Arrow SiC Reference Design
ON Semiconductor SiC Product Overview

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Sep 2021

Five Years Out


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ON Semiconductor
Stanley Lam, Sep 2021
Public Information

ON Semiconductor Today

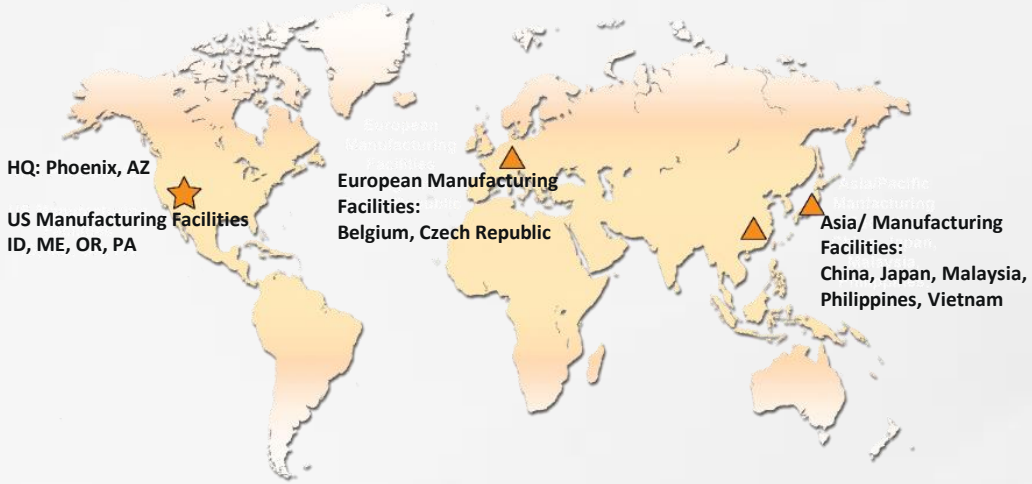
Headquarters: Phoenix, AZ

Employees: ~34,000 globally

Revenue: ~$5.25Bn(1)

Ticker: ON

Founded: Spun-off from Motorola 1999, IPO 2000



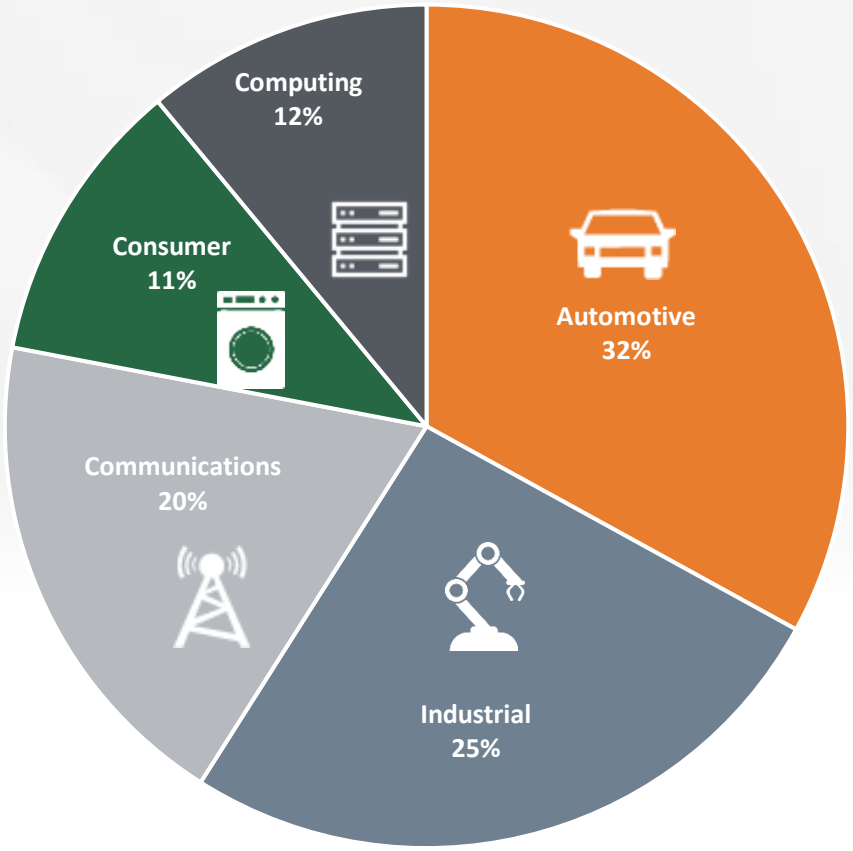
Automotive Sector (34% of Revenue)	Industrial/Medical/ Aero-Defense Sector (24% of Revenue)	Communications Sector (18% of Revenue)	Consumer Sector (11% of Revenue)	Computing Sector (13% of Revenue)
• Vehicle Electrification	• IoT Connectivity	• 5G Infrastructure Power	• Connectivity	• USB Type-C Solutions
• Active Safety & Autonomous Driving	• Energy Infrastructure	• USB Type-C Solutions	• Power Conversion	• Power Conversion
• Body & Interior Electronics	• Power Conversion		• Audio/Video/Imaging	• AC Power Adapter
• Connectivity & Power Management	• Motor Control		• Motor Control	• Server Power
• LED Lighting	• Sensors			
	• Wide Band Gap			

Product Capabilities
Custom, SoC, Embedded MCU, Connectivity, Sensors, Mixed-Signal, Analog, Logic, Discrete, Optoelectronics
Micro-Packages, Power Packages, Power Modules, Chip-Scale, Multi-Die
Software, Development Kits, Reference Designs

(1) Based upon 2020 results; Sector % based on 4Q20

Focused on the Fastest Growing Markets

2020 Revenue by End-Market



2020 REVENUE $5,255MM

AUTOMOTIVE

Power semiconductors for electrification, sensors for ADAS, LED lighting, analog power management for automotive processors

INDUSTRIAL

Energy efficiency for industrial systems, machine vision, robotics, automation, IoT

COMMUNICATIONS

5G, Wi-Fi

COMPUTING

Server CPU power management, Server power management

CONSUMER

Gaming, home entertainment systems, AR/VR, wearable devices

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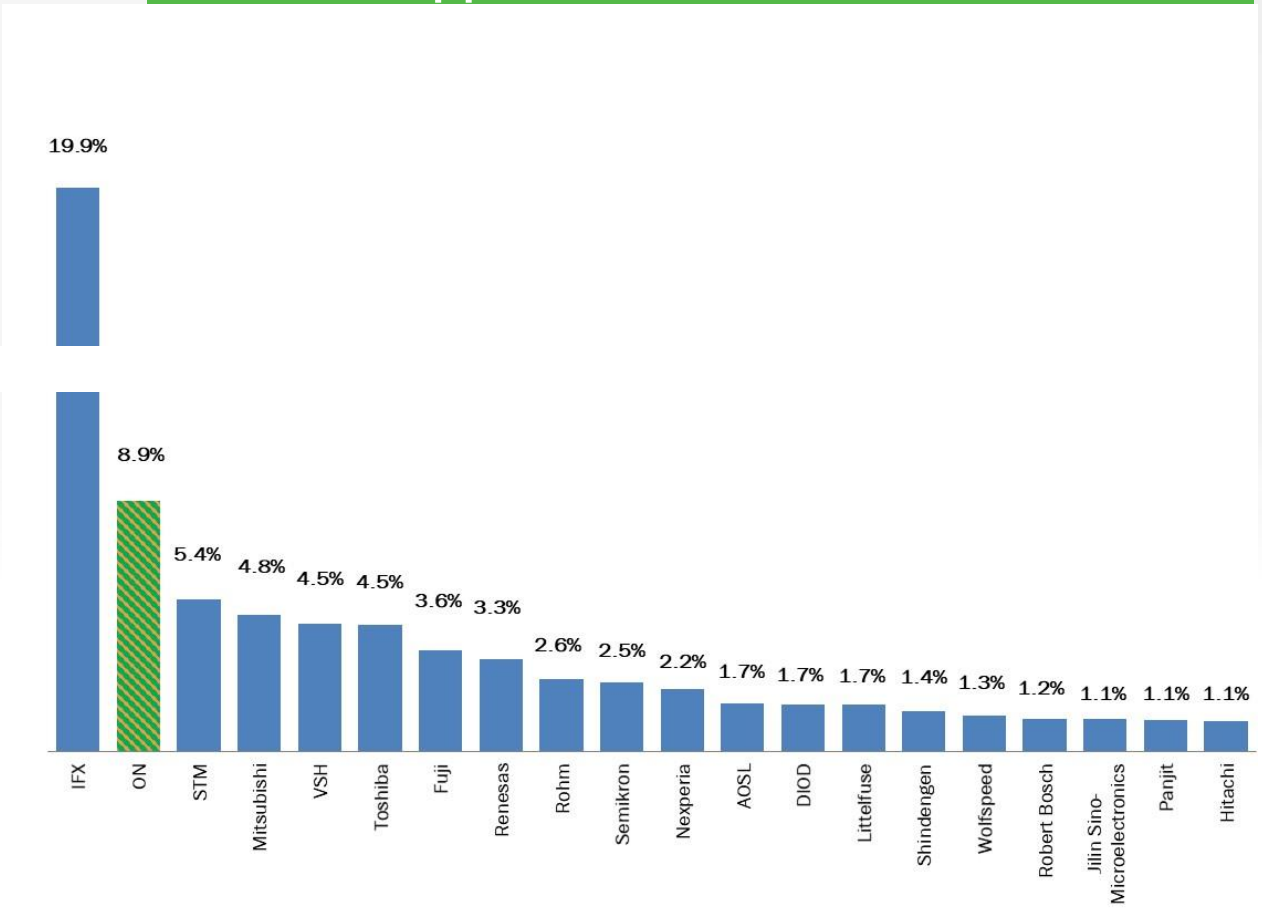
An Emerging Leader in Semiconductors

Top 20 IDMs – 2019 market share

Rank	Company	Market Share
1	Intel	16.5%
2	Samsung	12.3%
3	SK Hynix	5.3%
4	Micron	4.7%
5	TI	3.3%
6	STMicro	2.2%
7	Infineon	2.1%
8	KIOXIA	2.0%
9	NXP	2.0%
10	Sony	2.0%
11	Renesas	1.6%
12	Analog Devices	1.4%
13	**ON**	**1.3%**
14	Microchip	1.2%
15	Skyworks Solutions	0.8%
16	Qorvo	0.7%
17	ROHM	0.7%
18	Toshiba	0.6%
19	Robert Bosch	0.6%
20	Nichia	0.5%

Top power semiconductor discretes and modules suppliers – 2018 market share



Source: Informa CLT 4Q19, IHS *Annual Power Semiconductor Market Share Database - 2018*

Formidable Manufacturing Capabilities

- **Scale provides industry leading cost structure - 66 billion units shipped in 2019**
  - Ability to add capacity and source from multiple sites, including production ramp of 300mm fab
  - Front-end internal capacity to manufacture 150mm and 200mm silicon substrates
  - One of world's largest and most efficient back-end operations
- **Quality and delivery**
  - Better control as key differentiators in automotive and industrial markets
- **Technology and product development**
  - Accelerates time to market for new technologies and fine tune processes to maximize performance

Front-end & Substrate Facilities


Aizu, Japan


Gresham, OR, USA


Czech Republic Fab


Czech Republic Substrates

Bucheon, Korea


Portland, ME, USA


Oudernaarde, Belgium[1]


Seremban, Malaysia


Pocatello, ID, USA


Mountain Top, PA, USA


Niigata, Japan[2]


East Fishkill, NY[3]

Back-end Facilities


Leshan, China


Suzhou, China


Shenzhen, China


Carmona, Philippines


Tarlac, Philippines


Cebu, Philippines


Seremban, Malaysia


Vietnam OSBD


Vietnam OPP/IPM

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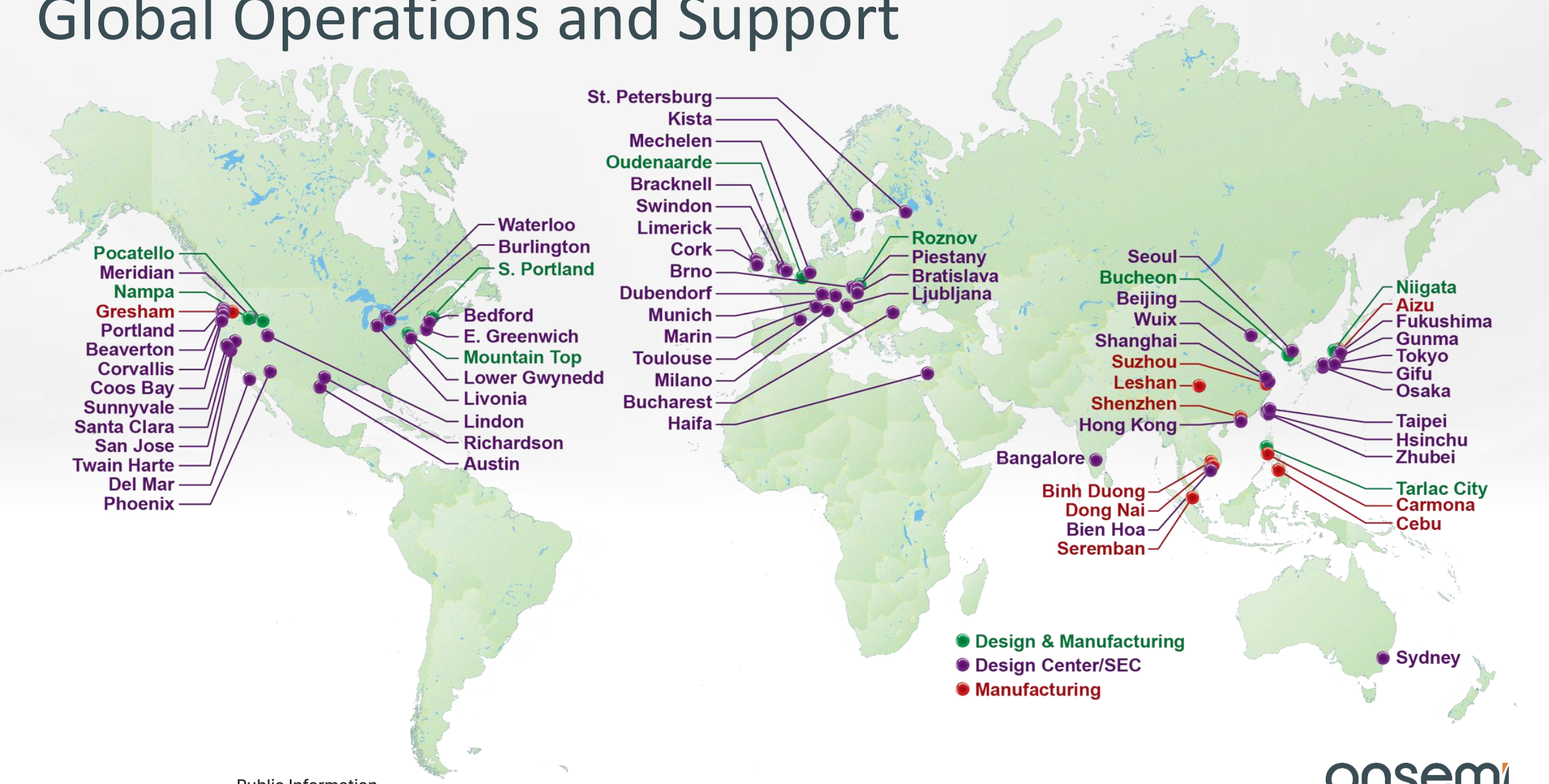
Global Operations and Support



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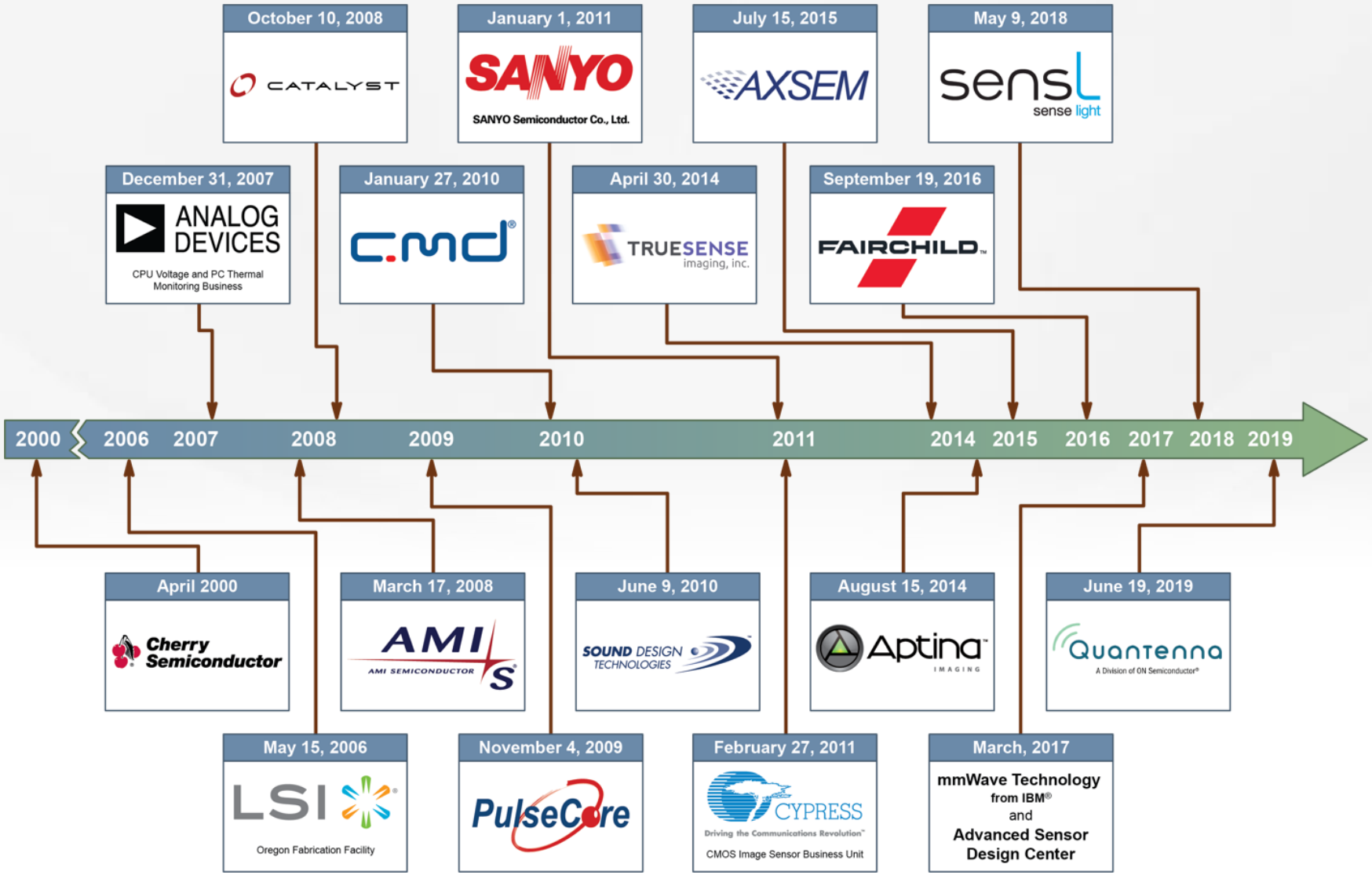
The Legacy Builds!



Power Solutions Group - Organization

APD

- Intelligent Power Module
- LV, MV, HV MOSFETs
- HV Rectifiers
- Automotive MOSFETs
- IGBTs
- Automotive Power Modules
- PIMs
- Wide Bandgap

ICPSD

- ESD Protection
- ear Regulators
- LED Protection
- Op-Amps
- Small Signal Devices
- Standard Logic
- eFuse
- Gate Drivers
- RF Discrete
- Opto
- Smart Passive Sensors
- EEPROM

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ON Semiconductor SiC Product Overview

Stanley Lam, Sep 2021

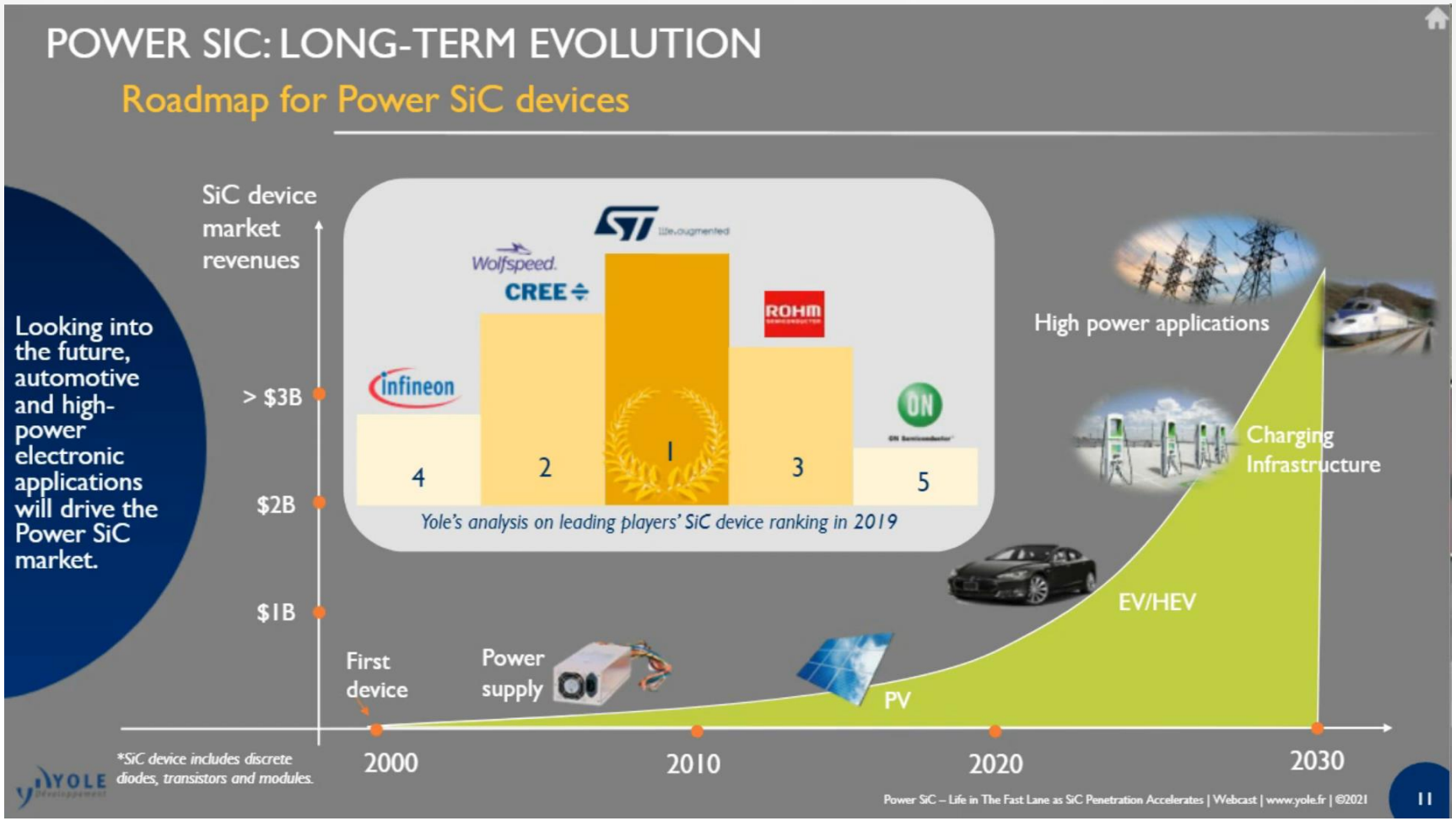
Public Information

Market Projection

SiC Market Projection

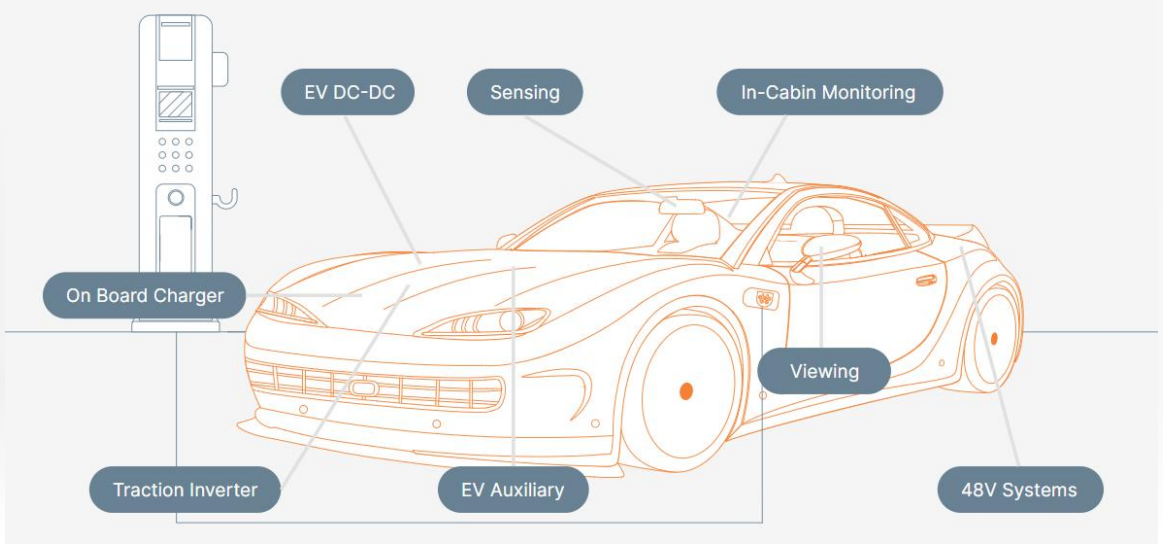
SiC $rev projection to exceed 3Bln usd by 2030

Key Growth Drivers: PV system, Automobile and High Power Infrastructures

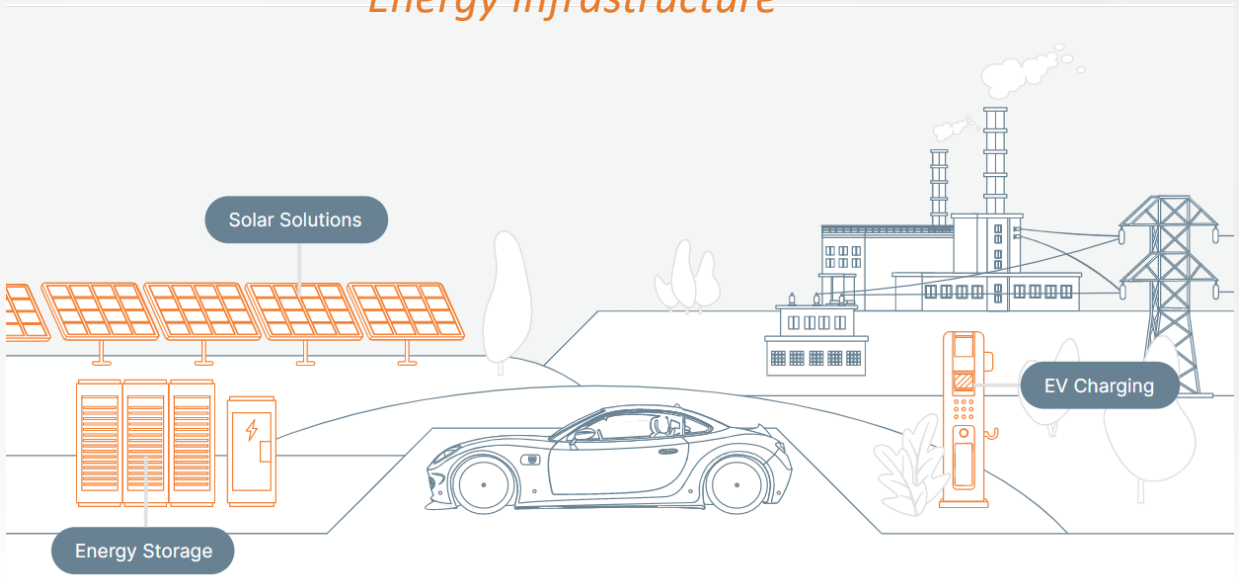


Catering for both Industrial and Automotive requirements

Automotive



Industrial
Energy Infrastructure



onsemi Automotive Qualified SiC
Traction Inverters: increase vehicle range
On-board Charger: more compact solution

onsemi Industrial Qualified SiC
Solar Inverters: more power in same size
UPS/Energy Storage: lower cooling costs

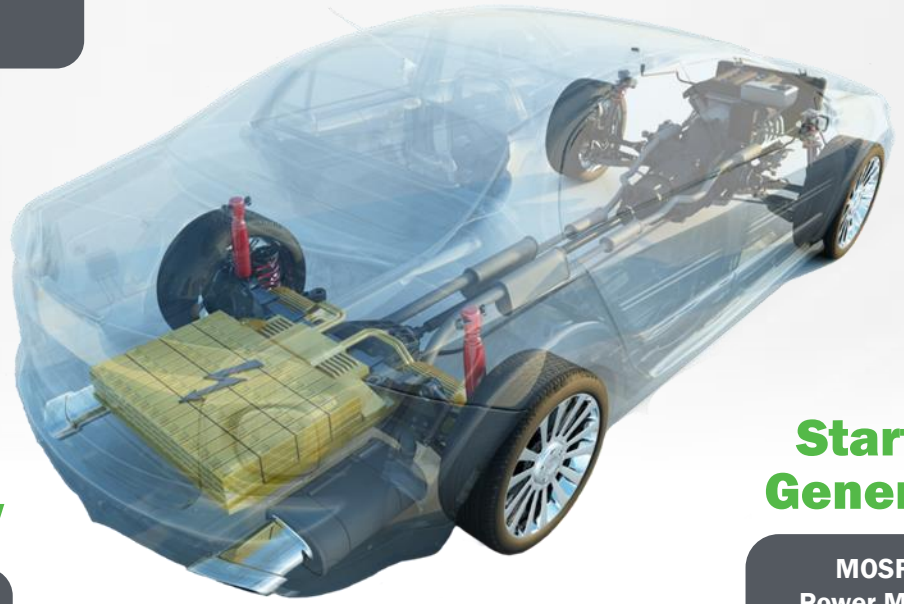
VEHICLE ELECTRIFICATION

I.C.E.

OBC

IGBTs, SiC FETs
PIMs
DC-DC
IVN

PHEV/BEV



Auxiliary Motor Control

IPMs, PIMs
Motor Drivers
MOSFETs
IVN

Main Drive

IGBTs, SiC FETs
PIMs
DC-DC
IVN

Starter-Generator

MOSFETs
Power Modules
Gate Driver,
Current
Sense

HV-48V-12V

MOSFETs
SiC, GaN
Power Modules
DC-DC

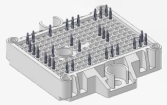
SiC Products

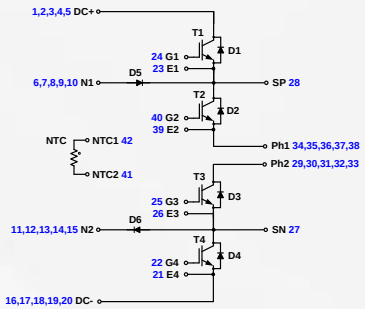
Industrial SiC Portfolio Overview

SiC Hybrid Modules – 1200V, 1000V, 650V

Q2

F2



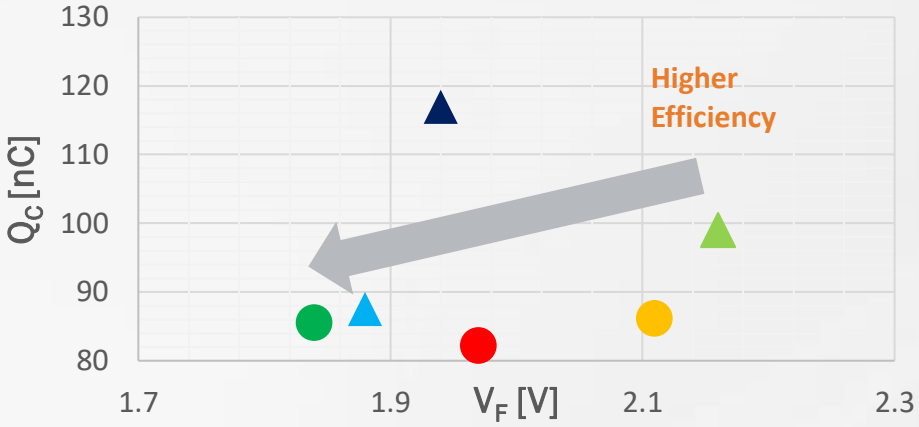


350A, 1000V I-type NPC
1000V IGBT + 1200V SiC Diode
Aluminum Oxide Substrate

Higher Power Density

400A, 1000V I-type NPC
1000V IGBT + 1200V SiC Diode
Silicon Nitride Substrate

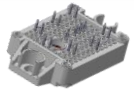
SiC Diodes – 1700V, 1200V, 650V



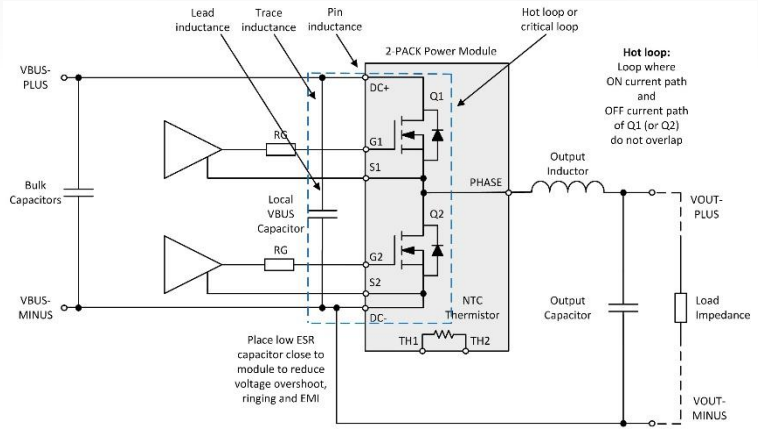
New Gen2
1200V
SiC Diode
Family

Full SiC MOSFET Modules – 1200V, 900V

F1

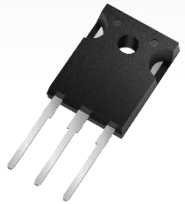


F2

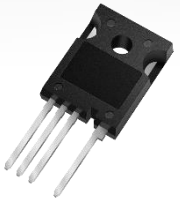


Higher Efficiency with same overshoot level

SiC MOSFETs – 1200V, 900V, 650V



TO247-3LD



TO247-4LD

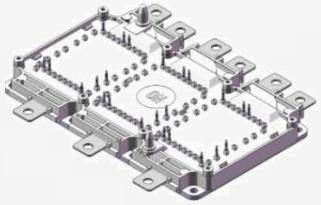
D2PAK-7LD

Faster switching
Lower module losses
More compact end product

Automotive SiC Portfolio Overview

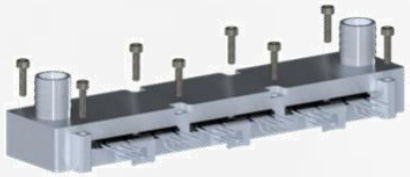
SiC Traction Modules – 1200V, 900V

VE-Trac™ Direct

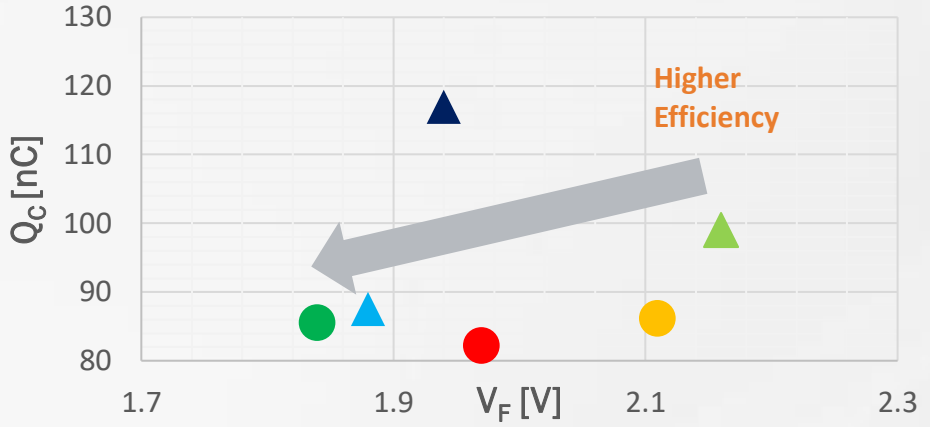


VE-Trac™ Dual

Higher Power Density With VE-Trac™ Dual



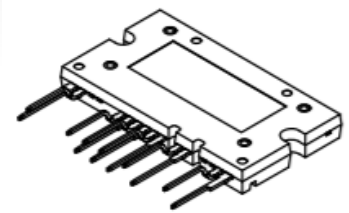
SiC Diodes – 1200V, 650V



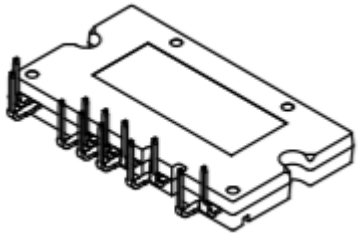
New Gen2 1200V SiC Diode Family

SiC Automotive Modules – 650V

APM16

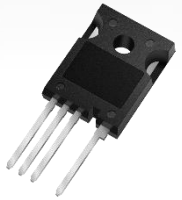


Higher Efficiency
Lower EMI by using an integrated solution



Transfer-molded module for highest power cycling and temperature cycling reliability

SiC MOSFETs – 1200V, 900V, 650V



TO247-4LD

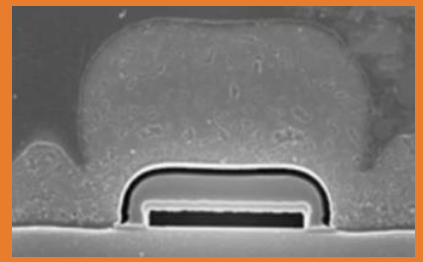
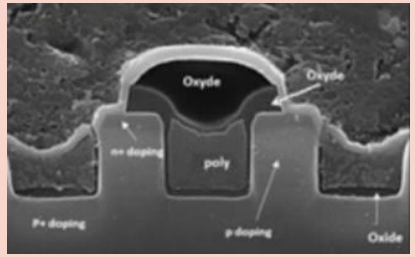
D2PAK-7LD

Faster switching
Lower module losses
More compact end product

SiC Technology Overview

SiC die structures

To serve different requirements, Planar and Trench are the 2 commonly adopted structures in the market. Trench may have better electrical performance, there are more challenges in manufacturing process and product reliability

Planar	- **shorter process time** - **Less complex to manufacture**	Wolfspeed. | A CREE COMPANY, ROHM SEMICONDUCTOR, ST life.augmented, Littelfuse, ON Semiconductor, Microsemi a Microchip company	
Trench	- smaller die size - lower on-resistance - lower switching loss	infineon, ROHM SEMICONDUCTOR	

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SiC Challenges

Benefits:

Enable High system power density, High operating temperature, High breakdown voltage, High switching frequency

Challenges:

Higher material cost (vs Si). Main cost in SiC manufacturing is raw wafer ~44%

Substrate suppliers are limited. Current mainstream supply is at 6” while 8” is new to the market.

SiC crystal structure is very difficult to be ideal which result in different kinds of dislocation. Hence affecting yield loss (more expensive).

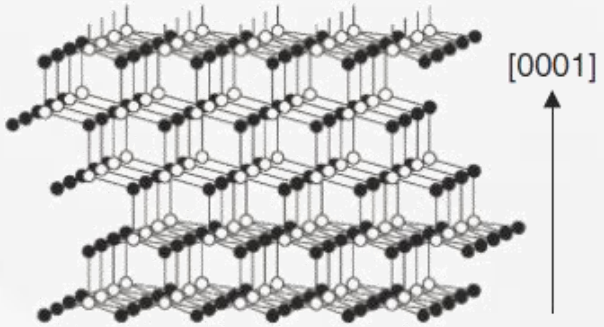
SiC wafer is transparent which increase the difficulty on marking and handling during manufacturing process.

Doping implantation for SiC needs to be done in high temperature.

Gate oxide is key concern for SiC reliability. This is especially critical for trench structure.

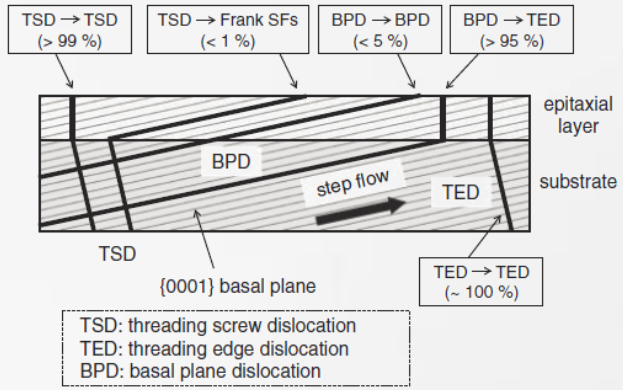
Challenges - SiC Wafers and Defects

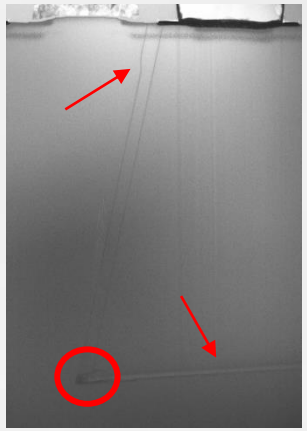
Ideal structure



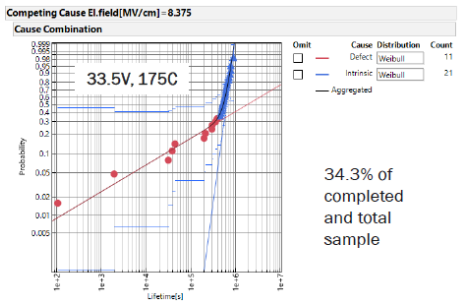
Japanese Journal of Applied Physics **54**, 040103 (2015)

Real SiC crystals have defects



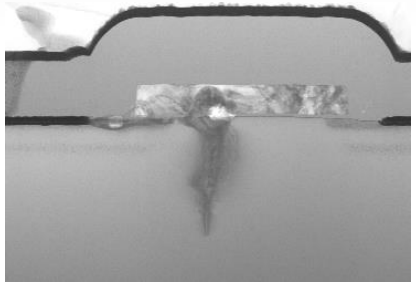


High voltage gate stress failure mode



34.3% of completed and total sample

Contaminants in gate oxide cause failure



onsemi takes considerable effort to prevent and detect defects in SiC products

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Ensuring reliable supply of SiC products

Product reliability

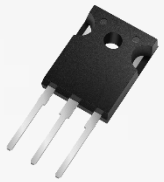
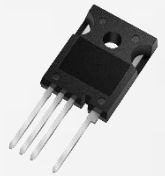
- Standard reliability testing at 100% rated voltage and 175C
- Intrinsic gate oxide reliability testing
- Cosmic radiation testing
- Validation of no drift in threshold or parameters

Manufacturing quality and reliability

- Defect scanning before and after epitaxial growth
- In-process controls
- 100% avalanche testing of all dies
- Product burn in to remove extrinsic gate oxide failures

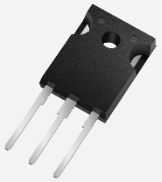
SiC MOSFETs

1200V SiC MOSFETs – M1 Family

ID @ 25C (A)	$R_{DS(ON)}$ (mΩ) typical	Die – Wafer and T&R	TO247-3	TO247-4	D2PAK-7L
					
90	20	NVC020N120SC1 NTC020N120SC1	NVHL020N120SC1 NTHL020N120SC1	NVH4L020N120SC1 NTH4L020N120SC1	NVBG020N120SC1 NTBG020N120SC1
55	40	NVC040N120SC1 NTC040N120SC1	NVHL040N120SC1 NTHL040N120SC1	NVH4L040N120SC1 NTH4L040N120SC1	NVBG040N120SC1 NTBG040N120SC1
40	80	NVC080N120SC1 NTC080N120SC1	NVHL080N120SC1A NTHL080N120SC1A	NVH4L080N120SC1 NTH4L080N120SC1	NVBG080N120SC1 NTBG080N120SC1
20	160	NVC160N120SC1 NTC160N120SC1	NVHL160N120SC1 NTHL160N120SC1	NVH4L160N120SC1 NTH4L160N120SC1	NVBG160N120SC1 NTBG160N120SC1

AECQ101 qualified automotive products start with “NV”
Industrial qualified products start with “NT”

900V SiC MOSFETs – M2 family

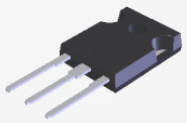
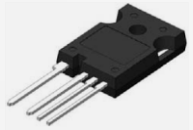
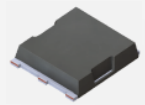
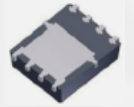
$R_{DS(ON)}$ (mΩ) typical	TO247-3	TO247-4	D2PAK-7L
			
20	NVHL020N090SC1 NTHL020N090SC1	NVH4L020N090SC1 NTH4L020N090SC1	NVBG020N090SC1 NTBG020N090SC1
60	NVHL060N090SC1 NTHL060N090SC1	NVH4L060N090SC1 NTH4L060N090SC1	NVBG060N090SC1 NTBG060N090SC1

AECQ101 qualified automotive products start with “NV”
Industrial qualified products start with “NT”

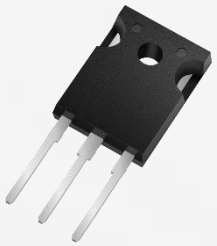
650V SiC MOSFETs – M2 family

Released
Engineering Sample available
In Development
Planning
(Sample / Release Date)

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

$R_{DS(ON)}$ TYP (mΩ)	TO-247-3	TO-247-4	D2PAK-7	TOLL	PQFN88
					
15	NVHL015N065SC1 NTHL015N065SC1	NVH4L015N065SC1 NTH4L015N065SC1	NVBG015N065SC1 NTBG015N065SC1		
25	NVHL025N065SC1 NTHL025N065SC1 (Sep’21/Mar ‘22)	NVH4L025N065SC1 NTH4L025N065SC1 (Jul/Dec ‘21)	NVBG025N065SC1 NTBG025N065SC1 (Feb’21/Mar ‘22)	TBA	TBA
45	NVHL045N065SC1 NTHL045N065SC1	NVH4L045N065SC1 NTH4L045N065SC1	NVBG045N065SC1 NTBG045N065SC1	TBA	TBA
60	NVHL060N065SC1 NTHL060N065SC1 (May/Dec ‘21)	NVH4L060N065SC1 NTH4L060N065SC1 (May’21/Mar ‘22)	NVBG060N065SC1 NTBG060N065SC1 (May’21/Mar ‘21)	TBA	TBA
75/80	NVHL075N065SC1 NTHL075N065SC1 (Oct’21/Mar ‘22)	NVH4L075N065SC1 NTH4L075N065SC1 (May’21/Mar ‘22)	NVBG075N065SC1 (May’21/Mar ‘21)	TBA	TBA
95		NVH4L095N065SC1 (Sep’21/Mar ‘22)	NVBG095N065SC1 (Sep’21/Mar ‘22)		

Loss example: 20A hard switched full bridge, 50% duty cycle

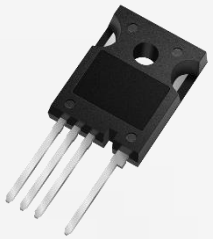


TO247-3LD
NTHL040N120SC1

Pcond = 11.3W
Pmax = 30W

EON = 1003 uJ
EOFF = 247 uJ

fsw max = 15 kHz



TO247-4LD
NTH4L040N120SC1

Pcond = 11.3W
Pmax = 30W

EON = 411 uJ
EOFF = 205 uJ

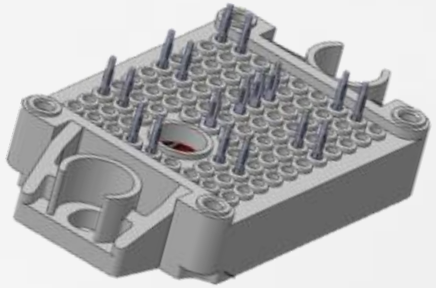
fsw max = 30.3 kHz

D2PAK7LD
NTGB040N120SC1

Pcond = 11.3W
Pmax = 30W

EON = 366 uJ
EOFF = 205 uJ

fsw max = 37.2 kHz



F1 Module

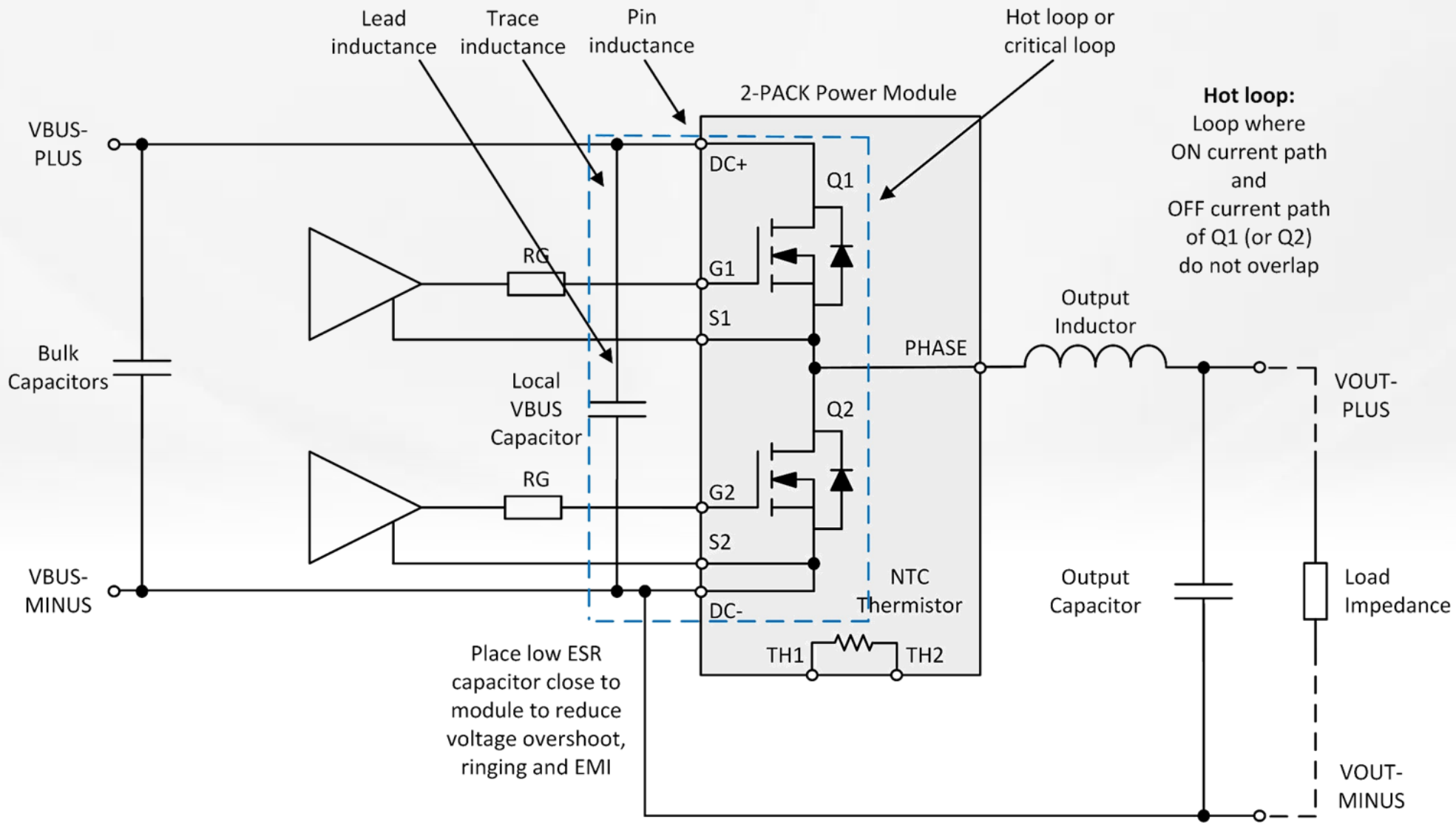
Pcond = 11.3W
Pmax = 30W

EON = 190 uJ
EOFF = 220 uJ

fsw max = 45.6 kHz

Faster switching
Lower module losses
More compact end product

One reason for improvement in module performance

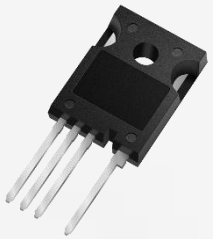


Use cases of different package types

TO247-3LD
NTHL040N120SC1

Used for simple replacement of IGBT with non-isolated driver

Needs thermal pad or thermal grease



TO247-4LD
NTH4L040N120SC1

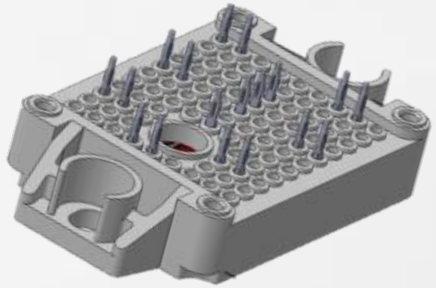
Recommended where the MOSFETs are mounted onto heatsink.

Needs thermal pad or thermal grease

D2PAK7LD
NTGB040N120SC1

Recommended for surface-mounted applications.

Heat goes through the PCB



F1 Module

Recommended for highest power density applications.

Heat sink on top of module.
TIM replaces need and quality issues with thermal grease

Industrial SiC MOSFET Modules

1200V SiC MOSFET 2-PACK Modules in F1 Package

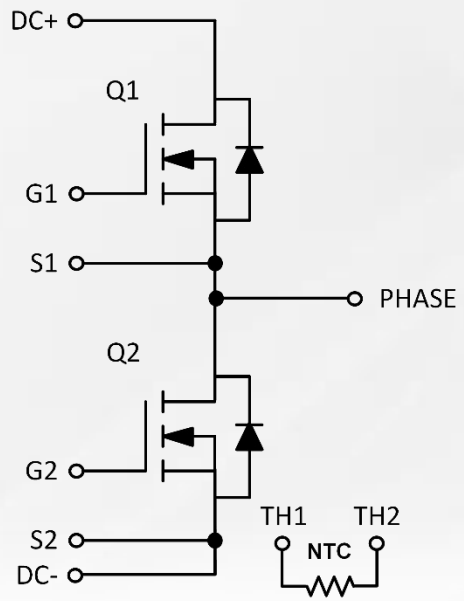
Features

- M1 SiC MOSFET planar technology with 18V-20V drive
  - 10mohm 1200V module
  - thermistor
  - Press-fit pins
- Works well with standard NCD5700x driver solutions from ON Semiconductor

Benefits

- Low thermal resistance from larger die than with trench MOSFETs
- Easy to drive with negative gate voltages
- Industry standard pinout

Block Diagram

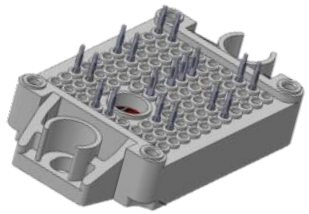


Specifications

Product	Dual Boost Components	Configuration
NXH010P120MNF1	Half Bridge 2-PACK 1200V 10mohm SiC MOSFET module	Press-fit pins

Package

F1



End products

- Solar Inverter
- UPS
- Energy Storage

Applications

- Industrial Applications

1200V SiC MOSFET 2-PACK Modules in F2 Package

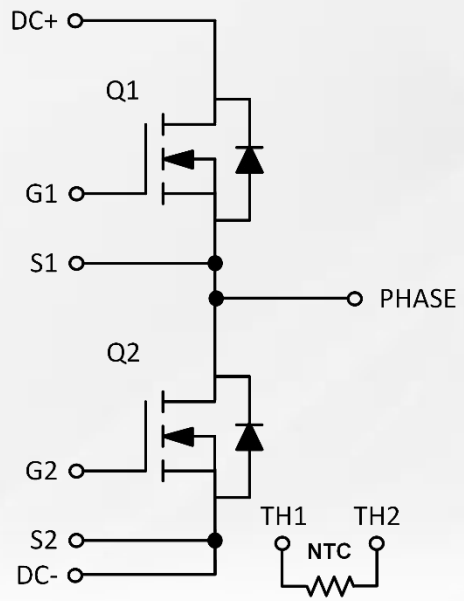
Features

- M1 SiC MOSFET planar technology with 18V-20V drive
  - 6mohm 1200V module
  - thermistor
  - Press-fit pins
- Works well with standard NCD5700x driver solutions from ON Semiconductor

Benefits

- Low thermal resistance from larger die than with trench MOSFETs
- Easy to drive with negative gate voltages

Block Diagram

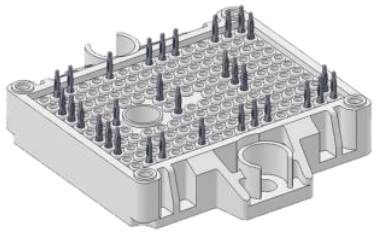


Specifications

Product	Dual Boost Components	Configuration
NXH006P120MNF2	Half Bridge 2-PACK 1200V 6mohm SiC MOSFET module	Press-fit pins

Package

F2



End products

- Solar Inverter
- UPS
- Energy Storage

Applications

- Industrial Applications

1200V SiC MOSFET 2-PACK Modules in Q0/Q1 Package

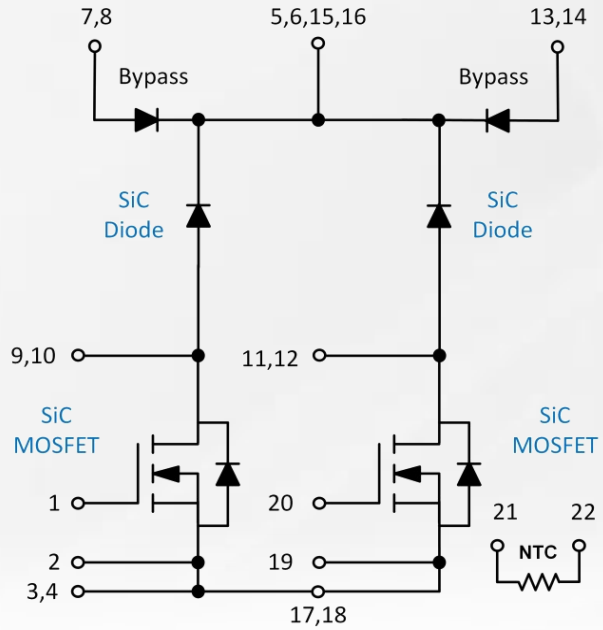
Features

- • 2 channel boost module family
  - 50A/1200V IGBT + SiC Diode
  - 40 mohm/1200V SiC MOSFET + SiC Diode
  - 80 mohm/1200V SiC MOSFET + SiC Diode
- 3 channel boost module (different pinouts)
  - 40 mohm/1200V SiC MOSFET + SiC

Benefits

- Easy mounting
- Better efficiency than competitor product
- Range of pin compatible SiC hybrid and full SiC options

Block Diagram



Specifications

Product	Dual Boost Components	Versions
NXH100B120H3Q0	2 channel 50A/1200V IGBT, 20A/1200V SiC Diode	S, P, TIM
NXH40B120MNQ0SNG	2 channel 40mΩ/1200V SiC MOSFET, 40A SiC Diode	Solder pin (S) Ni plated DBC
NXH80B120MNQ0SNG	2 channel 80mΩ/1200V SiC MOSFET, 20A SiC Diode	
NXH40B120MNQ1SNG	3 channel 40mΩ/1200V SiC MOSFET, 40A SiC Diode	
NXH240B120H3Q1PG	3 channel 60A/1200V IGBT, 20A/1200V SiC Diode	Press-fit (P)
NXH100B120H3Q0	2 channel 50A/1200V IGBT, 20A/1200V SiC Diode	S, P, TIM

Package

Q0BOOST

Q1

End products

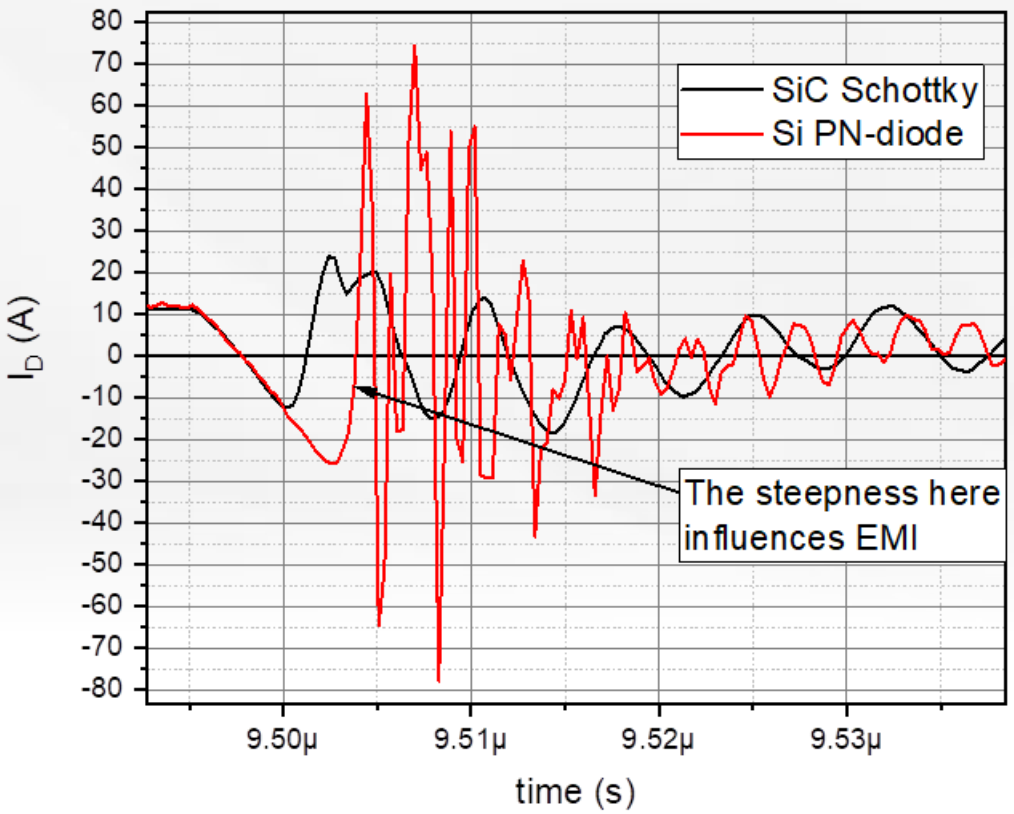
- Solar Inverter
- UPS
- Energy Storage

Applications

- Industrial Applications

SiC Diodes

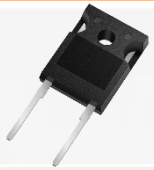
SiC Schottky EMI Performance



SiC diodes use a Schottky contact instead of a pn-junction like high voltage silicon diodes, they do not have the reverse recovery effect. As the reverse recovery is the main contributor to the diode switching losses, most diodes are engineered to have short reverse recovery times (e.g. ultrafast diodes). However, this causes the reverse recovery current to stop flowing abruptly (the ‘snap’), which causes an uncontrollable fast voltage transition. As the SiC Schottky diodes only have capacitive recovery effect, the peak currents are lower and the effect does not scale with load current or temperature.

This directly translates to lower switching losses.

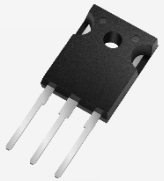
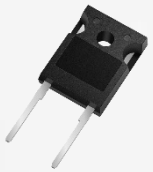
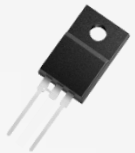
1200V SiC Diodes – D1 series

I (A)	VF (V)	Die	TO-247-3L Dual	TO-247-2L	TO-220-2L	D2PAK	DPAK
							
50	1.45	PCFFS50120AF		FFSH50120A			
40		PCFFS40120AF	FFSH40120ADN	FFSH40120A			
30		PCFFS30120AF	FFSH30120ADN	FFSH30120A			
20		PCFFS20120AF	FFSH20120ADN	FFSH20120A	FFSP20120A	FFSB20120A	
15		PCFFS15120AF	FFSH15120ADN	FFSH15120A	FFSP15120A		
10		PCFFS10120AF	FFSH10120ADN	FFSH10120A	FFSP10120A	FFSB10120A	FFSD10120A
8		PCFFS08120AF			FFSP08120A		FFSD08120A
5		PCFFS05120AF			FFSP05120A		

AECQ101 Automotive Qualified Diodes have “–F085” OPN suffix

onsemi

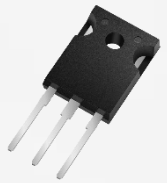
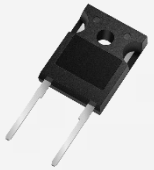
650V SiC Diodes – D1 Series

I (A)	VF (V)	Die	TO-247-3L	TO-247-2L	TO-220-2L	TO-220FP-2L	D2PAK	DPAK	PQFN-88
									
50	1.5	PCFFS5065AF	FFSH5065A-F155	FFSH5065A					
40		PCFFS4065AF	FFSH4065ADN	FFSH4065A					
30		PCFFS3065AF	FFSH3065ADN	FFSH3065A	FFSP3065A				
20			FFSH2065ADN	FFSH2065A	FFSP2065A	FFSPF2065A			
16			FFSH1665ADN	FFSH1665A	FFSP1665A				
12					FFSP1265A		FFSB1265A		FFSM1265A
10				FFSH1065A	FFSP1065A	FFSPF1065A	FFSB1065A	FFSD1065A	FFSM1065A
8					FFSP0865A	FFSPF0865A	FFSB0865A	FFSD0865A	FFSM0865A
6					FFSP0665A	FFSPF0665A	FFSB0665A	FFSD0665A	FFSM0665A
4					FFSP0465A		FFSB0465A	FFSD0465A	FFSM0465A

Single die device (instead of two parallel die) created as Wolfspeed drop-in replacement.

650V SiC Diodes – D2 Series

Automotive grade includes “–F085” OPN suffix

I (A)	VF (V)	TO-247-3L	TO-247-2L	TO-220-2L	TO-220-3L	D2PAK	DPAK	PQFN 88
								
50	1.35		FFSH5065B					
40		FFSH4065BDN			FFSP4065BDN			
30			FFSH3065B	FFSP3065B		FFSB3065B		
20		FFSH2065BDN	FFSH2065B	FFSP2065B	FFSP2065BDN	FFSB2065B FFSB2065BDN	FFSD2065B	FFSM2065B
10			FFSH1065B	FFSP1065B		FFSB1065B	FFSD1065B	FFSM1065B
8				FFSP0865B		FFSB0865B	FFSD0865B	FFSM0865B
6				FFSP0665B		FFSB0665B	FFSD0665B	FFSM0665B

Gen2 1200V SiC Diodes

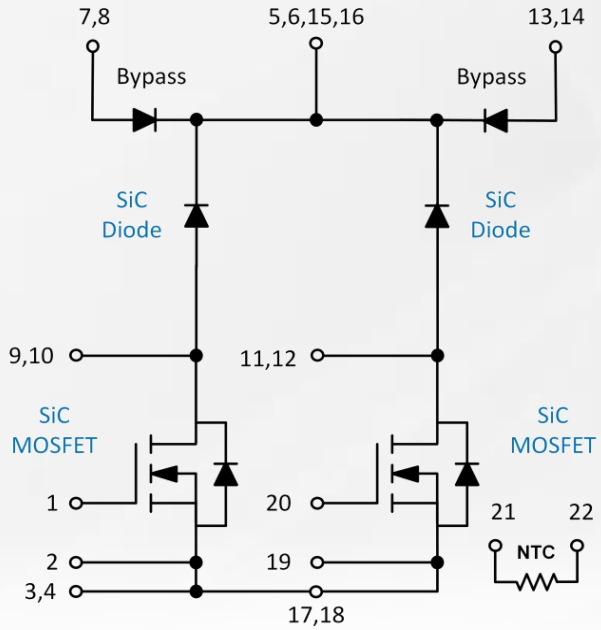
Features

- Low Vf x Qc figure of merit
  - Low Vf
  - Low Qc
  - Lower switching losses in device switching the product
- Avalanche rated diodes
- Automotive qualified versions

Benefits

- Higher power density & efficiency
  - Lower conduction losses
  - Lower diode switching losses
  - Lower MOSFET/IGBT switching losses
- Higher robustness against incoming high voltage spikes due to avalanche rating

Example Application



Specifications

Product	Dual Boost Components
NDSH20120C	20A 1200V TO247-2LD Gen2 SiC Diode - Industrial
NDSH50120C	50A 1200V TO247-2LD Gen2 SiC Diode - Industrial
NVDSH20120C	20A 1200V TO247-2LD Gen2 SiC Diode – Automotive
NVDSH50120C	50A 1200V TO247-2LD Gen2 SiC Diode - Automotive

Package

End products

- Solar Inverter
- UPS
- Energy Storage

Applications

- Industrial Applications

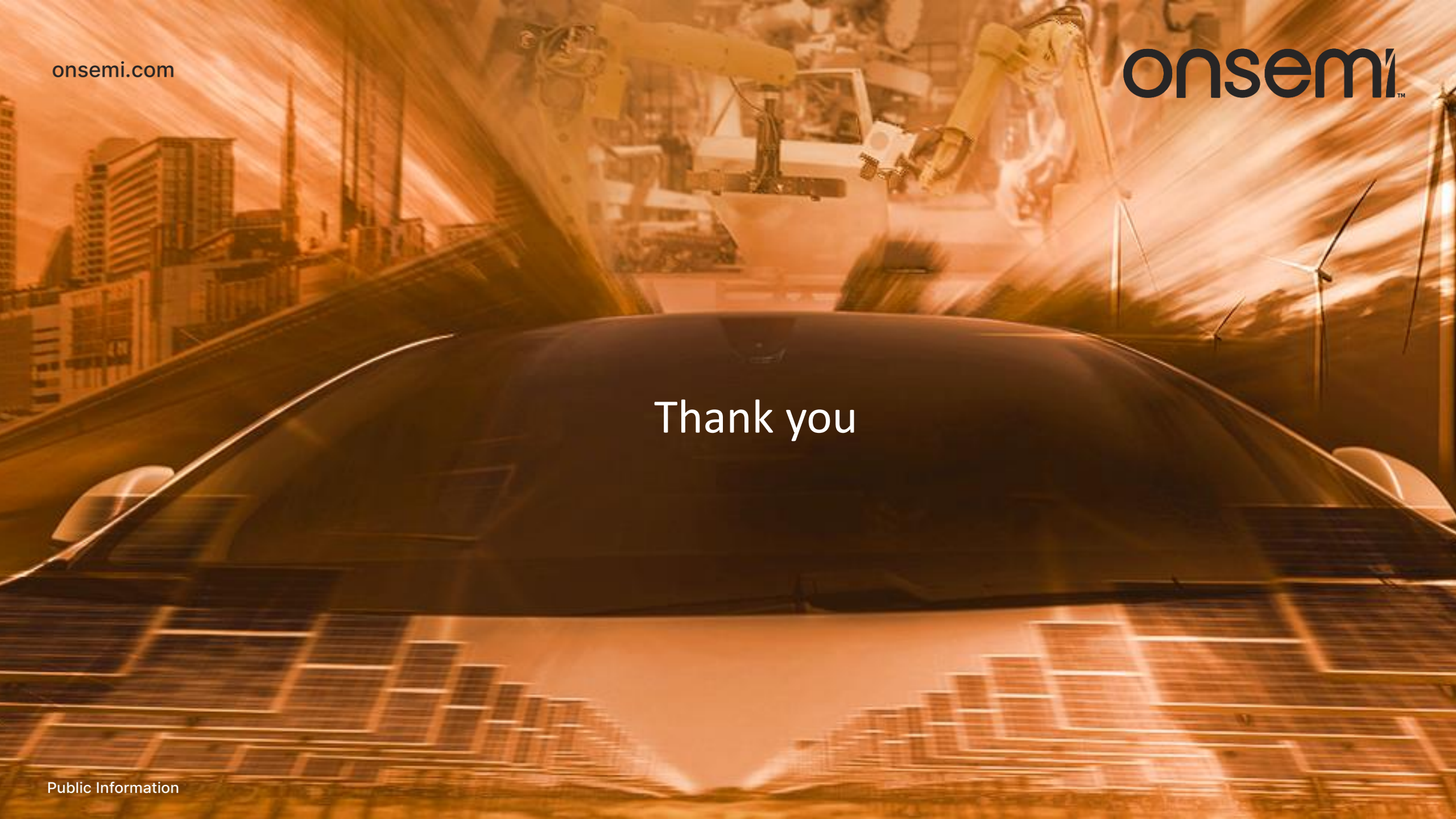
Solar Inverters

Benefit of SiC diodes and SiC MOSFET PV modules

SiC Hybrid circuits with IGBTs, SiC Diodes and SiC Mosfet are commonly used whether with modules and discretes

Full SiC circuits are more expensive but offering the best power density

and fast switching capability. System efficiency will be higher while the system size is smaller.


onsemi.com
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Thank you
Public Information

Arrow SiC Reference Design

Terence Tse

Sep 2021

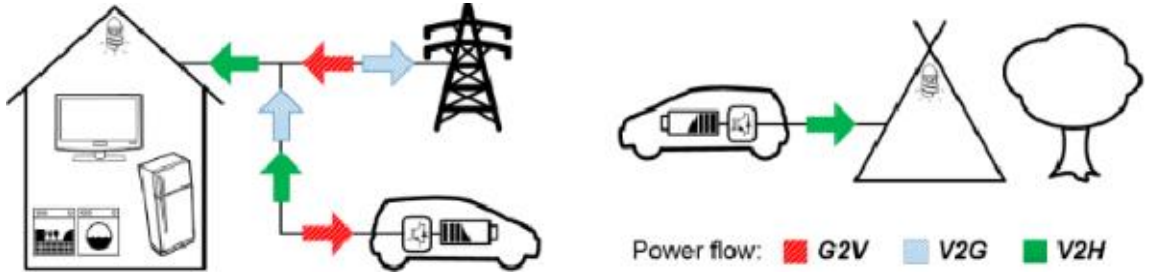
Five Years Out

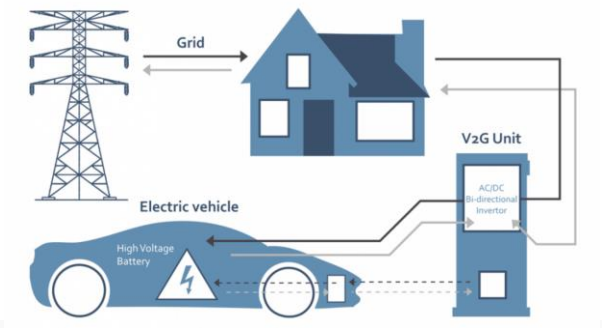
Arrow SiC devices reference design

- 10kW x2 Full Bridge Converter (DC/DC)
- 6.6kW Bidirectional Power Converter (AC/DC)

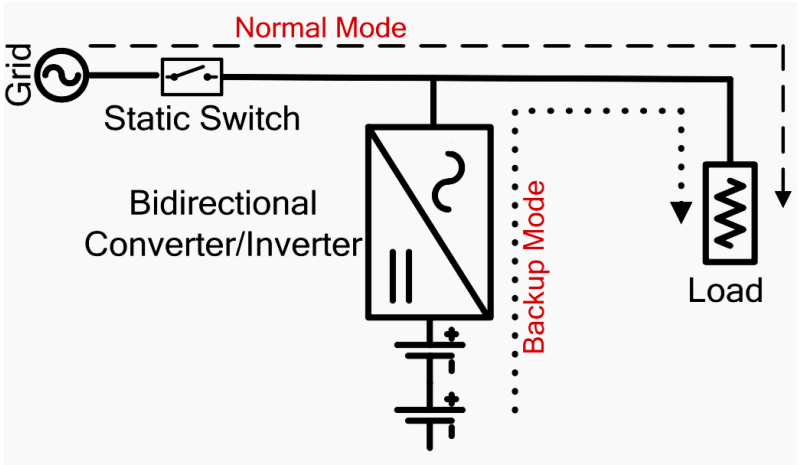
6.6kW Bidirectional Power Converter Applications

PV system



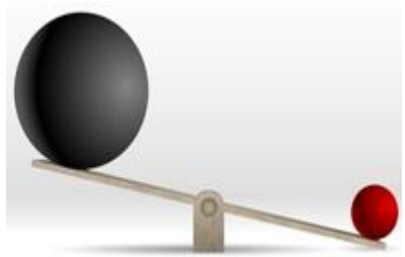


EV system



Energy storage system

OBC Market Trend



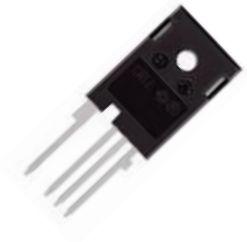
High Power Density

High Efficiency

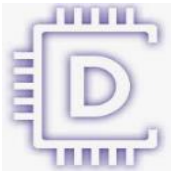
Lightweight

Bi-directional Power Flow

Planar Transformer



SiC MOSFET

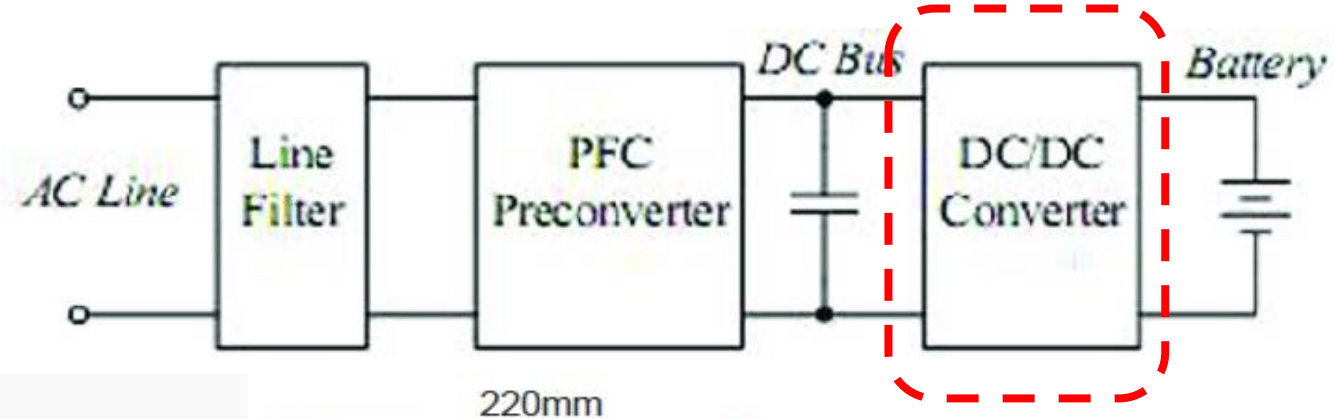


Digital Power Controller

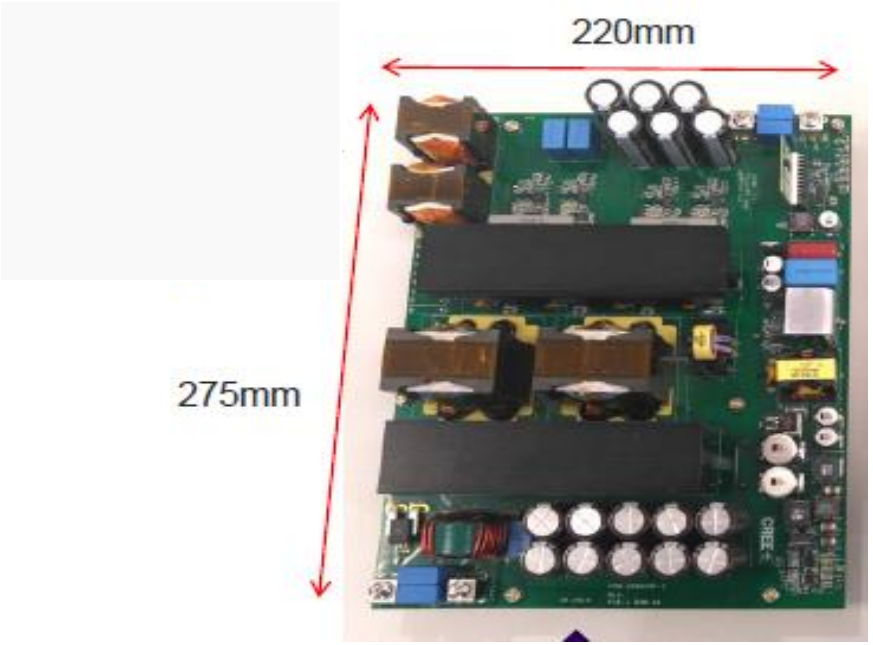
10kW x2 Full Bridge Converter (DC/DC)

(Uni-directional topology)

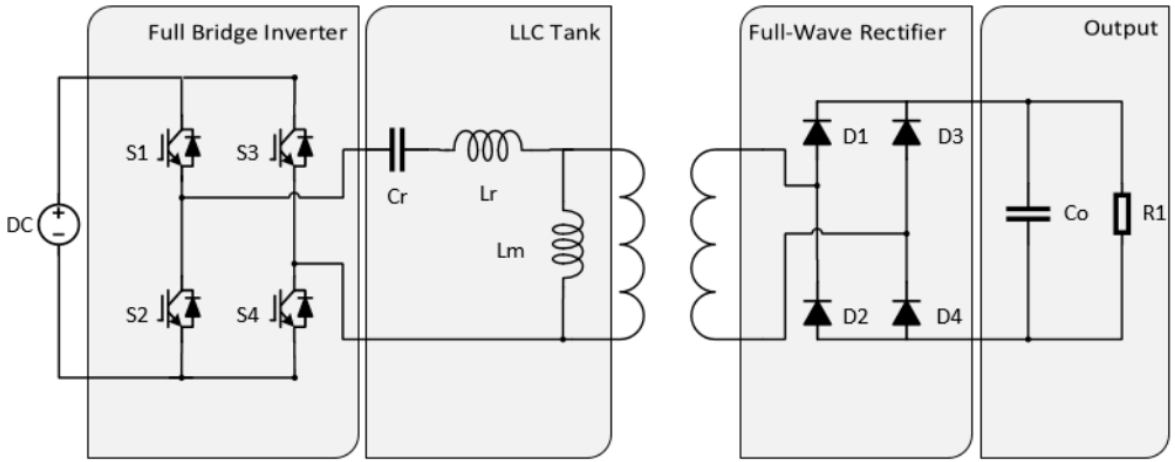
10kW x2 LLC Full Bridge Converter



Parameter	Value	Units
Input Voltage	650-750	VDC
Output Voltage	300-550	VDC
Switching Frequency	150-400	kHz
Continuous Output Power	20	kW
Peak Efficiency	>98.4	%
Power Density	60	W Cu/in



SiC Based 20kW LLC



10kW x2 LLC Full Bridge Converter

SiC MOS, Diodes:
NVHL060N090SC1 &
SiC Diodes FFSH50120A

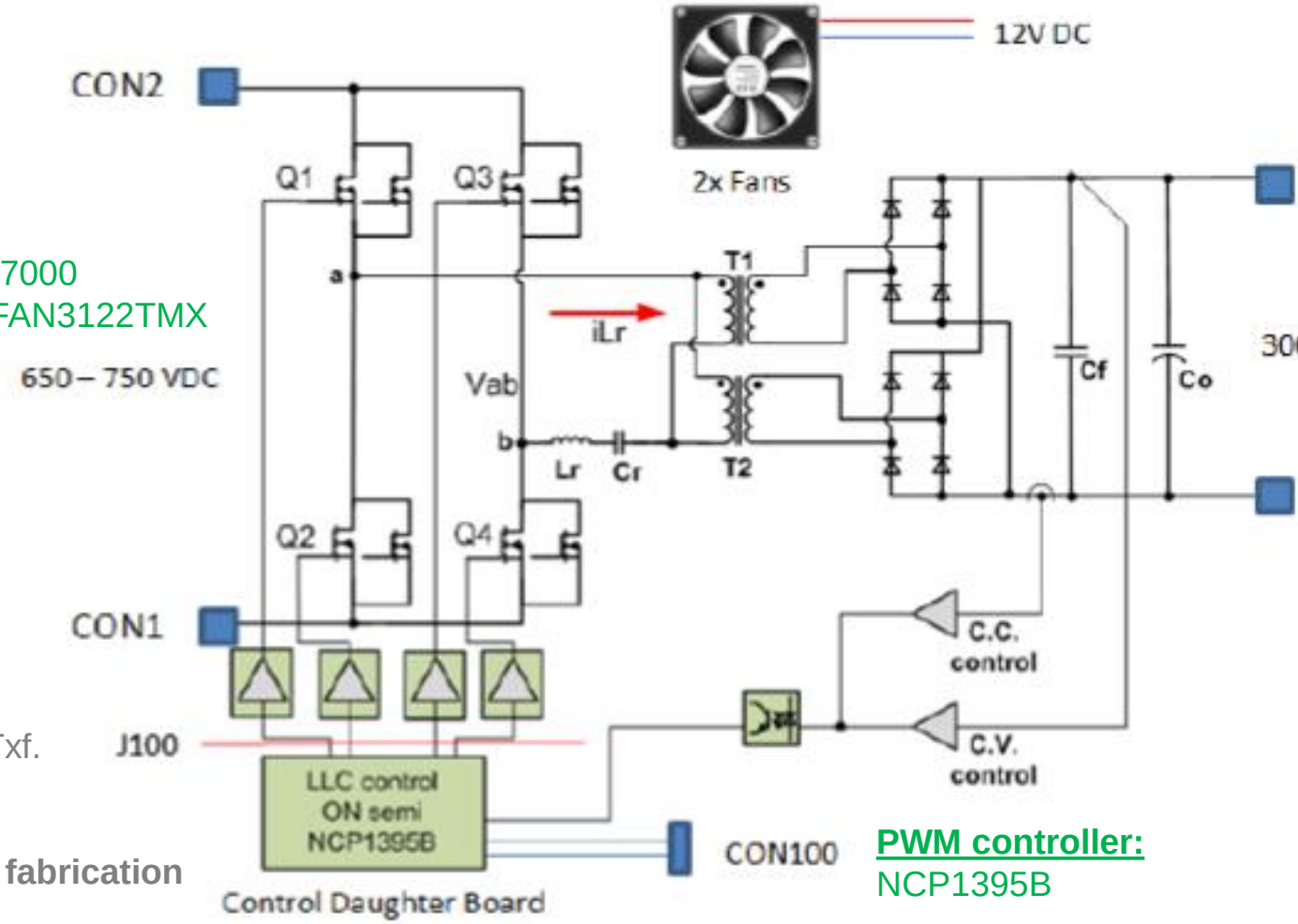
GATE DRIVE
Isolated Gate Driver: NCV57000
9A Totem pole Gate driver: FAN3122TMX

Diodes:
1N5819

Optocoupler:
FOD817A

Magnetics:
Sumida- Current Txf, Aux Txf.
Pulse- Inductors,

Main TXF: T1-2, abc Coils fabrication



PWM controller:
NCP1395B

E-cap: Nichicon

SMT-cap: Kemet/ Vishay

Resonant Tank Film Cap:
Panasonic/ Vishay

Current Sensor:
Allegro

Others:
LDO – NCVxxxx
Op-amp – NCSxxxx
Zener diode --- MMSZxxxx

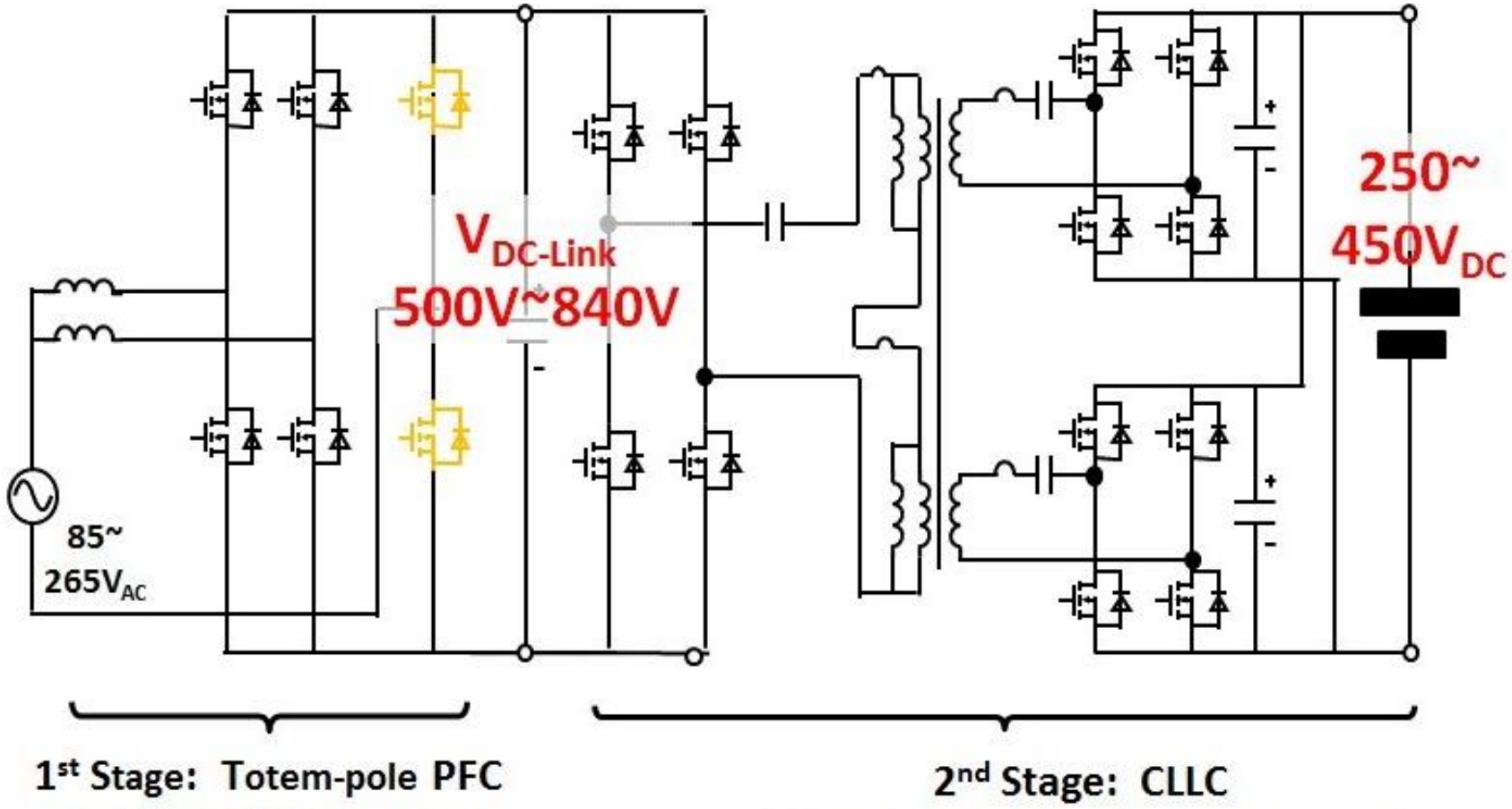
10kW x2 LLC Full Bridge Converter

Brand	Description
onsemi	SiC MOSFET NVHL060N090SC1 & SiC Diodes FFSH50120A
onsemi	Isolated Gate Driver, NCV57000
onsemi	9A Totem pole Gate driver, FAN3122TMX
onsemi	Schottky Barrier Rectifier, 1N5819
onsemi	Optocoupler, FOD817A
onsemi	PWM, UC2844B
onsemi	NCP1395B
onsemi	LDO – NCVxxxx, Op-amp – NCSxxxx, Zener diode --- MMSZxxxx

6.6kW Bi-directional Power Converter (AC/DC)

(Bi-directional topology)

6.6kW Bi-directional Power Converter

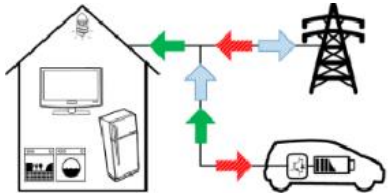


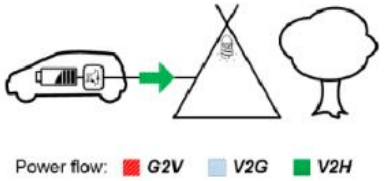
6.6kW Bi-directional Power Converter

Composition

Totem-Pole PFC

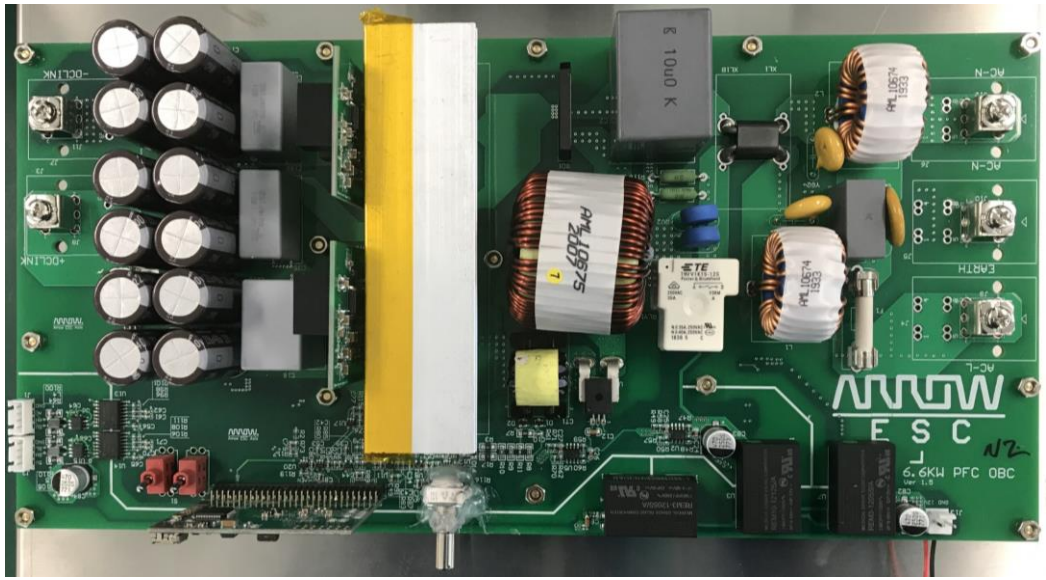
* Power Board
* Driver Board
* Control Board





CLLLC Resonant Converter

* Power Board
* Driver Board
* Control Board



6.6kW Bi-directional Power Converter

Advantages:

> Bi-directional

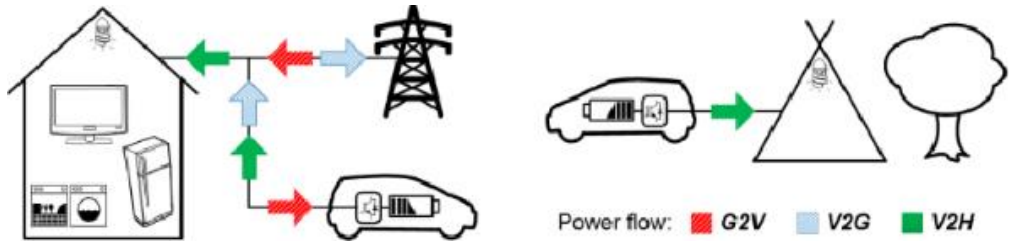
> High switching frequency

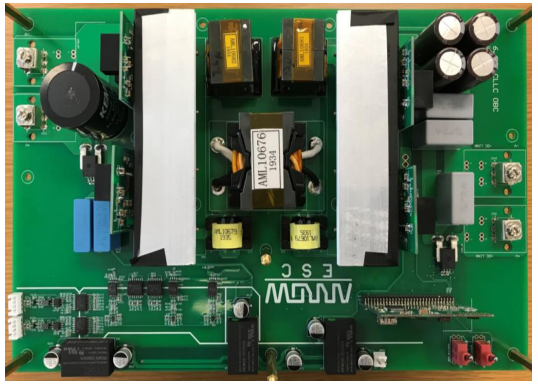
> Approx. 50% reduction in size vs IGBT design

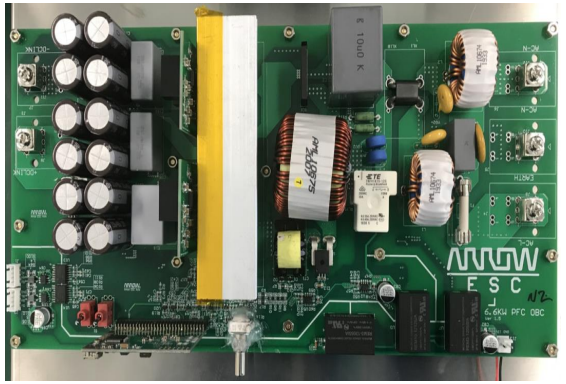
> High output power

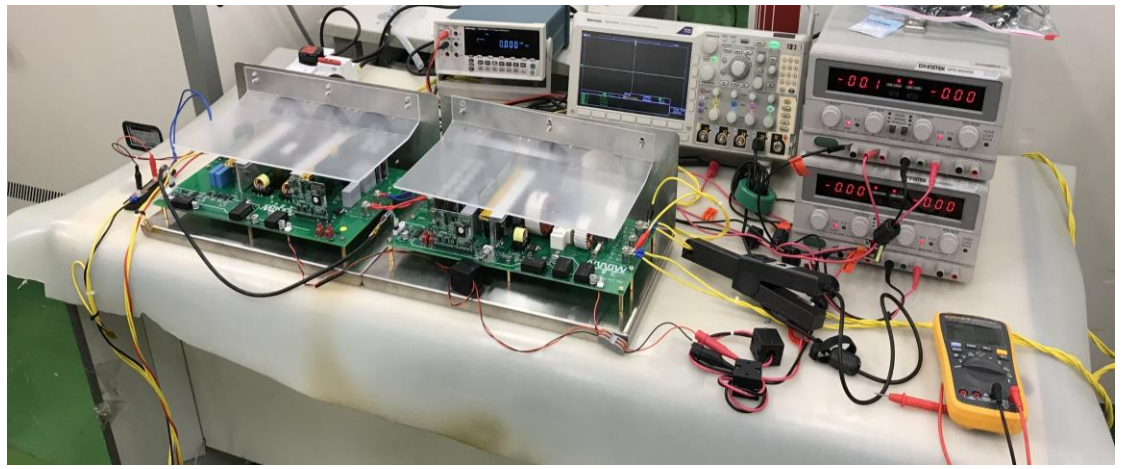
> High efficiency (>96%)

> Reinforced isolation





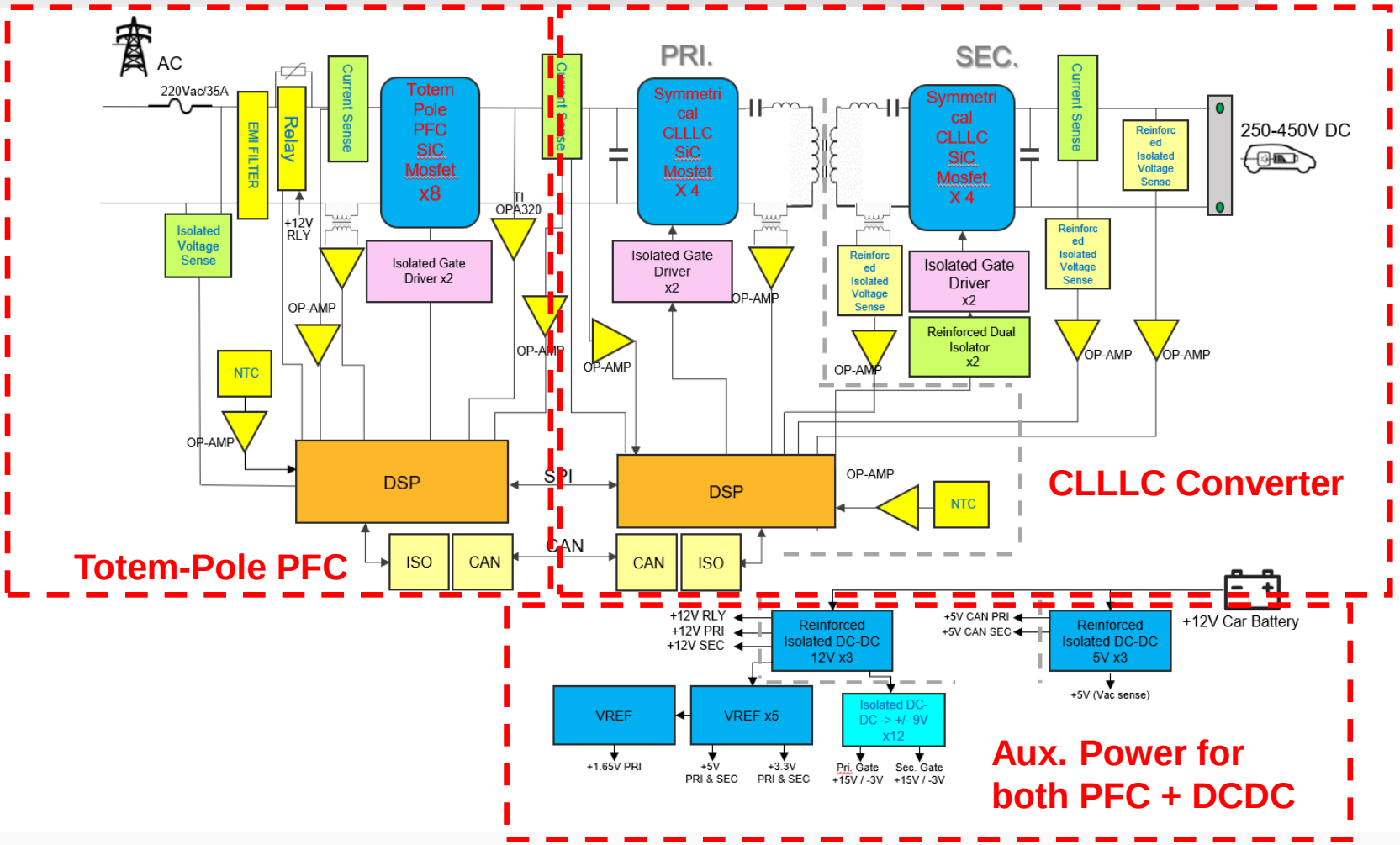




6.6kW Bi-directional Power Converter

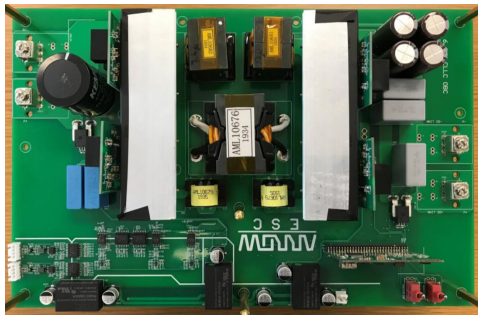
Block Diagram

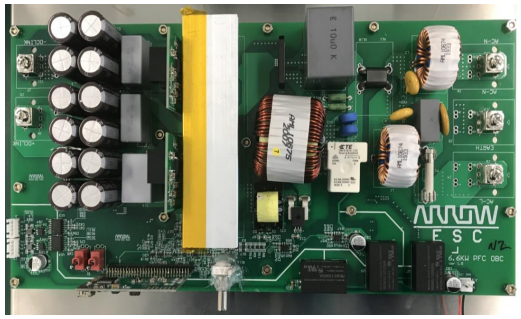
- 2 DSP are used
  - separate the system into PFC board and DCDC board
- DSP communication
  - Noise environment CAN BUS
- Isolated AUX power
  - Isolation consideration so that why used 3pcs isolation power units for each power converter
- AC zero cross
- PWM Soft start
- synchronous rectification for CLLLC

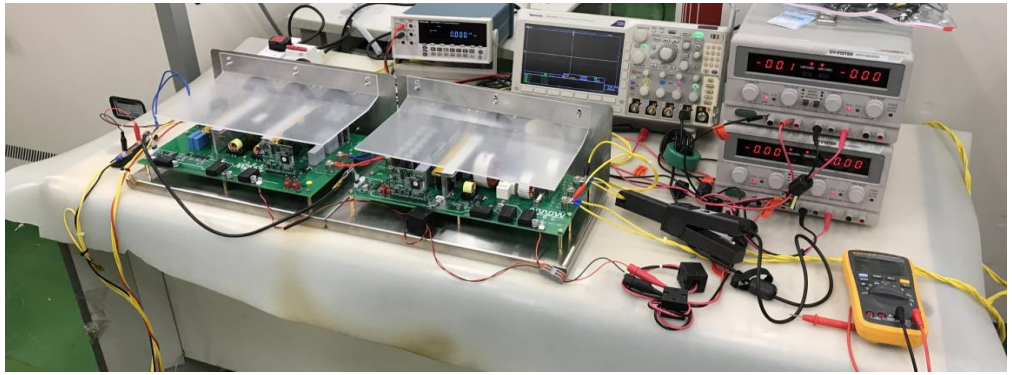


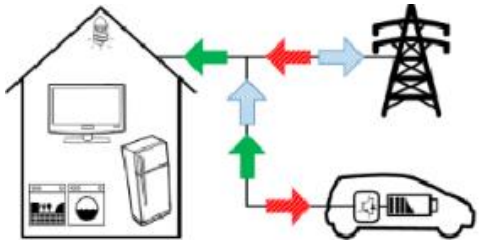
6.6kW Bi-directional Power Converter

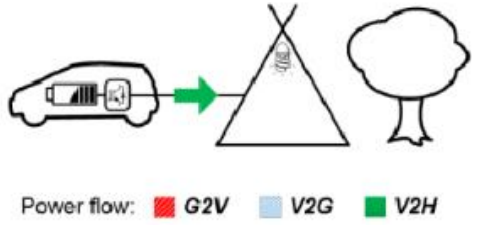
Part#	Part Description
NVH4L040N120SC1	SiC MOSFET, NCH, 1200V, 58A, 40mOhm, NVH4L040N120SC1 TO-247-4
NCV5500DADJR2G**	LDO, ADJ, VIN MAX 16V, 0.5A, SO8, ONSEMI, NCV5500DADJR2G**, LDO Regulator Pos 1.25V to 5V 0.5A Automotive 8-Pin SOIC N T/R
NCV57252	Dual channel isolated gate driver, AEC-Q100, NCV57252
NCV7344D10R2G	CAN 1Mbps Power Down 4V-36V Automotive 8-Pin SOIC T/R
NCV7351D13R2G	CAN/CAN FD Transceiver, High Speed
NCV8570BSN33T1G	LDO Regulator Pos 3.3V TSOP-5(SOT23-5)
NCV8730ASNADJT1G	LDO Regulator, 150 mA, 38 V, 1 µA IQ
NLV74LCX244DTR2G	Octal Buffer, Non-Inverting, Low Voltage, 3-State
NRVBAF260T3G	60 V, 2.0 A Low VF Schottky Rectifier
NRVBM110ET1G	Diode Schottky 10V 1A 2-Pin(1+Tab) Power Mite T/R
NCV21911SN2T1G	Op Amp Single Precision Amplifier 4V-36V 5-Pin SOT-23 T/R
SCV431ASN1T1G	Voltage reference, 2.495V-36V, Adj, SOT23, SCV431ASN1T1G
SMMBT2222ALT1	Trans GP BJT NPN 40V 1.1A 300mW 3-Pin SOT-23 T/R AEC?Q101
SURA8105T3G	Diode Switching 50V 2A 2-Pin SMA T/R AEC-Q101
SZMMSZ16T1G	ZENER DIODE, 16V, SOD-123, 500mW, AEC-Q101
SZMMSZ3V3T1G	ZENER DIODE, 3.3V, SOD-123, 500mW, AEC-Q101
SZMMSZ4680T1G	Zener Diodes ZEN SOD123 REG 0.5W 2.2V











Appendix
Engineering Solutions Center (ESC)

ESC – Centre of Excellence (COE)

Focus Area

Technologies

> Connectivity: wireless connectivity, driver, IoT protocol support, cloud platform, web services

> Embedded System: Linus, Android, BSP, devices drivers

> Power: BMS, AC/DC, DC/DC, USB Type-C

> Motor Control: compressor, BLDC, servo motor etc…

> Sensors: temperature, humidity, ozone, PM2.5, PM10, CO2, CO etc…

Thank You