

DC EV Charger

Updated: DEC-2023

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|-------------|--|
| Industry | Energy Infrastructure – DC EV Charger |
| Application | <p>The boom in the EV market has spurred the development of various industries, with EV charger undoubtedly being one of the most incentivized applications. To meet the growing needs of EV, more and faster charging infrastructures need to be established. Simultaneously, as a crucial means to achieve low-carbon goals, EV charging devices need to be designed efficiently.</p> <p>The trend towards higher power and greater efficiency in charging modules is expected. By adopting suitable power components and topologies, along with robust controllers, we will have more high-power charging stations, addressing range anxiety and reducing carbon emissions.</p> |

System Purpose

Growing the adoption of EV brings benefits to both consumers and society. Many countries have implemented tax breaks, reducing total cost of ownership for EV buyers. Meanwhile, highly electronic systems bring about more advanced vehicles which improves user experiences. In terms of environment and society, EV eliminates carbon emission, helping countries and enterprises achieve decarbonization targets. It also offers the opportunity to escape from the dependence on fossil fuels.

Refueling typically takes 5 minutes to cover hundreds of kilometers, so as an alternative to traditional fuel vehicles, minimizing charging time with the capability to achieve a similar range is always targeted. The mainstream EV charging solution is utilizing higher charging voltage. In comparison to AC charging with soft voltage limitations, DC fast charging can operate at 800 V, resulting in higher charging power, smaller current, reduced heat generation and losses.

There are two common types of DC charger. The one in larger size is three-phase fast charger used in commercial fast-charging stations, with a maximum output power of up to 600 kW per unit. A smaller type is the alternative to an AC charger, usually called a DC Wallbox, supporting single/three-phase AC input. It has a smaller output power for home use, such as 25 kW.



Market Information & Trends

Growing EV charger market

According to [Global EV Outlook 2023 by IEA](#), about 14M sets of electrical vehicles are estimated to be sold globally in 2023, marking 35% increase compared to 2022. To support the growing vehicle population, in 2022, there were more than 2.7M sets of public charging points installed worldwide, with prediction of 12.5M in 2030.

DC EV Charger

Market Information & Trends

Higher charging voltage and power

The first production EV with a system voltage of 800 V was released years ago when the other types had rated voltage between 300 V-500 V in their electrical systems. The 800 V platform signifies higher charging voltage, resulting in lower charging current, thinner wiring, lower power consumption, and a series of other advantages under the same power conditions. It also enables the possibility of higher charging power. Today, there are over 20 models globally launched or soon to be launched with 800 V system and charging stations providing charging power of over 350 kW are widespread in fast-charging stations.

Higher power density

High-power charger typically integrates multiple charging modules. In addition, a DC EV charger is essentially a cabinet that contains relays, meters, circuit breakers, auxiliary power supplies, fans, and various other components. While DC EV charger generally doesn't necessitate compact design, the presence of charging modules with higher power density allows for the incorporation of more modules within a single cabinet. This expansion within limited space enhances output capacity and concurrently provides extra space to address heat dissipation challenges.

Silicon Carbide devices in DC EV charger

Silicon carbide components have gradually been incorporated into high-performance DC EV chargers due to their evident advantages, such as lower $R_{DS(ON)}$, high-frequency switching characteristics, high voltage and temperature endurance. Rather than utilizing parallel configurations to handle higher currents, using power modules can effectively enhance power density, improve system reliability and avoid issues caused by parasitic effects.

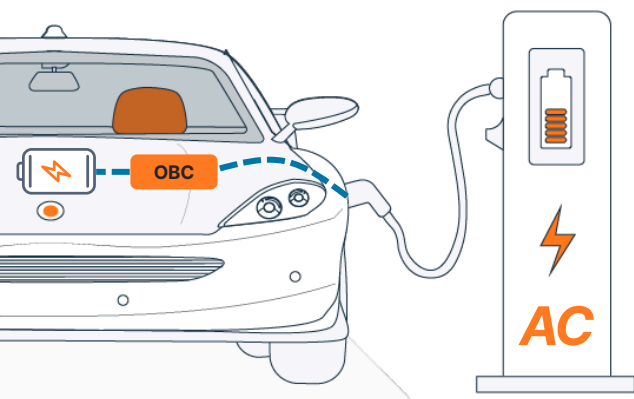
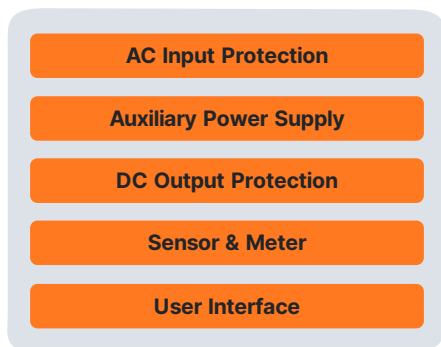
New ecosystem with ESS and solar inverter system

The expansion of DC charging stations poses challenges to the local power grid. Potential issues include the impact on the grid when a large number of charging devices operate simultaneously, harmonic pollution to the grid caused by low power factor equipment or equipment in a no-load state, and limitations imposed by the capacity of local electrical transformers. Connecting solar inverter systems and energy storage systems becomes essential. PV inverters can share a portion of the electrical load with the grid, while energy storage system, which is more crucial, can reduce the impact on the grid, realize energy arbitrage, and decrease user costs.

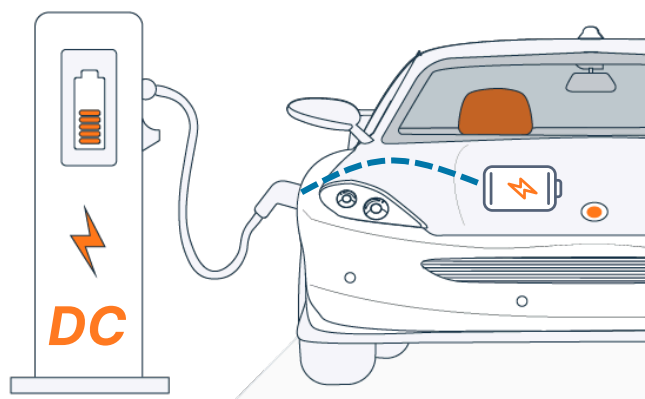
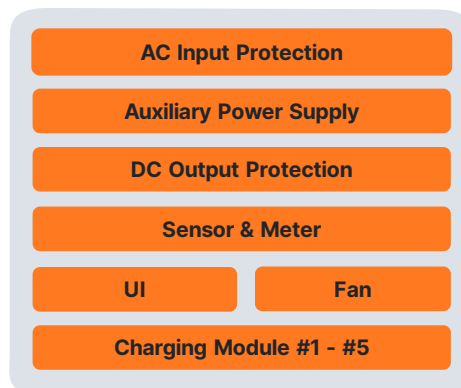


System Implementation

On Board Charger (AC Charger)



DC EV Charger (DC Charger)



System Description

Power conversion stages

The DC EV charger consists of a classic power conversion stage of AC-DC and DC-DC. The front end of the DC charger consists of a three-phase Power Factor Correction (PFC) boost stage, it could be implemented in a variety of topologies (two or three level) and uni- or bi-directional. See [AND90142 - Demystifying Three-Phase Power Factor Correction Topologies](#) to understand three level and example three level PFC circuit. The voltage level from the grid 400 V - 480 V (Three-phase) / 110 V - 240 V (Single-phase) is boosted up to 500 - 1000 V (and targeting higher). A subsequent DC-DC isolated stage converts the bus voltage into the required output voltage. The output voltage aligns with EV battery voltages (typically 400V or 800V) and need to cover the voltage charging profiles. Therefore, the DC-DC output range might swing from 150V up to 1000V. Specific implementations might be optimized for the 400 V or 800 V level.

The overall system efficiency of a DC EV charger is nowadays around 95%, main losses come from power conversion, cable, transformer. In a high-power system, even 1% losses generate massive heat, so improving efficiency is always a target for charger designers.

DC EV Charger

System Description

DC wallbox (charger)

DC wallbox (charger) is considered a replacement for traditional low-power AC chargers installed in places like parking lots, houses, offices, etc. It must be compact, lightweight and cost-effective. The key value of DC wallbox is that it defines the charging power rather than relying on an OBC. (AC charger is a simple system containing electricity meter and communication interfaces, without a high-power conversion stage.) With adoption of DC wallboxes, some manufacturers consider removing the OBC from their future EVs to decrease vehicle cost. However, this would also bring inconveniences as AC chargers can not be used.

Communication

Communication and connectivity are cornerstones of EV Chargers, fulfilling different functions: between stacked modules on the power stage, CAN, PLC, RS485, which depends on charger OEMs. Between vehicle and charger for the charging sequence. CAN or PLC are usually used. External connectivity for payment, service management, maintenance, software upgrades, preferred communication methods are BLE, Wi-Fi, 4G/5G.

Compliance and standard

There are several standards and protocols worldwide that define the requirements for DC charging, such as the IEC-61851 / SAE1772, GB/T, standards and the CHAdeMO, Combined Charging System (CCS) or Tesla Supercharger protocols. IEC 61000-3-2/4 defines the limitations of harmonics in power.

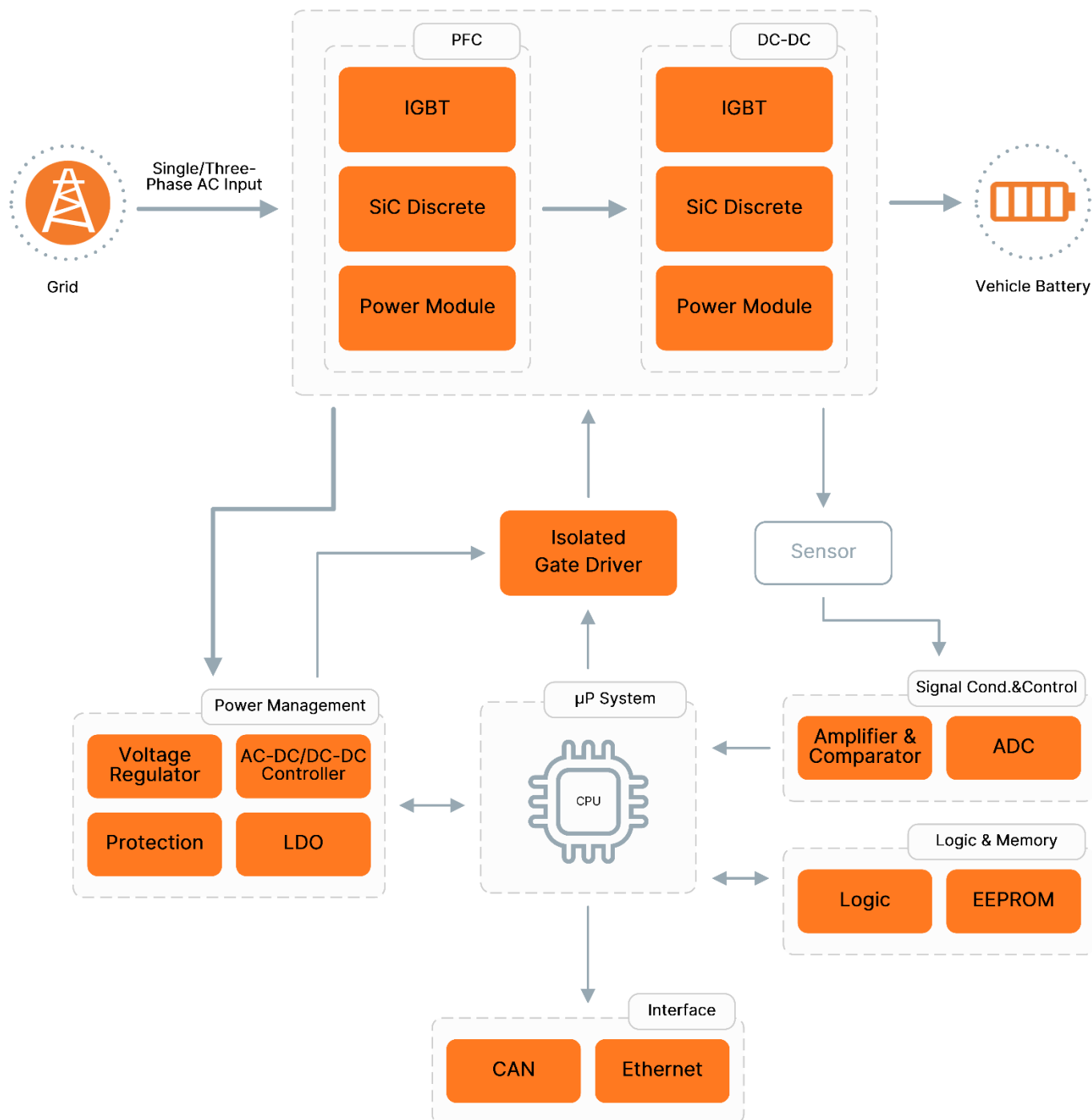
Discrete vs Power module

There are lots of aspects which influence 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 improve aspects 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.

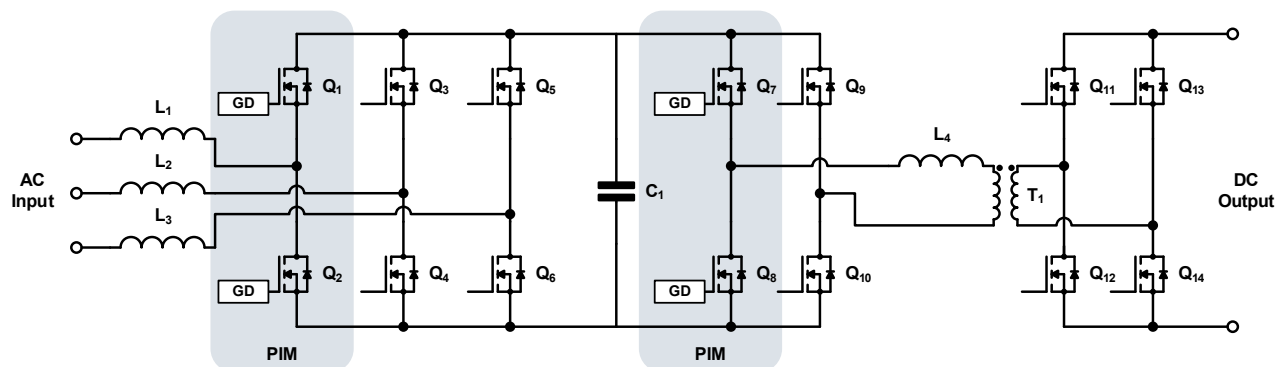


Solution Overview

System Block Diagram – DC EV Charger



Solution Overview



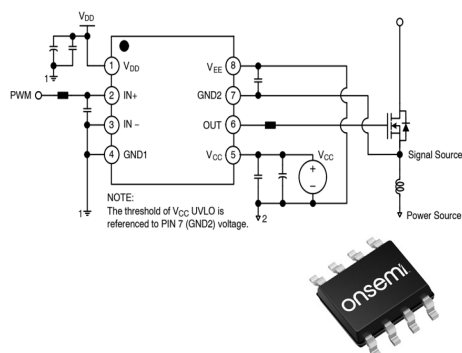
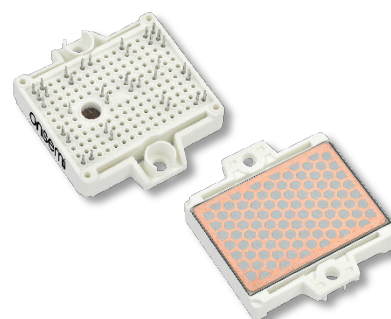
This is a common two-level EV charging circuit, consisting of a three-phase half-bridge stage and the second DAB (Dual Active Bridge) stage. This system has a simple structure, good operating efficiency and easy control. It runs phase-shift modulation and achieves ZVS at high loads, while maximizing efficiency across the broad charging voltage which ranges from 200 V to 1000 V. In the design of [25 kW DC EV charger](#), 7 × half bridge power modules are used.

onsemi's full SiC half-bridge PIM is a good fit in the design of DC EV charger, providing easy-to-mount packages and specifications, with excellent thermal resistance and parasitic inductance, realizing the system higher operating efficiency and power density.

EliteSiC, Full SiC Power Integrated Module, M3S

[NXH004P120M3F2](#), Half Bridge, 1200 V, 4 mΩ

- New 3rd generation SiC die inside
- Excellent FOM = [$R_{DS(ON)} \times E_{OSS}$]
- Low thermal resistance with HPS DBC
- Pre-applied thermal interface material

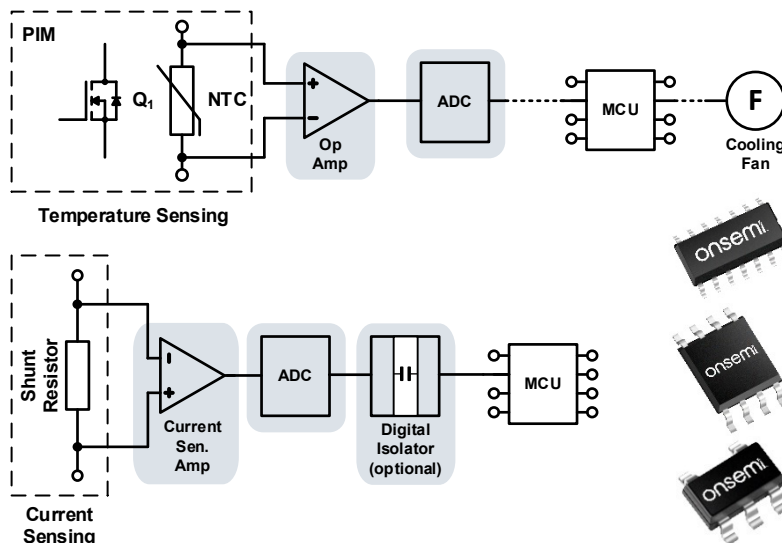


Converters consist of bridges that use wide band-gap components and have the risks of self turn-on on the low-side MOSFET. The major culprits include the miller capacitance, gate resistance and high dv/dt. One of the solutions is using gate drivers providing negative gate voltage.

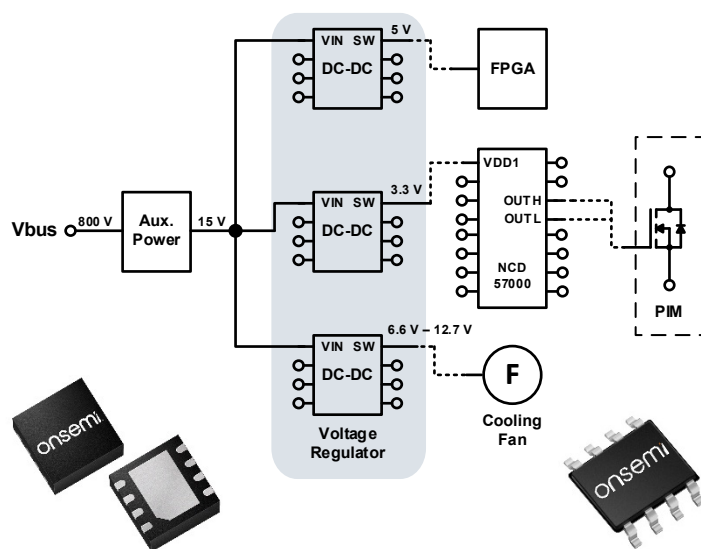
[NCP51752](#) is a single channel isolated gate driver, with 4.5 A/9 A source and sink peak current respectively. It offers short and matched propagation delays for fast switching applications. The most important feature of [NCP51752](#) is the innovative embedded negative bias rail mechanism (-2/-3/-4/-5 V).

Solution Overview

While operating at high power, it's crucial to monitor the states of power modules and other critical components, particularly their temperatures. **onsemi's** EliteSiC full SiC PIM integrates an NTC, enabling real-time observation and swift reactions to switch operating modes or activate cooling devices. Simultaneously, to prevent damage from short circuits and high currents, it's essential to place the current measuring circuit at the bridges. Such solution is cost-effective and offers better flexibility compared to DESAT protection in gate drivers.



onsemi offers various [products for signal conditioning and control](#). The [NCS2007x series](#) operational amplifiers provide rail to rail output operation, 3 MHz bandwidth, and are available in single, dual, and quad configurations. Its availability of various compact packages and broad range of supply voltages ranging from 2.7V to 36 V, make it ideal for different applications. To realize a high-accuracy current monitoring, [NCS21x](#) is recommended for its low supply voltage and low offset of the zero-drift architecture which enables current sensing across the shunt resistor with max. voltage drop as low as 10mV full-scale.



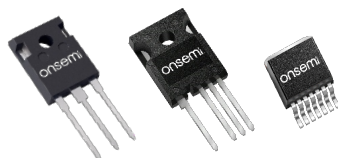
In the design of auxiliary power for [25 kW DC EV charger](#), [NCV890100](#) is used to power some of the low-voltage components. [NCV890100](#) is a fix-frequency, monolithic, buck switching regulator. It's suitable for systems with low noise and small form factor requirements. [NCV890100](#) is capable of converting the typical 4.5 V to 18 V input voltage range to outputs as low as 3.3 V at a constant switching frequency above the AM band, eliminating the need for costly filters and EMI countermeasures.

[NCP3064](#) is another DC-DC regulator, designed for step-up and step-down applications with minimized number of external components. Both have the integrated thermal shutdown protection (TSD).

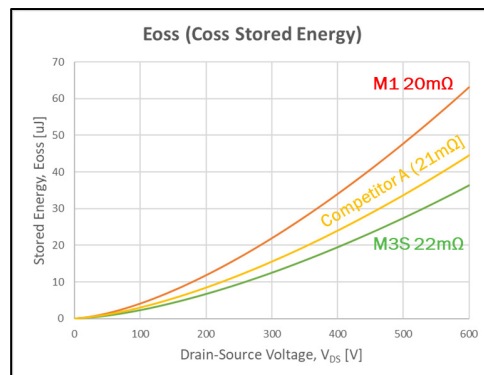
Solution Overview

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
- $R_{DS(ON)} = 22 \text{ m}\Omega$ @ $V_{GS} = 18 \text{ V}^*$
- Ultra low gate charge ($Q_{G(TOT)} = 137 \text{ nC}^*$)
- High speed switching with low cap. ($C_{OSS} = 146 \text{ pF}^*$)
- Kelvin Source*



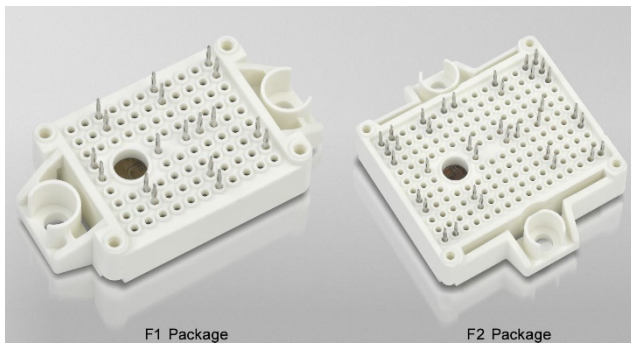
Learn more about M3 family - [AND90204 - onsemi EliteSiC Gen 2 1200 V SiC MOSFET M3S Series](#)



| | E_{OSS} [uJ] at 0-600V | FOM ($R_{ds(on)}^*$ E_{oss}) [Ω^*uJ] |
|-------------------|-----------------------------|--|
| 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



EliteSiC, Full SiC PIM, 900 V/1200 V

- Available configurations: Vienna, Half Bridge, Full Bridge
- 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

*Key characteristics of [NTH4L022N120M3S](#).

DC EV Charger

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 switch input and output capacitances. Higher sink and source current capability means quicker turn-on and turn-off of the switch, and eventually, smaller switching losses.

Fault detection. A gate driver is not only used to drive the switch but also protect the switch 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 a false turn on (especially in a quick switching system). Read [AND9949 – NCD\(V\)57000/57001 Gate Driver Design Note](#) to learn about 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.

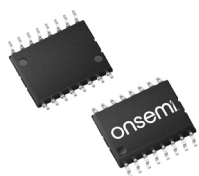
Compatibility. A pin-to-pin replacement is always preferred in a new project if there's no significant design change. Choosing a gate driver with similar specifications and package benefits a quick design.

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

Isolated Gate Driver for SiC

- 4.5 A/9 A source/sink peak current
- 36 ns propagation delay with 8 ns max delay matching
- 5 kV galvanic isolation, $\text{CMTI} \geq 200$ V/ns
- Dual channel
- SOIC-16WB with 8mm creepage distance



NCD57080

Isolated High Current Gate Driver

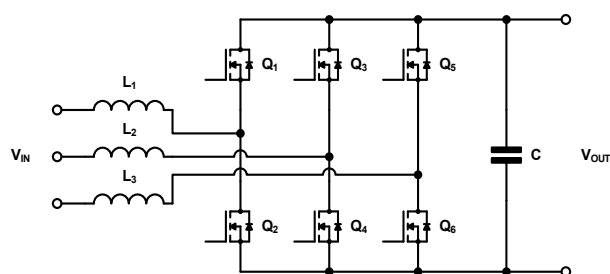
- High current peak output (6.5 A/6.5 A)
- UVLO, Active Miller Clamp
- 3.5 kV galvanic isolation, $\text{CMTI} \geq 100$ V/ns
- Typical 60 ns propagation delay
- Single channel
- SOIC-8WB with 8 mm creepage distance



DC EV Charger

Solution Overview

Common Topologies in AC-DC PFC



Active Front End

- No conduction losses caused by bridges
- Simple circuit, easy control, few components
- Switches need to endure full bus voltage and spikes
- WBG is preferred to reduce THD, inductor size
- Allowed for bidirectional conversion

Vienna Rectifier & T-NPC

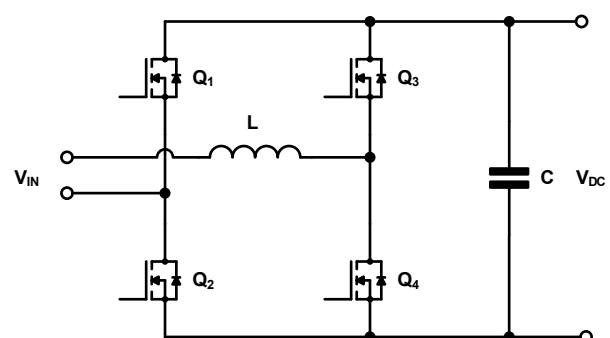
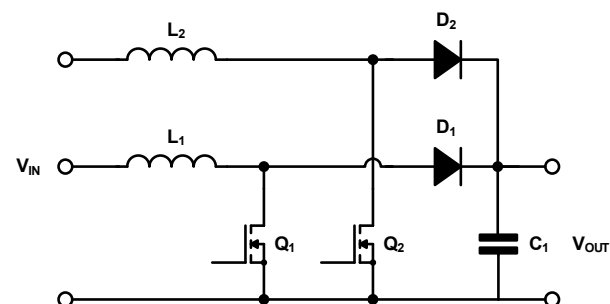
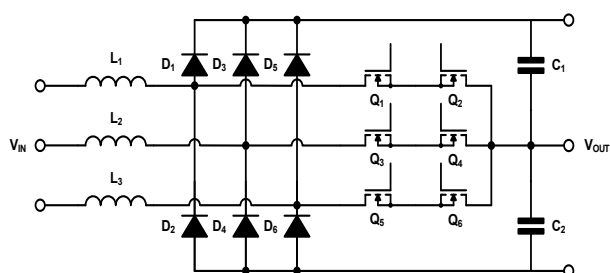
- Reduced THD and voltage stress on switches as a three-level configuration
- Easy control, only 1 driving signal is required to drive back-to-back switches per phase
- Halved bus voltage is applied to switches
- Unavoidable conduction losses caused by bridge
- Could be bidirectional with full-switch replacement

Interleaved Boost, Single-Phase

- Reduced inductor size, current stress, EMI
- Easy control, simple circuit, doubled/tripled components
- Easy approach to improve output power
- Unavoidable conduction losses caused by bridge
- Unidirectional operating only

Totem Pole PFC, Single-Phase

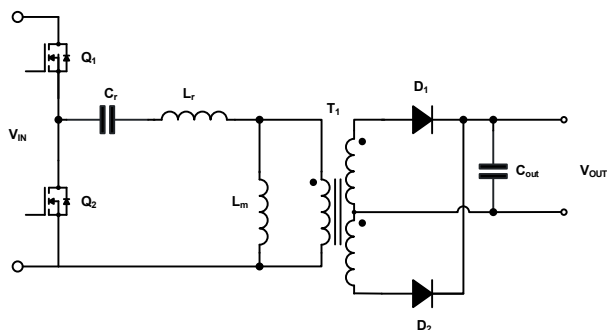
- Improved efficiency, EMI, THD, and reduced quantity of switches which are conducted per cycle
- High power density due to low quantity of switches
- Wide bandgap components are required to reduce recovery losses
- Zero crossing point noise, common mode noise
- Allowed for bidirectional conversion



DC EV Charger

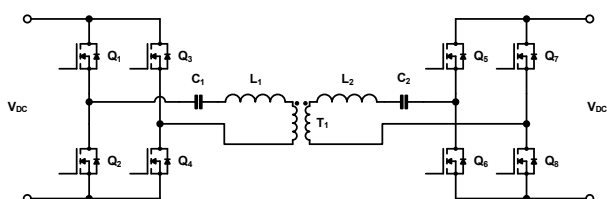
Solution Overview

Common Topologies in DC-DC Conversion



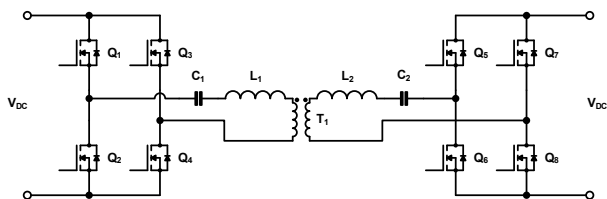
LLC Resonant Converter

- Frequency modulation, resonant converter achieves soft switching to improve efficiency
- ZVS at primary side, ZCS at secondary side
- Integrated inductor to save space
- Complicated resonant tank design and control
- Good EMI and output ripple
- Need extra DC-DC conversion to reach wide output range to ensure good efficiency
- WBG is preferred in such high-frequency/high voltage operation.
- Unidirectional operation only



Dual Active Bridge Converter

- Run phase-shift modulation To realize ZVS at high loads
- Unexpected loss caused by mismatch of current in both stages
- Complicated design regarding phase shift, transformer, frequency, etc. to reach expected efficiency
- WBG is preferred in such high-frequency/high voltage operation
- Reduced output current ripple to reduce size of output capacitor, preferred in high-power cases
- Bidirectional operation



CLLC Resonant Converter

- One additional capacitor added to realize bidirectional conversion based on LLC
- Complicated frequency modulation and passives selection to reach high efficiency in both directions.
- Need extra DC-DC conversion to reach wide output range to ensure good efficiency
- Better efficiency than DAB during entire load range

DC EV Charger

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Recommended Products

| Suggested Block | Part Number | Description |
|--|---------------------------------------|--|
| Single-Phase DC EV Charger (DC Wallbox) – Power Conversion Stage | | |
| PFC & DC-DC | 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 | |

DC EV Charger

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Recommended Products

| Suggested Block | Part Number | Description |
|--|---------------------------------------|--|
| Three-Phase DC EV Charger - Power Conversion Stage | | |
| PFC & DC-DC | NTH4L028N170M1 | Silicon Carbide (SiC) MOSFET -EliteSiC, 28 mΩ, 1700 V, M1, TO-247-4L |
| | NTH4L014N120M3P | Silicon Carbide (SiC) MOSFET - EliteSiC, 14 mΩ, 1200 V, M3P, TO-247-4L |
| | NTHL022N120M3S | Silicon Carbide (SiC) MOSFET - EliteSiC, 22 mΩ, 1200 V, M3S, TO-247-3L |
| | NTH4L040N120M3S | Silicon Carbide (SiC) MOSFET - EliteSiC, 40 mΩ, 1200 V, M3S, TO-247-4L |
| | NTBG070N120M3S | Silicon Carbide (SiC) MOSFET - EliteSiC, 65 mΩ, 1200 V, 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, 35A, 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 60 A FS7 IGBT, Fast Switching, TO-247-3L |
| | FGY75T120SWD | 1200 V 75 A FS7 IGBT, Fast Switching, TO-247-3L |
| | FGY140T120SWD | 1200 V 140 A FS7 IGBT, Fast Switching, TO-247-3L |
| | 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 | |

DC EV Charger

Recommended Products

| Suggested Block | Part Number | Description |
|----------------------|---|---|
| PFC & DC-DC | NXH006P120MNF2 | Full SiC PIM, EliteSiC, Half Bridge, 1200 V, 6 mΩ, M1 |
| | NXH010P120MNF1 | Full SiC PIM, EliteSiC, Half Bridge, 1200 V, 10 mΩ, M1 |
| | NXH004P120M3F2 | Full SiC PIM, EliteSiC, Half Bridge, 1200 V, 4 mΩ, M3S |
| | NXH003P120M3F2 | Full SiC PIM, EliteSiC, Half Bridge, 1200 V, 3 mΩ, M3S |
| | NXH020U90MNF2 | Full SiC PIM, EliteSiC, Vienna, 900 V 10 mΩ SiC MOSFET, 1200 V SiC Diode |
| | NXH008T120M3F2PTHG | Full SiC PIM, EliteSiC, T-NPC, 1200 V 8 mΩ SiC MOSFET, M3S |
| | NXH160T120L2Q1 | IGBT PIM, T-NPC, 1200 V, 160 A IGBT, 650 V, 100 A IGBT, Q1 |
| | NXH160T120L2Q2F2S1 | IGBT PIM, T-NPC, 1200 V, 160 A IGBT, 650 V, 100 A IGBT, Q2 |
| | Application Recommended PIM for PFC | |
| | NXH006P120MNF2 | Full SiC PIM, EliteSiC, Half Bridge, 1200 V, 6 mΩ, M1 |
| | NXH010P120MNF1 | Full SiC PIM, EliteSiC, Half Bridge, 1200 V, 10 mΩ, M1 |
| | NXH004P120M3F2 | Full SiC PIM, EliteSiC, Half Bridge, 1200 V, 4 mΩ, M3S |
| | NXH003P120M3F2 | Full SiC PIM, EliteSiC, Half Bridge, 1200 V, 3 mΩ, M3S |
| | NXH020F120MNF1 | Full SiC PIM, EliteSiC, Full Bridge, 1200 V, 20 mΩ, M1 |
| | NXH040F120MNF1 | Full SiC PIM, EliteSiC, Full Bridge, 1200 V, 40 mΩ, M1 |
| | Application Recommended PIM for DC-DC Stage | |
| | Rest Common Parts | |
| Isolated Gate Driver | NCD57080 | Gate Driver, Isolated Single Channel IGBT/MOSFET Driver ±6.5 A |
| | NCP51752 | Gate Driver, Isolated Single Channel Driver, 4.5 A/9 A, Neg. Bias Control |
| | NCD57252 | Gate Driver, Isolated Dual Channel IGBT Gate Driver |
| | NCD57000 | Gate Driver, Isolated Single Channel IGBT Gate 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 | 650V Integrated Power Switch with Error Amp and no bias winding |
| | NCP11184 | 800V Switcher, Enhanced Standby Mode 2.25 Ω |
| | NCP1076 | 700V Integrated Power Switch, 4.8 Ω |
| | Application Recommended Offline Regulator | |
| | NCP189 | LDO, 500 mA, Low noise, High PSRR, Low V _{DO} |
| | NCP718 | LDO Regulator, 300 mA, Wide Vin, Ultra-Low I _q |
| | NCP730 | LDO Regulator, 150 mA, 38 V, 1 uA I _q , with PG |
| | NCP731 | LDO Regulator, 150 mA, 38 V, 8 μV _{rms} with Enable and external Soft Start. |
| | NCP164 | LDO Regulator, 300 mA, Ultra-Low Noise, High PSRR with Power Good |
| | Application Recommended LDO | |

DC EV Charger

Recommended Products

| Suggested Block | Part Number | Description |
|------------------------|--|---|
| Power Management | NCP1251 | PWM Controller, Current Mode for Offline Power Suppliers |
| | NCP1362 | 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 ESD Protection Diode | |
| | NCID9 series | High Speed Dual/3ch/Quad Digital Isolator |
| | NIS3071 | Electronic fuse (eFuse) 4-channel, 8 V to 60 V, 10 A in 5x6mm package |
| | NCP3064 | Boost/Buck/Inverting Converter, Voltage Regulator, 1.5 A |
| | NTBG1000N170M1 | Silicon Carbide (SiC) MOSFET - EliteSiC, 960 mΩ, 1700 V, M1, D2PAK |
| | NTHL1000N170M1 | Silicon Carbide (SiC) MOSFET - EliteSiC, 960 mΩ, 1700 V, M1, TO-247-3L |
| | Application Recommended Zener Diode and others | |
| Signal Cond. & Control | NCS21 series | Current Sense Amplifier, 26 V, Low-/High-Side Voltage Out |
| | NCS2007 series | Operational Amplifier, Wide Supply Range, 3MHz CMOS |
| | LM393 | Comparator, Dual, Low Offset Voltage |
| | Application Recommended Amplifier & 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 |
| | 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 | |

DC EV Charger

Technical Documents

| Type | Description & Link |
|------------------|--|
| 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 |
| Whitepaper | TND6330 - Using Physical and Scalable Simulation Models to Evaluate Parameters and Application Results |
| 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 | TND6401 – Developing a 25 kW SiC-Based DC Fast Charger (DCFC) – Part 1 |
| Whitepaper | TND6402 – Developing a 25 kW SiC-Based DC Fast Charger (DCFC) – Part 2 (OPN Required) |
| Whitepaper | TND6403 – Developing a 25 kW SiC-Based DC Fast Charger (DCFC) – Part 3 (OPN Required) |
| Whitepaper | TND6404 – Developing a 25 kW SiC-Based DC Fast Charger (DCFC) – Part 4 (OPN Required) |

DC EV Charger

Technical Documents

| Type | Description & Link |
|------------|---|
| Whitepaper | TND6405 – Developing a 25 kW SiC-Based DC Fast Charger (DCFC) – Part 5 (OPN Required) |
| Whitepaper | TND6406 – Developing a 25 kW SiC-Based DC Fast Charger (DCFC) – Part 6 (OPN Required) |
| Whitepaper | TND6407 – Developing a 25 kW SiC-Based DC Fast Charger (DCFC) – Part 7 (OPN Required) |
| Whitepaper | TND6408 – Developing a 25 kW SiC-Based DC Fast Charger (DCFC) – Part 8 (OPN Required) |
| Whitepaper | TND6397 – Lessons Learnt: Developing a 25 kW Fast EV Charging Module (OPN Required) |
| Video | Designing Silicon Carbide (SiC) based DC Fast Charging System Session 1: 6-Pack Boost Active Front End (AFE) Design |
| Video | Designing Silicon Carbide (SiC) based DC Fast Charging System Session 2: Dual Active Bridge DC-DC Design |
| Video | Designing Silicon Carbide (SiC) based DC Fast Charging System Session 3: Gate Drivers, Auxiliary Supply, and Thermal Management |
| Video | Designing Silicon Carbide (SiC) based DC Fast Charging System Session 4: Measurement Results |
| Video | Bidirectional 25kW SiC-based DC Fast Charger Reference Design |
| Video | 25kW SiC Module Fast DC EV Charger Power Stage |
| Video | Introducing New Next-Generation 1200 V EliteSiC Half Bridge Power Integrated Modules (PIMs) M3S Technology |
| Video | Video – Understanding Single Pulse Avalanche Rating in Silicon Carbide MOSFETs |

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