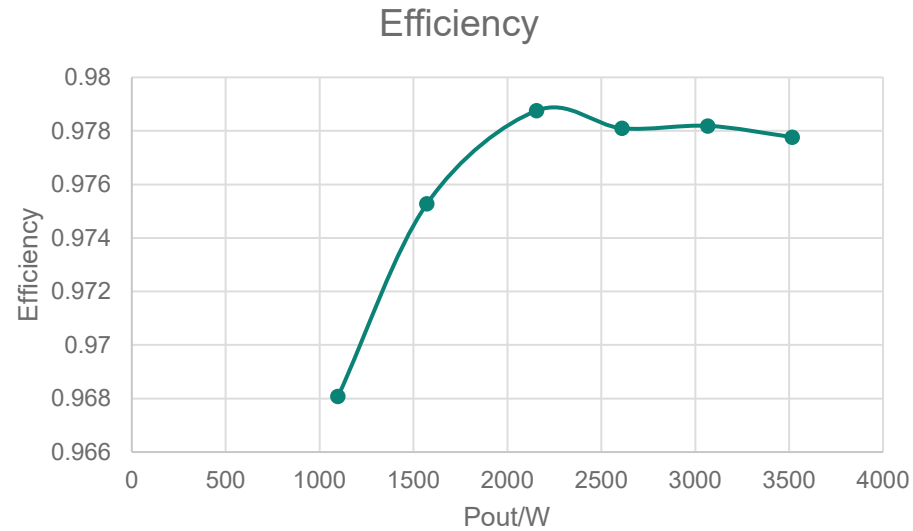
Key Components

1. Primary: 650V HEMT (IGT65R025D2) + 1EDB8275F.
2. Secondary: 100V GaN (IGC016K10S2) + 2EDB9259Y.

Infiniteon MV GaN + HV SiC Bidirectional LLC Reference Design

High-Efficiency Power Conversion

pcim
ASIA SHENZHEN



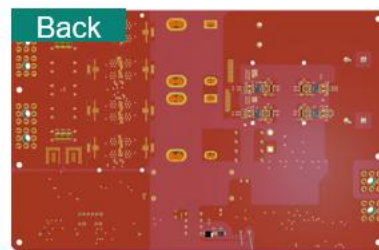
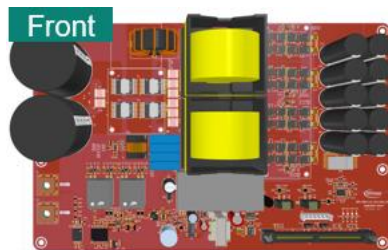
Performance Highlights

1. Efficiency: Peaks at 97.8%.
2. MV GaN + HV SiC on both sides for optimal performance.
3. Top Cooling



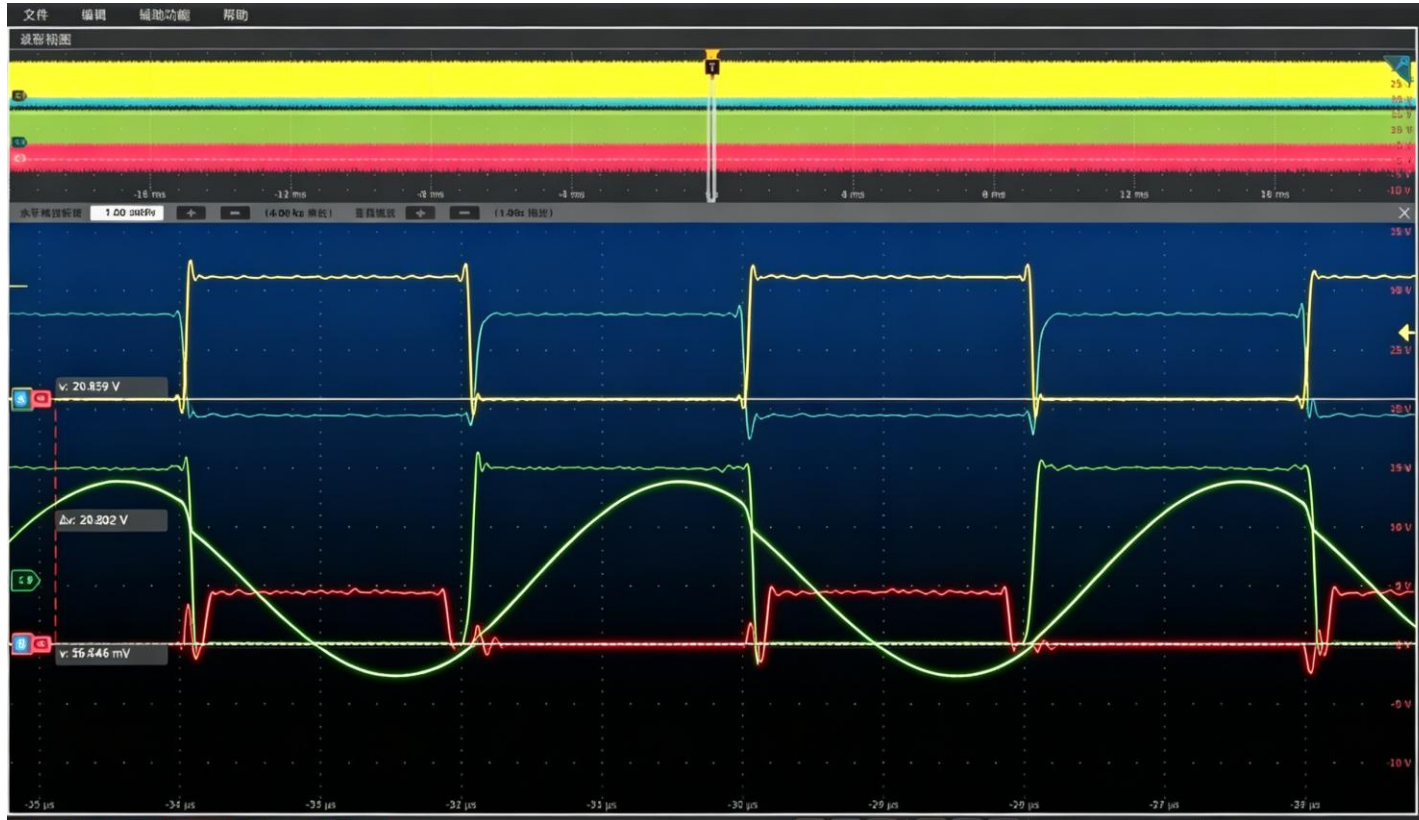
Key Components

1. Primary: 650V SiC (IMLT65R026M2H) + 1EDB9275F.
2. Secondary: 100V GaN (IGD01xK10S2) + 2EDL5014AA-U2D.



LLC Experimental Test Results

Soft-Switching Waveforms & Thermal Imaging Validation



- Measured waveforms validate ZVS soft switching of the LLC converter.
- Primary switch drain voltage resonates to zero in advance of gate signal assertion.
- Resonant current supplies energy for junction capacitor commutation.
- Zero-voltage turn-on minimizes switching loss and maximizes GaN efficiency.

Conclusion & Summary

Conclusions

Key Technical Innovations

- **Topology Breakthrough:** Single-stage LLC resonant converter simplifies architecture, reduces component count, and delivers inherently higher efficiency than traditional two-stage solutions for ESS.
- **WBG Leadership:** Infineon CoolGaN™ & SiC devices enable ultra-high switching frequencies, unlocking unprecedented power

Core Value Proposition

- **Extreme Density:** Maximizes WBG potential to achieve industry-leading power density, shrinking system footprint for compact ESS installations.
- **Optimized Power Stage:** IPOS (Input-Parallel Output-Series) design tailored for low-voltage, high-current battery systems, ensuring robust thermal performance.
- **Peak Efficiency:** Maintains >98.5% efficiency even at elevated frequencies, with soft-switching eliminating hard-switching losses.

Strategic Business Objectives

- Establish a new global benchmark for high-efficiency, high-power-density Bi-DC/DC converters in residential and commercial ESS markets.
- Accelerate WBG market adoption with a scalable, platform-based architecture that reduces customer development cycles and costs.

Validation & Future Outlook

- **Lab-Proven Results:** Infineon reference designs (Full GaN & GaN+SiC hybrid) confirm peak efficiencies >98.5%, with soft-switching fully validated.
- **Future-Proof Platform:** Scalable architecture addresses growing renewable energy integration needs, supporting the transition to smarter, more sustainable grids.
- **Cost Efficiency:** Higher power density and fewer components lead to lower BOM costs and improved system-level return on investment (ROI).

Thank You!

Questions & Answers