Vincotech

Fast Charging Solutions:
empowered by VIN’s Power Modules

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Status: 30/08/2022

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02 / Charger Trends
03 / Charger Market
04 / Power Converter Topologies
05 / Power Modules for DC Charger
06 / DC Charger Concepts – Vincotech reference designs

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01 / Charger at a Glance
Charging Modes

Slow charging

11 kW

3,5 h*

AC charging
- Conversion done by Onboard charger (OBC)
- Power limited by OBC, most commonly rated 7kW or 11kW, max. 22kW

VIN Target Application

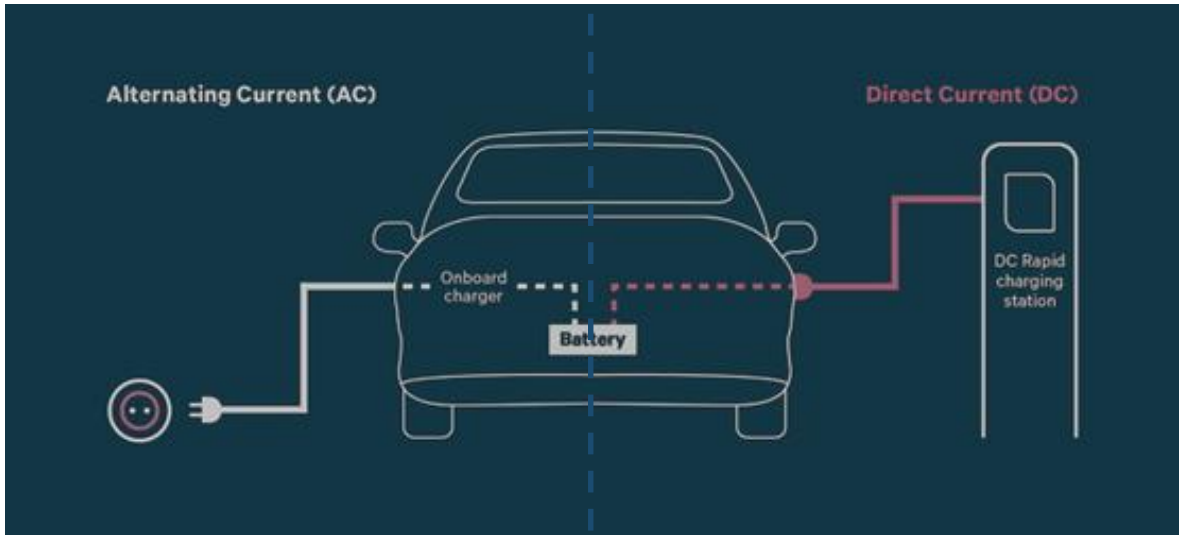
DC charging
- Off-board charger
- Highest power up to 350kW
- Current nominal power lower or equal to 50kW
- Shortest charging times

Fast charging

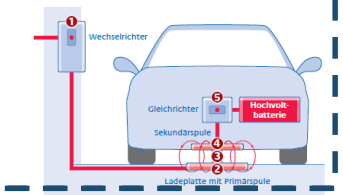
22 kW — 1,7 h* — Home

50 kW — 45 min* — Public

350 kW — 6 min* — Highway



Inductive Charging
- Wireless energy transfer
- Limited Power, up to 20kW
- Efficiency slightly higher than 90%
- Still a niche solution for now

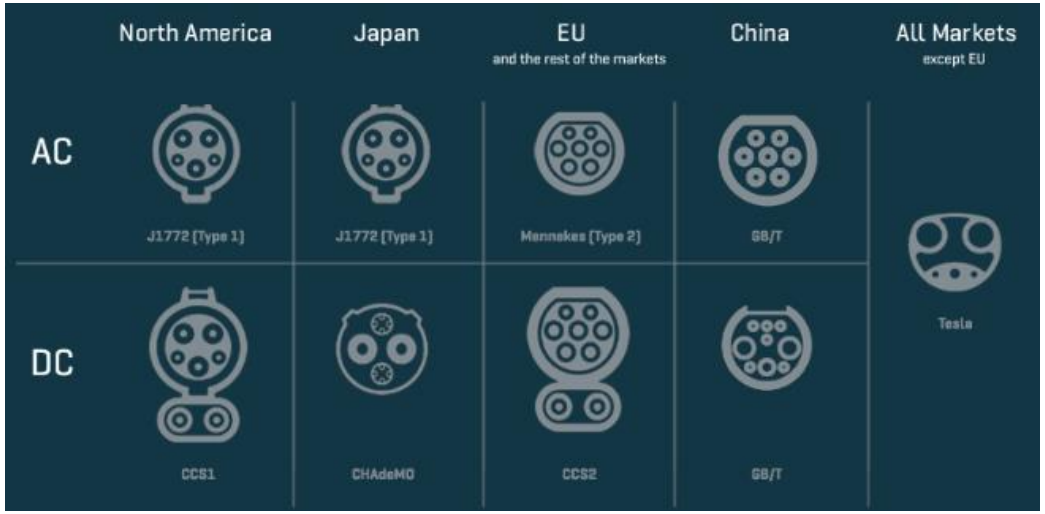


*Charging time for 190km @ 80% SoC, assuming an avg EV battery capacity of 48kWh and an avg EV consumption of 20kWh/100km

01 / Charger at a Glance
Standards and Protocols for Charging

- In order to regulate and standardize AC and DC charging technologies several standards and IEC norms have been developed which co-exist worldwide: IEC−68151, IEC−62196, IEC61980, ISO1740 9:2020, SAEJ1772,…
  - IEC61851 refers to 'Electric Vehicle Conductive Charging Systems'. This standard defines four different **charging modes** to categorize the mode of power delivery, protection installation and communication/control
  - In North America, the standard is SAEJ1772. The SAEJ1772 establishes 3 **charging levels** to categorize the rated power, voltage and current
  - IEC 62196-2/3 defines the **charger types**, used to categorize the different socket-outlets used to deliver power

- There are three main charging protocols extended worldwide: the **CHAdeMO** ('charge de move'), the **Combined Charging System** (CCS) and the **Tesla Supercharger**. In China, the only standard and implemented protocol is the GB/T, and is also exclusive to the region



01 / Charger at a Glance
Combined Charging System (CCS)

- CharIN is dedicated to support and establish the Combined Charging system (CCS) as the standard for charging Battery Electric Vehicles (BEVs) of all kinds
- VIN is CharIN regular member since 2018

Power Class	Power*	U_{min} in [V]	U_{max} in [V]	I_{min} in [A]	I_{peak} in [A]	I_{rated} in [A]	$P_{reference}$ in [kW]	Duration I_{peak}	Name (EN)
LPC	*xx (kW)*	≤200	≥920		**<20**	*<20*	**<8**	*inf*	*Low-Power Charging*
DC	*xx (kW)*	≤200	≥920	≤1	**≥20**	*≥20*	**≥8**	*inf*	DC Charging
FC	*xxx (kW)*	≤200	≥920	≤1	**≥125**	*≥94*	**≥50**	>=30 min	Fast Charging
UFC	*xxx (kW)*	≤200	≥920	≤5	**≥250**	*≥188*	**≥100**	>=20 min	Ultra-Fast Charging
HPC	*xxx (kW)*	≤200	≥920	≤5	**≥500**	*≥375*	**≥150**	>=10 min	High-Power Charging
MCS						*TBD*			

Position Paper / Recommendation of Charging Interface Initiative e.V. DC CCS Power Classes V7.1 2021-046-14

Megawatt
Charging
System (MCS)
To satisfy the market demand of the Truck and Bus industry to charge electric heavy-duty vehicles within a reasonable time, a new solution for high-power charging is needed

- Status 10/2022:CharIN website lists an overall number of deployed CCS charging points of more than **59.6k**

39k
CCS charging points **in Europe.**

5826
CCS charging points **in North America.**

13k
CCS charging points **in Asia/Pacific.**

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02 / Charger Trends

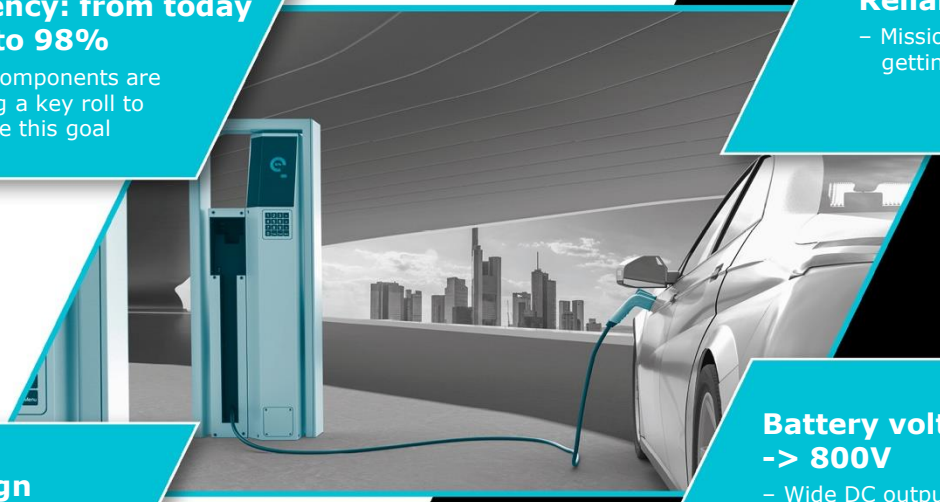
DC-Charger Trends and Key Drivers

Charging will shift towards public and workplace options, as more people without access to home charging start to buy EVs.

There will be a growing need for **DC fast chargers** with nominal power >22kW in the next years

For high power chargers (>30kW):

- The **modular design** is dominant over the monolithic design approach thanks to its benefits of high design flexibility and scalability
- The **power module** solution is preferred rather than the discrete solution with the benefits of optimal thermal management, simplified mechanical assembly, and low parasitic inductance
- **SiC power modules** will gain 16% of the total power module market by 2025* driven by Charging Infrastructure and EV/HEV



Bi-directional charging
- Not yet a global trend
- V2L, V2G or V2H

Efficiency: from today 95% to 98%
- WBG components are playing a key roll to achieve this goal

Reliability
- Mission profiles are getting harder

Modular design
- In the modular approach, a charger is built of several charger stacks connected in parallel

Battery voltage 400V -> 800V
- Wide DC output voltage range (200V->920V)

High power charging stations
- Fast charging
- Public charging and workplace charging
- Destination charging

*Yole report “Status of the power electronics industry: Market and Technology Report 2020”

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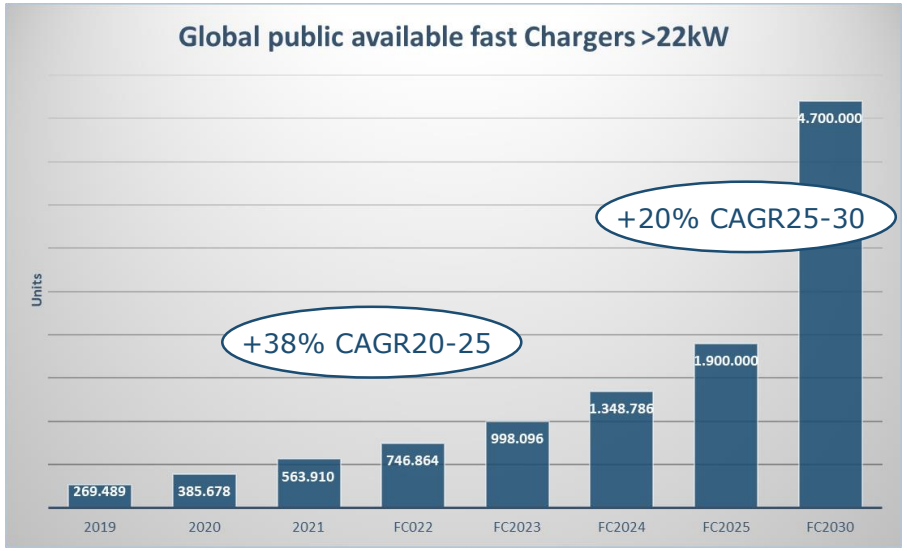
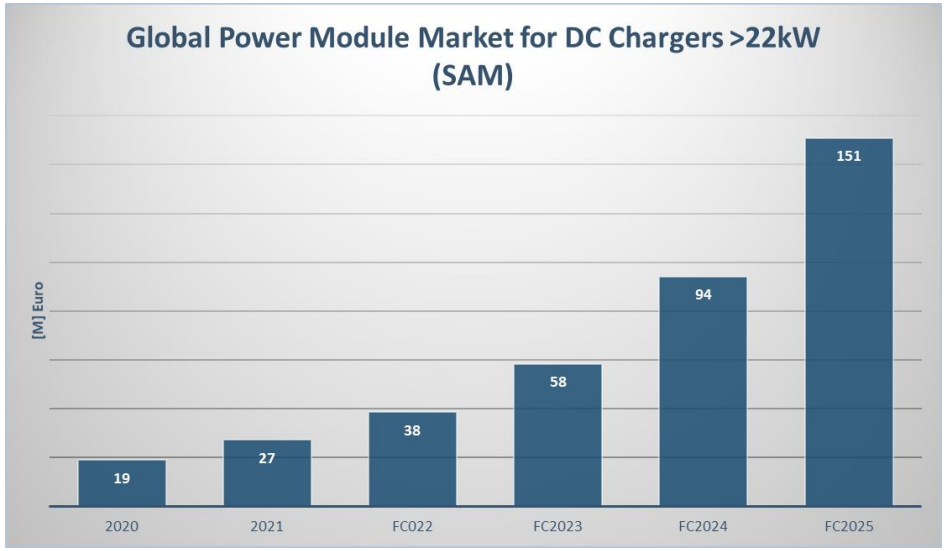
03 / Charger Market
Global Power Module Market

- The growing EV/HEV market will drive the roll-out of charging infrastructure
- Charging infrastructure and EVs/HEVs are showing by far the highest growth rates
- The global public available fast charger (>22kW) units are expected to growth from 564k units in 2021 to 1.900k units in 2025 which will be a 38% CAGR for the forecasted period. Compared with the 2021 report data it means a slightly cooling down. On the other hand for the forecasted period 2025-2030 the GAGR is expected to be higher compered with the last yer report
- 50kW will remain the mainstream in the coming years. A big push is expected for DC chargers >200kW
- The global power module market for DC Chargers is expected to be 150M€ in 2025 gaining share against discrete solutions, which are dominating the Asia market



source: IEA Global EV Outlook 2021



VIN estimation

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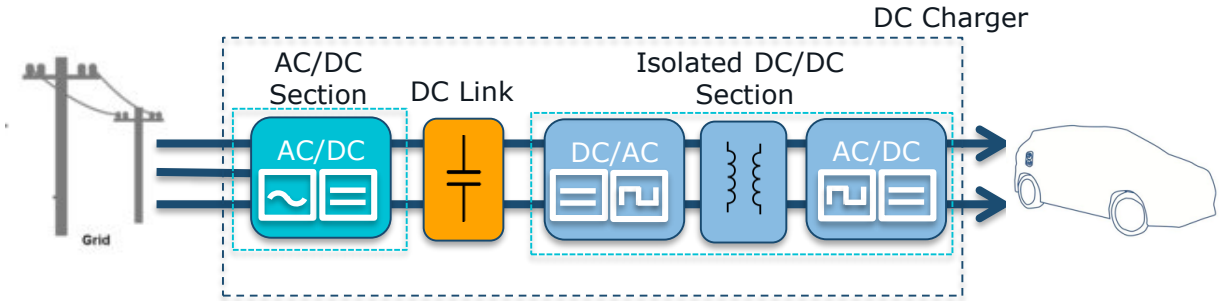
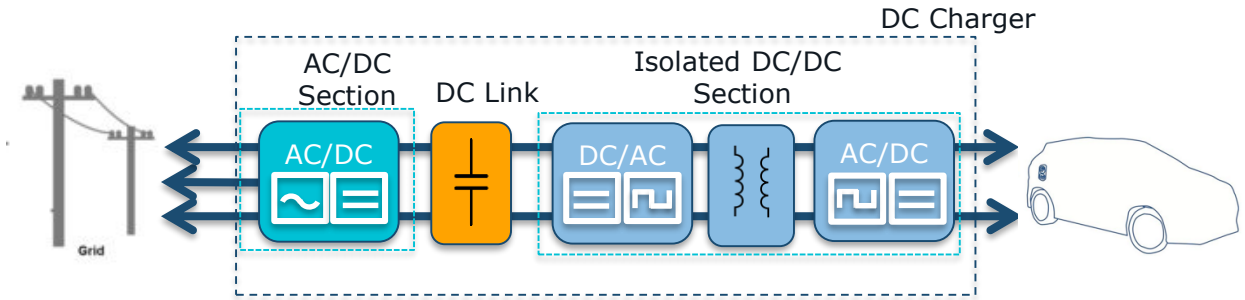
04 / Power Converter Topologies

DC-Charger System Architecture; Power/Charger <150kW

- System Architecture 1: This is the **state-of-the-art system architecture** for DC Charger 10kW up to 350kW. Depending on output power, this can be a system built from one or more charger stacks (charger modules). Supply is taken from low-voltage 3-phase grid.



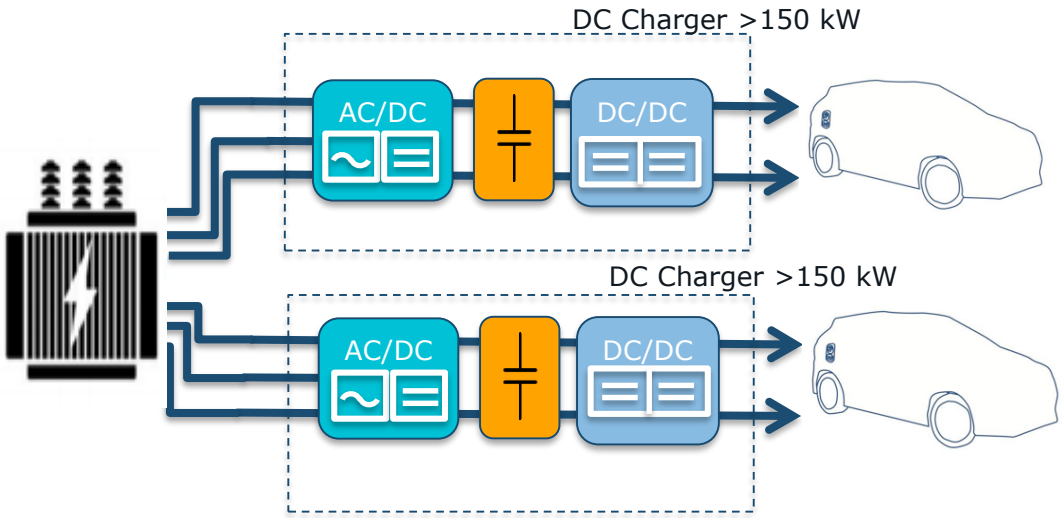
- System Architecture 2: The same as system architecture 1 but **bi-directional**. It is mainly designed for V2x applications

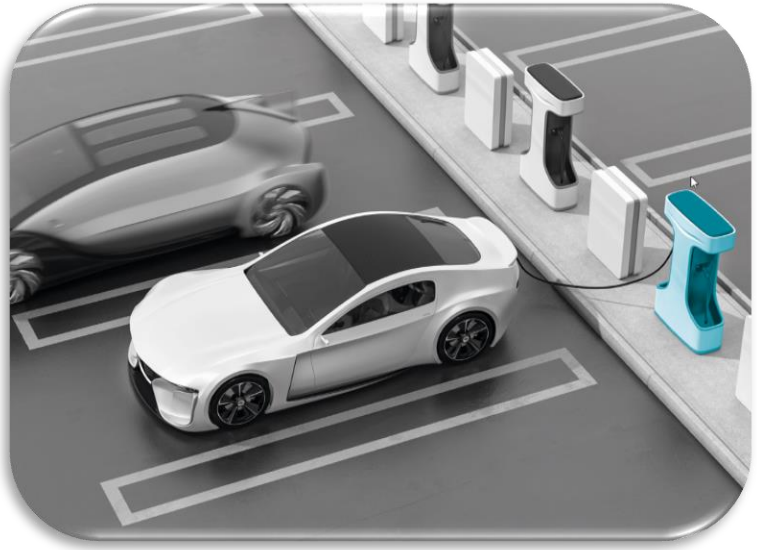


04 / Power Converter Topologies

DC-Charger System Architecture; Power/Charger >150kW

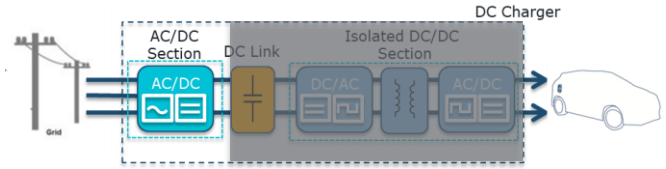
- System Architecture 3: Design aimed to serve the higher power (>150 kW) market, e.g. charging parks. A medium-voltage transformer furnishes power directly to the system. Separated windings per charger needed on the secondary side of transformer. The advantages of this system architecture are system costs and efficiency

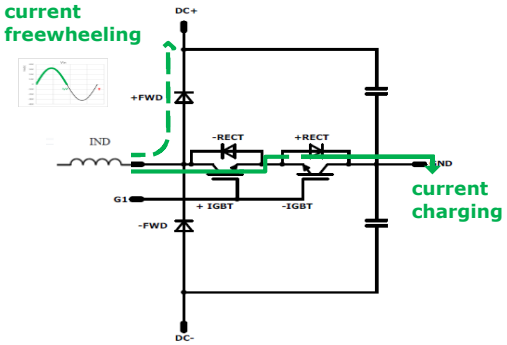




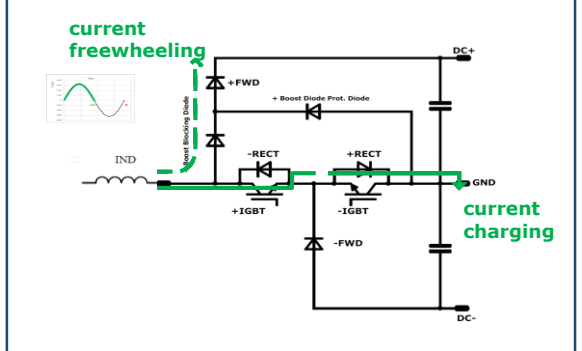
04 / Power Converter Topologies

DC-Charger System Architecture; Three-phase PFC Topologies for AC/DC

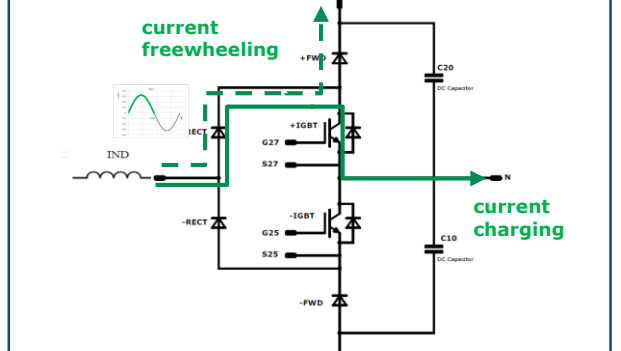




NPFC (Neutral Boost PFC)

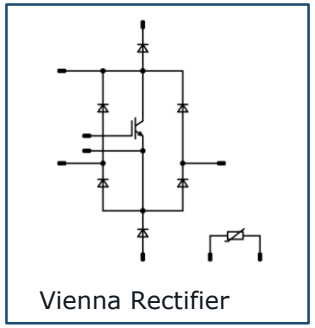


ANPFC (Advanced Neutral Boost PFC)*

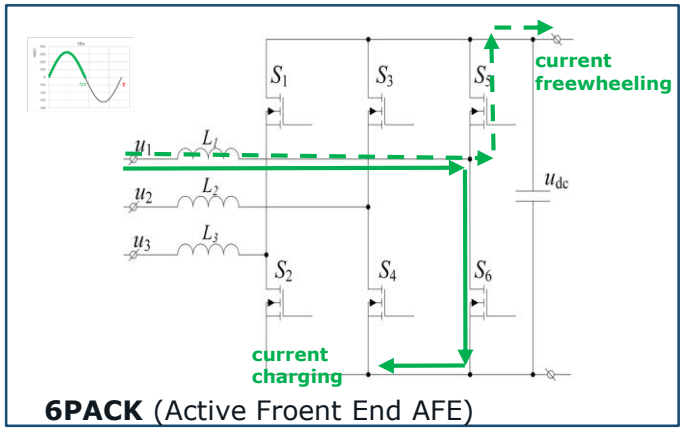


SPFC (Symmetric Boost PFC)

Common three-level (3L) PFC topologies for DC Charger for unidirectional charging



Vienna Rectifier



6PACK (Active Froent End AFE)

Common two-level (2L) PFC topology for DC Charger

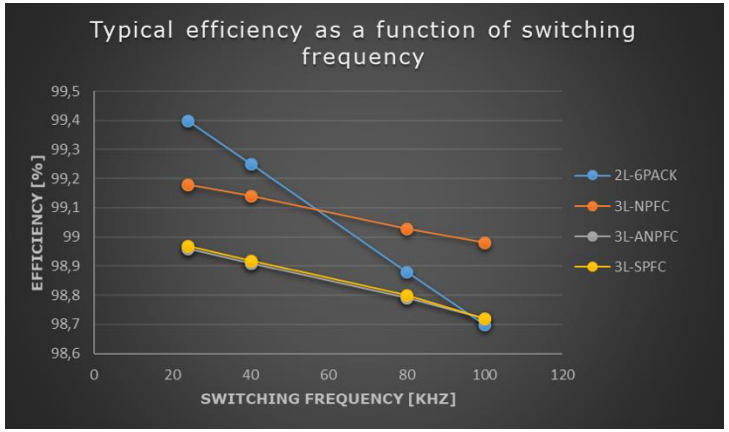
- There are several three-phase PFC topologies available which can be addressed with multiple 3L and 2L topologies with pros and cons in terms of efficiency, costs and design complexity
- Each of these topologies will influence
  - the blocking voltage rating of the semiconductors e.g. 650 V or 1200 V and as a result, the switching losses and the efficiency
  - the total system costs, e.g. PFC inductor size and costs
    - At a given frequency the current ripple at 2L is twice as high as in 3L applications which has an impact on the inductor core material and size
  - the thermal management, e.g. heat sink size
  - the design e.g. uni- or bi-directional. For **bi-directiona**l charging the 3L SPFC and NPFC are suitable by replacing the boost diodes with switches, and the 2L 6pack per se

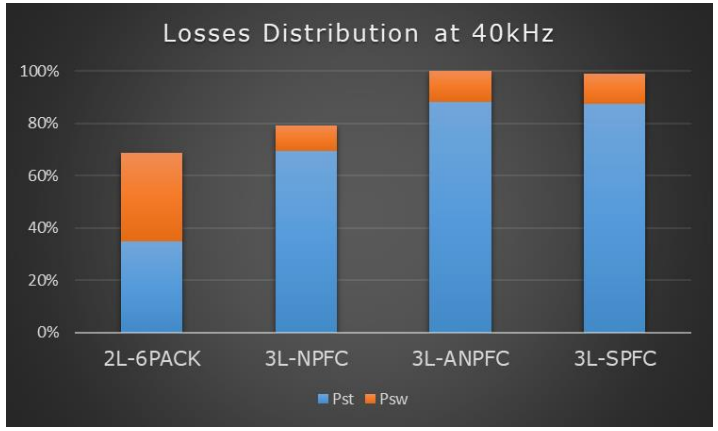
*Proprietary topology from Vincotech

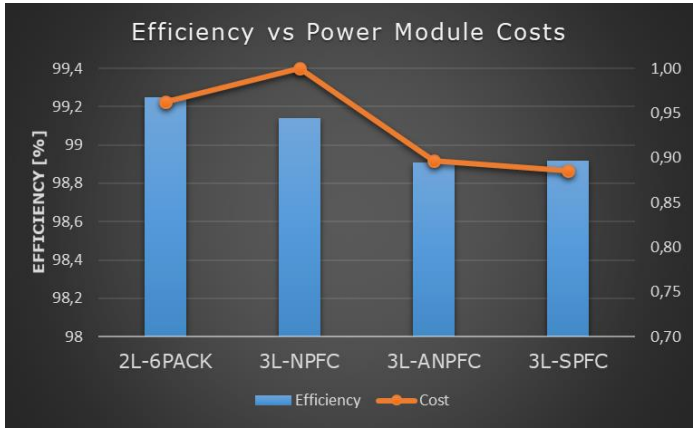
DC-Charger System Architecture; Three-phase PFC Topologies for AC/DC

Benchmark of 2L vs 3L in terms of **efficiency and power module costs**

- 30 kW Charger unit (Vin 230A, DC Link 800V, Ths 80°C, **Tjmax <130°C**)
- Similar chip technology for the main devices
  - 2L-6PACK: 1200V/16mOhm SiC MOSFET
  - 3L-NPFC: 650V/22,5mOhm SiC MOSFET and 1200V/60A SiC Diode
  - 3L-ANPFC and –SPFC: 650V/22,5mOhm SiC MOSFET and 650V/60A SiC Diode



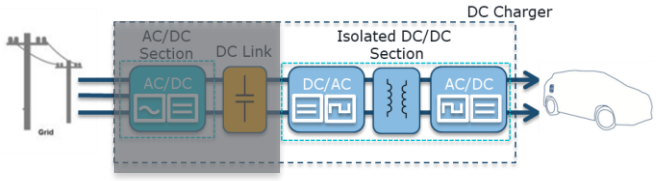


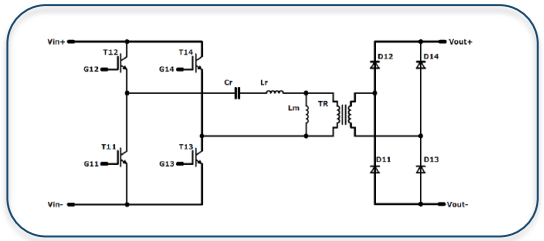


- 2L-6PACK is showing the best efficiency for fsw up to 60kHz, but has also high costs. The switching losses are limiting the efficiency at high switching frequencies
- NPFC has high efficiency also for higher fsw but with the drawback of higher costs because of the 1200V diodes
- ANPFC and SPFC are showing same efficiency, but ANPFC with single gate drive has a total cost advantage vs SPFC

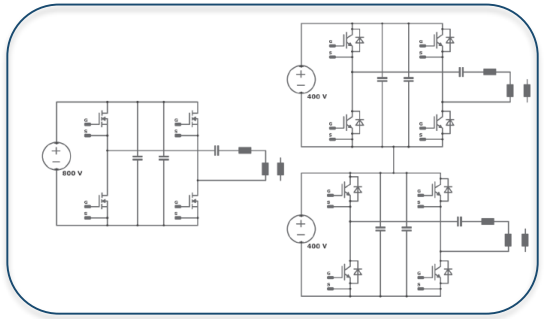
04 / Power Converter Topologies

DC-Charger System Architecture; LLC Topologies for DC/DC

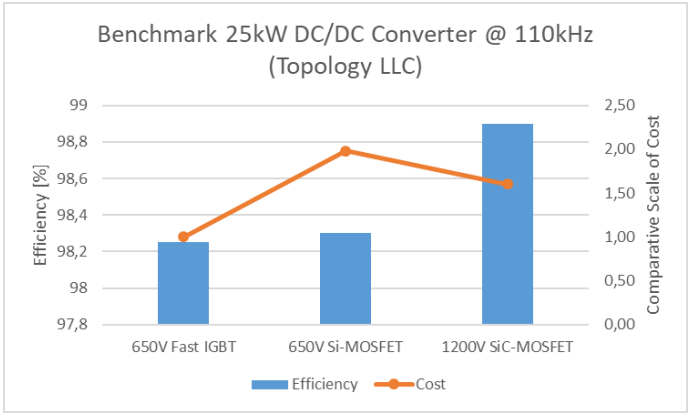




- Resonant topologies are often preferred for the DC/DC section
  - Reduce switching losses
  - Increase efficiency
  - Galvanic isolation
- The full bridge LLC converter with full bridge rectifier is on of the most used configuration for unidirectional charging
- It is a soft switching topology (ZVS, ZCS) resulting in a very high peak efficiency around the resonant frequency
- Multiple variants can be used for primary and secondary side with additional advantages and compromises
- For **bi-directiona**l charging the full bridge rectifier on the secondary side has to be replaced with a full bridge



Full bridge topologies: full bridge 1200V SiC MOSFET (left side), full bridge 650V fast IGBT in series (right side)



- ✓ The full bridge in series configuration (3-level) with the 650 V fast IGBT performs well in terms of both cost and efficiency
- ✓ If the application requires very high efficiency the full-bridge (2-level) with 1200 V SiC-MOSFET would be the configuration of choise. The price decrease of this chip technology over the last years favourites this option also from cost point of view

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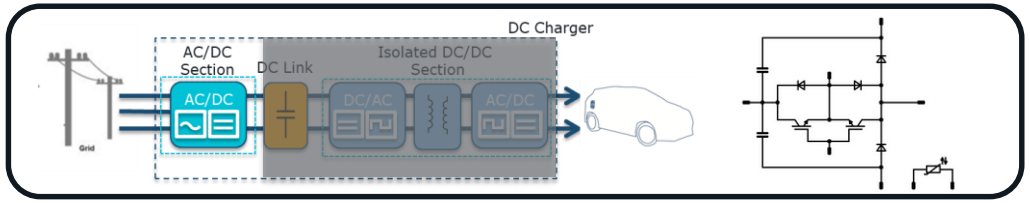
05 / Power Modules for DC Charger

3L Three-phase PFC: flowNPFC Product Line (T-Type PFC)



Voltage	Product Line	Technology	Product Family	Part Number	I_{Cnom} [A]			Application Power rating*	2022				2023				2024			
					30	75	100		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
650V	flowNPFC 0	IGBT H5	L70x	10-FZ07LBA100SM01-L705L18				Up to 16 kW												
		IGBT H5/SiC SBD						Up to 28 kW												
	flowNPFC 1	IGBT S5/SiC SBD	M82x					Up to 55 kW												
	flow3xNPFC 1	IGBT H5/SiC SBD	L39x	10-xY12NMB030SM-L394L08x				Up to 20 kW												
		IGBT H5/CalI4F	L39x	10-TY12NMB030SM01-L394L18				Up to 14 kW												

Voltage	Product Line	SiC Inside Technology	Product Family	Part Number	RDSon [mOhm]			Application Power rating*	2022				2023				2024			
					11	15	45		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1200V	flowMNPC E2 SiC	full SiC-MOSFET	LS2x	10-EY12NMA011ME30-LS28F18T				Up to 75 kW												
650V	flowMNPC E2 SiC	full SiC-MOSFET		10-EY12NMA016ME-LS28F16T New				Up to 60 kW												
	flowMNPC 0 SiC	full SiC-MOSFET						Up to 30 kW												
	flowNPFC 0 SiC	SiC MOSFET/SiC SBD						Up to 33 kW												
	flowNPFC 1 SiC	SiC MOSFET/SiC SBD	M82x					Up to 60 kW												
	flow3xNPFC S3 SiC	SiC MOSFET/SiC SBD						Up to 50 kW												

Ongoing R&D Project

Product Concept

Serial Status

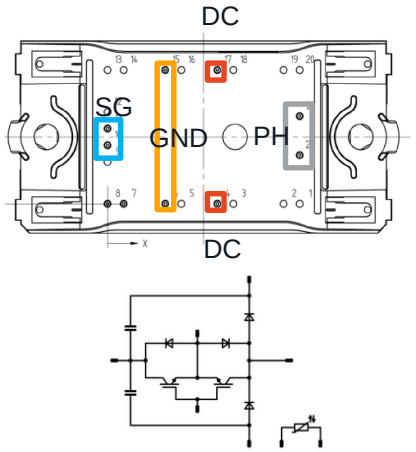
*Assuming a typical charging operation point: Vin 230V, Vout 700V, fsw 45kHz, Ths 80°C

Detailed product portfolio available at VIN web page: https://www.vincotech.com/products/by-topology/topology/pfc-three-phase-applications.html

05 / Power Modules for DC Charger
flowNPFC 0/1 Product Description

flowNPFC 0

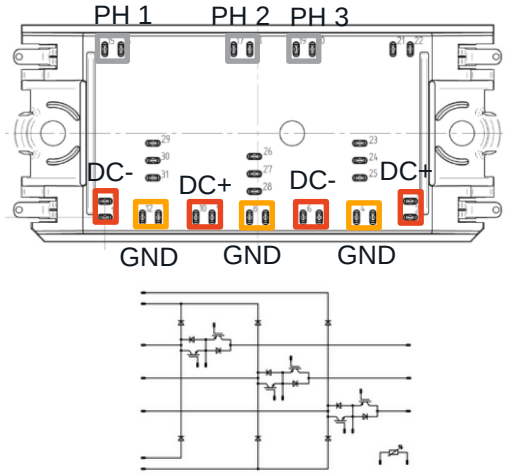
Pinout for product family L70x

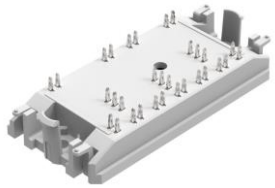


flow 0 housing

flow3xNPFC 1

Pinout for product family L39x





flow 1 housing

Function:
Neutral Power Factor Corrector (NPFC)

Features:
- Trenchstop5 H5 chip technology for high speed switching and high efficiency
- With fast recovery diodes or SiC Schottky body diodes
- Integrated DC capacitor
- Temperature sensor

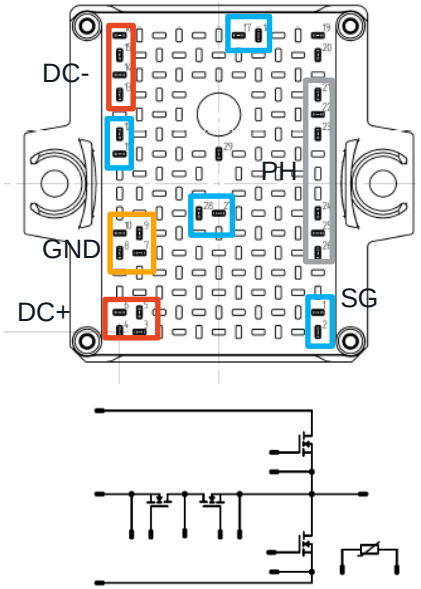
Housing:
- 12mm and 17mm height
- Solder and press-fit pins with Thermo-mechanical push-and-pull force relief
- Convex shaped substrate for superior thermal contact
- Pre-applied phase change material

05 / Power Modules for DC Charger
flowMNPC E2 Product Description

Pinout for product family LS2x equivalent to IFX*

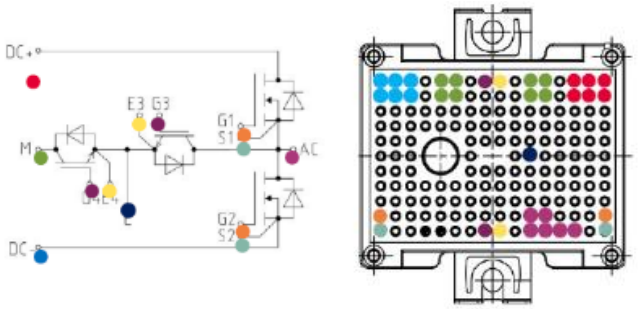
flow E2 housing

flowNPFC E2 SiC



*Not optimal pinout for high frequency operation

New IFX pinout for NPC2 available e.g. F3L8MR12W2M1H(P)_B11



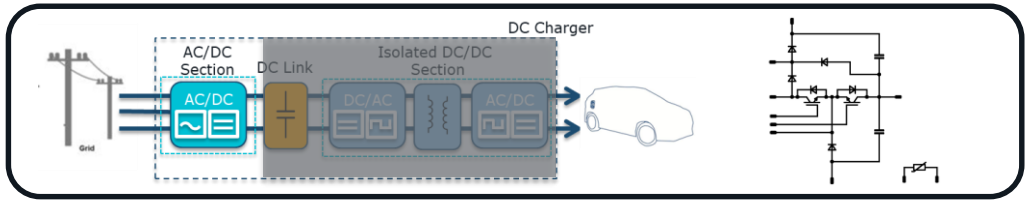
Function:
Neutral Power Factor Corrector (NPFC)

Features:
- SiC MOSFET Gen3 chip technology for high speed switching and highest efficiency
- For Bidirectional Chargers
- Integrated DC capacitors and gate resistors optional
- Temperature sensor

Housing:
- 12mm height
- Solder and press-fit pins with Thermo-mechanical push-and-pull force relief
- Convex shaped substrate for superior thermal contact
- Pre-applied phase change material

05 / Power Modules for DC Charger

3L Three-phase PFC: flowANPFC Product Line (Advanced T-Type PFC)



Voltage	Product Line	Technology	Product Family	Part Number	I_{Cnom} [A]			Application Power rating*	2022				2023				2024			
					30	50	100		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
650V	flowANPFC 0	IGBT fast	LK3x	10-PZ07ANA100RG02-LK39L88Y				Up to 22 kW												
		IGBT fast/SiC SBD		10-PZ07ANA100RG03-LK39L38Y				Up to 27 kW												
	flowANPFC 1	IGBT fast/SiC SBD	LH2x	10-PY07ANA100RG01-LH23L68Y				Up to 35 kW												
		IGBT S5/SiC SBD						Up to 50 kW												
	flow3xANPFC 1	IGBT fast	LK1x	10-FY073AA030RG02-LK12L08 10-FY073AA050RG01-LK14L08				Up to 11 kW												
		IGBT fast/SiC SBD		10-PY073AA050RG02-LK14L03Y				Up to 15 kW												
	flow3xANPFC 2	IGBT fast/SiC SBD	LN5x	30-PT073AA100SM02-LN55L88Y				Up to 30 kW												

Voltage	Product Line	Technology	Product Family	Part Number	RDSon [mOhm]			Application Power rating*	2022				2023				2024			
					11	15	22,5		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
650V	flowANPFC 1 SiC	IGBT fast/SiC SBD	LH2x					Up to 60 kW												

SiC Inside

Ongoing R&D Project

Product Concept

Serial Status

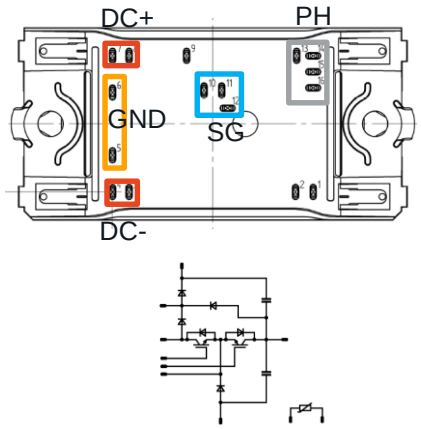
*Assuming a typical charging operation point: Vin 230V, Vout 700V, fsw 45kHz, Ths 80°C

Detailed product portfolio available at VIN web page: https://www.vincotech.com/products/by-topology/topology/pfc-three-phase-applications.html

flowANPFC 0/1 Product Description

flowANPFC 0

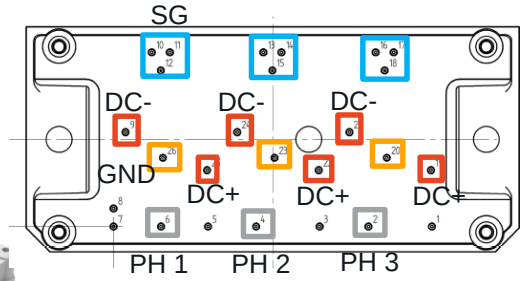
Pinout for product family LK3x



flow 0 housing

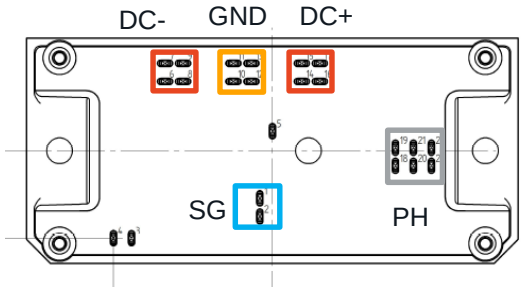
flow3xANPFC 1

Pinout for product family LK1x

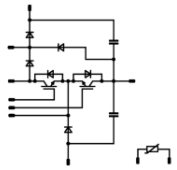


flow 1 housing

flowANPFC 1



Pinout for product family LH2x



Function:
Advanced Neutral PFC (ANPFC)

Features:

- Three-level high efficient topology
- Fast IGBT chip technology for high speed switching and high efficiency
- With fast recovery diodes or SiC Schottky body diodes
- Integrated DC capacitor
- Temperature sensor

Housing:

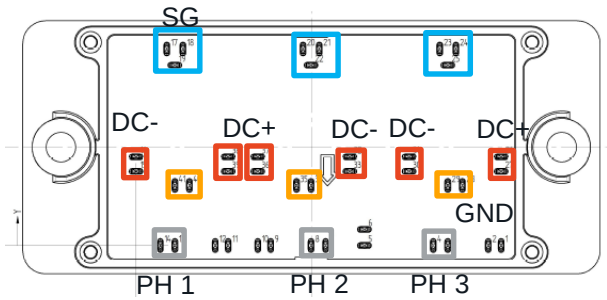
- 12mm and 17mm height
- Solder and press-fit pins with Thermo-mechanical push-and-pull force relief
- Convex shaped substrate for superior thermal contact
- Pre-applied phase change material

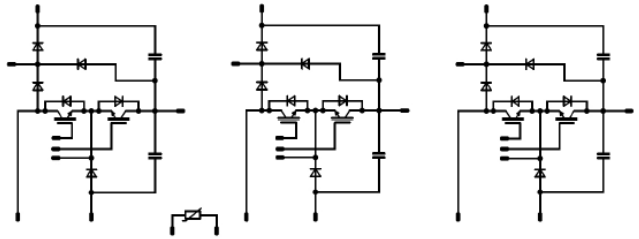
flowANPFC 2 Product Description

flow3xANPFC 2

flow 2 housing

Pinout for product family LN5x





Function:
Advanced Neutral PFC (ANPFC)

Features:

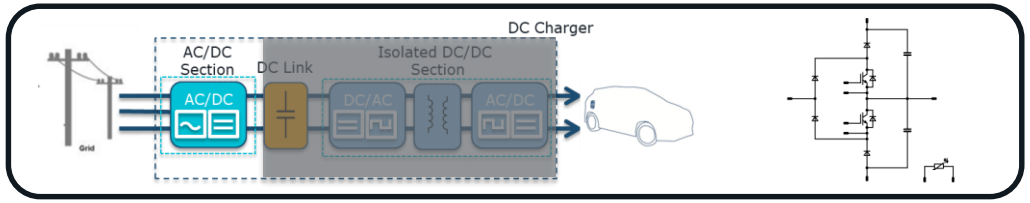
- Three-level high efficient topology
- Fast IGBT chip technology for high speed switching and high efficiency
- With fast recovery diodes or SiC Schottky body diodes
- Integrated DC capacitor
- Temperature sensor

Housing:

- 12mm height housing
- Solder and press-fit pins with Thermo-mechanical push-and-pull force relief
- Convex shaped substrate for superior thermal contact
- Pre-applied phase change material

05 / Power Modules for DC Charger

3L Three-phase PFC: flowSPFC Product Line (Advanced I-Type PFC)



Voltage	Product Line	Technology	Product Family	Part Number	I_{Cnom} [A]			Application Power rating*	2022				2023				2024			
					50	75	100		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
650V	flowSPFC 0	IGBT H5	L52x	10-FZ071SA050SM02-L524L18 10-FZ071SA075SM02-L525L18 10-FZ071SA100SM02-L526L18				Up to 25 kW												
		IGBT S5		10-FZ071SA075S501-L525L58				Up to 22 kW												

Voltage	Product Line	Technology SiC Inside	Product Family	Part Number	RDSon [mOhm]			Application Power rating*	2022				2023				2024			
					11	15	22,5		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
650V	flowSPFC 1 SiC	SiC MOSFET/SiC SBD						Up to 60 kW												

Ongoing R&D Project

Product Concept

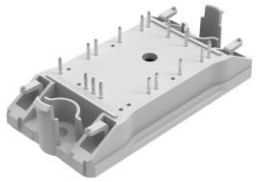
Serial Status

Detailed product portfolio available at VIN web page: https://www.vincotech.com/products/by-topology/topology/pfc-three-phase-applications.html

*Assuming a typical charging operation point: Vin 230V, Vout 700V, fsw 45kHz, Ths 80°C

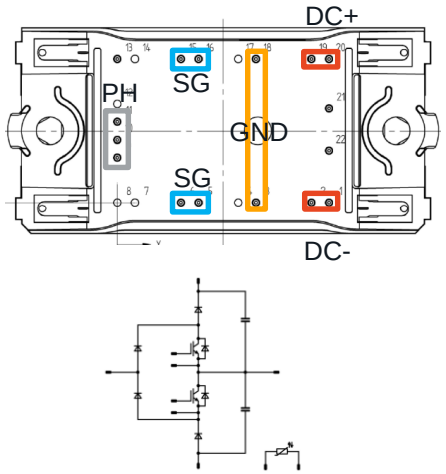
05 / Power Modules for DC Charger
flowSPFC 0 Product Description

Pinout for product family L52x



flow 0 housing

flowSPFC 0



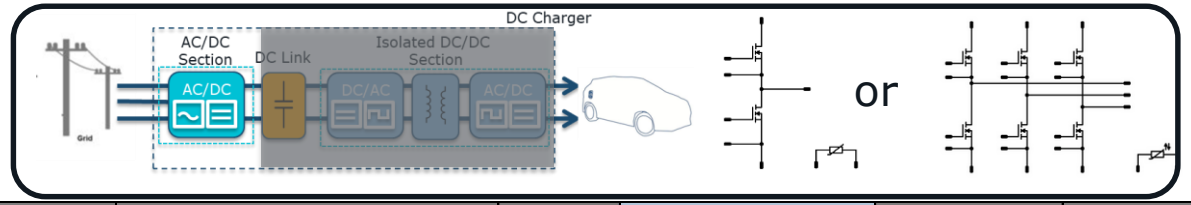
Function:
Symmetric Power Factor Corrector (SPFC)

Features:
- Trenchstop5 H5/S5 chip technology for high speed switching and high efficiency
- With fast recovery diodes or SiC Schottky body diodes
- Kelvin Emitter for improved switching performance
- Integrated DC capacitor
- Temperature sensor

Housing:
- 12mm and 17mm height
- Solder and press-fit pins with Thermo-mechanical push-and-pull force relief
- Convex shaped substrate for superior thermal contact
- Pre-applied phase change material

05 / Power Modules for DC Charger

2L Three-phase PFC: fastDUAL and flowPACK Product Line



Voltage	Product Line	Technology	Part Number	Product Family	R_{DSon} [mOhm]					Application Power rating*	2022				2023				2024			
					2	5	8	16	32		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1200V	flowDUAL E1 SiC	SiC MOSFET Gen3	10-EZ122PA016ME-LJ67F68T	LJ6x						up to 40 kW												
	flowDUAL E1 SiC	SiC MOSFET Gen3	10-EZ122PB032ME-PE07F18T	PE0x New																		
	flowDUAL E2 SiC	SiC MOSFET Gen3	10-EY122PA005ME-LU39F08T 10-EY122PA008ME-LU38F08T	LU3x						> 50 kW												
	flowDUAL E3 SiC	SiC MOSFET Gen3																				

Voltage	Product Line	Technology	Part Number	Product Family	R_{DSon} [mOhm]					Application Power rating*	2022				2023				2024			
					16	20	35	40	75		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1200V	flowPACK 1 SiC	SiC MOSFET Gen3	10-PY126PA016ME-L227F13Y	L22x						up to 22 kW												
	flowPACK 1 SiC	SiC MOSFET Gen3	10-PY126PA040MR-L226F28Y 10-PY126PA020MR-L227F28Y							up to 22 kW												
	flowPACK E1 SiC	SiC MOSFET Gen3	10-EZ126PB075ME-LS17F08T	LS1x						up to 11 kW												
900V	flowPACK 1 SiC	SiC MOSFET Gen3	10-PY096PA035ME-L224F18Y	L22x						up to 22 kW												

Ongoing R&D Project

Product Concept

Serial Status

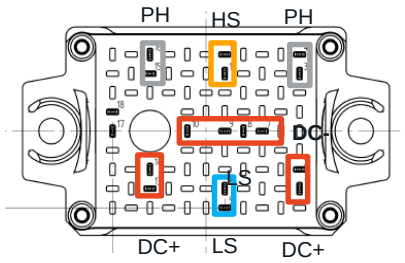
Detailed product portfolio available at VIN web page:
https://www.vincotech.com/products/by-topology/topology/sixpack.html
https://www.vincotech.com/products/by-topology/topology/half-bridge.html

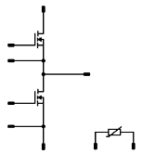
*Assuming a typical charging operation point: Vin 230V, Vout 700V, fsw 40kHz, Ths 80°C

*flow*DUAL SiC E1/E2 (Half-Bridge) Product Description

*flow*DUAL E1 SiC

flow E1 housing

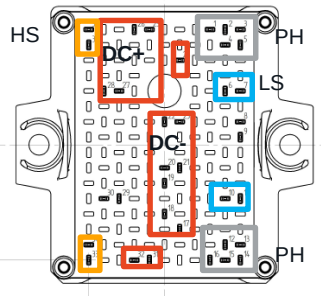


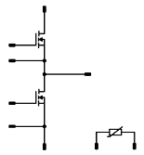


Pinout for product family LJ6x (equivalent to FF11MR12W1M1_B11 and FF23MR12W1M1_B11; not equivalent to FF45MR12W1M1_B11)

*flow*DUAL E2 SiC

flow E2 housing





Pinout for product family LU3x (equivalent to FFxxMR12W2M1_B11)

Function:
Half-Bridge

Features:
- Latest SiC chip technologies for high switching and high efficiency
- Kelvin emitter for improved switching performance
- Industry standard pinout
- Temperature sensor

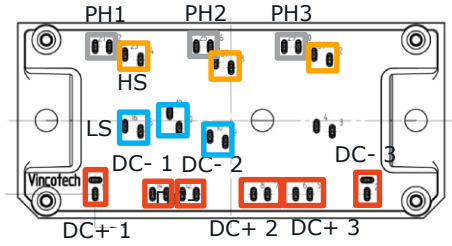
Housing:
- Industry standard 12mm housing
- Solder and press-fit pins with Thermo-mechanical push-and-pull force relief
- Convex shaped substrate for superior thermal contact
- Pre-applied phase change material

05 / Power Modules for DC Charger
*flow*PACK SiC 1/E1 (Sixpack) Product Description

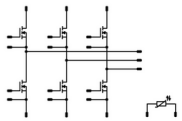
Vincotech

flowPACK 1 SiC

flow 1 housing



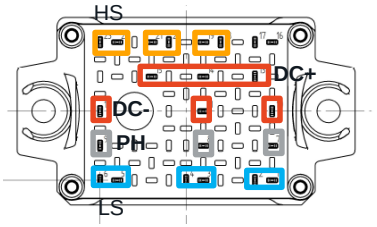
Pinout for product family L22x

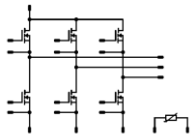


*flow*PACK E1 SiC

flow E1 housing

Pinout for product family LS1x (equivalent to FSxxMR12W1M1_B11)



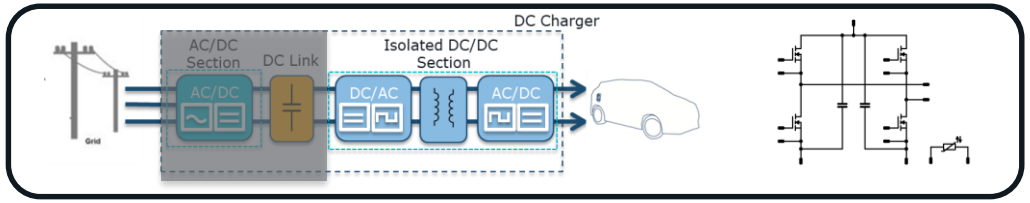


Function:
Sixpack

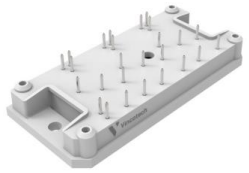
Features:
- Latest SiC chip technologies for high switching and high efficiency
- Sixpack with three separated legs
- Kelvin Emitter for improved switching performance
- Industry standard pinout
- Temperature sensor

Housing:
- 12mm and 17mm height
- Solder and press-fit pins with Thermo-mechanical push-and-pull force relief
- Convex shaped substrate for superior thermal contact
- Pre-applied phase change material

05 / Power Modules for DC Charger
DC-DC fastPACK (H-Bridge) Product Line



Voltage	Product Line	Technology	Product Family	Part Number	I_{Cnom} [A]							Application Power rating*	2022				2023				2024			
					15	30	40	50	75	80	100		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1200V	fastPACK 0	IGBT4 HS	P62x, P72x	V23990-P627-F8x-PM 10-FZ124PA040F2-P629F38 V23990-P629-F48-PM V23990-P729-F4x-PM								up to 11 kW												
		IGBT fast H	P62x	10-FZ124PA040F2-P629F38 New								up to 11 kW												
	fastPACK 1	IGBT4 HS	L58x	10-xY124PA040SH-L588F48 10-xY124PA080SH-L589F48								up to 22 kW												
		IGBT fast H		10-FY124PA080F2-L589F38 New								up to 22 kW												
650V	fastPACK 0	IGBT5 H5	P62x, L62x	10-xZ074PA030SM-L623F08x 10-xZ074PA050SM-L624F08 V23990-P623-F5x-PM 10-xx074PA075SM-L625F0xx								up to 22 kW												
		IGBT fast RGW	L62x	10-FZ074PA050RG-L624F88 10-PZ074PA075RG-L625F88Y New								up to 22 kW												
	fastPACK 1	IGBT5 H5	L58x	10-xY074PA100SM-L583Fxx								up to 30 kW												



Ongoing R&D Project

Product Concept

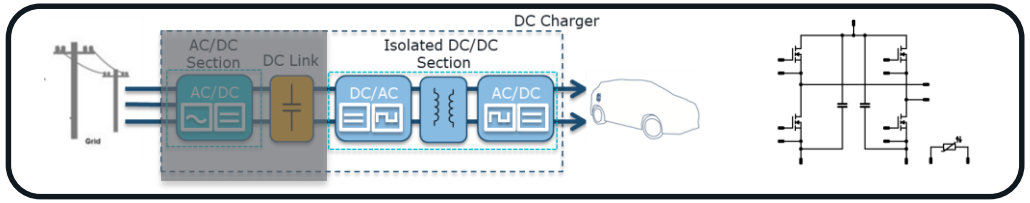
Serial Status

*Assuming a typical charging operation point: Vin 700V, Vout 480V, fsw 100kHz for SiC, Ths 80°C

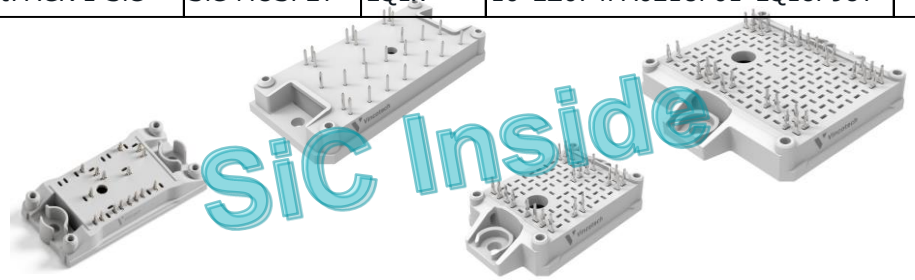
Detailed product portfolio available at VIN web page: https://www.vincotech.com/products/by-topology/topology/h-bridge.html

05 / Power Modules for DC Charger

DC-DC fastPACK SiC (H-Bridge) Product Line



Voltage	Product Line	Technology	Product Family	Part Number	R_{DSon} [mOhm]									Application Power rating*	2022				2023				2024			
					11	16	17	18	20	32	35	40	75		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1200V	fastPACK 0 SiC	SiC MOSFET Gen3	L62x	10-PZ124PA032ME03-L629F98Y 10-PZ124PA075ME03-L627F28Y										up to 11 kW												
	fastPACK E1 SiC	SiC MOSFET Gen3	LQ1x	10-EZ124PA016ME-LQ18F18T 10-EZ124PA032ME-LQ17F18T										up to 25 kW												
		SiC MOSFET Gen4	LR0x	10-EZ124PA018MR-LR09F08T New										up to 22 kW												
	fastPACK 1 SiC	SiC MOSFET Gen3	L58x											up to 50 kW												
	fastPACK E2 SiC	SiC MOSFET Gen3	LP4x	10-EY124PA011ME-LP40F18T 10-EY124PA016ME-LP49F18T										up to 50 kW												
950V	fastPACK 0 SiC	SiC MOSFET Gen3	L62x	10-xx094PB017ME02-L620F3xx 10-PC094PB035ME02-L629Fx6Y										up to 16 kW												
650V	fastPACK 1	Si MOSFET CFD7	L58x	10-PY064PA020F7-L582L88Y New 10-PY064PA040F7-L581L88Y																						
	fastPACK 1 SiC	SiC MOSFET	LQ1x	10-EZ074PA021UF01-LQ18F98T										up to 15 kW												



Ongoing R&D Project

Product Concept

Serial Status

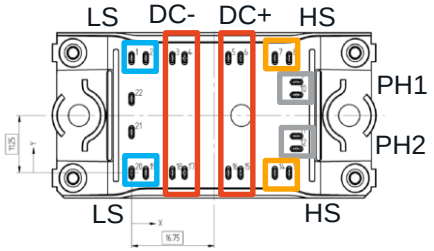
*Assuming a typical charging operation point: Vin 700V, Vout 480V, fsw 100kHz for SiC, Ths 80°C

Detailed product portfolio available at VIN web page: https://www.vincotech.com/products/by-topology/topology/h-bridge.html

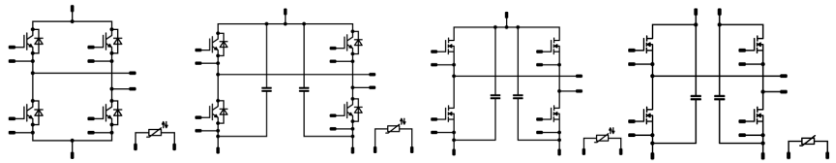
05 / Power Modules for DC Charger
*fast*PACK 0/1 SiC (H-Bridge) Product Description

fastPACK 0 / fastPACK 0 SiC

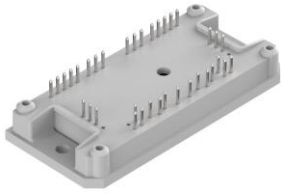
flow 0 housing



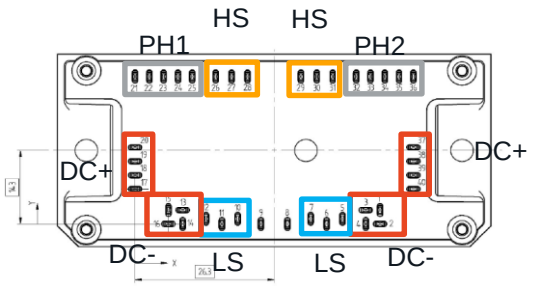
Pinout for product family P62x, P72x, L62x



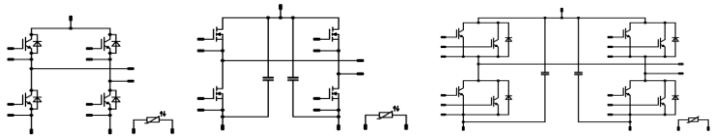
fastPACK 1; fastPACK 1 SiC



flow 1 housing



Pinout for product family L58x



Function:
H-Bridge (full bridge)

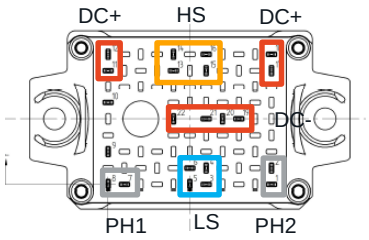
Features:
- Latest Si and SiC chip technologies for high switching and high efficiency
- Integrated DC capacitor
- Open emitter configuration
- Kelvin emitter for improved switching performance
- Temperature sensor

Housing:
- 12mm and 17mm height
- Solder and press-fit pins with Thermo-mechanical push-and-pull force relief
- Convex shaped substrate for superior thermal contact
- Pre-applied phase change material

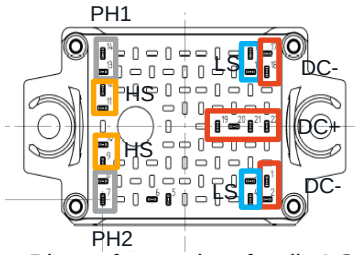
05 / Power Modules for DC Charger
*fast*PACK E1/E2 SiC (H-Bridge) Product Description

Vincotech

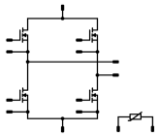
fastPACK E1 / fastPACK E1 SiC



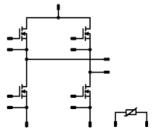
Pinout for product family LR0x (equivalent to F4-xxMR12W1M1_B11)



Pinout for product family LQ1x (equivalent to F4-xxMR12W1M1_B76; improved pinout)

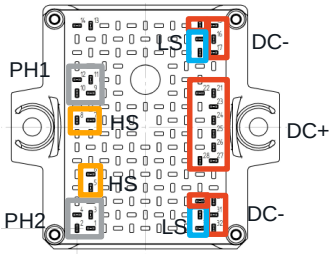


flow E1 housing

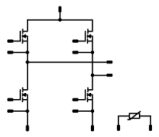


fastPACK E1; fastPACK E1 SiC

flow E2 housing



Pinout for product family LP4x (equivalent to F4-xxMR12W2M1_B11; not released at IFX web page yet)



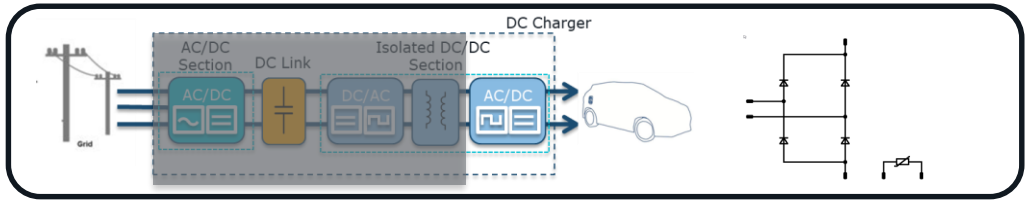
Function:
H-Bridge (Full Bridge)

Features:
- Latest Si and SiC chip technologies for high switching and high efficiency
- Integrated DC capacitor
- Open emitter configuration
- Kelvin emitter for improved switching performance
- Industry standard pinout
- Temperature sensor

Housing:
- Industry standard 12mm housing
- Solder and press-fit pins with Thermo-mechanical push-and-pull force relief
- Convex shaped substrate for superior thermal contact
- Pre-applied phase change material

05 / Power Modules for DC Charger

DC-DC fastPACK (Ultrafast Rectifier) Product Line

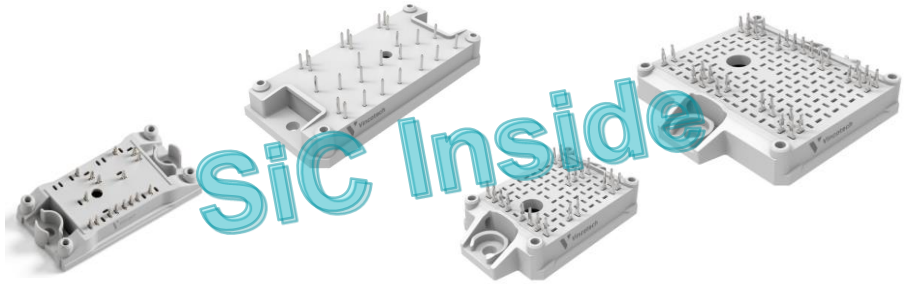


Voltage	Product Line	Technology	Product Family	Part Number	I_{Cnom} [A]									Application Power rating*	2022				2023				2024			
					10	18	20	30	60	80	100	120	160		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1700V	fastPACK E1 SiC	SiC SBD	LS0x	10-EZ174RA018RO-LS07J83T										up to 13 kW												
1200V	fastPACK 0 SiC	SiC SBD	LH0x	10-PZ12ORA100RO-LH00J88Y										up to 30 kW												
	fastPACK 1	Fast Diode	LH0x	10-PY120RA060VH-LJ92I08Y 10-PY120RA060VH01-LJ92I03Y 10-PY12ORA100CA-LJ95I03Y 10-PY12ORA120VH-LJ96I03Y										up to 35 kW												
	fastPACK 1 SiC	SiC SBD	LJ5x											up to 50 kW												
	fastPACK E1 SiC	SiC SBD	LS0x	10-EZ124RA010RO-LS06J88T 10-EZ124RA030RO-LS08J88T										up to 25 kW												
	fastPACK E2 SiC	SiC SBD	LP4x											up to 50 kW												
650V	fastPACK 0 SiC	SiC SBD	LH0x	10-PZ07O2A020RO-LH01J88Y										up to 15 kW												
	fastPACK 1	Fast Diode	LJ5x	10-PG07ORA160RF-LJ53I88T										up to 50 kW												

Ongoing R&D Project

Product Concept

Serial Status



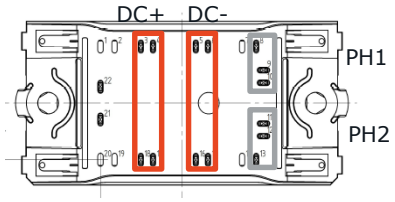
*Assuming a typical charging operation point: Vin 700V, Vout 480V, fsw 100kHz for SiC, Ths 80°C

Detailed product portfolio available at VIN web page: https://www.vincotech.com/products/by-topology/topology/ultrafast-rectifier.html

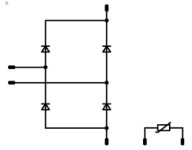
*fast*PACK 0/1 SiC (Ultrafast Rectifier) Product Description

fastPACK 0 / fastPACK 0 SiC

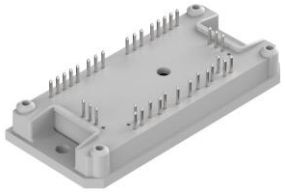
flow 0 housing



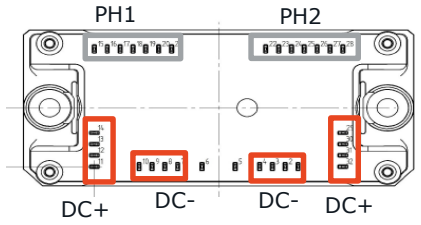
Pinout for product family LH0x



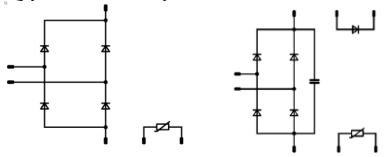
fastPACK 1; fastPACK 1 SiC



flow 1 housing



Pinout for product family LJ5x (LJ9x with bypass Diode)*



Function:
Bridge Rectifier

Features:
- Latest Si (fast) and SiC chip technologies for high switching and high efficiency
- Integrated DC capacitor
- Optional bypass diode
- Thin DCB for enhanced thermal performance
- Temperature sensor

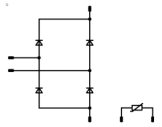
Housing:
- 12mm and 17mm height
- Solder and press-fit pins with Thermo-mechanical push-and-pull force relief
- Convex shaped substrate for superior thermal contact
- Pre-applied phase change material

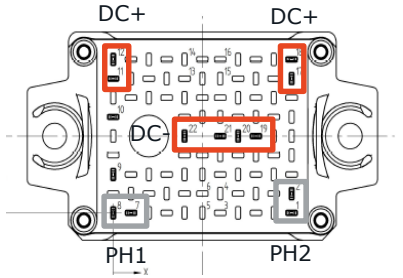
**Thin DCB and thin pin (T)*

*fast*PACK E1 SiC (Ultrafast Rectifier) Product Description

fastPACK E1 / fastPACK E1 SiC

flow E1 housing





Pinout for product family LS0x (equivalent to DDB2UxxN12W1RF_B11)

Function:
H-Bridge (Full Bridge)

Features:

- Latest Si (fast) and SiC chip technologies for high switching and high efficiency
- Integrated DC capacitor
- Industry standard pinout
- Temperature sensor

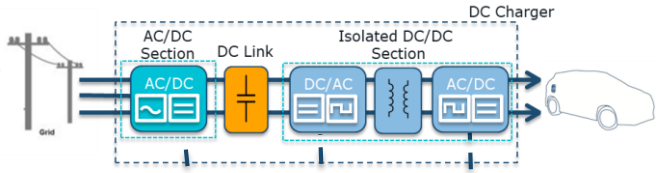
Housing:

- Industry standard 12mm housing
- Solder and press-fit pins with Thermo-mechanical push-and-pull force relief
- Convex shaped substrate for superior thermal contact
- Pre-applied phase change material

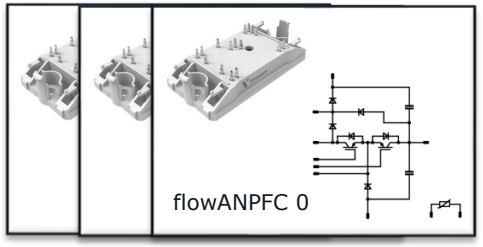
Agenda

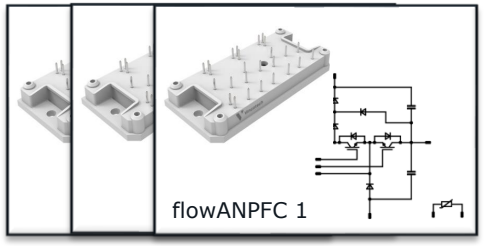
01 / Charger at a Glance
02 / Charger Trends
03 / Charger Market
04 / Power Converter Topologies
05 / Power Modules for DC Charger
06 / DC Charger Concepts – Vincotech reference designs

06 / DC Charger Concepts – Vincotech reference designs
22kW-25kW Uni-directional DC Charger Design Proposals



/ The AC/DC stage would have the highest losses inside the whole system architecture and it should be designed carefully



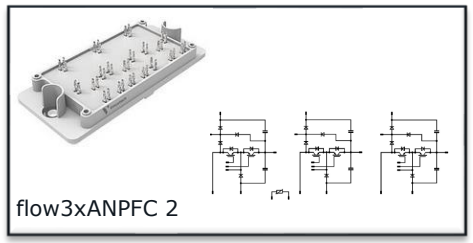


3x 10-PZ07ANA100RG02-LK39L88Y or
3x 10-PZ07ANA100RG03-LK39L38Y
3x 10-PY07ANA100RG01-LH23L68Y

- flowANPFC 0 low cost solution w/o SiC up to fsw 40kHz

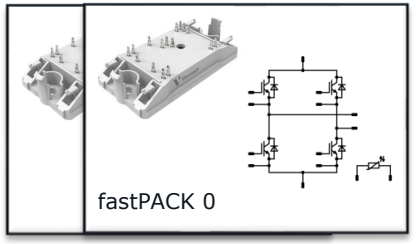
Or

- flowANPFC 0/1 high efficient solution w/ SiC up to fsw 80kHz

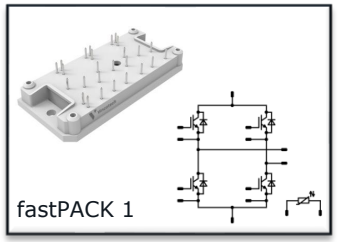


1x 30-PT073AA100SM02-LN55L88Y

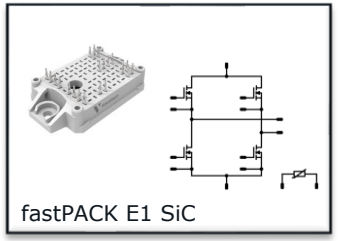
- 1 Module solution
- high efficient w/ SiC up to 80kHz



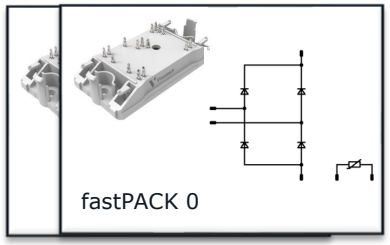
2x 10-PZ074PA030SM-L623F08Y



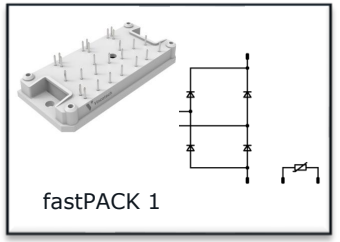
1x 10-PY124PA080SH-L589F48Y



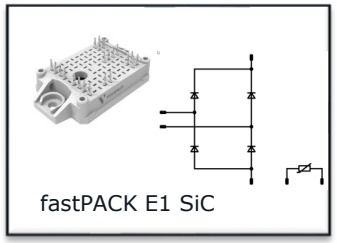
1x 10-EZ124PA018MR-LR09F08T



2x 10-PZ07O2A020RO-LH01J88Y



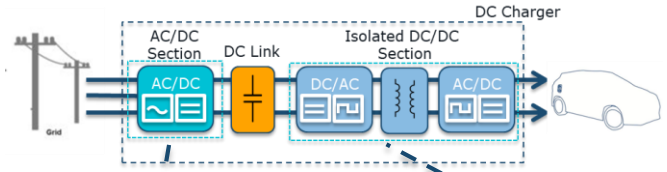
1x 10-PY120RA060VH01-LJ92I03Y

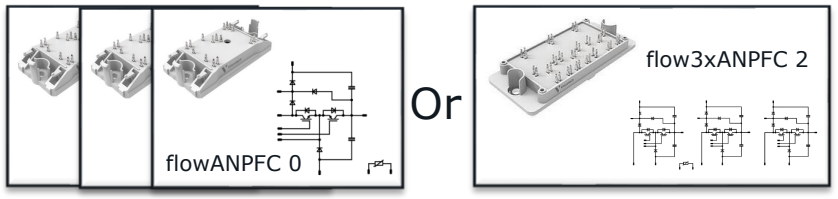


1x 10-EZ124RA030RO-LS08J88T

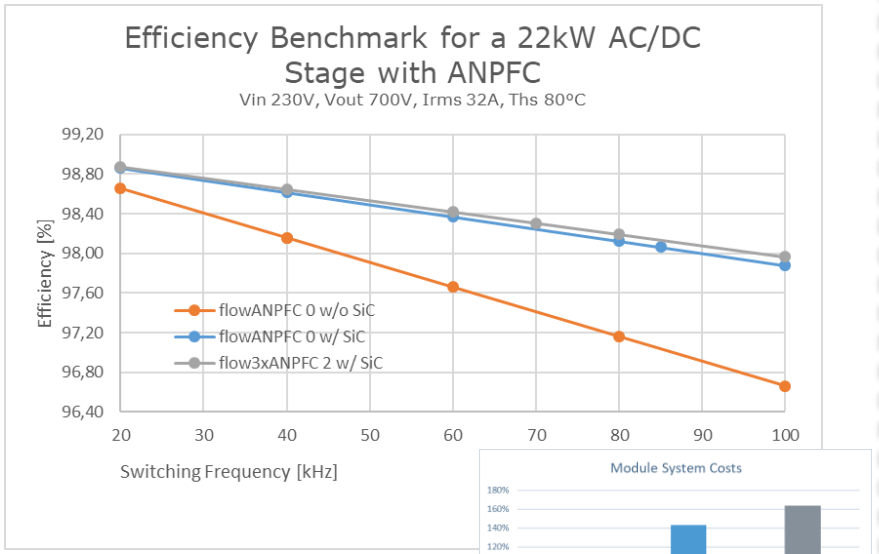
06 / DC Charger Concepts - Vincotech reference designs

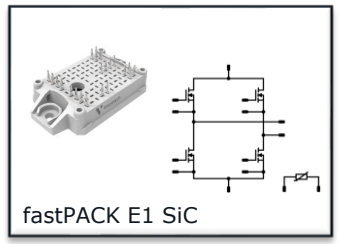
22kW Uni-directional DC Charger Design Proposals

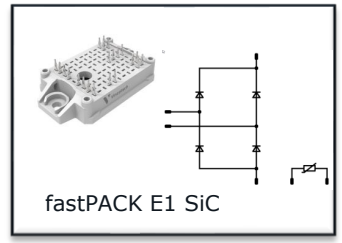




Or





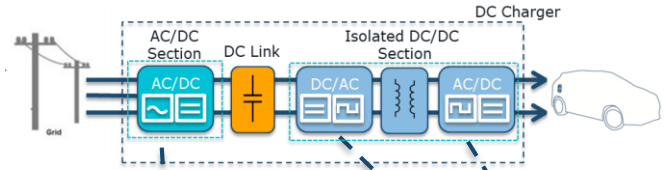


- Estimated efficiency 98.5% at Vin 700V, Vout 480V and fsw 100kHz

/ For a 22kW DC Charger the ANPFC topology is proposed as a high efficiency and cost competitive solution

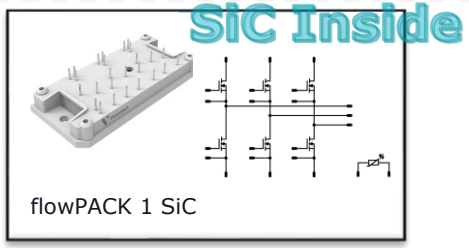
06 / DC Charger Concepts - Vincotech reference designs

25kW full-SiC bi-directional DC Charger Design Proposals

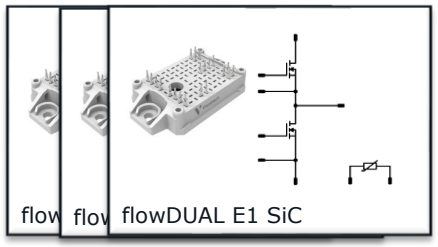


/ Scalable in 25kW steps for higher power

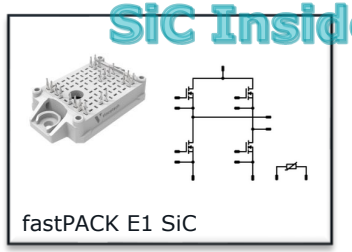
- **1 Module or 3x Module** solution with 2-level topology



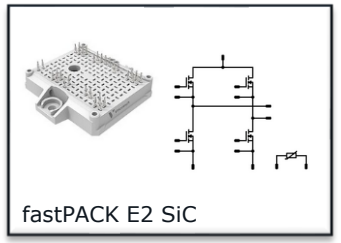
1x 10-PY126PA016ME-L227F13Y



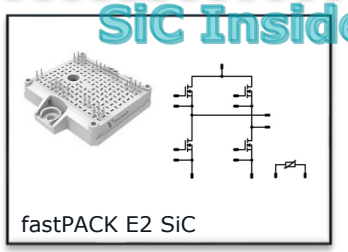
10-EZ122PA016ME-LJ67F68T



1x 10-EZ124PA016ME-LQ18F18T or

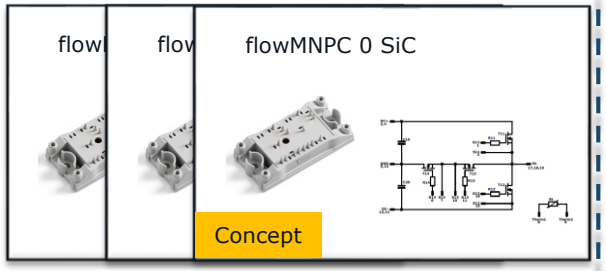


1x 10-EY124PA016ME-LP49F18T



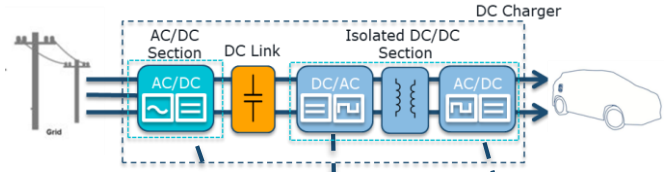
1x 10-EY124PA016ME-LP49F18T

- **3 x Module** solution with 3-level topology



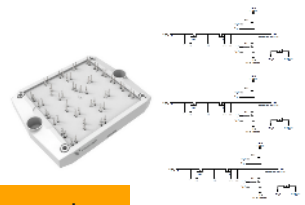
06 / DC Charger Concepts - Vincotech reference designs

50kW Uni-directional DC Charger Design Proposals



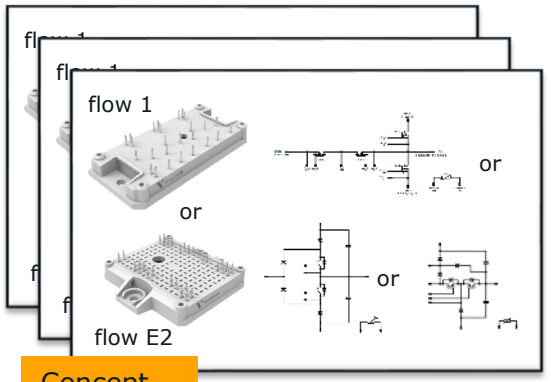
1 Module solution with 3-level topology

flow3xNPFC S3 SiC

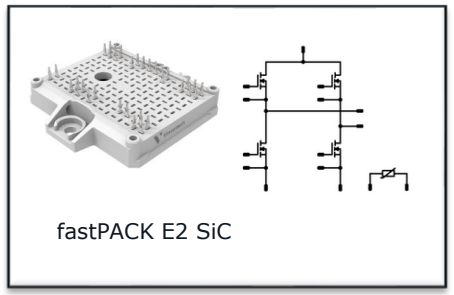


Concept

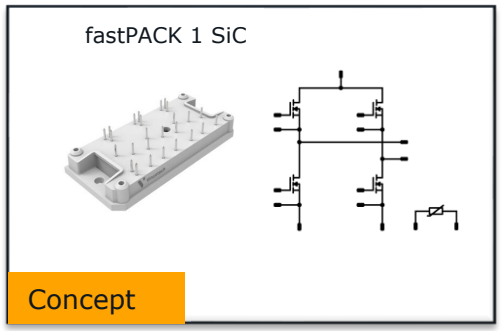
3x Module solution with 3-level topology



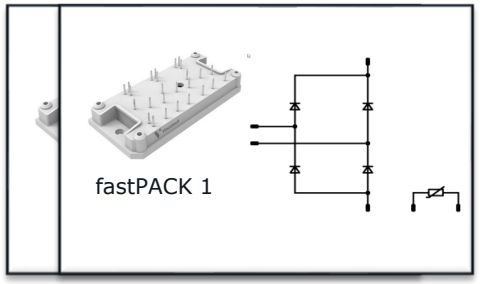
Concept



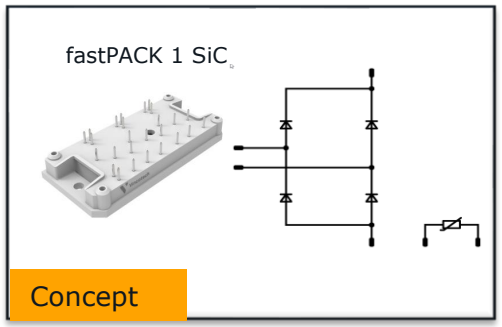
10-EY124PA011ME-LP40F18T



Concept



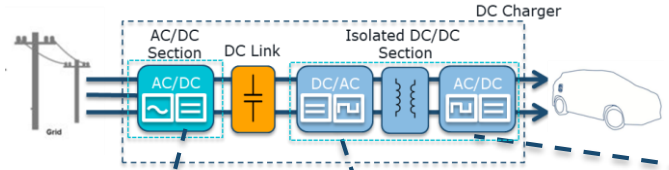
- 2x 10-PG07ORA160RF-LJ53I88T



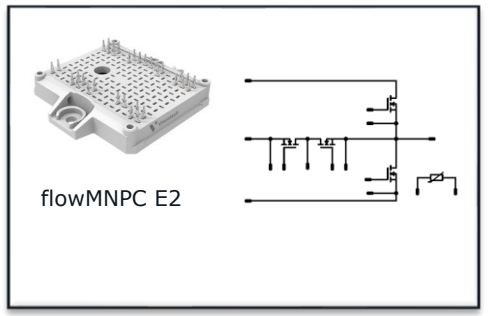
Concept

06 / DC Charger Concepts - Vincotech reference designs

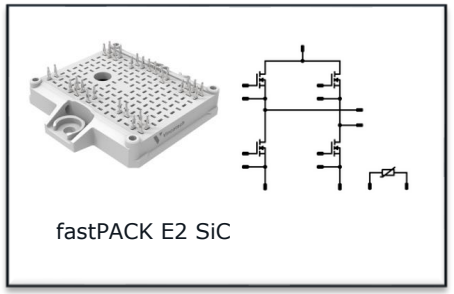
50kW Bi-directional DC Charger Design Proposals



Not recommended for high switching applications



10-EY12NMA011ME30-LS28F18T
10-EY12NMA016ME-LS28F16T



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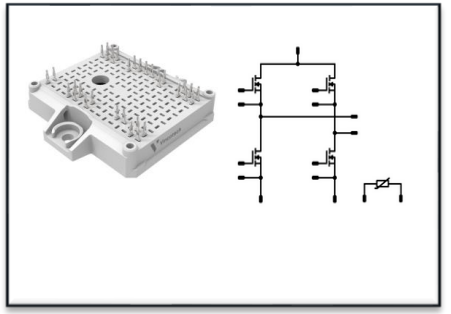

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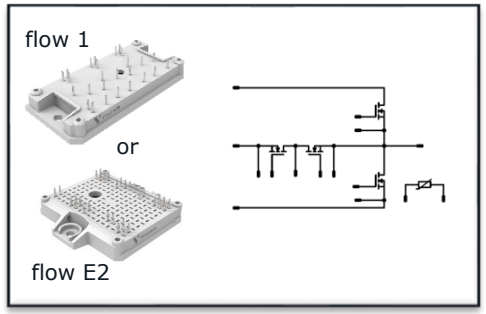
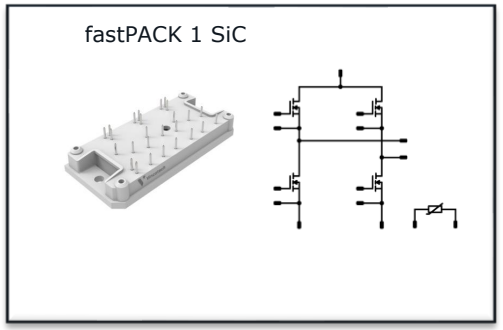
Recommended for high switching applications



Concept



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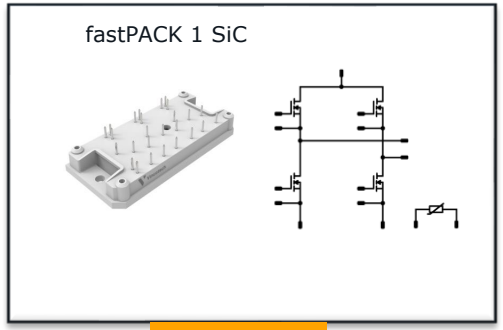
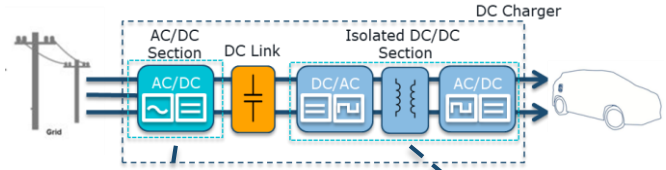


Concept

06 / DC Charger Concepts – Vincotech reference designs

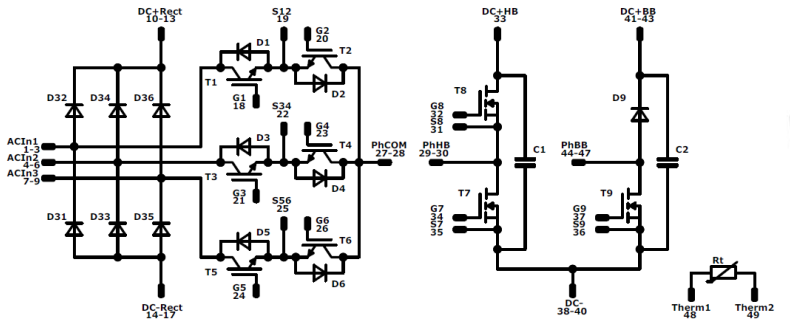
New PFC Concept Proposal for DC Charger

- **New Current Synthesizing PFC (CSPFC) topology** for highest efficiency at lowest total system costs through
  - Reduced number of SiC devices
  - Reduced number and size of the PFC inductors
- **Latest SiC-MOSFET chip technology** for high speed switching and high efficiency up to 100 kHz and >99% respectively
- Bi-directional ready
- Thin Al_2O_3 substrate eases the system's thermal design
- Temperature sensor



Any existing H-Bridge product

flowCSPFC S3



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EMPOWERING **YOUR IDEAS**