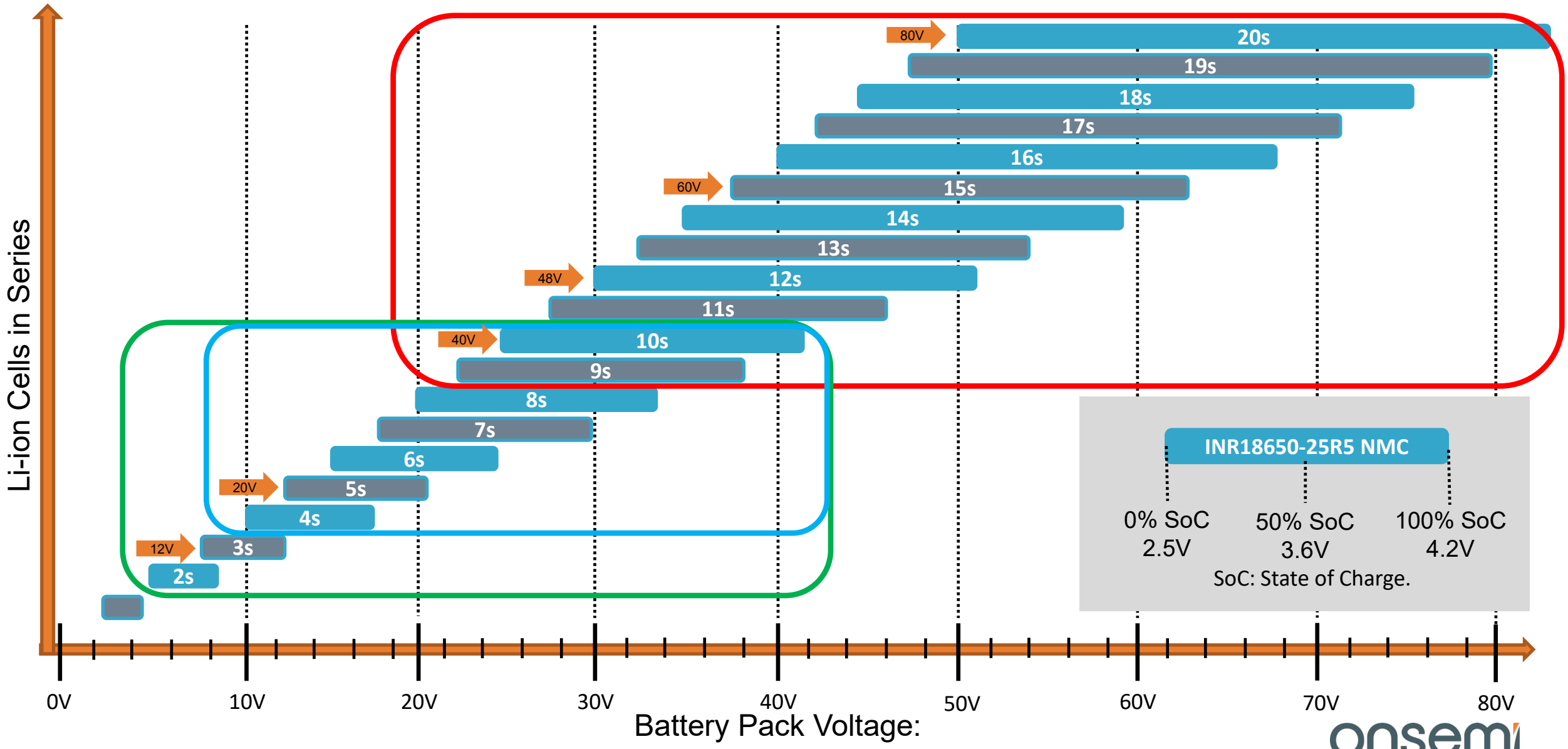
SiC-Based High-Density 1.0-11.0KW-30KW Totem Pole PFC and LLC based Industrial Charger Solutions

Prasad Paruchuri

Typical Applications by Li-ion Battery Packs



The applications of the 600W to 3KW Industrial and Light vehicle charger

The A00 size EV

Electrical Motorcar

Riding Lawn Mower

It's also downward compatible to some industrial applications like:

Automatic grass cutter

AGVs

Electrical tools

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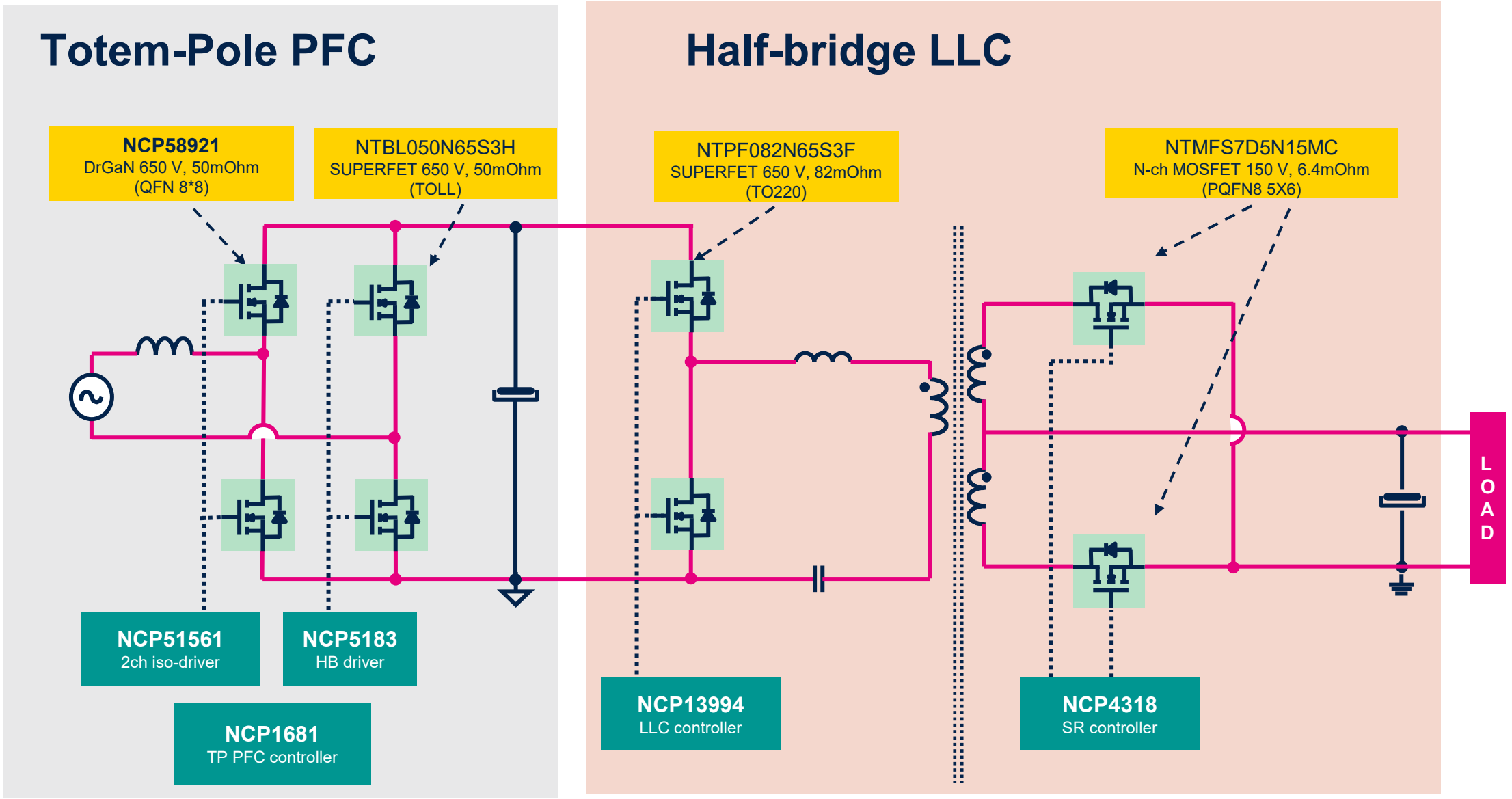
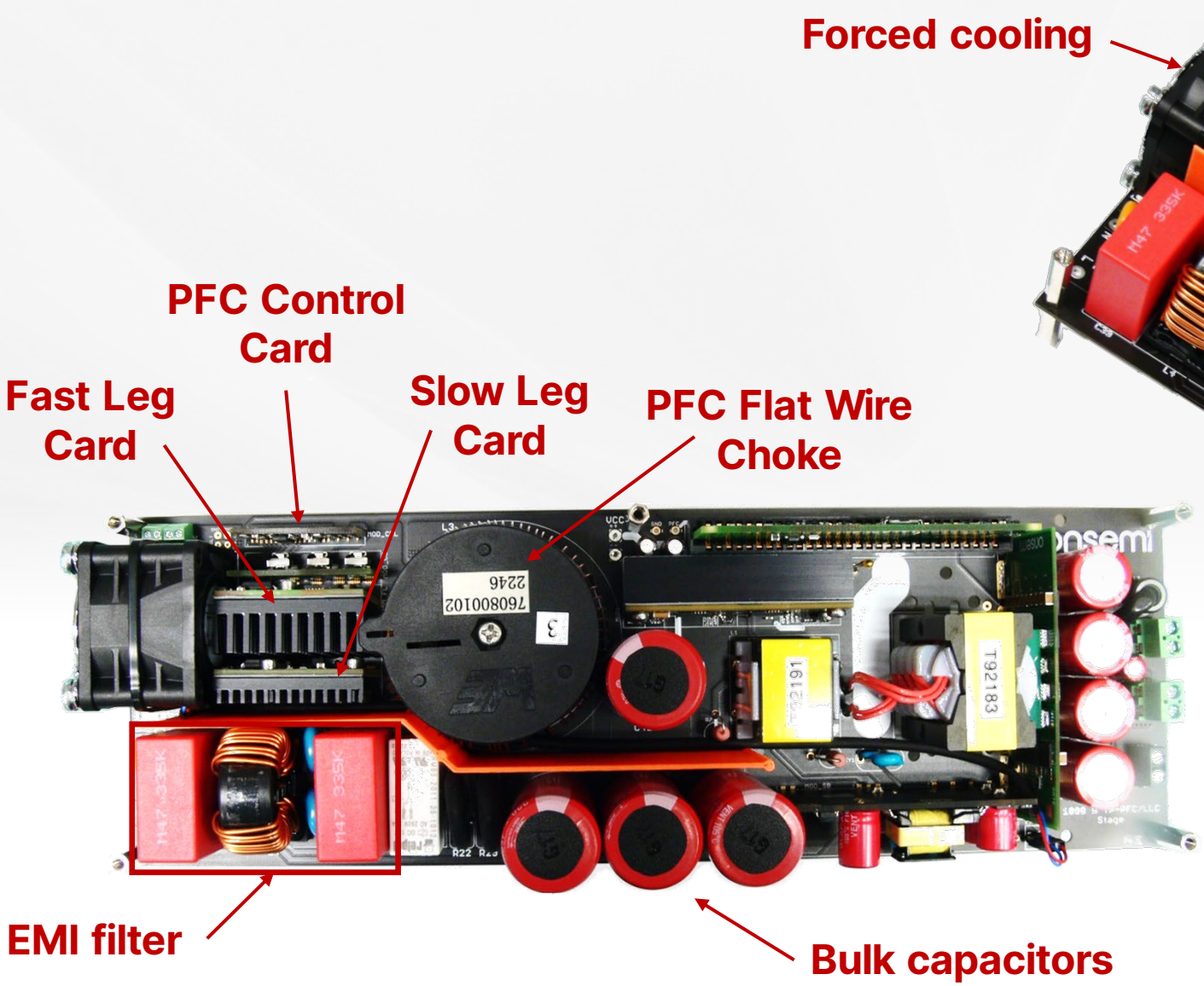
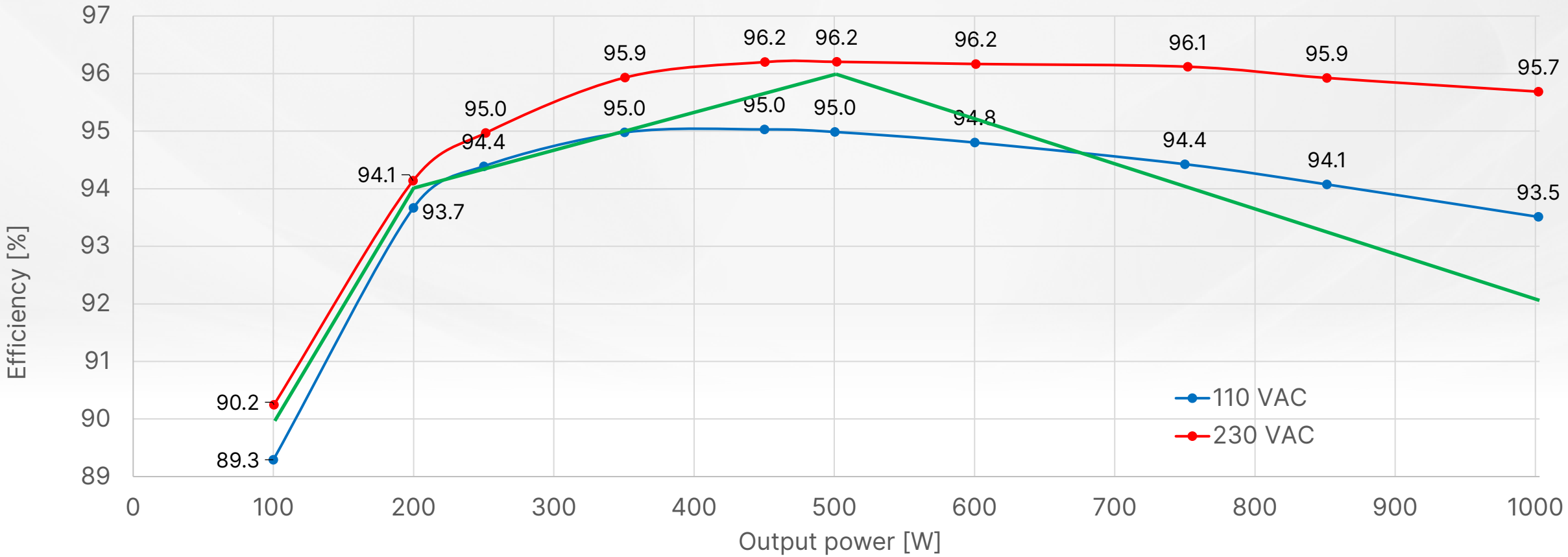
600W to 1KW Charger with TPFC + Half Bridge LLC Topology



1KW TP PFC-LLC Power Stage photograph



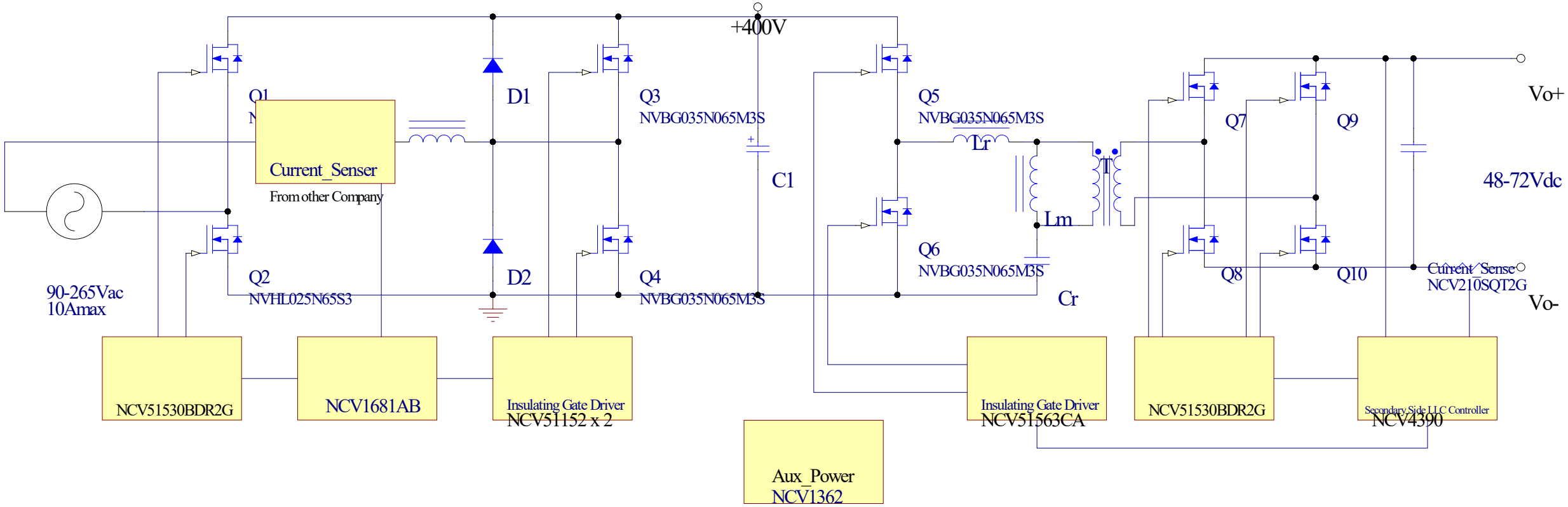
Efficiency vs. Output power



Measured efficiency excluding self-consumption (Without StandBy Card) meets M-CRPS for 230 V_{AC}

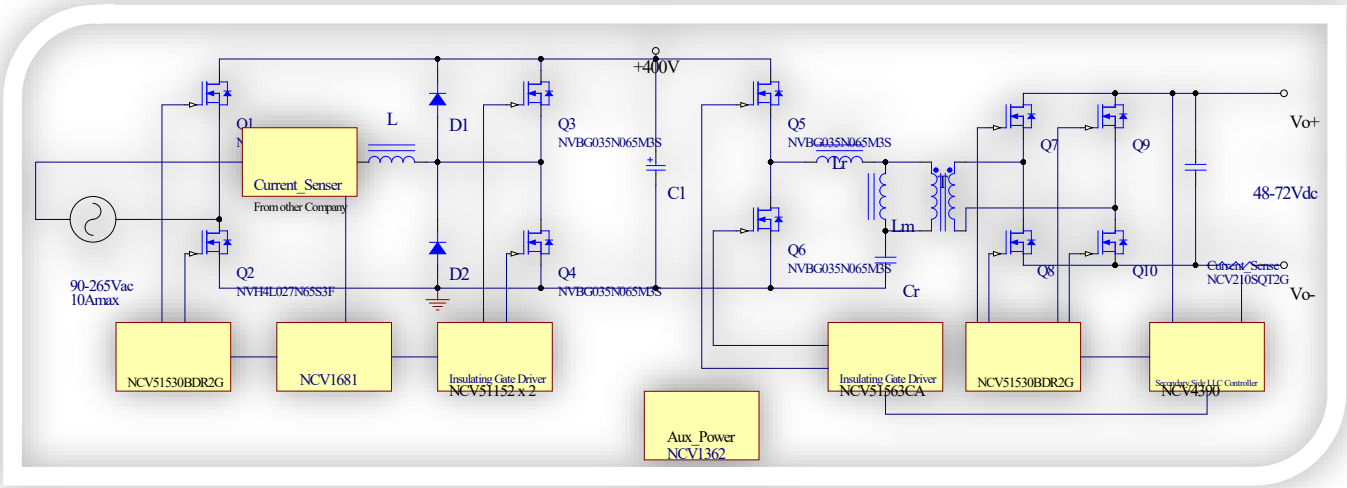
2KW Charger with SiC/GaN

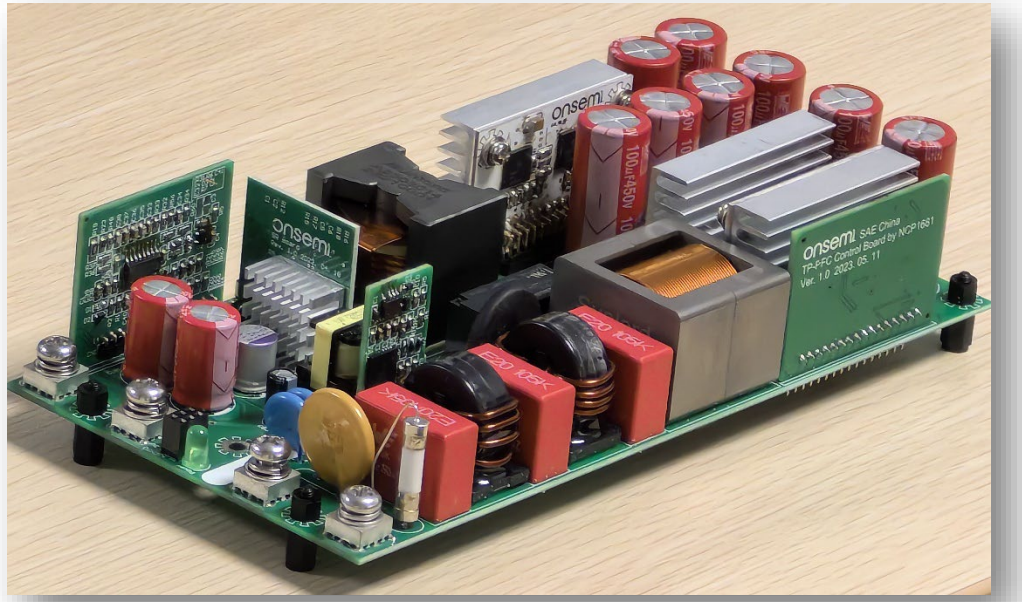
Block Diagram



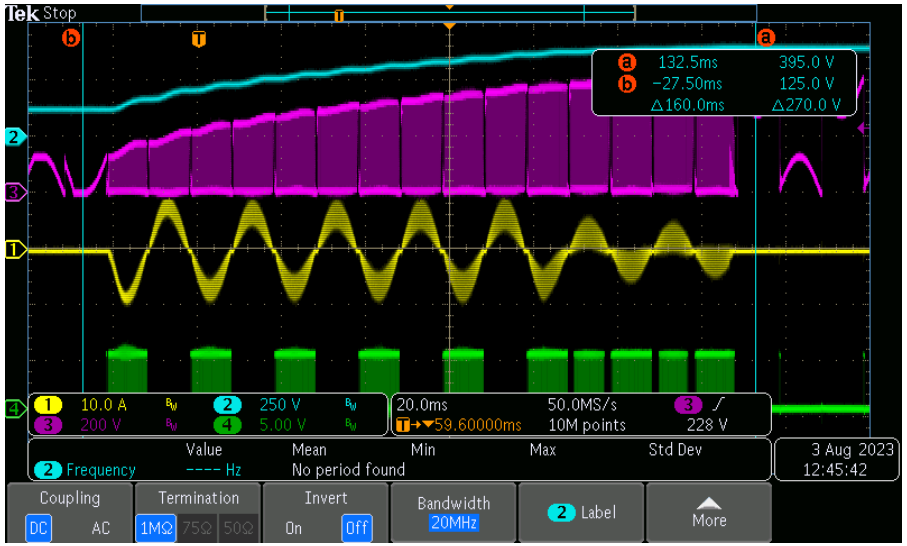
The 2KW Uni-directional EV charger

- Full hardware Control, No digital controller needed.
- 48-72V, 27Amax CC/CV output.
- Totem pole PFC + Half-Bridge LLC + QR flyback auxiliary power supply
- onsemi components including:
  - NCV51563CADWR2G,
  - NCV51152CA,
  - NCV1362AADR2G,
  - NCP1681ABD2R2G,
  - NCV4390DR2G,
  - NCP51530BDR2G,
  - NVBG033N65M3S,
  - NCV210RSQT2G,
  - NCV20072DR2G,
  - NVMFS3D6N10MCLT1G,

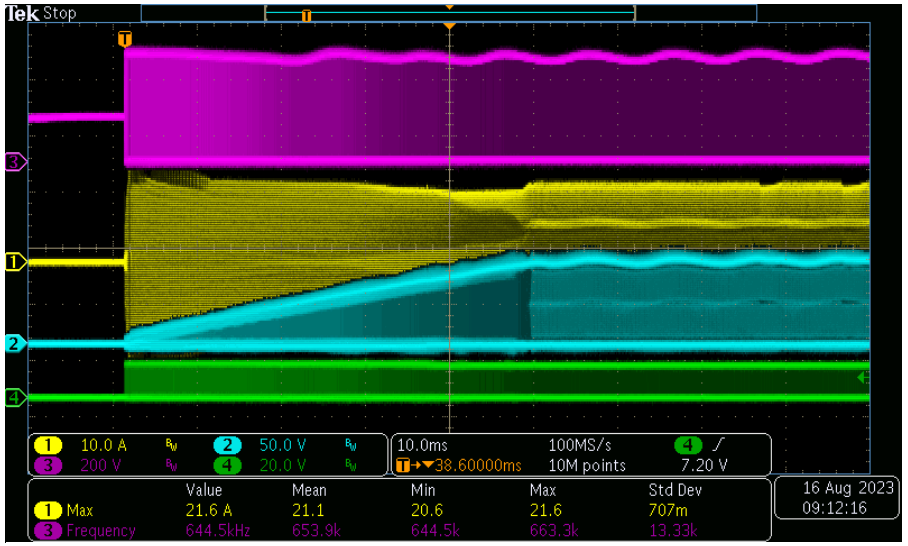




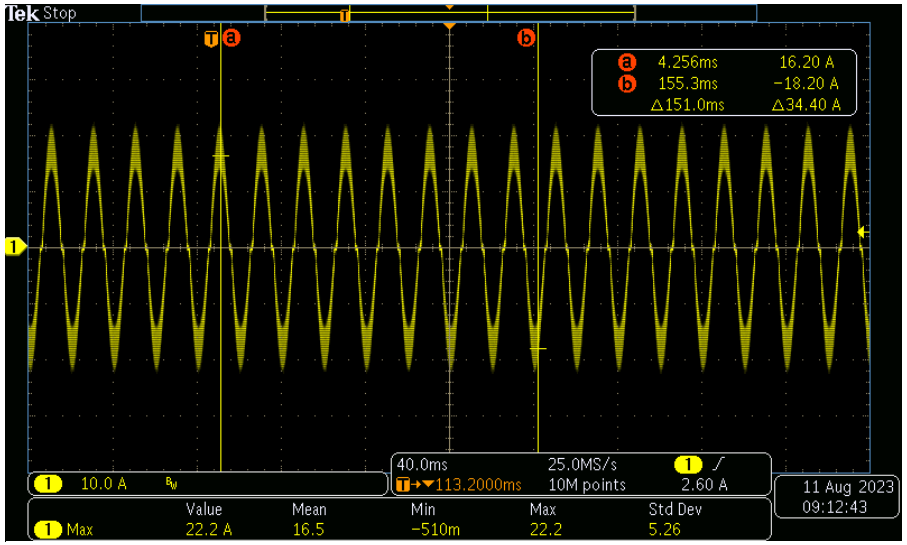
Key Waveforms



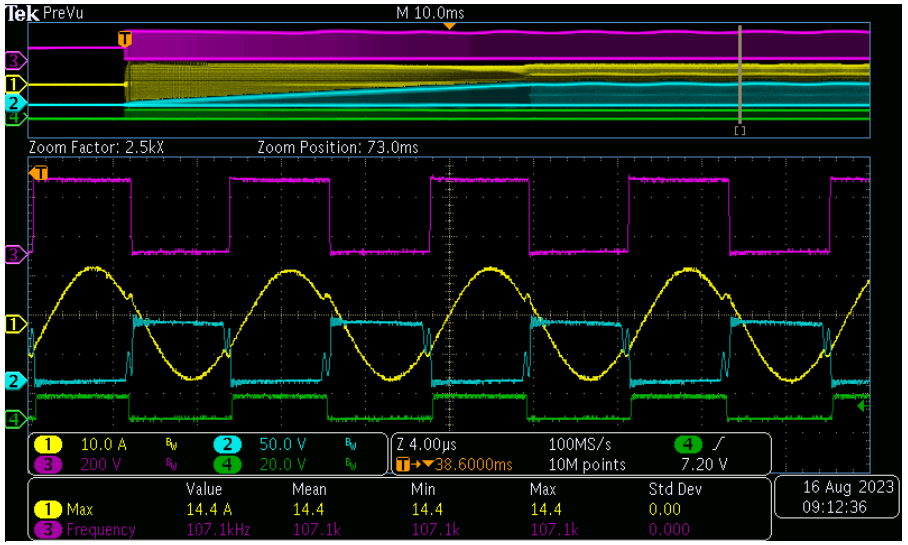
PFC stage powerup



LLC stage startup on heavy load

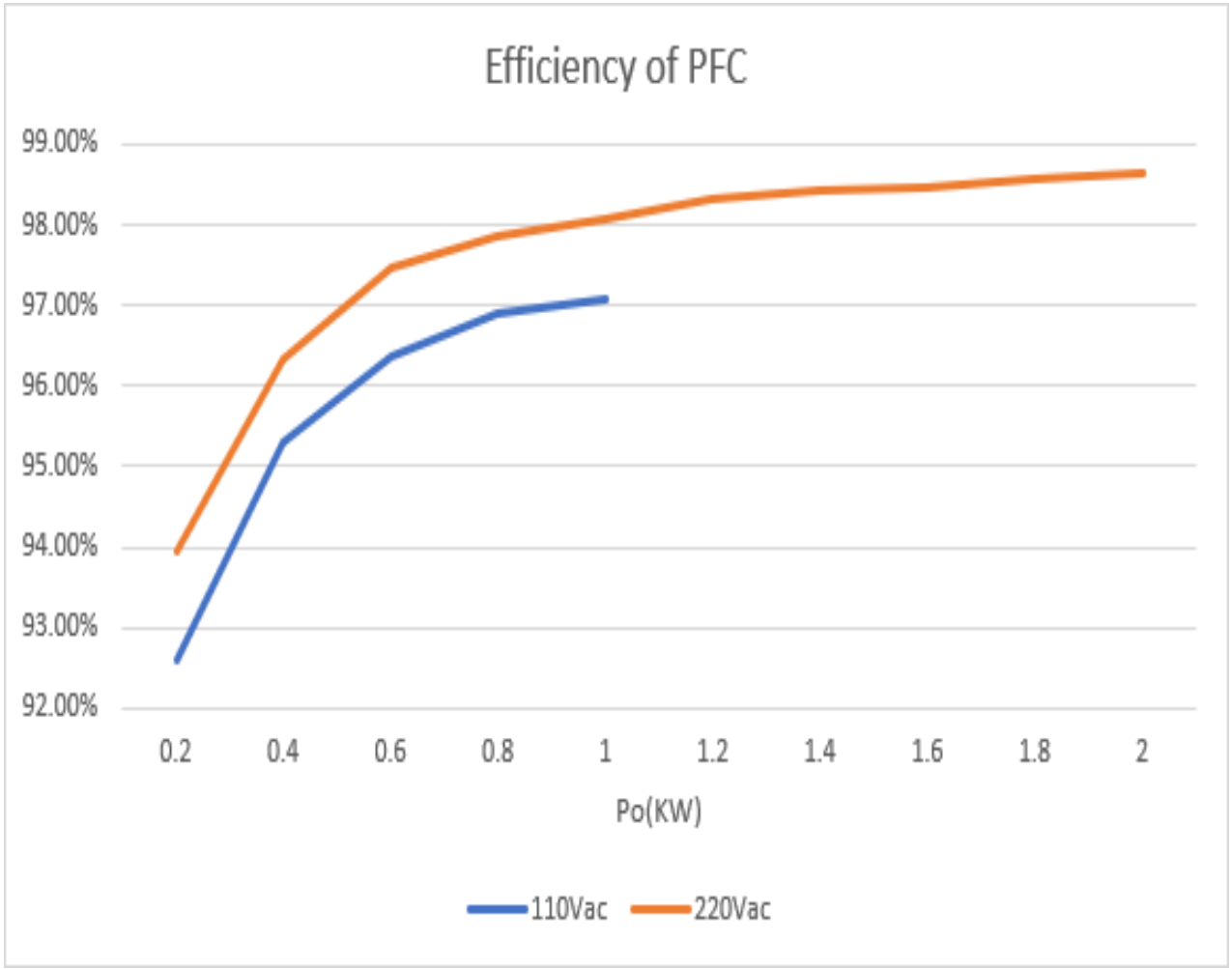


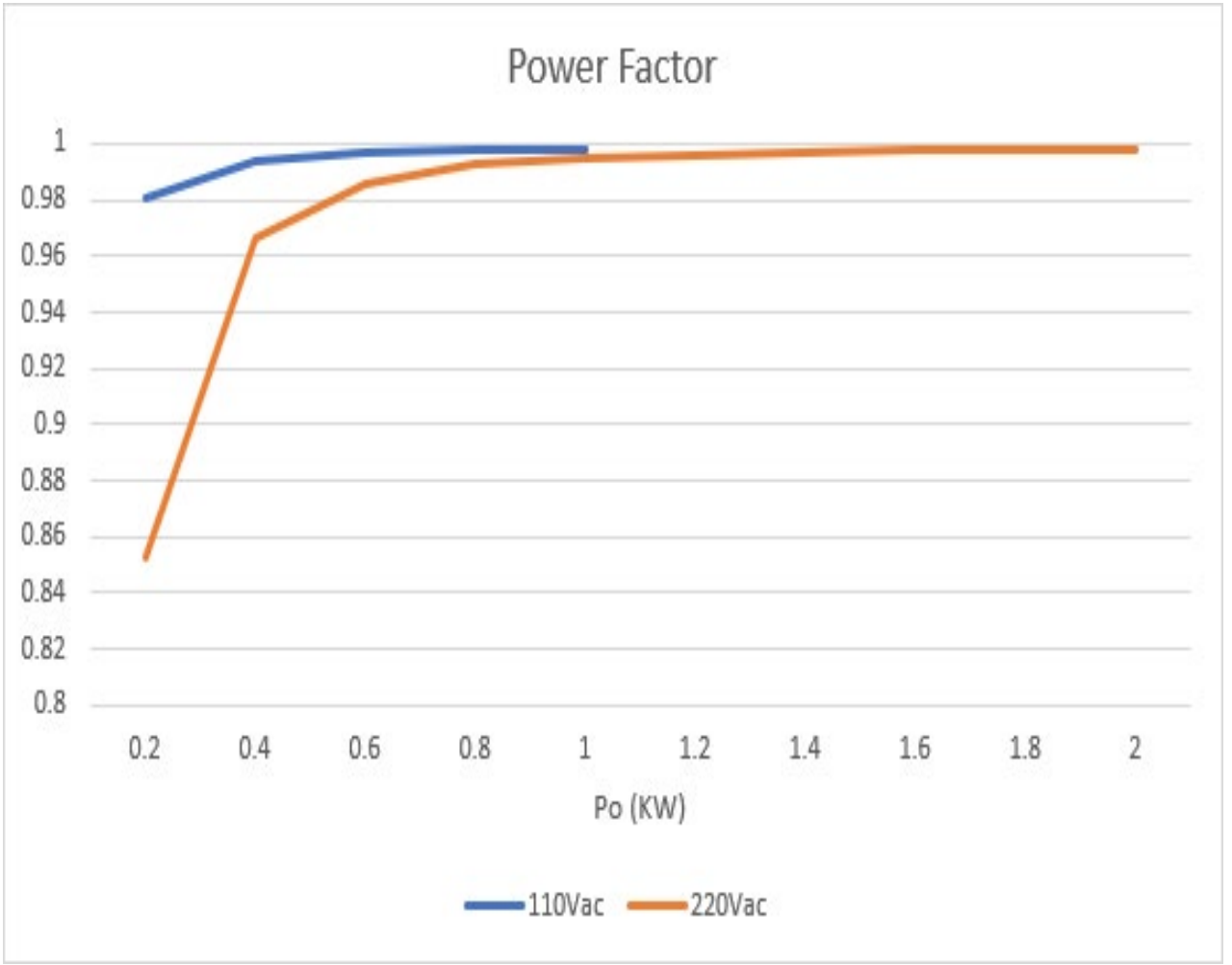
PFC stage steady operating



LLC stage steady operating

Efficiency and PF on PFC stage



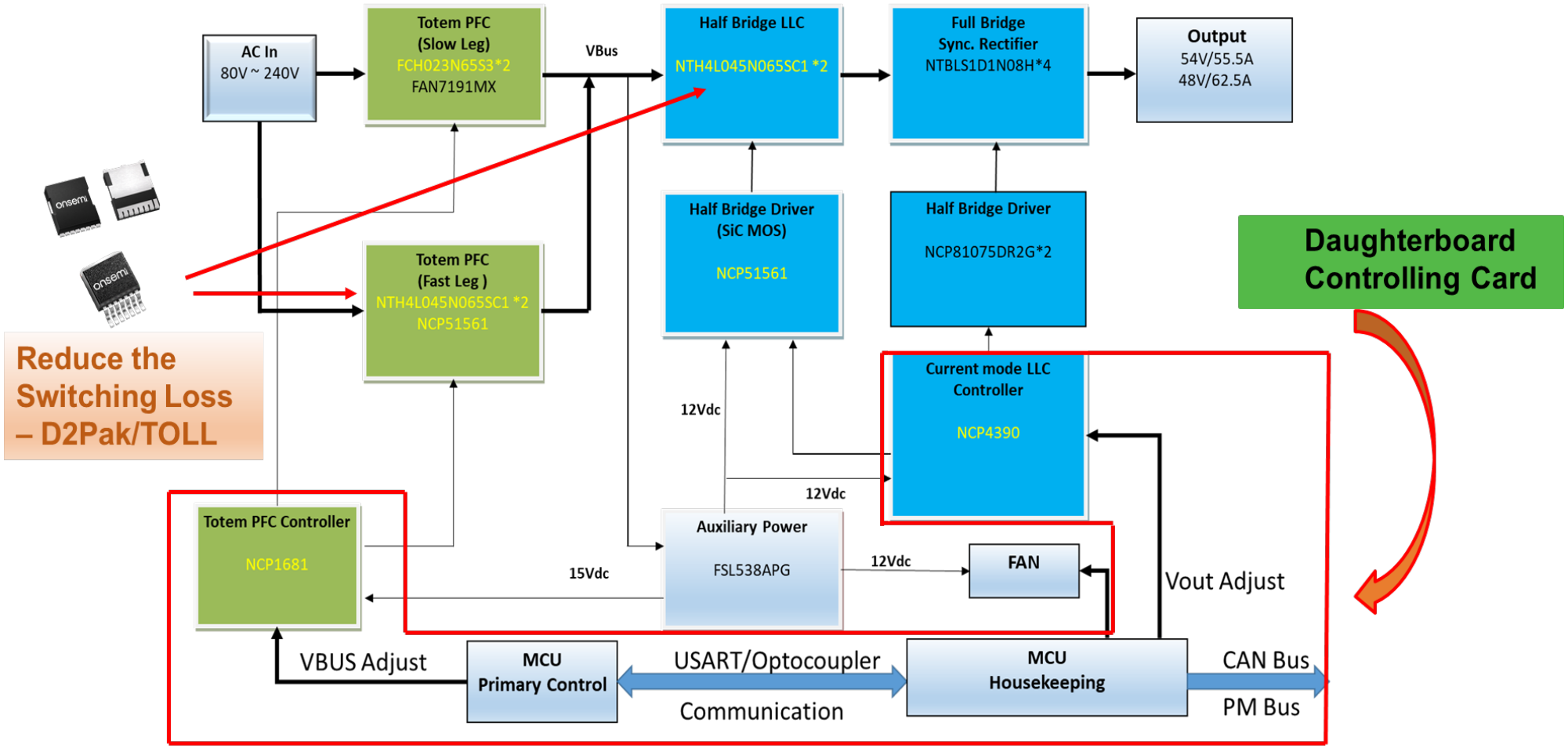


SiC-Based High-Density 3 kW Totem Pole PFC and Half Bridge LLC Charger

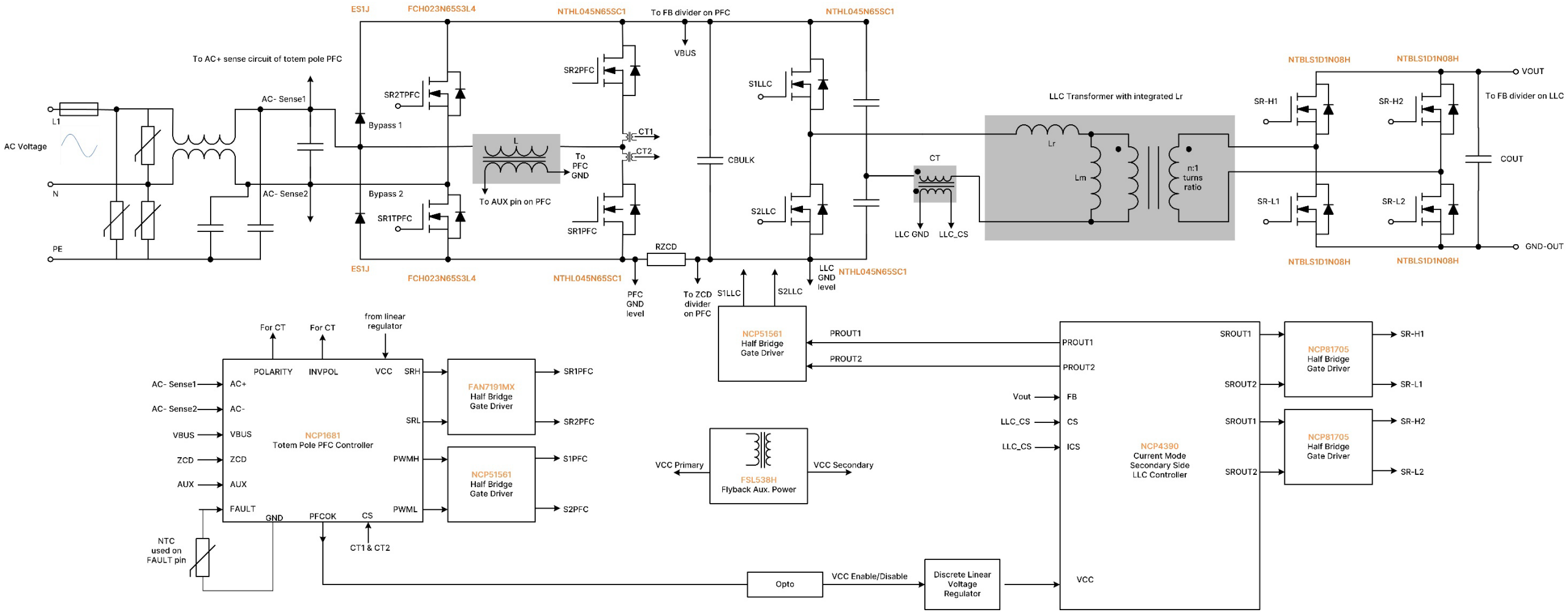
SiC-Based 3 kW Totem Pole PFC and LLC Power Supply

Design Parameter	Performance
Input Voltage	85 VAC to 230 VAC
Output Voltage	48 V
Output Current	62.5 A
Power Factor	Above 0.98 at 20% load – 100% load
Size	280 mm x 110 mm x 38 mm
Totem Pole PFC Efficiency	96.4 % (230VAC) 95.3% (115 VAC) @ 20% load; 98.2% at full load (230 VAC) – 150kHz switching 96.2 % (230VAC) 95.6% (115 VAC) @ 20% load; 98.4% at full load (230 VAC) – 95kHz switching
Total efficiency	94.2% peak efficiency at 115VAC 96.5% peak efficiency at 230VAC
Construction	Four layer FR4 PCB with two-layer PCB board for LLC and PFC controller

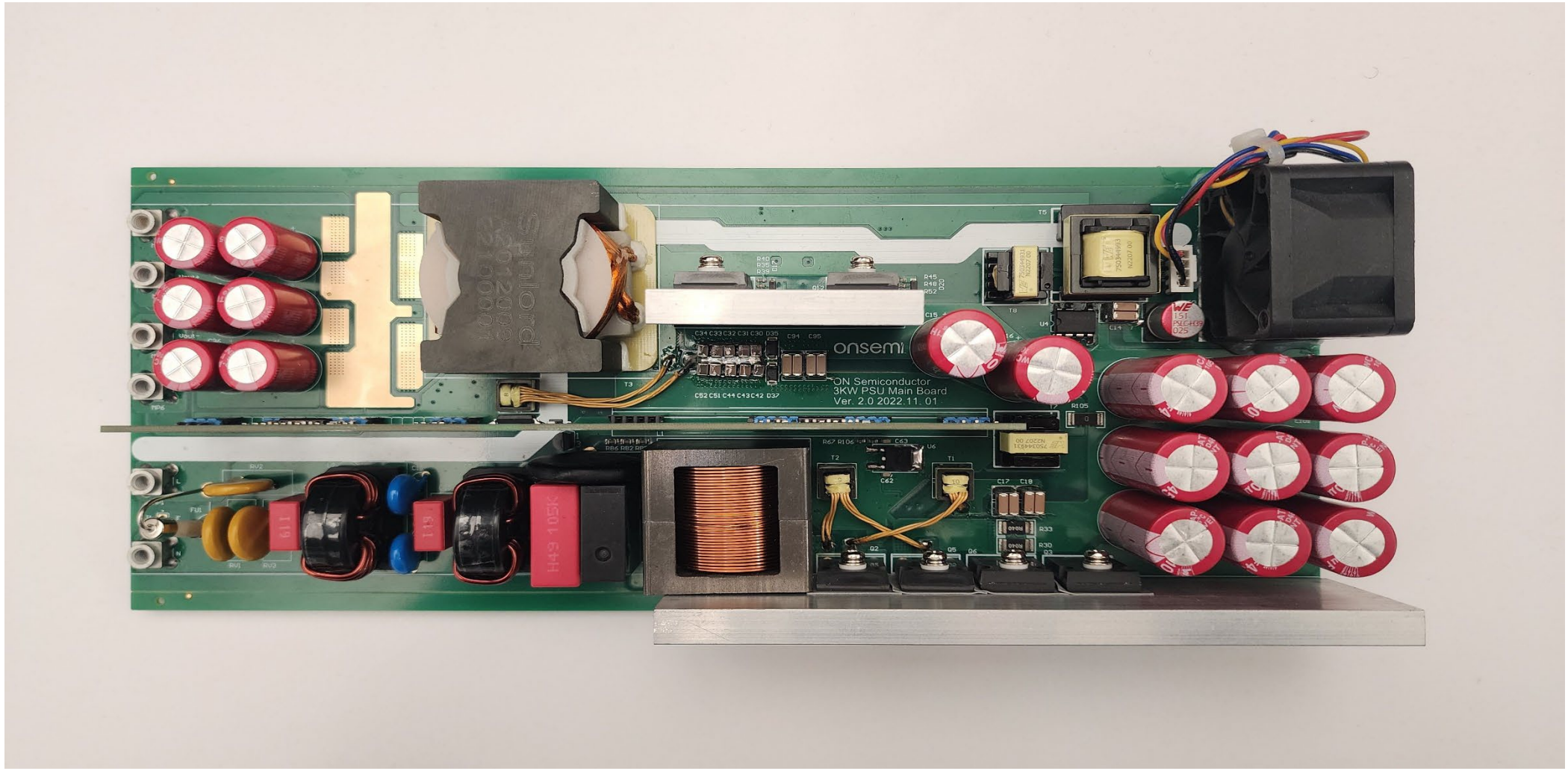
NCP1681 + NCP4390 with MCUs – 3KW PSU Block Diagram



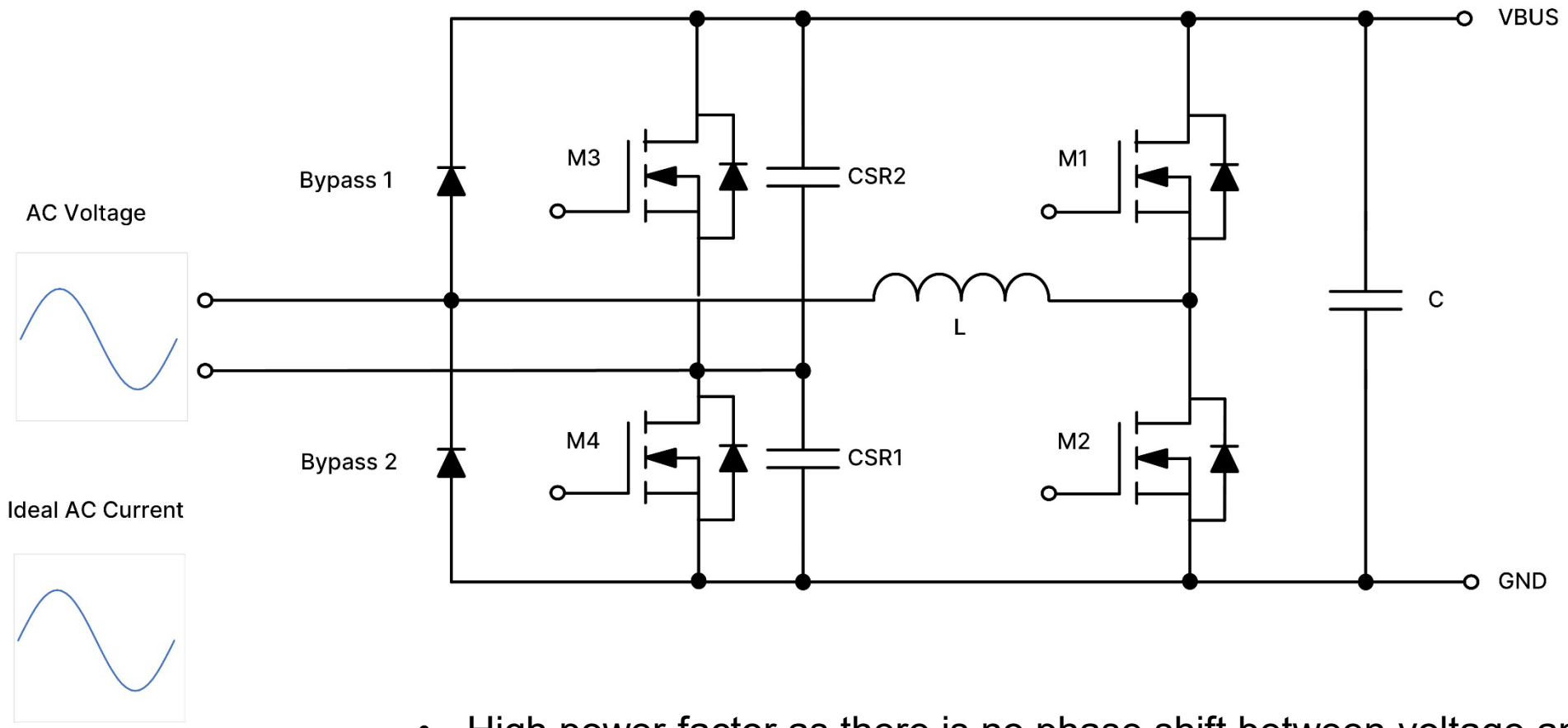
SiC-Based 3 kW Totem Pole PFC and LLC Power Supply



SiC-Based High-Density 3 kW Totem Pole PFC and LLC Power Supply

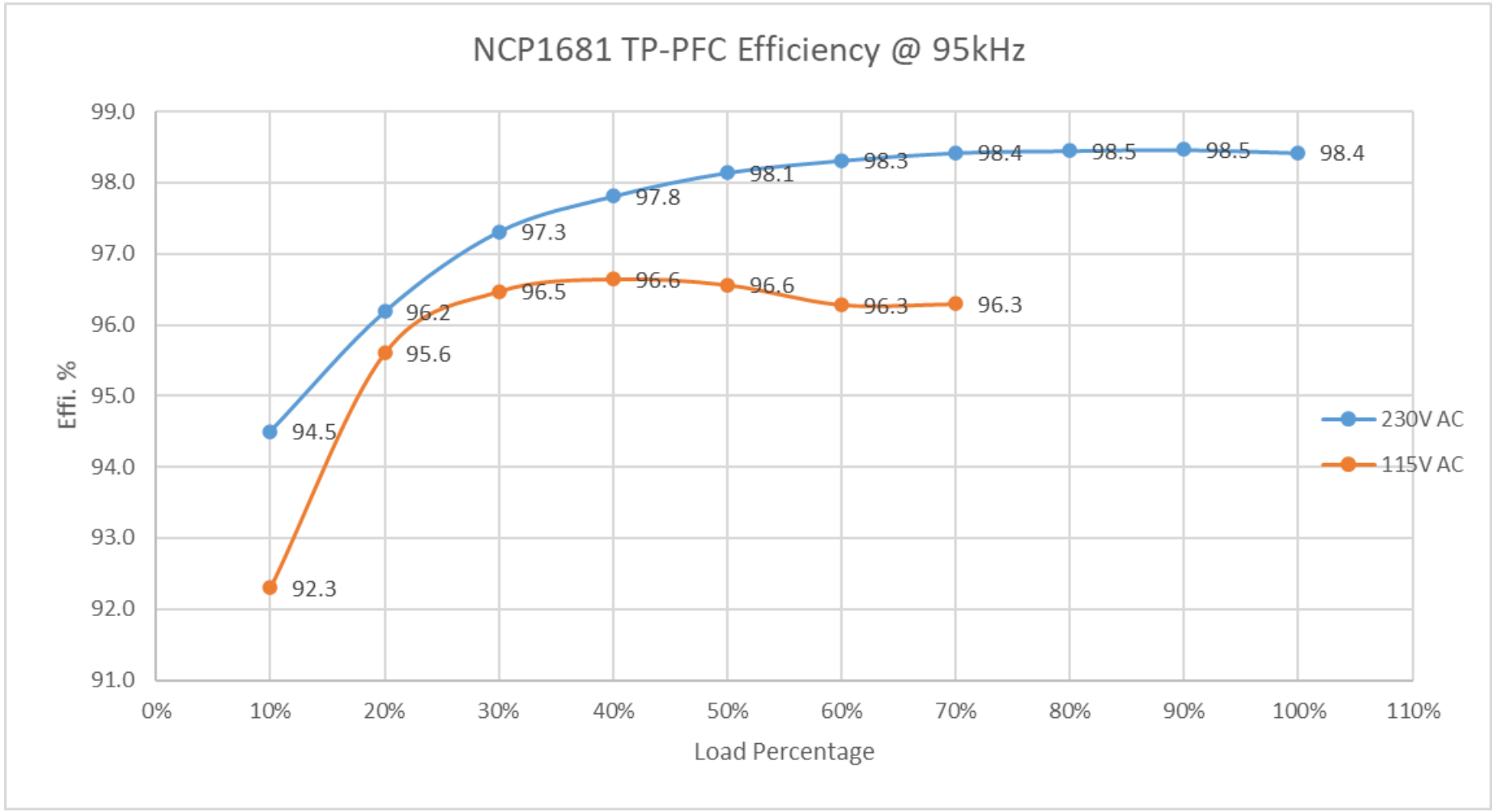


Purpose of PFC: Make current same shape as input voltage



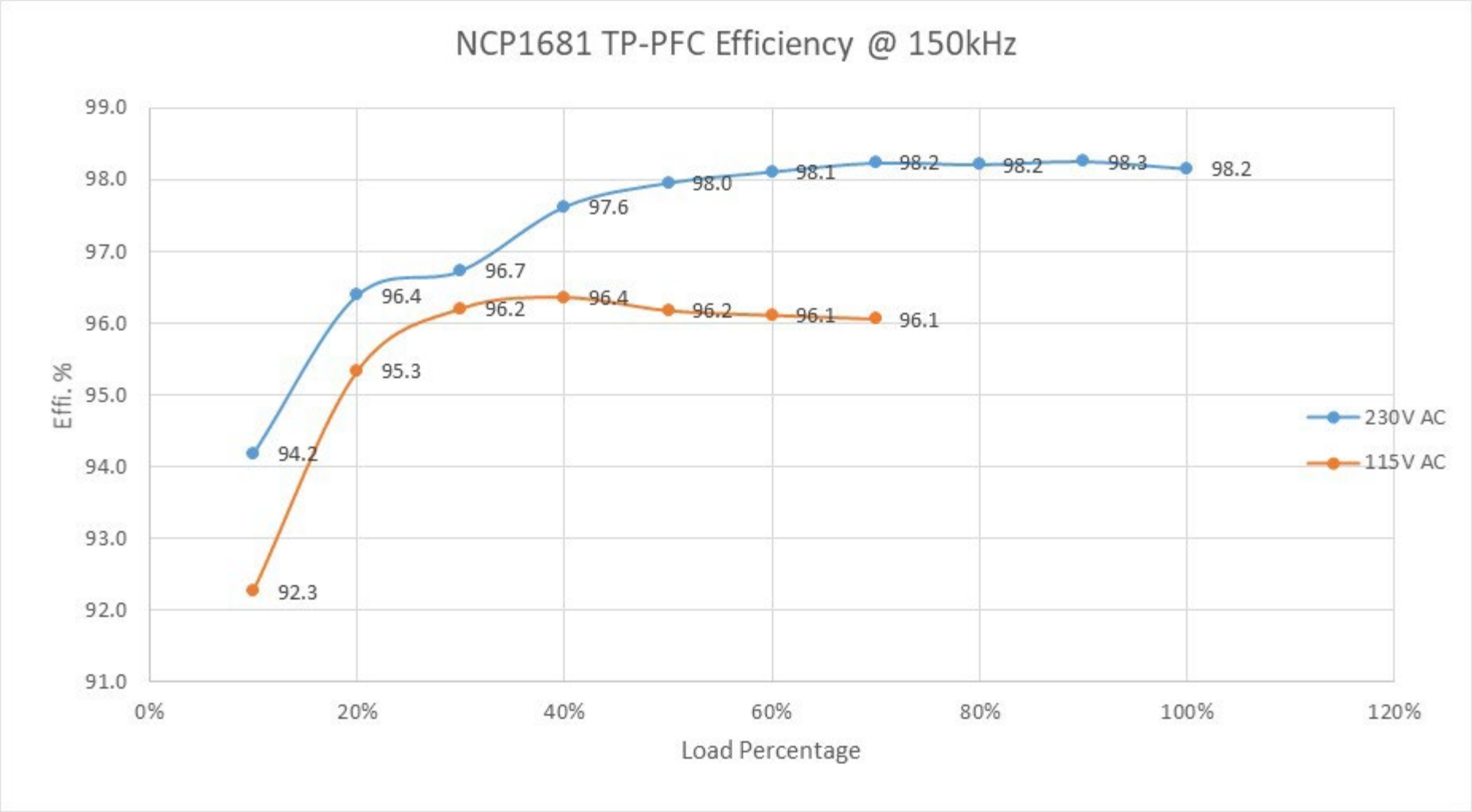
- High power factor as there is no phase shift between voltage and current
- Low total harmonic distortion
- Load should act like a resistive load

Efficiency with SiC@95kHz



NTHL045N065SC1: SiC, N-Channel, 650V, 42 mΩ, TO247−3L

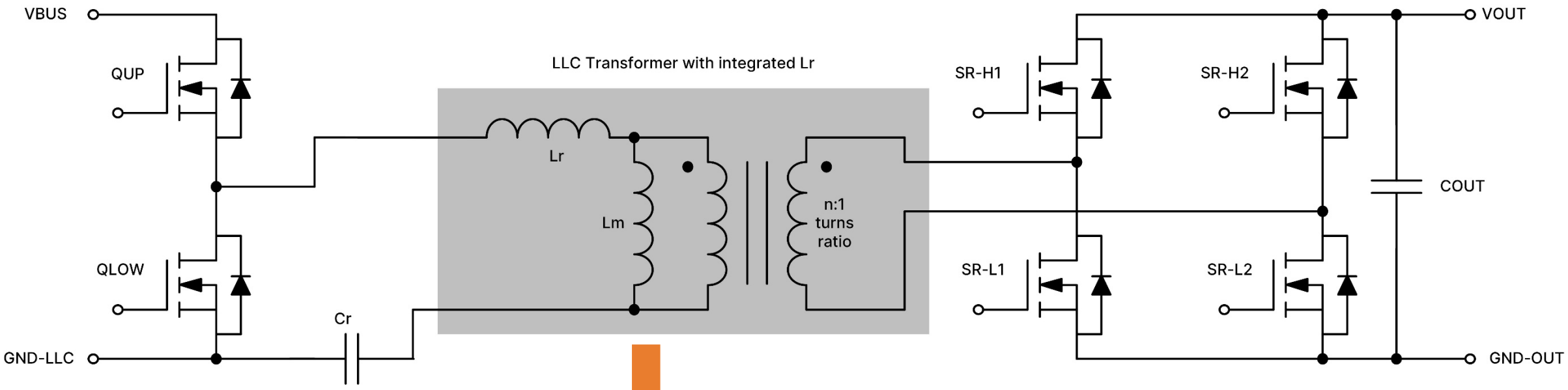
Efficiency with SiC@150kHz



NTHL045N065SC1: SiC, N-Channel, 650V, 42 mΩ, TO247−3L

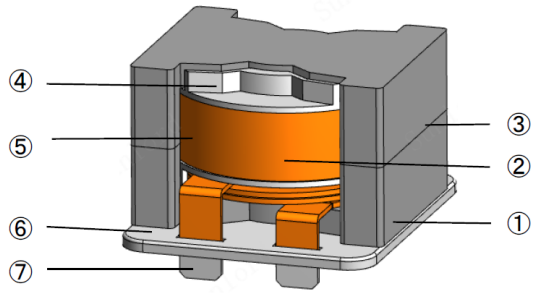
LLC Topology

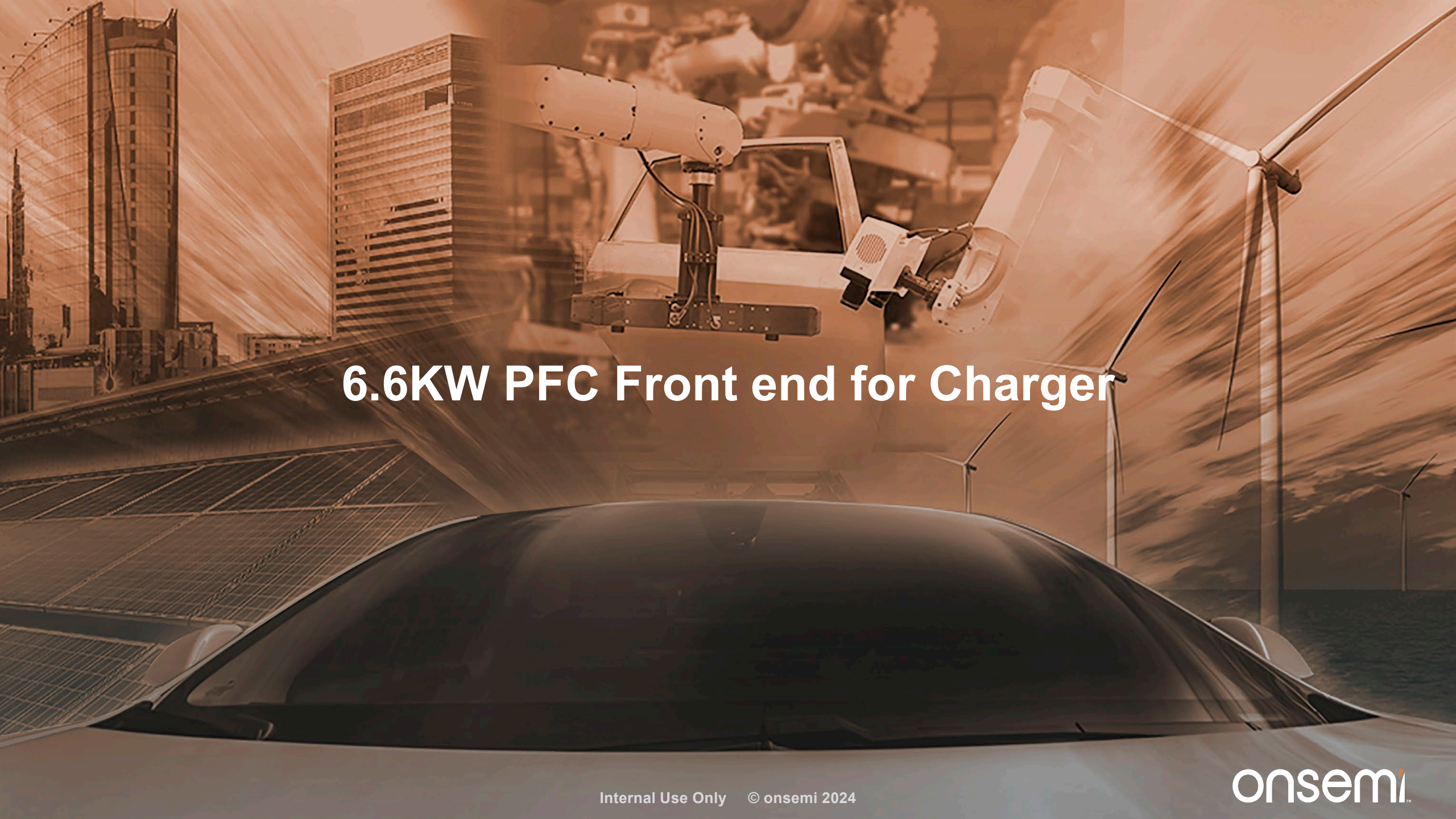
LLC Topology with integrated Lr



External capacitor

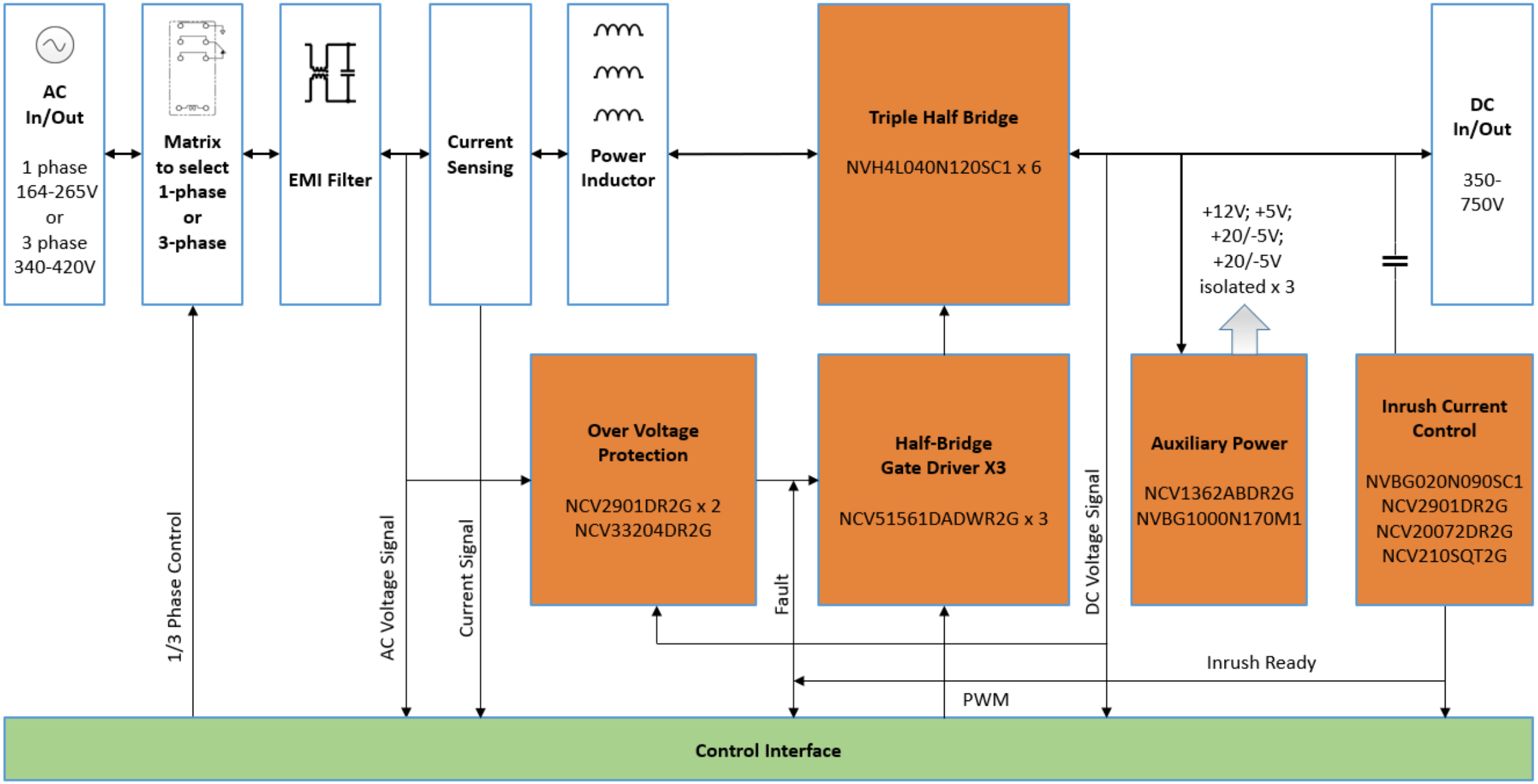
LLC Transformer includes series inductor





6.6KW PFC Front end for Charger

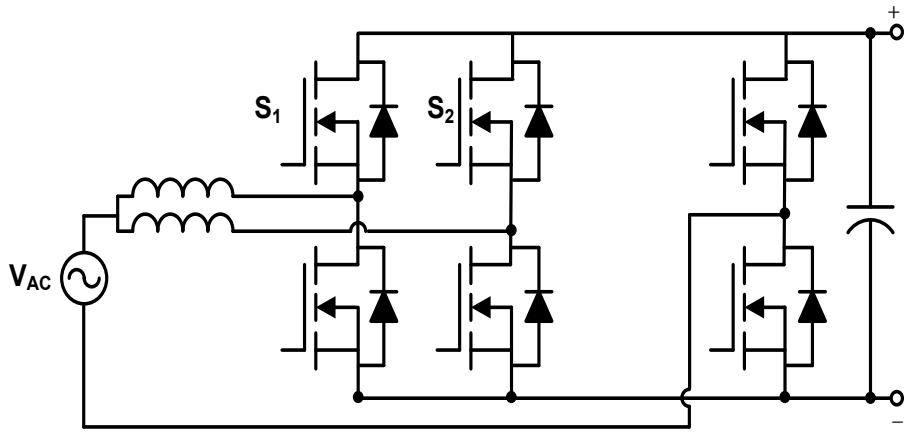
Block Diagram of a 6.0--11 kW PFC/Inverter



Advantage of IGBT solution vs MOSFET solution in PFC

Totem pole Bridgeless PFC for 6.6kW

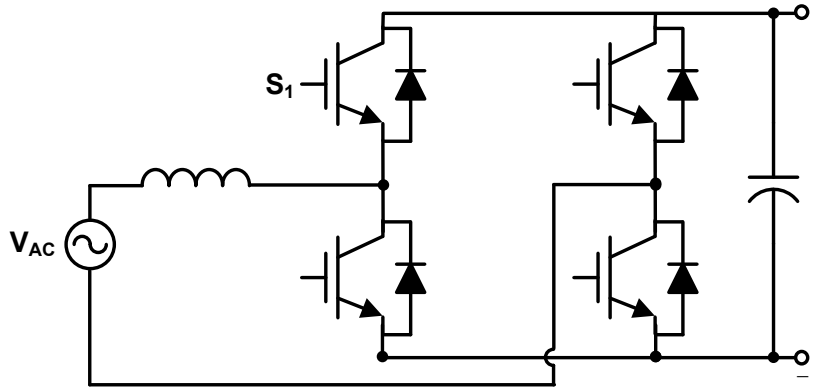
MOSFET Solution



CRM(Critical Conduction Mode)

- Multiple stages for high power
- Requires more MOSFETs & inductors

IGBT Solution



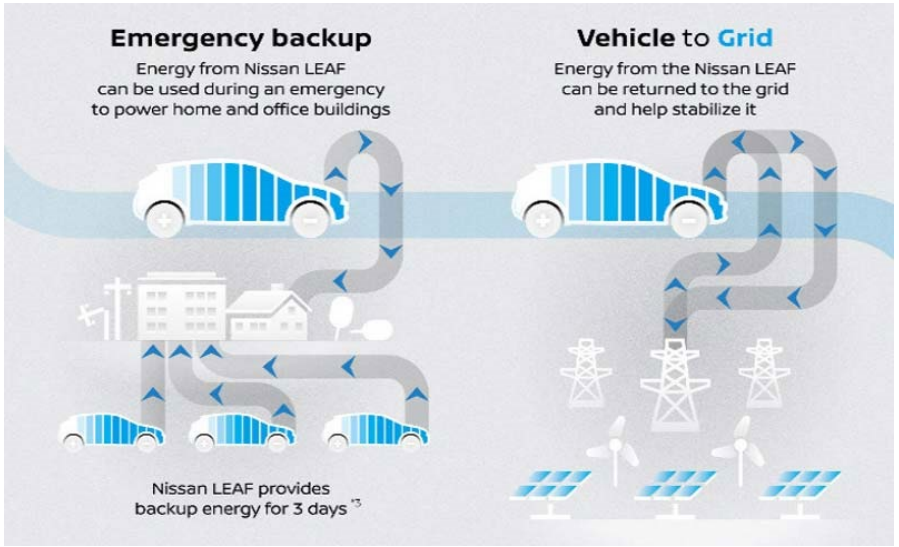
CCM(Continuouse Current Mode)

- Single stage for high power
- Good at handling high power
- Less components with smaller PCB size

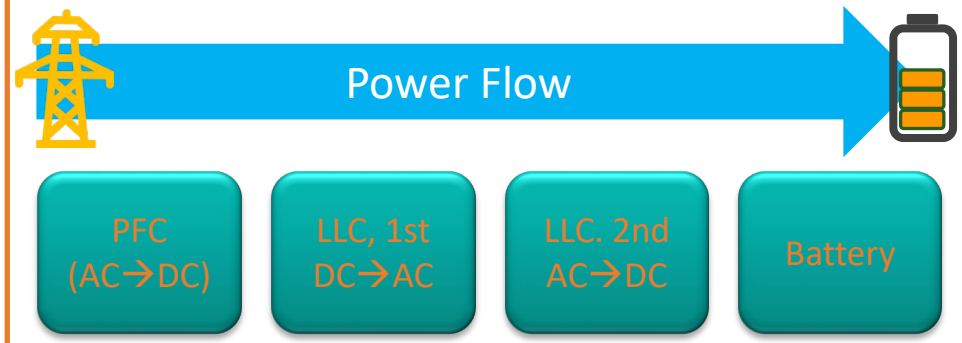
ON Board Charger Trend

G2V(Grid to Vehicle)

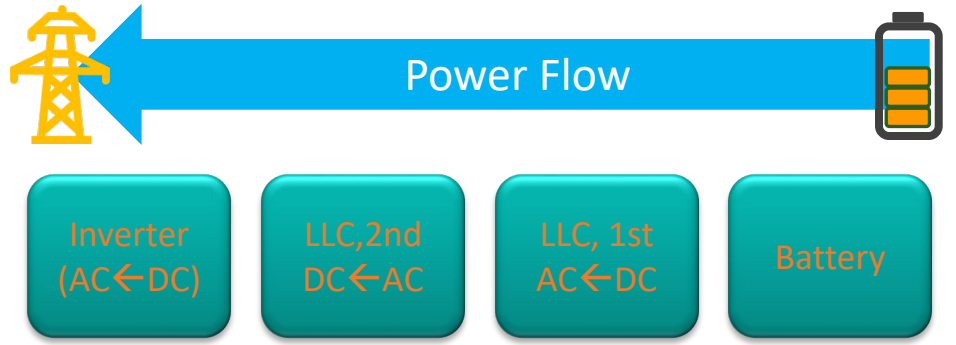
V2X(Vehicle to Grid, Home, Vehicle..)



Uni-directional Charging



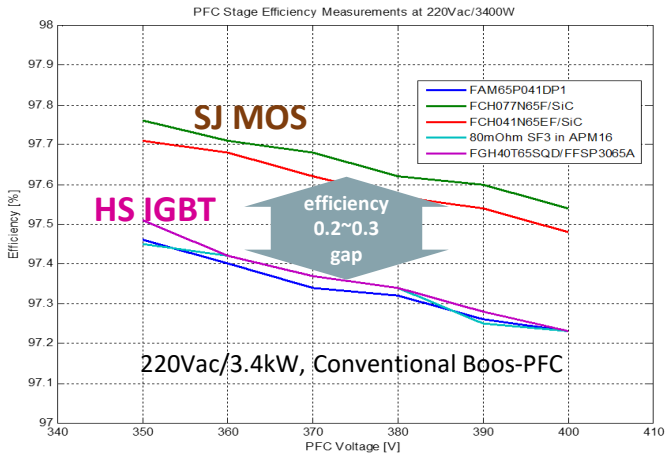
Bi-directional Charging

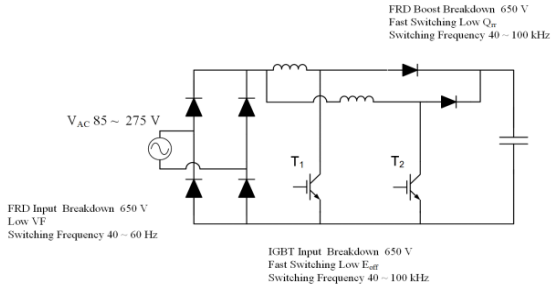


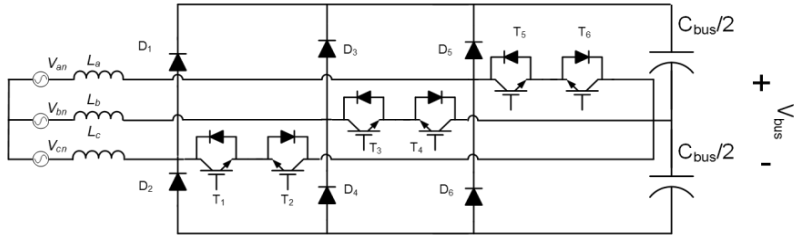
Topologies in OBC

PFC Stage

Switching Frequency
50 ~ 70kHz

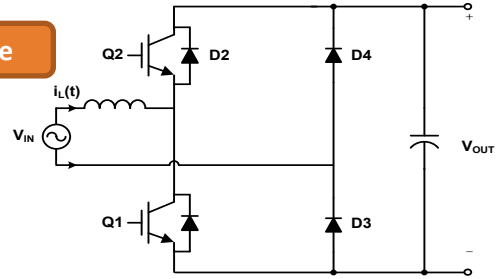




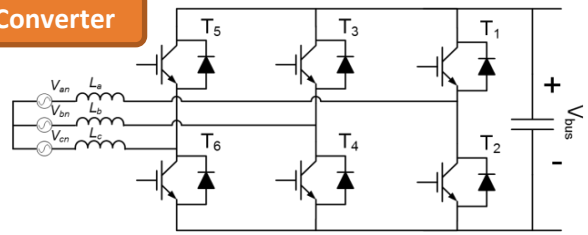


Bi-directional: IGBT has better efficiency

Totem-pole

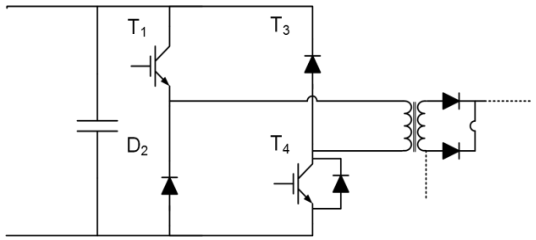


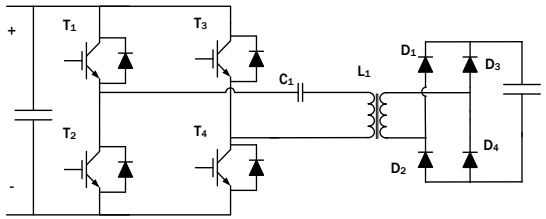
3Ø Converter

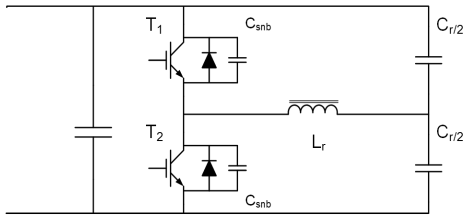


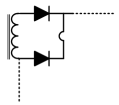
DC/DC Stage

Switching Frequency
Above 100 kHz







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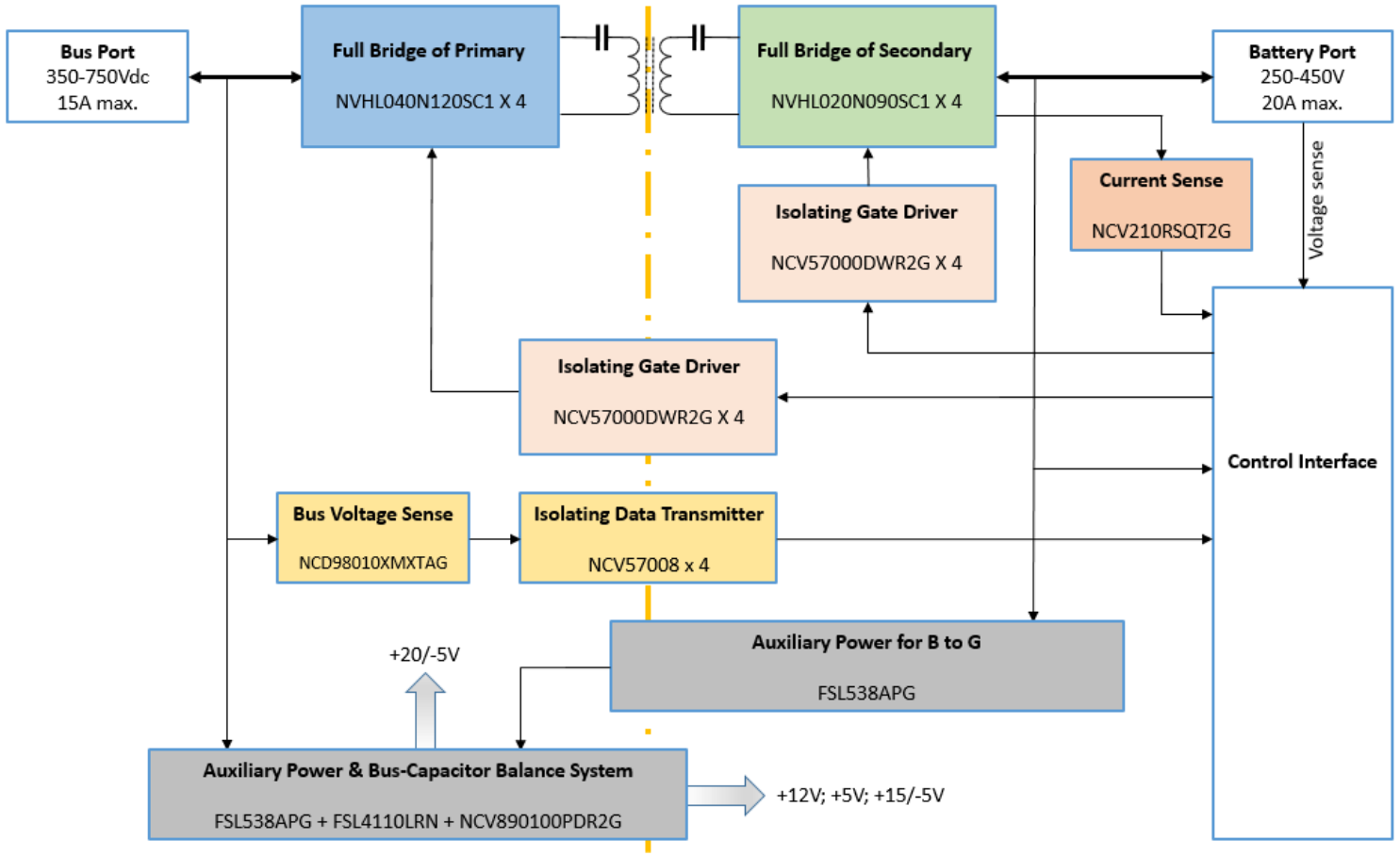
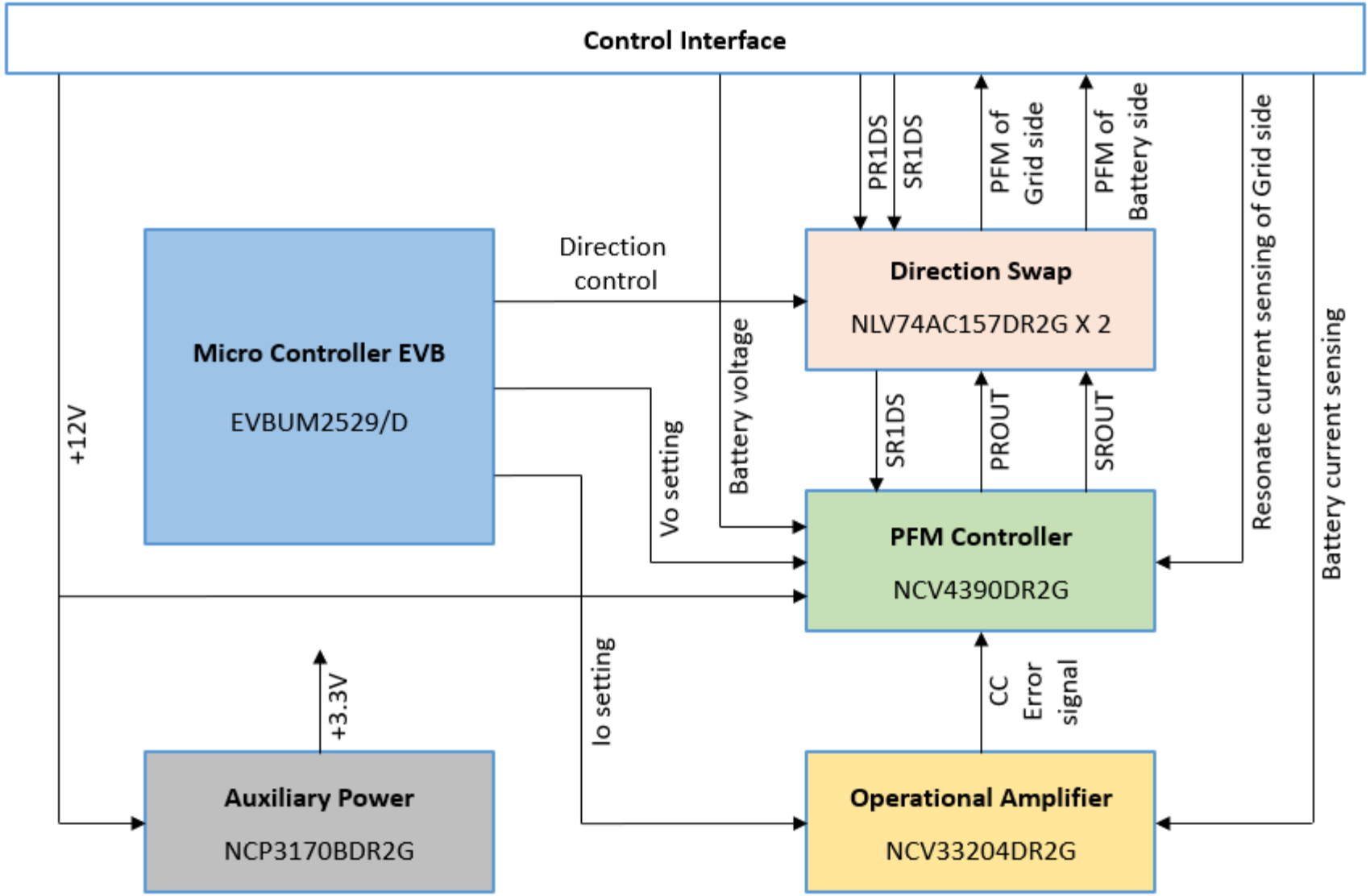
A 6.6KW CLLC Isolating DC-DC Converter for the Bi-directional Charger
Internal Use Only

6.6KW CLLC Converter

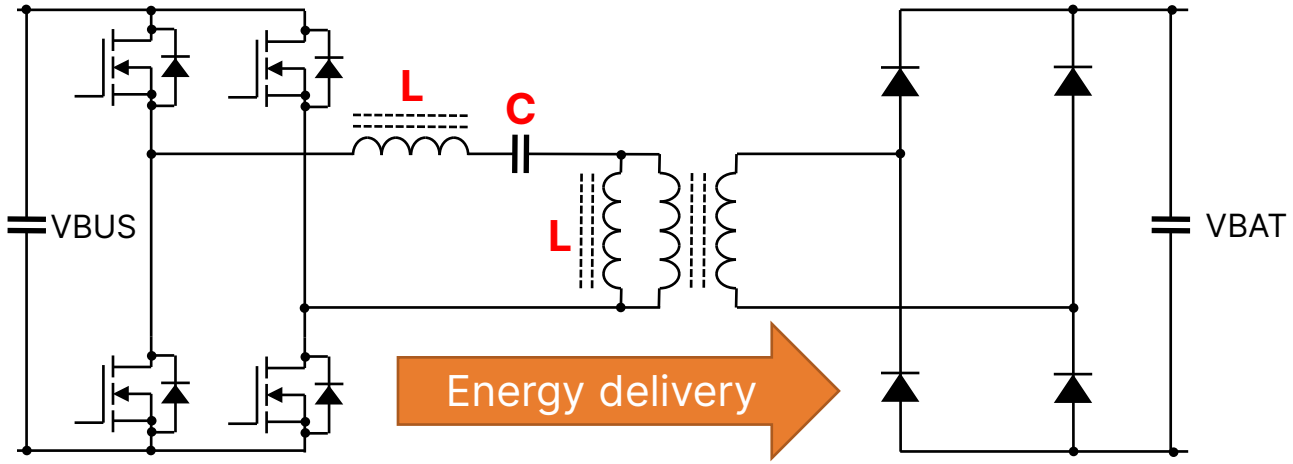


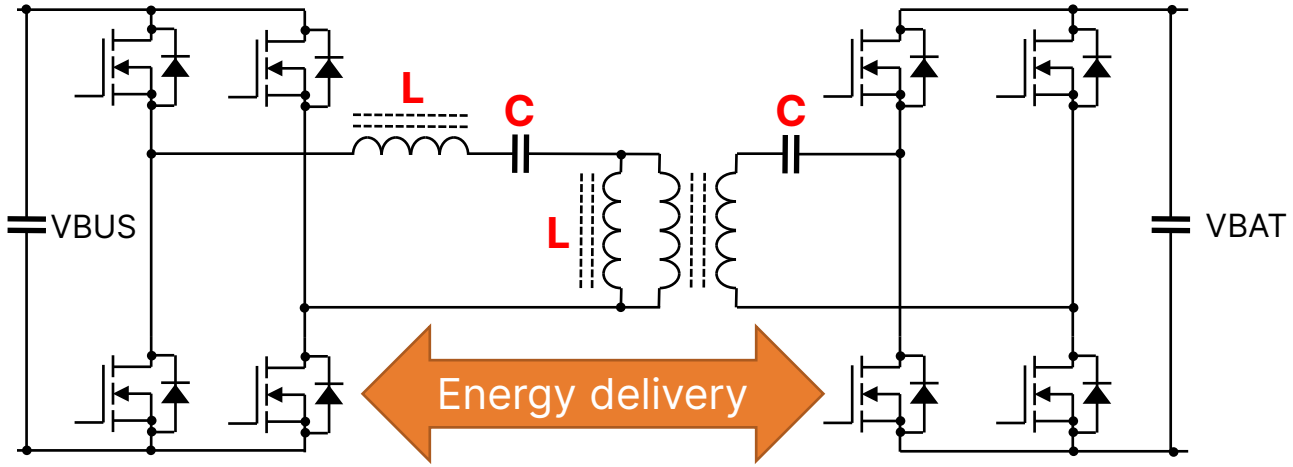
Devices:		
NCV57000, NCV210RSQT2G, NVHL040N120SC1, NVHL020N090SC1,	**Input**	Vbus: 350-750Vdc; Vbat: 350-450Vdc
	Output	Vbus: 400-650Vdc; Vbat: 250-450Vdc
	Topology	CLLC

Block diagram of the control board



Bidirectional CLLC Resonant DC-DC Converter





Benefit:

- High efficiency due to soft switching.
- Simple and cheap to implement.

Challenge:

- Narrow Gain variable range to meet the wide battery voltage.

Solution:

- High and variable Bus voltage which following the battery voltage.

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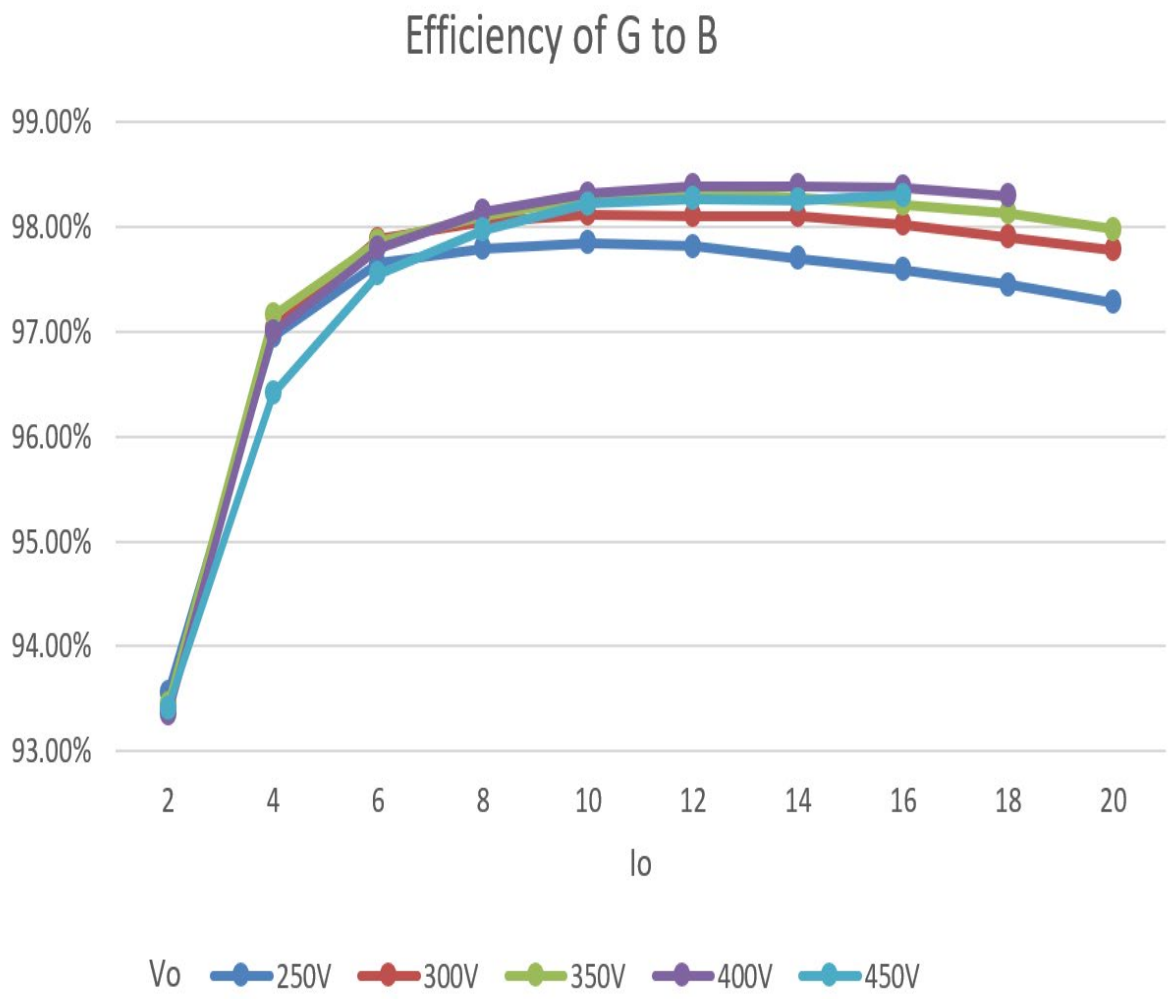
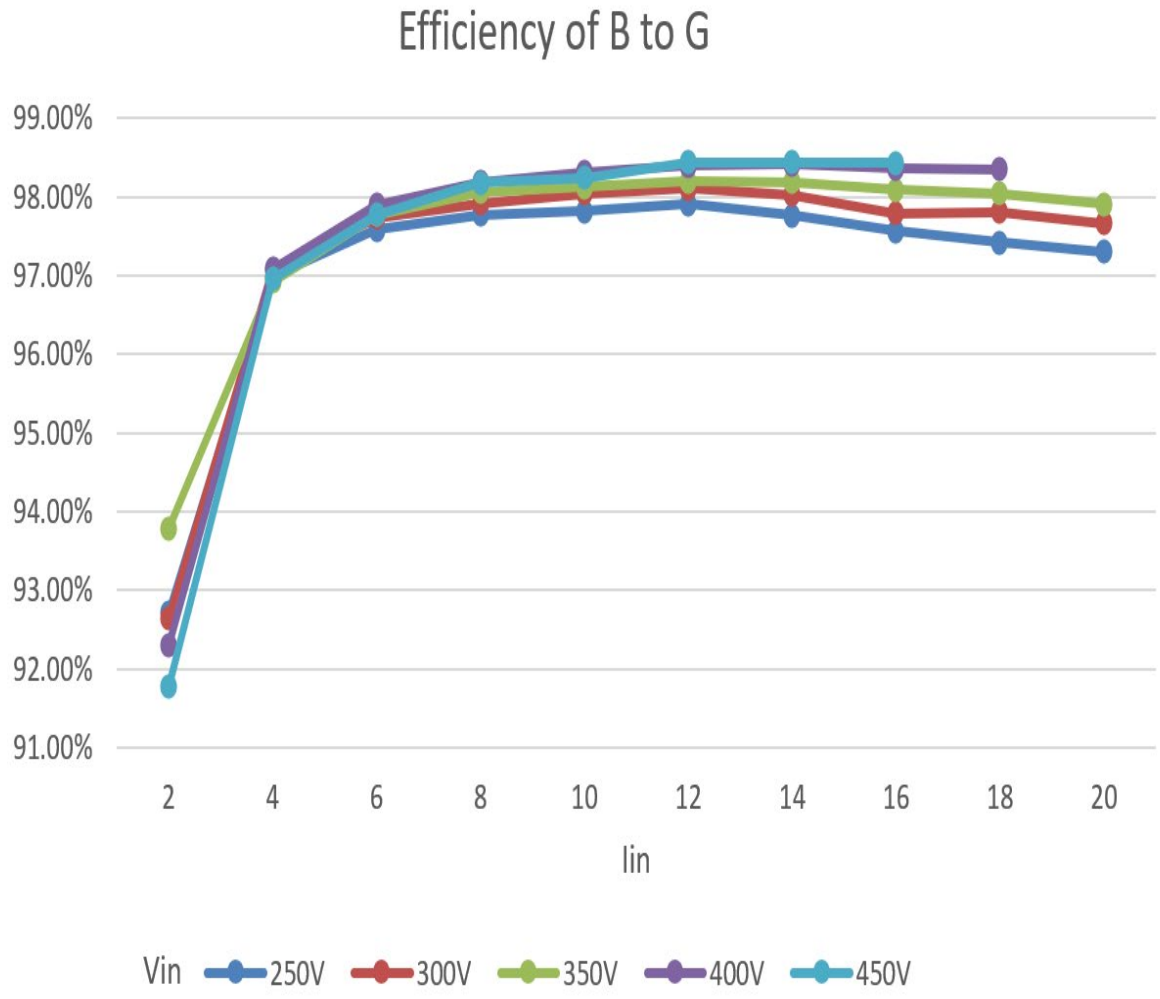
Performance





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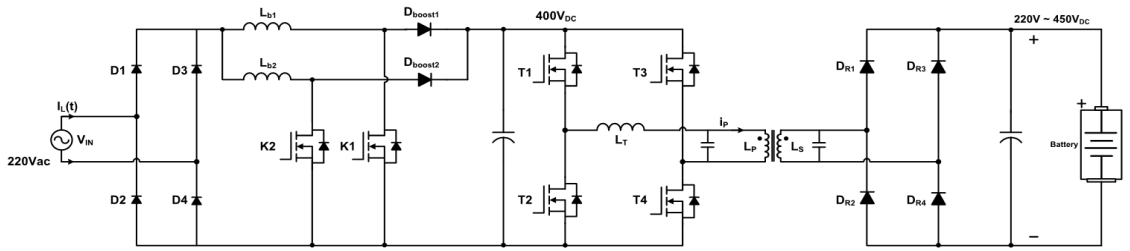
7.2KW-11KW Charger Solutions

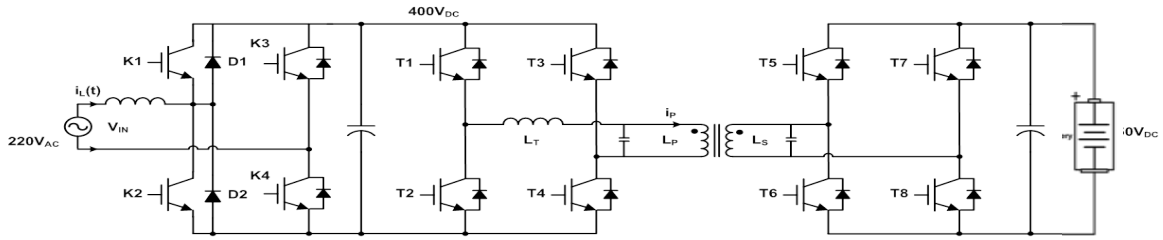
What's the difference between Uni & Bi-directional charging?

Uni-Directional Charging



- Faster devices are better for charging efficiency only
- MOSFET & Diode based solution preferred
- Reverse recovery performance is not critical

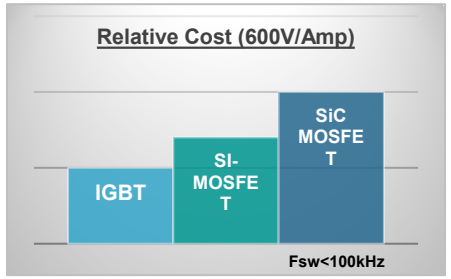
Bi-Directional Charging

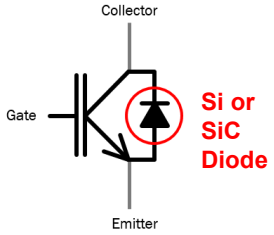


- Should consider charging and discharging efficiency
- Totem pole bridgeless PFC is essential and IGBT is effective solution
- Require both fast switching devices and low Vcesat and Vf devices for K3&4
- Switching devices' reverse recovery performance is critical

Advantage of IGBT vs. Si-MOSFET

- Superior on-state current density → Smaller chip size → Low cost
- Excellent forward and reverse blocking capability → Require co-pack diode which is better diode performance than intrinsic body diode of MOSFET
- Able to utilize the excellence of Si-IGBT and SiC Diode by integrating both in one package



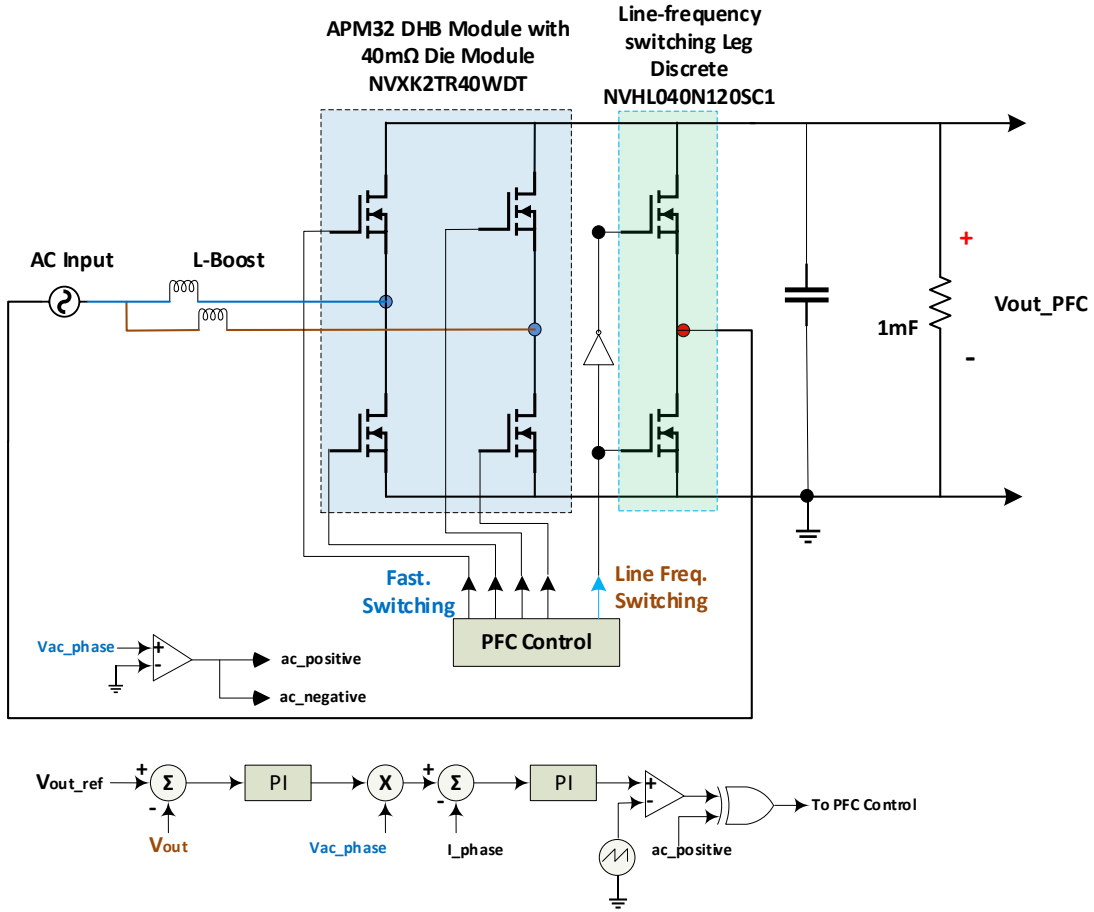


ON's IGBT solution

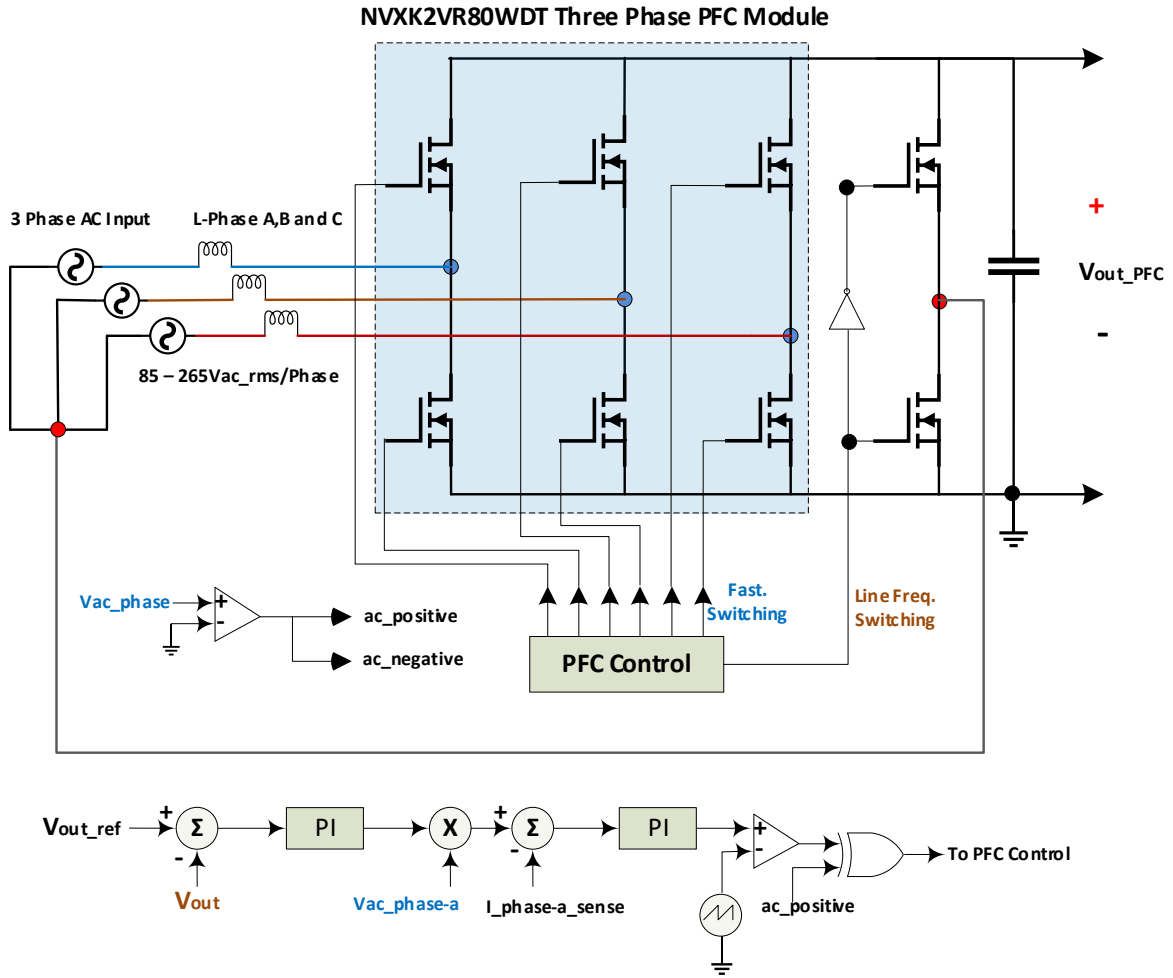
- Various line up with AEC Qualified FS4 650V IGBTs
- Hybrid IGBT solution integrated with SiC Diode. AFGHL50T65SQDC
- Single IGBT for K1 & K2 switches
- High Speed IGBT, 75A to 30A
- Low V_{CESAT} and V_F IGBT is under concept stage for K3 & K4 switches
- D2PAK and TO247 Package

Proposed APM32 7kW-11kW For PFC Stage

Single AC source 7kW 2-Ph Interleaved TTP PFC

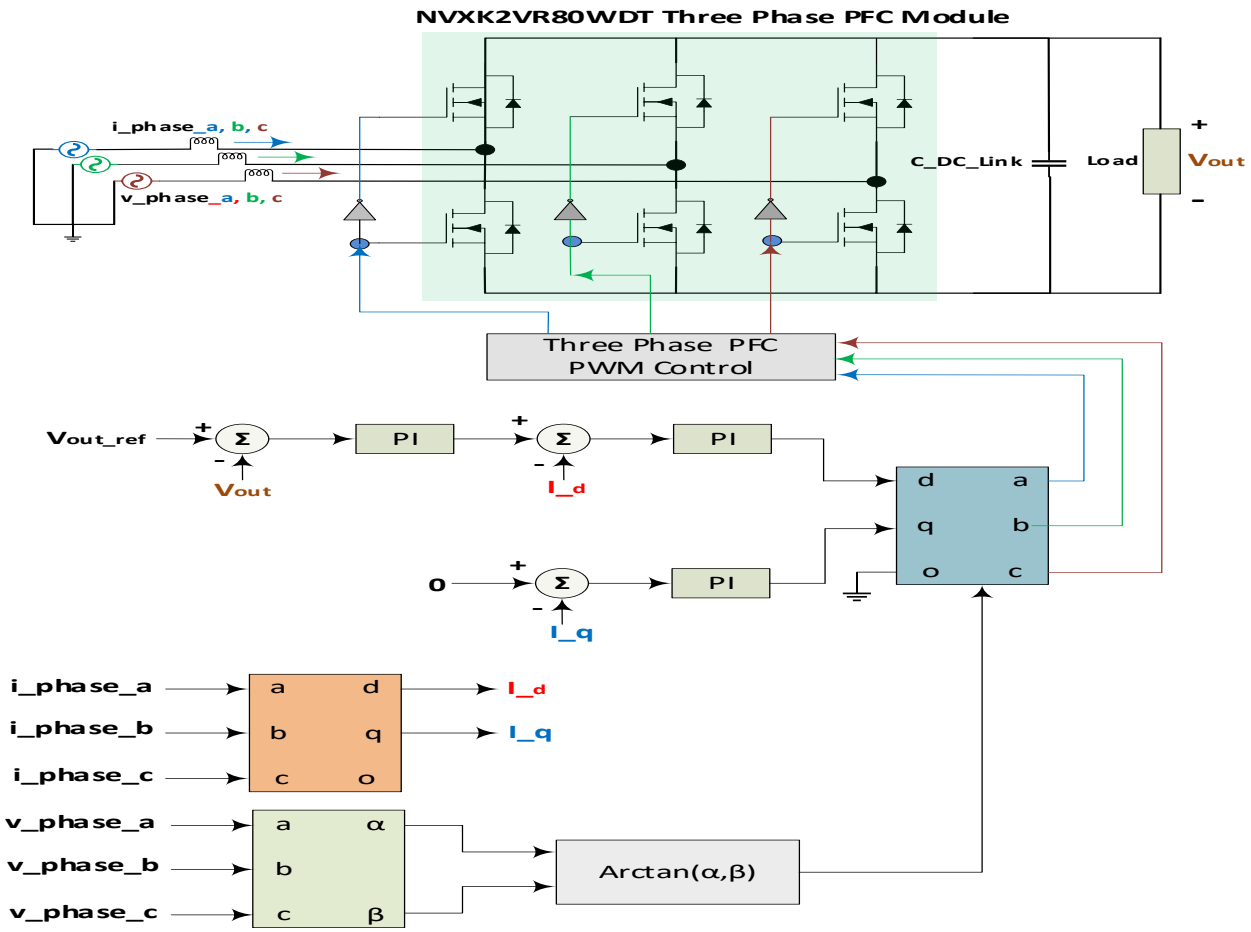


3-phase AC source 11kW 3-Ph interleaved TTP PFC

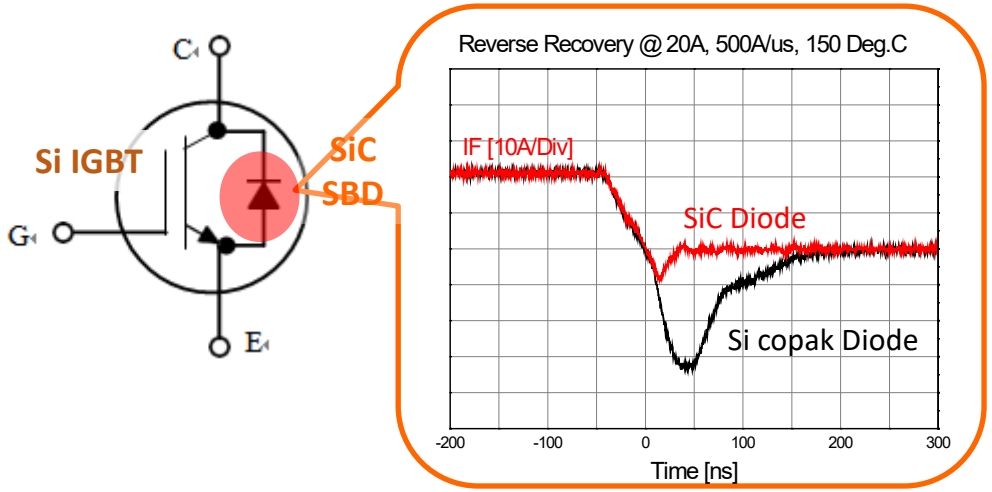


APM32 11kW OBC Design

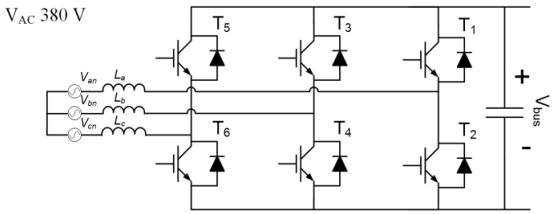
11kW 3-Phase, 2Level 6-switch PFC

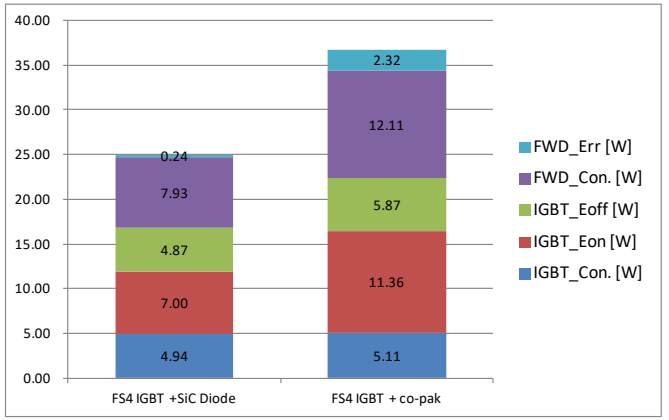


Benefits of Hybrid IGBT for OBC

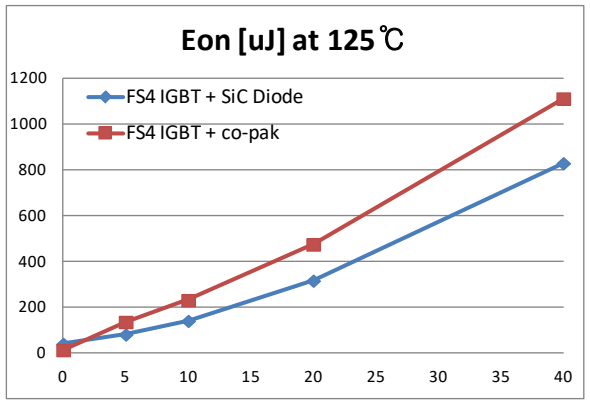


- **Loss Simulation Result for Totem-pole PFC**

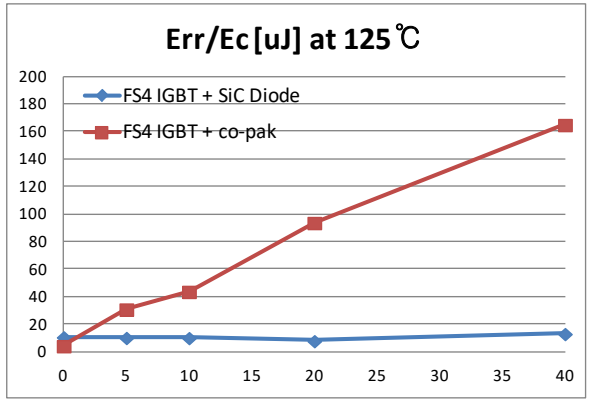




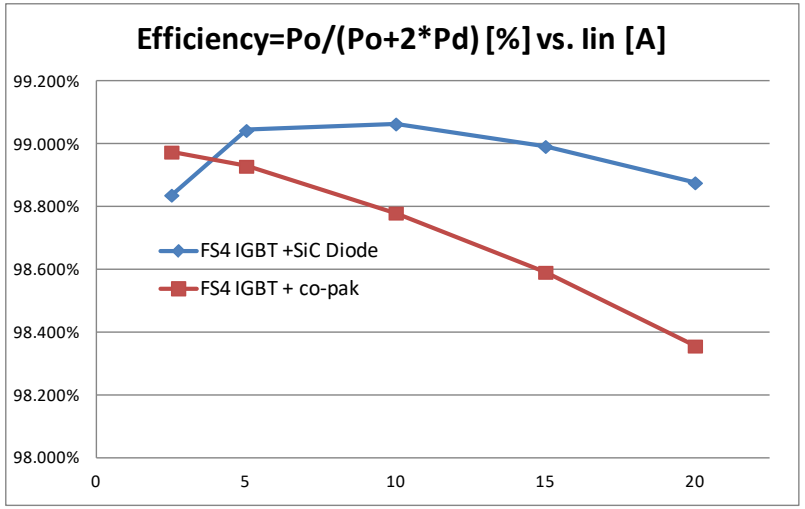
➢ **25% lower Eon loss**



➢ **Almost zero diode loss**

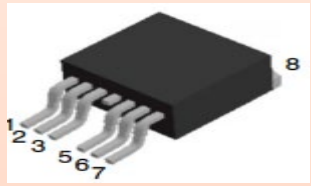


➢ **+0.55% efficiency improvement**



650V IGBT lineup for OBC/HV-DCDC

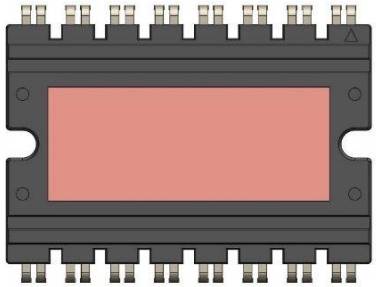
Released
In development
To be developed

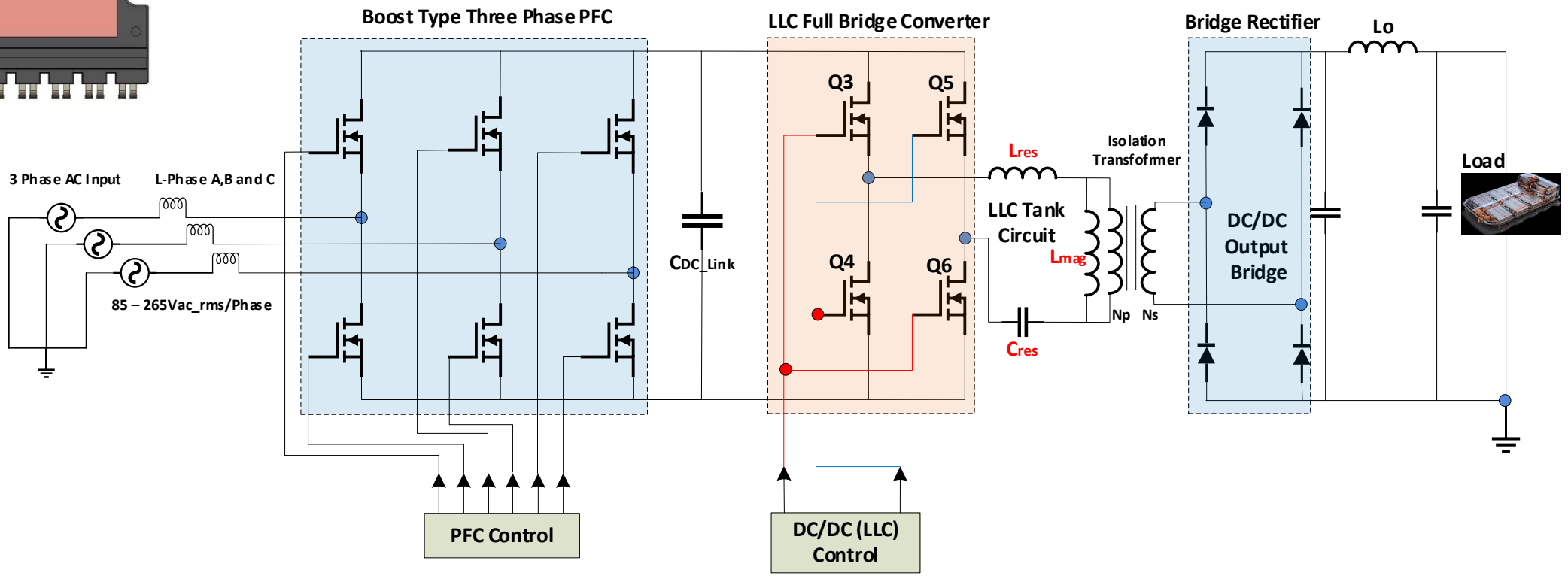
Spec				TO-263 (D2PAK)	D2PAK-7L	TO247-3L	Automotive Applications						
Voltage / Current @T_C=100℃	$V_{CE(SAT)}$ / E_{OFF} (μJ/A) @T_C=25℃	IGBT Type	Copak Diode rating				Traction Inverter	Aux. Inverter	OBC	Battery Discharge	Smart Relay (BDU)	PTC Heater	Aux. DC/DC
650 / 30	1.6/5	FS4	full	AFGB30T65SQDN					V			V	V
650 / 40	1.6/7	FS4	full	AFGB40T65SQDN		AFGHL40T65SQD			V			V	V
650 / 40	1.6/7	FS4	n/a			AFGHL40T65SQ			V			V	V
650 / 50	1.6/9	FS4	half			AFGHL50T65SQD			V			V	V
650 / 50	1.6/9	FS4	n/a			AFGHL50T65SQ			V			V	V
650 / 50	1.6/5	FS4	SiC		Hybrid	AFGHL50T65SQDC			V				V
650 / 50	1.4/5.8	FS4	half		AFGBG50T65LQD				V				V
650 / 70	1.6/13.8	FS4	SiC		AFGBG70T65SQDC	Hybrid			V				V
650 / 70	1.6/15.8	FS4	n/a		AFGBG70T65SQ				V				V
650 / 75	1.6/15	FS4	half			AFGHL75T65SQD			V			V	V
650 / 75	1.6/15	FS4	full			AFGHL75T65SQDT			V			V	V
650 / 75	1.6/14.8	FS4	SiC		Hybrid	AFGHL75T65SQDC			V				V
650/50	1.6/TBD	FS7	SIC		AFGBG50T65SWDC				V				

In Development

In Development

APM32 1200V SiC Power Modules for 11KW Charger Application

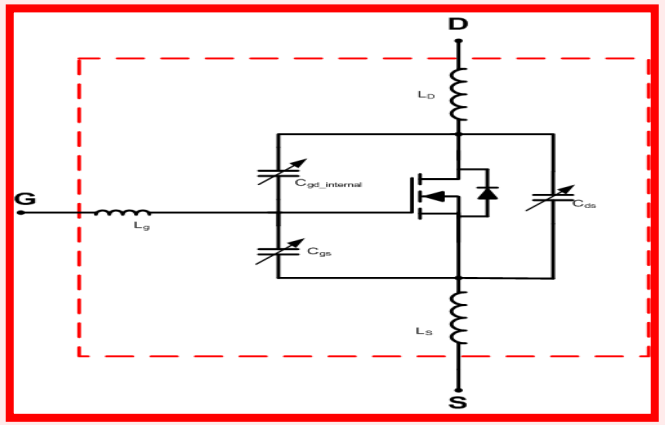




Definition of Fast / Easy Drive / FRFET version Si HV SJ FETs

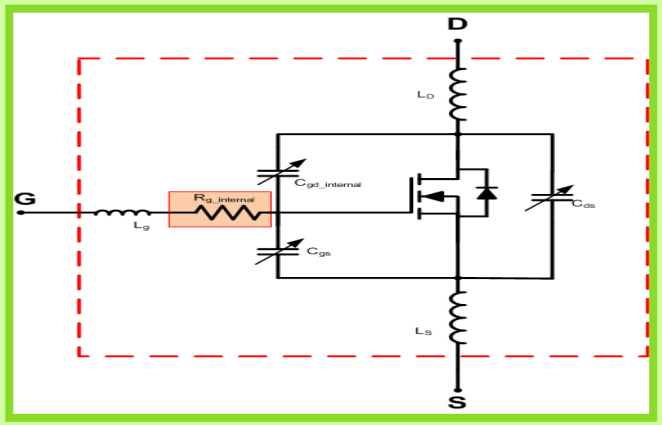
FAST Version

- High efficiency
- Hard Switching Topologies
- Reduced Qg and Eoss



Easy Drive Version

- Hard/Soft Switching Topologies
- Easy to drive
- Low EMI and Voltage spikes
- Internal Rg and optimized Cap

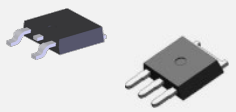
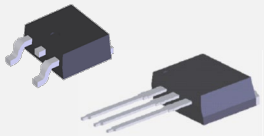
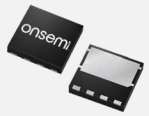
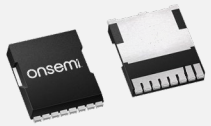
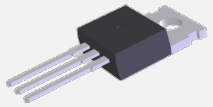
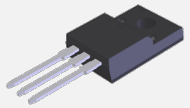
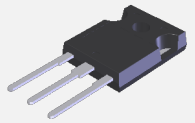
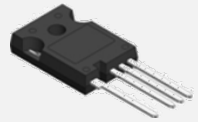


FRFET Version

- Soft switching topologies
- Better system reliability
- Small Qrr and Trr
- Robust diode ruggedness

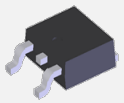
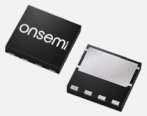
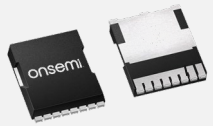
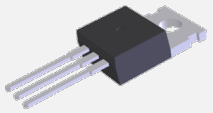
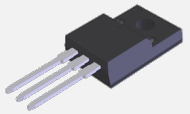
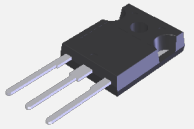
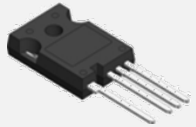
650V SUPERFET® III Easy Drive

- H: TO-247AB, HD: TO-247AD
- L4 : TO247-4L
- L(1) : TO-220F narrow lead
- R0 : No internal Rg

PKG	D / IPAK	D2 / I2PAK	Power88	TOLL	TO-220	TO-220F	TO-247	TO-247-4L
RDS(on)								
23mΩ							FCH023N65S3	FCH023N65S3L4
29mΩ							FCH029N65S3	
40mΩ							FCH040N65S3 FCHD040N65S3	
67/70mΩ		FCB070N65S3		NTBL070N65S3	FCP067N65S3	FCPF067N65S3	FCH067N65S3	
80mΩ			FCMT080N65S3					
99mΩ		FCB099N65S3	FCMT099N65S3		FCP099N65S3	FCPF099N65S3	FCH099N65S3	
125mΩ		FCB125N65S3	FCMT125N65S3		FCP125N65S3 FCP125N65S3R0	FCPF125N65S3	FCH125N65S3R0 FCHD125N65S3R0	
165mΩ					FCP165N65S3 FCP165N65S3R0	FCPF165N65S3L1 FCPF165N65S3R0L	FCH165N65S3R0	
180/190/199mΩ		FCB199N65S3	FCMT180N65S3		FCP190N65S3 FCP190N65S3R0	FCPF190N65S3L1 FCPF190N65S3R0L	FCHD190N65S3R0	
250/260mΩ	FCD260N65S3	FCB260N65S3	FCMT250N65S3		FCP260N65S3	FCPF250N65S3L1 FCPF250N65S3R0L		
360mΩ	FCD360N65S3R0 FCU360N65S3R0		FCMT360N65S3		FCP360N65S3R0	FCPF360N65S3R0L		
600mΩ	FCD600N65S3R0 FCU600N65S3R0				FCP600N65S3R0	FCPF600N65S3R0L		

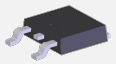
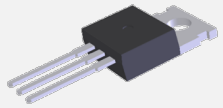
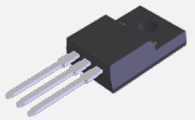
650V SUPERFET® III FRFET®

- H: TO-247AB, HD: TO-247AD
- 4L : TO247-4L
- HF : High efficiency FRFET
- Z : Zener diode b/w Gate and Source

PKG	D2PAK	Power88	TOLL	TO-220	TO-220F	TO-247	TO-247-4L
RDS(on)							
27mΩ						NTH027N65S3F NTHL027N65S3HF	NTH4L027N65S3F
33mΩ						NTHL033N65S3HF	
40mΩ						NTHL040N65S3F NTHL040N65S3HF NTHLD040N65S3HF	NTH4L040N65S3F
50mΩ						NTHL050N65S3HF	
65mΩ						NTHL065N65S3F NTHL065N65S3HF	
82mΩ	NTB082N65S3F		NTBL082N65S3HF	NTP082N65S3F NTP082N65S3HF	NTPF082N65S3F	NTHL082N65S3F NTHL082N65S3HF	
90 / 95mΩ	NTB095N65S3HF	NTMT090N65S3HF		NTP095N65S3HF		NTHL095N65S3HF	
110mΩ	NTB110N65S3HF	NTMT110N65S3HF		NTP110N65S3HF	NTPF110N65S3HF	NTHL110N65S3F	
150mΩ	NTB150N65S3HF	NTMT150N65S3HF		NTP150N65S3HF	NTPF150N65S3HF		
190mΩ	NTB190N65S3HF	NTMT190N65S3HF		NTP190N65S3HF	NTPF190N65S3HF	NTHL190N65S3HF	

• Z : Zener diode b/w Gate and Source

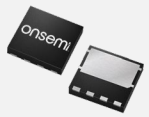
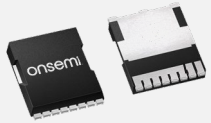
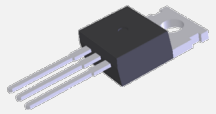
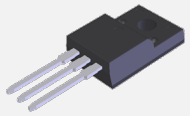
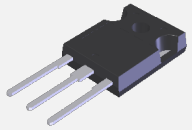
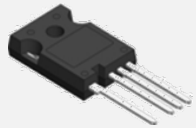
800V SUPERFET® III Easy Drive

PKG	DPAK	TO-220	TO-220F
RDS(on) / ID / Qg			
360mΩ / 13.5A / 20.0nC	NTD360N80S3Z	NTP360N80S3Z	NTPF360N80S3Z
450mΩ / 11.1A / 16.3nC			NTPF450N80S3Z
600mΩ / 8.5A / 12.3nC	NTD600N80S3Z		NTPF600N80S3Z

600V SUPERFET® V MOSFET Line up

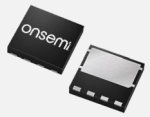
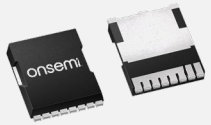
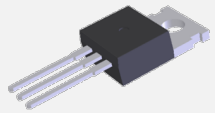
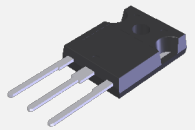
600V SUPERFET® V FAST

Released
In Development
(Sample / Release Date)

PKG	Power88	TOLL	TO-220	TO-220F	TO-247	TO-247-4L
RDS(on)						
17mΩ					NTHL017N60S5H	
41mΩ					NTHL041N60S5H	NTH4LN041N60S5H
48/51mΩ		NTBL048N60S5H				
61mΩ	NTMT061N60S5H	NTBL061N60S5H			NTHL061N60S5H	NTH4LN061N60S5H
80mΩ		NTBL080N60S5H				
100mΩ	NTMT100N60S5H	NTBL100N60S5H		NTPF100N60S5H (it will be EOL)		
125mΩ	NTMT125N60S5H	NTBL125N60S5H	NTP125N60S5H			
150/165mΩ		NTBL150N60S5H				
185mΩ	NTMT185N60S5H		NTP185N60S5H		NTHL185N60S5H	

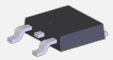
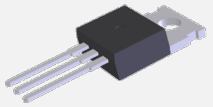
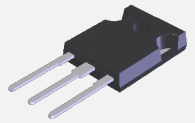
600V SUPERFET® V FRFET® - Planning stage

Released
In Development
(Sample / Release Date)

PKG	Power88	TOLL	TO-220	TO-247
RDS(on)				
19mΩ				NTHL019N60S5F
24mΩ				
40mΩ				
50mΩ				
61mΩ	NTMT061N60S5F			
70mΩ				
105mΩ				
125mΩ			NTP125N60S5FZ	

600V SUPERFET® V Easy Drive

Released
In Development
(Sample / Release Date)

PKG	DPAK	Power88	TO-220	TO-247
RDS(on)				
80mΩ		NTMT080N60S5		
99mΩ				NTHL099N60S5
120mΩ				NTHL120N60S5Z
199mΩ				
280mΩ	NTD280N60S5Z	NTMT280N60S5Z		

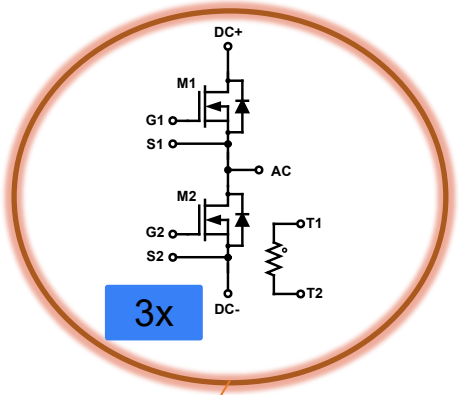
25-30KW Industrial Charger for 120-400V Battery.

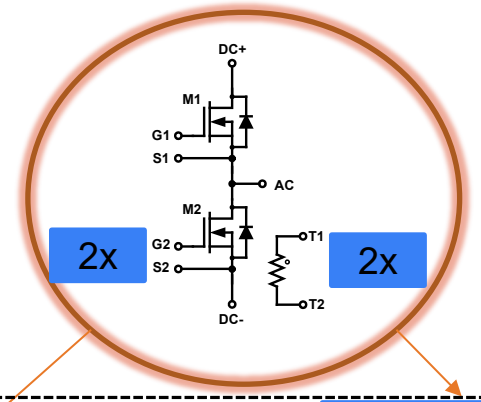
Complete System PFC + DC-DC Converter Specification

AC input	**Voltage input rating**	**Three-phase 400 Vac (EU), 480 Vac (US)**
	Max. input current	40 A
	Frequency	50/60 Hz
	Power factor	>0.99
	Efficiency	>96%
DC output	Output voltage	200 V to 1000 V
	Max. output power	25 kW
	Max. output current	50 A
Protections	Output	OVP, OCP, SC
	Input	UVP, OVP, inrush current
	Internal	Desat (gate driver), thermal (NTC on power device)
User Interface	Push buttons	Yes
	GUI	Yes.
Communication buses	Internal	SPI, I^2C
	External	Isolated CAN, Ethernet, USB/UART
Environmental	Operating temperature	0°C to 40°C
Max. mechanical dimensions	PCB	450 x 300 x 280 mm (PFC and dc-dc stacked)
Standards	Regulation	Following guidelines described in EN55011 Class A. **Will not be tested.**
	EV systems	Following guidelines described in IEC 61851. **Will not be tested**

PFC + DC-DC

7x Half bridge PIM modules
SiC MOSFET, 10mΩ, 1200V
F1 package





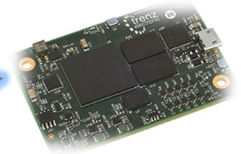
Ultra Fast
DC charger

25kW

DC out
400V/800V

DC Cable
e.g. CCS,
CHAdeMo

seco-te0716-gevb



onsemi

25kW DC output module

Bidirectional 3ph PFC PCB #1

Bidirectional Phase Shifted Dual Active Bridge DC/DC PCB #2

3p
AC grid

EMI

Inrush current

3x voltage sense

3x current sense

V

A

°C

Aux. PSU
Separate for
PFC and DCDC

SECO-
HVDCDC1362
-40W15V

Isol. Gate Drv
6x NCD57000

Isol. Gate Drv
6x NCD57000

Isol. Gate Drv
6x NCD57000

Ethernet
CAN NCV7342

Ethernet
CAN NCV7342

UCB #1

ADC

ADC

PWM

ETH/
CAN

PWM

UCB #2

ADC

ADC

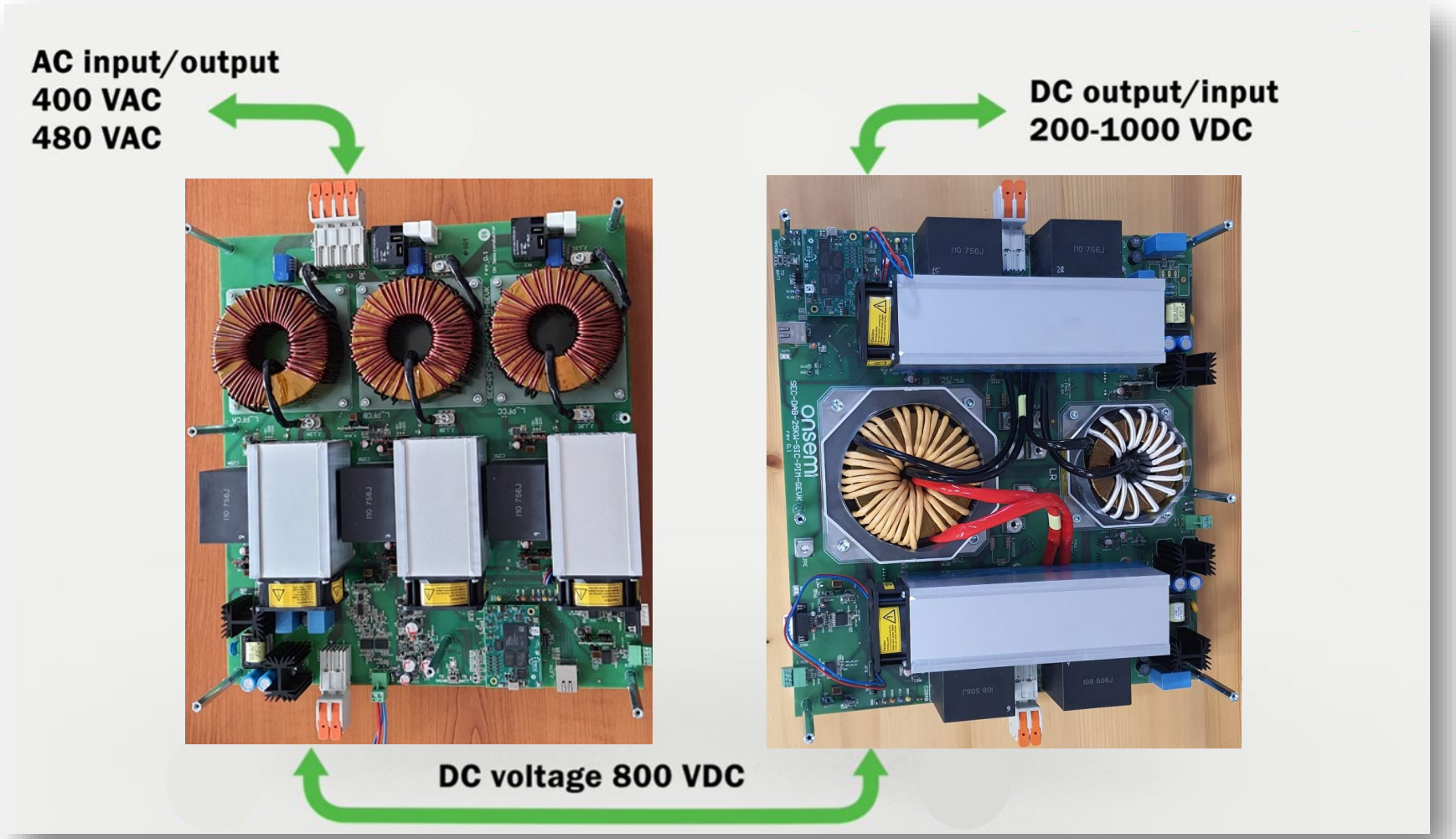
ADC

PWM

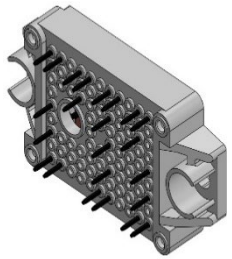
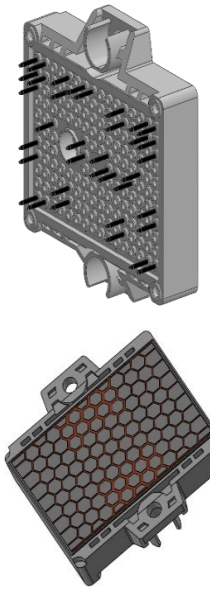
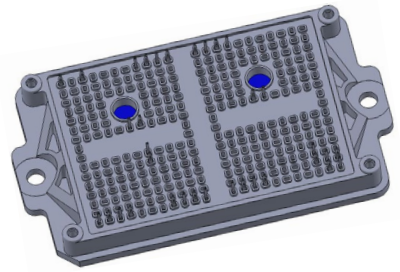
ETH/
CAN

onsemi

Prototypes: PFC + DC-DC



Gel-filled Modules for Energy Infrastructure

F1	Q0	F2	Q1	Q2	F5
					
				with base plate	**with base plate**
1.2 mm press-fit pins Solder pins	1.2 mm press-fit pins 1.6 mm press-fit pins Solder pins	1.2 mm press-fit pins Solder pins	1.2 mm press-fit pins 1.6mm press-fit pins Solder pins	1.6 mm press-fit pins Solder pins	1.2 mm press-fit pins Solder pins
With TIM/no TIM	With TIM/no TIM	With TIM/no TIM	With TIM/no TIM	With TIM/no TIM	With TIM/no TIM

1200V M3S SiC MOSFET 2-PACK Modules in F1 Package

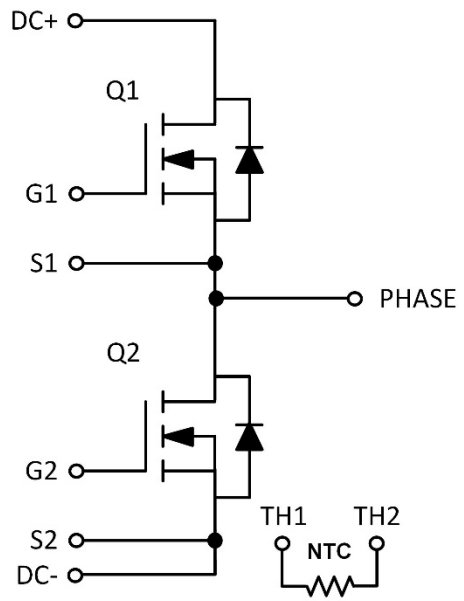
Features

- M3S SiC MOSFET planar technology with 15V-18V drive
  - 8mohm 10mohm, 15mohm and 30mohm versions
  - thermistor
  - Press-fit pins
- Works well with standard NCD5700x driver solutions from onsemi

Benefits

- Optimized switching performance with M3S technology
- Easy to drive with negative gate voltages
- Industry Standard Pinout

Block Diagram

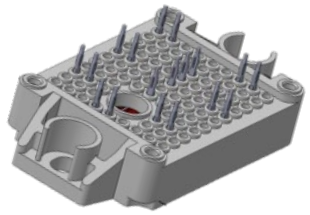


Specifications

Product	Description	Configuration
NXH008P120M3F1	Half Bridge 2-PACK 1200V 8mohm SiC MOSFET module	Press-fit pins TIM option
NXH010P120M3F1	Half Bridge 2-PACK 1200V 10mohm SiC MOSFET module	
NXH015P120M3F1	Half Bridge 2-PACK 1200V 15mohm SiC MOSFET module	
NXH030P120M3F1	Half Bridge 2-PACK 1200V 30mohm SiC MOSFET module	

Package

F1



End products

- Solar Inverter
- UPS
- Energy Storage

Applications

- Industrial Applications

* Under development

Performance Comparison – 25kW Bidirectional DCFC 1200V SiC MOSFET Half bridge - M1 Vs. M3S

* All Simulated

Key Parameters @ conditions		NXH010P120MNF1PG	NXH010P120M3F1PTHG
PFC Vin (L-L) = 480V VDC_out = 800V Fsw = 70kHz L=130uH Ta = 45 ^{0}C	Switching Losses (@ 25kW)	127.6 W	82.4 W
	Conduction Losses (@ 25kW)	42.4 W	44.2 W
	Total Losses (@ 25kW)	170 W	126.6 W
DAB VDC_in = 800V VDC_out = 600V Fsw = 100kHz L=18uH Ta = 45 ^{0}C	Switching Losses (@ 25kW)	80 W	62.7 W
	Conduction Losses (@ 25kW)	114.2 W	116.4 W
	Total Losses (@ 25kW)	194.2 W	179.1 W

20% ↓

15% ↓

1200V SiC MOSFET 2-PACK Modules in F2 Package

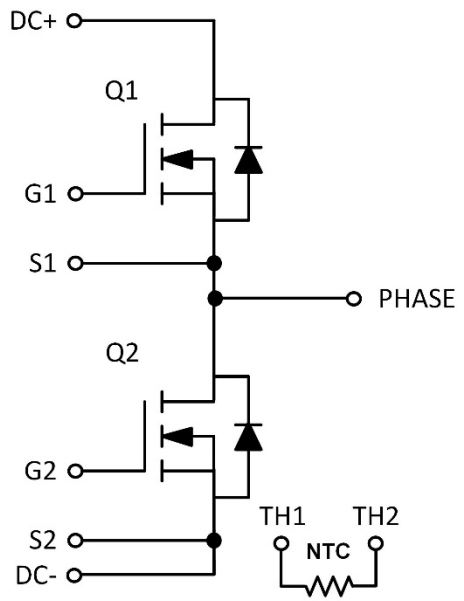
Features

- M1 SiC MOSFET planar technology; 18V-20V drive
  - 6mohm 1200V module
- M3S SiC MOSFET planar technology; 15-18V drive
  - 3mohm 1200V module
  - 4mohm 1200V module
- Works well with standard NCD5700x driver solutions from onsemi

Benefits

- Optimized switching performance with M3S
- Industry leading low Rdson half-bridge
  - Si_3N_4 DBC for lower R_{thjc}
- Easy to drive with negative gate voltages

Block Diagram

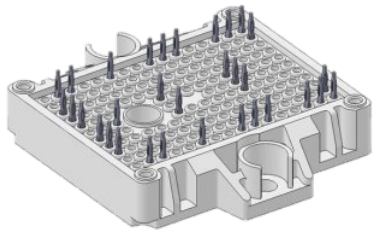


Specifications

Product	Description	Configuration
NXH006P120M3F2PTHG	Half Bridge 2-PACK 1200V 6mohm SiC MOSFET module	Press-fit pins TIM option
NXH004P120M3F2PTHG	Half Bridge 2-PACK 1200V 4mohm SiC MOSFET module	
NXH003P120M3F2PTHG	Half Bridge 2-PACK 1200V 3mohm SiC MOSFET module	

Package

F2



End products

- Solar Inverter
- UPS
- Energy Storage

Applications

- Industrial Applications

1200V M3S SiC MOSFET 4-PACK Modules in F1 Package

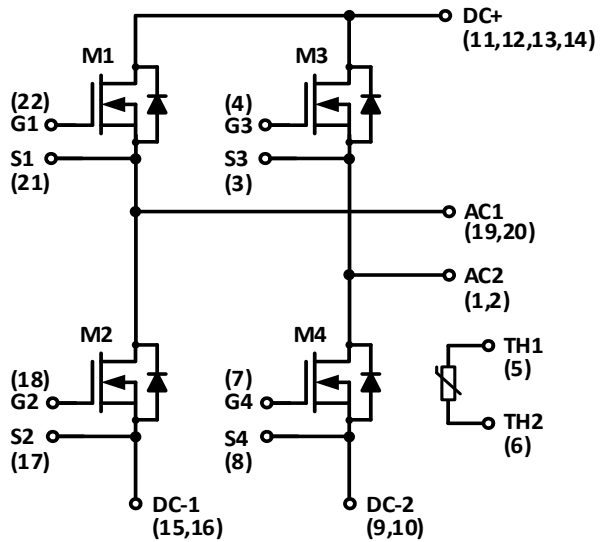
Features

- M3S SiC MOSFET planar technology with 15V-18V drive
  - 15mohm and 30mohm 1200V modules
  - thermistor
  - Press-fit pins
- Works well with standard NCD5700x driver solutions from onsemi

Benefits

- Optimized switching performance with M3S technology
- Easy to drive with negative gate voltages
- Industry Standard Pinout

Block Diagram

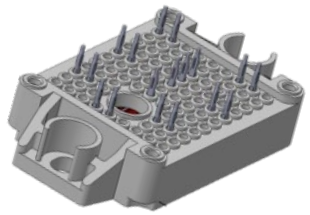


Specifications

Product	Description	Configuration
NXH015F120M3F1	Full Bridge 4-PACK 1200V 15mohm SiC MOSFET module	Press-fit pins TIM option
NXH030F120M3F1	Full Bridge 4-PACK 1200V 30mohm SiC MOSFET module	

Package

F1



End products

- Solar Inverter
- UPS
- Energy Storage

Applications

- Industrial Applications

* Under development

1200V M3S SiC MOSFET 4-PACK Modules in F2 Package

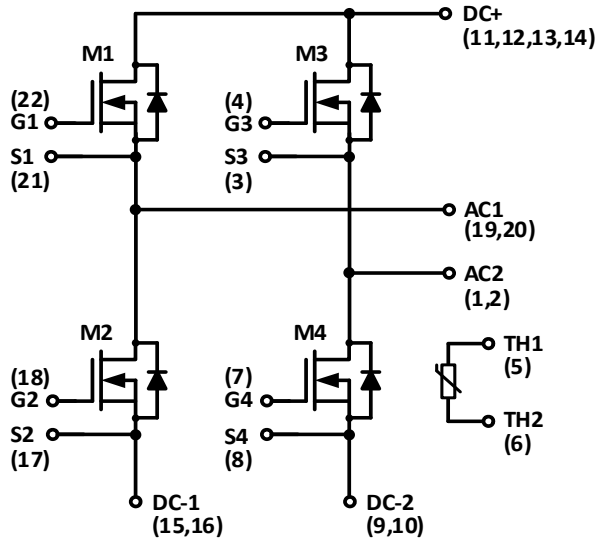
Features

- M3S SiC MOSFET planar technology with 15V-18V drive
  - 8mohm and 15mohm 1200V modules
  - thermistor
  - Press-fit pins
- Works well with standard NCD5700x driver solutions from onsemi

Benefits

- Optimized switching performance with M3S technology
- Easy to drive with negative gate voltages
- Industry Standard Pinout

Block Diagram

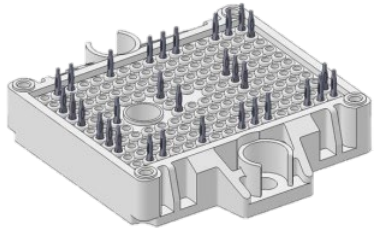


Specifications

Product	Description	Configuration
NXH008F120M3F2	Full Bridge 4-PACK 1200V 8mohm SiC MOSFET module	Press-fit pins TIM option
NXH015F120M3F2	Full Bridge 4-PACK 1200V 15mohm SiC MOSFET module	

Package

F2



End products

- Solar Inverter
- UPS
- Energy Storage

Applications

- Industrial Applications

* Under development

SiC MOSFET 6-PACK Modules in F1 Package

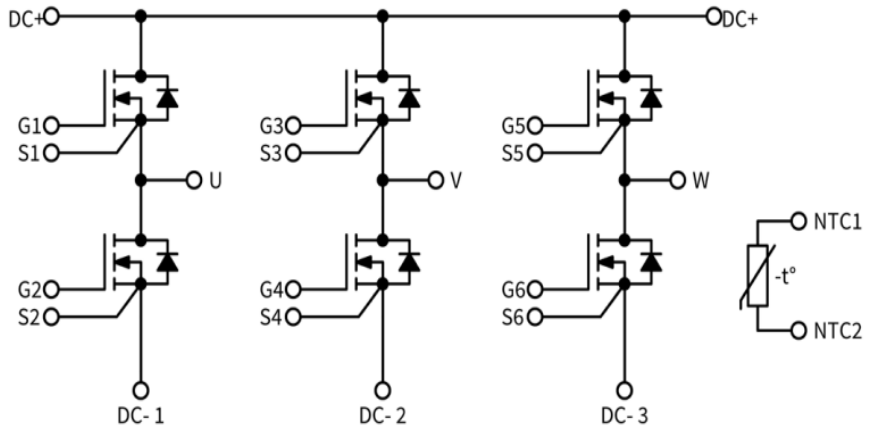
Features

- M3S SiC MOSFET planar technology; 15V-18V drive
  - 10mohm 650V module
  - 22, 30mohm 1200V modules
  - Press-fit pins and TIM
- Works well with standard NCD5700x driver solutions from onsemi

Benefits

- Optimized switching performance with M3S
- Industry leading low Rdson 6 PACK
- Easy to drive with negative gate voltages

Block Diagram

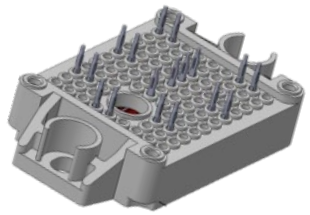


Specifications

Product	Description	Configuration
NXH010S065M3F1*	6-PACK 650V 10mohm SiC MOSFET module	Press-fit pins TIM option
NXH022S120M3F1*	6-PACK 1200V 22mohm SiC MOSFET module	
NXH030S120M3F1*	6-PACK 1200V 30mohm SiC MOSFET module	

Package

F1



End products

- Solar Inverter
- EV-C
- UPS

Applications

- Industrial Applications

* Under development

SiC SPM®31 (Mini)

Features

- 1200V M3P SiC MOSFET (Vgs : 0V ~ 18V)
- Miller Clamp function into gate drivers
- Pin compatible with ‘M’ Competitor Mini DIP & Onsemi IGBT SPM31
- Very low thermal resistance with AIN DBC substrate
- Built in bootstrap circuit
- NTC thermistor for junction temperature monitoring
- Temperature sensing and output voltage function in LVIC
- No side dummy for more creepage
- High power density, High efficiency, Fast switching capability

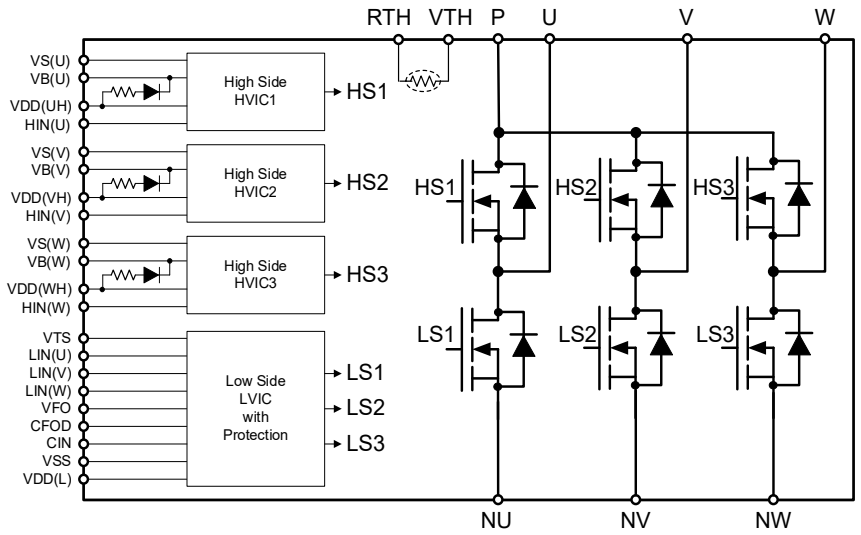
1200V Line-up

Product	Voltage	Rds(on)	Substrate	Remark
NFAM5812SCBUT	1200V	58 mΩ (40A)	DBC	- ES : Available - Product release : . Q4`24 (60A) . Q1`25 (40-50A)
NFAM4512SCBUT	1200V	45 mΩ (50A)	DBC	
NFAM3212SCBUT	1200V	32 mΩ (60A)	DBC (AIN)	

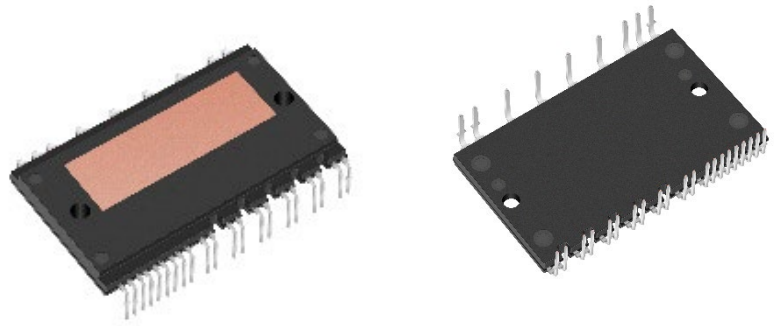
Target Application

- Servo Motor
- Industrial Inverter
- HVAC

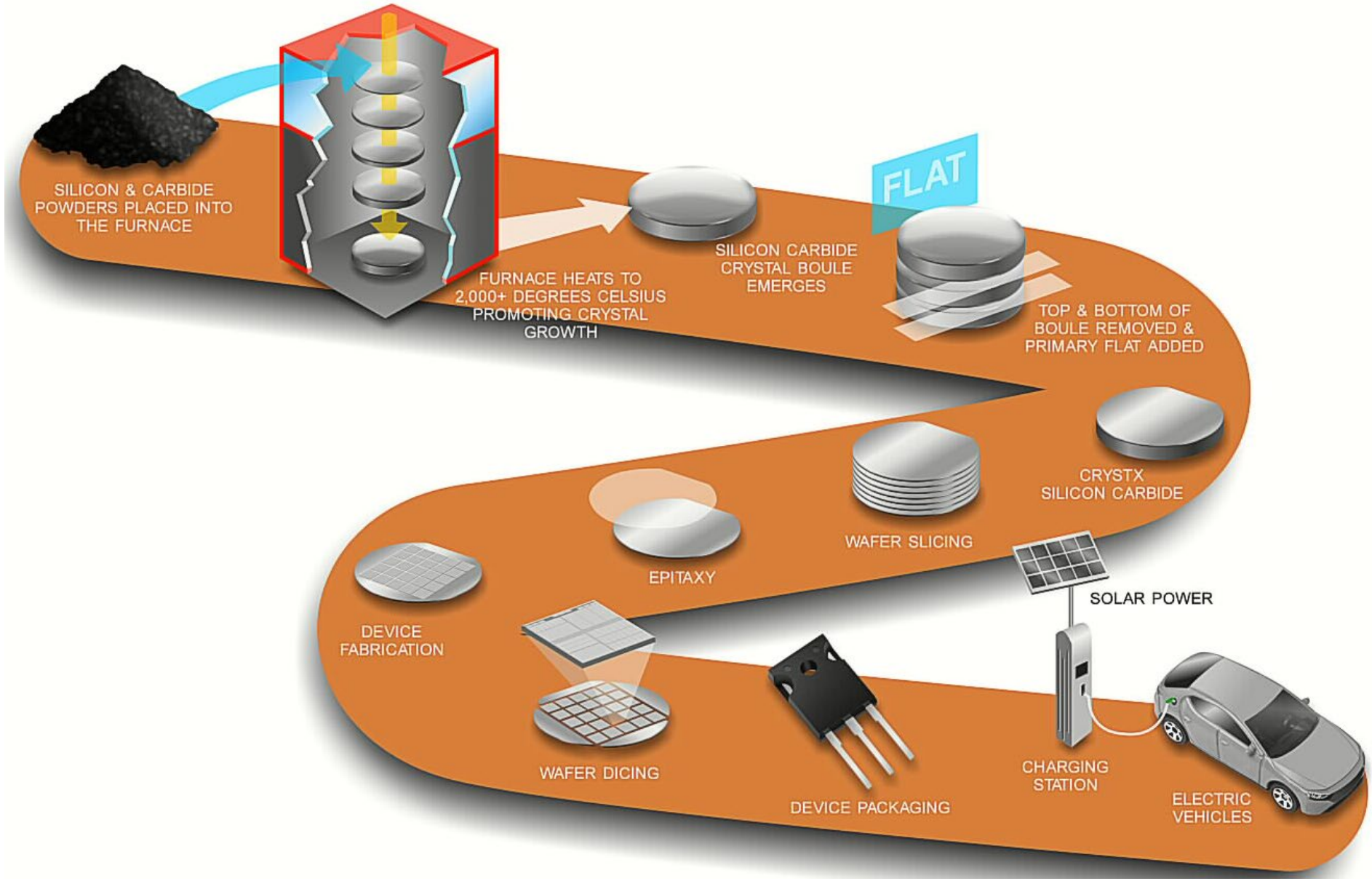
Block Diagram



Package: 54.5 mm × 31 mm × 5.6 mm



onsemi EliteSiC vertical integration – Unique for the industry



SiC Players market shares

[Source: Yole, 2024]

onsemi SiC MOSFET and Diode Families

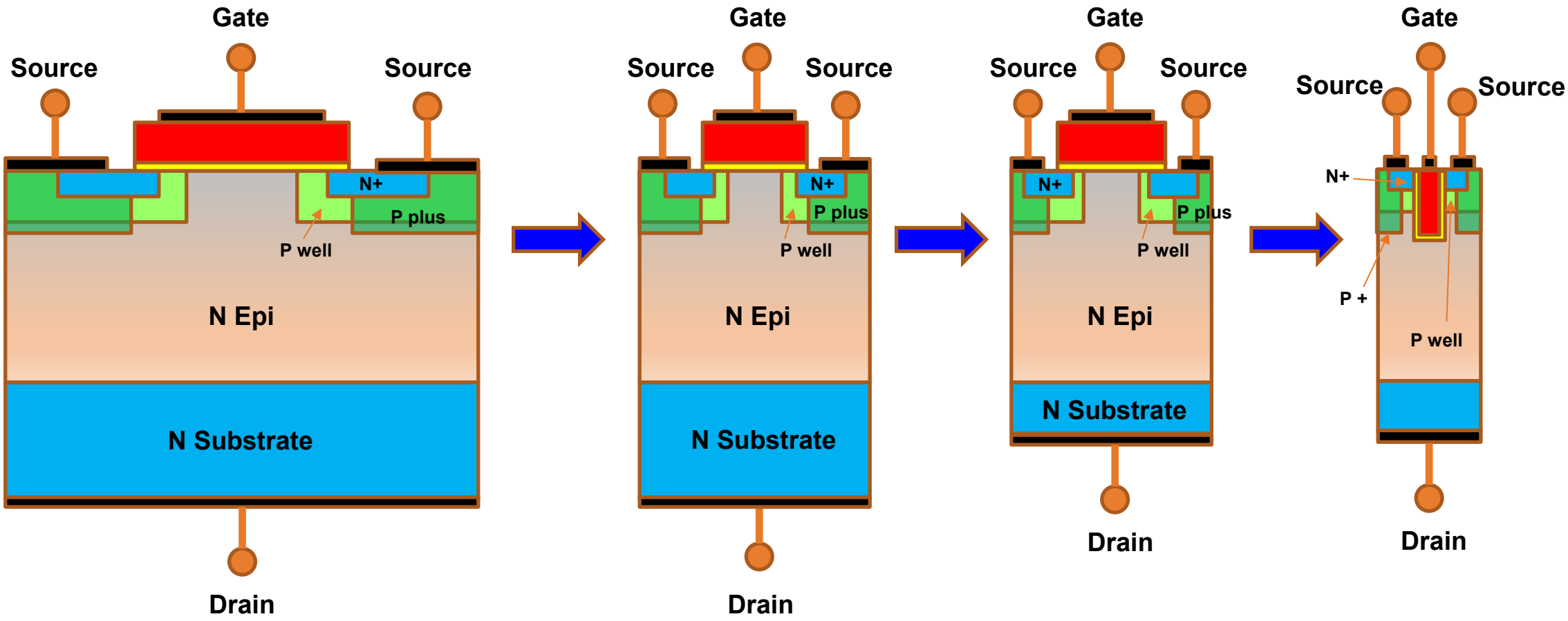
Family	Series	Optimization	650 / 750V	900V	1200V	1700V	Primary Applications
M1	M1	Low RDS(ON) High SCWT			..120SC1	..170M1	
M2	M2	Low RDS(ON) High SCWT	..065SC1 ..075SC1	..090SC1			
M3	M3S	High speed	..065M3S		..120M3S		
	M3P, M3E	High SCWT	..075M3E		..120M3P		
M4	M4S	High speed			..120M4S		
	M4T	High SCWT			..120M4T		

Family	Optimization	650V		1200V	1700V	Primary Applications
D1	High IFSM	..065A		..120A	..170A	
D2	Low QC	..065B				
D3	Low QC x VF			..120C		

Traction On-board Charger EV Charging Station UPS/Energy Storage Solar High Power Industrial

In Development

onsemi SiC MOSFET Technology evolution



1200V/1700V M1

650V/750V/900V M2

650V/1200V M3

Narrow cell pitch

Planar Gate structure

1200V M4

Narrow cell pitch

Trench Gate structure

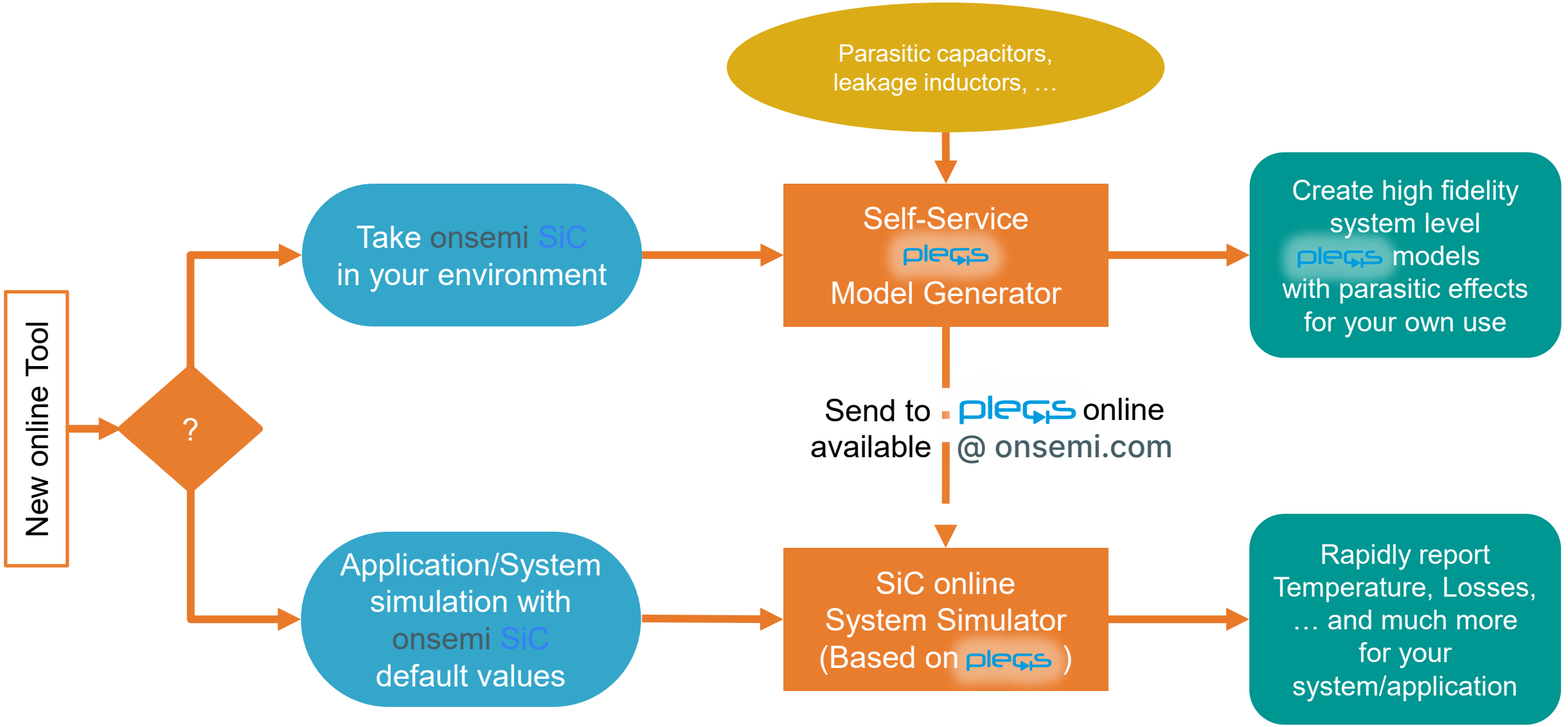
2025 release

Advantages of onsemi EliteSiC technology

- Proven Quality / Robust Planar Design
  - In-process Control and Burn-in
  - Defect Scanning during Manufacturing
  - 100% Avalanche testing of All Dies
  - No Drift in Threshold or Parameters
  - High Reliability Gate Oxide
  - Automotive Qualification AECQ-100
- Best in class design tools
  - Physical & Scalable accurate Simulation Models
  - Application notes and Design guides
- Fully Integrated Manufacturing
  - Form Powder to Products
- New 3rd generation SiC offering
  - Optimized for High temperature operation
    - Diodes : Low series-resistance temperature dependency
    - MOSFETs : Stable reverse recovery over temperature
  - Improved parasitic capacitances for High Frequency High Efficiency application
  - Large die with low $R_{DS(on)}$ available
- Automotive or Industrial grade for All Values and Packages
- Wide offering in Standard and Custom Power Integrated Modules (PIM)
- Large portfolio of Voltages and $R_{SD(on)}$ available in 3- and 4-Leads packages

New onsemi online simulator

New tool flow and interaction

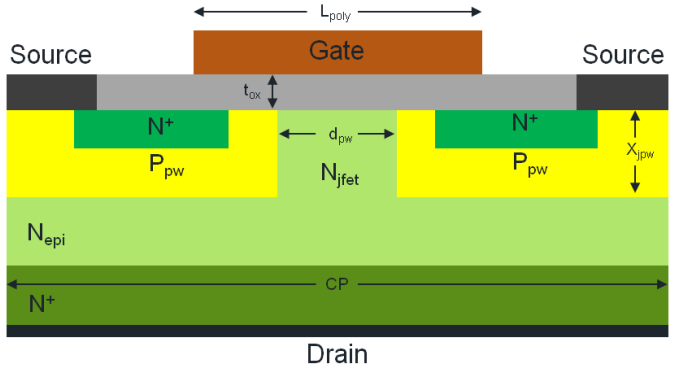


Physical & Scalable SiC MOSFET Models in FIT

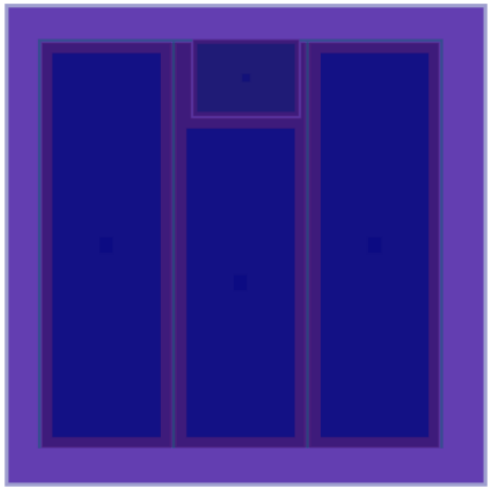
Physically Based SPICE Models for SiC MOSFETs

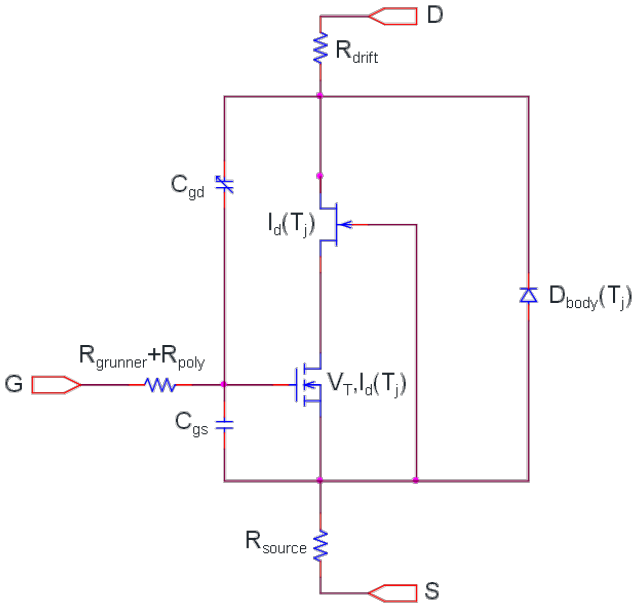
- Models are derived from physics-based formulations.
  - Published in APEC 2017
- Inputs include device technology (cross section) and layout information (GDS)
- Extensive verification to hardware performed.
- Design new devices through sizing and layout configuration.
- Accurate corner and statistical modeling
  - Published in ISPSD 2020

Device Technology



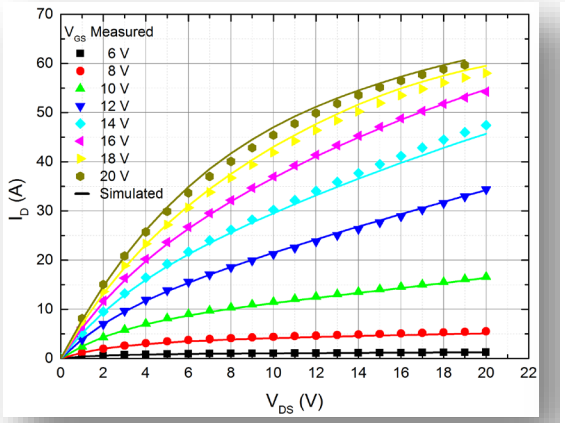
Layout/GDS

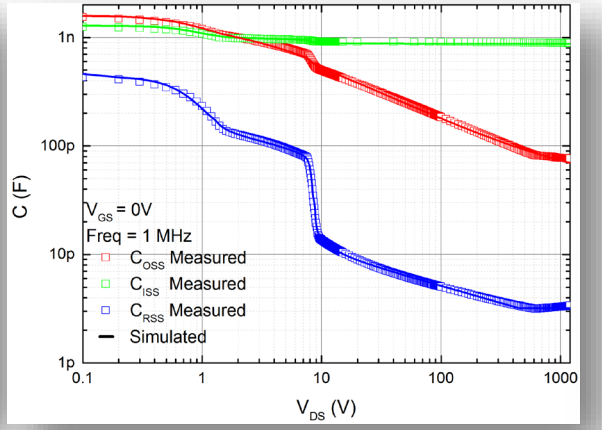


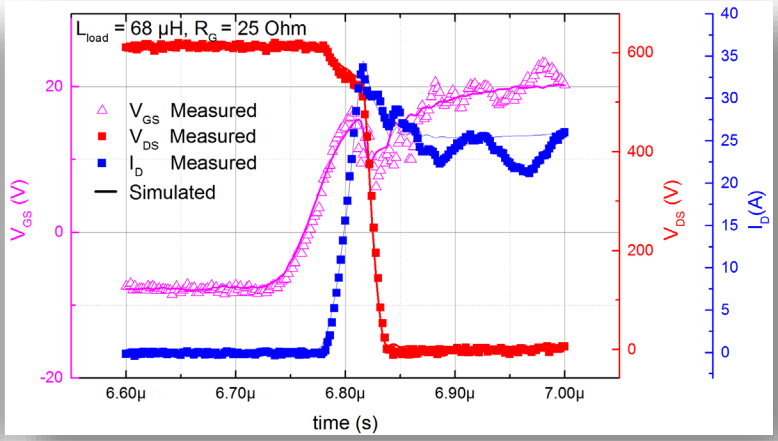


Physical Structure

Physical & Scalable SPICE Model

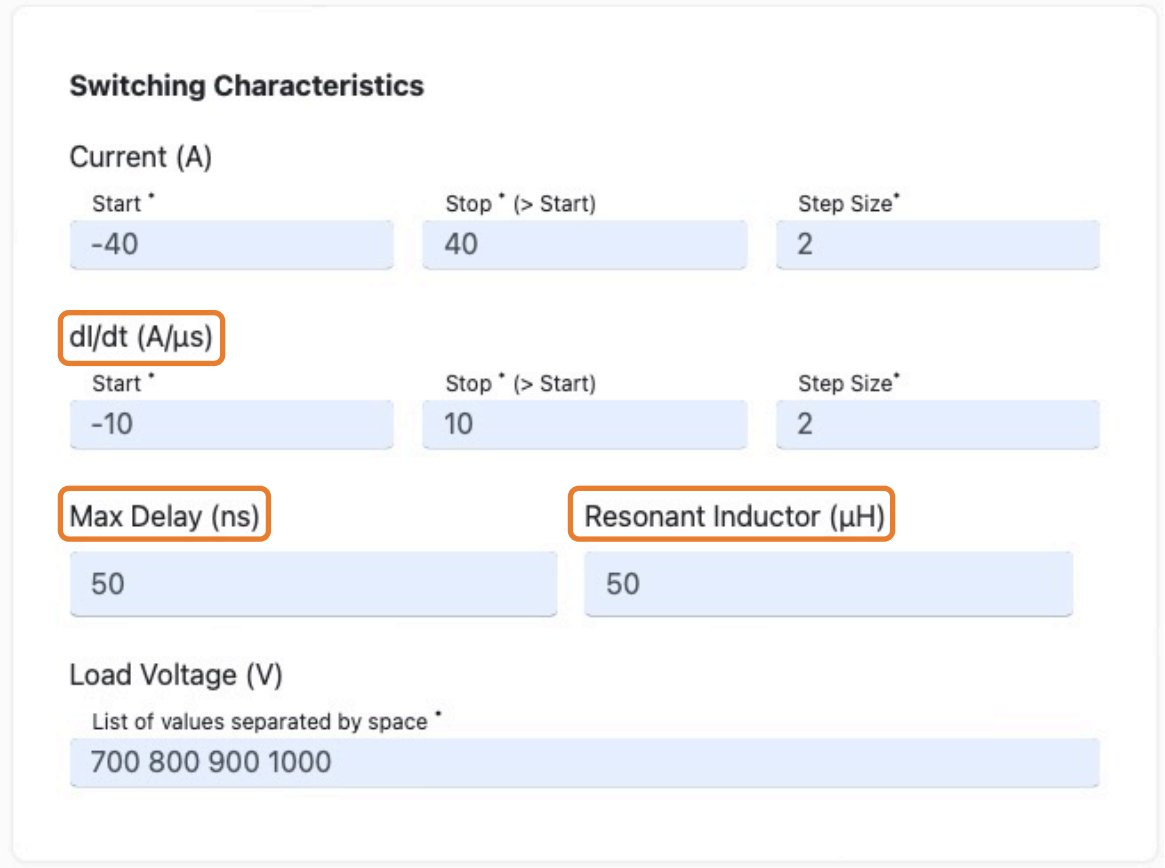






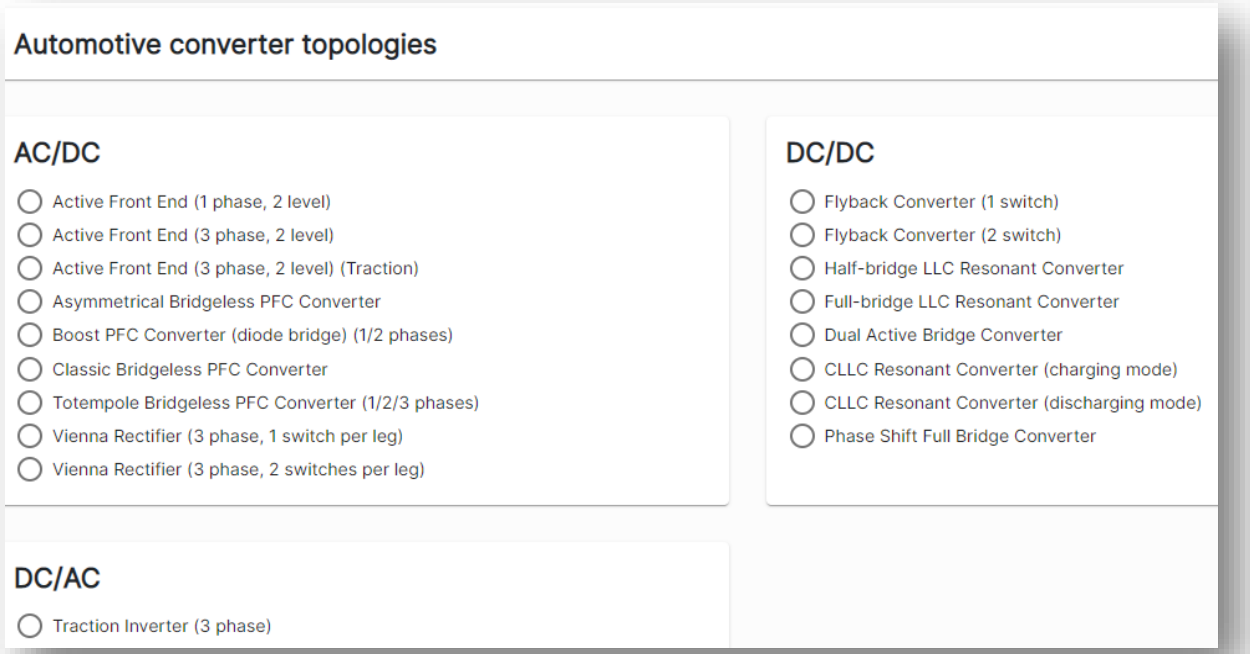
Model Generator extended Parameters for Soft Switching

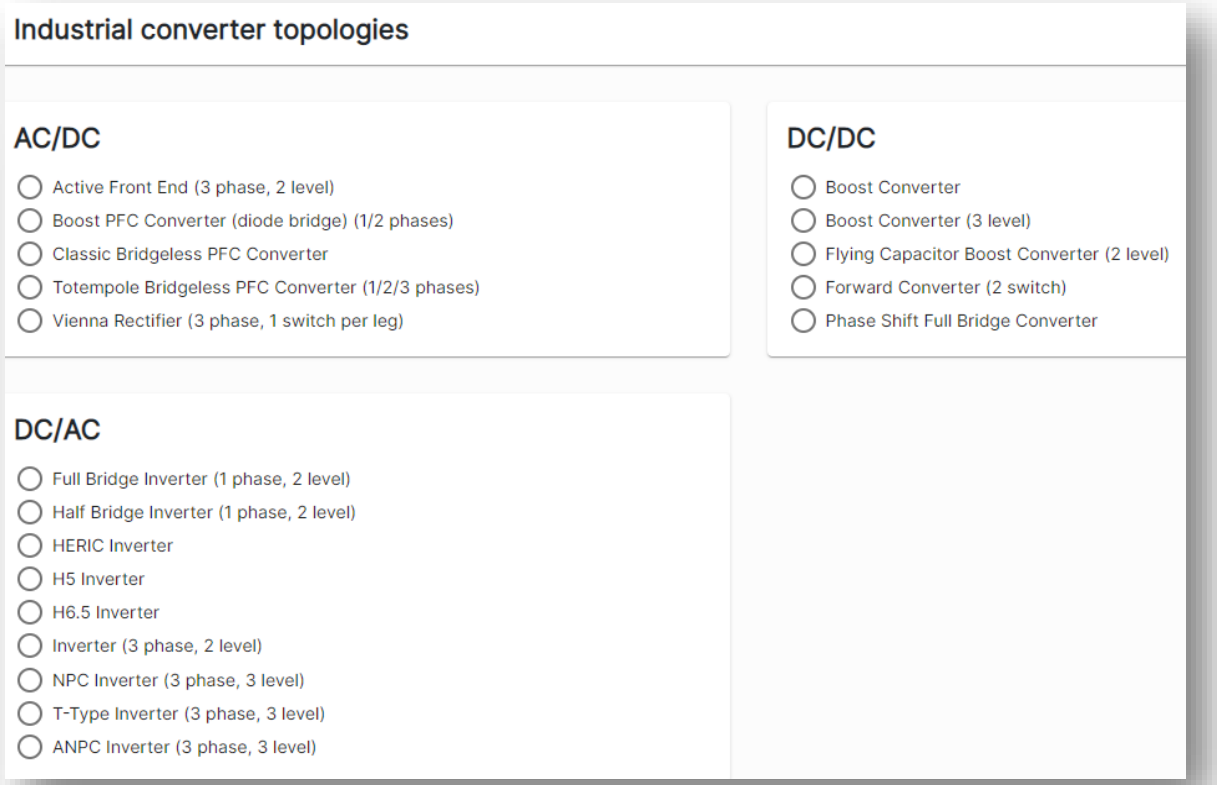
- For Soft Switching, extra parameters are needed to evaluate if the system will or will not operate in soft switching.
  - The resonant inductor value,
  - The resonant inductor di/dt range,
  - The maximum delay or dead time between two switching events.
- Partial soft switching is also model with this method when resonant energy available and/or dead time are not enough.



Online Simulator Topologies & Products

All major topologies are available :





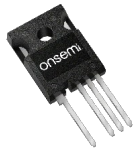
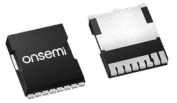
onsemi.com products available :

- All SiC MOSFET Discretes
- All SiC Power Modules (PIM and Traction)
- As new SiC products are released, they will be populated in SSPMG and the online simulator

SiC MOSFET Portfolio

650V & 750V SiC MOSFETs – M2 Family

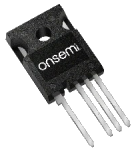
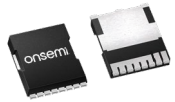
Automotive grade uses “NV”, Industrial grade uses “NT”

BVdss (V)	$R_{DS(ON)}$ (mΩ) Typical @Vgs:15V	$R_{DS(ON)}$ (mΩ) Typical @Vgs:18V	TO-247-3L	TO-247-4L	D2PAK-7L	TOLL	Power88
							
750	18	13.5		NVH4L018N075SC1 NTH4L018N075SC1			
650	15	12	NVHL015N065SC1 NTHL015N065SC1	NVH4L015N065SC1 NTH4L015N065SC1	NVBG015N065SC1 NTBG015N065SC1		
	25	19	NVHL025N065SC1 NTHL025N065SC1	NVH4L025N065SC1 NTH4L025N065SC1	NVBG025N065SC1 NTBG025N065SC1		
	45	33	NVHL045N065SC1 NTHL045N065SC1	NVH4L045N065SC1 NTH4L045N065SC1	NVBG045N065SC1 NTBG045N065SC1	NTBL045N065SC1	NTMT045N065SC1
	60	44	NVHL060N065SC1 NTHL060N065SC1	NVH4L060N065SC1 NTH4L060N065SC1	NVBG060N065SC1 NTBG060N065SC1	NTBL060N065SC1	
	75	57	NVHL075N065SC1 NTHL075N065SC1	NVH4L075N065SC1 NTH4L075N065SC1	NVBG075N065SC1	NTBL075N065SC1	
	95	78		NVH4L095N065SC1 NTH4L095N065SC1	NVBG095N065SC1		

650V SiC MOSFETs – M3 Family

Released
In Development
(Sample / Release Date)
In Plan

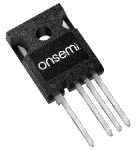
Automotive grade uses “NV”, Industrial grade uses “NT”

$R_{DS(ON)}$ (mΩ) Typical @Vgs:18V	TO-247-3L	TO-247-4L	D2PAK-7L	TOLL	BPAK (Top Cool SMD PKG)
					
8	NTHL008N065M3S	NTH4L008N065M3S	NTBG008N065M3S		NTTC008N065M3S
12	NTHL012N065M3S (Available / Nov ’24)	NVH4L012N065M3S NTH4L012N065M3S (Available / Nov ’24)	NVBG012N065M3S NTBG012N065M3S (Available / Nov ’24)	NTBL012N065M3S (Available / Q2 ’25)	NVTC012N065M3S NTTC012N065M3S (Jul ’24 / Q2 ’25)
16	NTHL016N065M3S (Available / Nov ’24)	NVH4L016N065M3S NTH4L016N065M3S (Available / Nov ’24)	NVBG016N065M3S NTBG016N065M3S (Available / Nov ’24)	NTBL016N065M3S (Available / Q2 ’25)	NVTC016N065M3S NTTC016N065M3S (Aug ’24 / Q2 ’25)
23	NVHL023N065M3S NTHL023N065M3S	NVH4L023N065M3S NTH4L023N065M3S	NVBG023N065M3S NTBG023N065M3S	NTBL023N065M3S (Available / Aug ’24)	NVTC023N065M3S NTTC023N065M3S (Jul ’24 / Q2 ’25)
32	NTHL032N065M3S (Available / Jul ’24)	NVH4L032N065M3S NTH4L032N065M3S (Available / Jul ’24)	NVBG032N065M3S NTBG032N065M3S (Available / Jul ’24)	NTBL032N065M3S (Available / Aug ’24)	NVTC032N065M3S NTTC032N065M3S (Aug ’24 / Q2 ’25)

750V SiC MOSFETs – M3 Family

In Plan

Industrial grade uses “NT”

$R_{DS(ON)}$ (mΩ) Typical @Vgs:18V	TO-247-4L	D2PAK-7L	BPAK (Top Cool SMD PKG)
			
8	NTH4L008N075M3E	NTBG008N075M3E	NTTC008N075M3E
10	NTH4L010N075M3E	NTBG010N075M3E	NTTC010N075M3E
13	NTH4L013N075M3E	NTBG013N075M3E	NTTC013N075M3E

1200V SiC MOSFETs – M3 Family

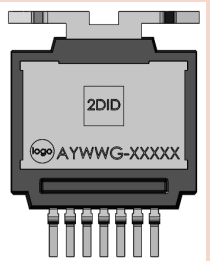
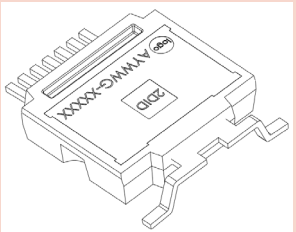
Released
In Development
(Sample / Release Date)

Automotive grade uses “NV”, Industrial grade uses “NT”

$R_{DS(ON)}$ (mΩ) Typical @Vgs:18V	TO-247-3L	TO-247-4L	D2PAK-7L	BPAK (Top Cool SMD PKG)	Die
					
13		NTH4L013N120M3S			NTCR013N120M3S
14		NTH4L014N120M3P	NTBG014N120M3P		
22	NTHL022N120M3S	NVH4L022N120M3S NTH4L022N120M3S	NVBG022N120M3S NTBG022N120M3S	NVTC022N120M3S NTTC022N120M3S (Available / Dec ’24)	
29	NTHL030N120M3S	NVH4L030N120M3S NTH4L030N120M3S	NVBG030N120M3S NTBG030N120M3S	NVTC030N120M3S NTTC030N120M3S (Available / Dec ’24)	
40	NTHL040N120M3S	NVH4L040N120M3S NTH4L040N120M3S	NVBG040N120M3S NTBG040N120M3S	NVTC040N120M3S NTTC040N120M3S (Available / Dec ’24)	NTCR040N120M3S (Q3 / Q4 ’24)
65	NTHL070N120M3S	NVH4L070N120M3S NTH4L070N120M3S	NVBG070N120M3S NTBG070N120M3S	NVTC070N120M3S NTTC070N120M3S (Available / Dec ’24)	

1200V M3S BPAK prototype sample schedule

Part number	Rdson (mohm)	Tech	Prototype sample schedule
NTTC070N120M3S	65	M3S 1200V	Available
NTTC040N120M3S	40	M3S 1200V	Available
NTTC030N120M3S	30	M3S 1200V	Available
NTTC022N120M3S	22	M3S 1200V	Available

POD Option#	Top view	Side view	Angle view
Top Cool			

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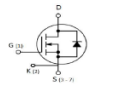
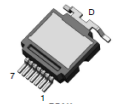
MOSFET – SiC Power, Single N-Channel, M3S, BPAK
1200 V, 22 mΩ, 82 A

Product Preview
NTTC022N120M3S

$V_{(BR)DSS}$	$R_{DS(ON)}$ TYP	I_D MAX
1200 V	22 mΩ @ 18 V	82 A



N−CHANNEL MOSFET



BPAK
CASE TBD

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Parameter		Symbol	Value	Unit
Drain−to−Source Voltage		V_{DSS}	1200	V
Gate−to−Source Voltage		V_{GS}	−8/+22	V
Recommended Operation Values of Gate−to−Source Voltage	T_C < 175°C	V_{GSop}	−3/+18	V
Continuous Drain Current	T_C = 25°C	I_D	82	A
Power Dissipation		P_D	435	W
Continuous Drain Current	T_C = 100°C	I_D	60	A
Power Dissipation		P_D	217	W
Pulsed Drain Current	T_C = 25°C, t_p = 10 μs	I_{DM}	530	A
Operating Junction and Storage Temperature Range		T_J, T_{stg}	−55 to +175	°C
Source Current (Body Diode)		I_S	96	A
Single Pulse Avalanche Energy (T_J = 25°C, V_{GS} = 18 V, I_{LPK} = 80 A, L = 1 mH, R_G = 25 Ω)		E_{AS}	3200	mJ
Lead Temperature for Soldering Purposes (1/8" from case for 10 seconds)		T_L	260	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

THERMAL CHARACTERISTICS

Parameter	Symbol	Value	Unit
Thermal Resistance, Junction−to−Case	$R_{θJC}$	0.34	°C/W
Thermal Resistance, Junction−to−Ambient	$R_{θJA}$	TBD	

ORDERING INFORMATION

Device	Package	Shipping†
NTTC022N120M3S	BPAK	TBD / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

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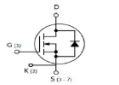
DATA SHEET
www.onsemi.com

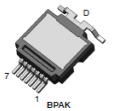
MOSFET – SiC Power, Single N-Channel, M3S, BPAK
1200 V, 30 mΩ, 61 A

Product Preview
NTTC030N120M3S

$V_{(BR)DSS}$	$R_{DS(ON)}$ TYP	I_D MAX
1200 V	30 mΩ @ 18 V	61 A



N−CHANNEL MOSFET



BPAK
CASE TBD

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Parameter		Symbol	Value	Unit
Drain−to−Source Voltage		V_{DSS}	1200	V
Gate−to−Source Voltage		V_{GS}	−8/+22	V
Recommended Operation Values of Gate−to−Source Voltage	T_C < 175°C	V_{GSop}	−3/+18	V
Continuous Drain Current	T_C = 25°C	I_D	61	A
Power Dissipation		P_D	326	W
Continuous Drain Current	T_C = 100°C	I_D	44	A
Power Dissipation		P_D	163	W
Pulsed Drain Current	T_C = 25°C, t_p = 10 μs	I_{DM}	399	A
Operating Junction and Storage Temperature Range		T_J, T_{stg}	−55 to +175	°C
Source Current (Body Diode)		I_S	67	A
Single Pulse Avalanche Energy (T_J = 25°C, V_{GS} = 18 V, I_{LPK} = 80 A, L = 1 mH, R_G = 25 Ω)		E_{AS}	3200	mJ
Lead Temperature for Soldering Purposes (1/8" from case for 10 seconds)		T_L	260	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

THERMAL CHARACTERISTICS

Parameter	Symbol	Value	Unit
Thermal Resistance, Junction−to−Case	$R_{θJC}$	0.46	°C/W
Thermal Resistance, Junction−to−Ambient	$R_{θJA}$	TBD	

ORDERING INFORMATION

Device	Package	Shipping†
NTTC030N120M3S	BPAK	TBD / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

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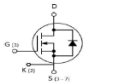
DATA SHEET
www.onsemi.com

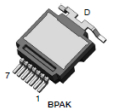
MOSFET – SiC Power, Single N-Channel, M3S, BPAK
1200 V, 40 mΩ, 45 A

Product Preview
NTTC040N120M3S

$V_{(BR)DSS}$	$R_{DS(ON)}$ TYP	I_D MAX
1200 V	40 mΩ @ 18 V	45 A



N−CHANNEL MOSFET



BPAK
CASE TBD

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Parameter		Symbol	Value	Unit
Drain−to−Source Voltage		V_{DSS}	1200	V
Gate−to−Source Voltage		V_{GS}	−8/+22	V
Recommended Operation Values of Gate−to−Source Voltage	T_C < 175°C	V_{GSop}	−3/+18	V
Continuous Drain Current	T_C = 25°C	I_D	45	A
Power Dissipation		P_D	242	W
Continuous Drain Current	T_C = 100°C	I_D	32	A
Power Dissipation		P_D	121	W
Pulsed Drain Current	T_C = 25°C, t_p = 10 μs	I_{DM}	286	A
Operating Junction and Storage Temperature Range		T_J, T_{stg}	−55 to +175	°C
Source Current (Body Diode)		I_S	52	A
Single Pulse Avalanche Energy (T_J = 25°C, V_{GS} = 18 V, I_{LPK} = 40 A, L = 1 mH, R_G = 25 Ω)		E_{AS}	800	mJ
Lead Temperature for Soldering Purposes (1/8" from case for 10 seconds)		T_L	260	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

THERMAL CHARACTERISTICS

Parameter	Symbol	Value	Unit
Thermal Resistance, Junction−to−Case	$R_{θJC}$	0.62	°C/W
Thermal Resistance, Junction−to−Ambient	$R_{θJA}$	TBD	

ORDERING INFORMATION

Device	Package	Shipping†
NTTC040N120M3S	BPAK	TBD / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

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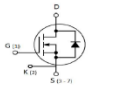
DATA SHEET
www.onsemi.com

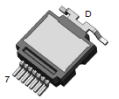
MOSFET – SiC Power, Single N-Channel, M3S, BPAK
1200 V, 65 mΩ, 29 A

Product Preview
NTTC070N120M3S

$V_{(BR)DSS}$	$R_{DS(ON)}$ TYP	I_D MAX
1200 V	65 mΩ @ 18 V	29 A



N−CHANNEL MOSFET



BPAK
CASE TBD

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Parameter		Symbol	Value	Unit
Drain−to−Source Voltage		V_{DSS}	1200	V
Gate−to−Source Voltage		V_{GS}	−8/+22	V
Recommended Operation Values of Gate−to−Source Voltage	T_C < 175°C	V_{GSop}	−3/+18	V
Continuous Drain Current	T_C = 25°C	I_D	29	A
Power Dissipation		P_D	163	W
Continuous Drain Current	T_C = 100°C	I_D	21	A
Power Dissipation		P_D	82	W
Pulsed Drain Current	T_C = 25°C, t_p = 10 μs	I_{DM}	183	A
Operating Junction and Storage Temperature Range		T_J, T_{stg}	−55 to +175	°C
Source Current (Body Diode)		I_S	35	A
Single Pulse Avalanche Energy (T_J = 25°C, V_{GS} = 18 V, I_{LPK} = 30 A, L = 1 mH, R_G = 25 Ω)		E_{AS}	450	mJ
Lead Temperature for Soldering Purposes (1/8" from case for 10 seconds)		T_L	260	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

THERMAL CHARACTERISTICS

Parameter	Symbol	Value	Unit
Thermal Resistance, Junction−to−Case	$R_{θJC}$	0.92	°C/W
Thermal Resistance, Junction−to−Ambient	$R_{θJA}$	TBD	

ORDERING INFORMATION

Device	Package	Shipping†
NTTC070N120M3S	BPAK	TBD / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

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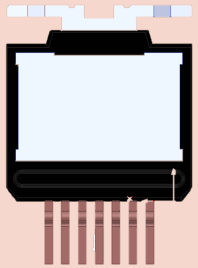
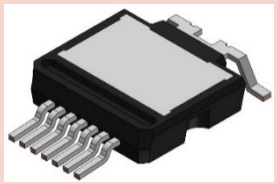
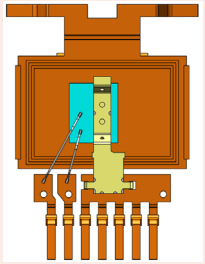
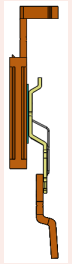
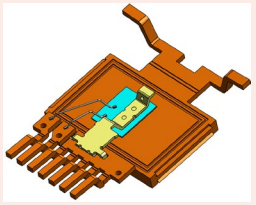
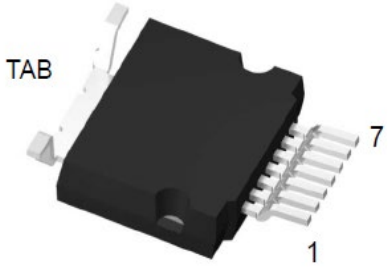
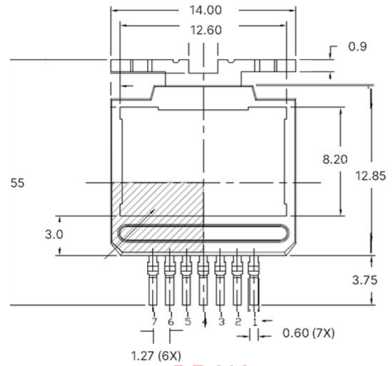
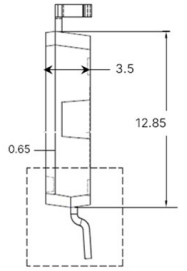
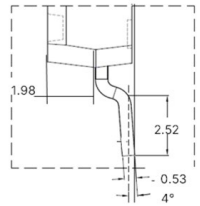
BPAK, Top Cool SMD PKG: Introduction

POD Option#	Top view	Side view	Angle view
Top Cool			
solder DA + solder clip			







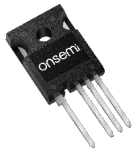


ST's HU3PAK

BPAK

Same footprint and package thickness.
Pin-to-Pin compatible

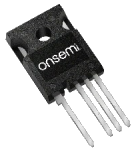
1700V SiC MOSFETs – M1 Family

$R_{DS(ON)}$ (mΩ) Typical @Vgs:20V	TO-247-3L	TO-247-4L	D2PAK-7L
			
28		NTH4L028N170M1	NTBG028N170M1
1000	NTHL1000N170M1		NTBG1000N170M1

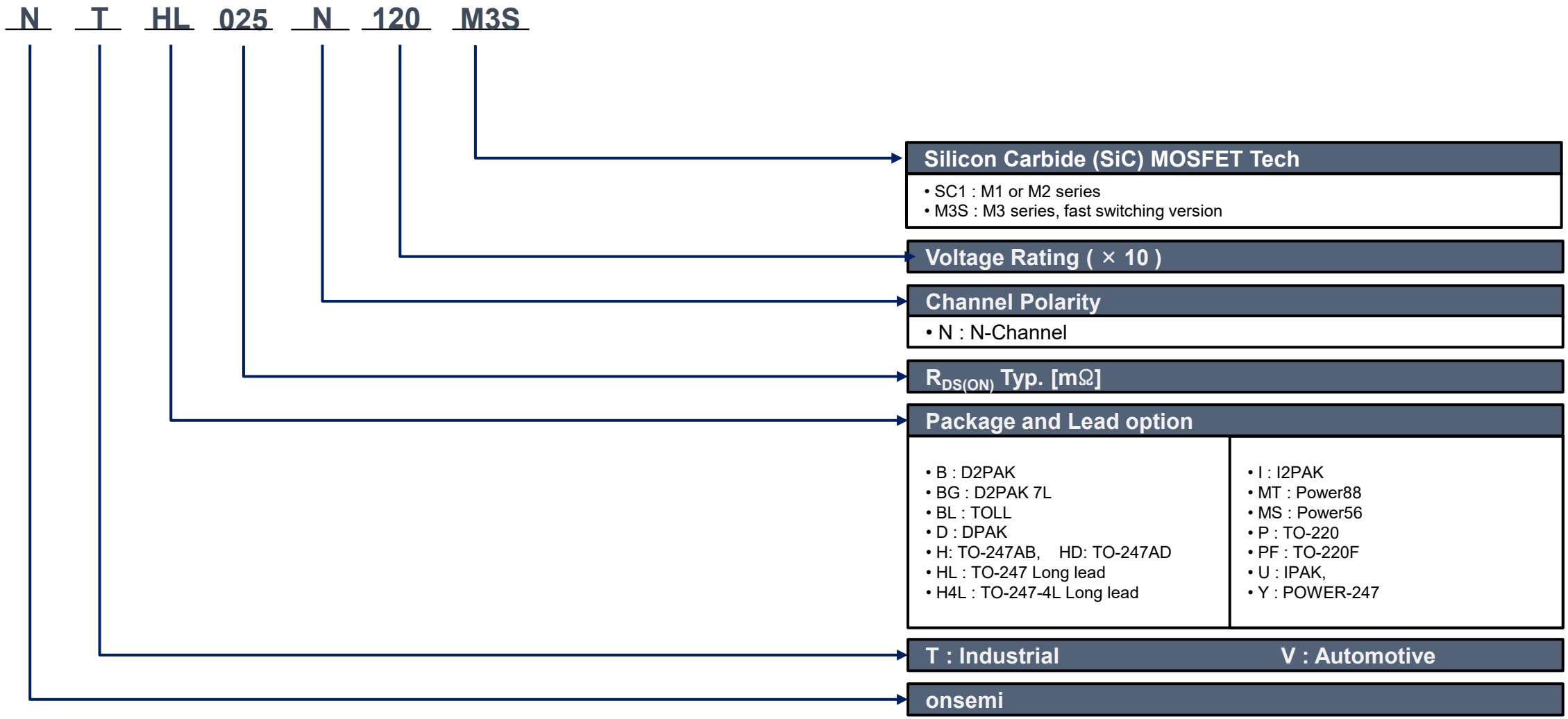
1200V SiC MOSFETs – M4 Family

In Plan

Industrial grade uses “NT”

$R_{DS(ON)}$ (mΩ) Typical @Vgs:18V	Premium TO-247-4L	Premium D2PAK-7L	BPAK (Top Cool SMD PKG)
			
7	NTH4L007N120M4S	NTBG007N120M4S	NTTC007N120M4S
8	NTH4L008N120M4T	NTBG008N120M4T	NTTC008N120M4T
9	NTH4L009N120M4S	NTBG009N120M4S	NTTC009N120M4S
13	NTH4L013N120M4S	NTBG013N120M4S	NTTC013N120M4S
18	NTH4L018N120M4S	NTBG018N120M4S	NTTC018N120M4S
25	NTH4L025N120M4S	NTBG025N120M4S	NTTC025N120M4S
36	NTH4L036N120M4S	NTBG036N120M4S	NTTC036N120M4S
41	NTH4L041N120M4S	NTBG041N120M4S	NTTC041N120M4S

Ordering Information for SiC MOSFET

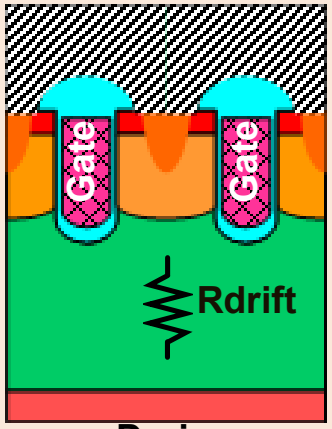


MV MOSFET Technology Roadmap

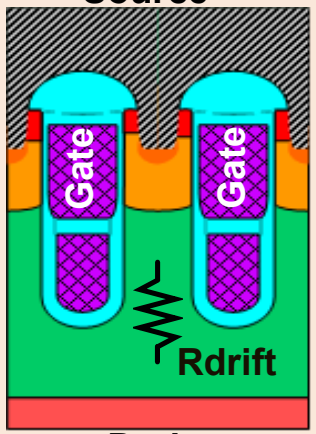
Shielded Gate MOSFET Benefits

Conduction Loss

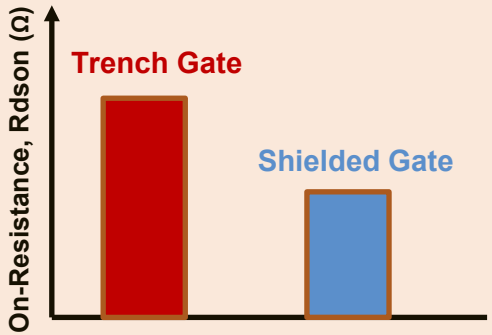
Trench Gate



Shielded Gate

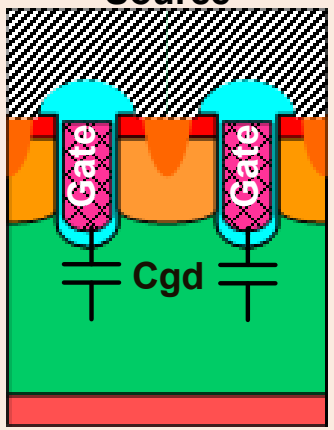


Lower On Resistance
- Improve Conduction Loss

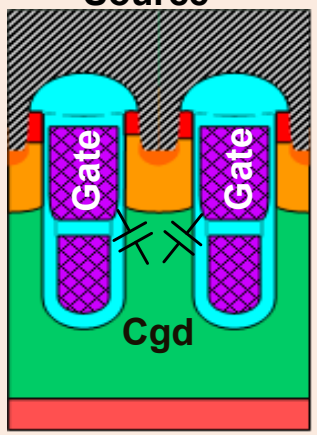


Switching Loss

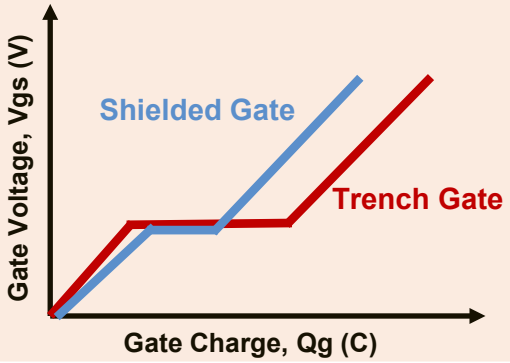
Trench Gate



Shielded Gate

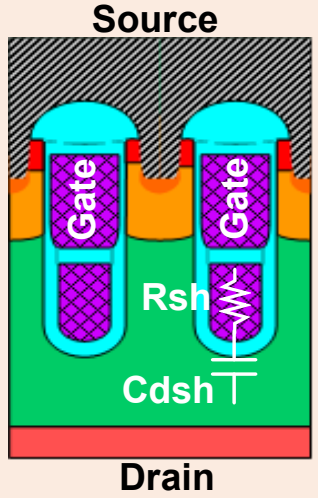


Lower Qg
- Improve Switching Loss

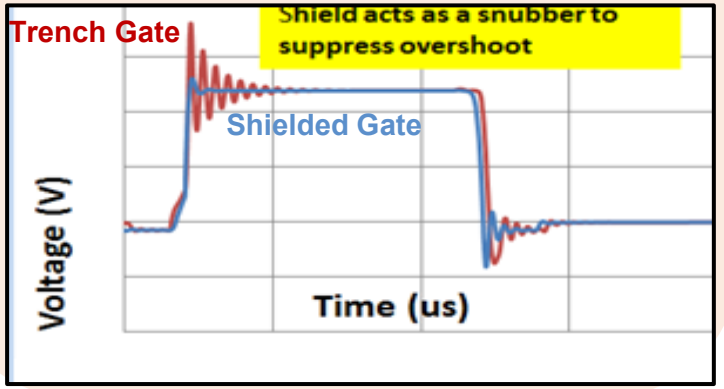


Voltage Spike

Shielded Gate



Snubber-Like (Inherent RC Snubber)
- Suppress overshoot / minimize ringing



T10 Technology Focus and Targets

Improve FOM, Rsp, and Power Density	→	Enhance Performance and Reduce Cost
Lower Rsp, Lower Qg/Qgd, Lower Qgd/Qgs	→	Improve Overall Efficiency
Lower Qoss and Lower Qrr	→	Improve Switching Losses
Softer Recovery Diode and Lower Qrr	→	Reduce Ringing, Overshoot, and Noise
Robustness and Excellent UIS	→	Improve Avalanche Ruggedness

T10 Optimized Technology

Higher Power Density

T10S
Fast Switching DC-DC Applications

Improved FOM

Low Qrr

Improved Avalanche Ruggedness

T10M
Motor Control Applications

Lowest RDS(on)

Low Qrr

Softer Recovery Diode

T10 80V FOM Comparison

- **Markets**
  - Battery-Powered Equipment, Servers, Telecom/Networking, Datacenters.
- **Key Parameters**
  - Best-in-class $RDS_{(ON)}$, Lowest FOM (Qrr*Rds, Qoss*Rds, Qsw*Rds) in the market.
  - Primary side & Secondary side common MOSFET design.
  - Softer body diode
- **Application Benefits**
  - Improved power loss at higher frequency
  - Better at combined Hard-switching and Soft-switching applications
  - Smoother Vds switching & better gate-bounce immunity technology
- **T10 80V Portfolio plan**

Part #	Package	VDS (V)	VGS (V)	Max.RDS(on) VGS = 10V (mΩ)	Samples	Status
NTMFWS1D5N08X	**HEFET 5x6**	**80**	**±20**	**1.5**	**Now**	**Now**
NTMFWS2D1N08X	HEFET 5x6	80	±20	2.1	Q3 23	Q4 23
NTMFWS2D5N08X	SO8FL 5x6	80	±20	2.5	Q3 23	Q4 23
NTMFWS3D0N08X	SO8FL 5x6	80	±20	3.0	Q3 23	Q4 23
NTMFWS3D5N08X	SO8FL 5x6	80	±20	3.5	Q3 23	Q4 23
NTMFWS4D0N08X	SO8FL 5x6	80	±20	4.0	Q3 23	Q4 23
NTBLS0D8N08X	**TOLL**	**80V**	**±20**	**0.8**	**Now**	**Aug'23**
NTTFWS5D6N08XL	u8FL 3x3	80V	±20	5.6	Q3 23	Q4 23

- **T10 vs. Optimos5, T8, PTNG comparison**
  - Best-in-class 80V, $RDS_{(ON)}$, in 5x6 package (Max. 1.5mΩ, Typ. 1.1mΩ)
  - Better Qrr FOM, Qoss FOM and Qg FOM than Competitor's Gen 5
  - Better Soft switching performance than Optimos5 thanks to the better body diode softness

Generation / Product	NTMFWS1D5N04X	Competitor	NTMFS6H800N	FDMS2D5N08C
Specification	**T10**	**Gen 5**	**T8**	**PTNG**
BV_{DSS} at T_J=25°C [V]	80	80	80	80
$R_{DS(ON)} \times Q_{rr}$ FOM [mΩ*nC]	**266**	**476**	**529**	**380**
$R_{DS(ON)} \times Q_{OSS}$ FOM [mΩ*nC]	**132**	**154**	**192**	**181**
$R_{DS(ON)} \times Q_{G(TOT)}$ FOM [mΩ*nC]	**96**	**138**	**135**	**145**
$R_{DS(ON)} \times Q_{SW}$ FOM [mΩ*nC]	**28**	**48**	**48**	**45**
* $R_{DS(ON)}$ @ I_D=50A [mΩ]	1.11	1.41	1.65	2.17
* Q_{RR} @ I_D=50A, di/dt=1000A [nC]	241	337	322	175
* Q_{OSS} @V_{DS}=40 V [nC]	120	110	117	83
* $Q_{G(TOT)}$ @ V_{DS}=40V, I_D=50A [nC]	87	98	82	67
* Q_{SW} @ V_{DS}=40V, I_D=50A [nC]	25	34	29	21

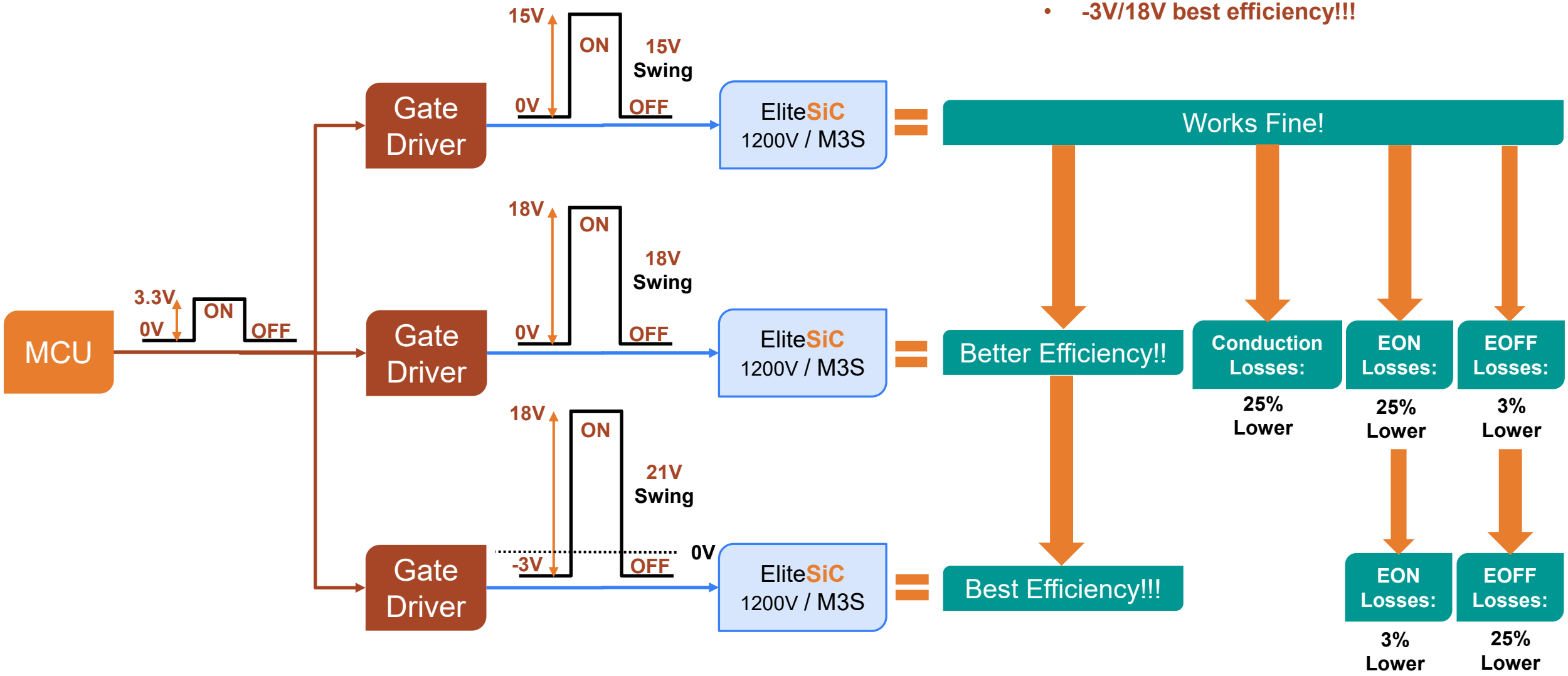
150V MOSFET Solution

Product	Package	Dimensions (mm)	Channel Polarity	VDSS (V)	VGS (V)	VGS(th) Min (V)	VGS(th) Max (V)	ID Max (A)	RDS(on) Max VGS = 10V (mΩ)	Qg Typ VGS = 10V (nC)	Ciss Typ (pF)	Coss Typ (pF)	Crss Typ (pF)	Qrr Typ (nC)
NTTFS022N15MC	PQFN-8	3x3	N-Channel	150	±20	2.5	4.5	37.2	22	17	1315	380	6	155
NTTFS034N15MC	PQFN-8	3x3	N-Channel	150	±20	2.5	4.5	27	31	12	905	270	5	126
FDMC86260	PQFN-8	3x3	N-Channel	150	±20	2	4	25	34	9.7	1000	105	4.8	85
NTTFD9D0N06HL	WQFN-12	3x3	N-Channel	150	±20	1.2	2	38	9	13.5	948	188	12.3	14
NTMFSC012N15MC	DFN8 Dual Cool	5x6	N-Channel	150	±20	2.5	4.5	80	11.4	32.4	2490	676	9	559
FDMS86200DC	DFN-8 Dual Cool	5x6	N-Channel	150	±20	2	4	40	17	19	2110	205	8.1	126
FDMS8D8N15C	PQFN-8	5x6	N-Channel	150	±20	2.5	4.5	85	8.8	38	3132	927	5.3	108
NTMFS011N15MC	PQFN-8	5x6	N-Channel	150	±20	2	4.5	78	11.5	30.7	2478	728	7.9	227
FDMS86255	PQFN-8	5x6	N-Channel	150	±20	2	4	45	12.4	29	3200	291	11	165
FDMS86200	PQFN-8	5x6	N-Channel	150	±20	2	4	35	18	18	2041	203	10	113
NTMFS022N15MC	PQFN-8	5x6	N-Channel	150	±20	2.5	4.5	41.9	22	17	1315	380	6	155
FDMS86250	PQFN-8	5x6	N-Channel	150	±20	2	4	30	25	14	1750	165	8.8	112
NTMFS034N15MC	PQFN-8	5x6	N-Channel	150	±20	2.5	4.5	31	31	12	905	270	5	126
NTMTS4D3N15MC	DFNW-8	8x8	N-Channel	150	±20	2	4.5	174	4.45	79	6514	1750	12.5	194
NTMTSC4D3N15MC	DFNW-8	8x8	N-Channel	150	±20	2	4.5	174	4.45	79	6514	1750	12.5	194
NTMTS6D0N15MC	DFNW-8	8x8	N-Channel	150	±20	2	4.5	135	6.4	58	4815	1482	9.7	125
NTMFS7D5N15MC	PQFN-8	8x8	N-Channel	150	±20	2.5	4.5	95.6	7.9	46	3835	1070	11	111
NTMFS015N15MC	PQFN-8	8x8	N-Channel	150	±20	2.5	4.5	61	14	27	2120	595	10.5	197
FDMT800150DC	PQFN-8 Dual Cool	8x8	N-Channel	150	±20	2	4	99	6.5	77	5660	520	17	233
FDMT800152DC	PQFN-8 Dual Cool	8x8	N-Channel	150	±20	2	4	72	9	38	4196	379	16	187
NTBLS4D0N15MC	TOLL 8L	10x11	N-Channel	150	±20	2	4.5	187	4.4	90.4	7490	2055	27.2	180
FDBL0630N150	TOLL 8L	10x11	N-Channel	150	±20	2	4	169	6.3	70	5805	536	16	323

Driving EliteSiC 1200V M3S

EliteSiC 1200V M3S Gate Drive Swing:

- 0V/15V works fine
- 0V/18V better efficiency
- -3V/18V best efficiency!!!



NCD(V)57100/101 16-pin Isolated Gate Driver

Features

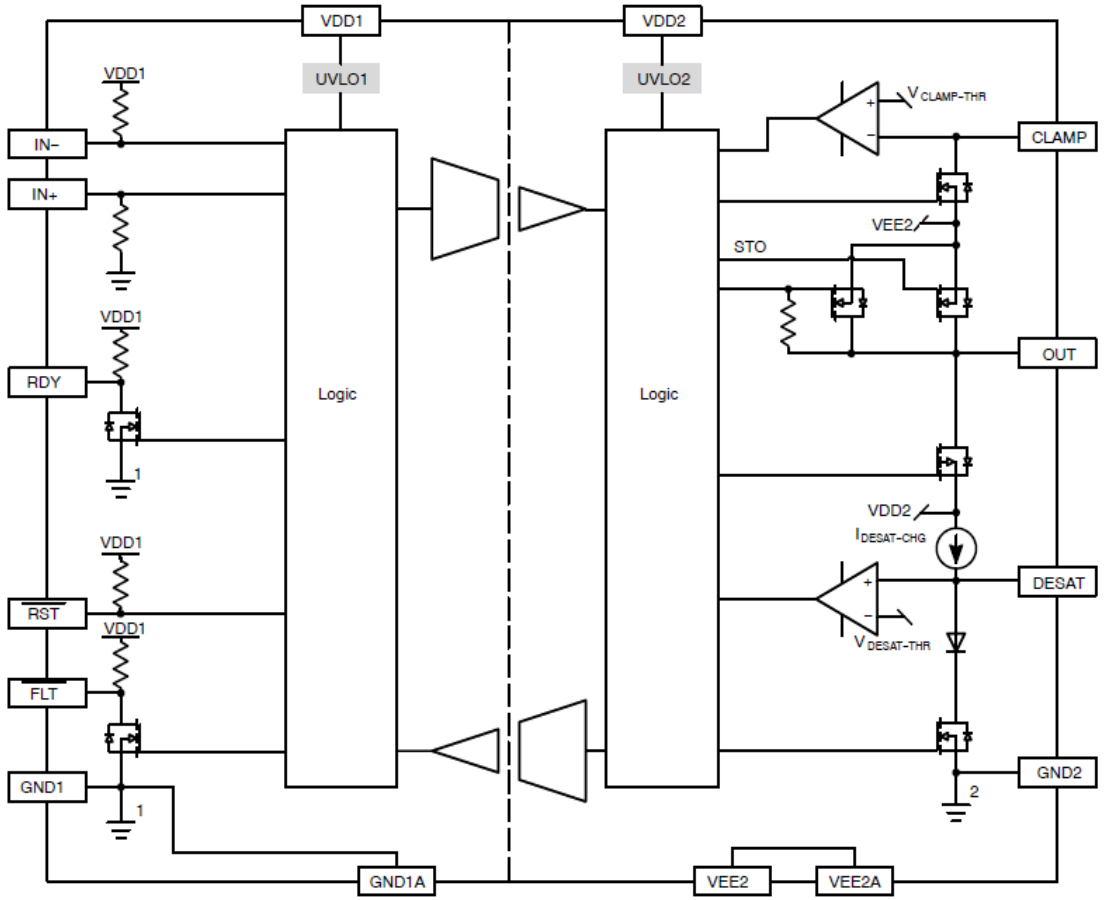
- High current (7 A / 7 A src/snk) at Miller Plateau Voltage
- Galvanic Isolation with >5 kV withstand & 1400 V working voltage
- CMTI > 100 kV/us @ 1300 V
- Typical 66 ns propagation delays
- Soft turn-off(2.4 us or 1 us options)
- Desat detect with programmable delay
- IGBT gate clamp during short circuit
- Miller clamp with high sink current
- Tight UVLO for IGBT safety
- Diagnostics
- UL1577 Recognized: File No. E509109, Vol .1

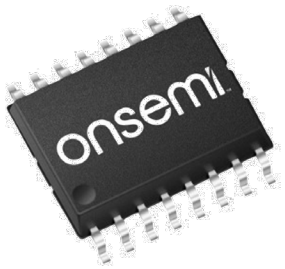
Markets & Applications

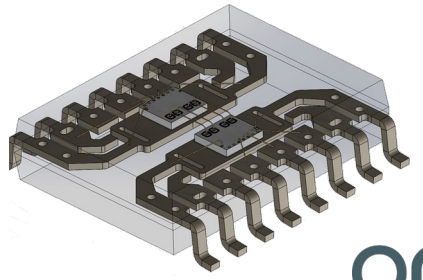
- Solar Inverters, Motor Drives, EV Chargers, Automotive Powertrain

Package / Options

- SOIC-16 Wide Body







NCD(V)5709x – 5 kV Isolated Single Channel Gate Driver

Value Proposition

NCx57090y, NCx57091y are high−current single channel IGBT/MOSFET gate drivers with 5 kVrms internal galvanic isolation, designed for high system efficiency and reliability in high power applications. The devices accept complementary inputs and depending on the pin configuration, offer options such as Active Miller Clamp (version A/D/F), negative power supply (version B) and separate high and low (OUTH and OUTL) driver outputs (version C/E) for system design convenience.

Unique Features

- High Peak Output Current (+6.5 A/−6.5 A)
- Low Clamp Voltage Drop Eliminates the Need of Negative Power Supply to Prevent Spurious Gate Turn−on (Version A/D/F)
- Short Propagation Delays with Accurate Matching
- IGBT/MOSFET Gate Clamping during Short Circuit
- IGBT/MOSFET Gate Active Pull Down
- Tight UVLO Thresholds for Bias Flexibility
- Wide Bias Voltage Range including Negative VEE2 (Version B)

Other Features

- 3.3 V, 5 V, and 15 V Logic Input
- 5 kVrms Galvanic Isolation
- High Transient Immunity
- High Electromagnetic Immunity
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable
- These Devices are Pb−Free, Halogen Free/BFR Free and are RoHS Compliant

Market & Applications

- Motor Control
- Uninterruptible Power Supplies (UPS)
- Industrial Power Supplies
- Automotive Applications
- Industrial Power Supplies
- Solar Inverter

Typical Application Circuit

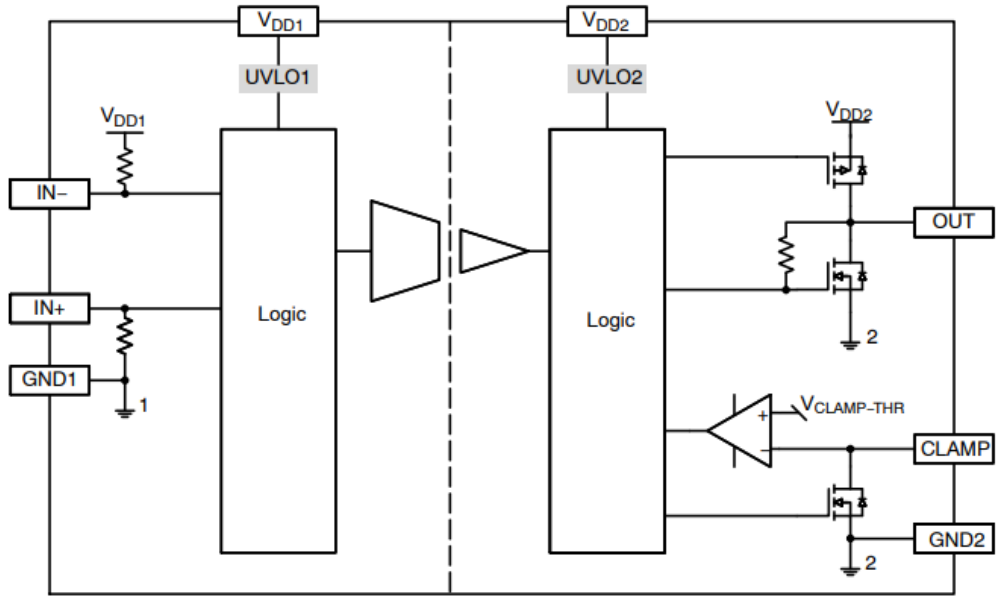


Figure 2. Simplified Block Diagram, NCD57090A/D/F

Ordering & Package information

- SOIC8-WB

RTM Product Tier #1

Released and On Target!!!

NCP/V51752 – 3.7 kV Isolated High Performance SiC Drivers

Value Proposition

The NCP51752 is isolated 1-channel gate driver with up to 4.5-A/9-A source and sink peak current. It is designed for very fast switching to drive power SiC power switches.
The NCP51752 offers short and matched propagation delays and has **integrated mechanism to generate negative bias in the gate drive loop to offer safe OFF state** for any type of SiC.

Unique Features

- Input side isolated from output drivers by 3.7-kVRMS isolation barrier
- 45 ns Prop Delay & +/-5 ns Max PWD
- **>= 200 V/ns dV/dt Immunity**
- 20 ns Max. part-to- part Skew
- **Embedded neg bias voltage generation**

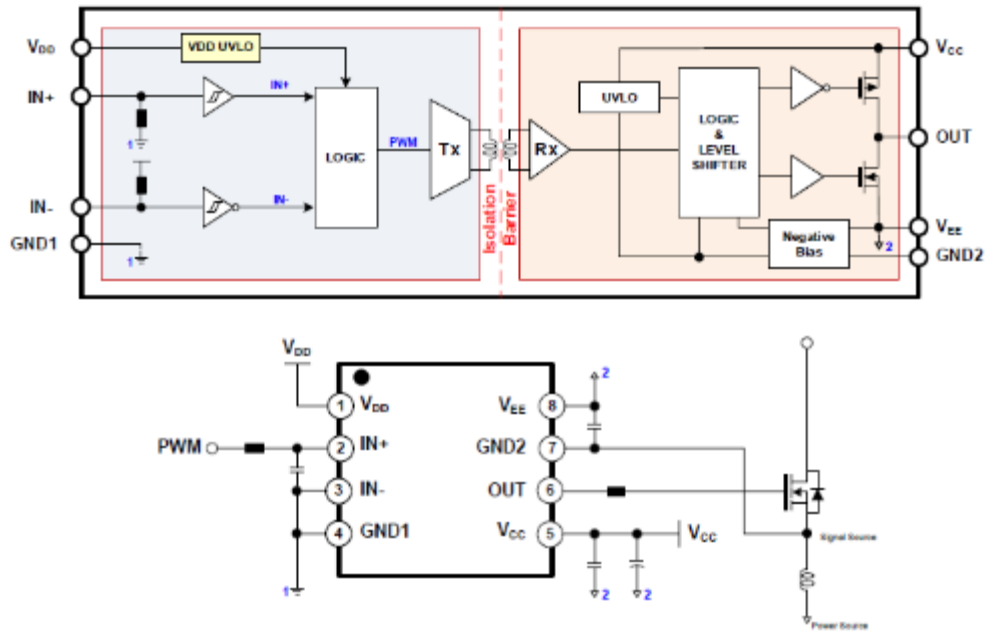
Benefits

- Give reliable operation and safety
- Efficient switching
- High Robustness
- Easier design
- Simple and Safe SiC turn-off

Other Features

- Typical Source/Sink Current Capability up to 4.5-A/9-A
- Vdd up to 20V
- Programmable Input Logic
- Enable/IN+
- Different UVLO options: 5/8-V & 12/17-V
- Different Neg bias voltages : -2/-3/-4/-5 V

Typical Application Schematic



Market & Applications

- Isolated Converters in Offline AC-to-DC Power Supplies
- Motor Drive and DC-to-AC Solar Inverters
- HEV and EV On-Board chargers

Package Information

- SOIC-8 NB for space saving
- OPN : NCP51752xyDR2G

x: A/B/C/D UVLO levels
y: A/B/C/D Neg. bias levels

NCD(V)575xx – 5 kV Isolated Dual Channel Gate Driver

Value Proposition

NCx575y0 are high−current two channel isolated IGBT gate drivers with 5 kVrms internal galvanic isolation from input to each output and functional isolation between the two output channels. The device accepts 3.3 V to 20 V bias voltage and signal levels on the input side and up to 32 V bias voltage on the output side. The device accepts complementary inputs and offers separate pins for Disable (NCx57540) or Enable (NCx57530) and Dead Time control for system design convenience.

Unique Features

- High Peak Output Current (±6.5 A)
- Configurable as a Dual Low−Side or Dual High−Side or Half−Bridge Driver
- Programmable Overlap or Dead Time control
- Disable Pin to Turn Off Outputs for Power Sequencing (NCx57540)
- Enable Pin for Independent Driver Control (NCx57530)
- IGBT Gate Clamping during Short Circuit
- Short Propagation Delays with Accurate Matching
- Tight UVLO Thresholds on all Power Supplies • 3.3 V, 5 V, and 15 V Logic Input

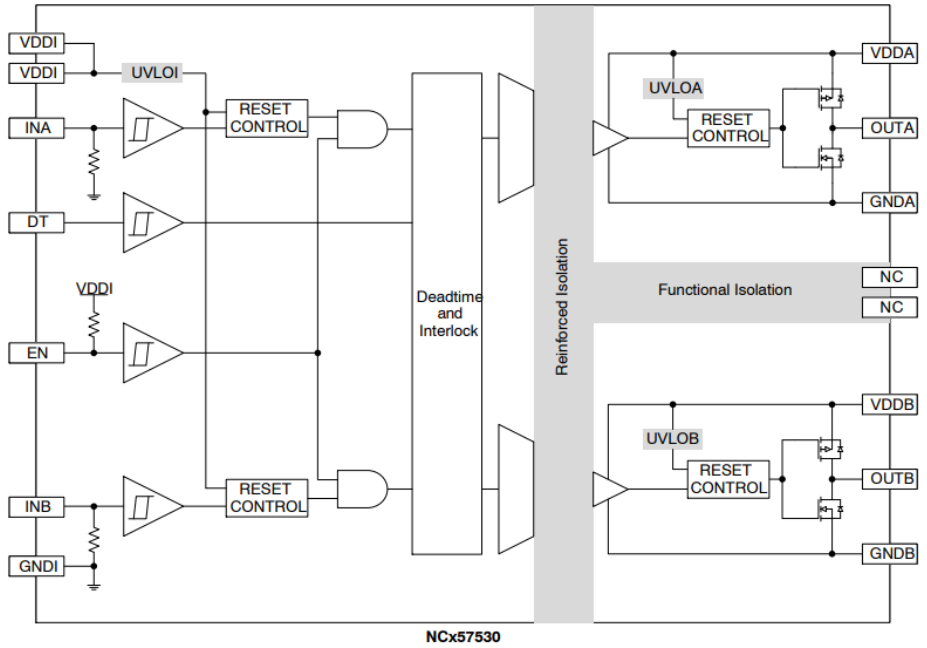
Other Features

- 5 kVrms Galvanic Isolation from Input to each Output and 1.5 kVrms Differential Voltage between Output Channels
- 1200 V Working Voltage (per VDE0884−11 Requirements)
- High Common Mode Transient Immunity
- Case 752AJ for Improved Insulation Between Output Channels
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable
- This Device is Pb−Free, Halogen Free/BFR Free and is RoHS Compliant

Market & Applications

- EV Chargers
- Motor Control
- Uninterruptible Industrial Power (UPS)
- Automotive Applications
- Welding
- Solar Inverter

Typical Application Circuit



NCx57530

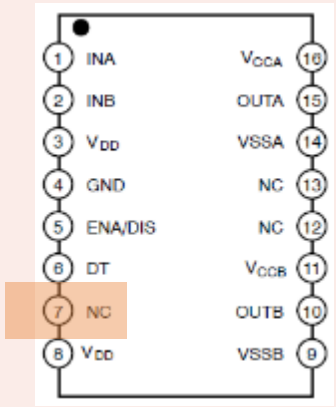
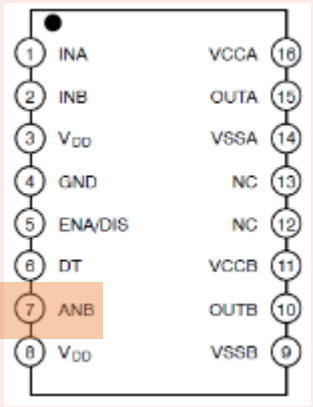
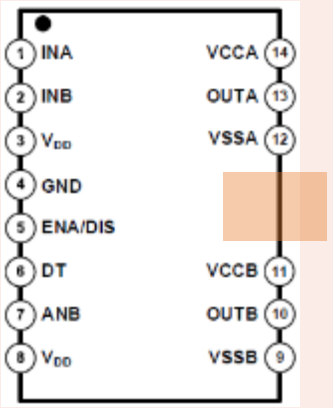
Ordering & Package information

- SOIC-16WB

RTM Product Tier #1

Released and On Target!!!

NCP5156x/NCV5156x Comparison

	NCP51560	NCP51561	NCP51563
OPNs	NCP51560AB NCP51560BB	NCP51561BA NCP51561BB NCP51561DA NCP51561DB	NCP51563BB NCP51563CA
Pin Assignment			
Pin #7	NC	ANB (pull-up/down)	ANB (pull-up/down)
Ch to Ch voltage	1,500 V	1,500 V	1,850 V
INA, INB	Min. -5 V / Max. 20 V	Min. -5 V for 50ns / Max. 20 V	Min. -5 V for 50ns / Max. 20 V
Power up sequence	Power-up delay time during Vccx start-up	Internal settling time $t_{PORUV,OUT}$ = 18us	Internal settling time $t_{PORUV,OUT}$ = 18us
PKG	SOIC-16 WB	SOIC-16 WB	SOIC-16 WB (pin #12/13 removed)
Automotive Part	On demand	NCV51561	NCV51563

NCP781 – 150V Wide Input Voltage Linear Regulator with Low Iq

Value Proposition:

The NCP781 is high-performance linear regulator with very wide operating input operating voltage range 6 .. 150 V DC, matching the input voltage range for bus voltages. This part is capable to deliver up to 100mA of output current and offers ±3% accuracy over full operating temperature range. The NCP781 is optimized for high-voltage inputs, and ideal for usage in harsh environment.

Unique Features

- Vin up to 150 V
- Adjustable Vout 1.23-15 V
- Fixed Vout 1.5-15 V
- Very High PSRR 80dB@1kHz
- Noise 130uVrms @ 1.23V
- ±3% Vout accuracy over load/line/temp

Other Features

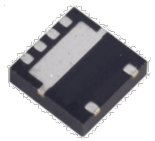
- Enable pin
- Current limiter 110 (140) mA
- Short circuit limiter
- Thermal shutdown 150C with hysteresis

Market & Applications

- Telecom & Plugged IoT
- Industrial equipment

Package

- u8LL (3.3 x 3.3 x 1mm)



Application Data

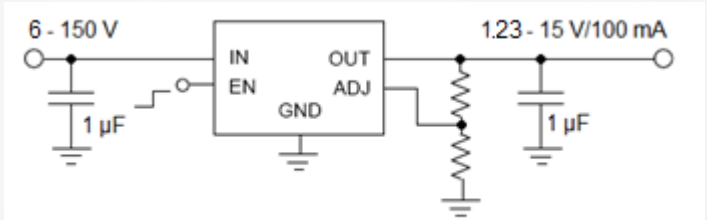


Figure 2. Typical Application for Adjustable Voltage Option

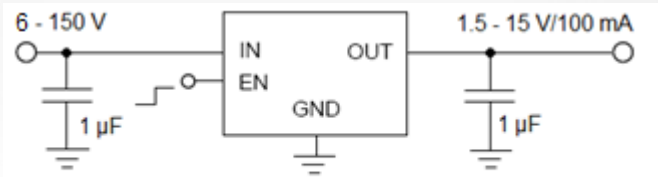
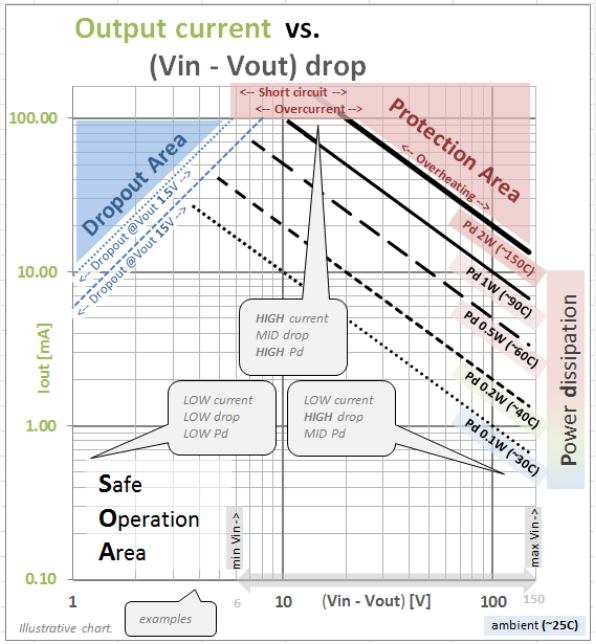


Figure 1. Typical Application for Fixed Voltage Option

150 V capable package & fits to required standards !!!

IPC2221A
IEC60664
IEC60730



Ordering Information

Device	Enable pin	Predefined voltages
NCP781	Yes	ADJ /1.5/3.3/5/9/10/12/15 V (customized voltages upon request)

onsemi