High-power semiconductor solutions for green hydrogen electrolyzer applications

March 2023

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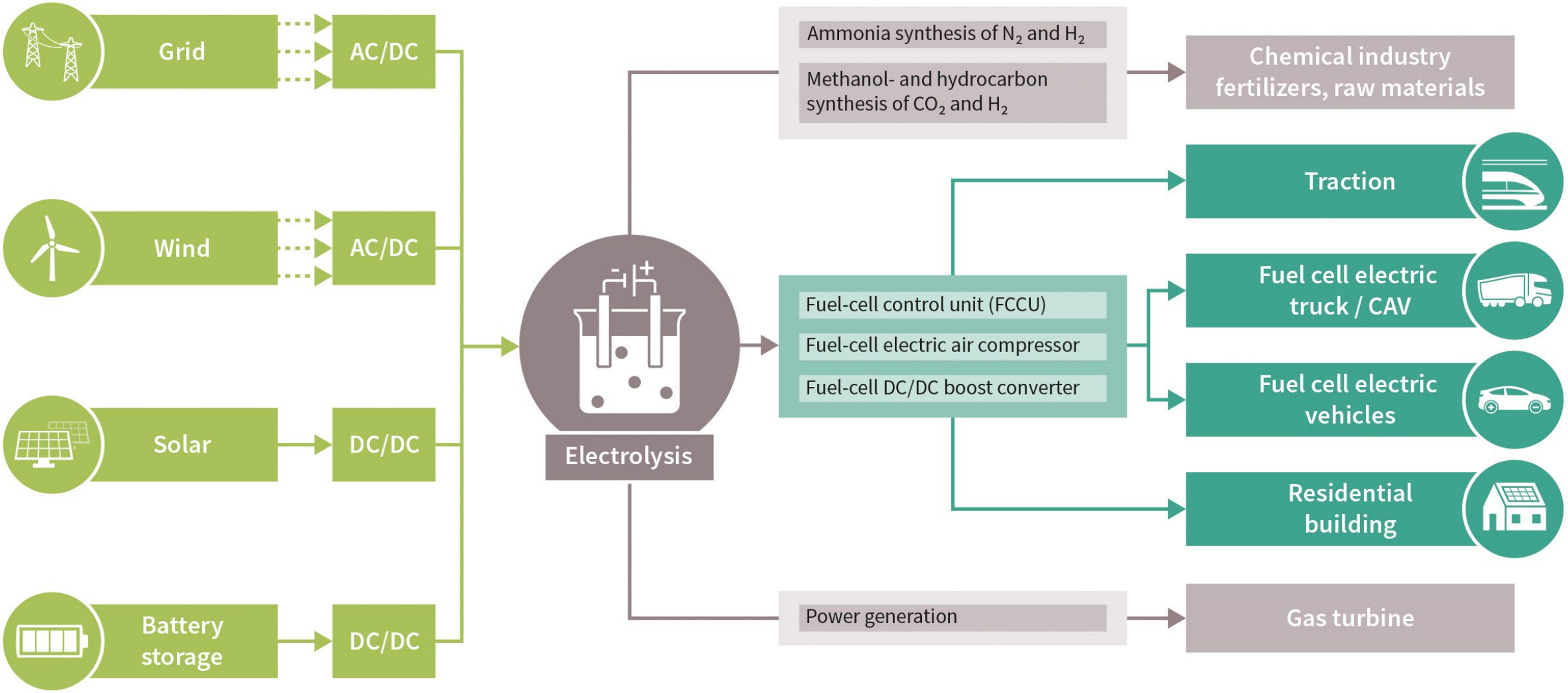
Hydrogen Electrolysis – a part of the future Energy System



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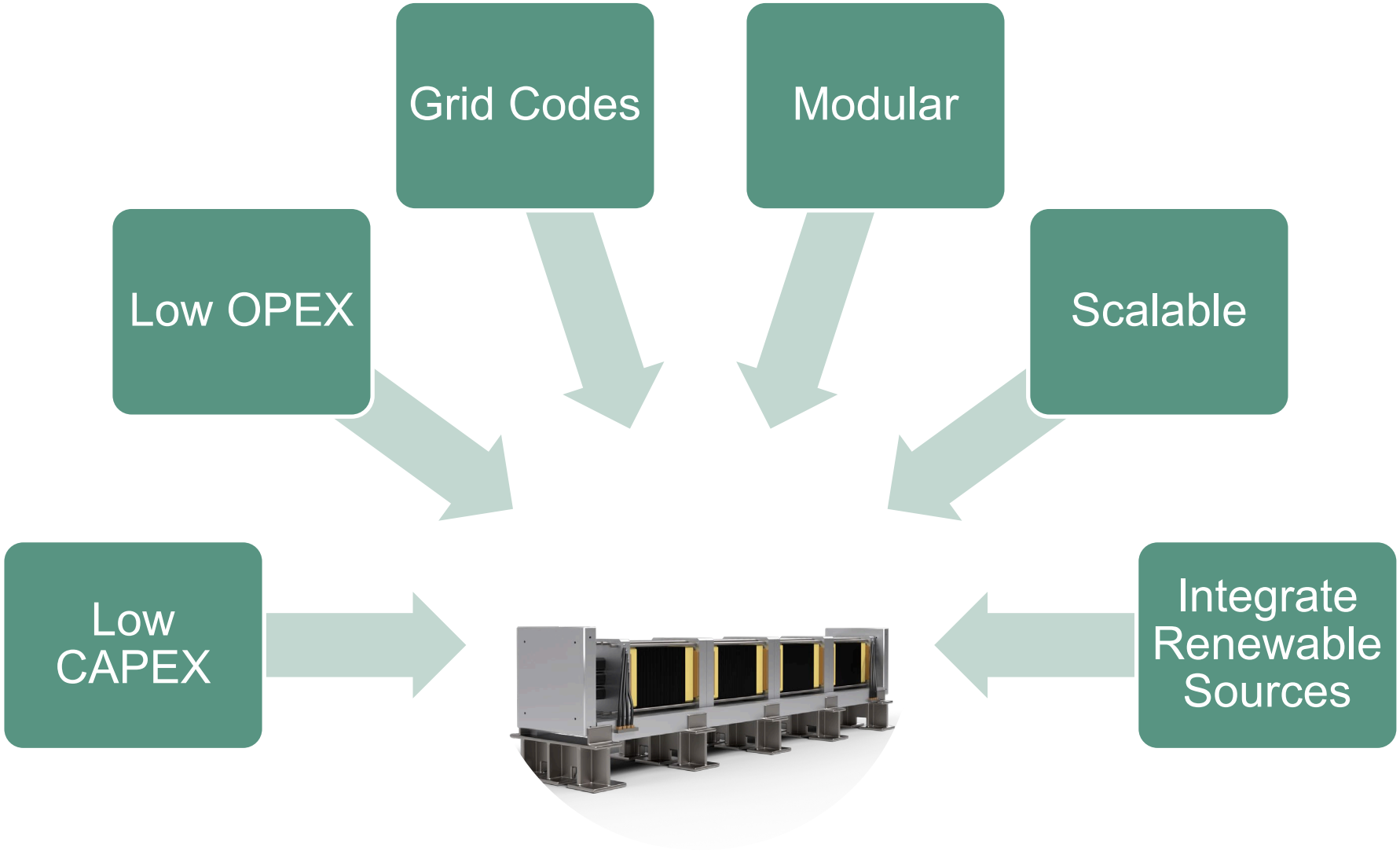
Electrolyzer plant system requirements



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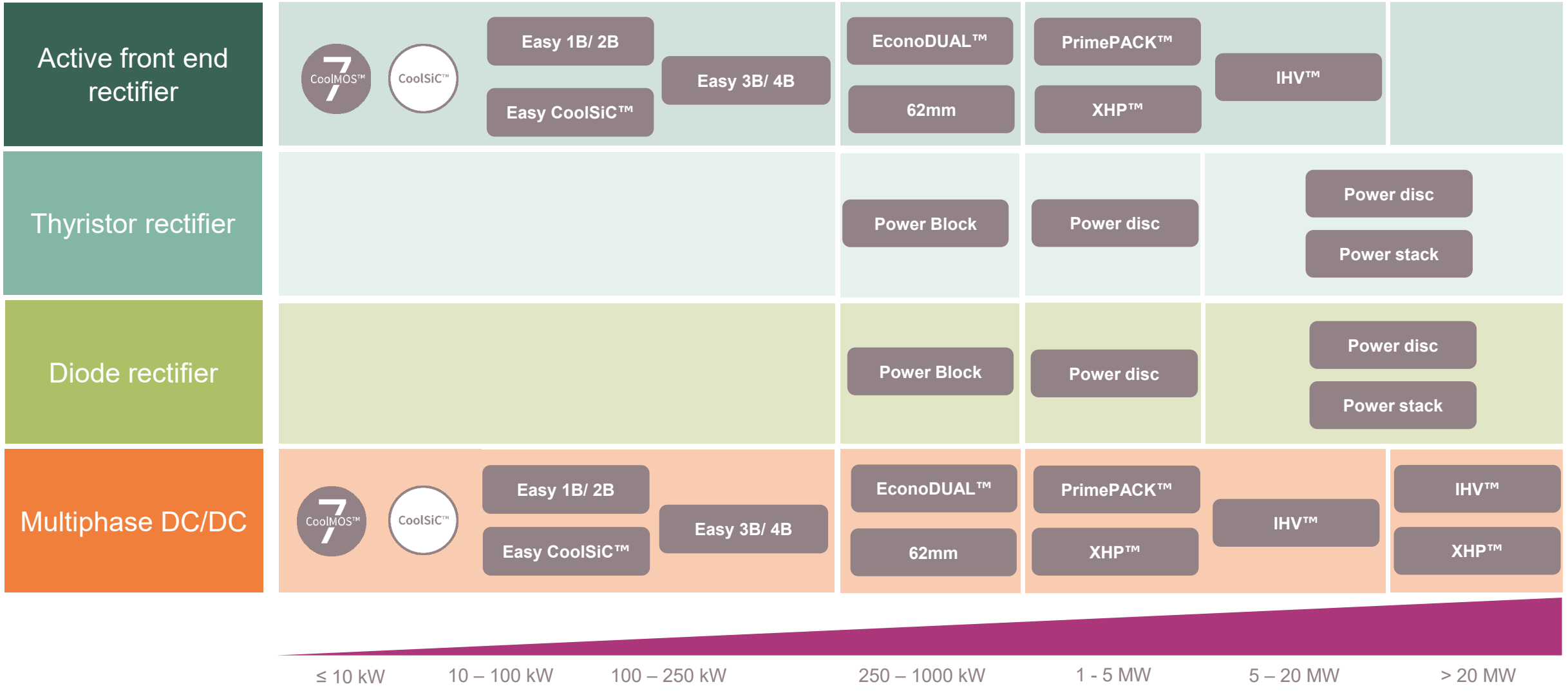
Power quality, efficiency, cost and reliability are mainly shaping Infineon's power solution offerings for hydrogen electrolysis



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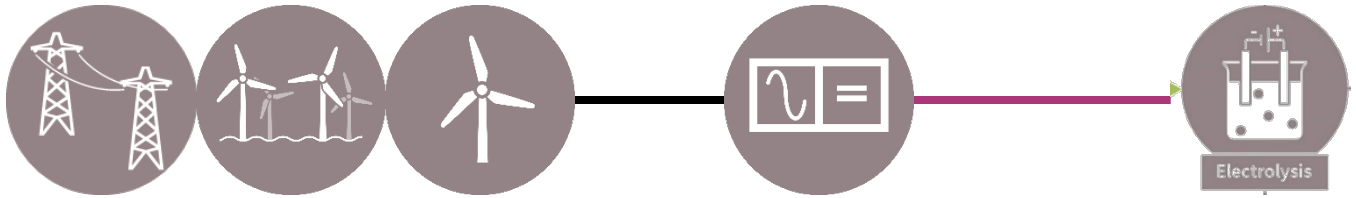
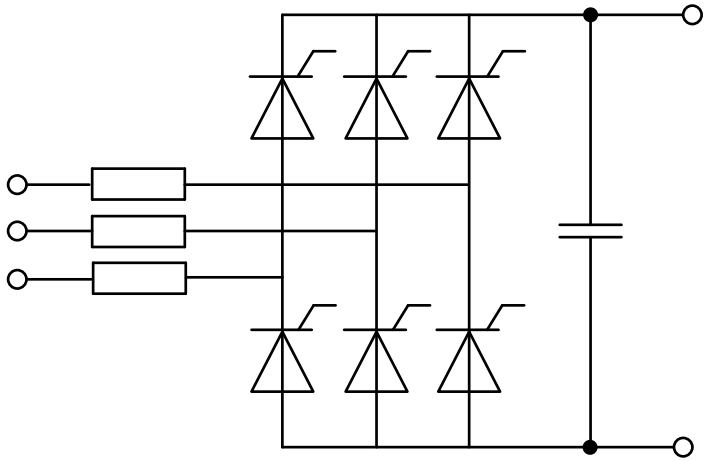
AC-DC power conversion topologies

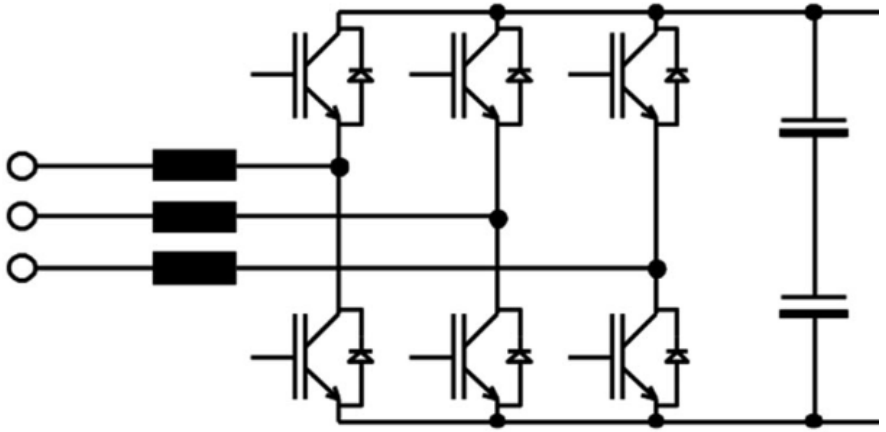


Diode / Thyristor rectifiers



- High current density
- Predesigned stacks available

Active front end / Active rectifiers



- Unity power factor
- <5% THD
- Can provide grid support

Infineon's wide power semiconductor portfolio for all AC-DC power conversion needs

System power

250 – 500 kW

60mm Power Block

60mm Prime Block

1-2 MW

Power discs 111mm

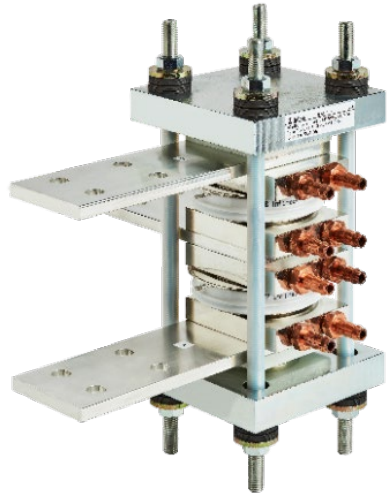
2-5 MW

Power discs 120mm

PrimePACK™3

>5 MW

Customized Power Stacks



60mm thyristor – diode modules fits to system requirements

Module housing and topologies

Key applications

Possible 60mm module portfolio

Topology	Module name	TIM
Thyristor / Thyristor	TT700N22KOF	TT700N22KOF_TIM
Thyristor / Diode	TD700N22KOF	TD700N22KOF_TIM
Diode /Diode	DD700N22KOF	DD700N22KOF_TIM

› Different module options can fit to application, depending on the used system concept

Key features

› Best-in-class power density in standard 60mm housing

› Highest surge current in 60mm housing

› Short-on-fail capability

Benefits

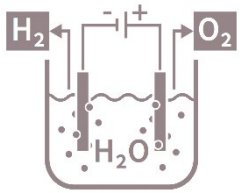
› Avoid paralleling of modules and higher short-term overload

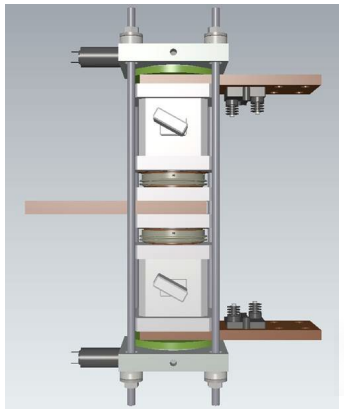
› High volume production on highest quality level

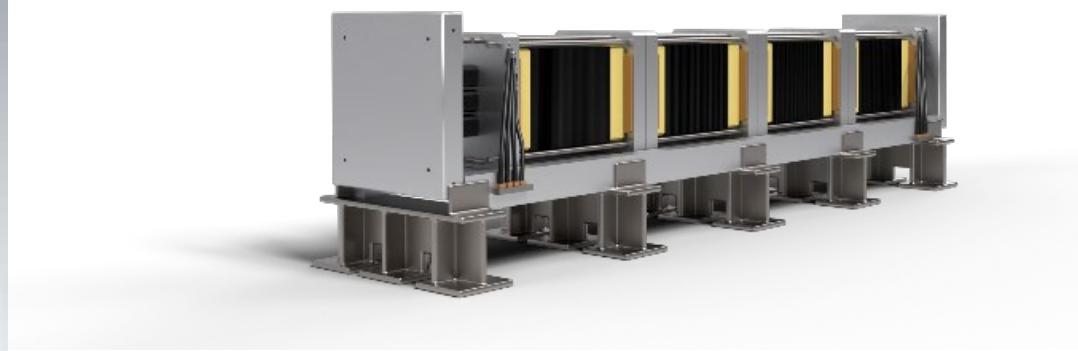
› Reliable partner with own chip development and latest production technology

Subject to change without prior notice. The following represents the current view of the projects. It is intended for information purposes only and should not be interpreted as a commitment. Infineon makes no warranties, express or implied, in this document.

Infineon’s thyristor stack design offers a perfect fit and easy installation







Requirements

- High output current need for electrolysis
- High power density (A/ cm2) for mechanical fit
- High efficiency
- Low €/ MW on system level

Features

- 10 MW power for a 3-phase system
- Full system integrated with thyristor, fuses and snubber circuit

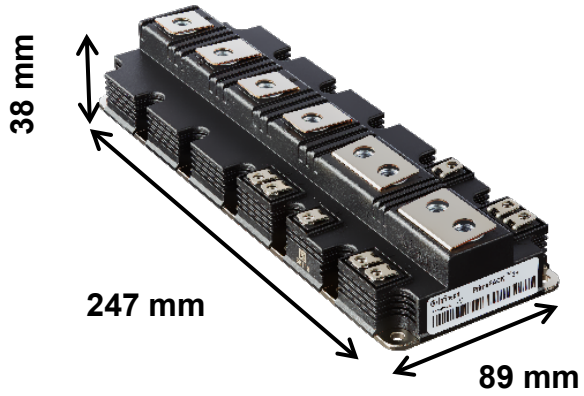
Benefits

- Easy to implement on customer application
- Reduced €/ MW
- Faster time-to-market for customers

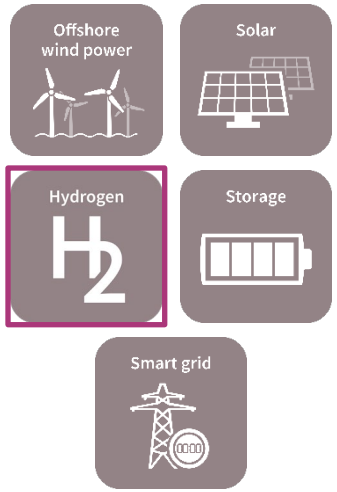
New electrolyzer thyristor stack enables faster time-to-market with outstanding power density

PrimePACK™3+ high current IGBTs for all grid connected converters

Module housing and applications



Key applications



Key features

- 2300 V new voltage class in IGBT7
- IGBT7 rated for overtemperature operation
- IGBT5.XT best-in-class reliability
- Diode optimized for rectifier operation
- High current density in standard PrimePACK™ 3+ housing

PrimePACK™3+ module portfolio

Chip Technology	Module Name	TIM
IGBT7	FF1800R23IE7	FF1800R23IE7P
IGBT5.XT	FF1800R17IE5	FF1800R17IE5P
IGBT5.XT	FF1700XTR17IE5D	FF1700XTR17IE5DP

- Different module options can fit to application, depending on the used system concept

Benefits

- Common mechanical design for various Electrolyzer cell voltages
- Module designed for 1500 V DC applications
- High current density for reduced paralleling
- Larger diode tuned for rectifier operation

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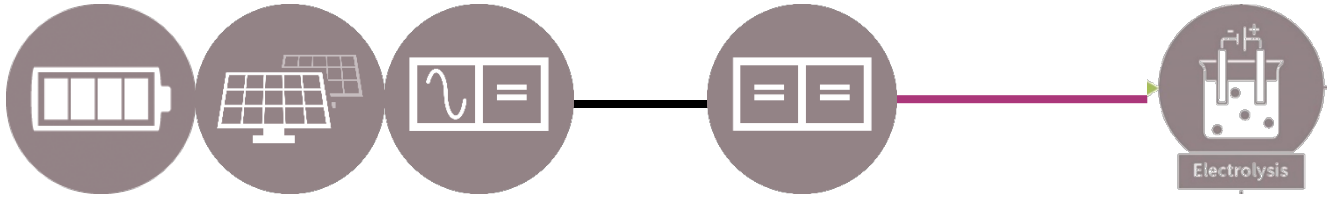
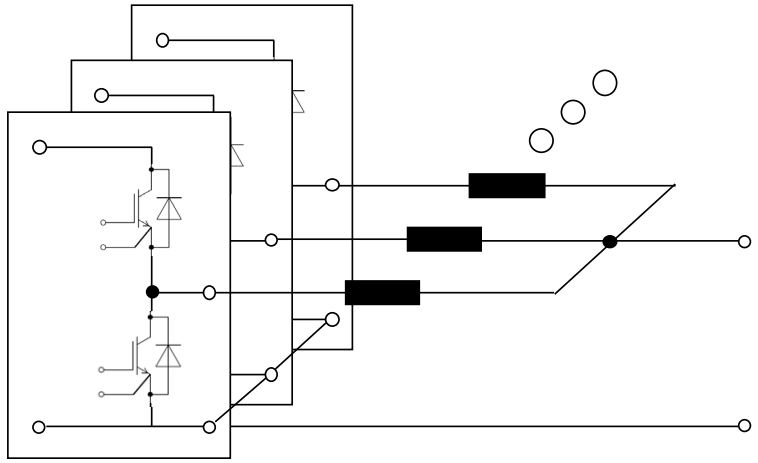
DC-DC power conversion topologies

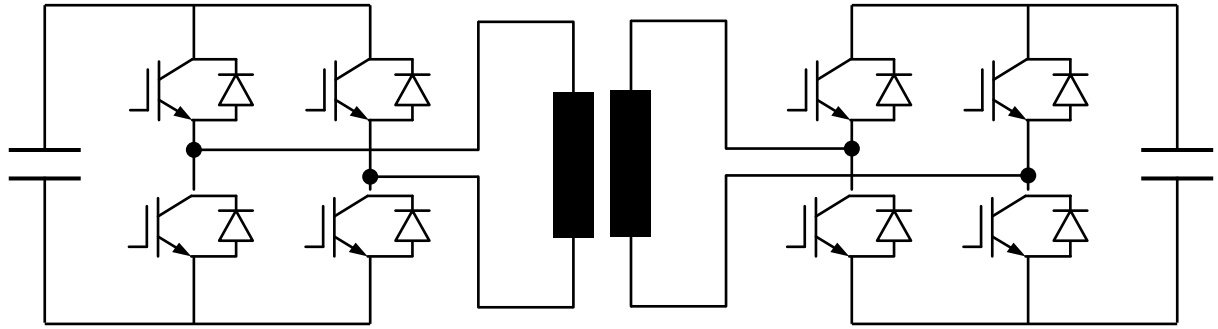


Interleaved buck



- Simple Design, similar to Chopper config
- No isolation – less effort in magnetics design
- Modular design for High DC currents

Dual active bridge



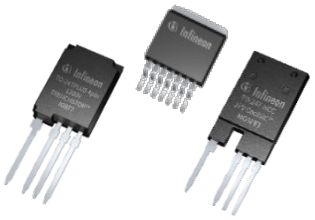
- Inherent galvanic isolation
- High frequency design for smaller transformer and magnetics
- Large step down is efficient via transformer

Infineon's wide power semiconductor portfolio for all DC-DC power conversion needs

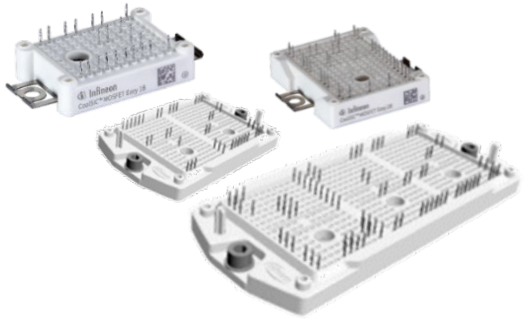
System power

10 kW | **100 kW** | **250 kW** | **500 kW** | **>1000 kW**

Discretes



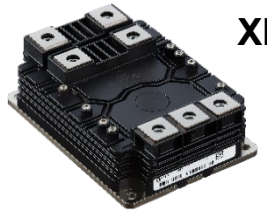
Easy B



62mm

EconoDUAL™

XHP™



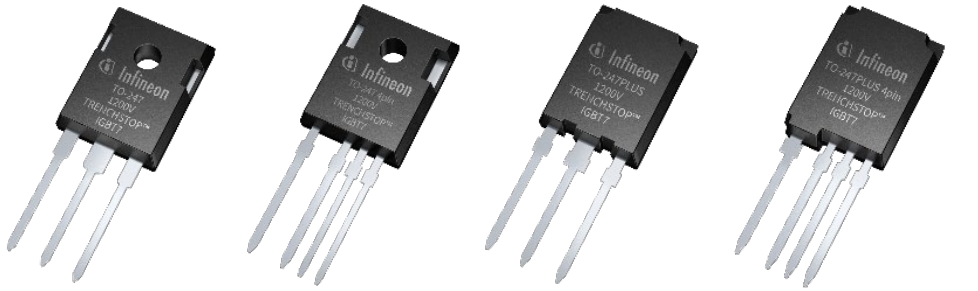
IHV

PrimePACK™

CoolMOS™ | CoolSiC™ | IGBT

Discrete TRENCHSTOP™ IGBT7 H7 products – Benchmark performance with state-of-the-art quality

Package types



Key applications

Portfolio 650 V and 1200 V

Current Inom (A)	TO-247-3 High Creep. & Clear.	TO247-4pin	TO247PLUS-3pin	TO247PLUS-4pin
40	IKWH40N65EH7	IKZA40N65EH7		
50	IKWH50N65EH7	IKZA50N65EH7		
75	IKWH75N65EH7	IKZA75N65EH7		
100	IKWH100N65EH7	IKZA100N65EH7		
120			IKQ120N65EH7	IKY120N65EH7
150			IKQ150N65EH7	IKY150N65EH7

650 V

Current Inom (A)	TO247-3	TO247-4pin assymetric	TO247PLUS-3pin	TO247PLUS-4pin
40	IKW40N120CH7	IKZA40N120CH7		
50	IKW50N120CH7	IKZA50N120CH7	IKQ50N120CH7	IKY50N120CH7
75	IKW75N120CH7	IKZA75N120CH7	IKQ75N120CH7	IKY75N120CH7
100			IKQ100N120CH7	IKY100N120CH7
120			IKQ120N120CH7	IKY120N120CH7
140			IKQ140N120CH7	IKY140N120CH7

1200 V

Key features

- Two voltage classes: 650 V and 1200 V
- Two additional flavors available: T7, S7 offering SC robustness
- High current rating TO-247PLUS, 3/4 legs up to 150 A
- Ultra low switching losses
- High-speed diode, very soft and low Qrr
- HV-H3TRB pass by Jedec standard

Benefits

- IGBT7 replaces almost all predecessor IGBT technologies
- Benchmark performance with best price/performance ratio
- Reduces paralleling, alternative to module solution
- Highest power density without heatsink redesign
- Improved EMI performance eases design
- Higher reliability in hard operating conditions

Discrete 2000 V CoolSiC™ MOSFET offers increased power density and voltage margin

Package

TO-247-4-PLUS-HCC
high creepage,
high clearance package

Key applications

Portfolio 2000 V CoolSiC™ MOSFETs

	$R_{DS(on)}$ [mΩ]	TO-247-4-PLUS-HCC high creepage, high clearance
2000 V	12	IMYH200R012M1H
	24	IMYH200R024M1H
	50	IMYH200R050M1H
	75	IMYH200R075M1H
	100	IMYH200R100M1H

- 2000 V CoolSiC™ MOSFET portfolio complements existing 650 V, 1200 V and 1700 V CoolSiC™ MOSFET offering

Key features

- 2000V SiC MOSFET for high DC-link systems up to 1500 V_{DC}
- Innovative HCC package with 14 mm/5.5 mm creepage/clearance distances
- .XT interconnection technology
- Improved humidity robustness

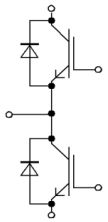
Benefits

- Lowest $R_{DS(On)}$
- Minimized conduction losses
- Low switching losses
- Lowest reverse recovery loss
- Best-in-class thermal performance
- Robust body diode for hard commutation
- Wide V_{GS} range (-7 to 20 V)

62mm product family fits to system requirements

Module housing and topologies

Half Bridge



Key applications

Possible 62mm module portfolio

Chip technology	Module name	TIM
IGBT7	FF800R12KE7	FF800R12KE7P
SiC 2.0 kV	FF3MR20KM1H	FF3MR20KM1HP
SiC 1.2 kV	FF2MR12KM1H	FF2MR12KM1HP

› Different module options can fit to application, depending on the used system concept

Key features

› Baseplate module with screw terminals, available as standard version and with pre-applied TIM

› Leading 1200 V and 2000 V CoolSiC™ chip technology enables high-speed switching frequencies >20 kHz

› Low inductive module design of typically 20 nH and symmetrical internal construction

Benefits

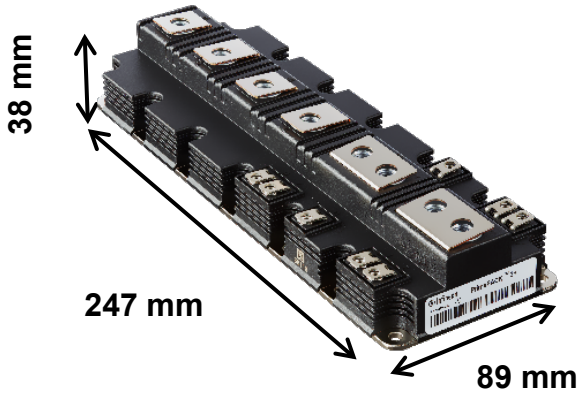
› Modules using latest chip technology in established housing

› High volume production on highest quality level

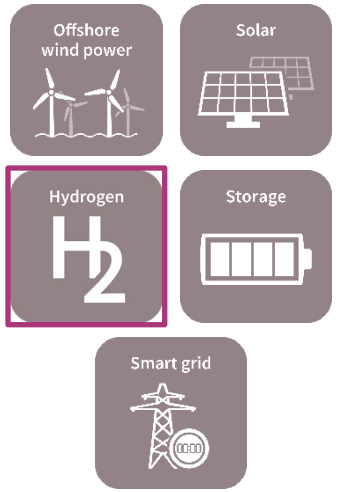
› Reliable partner with own chip development and latest production technology

PrimePACK™3+ high current IGBTs for all grid connected converters

Module housing and applications



Key applications



Key features

- 2300 V new voltage class in IGBT7
- IGBT7 rated for overtemperature operation
- IGBT5.XT best-in-class reliability
- High current density in standard PrimePACK™ 3+ housing

PrimePACK™3+ module portfolio

Chip Technology	Module Name	TIM
IGBT7	FF1800R23IE7	FF1800R23IE7P
IGBT5.XT	FF1800R17IE5	FF1800R17IE5P
IGBT7	FF2400R12IP7	FF2400R12IP7P

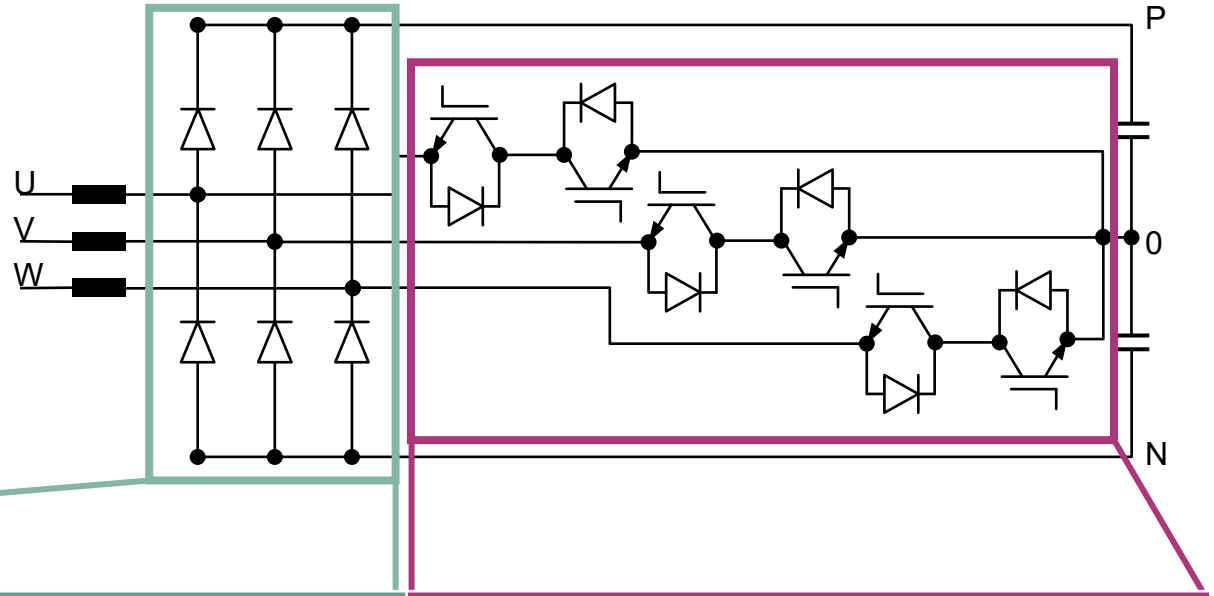
- Different module options can fit to application, depending on the used system concept

Benefits

- Common mechanical design for various Electrolyzer cell voltages
- Module designed for 1500 V DC applications
- High current density for reduced paralleling

Vienna rectifier

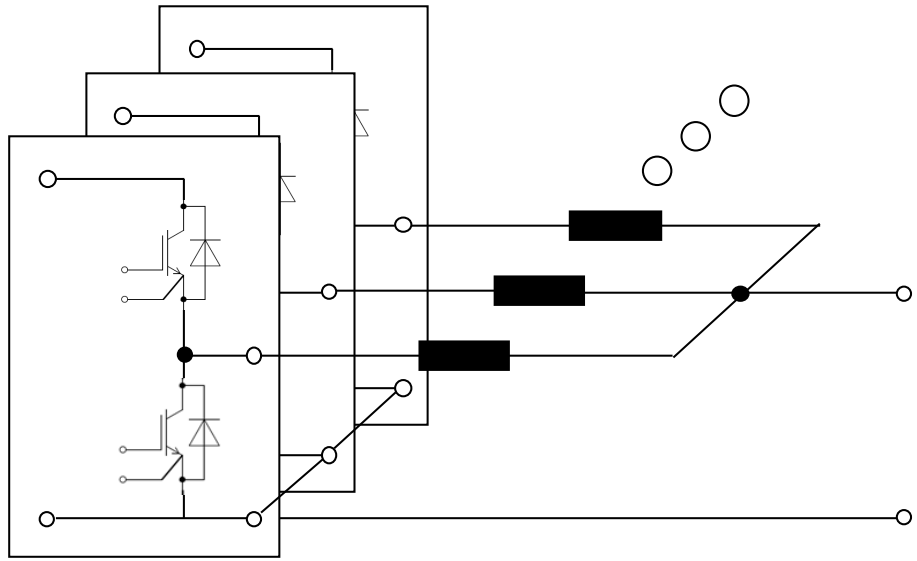
- Unity power factor
- Low THD <5% (Pushed to higher frequencies)
- Optimized for unidirectional operation
- Ideal for Low Voltage systems (<1500 V)



Diode solutions		Middle leg solution
DD1200S17H4_B2	DD1200S12H4	FF2400RB12IP7
1700 V – 1200 A – Diode	1200 V – 1200 A – Diode	1200 V – 2400 A – IGBT7
High reliability and robust module	High surge current capability	Common collector module
Standardized housing	10.2 kV AC Isolation	Low stray inductance design

DC-DC – Interleaved buck converter

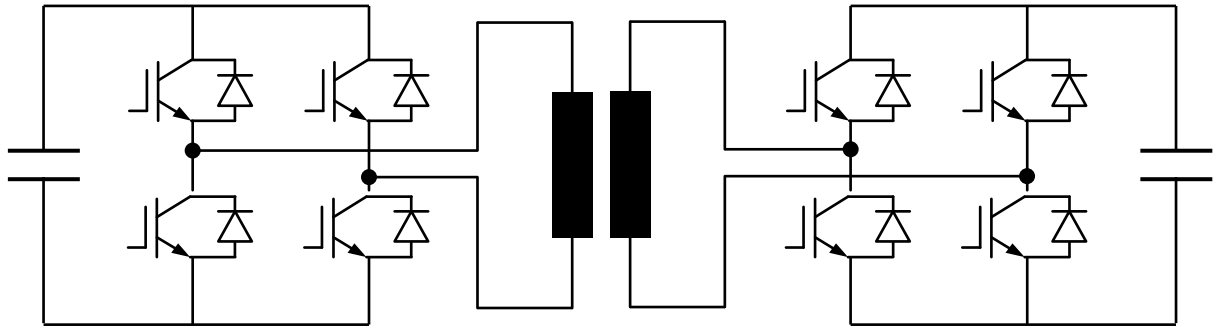
- Simple Design, similar to chopper config
- Improves performance of thyristor and diode rectifiers
- No isolation – less effort in magnetics design
- Low ripple current – better life of Electrolyzer
- Modular design for High DC currents



Solution for 1500 V DC	Solution for high currents	Solution for high reliability
FF1800R23IE7	FF2400R12IP7	FF1800R17IE5
2300 V – 1800 A – IGBT7	1200 V – 2400 A – IGBT7	1700 V – 1800 A – IGBT5
New Voltage class for 1500 V DC	IGBT7 Technology	Best in class reliability
Low failure due to Cosmic Rays	Highest current in PrimePACK™	No failures due to Bond wire lift off

DC-DC – Dual active bridge

- Inherent galvanic isolation
- High frequency design for smaller transformer & magnetics
- Large step down is efficient via transformer



Solution for 1500 V DC	Solution for high frequencies	Solution for high currents
FF1800R23IE7	FF2000XTR33T2M1	FF2400R12IP7
2300 V – 1800 A – IGBT7	3300 V – 2mΩ – SiC	1200 V – 2400 A – IGBT7
New Voltage class for 1500VDC	Silicon Carbide Solution	IGBT7 Technology
Low failure due to Cosmic Rays	XHP Package	Highest current in PrimePACK™

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Green hydrogen as part of the future energy system

- Infineon’s power semiconductor portfolio covers the full performance spectrum for various AC grid and DC-coupled hydrogen application up to MW scale.
- Infineon provides full tailored solutions for high current rectifiers.
- Infineon's Thyristor Stack design offers a perfect fit and easy installation which enables faster time-to-market with outstanding power density.
- PrimePACK™ with IGBT 7 enables highest power quality and density for multiple megawatt converters design.

Find more information about our leading product portfolio on our websites:

- Application page on Hydrogen electrolyzer
- Video on solutions for hydrogen electrolysis
- Product page on Thyristor / Diode discs
- Product page on Thyristor modules
- Product page for PrimePACK™
- 62mm IGBT modules

Part of your life. Part of tomorrow.