



面向热泵应用的英飞凌功率半导体解决方案

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2023-8-18



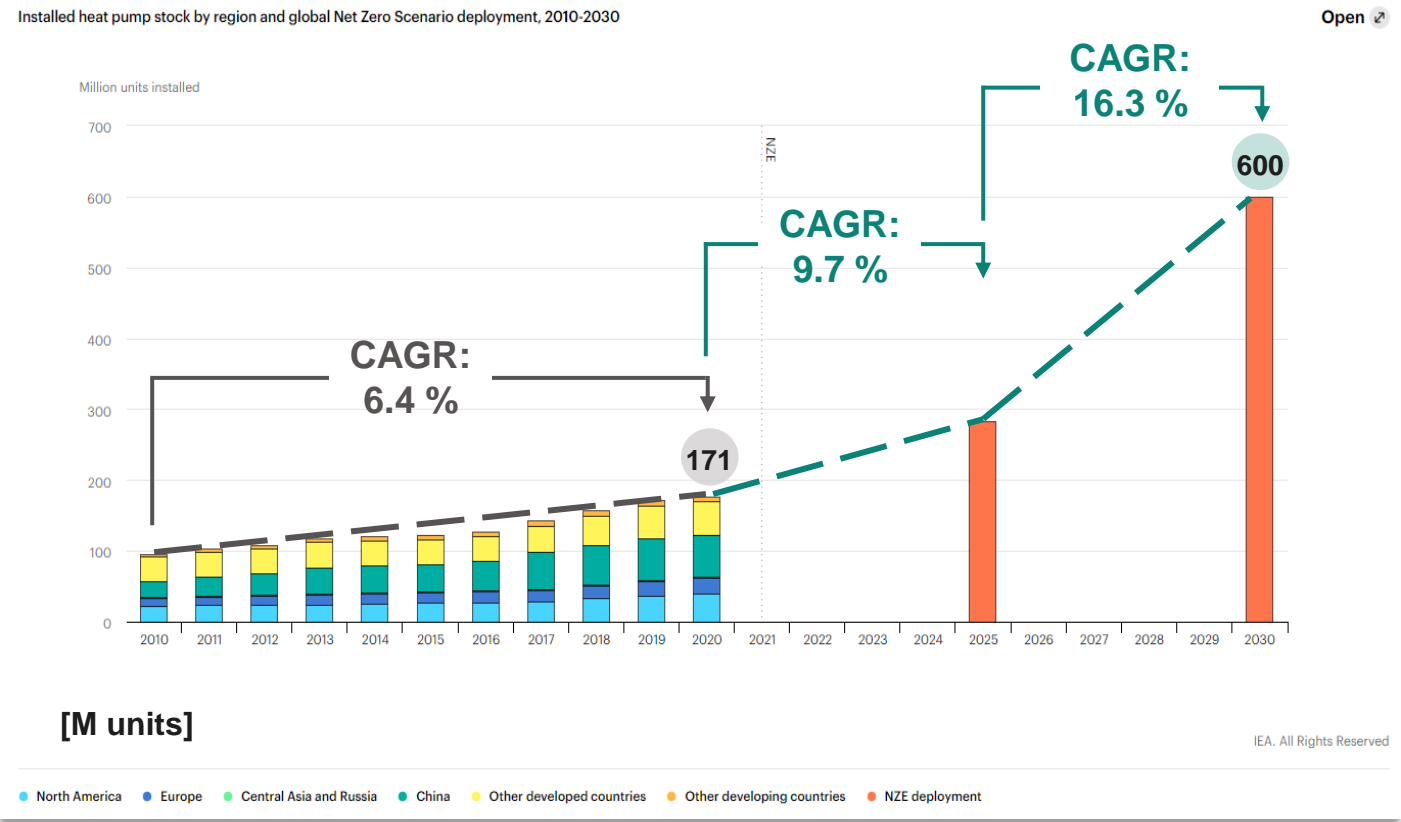
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Global focus: Booming heat pump market deployment scenario by 2030



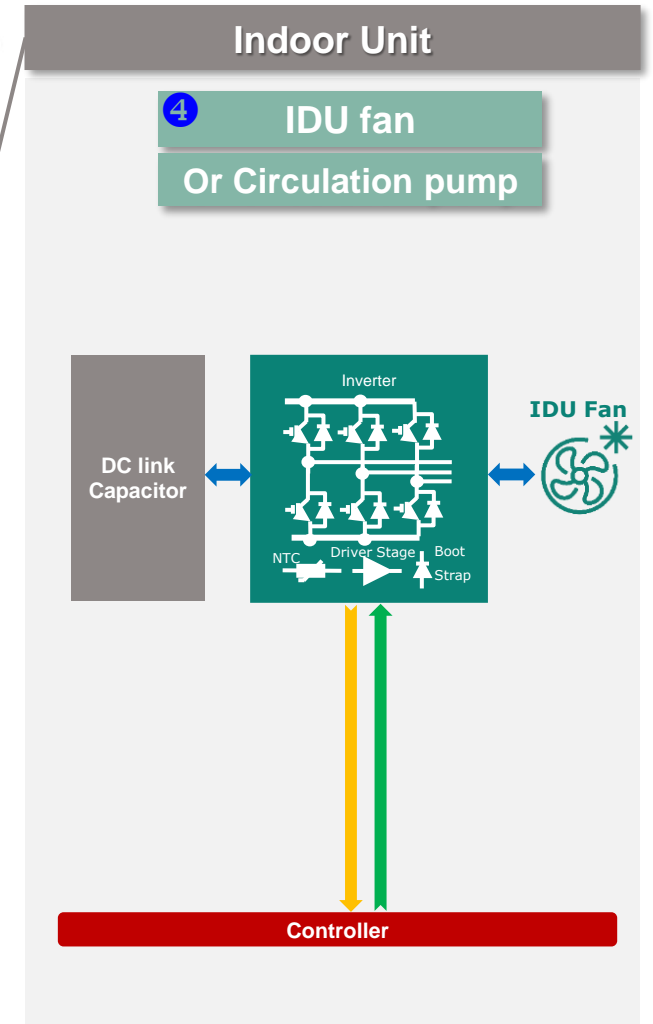
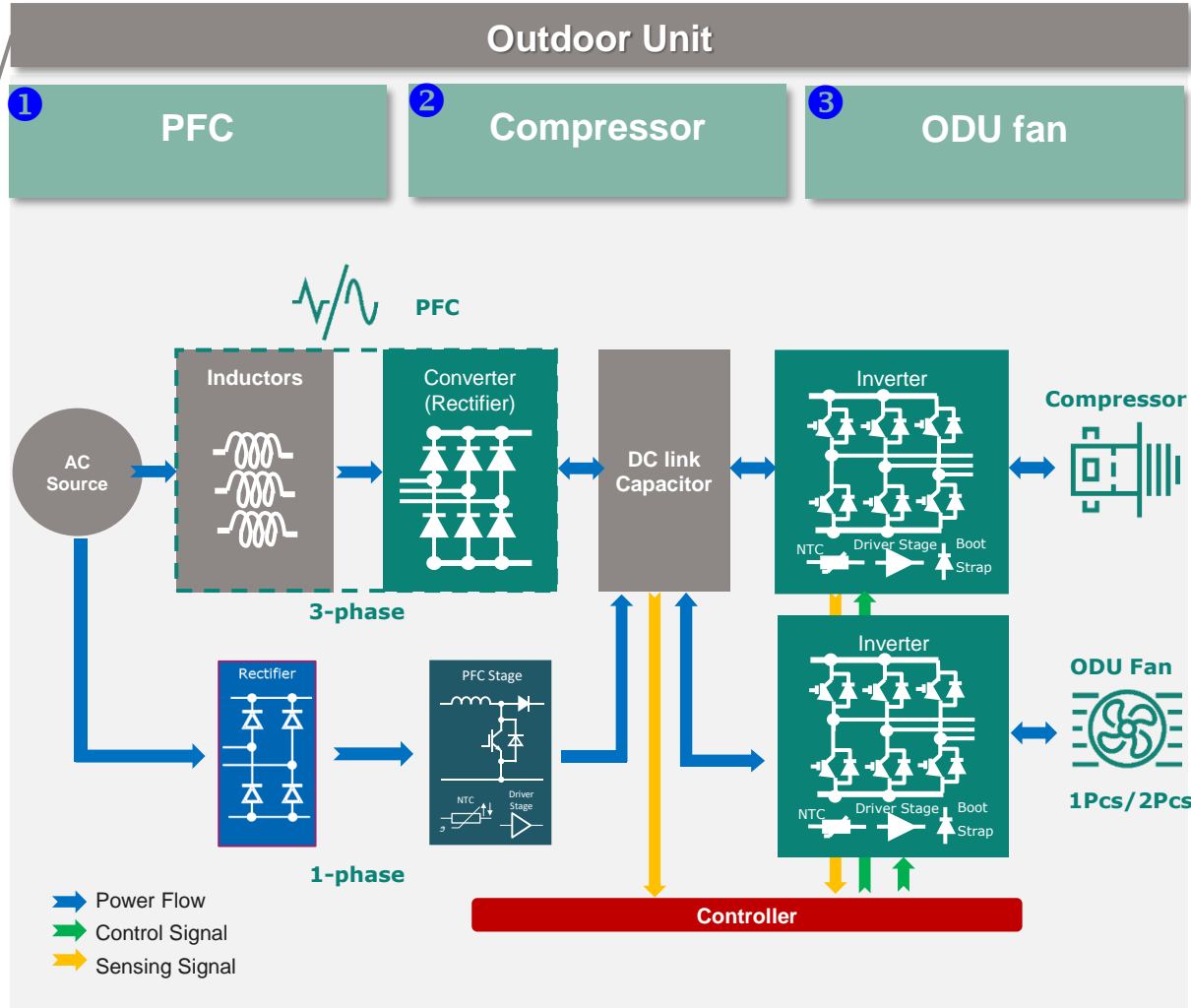
Source: IEA, 2021

> 450 M units
heat pump set will be needed

> 1,500 M pcs
Power devices will be needed

- PFC
- Compressor
- ODU fan
- IDU fan
- Circulation pump

Heat pump topologies power stage technical blockdiagram



Market segmentation of heat pump according heating power

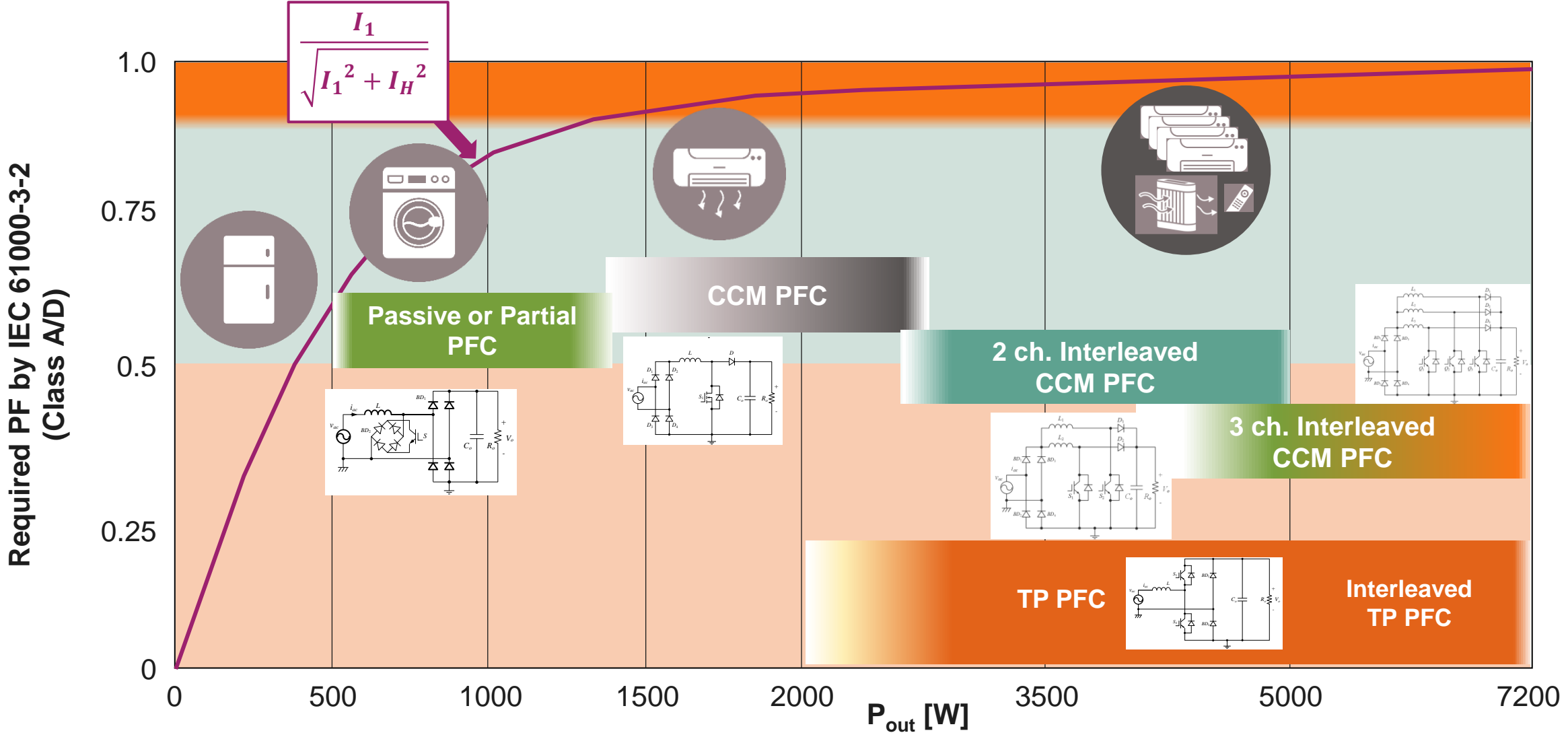
Application market segments					
Heating power		Overview electrical power requirement			
		Voltage supply	Compressor	Circu. pump	Fan
Residential to commercial	2 kW to 8 kW	230 V/ 1 PN/ 50 Hz	< 3 kW	< 60 W	< 125 W
	8 kW to 13 kW	230 V/ 1 PN/ 50 Hz	< 4 kW	< 180 W	< 230 W
		400 V/ 3 PN/ 50 Hz	< 5 kW		
	13 kW to 20 kW	400V/ 3 PN/ 50 Hz	< 8 kW	< 300 W	< 290 W
Commercial	> 20 kW	400 V/ 3 PN/ 50 Hz	> 8 kW	> 500 W	> 580 W



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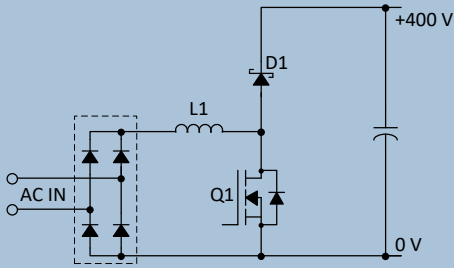
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Single phase input PFC Topology positioning



Topologies for 1-phase PFC

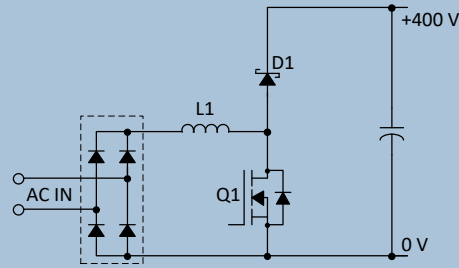
Classic PFC



- Less System Cost
- Less Efficiency

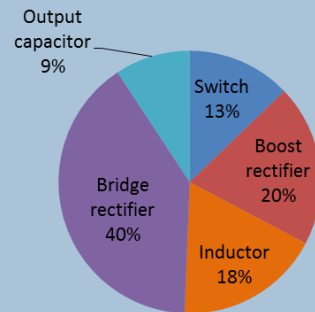
- IGBT (Q1)
- Si Diode (D1)

Classic PFC(SiC)



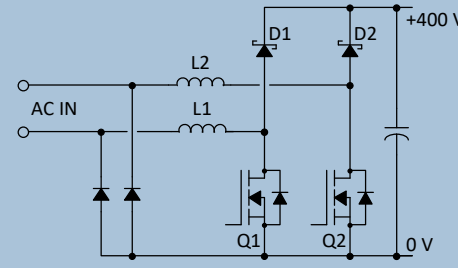
- Less System Cost
- Less Efficiency
- High Power Density

Classic PFC 3kW 65kHz 230Vac 75% load
Total Ploss = 43.9W



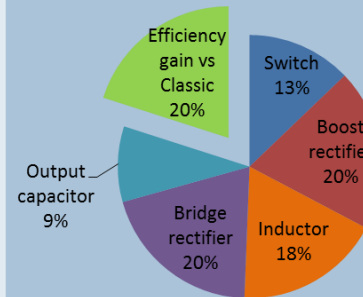
- CoolMOS™ / IGBT (Q1)
- SiC (D1)

Dual Boost PFC



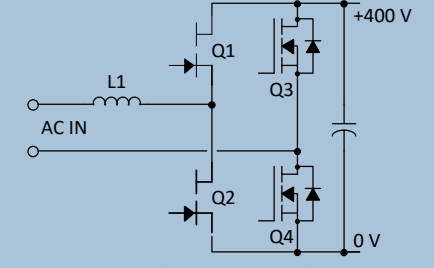
- High System Cost
- High Efficiency
- Less Power Density

DualBoost PFC 3kW 65kHz 230Vac 75% load
Total Ploss = 35.1W



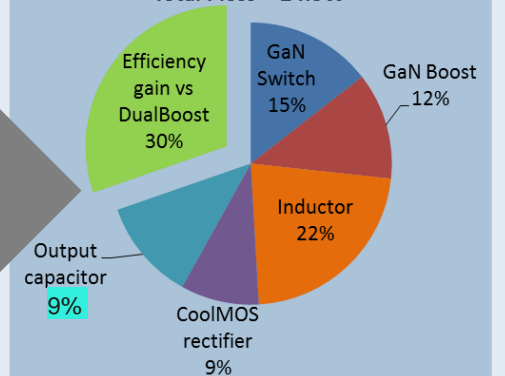
- CoolMOS™/IGBT(Q1, Q2)
- SiC (D1, D2)

Totem Pole PFC



- Less System Cost
- Highest Efficiency
- Best Cost of Ownership

Totem Pole PFC 3kW 65kHz 230Vac 75% load
Total Ploss = 24.5W



- GaN (Q1, Q2)
- CoolMOS™ (Q3, Q4)

GaN enables hard commutation on internal "diode"

Product positioning for PFC Application (650V)

If low system cost is required

Performance
650 V WR5 TO-247-3
 30-50 A



Price Performance
650 V WR6 TO-247-HCC
 20-70 A



Supersede WR5 product family

If SC capability is required

Premium Performance
650 V ET7 TO-247-3
 20-75 A



Supersede Highspeed3 product family

Best fit diode family is Rapid1 up to 80 A

If Advanced Isolation is required

Performance
650 V H5 TO-247-3-AI
 40-75 A



600 V Highspeed3
 TO-247-3-AI
 40-90 A



Rapid1 diode 40/60/80A

If Co-packed diode utilization is required For Bridgeless PFC topology

Premium Performance
650 V ET7 TO-247-3
 20-75 A



Price Performance
650 V EH5 TO-247-3/4
 15-75 A

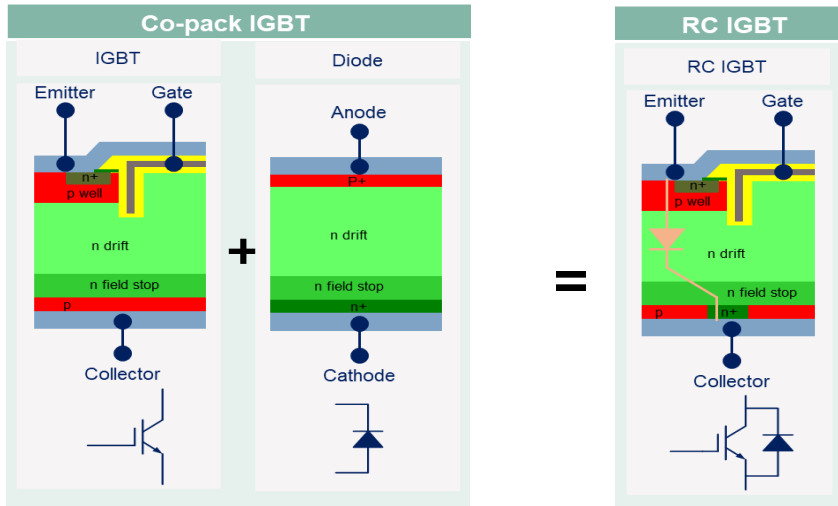


Performance
650 V RH5 TO-247-3/4
 40-75 A



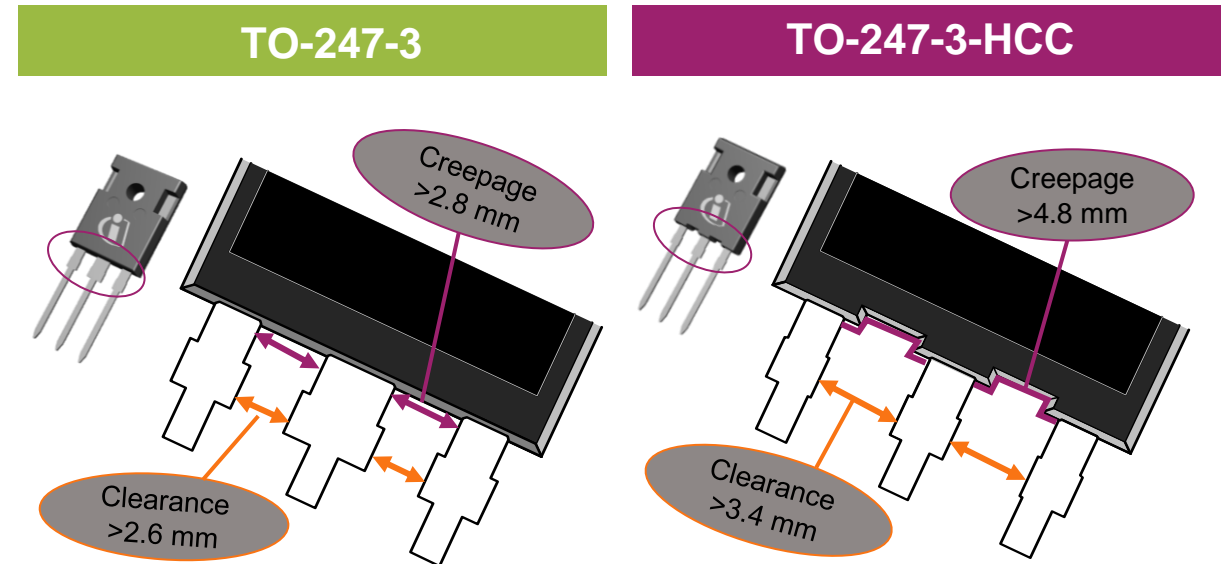
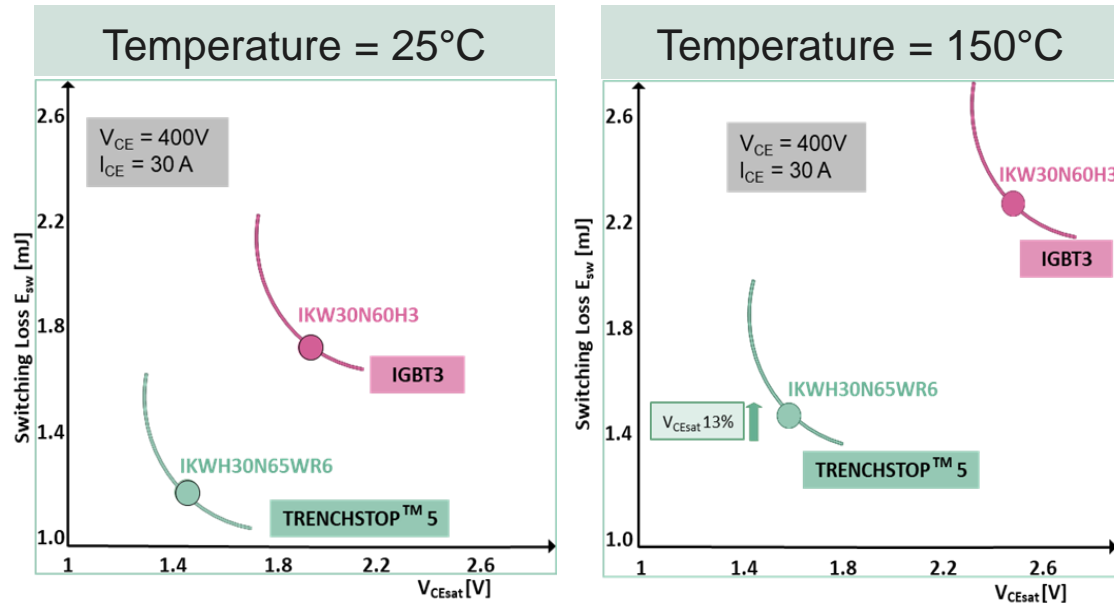
TRENCHSTOP™ 5 WR6

Reverse conducting IGBT technology

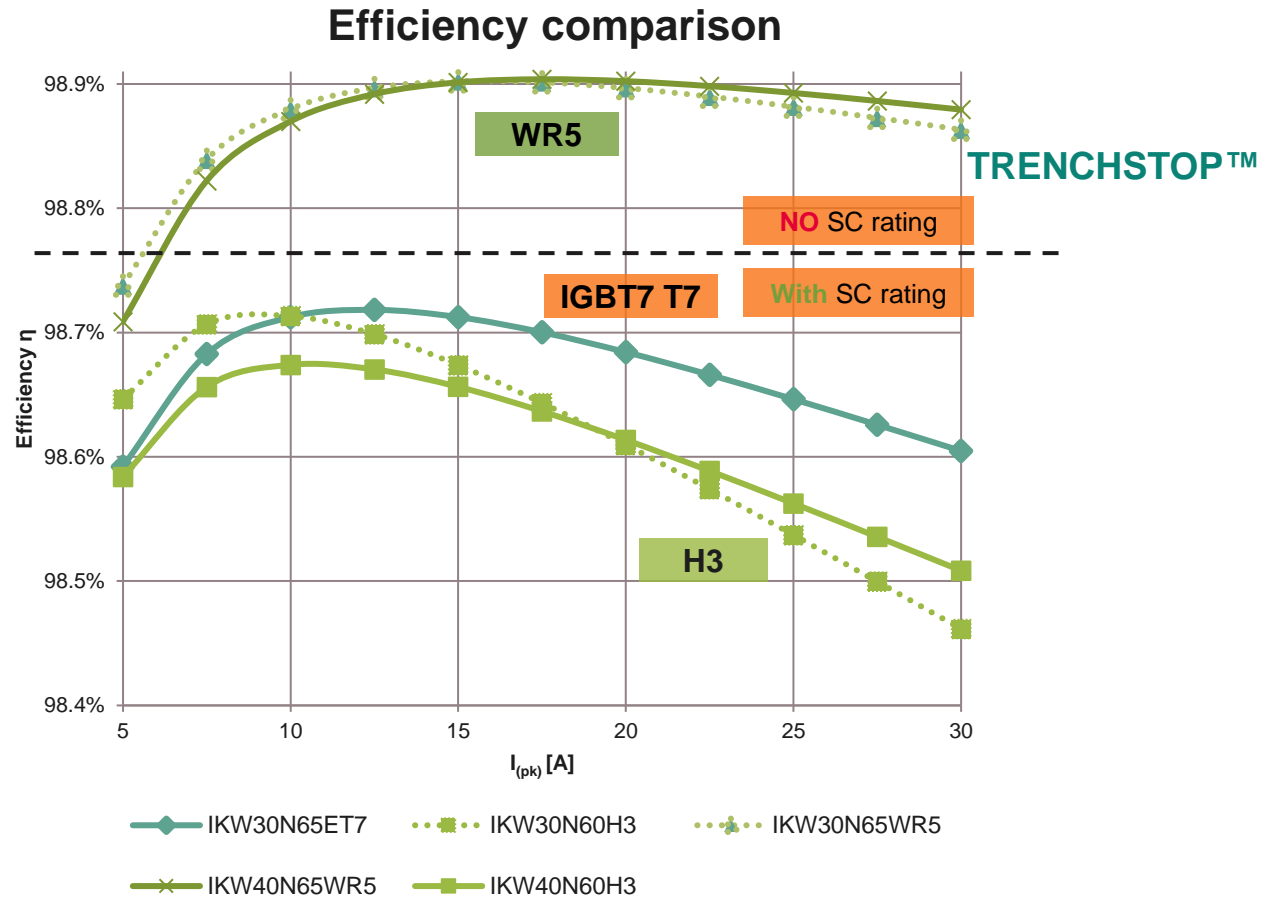
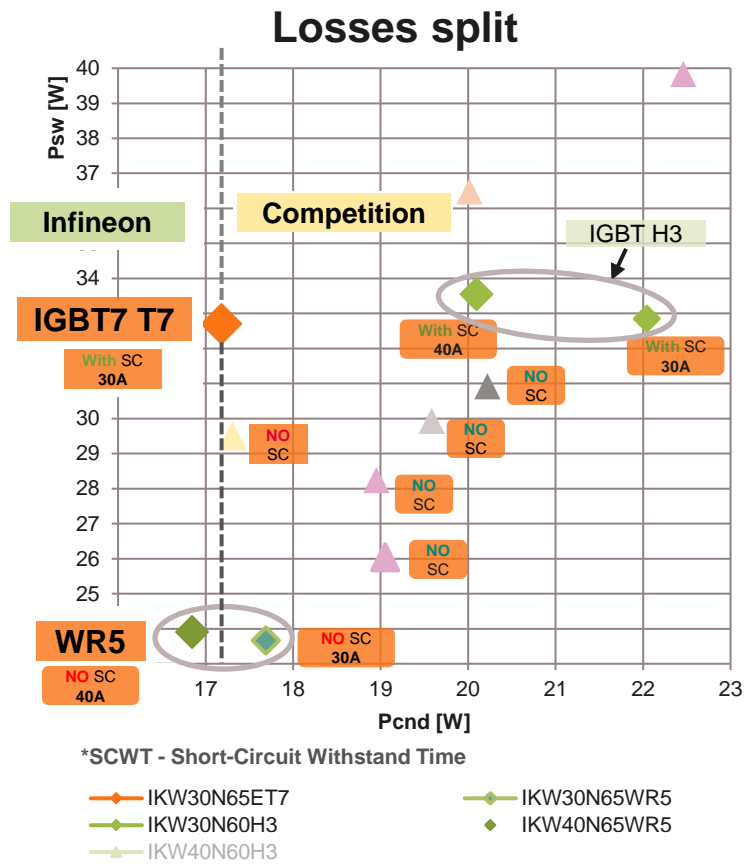


Features

- › Monolithic diode optimized for PFC and welding applications
- › Very low V_{CEsat} : 1.45 V @ I_{nom}
- › low E_{sw} : allowing fsw upto 75 kHz
- › Stable temperature behavior → Low temperature dependence of V_{CEsat}
- › Improved system reliability against package contamination



650 V TRENCHSTOP™ IGBT7 T7 in PFC topology

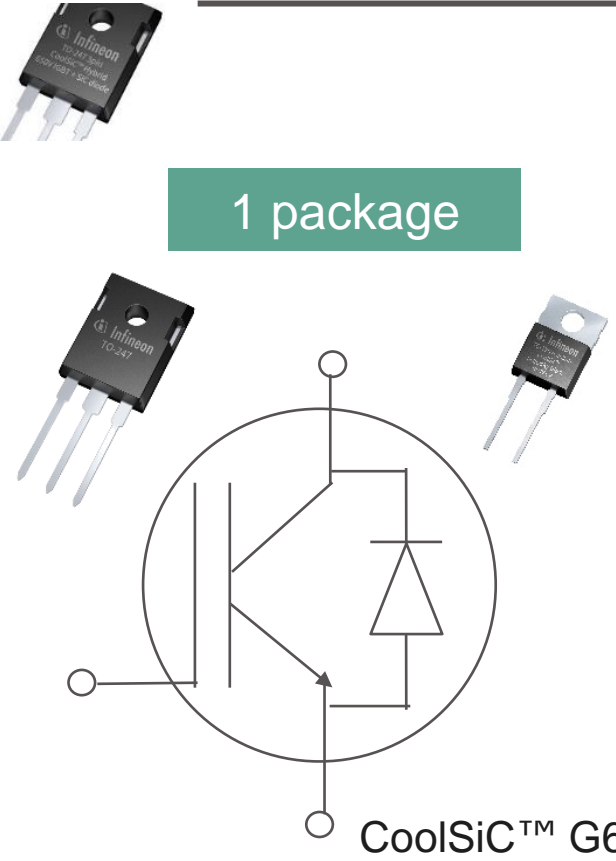


Infineon offer the best-in-class devices for PFC application, with or without SCWT

The PFC test conditions and simulation validation, for details and complete of application tests look appendix
 $I_{in(pk)}=16$ Arms, $V_{in}=180$ Vrms, $V_{out}=400$ V, $V_{in}=180$ Vrms, $F_{pwm}=30$ kHz, $P_i=3$ kW, $T_j=100^\circ\text{C}$, $R_{g(on/off)}=22/10$ ohm

Infineon's Hybrid Discrete

Optimize cost-performance in a hard commutation system!

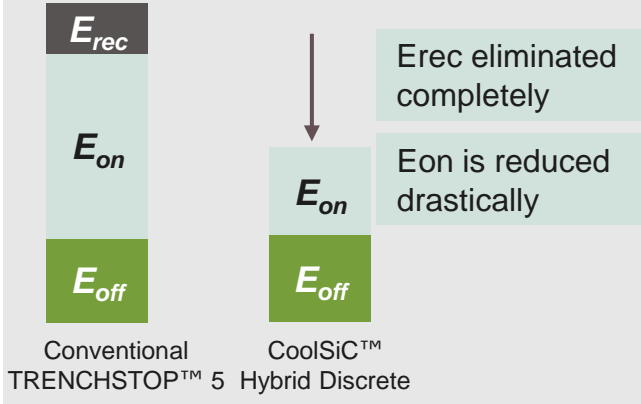
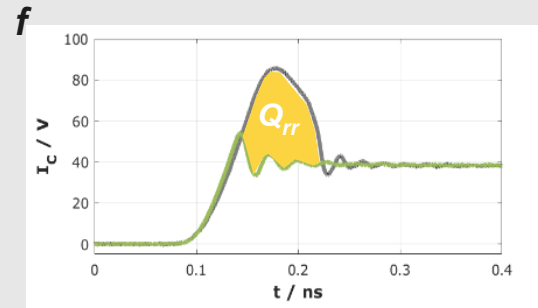


Up to -50%
(depending on the gate resistors)

TRENCHSTOP™ 5

Loss savings with CoolSiC™

diodes = losses caused by reverse recovery = $\frac{1}{2} \cdot Q_{rr} \cdot V_{bus}$

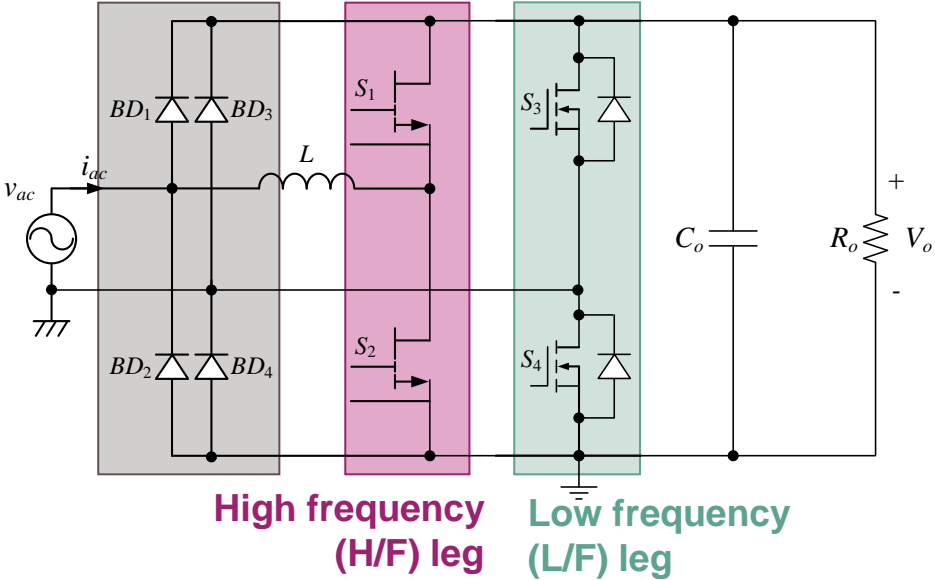


Rule of Thumb

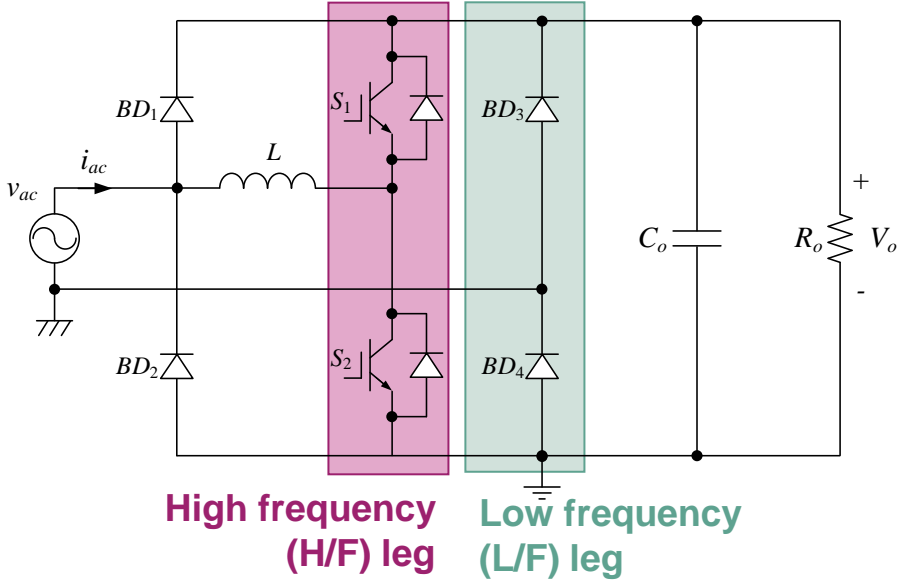
- › Switching losses reduced by up to 50%
→ 50%-100% higher f_{sw}
- › 0.1%/10 kHz efficiency improvement

Bridgeless Totem-pole PFC with IGBT solution

Typical TP PFC



TP PFC with IGBT solution



Advantages

- › High efficiency up to **99%**
- › Good EMI performance
- › Single inductor

Drawbacks

- › Too high BOM cost
 - Requiring **WBG device & Low R_{DSon} CoolMOS**
 - B/D is still needed to bypass inrush current

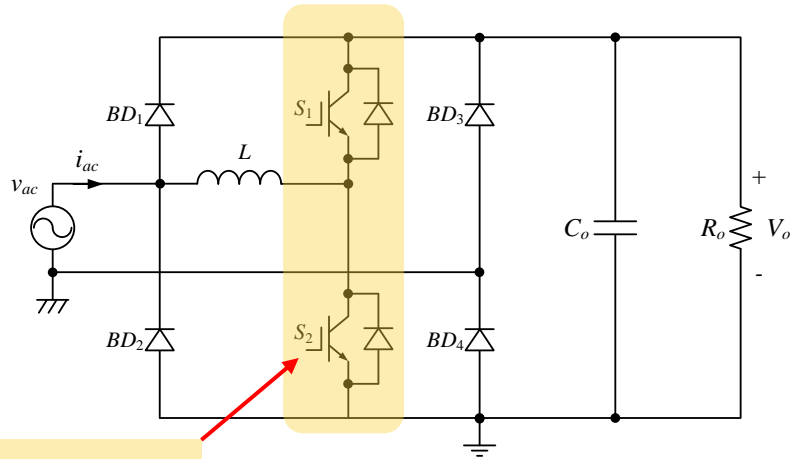
Simple & cost effective

- › High freq. leg: WBG → IGBT
(Hybrid discrete or full rated EH5)
- › Low freq. leg: CoolMOS → Bridge rectifier

Maintaining advantages of typical TP PFC

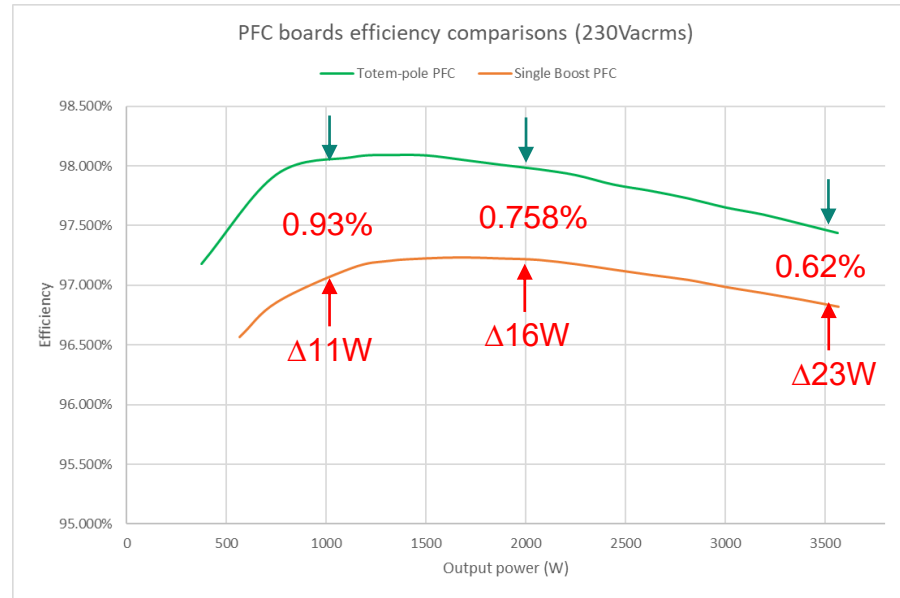
- › Higher efficiency than conventional boost PFC
- › Good EMI performance
- › Requiring single inductor

Test results of 3HP totem-pole PFC solution RAC with hybrid IGBT

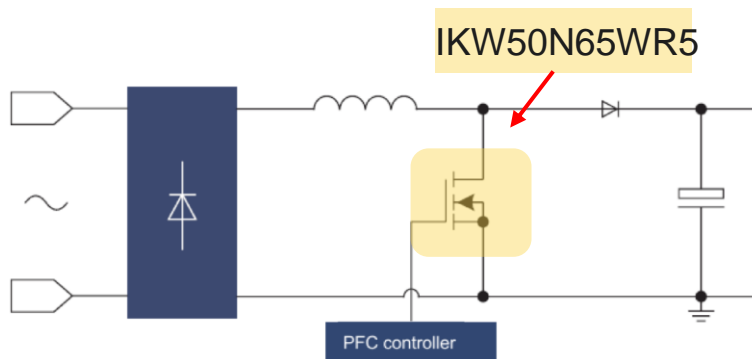
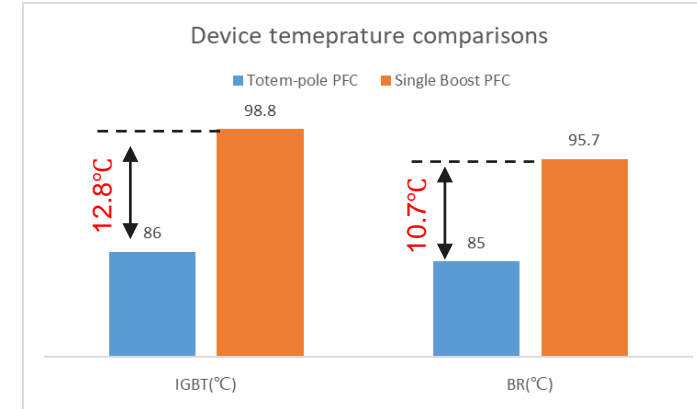


IKW50N65RH5

Hybrid IGBT in totem-pole PFC



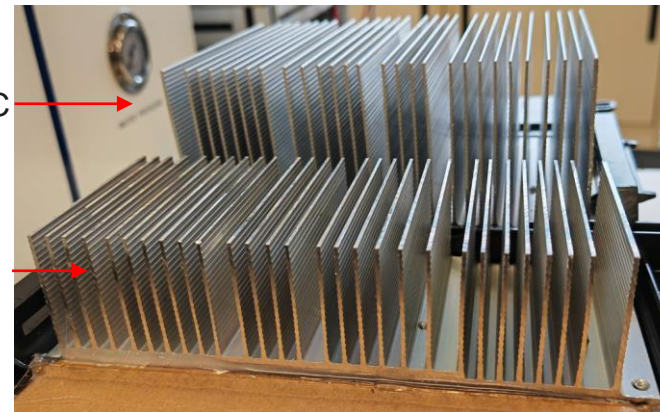
Efficiency comparison (Fs=60kHz)



Traditional single boost PFC

For single boost PFC

For totem-pole PFC



Heatsink size

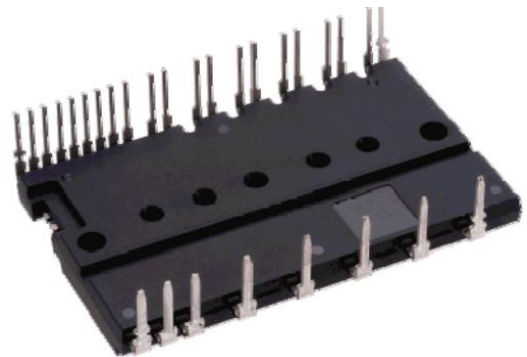
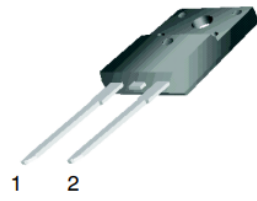
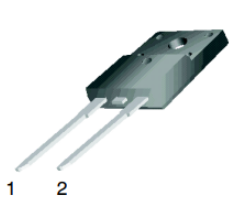
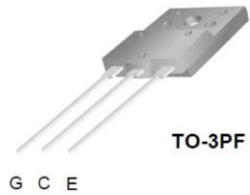
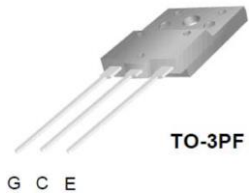
- › Old : 154 x 101 x 71
- › New: 154 x 62 x 46

Size drops **60.2%**

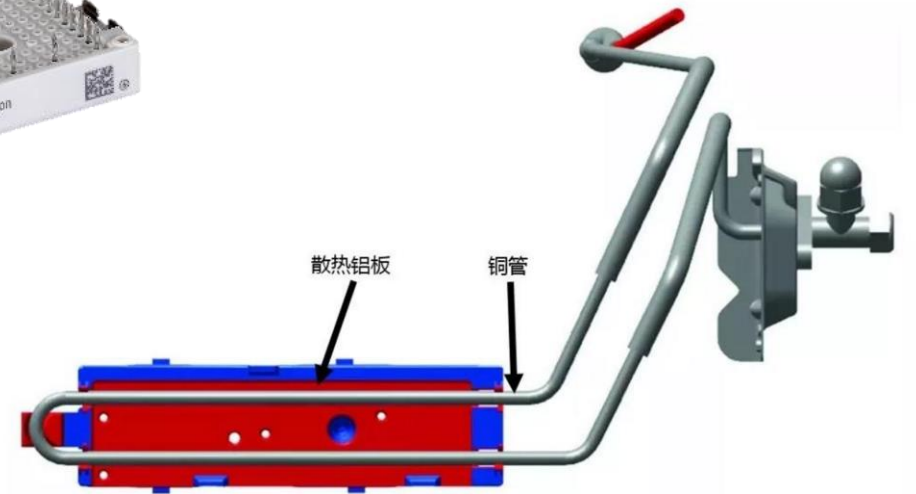
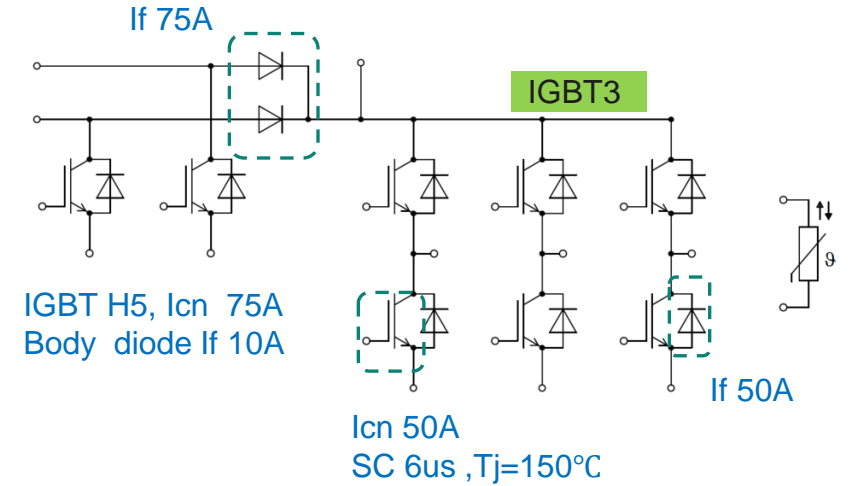
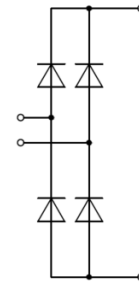
Weight drops **50%**



FB50R07W2E3_C36 Easy2B module → smaller heat think size, high level integration



V_{rrm}=1200V C36
I_f 50A



Power loss and junction temperature comparisons

Fixed heatsink, Th=90C 70kHz, L=36uH 60kHz, L=50uH	Power loss				Junction Tj	
	BR loss (W)	PFC IGBT loss (W)	FRD loss (W)	INV loss (W)	Tjmax-Boost IGBT(°C)	Tjmax-INV IGBT(°C)
Rg=8R, Fs=70khz,Pout=8KW	77.82	72.4	52.1	85.92	141.53	103.3
Rg=12R, Fs=70khz,Pout=8KW	77.82	74.17	52.1	85.92	142.82	103.3
Rg=12R, Fs=60khz,Pout=8KW	77.14	66.44	54.39	85.92	136.8	103.3
Rg=12R, Fs=60khz,Pout=7KW	66.2	57.03	43.81	85.92	130.12	103.3

Summary:

- 1.Total power loss of module is up to 290 Watts for case 2, and the maximum junction temperature is higher than 142.82°C ;
- 2.If PFC switching frequency could down to 60khz and output power is also down to 7kw, it is possible to use this module to take over this request.
3. Though these are simulation results, they are also helpful to evaluate system design.

CIPOS™ Micro IPM product family for fan

Product overview

DIP 29x12 (F)
SOP 29x12 (F)



Dimension [mm]	29x12x2.9
Configuration	3-phase
Voltage rating	600 V
Package type	SOP, DIP
MOSFET Rds(on) max	IGBT (2/4/6 A)

Typical applications

- › Split air conditioning systems:
- › Indoor & outdoor fan drive
- › Circulation pumps
- › Ceiling & floor fans
- › Air purifiers
- › Small compressors
- › 10-200 W motor drives



Key features

- › Wide range of product coverage with various switch technologies
- › Various application optimized options available
- › Pin-comparable solution to one of the main solution in the market

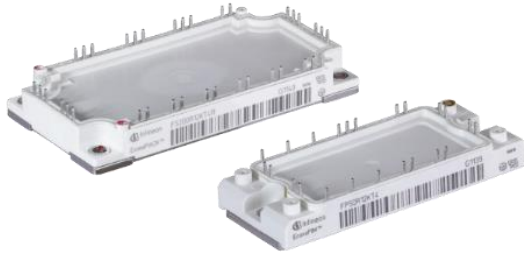
Value proposition

- › Reduce system costs and fast time to market
- › Provide wide switching speed range
- › High power density and high efficiency and high output power in one small package
- › Offer very low loss by using the advanced MOSFET technology

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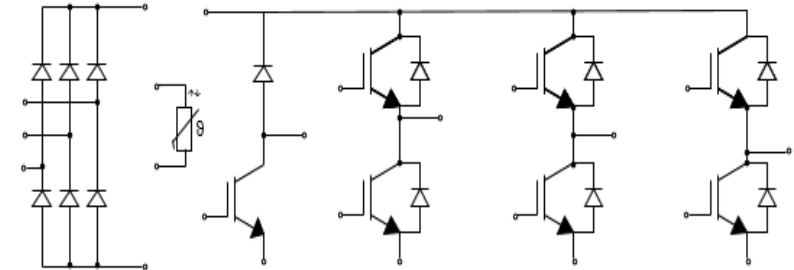
Econo2 & Econo3 modules for passive PFC



Key features

- › Established RoHS-compliant housing concept for high volume production
- › Modules with base plate for increased robustness in standard solder pins or high reliability PressFIT pins
- › Available with state-of-the-art IGBT7 technology
- › Numerous topologies, voltages (600V-1700V) and currents (15A-200A) for broad range of applications
- › Integrated configurations includes NTC, shunt, pre-applied Thermal Interface Material (TIM), Advance H2S protection

Exemplary schematic/topology:



PIM with NTC

Benefits

- › High reliability and quality
- › Cost-efficient
- › Fast, simplified, low-cost mounting
- › Design flexibility and simple integration in power electronic applications
- › High power density

Passive PFC solution for heat pump (with DC reactor)

PIM (AC → DC → AC)

Si PIM

- > FP35R12KT4
- > FP35R12N2T7

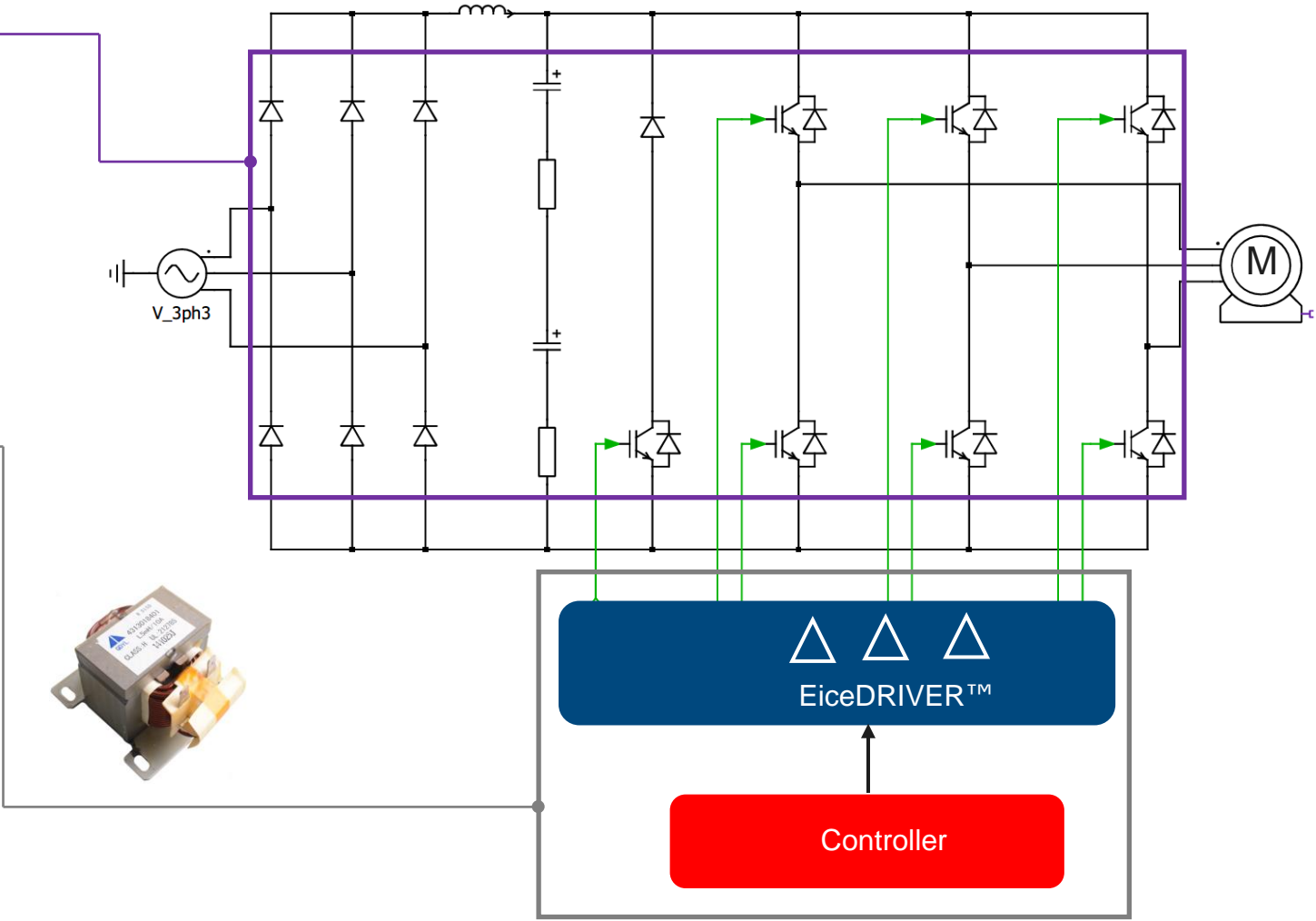
Driver and control unit

Gate driver

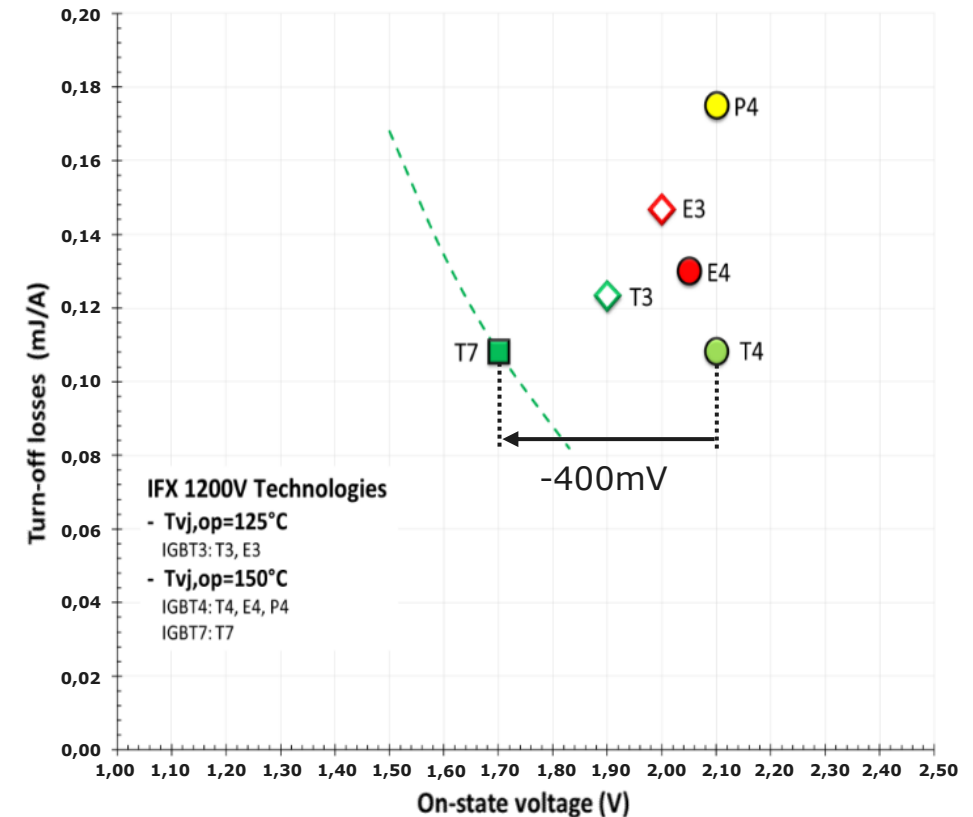
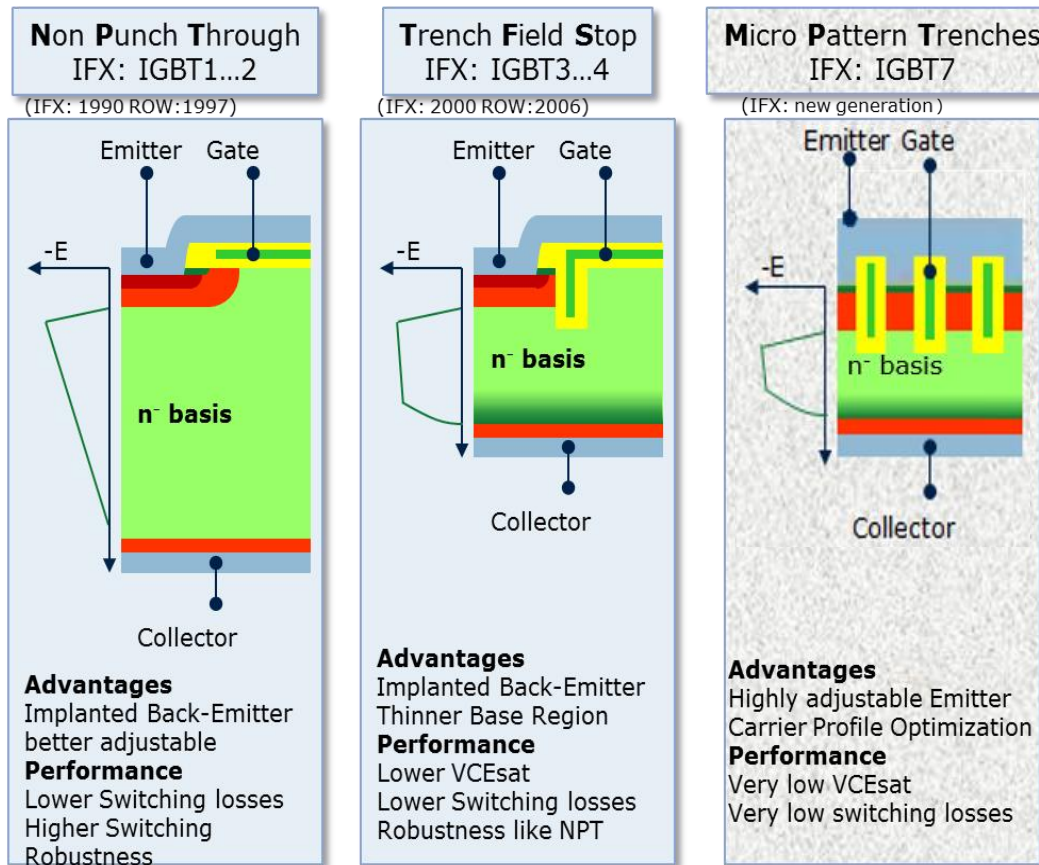
- > 1ED020I12-F2

μController

- > XMC4000 series



Chip technology and performance improvement



With MPT technology, IGBT7 $V_{CE(SAT)}$ is reduced by 20% compared to IGBT4, while keeping the turn off losses at same level.

Summary of IGBT7

T_{vjop}, increased up to **175°C for overload**, help to increase power density

Low losses, new chip technology bring extremely low losses, and is optimized for low V_{cesat}. While E_{sw} keeps same level at same dv/dt

dv/dt, is optimized for 2-8kV/μs, tailored for drive application

Robustness, IGBT7 is with robust edge termination. Rectifier is with surge current robustness

IGBT7

Compact, chip is smaller, higher power density can be achieved while keep same performance

Simple, is optimized for application condition, only with gate resistor to drive is enough

Short circuit, is tailored for better performance, 8μs @ 150°C is enough for drive application

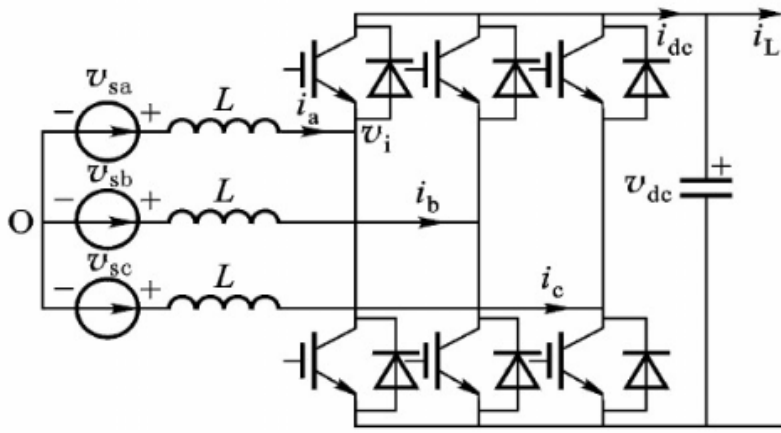
Portfolio of the TRENCHSTOP™ IGBT7 chip 1200 V

	Package	10 A	15 A	25 A	35 A	50 A	75 A	100 A	150 A	200 A	300 A	450 A	600 A	750 A	900 A
PIM	EasyPIM™ 1B	█	█	★											
	EasyPIM™ 2B			█	█	★				★	Frame Size Jump				
	EasyPIM™ 3B					█	█	█		★	Power Extension				
SixPACK	EasyPACK™ 1B			█	█	★									
	EasyPACK™ 2B					█	█	★							
	EasyPACK™ 3B							█	█	█					
PIM	EconoPIM™ 2			█	█	█	█	█							
	EconoPIM™ 3							█	█	★					
SixPACK	EconoPACK™ 2					█	█	█	█						
	EconoPACK™ 3								█	█					
Dual	EconoDual™ 3										█	█	█	★	★

PrimePACK currents up to 1600 A are feasible

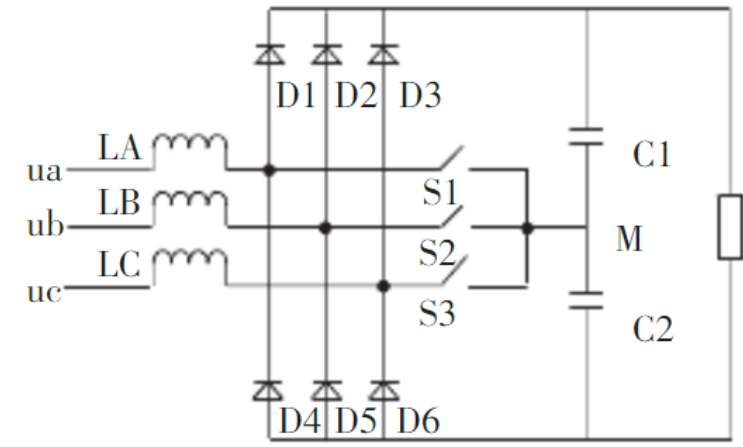
3-phase APFC topologies for heat pump

3-phase B6 PFC



- › 结构简单
- › 低THD, 高功率因数
- › 需要1200V的快速开关器件
- › 适用6kW - 30kW

3-phase Vienna PFC

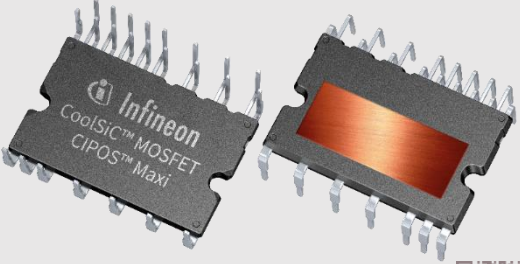


- › 三电平拓扑
- › 结构相对复杂, 器件较多
- › 工业上成熟拓扑
- › 适用6kW - 30kW

8kW rectifier with SiC IPM IM828-XCC

Products

DIP 36x23D package



Dimension [mm]	36 x 22.7 x 3.1 mm ³ with 24 pins
Configuration	3-phase inverter with open emitters
Voltage rating	1200 V
Rds(on)	55 mΩ (I _D =20 A, V _{in} =5 V, T _J < 25°C)
I _D DC drain current	20 A (T _C = 80°C, T _J < 150°C)

Rectifier specifications

- Input voltage: 310Vac – 415Vac
- Output voltage: 660Vdc- 675Vdc
- Output power: 8KW
- Switching frequency: 36kHz

Value proposition

- Offer very low loss by using the advanced CoolSiC™ MOSFET technology
- High power density and high efficiency
- High output power in one small package
- Provide wide switching speed range
- Minimize system size and reduce system costs
- Fast time to market

Application

- > Commercial air conditioners
 - Active filter (PFC)/compressor
- > Industrial motor drives
- > Pumps

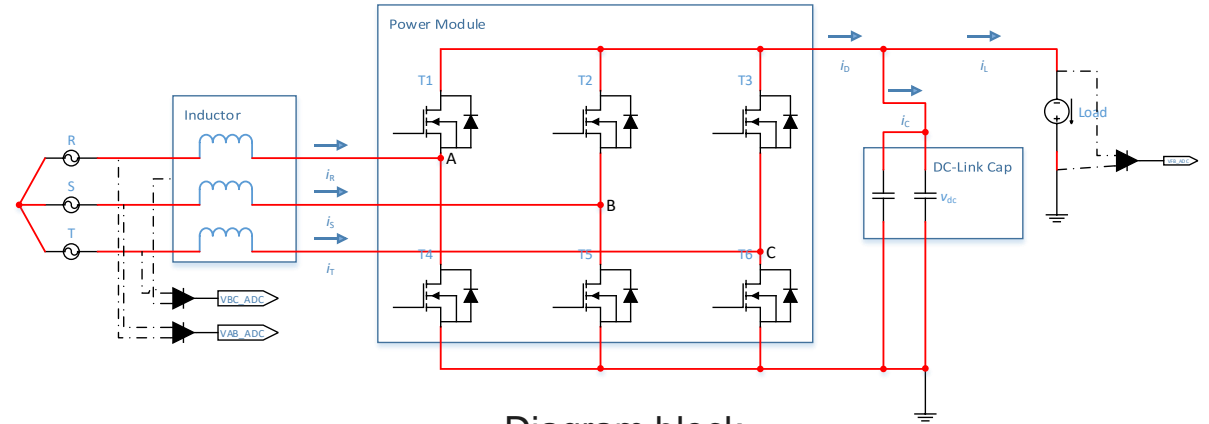
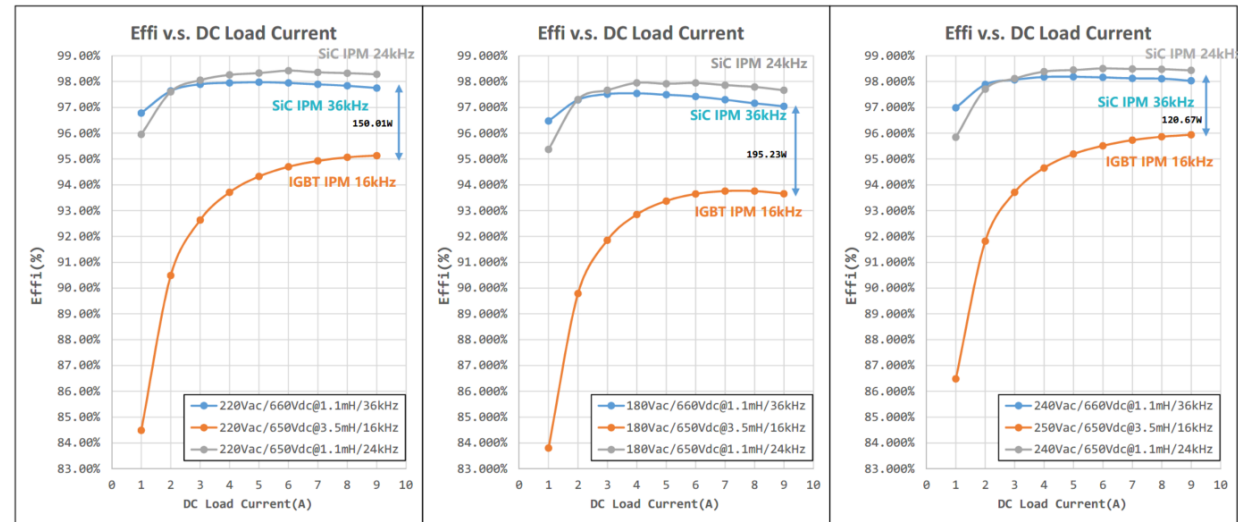
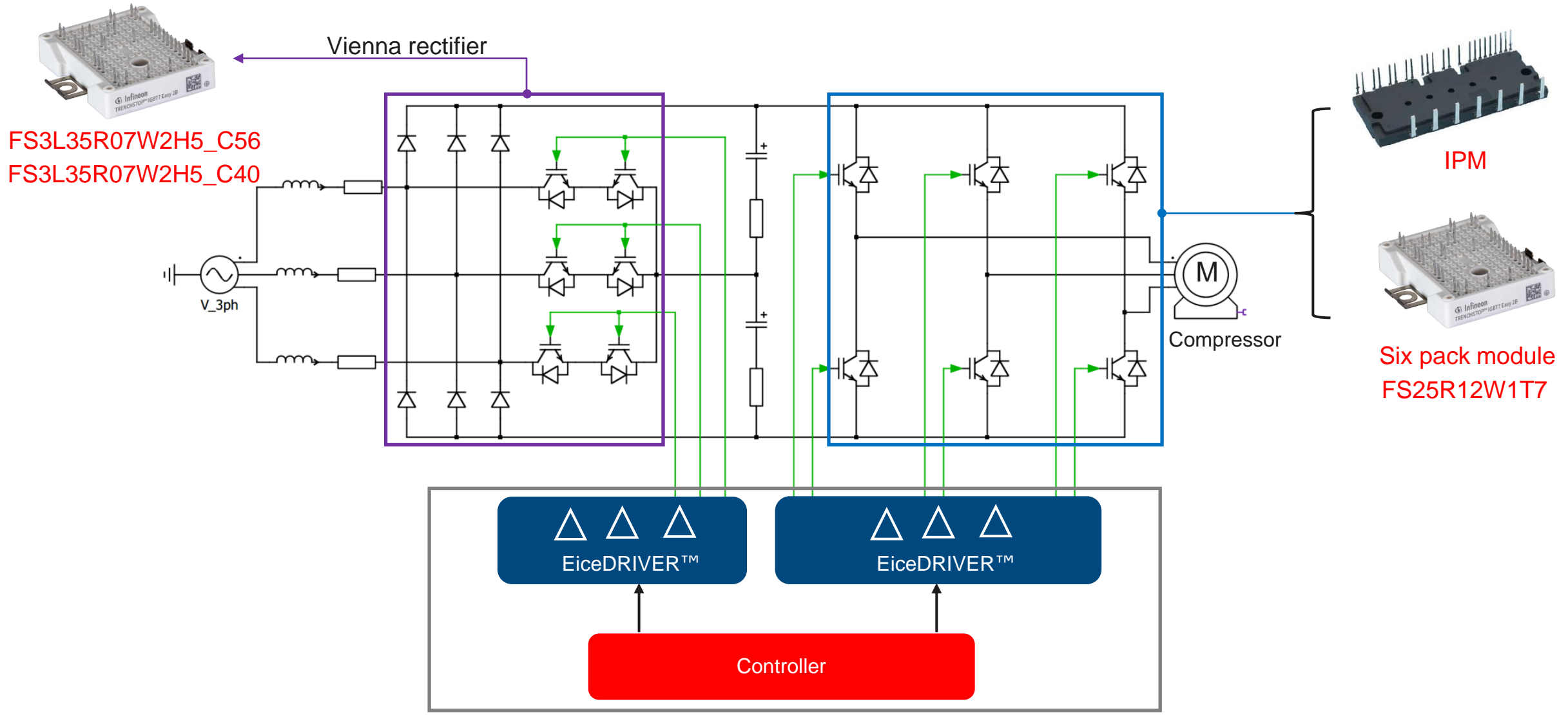


Diagram block



Efficiency comparison

Current heat pump solution with 3-phase Vienna APFC



1200V EC7 Rapid diode portfolio in TO247-2 pin

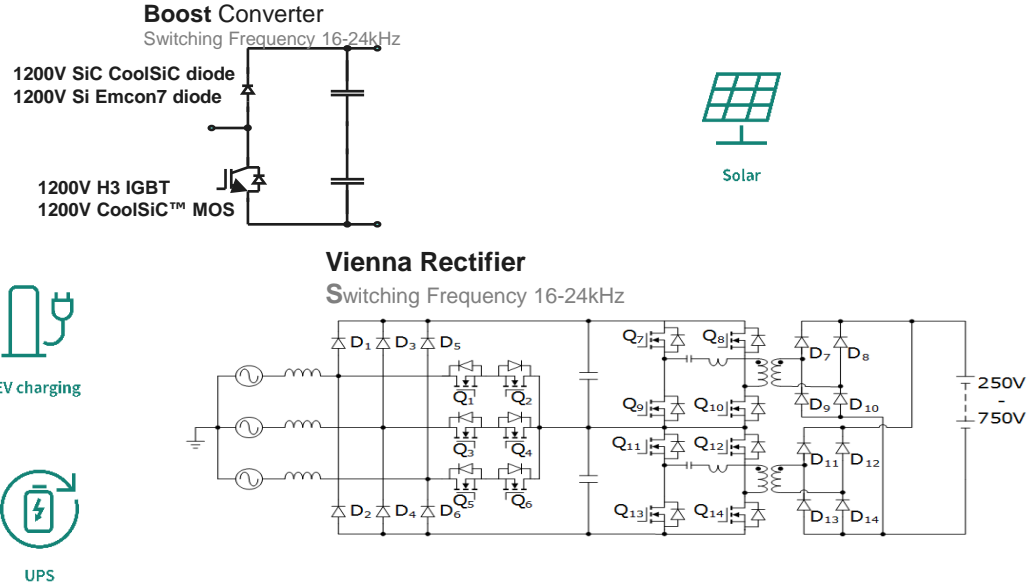
Key features

1	Complementary to 1200 CoolSiC™ portfolio: 1200V Rapid EC7 diode in TO-247-2pin
2	New generation, ultra fast diode
3	Low Vf, low Qrr 1200V diode
4	TO-247-2pin package compatible to competitors
5	Broad portfolio, up to 140A – as showed below

Portfolio

[If,Tc=100°C]	Product Name
30 A	IDWD30E120D7
40 A	IDWD40E120D7
50 A	IDWD50E120D7
60 A	IDWD60E120D7
75 A	IDWD75E120D7
100 A	IDWD100E120D7
120 A	IDWD120E120D7
140 A	IDWD140E120D7

Visualization



Release dates

- > **ES grade samples** available
- > **Preliminary datasheets** available Q3CY23
- > NPI launch date Q1 2024

3种3相PFC不同方案的对比

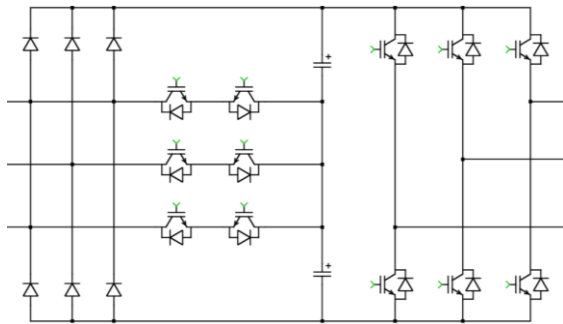
	Existing	1	2	3	4
	3ph Diode Bridge Solution	IGBT IPM Solution	IGBT Module Solution	SiC IPM Solution	Si Vienna Solution
功率器件	IFX: FP35R12N2T7	MIT : PSS50SA2FT	IFX: FS35R12W1T4	IFX: IM828-XCC SiC IPM	IFX:FS3L35R07W2 H5_C56
电感/电抗器	25mH/15A	3.8mH/15A	3mH/13A	0.6mH/13A	0.6mH/13A
输出直流滤波电容	1500uF	1500uF	1500uF	820uF	820uF
Control Method	Na	1xPWM Interruption	1xPWM Interruption	2xPWM Interruption	2xPWM Interruption
开关频率	Na	10kHz	16kHz	36kHz	30khz<Fs<40khz
输入电压范围	310~415Vac	310~415Vac	310~415Vac	310~415Vac	310~415Vac
输出电压 /功率	400-500Vdc/8kw	650-700Vdc/8kw	650-700Vdc/8kw	650~700Vdc/8kw	650~700Vdc/8kw
输出电流	12Arms	12Arms	12Arms	12Arms	12Arms
电感/电抗器图片					


EconoPIM™ 2 1200V with Vienna PFC and IGBT7 for Heat Pumps

Key Features

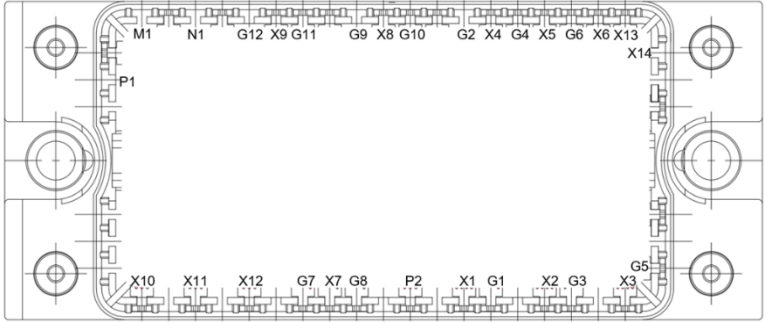
- Integrated module with Vienna PFC and compressor inverter for heat pump application
- Well established small Econo2 package with high volume production
- Equipped with in house state of the art IGBT7 technology
- All in one solution for ease of use and compact design
- Enabling designs to for fulfil limits for harmonic current emissions as specified by IEC 61000-3-2 for European market
- Active PFC reduces inductor size as compared to passive PFC solution

Full-Bridge Vienna Rectifier and Inverter



		1200V
Econo 2 	35A	<i>FP35R12N2T7_B57</i>
	50A	<i>FP50R12N2T7_B57</i>
	75A	<i>FP75R12N3T7_B57</i>

Lead type
Possibility extension up to Econo 3



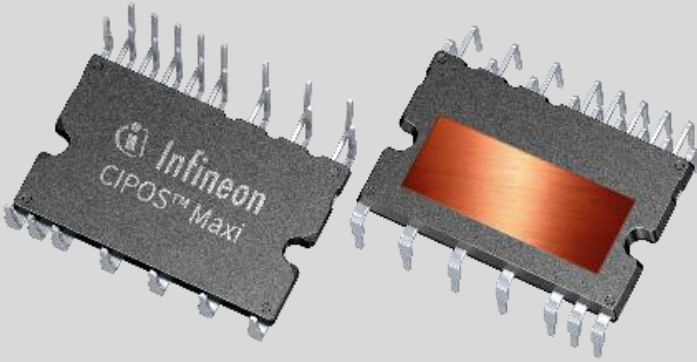
Pin out of FP35R12N2T7_B57



IM818-series at a glance: 1200V IPM for fan

Products

DIP 36x23D



Dimension [mm]	36 x 22.7 x 3.1 mm ³ with 24 pins
Configuration	3-phase inverter with open emitters
Voltage rating	1200 V
IGBT current Rating	5 A, 10 A, 15 A (T _C = 80 °C, T _J < 150 °C)

Key features

- > Fully isolated dual In-line molded module with **1200 V TRENCHSTOP™ IGBT**
- > **Power capability over 3 kW**
- > Rugged 1200 V SOI gate driver technology (6ED)
- > Integrated bootstrap functionality
- > Over current shutdown
- > Under-voltage lockout at all channels
- > Independent temperature thermistor
- > Low side pins accessible for all phase current monitoring

Application

- > Commercial air conditioners
 - Outdoor fan / active filter
- > Industrial motor drives
- > Pumps
- > Fans

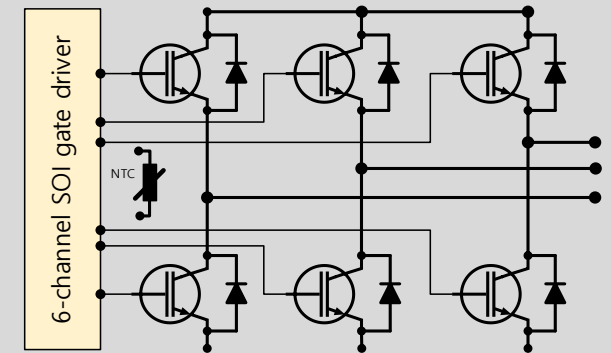


Product line

Part No.	Package	Current Rating	Voltage Rating	Ver.
IM818-SCC	DIP 36x23D	5 A	1200 V	IGBT 4
IM818-MCC	DIP 36x23D	10 A	1200 V	IGBT 4
IM818-LCC	DIP 36x23D	15 A	1200 V	IGBT 4

Topology

Topology: 3-phase inverter

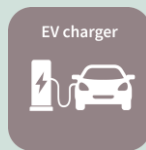


EiceDRIVER™ Enhanced F3 (1ED332xMx12N) – Product overview

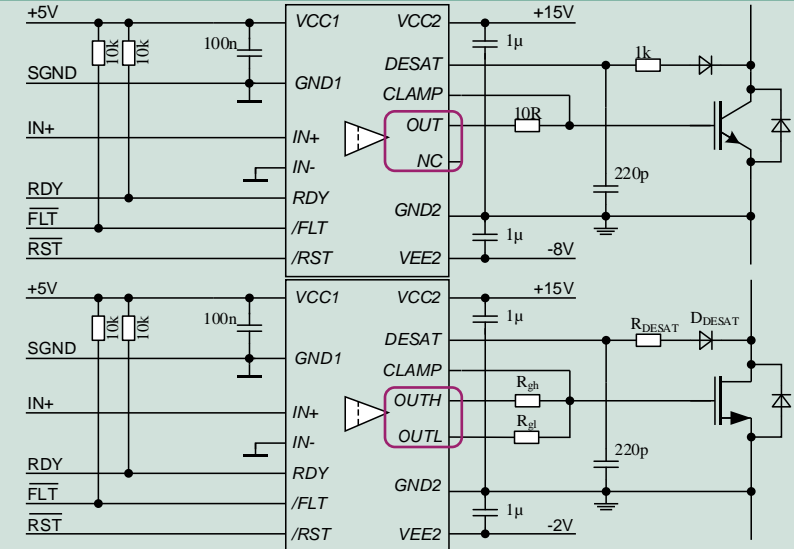


Product highlights

- › Single-channel isolated gate driver with up to **6 / 8.5 A**
- › **Active Miller clamp, DESAT, soft-off**
- › Propagation delay **85 ns typ.** (with 35 ns typ. input filter)
 - › Prop. delay matching (part to part) **+/- 15 ns**
- › **DSO-16 300 mil package**
 - › **8 mm creepage** distance, standard 1.27 mm pitch
 - › Pin-compatible to 1ED020I12-F2/B2
- › Isolation capabilities & certification
 - › **UL 1577 certified** VISO = 5.7 kV(rms)
 - › **VDE 0884-11 certified** VIORM = 1767 V(peak) **reinforced isolation**
- › For IGBTs, MOSFETs, CoolSiC™ / SiC MOSFETs **up to 2300 V**



Sample schematic



Value proposition

- › Accurate short-circuit protection (DESAT) & soft shutdown
- › Up to 8.5 A driving capability & 40 V output supply voltage range
- › Optimized specifications for driving SiC
- › Fulfilling highest isolation standards
 - › UL1577 and VDE-11



EiceDRIVER™ F3 (1ED33xx) – Family overview



F3				
	1ED3320MC12N	1ED3321MC12N	1ED3322MC12N	1ED3323MC12N
Output current (typ.)	+ 3.3 A / -6 A	+ 6 A / -8.5 A	+ 6 A / -8.5 A	+ 6 A / -8.5 A
UVLO2 on / off (typ.)	12.0 / 11.0 V	12.0 / 11.0 V	13.6 / 12.6 V	12.0 / 11.0 V
Output configuration	Separate source/sink	Separate source/sink	Separate source/sink	Single output
Prop. delay / filter time (typ.)	85 ns / 35 ns			
Protection features	Active Miller Clamp, DESAT	Active Miller Clamp, DESAT	Active Miller Clamp, DESAT	Active Miller Clamp, DESAT
DESAT behavior	Soft-off	Soft-off	Standard	Standard
CMTI	300 kV/μs			
Output supply voltage range	40 V			
Package	300-mil (DSO-16)			
Pinouts	<p>Pinout diagram for 1ED3320MC12N and 1ED3321MC12N. Pins 1-8 are on the left, 9-16 on the right. Pin 1: VEE2, Pin 2: DESAT, Pin 3: GND2, Pin 4: OUTH, Pin 5: VCC2, Pin 6: OUTL, Pin 7: CLAMP, Pin 8: VEE2. Pin 9: GND1, Pin 10: IN+, Pin 11: IN-, Pin 12: RDY, Pin 13: /FLT, Pin 14: /RST, Pin 15: VCC1, Pin 16: GND1.</p>		<p>Pinout diagram for 1ED3322MC12N and 1ED3323MC12N. Pins 1-8 are on the left, 9-16 on the right. Pin 1: VEE2, Pin 2: DESAT, Pin 3: GND2, Pin 4: NC, Pin 5: VCC2, Pin 6: OUT, Pin 7: CLAMP, Pin 8: VEE2. Pin 9: GND1, Pin 10: IN+, Pin 11: IN-, Pin 12: RDY, Pin 13: /FLT, Pin 14: /RST, Pin 15: VCC1, Pin 16: GND1.</p>	

Certification

- 1ED332xMC12N: UL 1577, 5.7kV(rms) + VDE 0884-11, 1767 V(peak)

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Summary



- › **Infineon is the power system solution provider of choice for a greener future with heat pumps**
- › **Heat pump application request higher frequency and higher efficiency active PFC solution**
- › **High integration power solution enable higher power density and fast time to market heat pump system**

