System Solution Guide

Solar Inverter

Updated: MAR-2024

Industry	Energy Infrastructure – Solar Inverter
Application	Renewable energy such as solar and wind power is one of the most efficient way to lower carbon emissions. Unlike wind power, solar inverter is widely used in a variety of use cases. Nowadays, in conjunction with the energy storage system, people can control and store this free energy. The core of solar inverter is the high-power conversion stages, DC-DC boost converter and DC-AC inverter. With the development of power switches and new demands generated by the end products, a lot of new topologies are invented. Learn and understand these topologies, as well as products which are commonly used, is contributing a deep understanding and fast design of the entire system.

System Purpose

With the continuous explosion of civilization and population density, the increasing rate of CO_2 emissions begin to become uncontrollable. Global warming caused by carbon emissions will lead to climate deterioration and will inevitably harm our homeland. So, as a solution, we need to use clean energy, such as wind and solar energy.

Key benefits brought by solar energy are it is a “free” energy as long as a solar inverter system is installed. This process is environmentally friendly, as it produces no emissions, and it relies on an abundant and sustainable resource: the sun. Using solar power helps to combat climate change, reduces dependence on fossil fuels, and provides a reliable source of energy. Additionally, it often leads to long-term cost savings for individuals and businesses by lowering electricity bills.

There are various categories of solar inverter with differentiated type (central, string, micro) or differentiated end application (residential, commercial, utility-scale). At present, string inverter is the most popular type as it has the characteristics of flexibility and ease of installation. With the continuous iteration of power devices, the power level/power density of a single set of inverter is increasing while the unit price and size is getting lower, which makes it the mainstream of the solar inverter market.

Central solar inverter is always installed in the utility-scale station with ultra high capacity. However, because of the limitation of installing location, the total newly-install capacity has been surpassed by string solar inverter in recent years. Micro solar inverter is used for residential power generation, at the same time, it’s also found widely to power the city infrastructure such as streetlights and traffic lights.

Market Information & Trends

Silicon Carbide Replacement

Silicon Carbide aids in providing higher efficiency for actual trends. SiC devices are most useful for higher voltages compared with traditional silicon MOSFET/IGBTs. Higher voltage devices can simplify the topology, eliminating the need for multilevel converters. SiC inverter solutions have lower losses than IGBT solutions. SiC MOSFETs are also faster switching, which can shrink the size of the passive devices, particularly the inductors. These two factors increase power density, allowing higher power in the same size and weight equipment.

However, trade-offs between cost and performance must be made, understand the actual requirements and decide the most appropriate solution.

IGBT & SiC Diode

SiC diode replacement is becoming common especially in DC-DC stage because the cost is getting affordable, no need for big changes regarding circuit design, and the most important, system performance is well improved. Besides, the improved frequency can reduce the passive sizes.

Market Information & Trends

In high-power products (> about 200 kW), IGBT is the 1st choice because IGBT has a good performance when dealing with high current. And the system doesn't require a very high operating switching rate, which means the slow turn-off of IGBT won't bring too much trouble. Another point is that a full SiC system requires a completely new system design which costs a lot. For example, the driving circuit of IGBT-based converter is not compatible with a SiC-based system. New protection approach also needs to be considered because SiC components have smaller short circuit withstand time (SCWT) than IGBT.

Higher Bus Voltage

High power demands are growing, using 1500 V instead of 1100 V strings reduces the cost of the interconnection for a given power as current is lower. To meet such trend, higher voltage switches were developed. With either high-voltage switches or multi-level topology, the operating power of a solar inverter can be improved significantly. See comparison between 1500 V inverter and 1100 V inverter.

Table 1: Comparison between 1500V (Model-2) and 1100V solar inverter.

Part Number	MODEL-2	MODEL-1
Dimension	1091×678×341 mm	1008×678×343 mm
Rated Output Power	**250 kW**	**136 kW**
Max. Bus Voltage	**1500 V**	**1100 V**
Max. Input Current per MPPT	30 A	30 A
Number of Strings per MPPT	2	2
Weight	**111 kg**	**98.5 kg**

Return of the Two-level Topology?

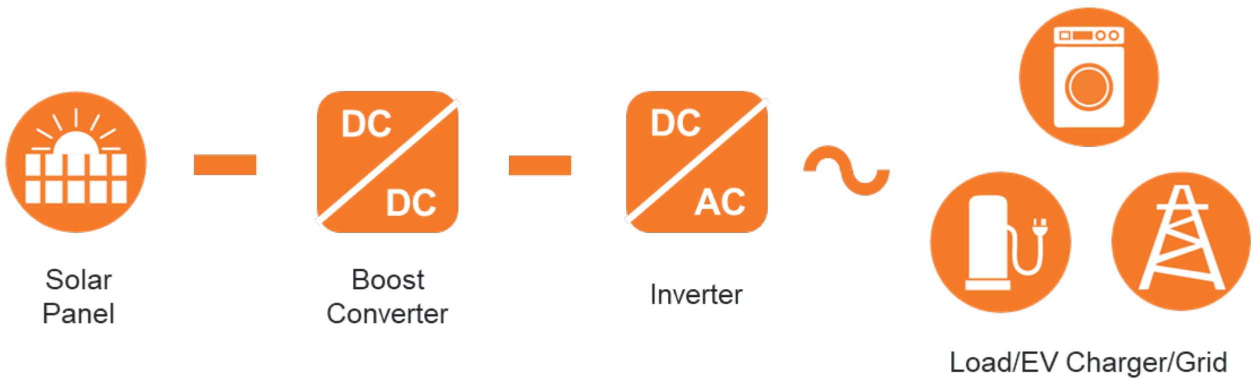
As it was just mentioned in previous part, three-level solar inverter is usually preferred in high-power solar inverter for its optimized EMI performance, switching losses and current ripple on inductor. However, it also brings challenges to PCB design and switching scheme. As the development of SiC, power modules and power discrete with max. operating voltage ≥ 2000 V has been developed and released. While there are still gaps (increased requirements on the rest components/accessories) between mass production, a two-level 1500 V system will dramatically reduce the design and control complexity, as well as the size of end products.

Hybrid Solar Inverter

Free solar energy is great, controlling the free energy is even better! Hybrid solar inverter is a new product series usually for residential cases which has an additional DC-DC converter coupled to the bus of solar inverter. The extra DC-DC converter will be connected with a battery pack providing back-up energy or energy arbitrage. This new system is integrated into a case which has similar appearance with classic residential solar inverter.

Solar Inverter

System Implementation



System Description

Sytem Components and Functions

The main components of a string inverter system are the array of solar panels, the DC link capacitors and the inverter (DC/AC converter). Frequently DC-DC boost stages are used between the PV strings and the DC link. These systems fulfill two main functions: 1) elevate the output voltage of the PV string to the DC link operating level. 2) implement the MPPT (Maximum Power Point Tracking) function, that maximizes the power generated by the PV strings in different environmental and sun irradiation conditions. In situations where the PV string reaches the DC link operating voltage level, the DC/DC converter is bypassed (via a low V_F diode) to maximize efficiency.

Power and Voltage Levels

The inverter stage exists in single-phase and three-phase configurations. The single-phase are rated from below 1 kW and up to 10 kW (depending on the region) and feature DC links voltage levels typically between 300 V and 600 V. Three - phase systems cover a broad range of powers, from 15 kW in light commercial type, up to above 300 kW in utility-scale applications. The DC link is typically operated at 1100 V (residential, commercial and utility) or 1500 V (commercial and utility).

Topologies

Across the wide spectrum of power levels and voltage, different power semiconductor solutions are adopted. Power Integrated Modules (PIM) with IGBTs, SiC MOSFETs and or SiC/Hybrid are typically preferred solutions for the higher powers. To deal with system of high bus-voltage, multi-level must be taken into consideration. See AND90142 - Demystifying Three-Phase Power Factor Correction Topologies to understand three-level and example three level PFC circuit, the same approach to inverter section. Two-level system also has its advantages in system complexity, control complexity, but it requires more on power switches.

Discrete vs Power module

See the comparison in next page, there are lots of aspects to influence your customer's decision, but for high-power products, module solution is highly recommended especially when dealing with multiple discrete MOSFET/IGBT in parallel, module approach will simplify a lot such as the long-term performance caused by imbalanced current and heat, switching timing, wiring connections, etc. Read AND9100 – Paralleling of IGBTs to learn more.

System Description

Table 2: Evaluate using Power integrated modules (PIM) or Discrete components to build a solar inverter.

Category	Item	PIM	Discrete	Note
Design Cost and Space saving	Manufacturing	Excellent	Moderate	Modules simplify manufacturing process
	PCB Design	Easy	Difficult	Need designer's know-how
	PCB Area	Small	Large	Discretes need about 50 % larger space
	Number of Parts	Single	Multiple items	Module Solution integrates essential peripherals
	BOM Cost	Moderate	Good	PIM is more expensive
	Second Source	Not Easy	Relatively easy	More PIM with P2P package is now available
	Total Cost	Good	Moderate	Need to consider cost of assembly, scrap, rework, PCB, management
Component Performance	Thermal Impedance	Lower	Higher by isolation material	Failure might be caused by poor isolation material
	Isolation	Stable isolation by DBC	Unstable	Higher failure rate caused by poor isolation material / process
	Temperature Sensor	NTC soldered on DBC	NTC mounted far from dice	Contact concern if mounted on heatsink
	Matching Among Devices	Optimized	Not easy	Needs additional sorting for paralleling. Needs to evaluate multiple combinations
	Die Selection	Optimized, no waste	Must select existing one	e.g. T-NPC needs fast NP diodes
	Reliability	Good, Proven as a single device	Moderate	Depends on customer's design and manufacturing quality

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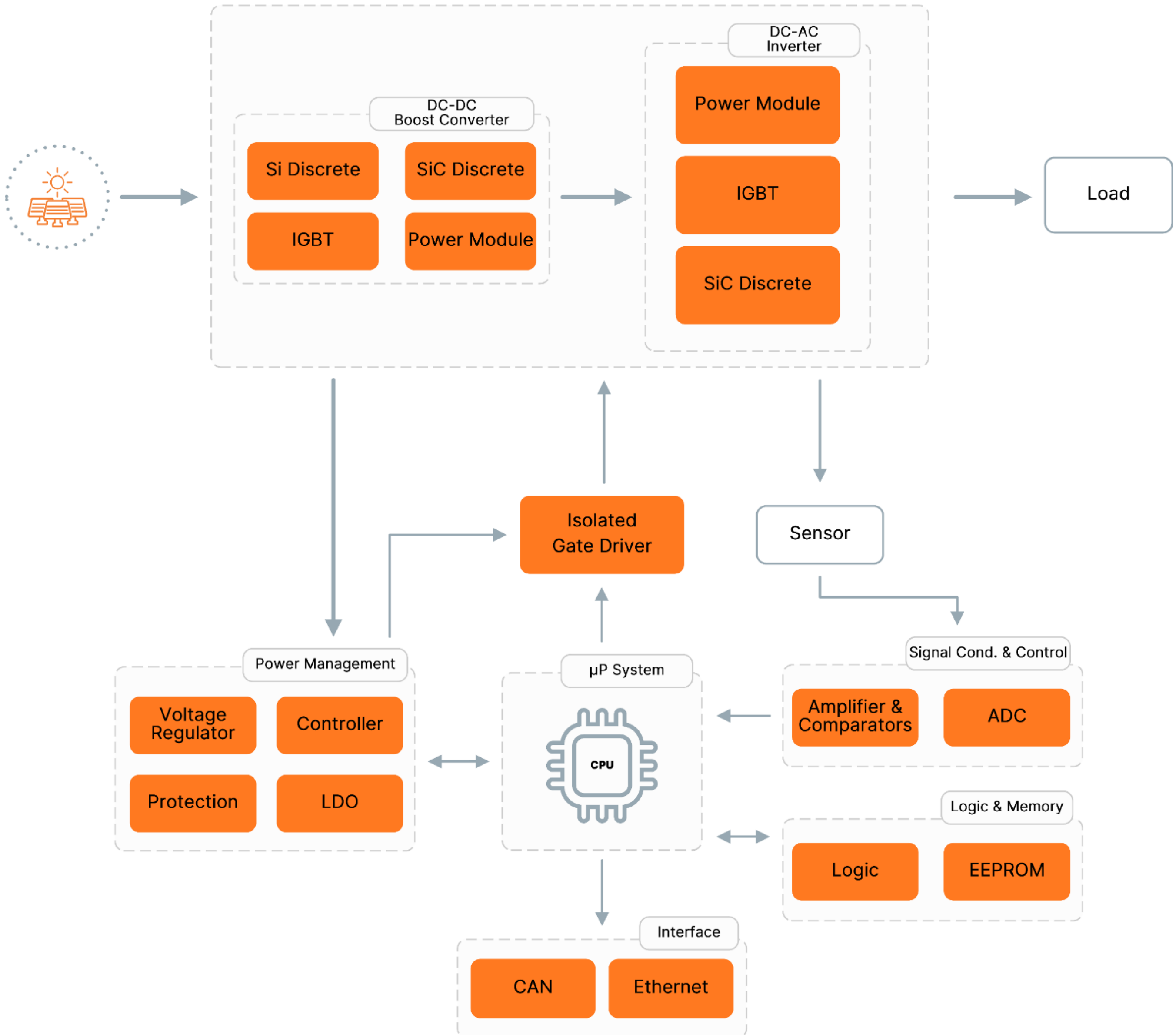
Solution Overview

Block Diagram – Solar Inverter



Find Interactive Block Diagram on the Web

Solution Overview

Micro Inverter – Low Power Solution

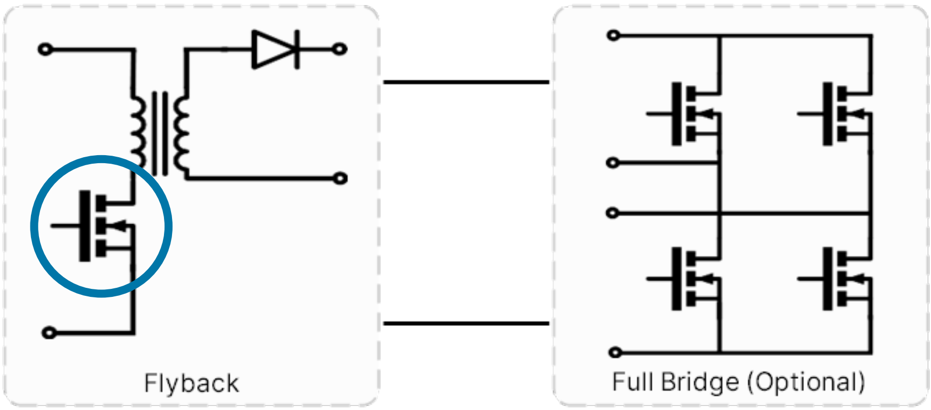
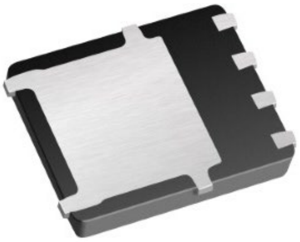


Figure 1: Simplified Power Conversion Stages of a Micro Inverter

Power MOSFET, 80 V, T10 Technology

Features

- V_{DSS} = 80 V, I_D = 253 A, $R_{DS(ON)}$ = 1.43 mΩ
- Low Q_{RR} = 224nC
- Latest Shield gate architecture
- Low Q_G to minimize driver losses
- **Application** : Primary switch in isolated DC-DC converters and motor drivers.



NTMFWS1D5N08X
SO8FL package

Power MOSFET, 150 V, PQFN-8

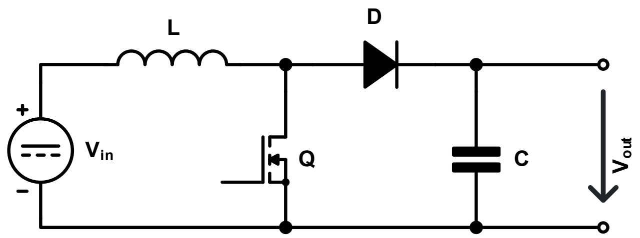
Features

- V_{DSS} = 150 V, I_D = 31 A, $R_{DS(ON)}$ = 31 mΩ
- Small footprint (5 x 6 mm) for compact design
- Low Q_G to minimize driver losses
- **Application** : Primary switch in isolated DC-DC converters and SMPS.

NTMFS034N15MC PQFN-8 package

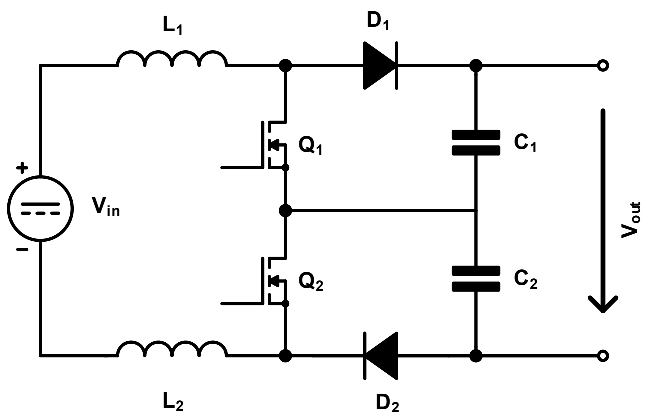
Solution Overview

String Inverter - DC-DC Boost Stage



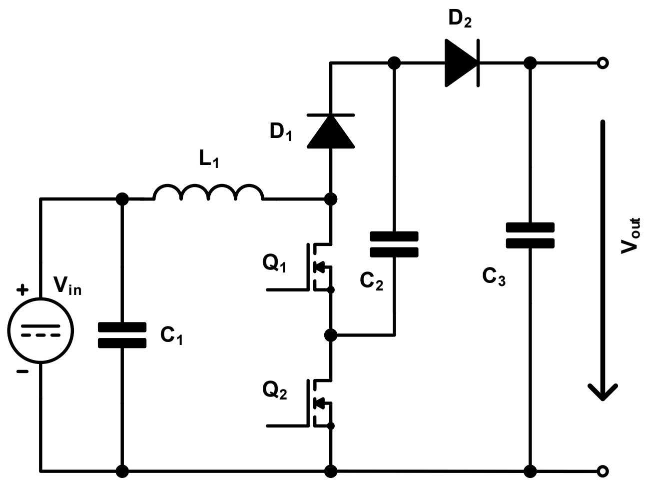
Two-level single boost

- Simplest circuit and easiest control
- Low bom cost, low failure rate
- Normal efficiency
- Moderate size and EMI
- Power components with full voltage requirements



Three-level symmetric boost

- Reduced stress on inductor, MOSFET/IGBT, diode
- Reduced inductor size, weight
- Simple circuit and easy control
- Good efficiency
- Better harmonic quality and lower dv/dt
- Target – 3Ph 1100 V/1500 V projects in most of current customers



Three-level flying capacitor boost

- Only 1 inductor, double inductor frequency, smaller size
- Shared ground simplifies (EMI inductor, Y cap, connector and wires, potential induced degradation circuit)
- Extra curcuit of flying cap and extra start-up circuit
- Best efficiency among 3 options
- Better harmonic quality and lower dv/dt
- Target – 3-Ph >1500 V with higher efficiency requirements

Solution Overview

3 Channel Flying Cap. Boost SiC Hybrid PIM

Features

- 1000 V low $V_{CE(SAT)}$ fast switching IGBT modules with integrated 1200 V SiC diode (Hybrid PIM)
- Module with low thermal impedance baseplate
- Solder pin and press-fit pin options available
- Internal NTC thermistor

[NXH600B100H4Q2F2](NXH600B100H4Q2F2)

Benefits

- Easy module mounting, higher output power
- Flexibility to support different manufacturing processes
- Excellent efficiency and thermal losses.
  Higher output power than with 1200 V IGBT solutions

Application

- 1500 V decentralized utility-scale solar inverter

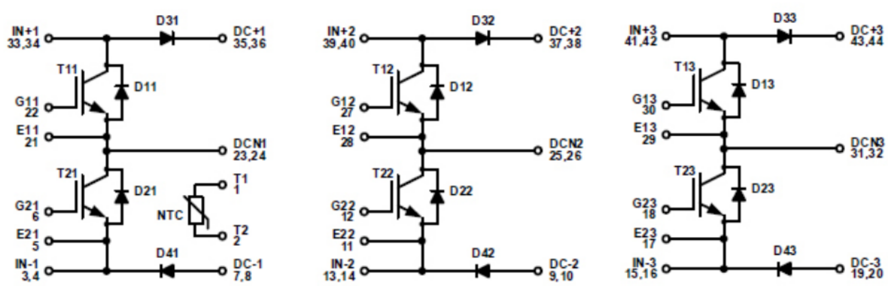
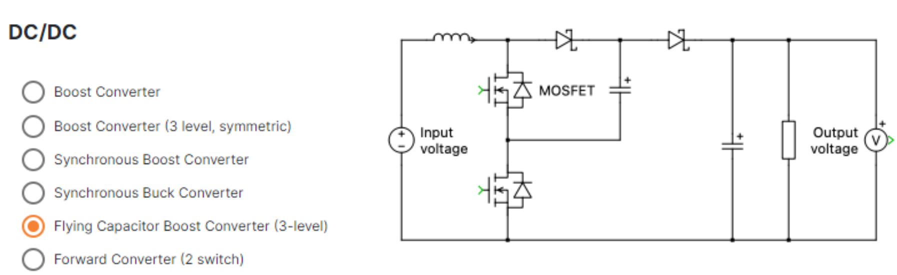


Figure 2: Schematic diagram of NXH600B100H4Q2F2 3 Channel Symmetric Boost module design.

Features of flying capacitor boost converter

IGBT can be considered thanks to reduced switching frequency of switches. Hybrid PIM integrates SiC boost diodes, which are preferred to save losses. One inductor is required with lower current. Discover more about main advantages brought by three-level topologies in the White Paper TND6386 - Topologies for Commercial String Solar Inverter. (Requires onsemi Webpage login)

Use Elite Power Simulator to run your flying capacitor boost converter simulation:



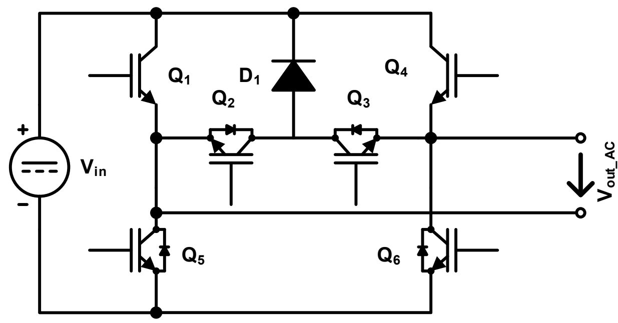
Solar Inverter

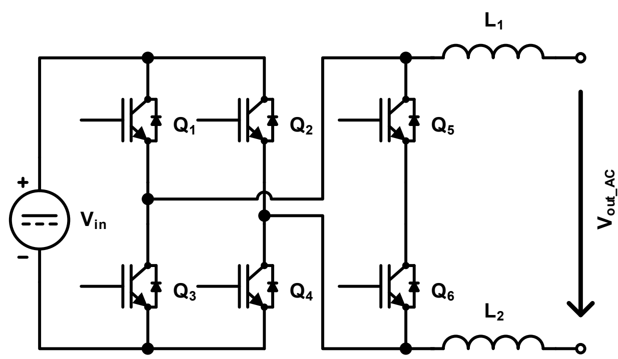
Solution Overview

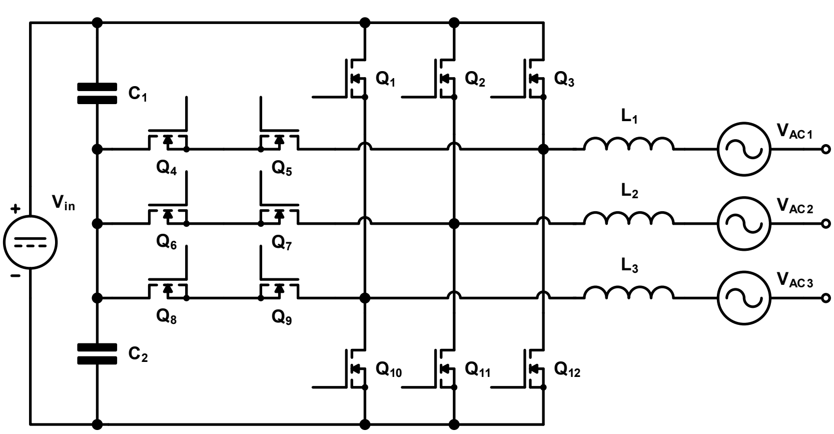
String Inverter - DC-AC Inverter Stage topologies

HERIC/H6.5

- Widely used in 1-Ph solar inverter design
- Complex circuit and control
- Better efficiency with 3 level topology than half bridge
- 6 switches (6*Vd), 5 diodes (1 less than HERIC)
- Reduced CM leackage current when the transformer is removed
- Target power level < 10 kW







T-NPC

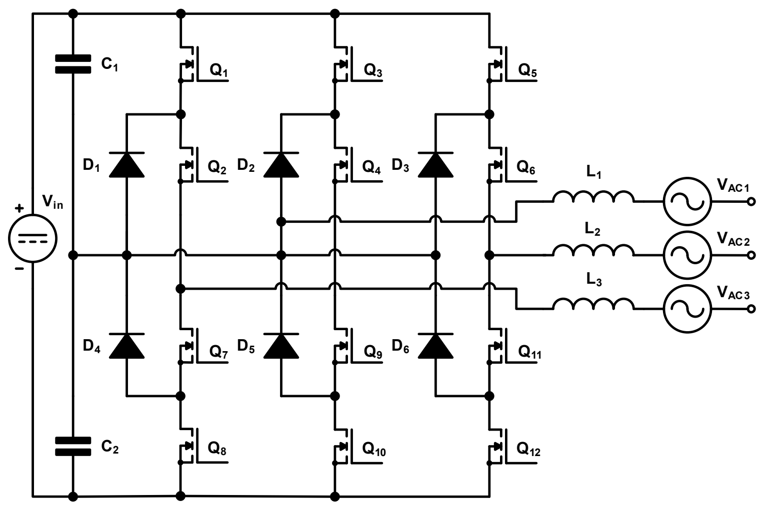
- Simple circuit and easy control, widely used
- Full voltage on only vertical switches
- Better efficiency with 3 level topology, low switching loss
- Better harmonic quality and lower dv/dt
- Target – 3-Ph, 1100 V system with 20 kW~100 kW output power

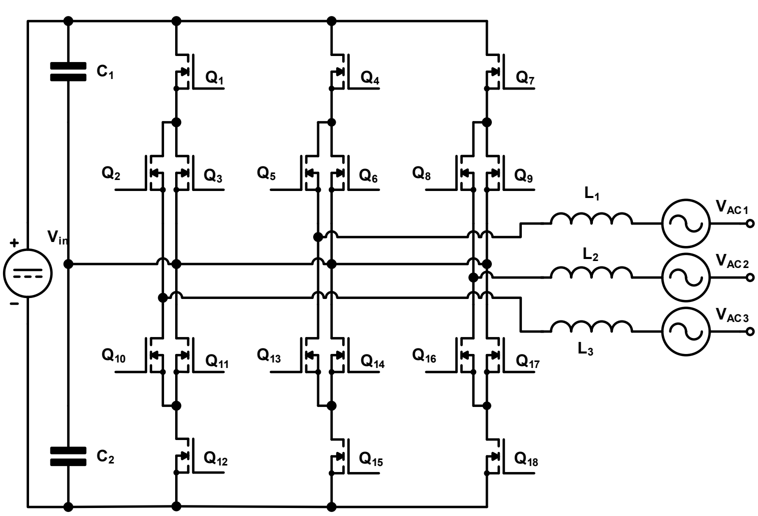
Solution Overview

String Inverter - DC-AC Inverter Stage topologies

I-NPC

- Simple circuit and easy control, widely used
- Halved voltage on switches
- Better efficiency with 3 level topology
- Better harmonic quality and lower dv/dt
- Loss imbalance
- Target – up to 1500 V system with 40 kW~220 kW output power





A-NPC

- Complex circuit and complex control
- Halved voltage on switches
- High efficiency with 3 level topology
- Better harmonic quality and lower dv/dt, lower inductance
- Flexible commutation path selection
- Target – up to 1500 V system with >200 kW output power

Solution Overview

A-NPC vs I-NPC Topologies

I-NPC has been improved to be a good option for high power solar inverter system for decades. However, with the increasing requirements according to the system evolution, the loss-balancing issue of I-NPC is becoming critical. In the case of PF=-1 and small modulation index (M=0.05) the inner IGBTs are the most stressed devices for rectifier operating mode. The outer IGBTs are the most stressed devices for inverter operating mode when PF=1 and M=0.95. All operating points in between are less critical. As a result, A-NPC was proposed with two clamped diodes replaced by two IGBTs with anti-parallel diodes. With this approach, commutation path is becoming more flexible, optimizing the loss/heat distribution to eventually improve the output power and efficiency.

Read TND6436 - Common IGBT Topologies Used In Energy Infrastructure Applications to understand more about A-NPC.

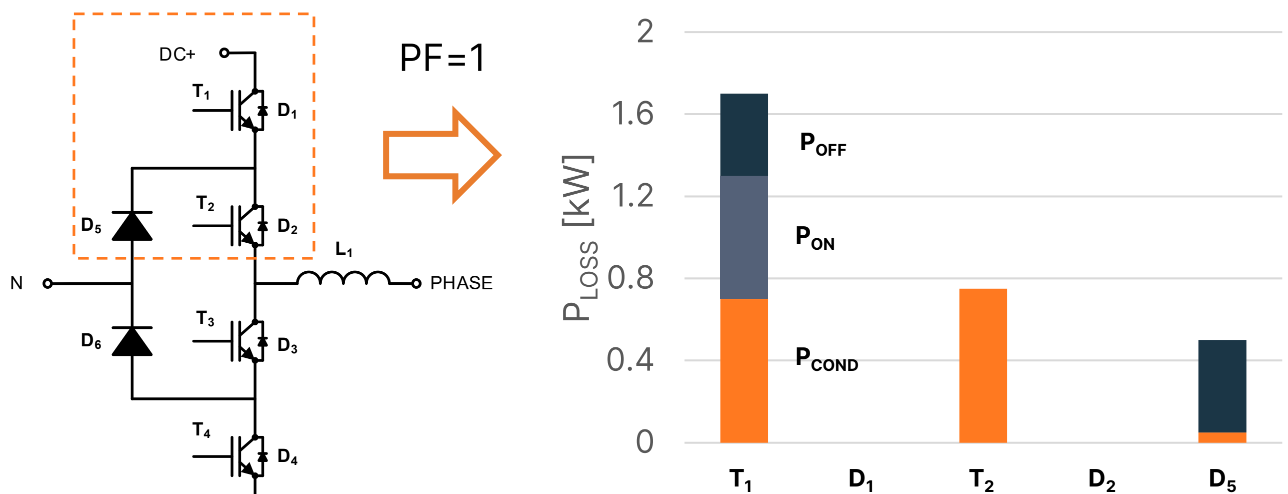


Figure 3: Power loss distribution of I-NPC when PF=1

Three-level A-NPC PIM, Q2 Pack

Features

- V_{CE} = 1000 V, I_C = 800 A, IGBT FS4
- Module design offers high power density
- Low Inductive Layout
- Internal NTC thermistor
- Solder and press-fit options

Benefits

- Balanced loss and heat dissipation
- Flexible commutation path selection

Application

- 1500 V decentralized utility-scale solar inverter

NXH800A100L4Q2F2

Solution Overview

EliteSiC, 1200 V MOSFET, M3S

- New Family of 1200 V M3S Planar SiC MOSFET
- Optimized for high temperature operation
- Improved parasitic cap for high-frequency operation
- $R_{DS(ON)}$=22 mΩ @V_{GS}=18 V*
- Ultra low gate charge ($Q_{G(TOT)}$)=137 nC*
- High speed switching with low cap. (C_{OSS}=146 pF)*
- 4-pin package with Kelvin Source*

Learn more about M3 family - AND90204 - onsemi EliteSiC Gen 2 1200 V SiC MOSFET M3S Series

*Key characteristics of NTH4L022N120M3S.

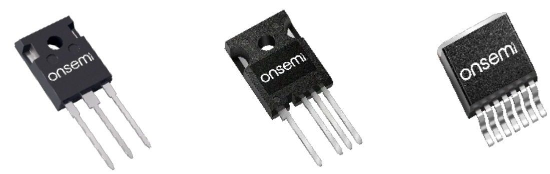


Figure 4: Package variants of M3S MOSFET family TO-247-3LD (left) , TO-247-4LD (middle), D2PAK-7L (right)

Figure 5: Chart Comparison of E_{OSS} parameter

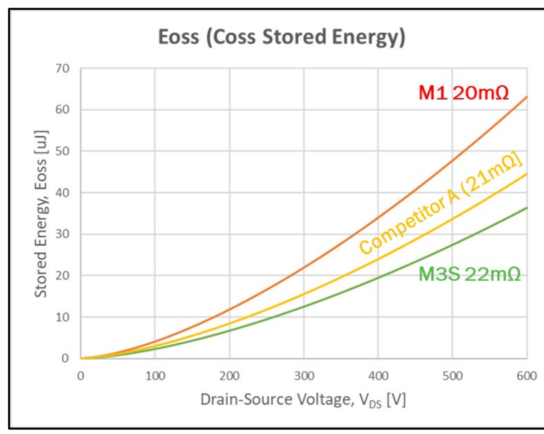


Table 3: Comparison of E_{OSS} parameter between M3S, M1 MOSFET families and Competitor A

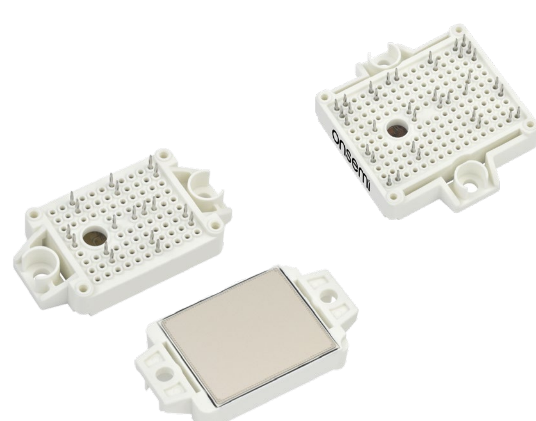
	E_{OSS} [uJ] at 0-600V	FOM [Ω*uJ] $R_{DS(on)}$*E_{OSS}
onsemi M1 20mΩ	63	1.38
onsemi M3S 22mΩ	36	0.77
Competitor A 21mΩ	45	0.86

Field Stop VII, IGBT, 1200 V

- New Family of 1200 V Trench Field Stop VII IGBT
- Trench narrow mesa & Proton implant multiple buffer
- Fast switching type and low $V_{CE(SAT)}$ type available
- Improved parasitic cap for high-frequency operation
- Common packages
- Target applications - Energy infrastructure, Factory Automation

Full SiC Power Integrated Modules (PIM)

- Large portfolio of entirely SiC power integrated modules in half-bridge, full-bridge and other larger topology configurations.
- Low thermal resistance, internal NTC thermistor
- Improved $R_{DS(ON)}$ at higher voltage
- Improved efficiency and higher power density
- Flexible solution for high reliability thermal interface



Solution Overview

How to Choose a Gate Driver

Current driving capability. The fact of turn-on and turn-off of a switch is the discharging and charging process of the input and output capacitors. Higher sink and source current capability means quicker turn-on and turn-off, and eventually, smaller switching losses.

Fault detection. A gate driver is not only used to drive switches but protect switches and even the entire system. For example, UVLO (under voltage lock out) ensures the power supply of gate driver is in a good condition, DESAT (Desaturation) is used to detect the short circuit and active miller clamp is to prevent false turn on especially in a quick switching system. Read AND9949 – NCD(V)57000/57001 Gate Driver Design Note to learn the protecting functions.

Immunity. CMTI (Common Mode Transient Immunity) determines if this product can be used in a quick-switching system, it is defined as the maximum tolerable rate of the rise or fall of the common-mode voltage applied between the input and output circuit in a gate driver. High power system is operating at very quick changing rate which generates very large voltage transient, for example, >100 V/ns. The isolated gate driver needs to be able to withstand CMTI above the rated level to prevent noise on the low-voltage circuitry side, and to prevent failure of the isolation barrier.

Propagation delay. Propagation delay is defined as the time delay from 10% of the input to 90% of the output (might be different among suppliers), this delay affects the timing of the switching between devices, which is critical in high-frequency applications. Dead time is set to avoid shoot-through and further damage, the less dead time is set, the less switching loss you will have.

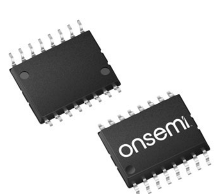
Compatibility. A pin-to-pin replacement is always preferred in a new project if there's no significant design change. Choosing a gate driver with similar specifications and package is benefit for a quick design.

Of course, not every point needs to be followed. For example, unlike IGBT, the output characteristic of SiC MOSFET behaves more like a variable resistance and there's no saturation region, which means the normal desaturation detecting principle doesn't work. As one of the solution, a current sensor is usually used to detect overcurrent, or a temperature sensor for abnormal temperature.

NCP51561

Dual Channel Isolated Gate Driver

- 4.5A / 9A Source/Sink Peak Current
- Typical 36 ns propagation delay with 5ns max delay matching
- Single or Dual Input Modes via ANB
- 5 kV galvanic isolation, CMTI ≥ 200 kV/µs
- SOIC-16WB with 8mm creepage distance



NCD57080 / NCD57090

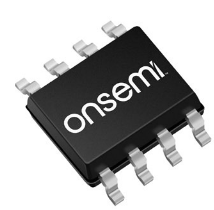
Single Channel Isolated Gate Driver

- 6.5 A Source/Sink Peak Current
- Available with Split Output Active Miller Clamp or Negative Bias versions
- 3.3 V, 5 V and 15 V Logic Input
- 3.5 kV galvanic isolation, CMTI ≥ 100 kV/µs
- SOIC-8 with 4mm creepage distance (NCD57080)
- SOIC-8WB with 8mm creepage distance (NCD57090)

NCD57100

Single Channel Isolated Gate Driver

- 7 A Source/Sink Peak Current
- UVLO and DESAT Protection
- Wide Bias Voltage Range including Negative VEE
- 3.3 V, 5V and 15 V Logic Input
- 3.5 kV galvanic isolation, CMTI ≥ 100 kV/µs
- SOIC-16WB with 8mm creepage distance



Recommended Products

Suggested Block	Part Number	Description
Single Phase Solar Inverter - Power Conversion Stage		
DC-DC Boost Converter & DC-AC Inverter	NTMFS0D4N04XM	Power MOSFET, N-Channel, 40 V, 0.7 mΩ, 323 A, SO8-FL 5x6
	NTMFWS1D5N08X	Power MOSFET, N-Channel, SO8FL-HEFET, 80 V, 1.43mΩ, 253 A
	NTBGS004N10G	Power MOSFET, N-Channel, 203 A, 100 V, D2PAK 7L
	NTMFS3D2N10MD	N-Channel Shielded Gate PowerTrench® MOSFET 100 V, 142 A, 3.2 mΩ
	NTMFS7D5N15MC	N-Channel Shielded Gate PowerTrench® MOSFET 150 V, 95.6 A, 7.9 mΩ
	Application Recommended Si MOSFET for Micro Inverter	
	NTBG015N065SC1	Silicon Carbide (SiC) MOSFET - EliteSiC, 12 mΩ, 650 V, M2, D2PAK-7L
	NTBL045N065SC1	Silicon Carbide (SiC) MOSFET - EliteSiC, 33 mΩ, 650 V, M2, TOLL
	NTH4L015N065SC1	Silicon Carbide (SiC) MOSFET - EliteSiC, 12 mΩ, 650 V, M2, TO-247-4L
	NTMT045N065SC1	Silicon Carbide (SiC) MOSFET - EliteSiC, 33 mΩ, 650 V, M2, Power88
	NTHL075N065SC1	Silicon Carbide (SiC) MOSFET - EliteSiC, 57 mΩ, 650 V, M2, TO-247-3L
	Application Recommended SiC MOSFET	
	FFSD0665B	Silicon Carbide (SiC) Schottky Diode – EliteSiC, 6 A, 650 V, D2, DPAK
	FFSP0665B	Silicon Carbide (SiC) Schottky Diode – EliteSiC, 6 A, 650 V, D2, TO-220-2L
	FFSB0665B	Silicon Carbide (SiC) Schottky Diode – EliteSiC, 6 A, 650 V, D2, D2PAK-2L
	FFSM0865B	Silicon Carbide (SiC) Schottky Diode – EliteSiC, 8 A, 650 V, D2, Power88
	FFSB1065B	Silicon Carbide (SiC) Schottky Diode – EliteSiC, 10 A, 650 V, D2, D2PAK-2L
	Application Recommended SiC Diode	
	FGAF40S65AQ	650 V 40 A FS4 RC IGBT, optimum performance for PFC, TO-3PF
	FGHL50T65LQDT	650 V 50 A FS4 low Vce(sat) IGBT with full rated copack diode,TO-247-3L
	FGHL50T65LQDTL4	650 V 50 A FS4 low Vce(sat) IGBT with full rated copack diode,TO-247-4L
	FGH4L50T65SQD	650 V 50 A FS4 high speed IGBT with copack diode, TO-247-4L
	FGH4L50T65MQDC50	650 V 50 A FS4 high speed IGBT with SiC diode, TO-247-4L
	Application Recommended IGBT Discrete	
	NXH50M65L4Q1	IGBT PIM, H6.5 Topology, 650 V, 50 A IGBT, 650 V, 50 A Diode
	NXH75M65L4Q1	IGBT PIM, H6.5 Topology, 650 V, 75 A IGBT, 650 V, 50 A Diode
	Application Recommended PIM for Single-Phase Inverter Stage	

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Recommended Products

Suggested Block	Part Number	Description
Three Phase Solar Inverter - Power Conversion Stage		
DC-DC Boost Converter & DC-AC Inverter	NTH4L028N170M1	Silicon Carbide (SiC) MOSFET - EliteSiC, 28 mΩ, 1700 V, M1, TO-247-4L
	NTH4L014N120M3P	Silicon Carbide (SiC) MOSFET - EliteSiC, 14 mΩ, 1200V, M3P, TO-247-4L
	NTHL022N120M3S	Silicon Carbide (SiC) MOSFET - EliteSiC, 22 mΩ, 1200V,M3S, TO-247-3L
	NTH4L040N120M3S	Silicon Carbide (SiC) MOSFET - EliteSiC, 40 mΩ, 1200V,M3S, TO-247-4L
	NTBG070N120M3S	Silicon Carbide (SiC) MOSFET - EliteSiC, 65 mΩ, 1200V,M3S, D2PAK-7L
	NTBG020N090SC1	Silicon Carbide (SiC) MOSFET - EliteSiC, 20 mΩ, 900 V, M2, D2PAK-7L
	NTBG015N065SC1	Silicon Carbide (SiC) MOSFET - EliteSiC, 12 mΩ, 650 V, M2, D2PAK-7L
	NTBL045N065SC1	Silicon Carbide (SiC) MOSFET - EliteSiC, 33 mΩ, 650 V, M2, TOLL
	NTH4L015N065SC1	Silicon Carbide (SiC) MOSFET - EliteSiC, 12 mΩ, 650 V, M2, TO-247-4L
	NTHL075N065SC1	Silicon Carbide (SiC) MOSFET - EliteSiC, 57 mΩ, 650 V, M2, TO-247-3L
	Application Recommended SiC MOSFET	
	NDSH25170A	Silicon Carbide (SiC) Schottky Diode – EliteSiC, 25A,1700 V,D1, TO-247-2L
	FFSH10120A	Silicon Carbide (SiC) Schottky Diode – EliteSiC, 10 A,1200 V,D1, TO-247-2L
	FFSB20120A	Silicon Carbide (SiC) Schottky Diode – EliteSiC, 20 A,1200 V,D1, D2PAK-2L
	FFSH30120ADN	Silicon Carbide (SiC) Schottky Diode – EliteSiC, 30 A,1200V,D1, TO-247-3L
	FFSH40120ADN	Silicon Carbide (SiC) Schottky Diode – EliteSiC, 40 A,1200V,D1, TO-247-3L
	NDSH50120C	Silicon Carbide (SiC) Schottky Diode – EliteSiC, 50 A,1200 V,D3,TO-247-2L
	FFSD0665B	Silicon Carbide (SiC) Schottky Diode – EliteSiC, 6 A, 650 V, D2, DPAK
	FFSP0665B	Silicon Carbide (SiC) Schottky Diode – EliteSiC, 6 A, 650 V, D2, TO-220-2L
	FFSB0665B	Silicon Carbide (SiC) Schottky Diode – EliteSiC, 6 A, 650 V, D2, D2PAK-2L
	FFSB1065B	Silicon Carbide (SiC) Schottky Diode – EliteSiC, 10 A, 650 V, D2, D2PAK-2L
	Application Recommended SiC Diode	
	FGHL40T120RWD	1200 V 40 A FS7 IGBT, Low Vce(sat), TO-247-3L
	FGHL60T120RWD	1200 V 60 A FS7 IGBT, Low Vce(sat), TO-247-3L
	FGHL40T120SWD	1200 V 40 A FS7 IGBT, Fast Switching, TO-247-3L
	FGY75T120SWD	1200 V 75 A FS7 IGBT, Fast Switching, TO-247-3L
	FGH4L40T120LQD	1200 V 40 A Ultra Field Stop, Fast Switching, TO-247-4L
	FGHL50T65LQDT	650 V 50 A FS4 low Vce(sat) IGBT with full rated copack diode,TO-247-3L
	FGHL50T65LQDTL4	650 V 50 A FS4 low Vce(sat) IGBT with full rated copack diode,TO-247-4L
	FGH4L50T65SQD	650 V 50 A FS4 high speed IGBT with copack diode, TO-247-4L
	FGH4L50T65MQDC50	650 V 50 A FS4 high speed IGBT with SiC diode, TO-247-4L
	Application Recommended IGBT Discrete	

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Recommended Products

Suggested Block	Part Number	Description
DC-DC Boost Converter & DC-AC Inverter	NXH450B100H4Q2	Hybrid PIM, 3-Channel Symmetric Boost, 1000 V IGBT, 1200 V SiC Diode
	NXH300B100H4Q2F2	Hybrid PIM, 3-Channel Flying Cap. Boost, 1000 V IGBT, 1200 V SiC Diode
	NXH240B120H3Q1P1G	Hybrid PIM, 3-Channel Boost, 1200 V IGBT, 1200 V SiC Diode
	NXH100B120H3Q0	Hybrid PIM, 2-Channel Boost, 1200 V IGBT, 1200 V SiC Diode
	NXH40B120MNQ1	Full SiC PIM, EliteSiC, 3-Ch Boost, 1200 V SiC MOSFET, 1200 V SiC Diode
	NXH40B120MNQ0	Full SiC PIM, EliteSiC, 2-Ch Boost, 1200 V SiC MOSFET, 1200 V SiC Diode
	Application Recommended PIM for Boost Converter Stage	
	NXH800A100L4Q2F	IGBT PIM, A-NPC, 1000 V, 800 A IGBT
	NXH600N65L4Q2F2	IGBT PIM, I-NPC, 650 V, 600 A IGBT, 650 V, 300 A Diode
	NXH450N65L4Q2	IGBT PIM, I-NPC, 650 V, 450 A IGBT, 650 V, 375 A Diode
	NXH350N100H4Q2F2	Hybrid PIM, I-NPC, 1000 V, 350 A IGBT, 1200 V, 100 A SiC Diode
	NXH80T120L3Q0	IGBT PIM, T-NPC, 1200 V, 80 A IGBT, 600 V, 50 A IGBT
	NXH40T120L3Q1	IGBT PIM, 3-Ch T-NPC, 1200 V,40 A IGBT, 650 V, 25 A IGBT
	NXH200T120H3Q2	Hybrid PIM, Split T-NPC, 1200 V, 200 A IGBT, 650V, 150A IGBT, SiC Diode
	NXH006P120MNF2	Full SiC PIM, EliteSiC, Half Bridge, 1200 V, 6 mΩ, M1
	NXH010P120MNF1	Full SiC PIM, EliteSiC, Half Bridge, 1200 V, 10 mΩ, M1
	Application Recommended PIM for Inverter Stage	
Rest Common Parts		
Isolated Gate Driver	NCD57080	Gate Driver, Isolated Single Channel IGBT/MOSFET Driver ±6.5 A
	NCP51105A	Gate Driver, Single 2.6 A High-Speed, Low-Side Gate Driver with OCP
	NCD57252	Gate Driver, Isolated Dual Channel IGBT Gate Driver
	NCD57000	Gate Driver, Isolated Single Channel IGBT Gare Driver 4 A / 6 A
	NCP51561	Gate Driver, Isolated Dual Channel Gate Driver for SiC, 4.5 A / 9 A
	Application Recommended Gate Driver	
Power Management	FSL336LR	650 V Integrated Power Switch with Error Amp and no bias winding
	NCP11184	800 V Switcher, Enhanced Standby Mode 2.25 Ω
	NCP1076	700 V Integrated Power Switch, 4.8 Ω
	Application Recommended Offline Regulator	
	NCP718	LDO Regulator, 300 mA, Wide Vin, Ultra-Low Iq
	NCP730	LDO Regulator, 150 mA, 38 V, 1 uA IQ, with PG
	NCP731	LDO Regulator, 150 mA, 38 V, 8 μVrms with Enable and external Soft Start.
	NCP164	LDO Regulator, 300 mA, Ultra-Low Noise, High PSRR with Power Good
	Application Recommended LDO	

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Recommended Products

Suggested Block	Part Number	Description
Power Management	NCP1251	PWM Controller, Current Mode for Offline Power Suppliers
	NCP1342	Quasi-Resonant Flyback Controller with Valley Lock-out Switching
	NCP1680	Totem-Pole PFC Controller, CrM
	NCP1568	AC-DC Active Clamp Flyback PWM Controller
	NCP13992	Current Mode Resonant Controller
	Application Recommended Offline Controller	
	NUP2105	27 V ESD Protection Diode - Dual Line CAN Bus Protector
	NUP3105L	32 V Dual Line CAN Bus Protector in SOT-23
	ESDM2032MX	3.3 V Bidirectional ESD and Surge Protection Diode
	ESDM3032MX	3.3 V Bidirectional Micro–Packaged ESD Protection Diode
	Application Recommended Protection ESD Diode	
	NCID9 series	High Speed Dual/3ch/Quad Digital Isolator
	NIS3071	Electronic fuse (eFuse) 4-channel, 8V to 60V, 10A in 5x6mm package
	MM5Z series	500 mW Tight Tolerance Zener Diode Voltage Regulator
	Application Recommended Zener Diode & others	
Signal Cond. & Control	NCS21 series	Current Sense Amplifier, 26V, Low-/High-Side Voltage Out
	NCS2007 series	Operational Amplifier, Wide Supply Range, 3MHz CMOS
	Application Recommended Amplifier	
	LM393	Comparator, Dual, Low Offset Voltage
	NCS2202	Comparator, Low Voltage, Open Drain
	Application Recommended Comparator	
	NCD98010	12-Bit Low Power SAR ADC Unsigned Output
	NCD98011	12-Bit Low Power SAR ADC Signed Output
	Application Recommended ADC	
Logic & Memory	CAT24M01	EEPROM Serial 1 MB I2C
	CAT24C64	EEPROM Serial 64 kb I2C
	Application Recommended EEPROM	
	MC74AC00	Quad 2-Input NAND Gate
	74LCX08	Low Voltage Quad 2-input AND Gate with 5 V Tolerant Inputs
	Application Recommended Logic Gate	
Interface	NCN26010	Ethernet Controller,10 Mb/s,Single-Pair, MAC+PHY, 802.3cg, 10BASE–T1S
	NCV7340	CAN Transceiver, High Speed, Low Power
	Application Recommended Interface Components	

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Technical Documents

Type	Description & Link
Application Note	AND90082 - Performance Comparison of 1200 V SiC MOSFET and Si IGBT Used in Power Integrated Module for 1100 V Solar Boost Stage
Application Note	AND90204 – onsemi EliteSiC Gen2 1200V SiC MOSFET M3S Series
Whitepaper	TND6396 – Silicon Carbide – From Challenging Material to Robust Reliability
Whitepaper	TND6260 - Physically Based, Scalable SPICE Modeling Methodologies for Modern Power Electronic Devices
Application Note	AN1040 – Mounting Considerations for Power Semiconductors
Application Note	AND90103 – onsemi M1 1200V SiC MOSFETs & Modules: Characteristics and Driving Recommendations
Application Note	AND9949 – NCD(V)57000/1 Gate Driver Design Note
Whitepaper	TND6237 – SiC MOSFETs: Gate Drive Optimization
Application Note	AND90190 – Practical Design Guidelines on the Usage of an Isolated Gate Driver
Application Note	AND9674 – Design and Application Guide of Bootstrap Circuit for High-Voltage Gate-Drive IC
Application Note	AND90004 – Analysis of Power Dissipation and Thermal Considerations for High Voltage Gate Drivers
Application Note	AND90061 – Half-Bridge LLC Resonant Converter Design Using NCP4390/NCV4390
Application Note	AND9925 – FAN9672/3 Tips and Tricks
Application Note	AND8273 – Design of a 100W ACF DC-DC Converter for Telecom System Using NCP1262
Application Note	AND9750 – Current Sense Amplifiers, FAQ
Whitepaper	TND6386 – Topologies for Commercial String Solar Inverter
Application Note	TND6392 – Optimizing Residential Solar Energy System for Efficiency, Reliability and Cost

Technical Documents

Type	Description & Link
Whitepaper	TND6395 – SiC Simulations
Application Note	AND90216 - Technical Advantages of onsemi's New Elite Power Simulator and Self-Service PLECS Model Generator
Video	Video - 1500V 225kW Solar Inverter Demo
Video	Video – Digital Isolator: Technology and Product Showcase
Video	Video – SiC Solutions for Energy Infrastructure Market
Video	Video – ACDC Power Supply Solutions
Video	Video – Introducing New – Q0&Q2 series of Power Modules
Ref Design (Evaluation Board)	25kW DC EV Charger (For Reference Only)
Ref Design (Evaluation Board)	15 W SiC High-Voltage Auxiliary Power Supply for HEV & BEV Applications
Ref Design (Evaluation Board)	40 W SiC high-voltage auxiliary power supply for HEV & BEV applications
Whitepaper	3kW Totem-Pole PFC and Secondary-Side Regulated LLC Power Supply Using SiC MOSFETs - 3KW-TPLLC-GEVB
Ref Design (Evaluation Board)	6-18 Vdc Input Isolated SiC Gate Driver Supply +20V/-5V/5V with Automotive Qualified NCV3064 Controller Evaluation Board
Ref Design (Evaluation Board)	6-18 Vdc Input Isolated IGBT Gate Driver Supply +15V/-7.5V/7.5V with Automotive Qualified NCV3064 Controller

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