Power system topology selection

Selection guide

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Why topology selection matters

Topology selection is a critical aspect of power system design, as it directly impacts the efficiency, reliability, and cost-effectiveness of the system. By choosing the right topology, designers can minimize power losses, improve fault tolerance, and reduce the risk of overheating. With a wide range of topologies available, selecting the optimal configuration requires careful consideration of the system's power requirements, efficiency targets, reliability needs, and cost constraints.
At Infineon, we understand the importance of topology selection and offer a range of power electronic devices and solutions that can help designers create efficient, reliable, and cost-effective power systems. Whether you're designing a power supply for a data center, a motor drive for an industrial application, or a power conversion system for a renewable energy installation, our expertise and products can help you select the right topology for your needs.

Topologies overview

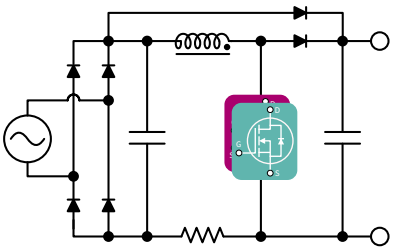
Application	AC/DC	DC/DC	DC/AC
Industrial SMPS	– Boost – Totem-pole – Vienna rectifier	– LLC HB – LC FB – ZSV PS FB	–
DC EV charging	– Vienna rectifier – B6 – ANPC	– FB LLC – DAB – CLLC	–
Solar	–	– CLLC – DAB – Buck – Buck-boost	– Heric – ANPC – Cyclo converter – Flyback FB – PS FB
Home appliances	**Please refer to industrial SMPS and lighting**	–	– B6
Robotics and drones	–	–	– B6
Lighting	- Boost - Flyback - Interleaved boost	- Buck - Hybrid flyback - LLC	–

Click on the applications or topologies for more details.

Industrial SMPS

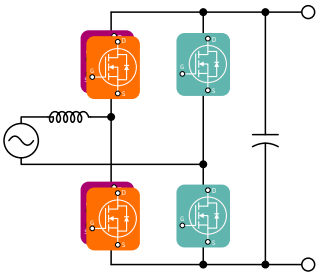
AC/DC (PFC)

CCM/CrCM boost



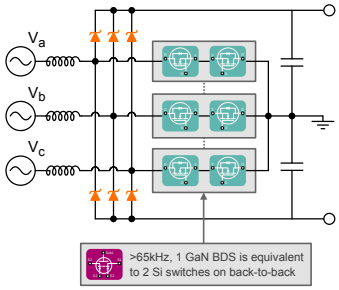
- Low active component count
- Power range: up to 3 kW for single-phase
- Power density < 20 W/in^3
- Efficiency up to 98%
- Parallelized for 3-phase input at power >7 kW, requiring a matching 3-phase input DC/DC, see DAB for DC EV charging
- Ease of use with analog controller
- Voltage class: 650 V – 800 V

CCM totem-pole



- High performance
- Power range: 1 kW – 7 kW
- Power density ~ 80 W/in^3
- Efficiency up to 99%
- SiC or GaN switches at the high frequency allow for a decrease in the size of the passives
- Voltage class: 600 V – 750 V

Vienna rectifier

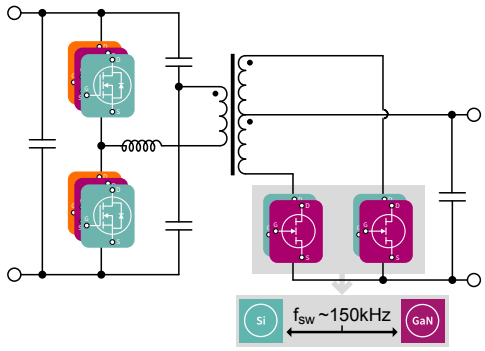


- Ease-of-use at high performance
- Power range: 7 kW - 25 kW
- Efficiency up to 97.5%
- 1 GaN bidirectional (BDS) switch can replace 2 Si switches, saving cost and layout area
- Modular approach with LLC for multi-phase in high-power classes
- Alternative: B6 topology could be considered, see DC EV charging

Si SiC GaN

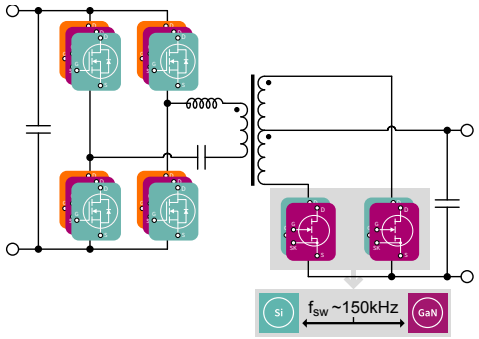
DC/DC

LLC HB



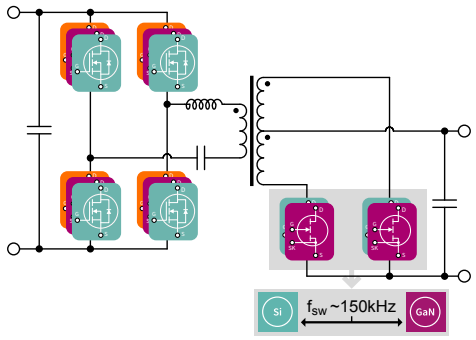
- Best for variable loads
- Soft switching (resonant)
- High efficiency and high power density
- Reduced layout area and easy control
- GaN for best efficiency and highest power density
- Voltage classes: 600 V – 700 V for LLC, 60 V – 100 V for SR

LLC FB



- Compared to LLC HB, FB allows to double the current capability on the primary side
- Reduced transformer size
- More even distribution of thermal losses
- Voltage classes: 600 V – 700 V for LLC, 60 V – 100 V for SR

ZVS PS FB



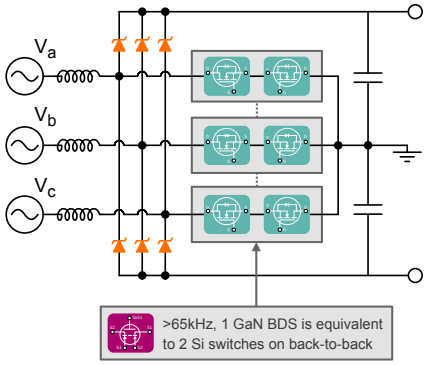
- Best for constant loads
- Soft switching (quasi-resonant)
- Ease-of-use at high efficiency
- GaN for best efficiency and highest power density
- Voltage classes: 600 V – 700 V for LLC, 40 V – 200 V for SR

Si SiC GaN

DC EV charging

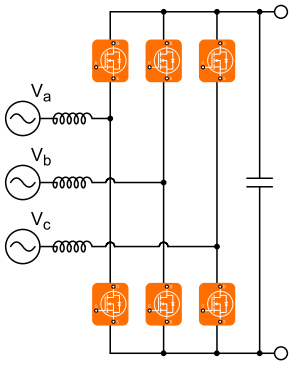
AC/DC (PFC)

Vienna rectifier (unidirectional)



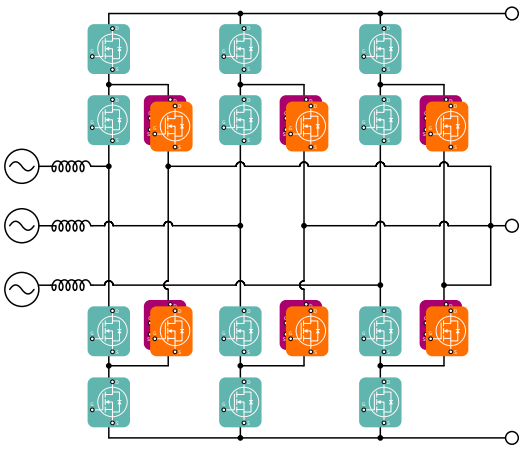
- Efficiency up to 97.5%
- Ease-of-use at high performance
- Modular approach with LLC for multi-phase in high-power classes

B6 (bidirectional)



- Efficiency up to 97.5%
- Simple and efficient at high power-density
- Lower BOM due to low component count
- Easy control and widely known

ANPC (bidirectional)

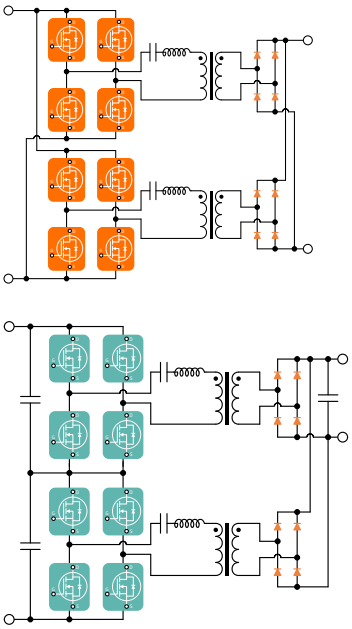


- Maximum efficiency with > 99%
- High power density and higher reliability due to lower $T_{junction}$
- Flexible for single- or three-phase input

Si SiC GaN

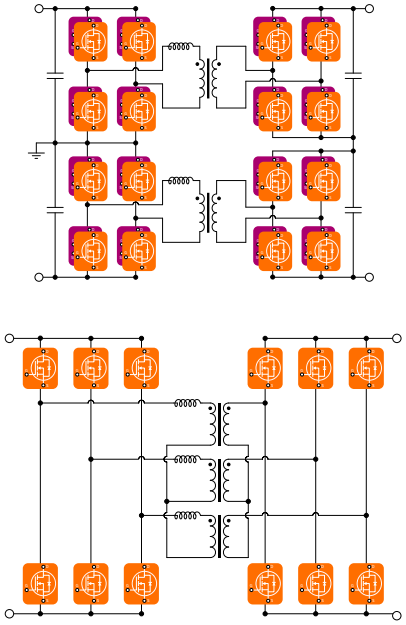
DC/DC

FB LLC (unidirectional)



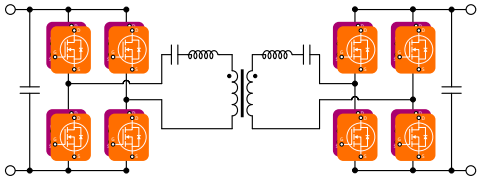
- Many variants of LLC
- Ease to achieve target efficiency and power density
- Ease to optimize the usage of power devices
- Wide output voltage due to the possibility to mix the control methods, PWM and frequency
- Achieve ZVS at any loading

DAB (bidirectional)



- Very flexible with high efficiency
- Wide output voltage to support multiple battery voltages
- Ease of control with fixed frequency PWM
- Low passive component count to achieve bidirectional power flow

CLLC (bidirectional)



- Peak efficiency due to achievable ZVS in the full voltage range
- High power density
- Compatible with SiC and GaN
- Low EMI noise due to resonant operation
- Reuse LLC design know-how

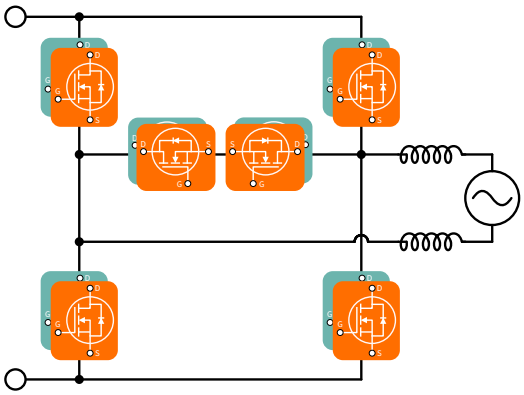
Si SiC GaN

Solar

String/hybrid inverters and energy storage

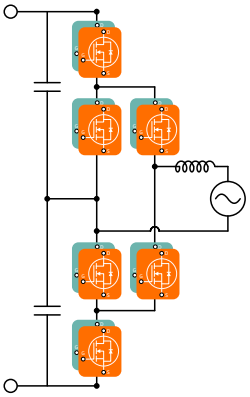
DC/AC

Heric



- Reduced EMI and common mode noise leakage
- Easy to scale power capability via multilevel approaches

ANPC



- Maximum efficiency > 99% at full-load
- High power density and higher reliability due to lower $T_{junction}$
- Flexible for single or three-phase output

Inverter stage and non-isolated DC/DC are lower frequency <50 kHz, conventionally with Si IGBTs.

Wide bandgap offers:

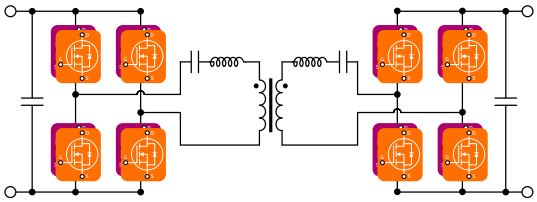
- Conduction losses are dominant
- SiC offers significant efficiency improvement vs. IGBTs
- SiC offers better $R_{DS}{}^{*}{}_{temp}$ coefficient vs. GaN
- SiC offers higher current capability vs. GaN

Si SiC GaN

DC/DC (battery charging)

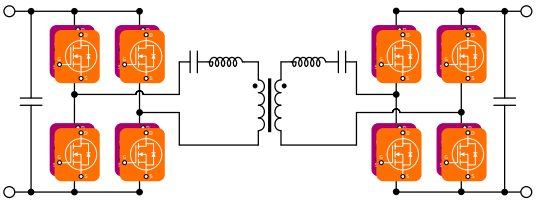
48-120 V_{DC}

CLLC



- Peak efficiency > 96%
- High power density
- Compatible with all power technologies.
- Simple and known

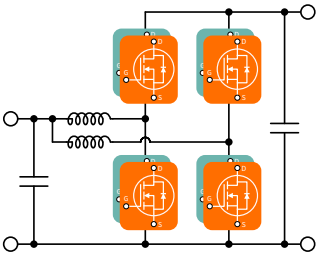
DAB



- Wide output voltage supports different battery chemistry.
- Modular approach and easy matching with inverter stage.

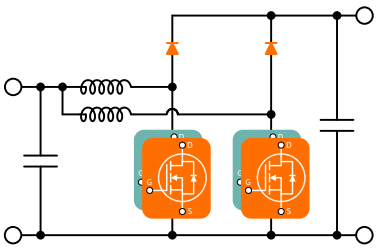
250-470 V_{DC}

Buck-boost



- Optimized cost vs performance
- Well-known and easy to control

PV boost MPPT



- Reduced component count

Isolated bi-directional DC/DC are ideal for battery charge and discharge.

Operating at a higher switching frequency ~100 kHz, wide bandgap offers:

- SiC has higher current capability for the 100% overload requirement for ESS
- GaN offers better efficiency at a higher frequency due to better FOM and no Q_{rr}
- Wide-bandgap products lead to smaller transformers and higher power density for size-constrained projects

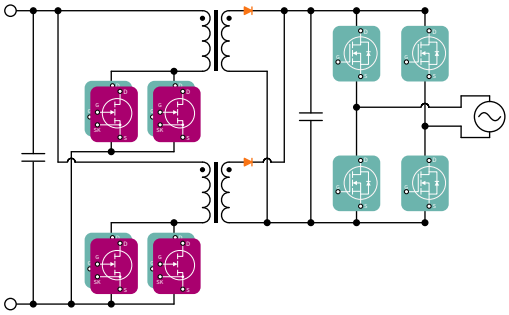
Si SiC GaN

Solar

Microinverters and optimizers

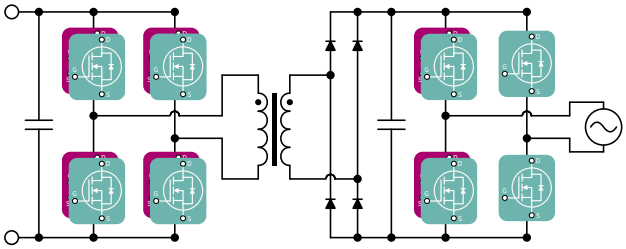
DC/AC microinverters

Flyback + unfolder



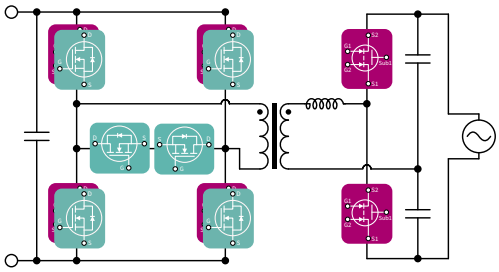
- Ease of use and simple control
- Energy stored on the low voltage side requires a larger input capacitor
- Limited or no reactive power capability

Phase shift full bridge + H4



- Maximum efficiency > 99% at full-load
- High power density and higher reliability due to lower $T_{junction}$
- Flexible for single or three-phase output

Cyclo converter

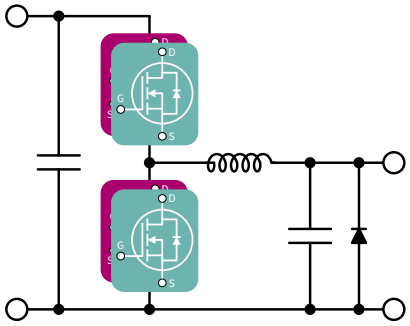


- Highest efficiency due to ZVS and ZCS operation
- High power density
- Reduced component count
- Reactive power capability
- 650 V GaN BDS on the secondary side allows to save footprint and cost

Si SiC GaN

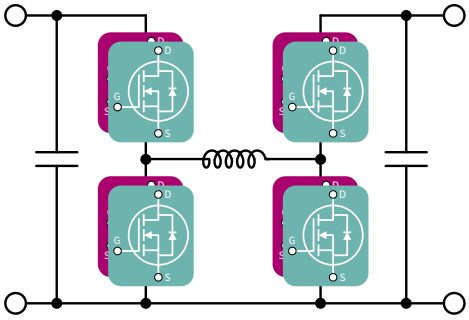
DC/DC power optimizers

Buck



- Effiency greater then 99%
- Higher power via paralleling of switches
- Low component count

Buck-boost



- Ensure a more stable string voltage than buck

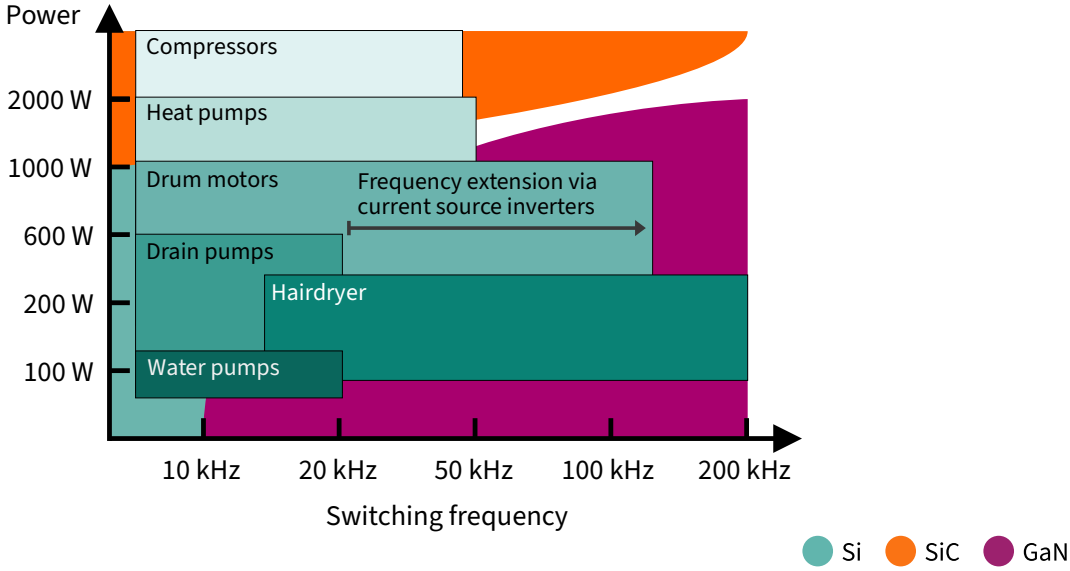
Optimize the overall power output of the photovoltaic (PV) panel(s) under different performance conditions, such as sun shading, to enable Maximum Power Point Tracking (MPPT).

It fulfills Rapid Shut Down (RSD) regulations at the PV panel level.

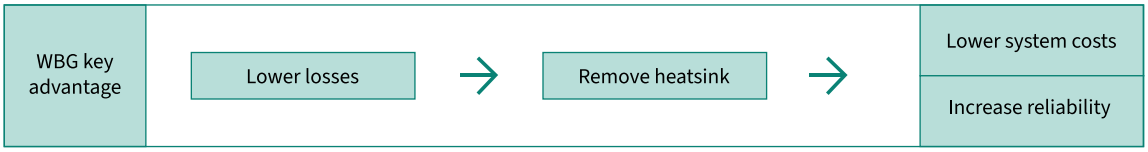
Si GaN

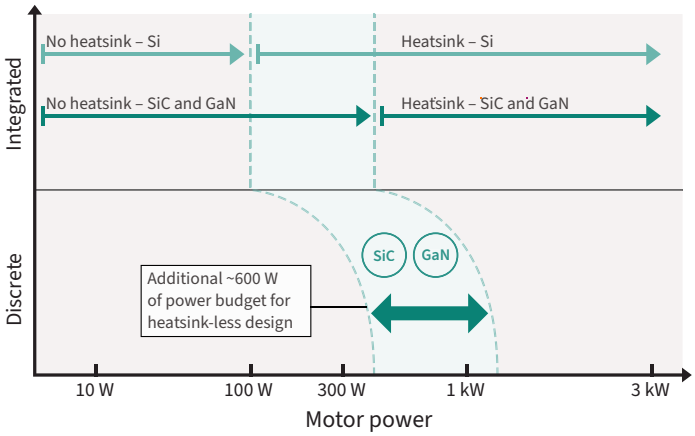
Home appliances (motor drives)

Motor control in home appliances is typically based on B6 inverters using IGBTs, in some cases Silicon MOSFETs. New levels of efficiency are required to meet the new standards on energy efficiency in virtually all markets worldwide. Energy labels are shown to the consumer and influence their purchase decisions.
To achieve the A-Class standard, wide-bandgap power semiconductors offer power savings in both the low and high-power classes. Further savings can be achieved with an optimized approach at the system level, such as integration of the inverter with the motor or simplified manufacturing via SMD packages.



It is possible to reduce the size of passive components, including the heatsink, in many cases. These improvements allow the inverter to simultaneously increase efficiency, reduce its overall dimensions, and maintain cost competitiveness with traditional designs.





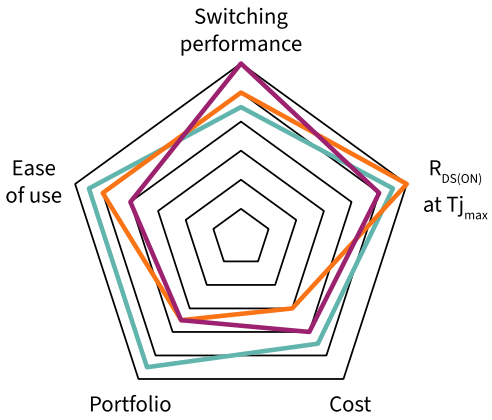
Benefits of heatsink-less designs

- No condensation on the heatsink increases reliability
- Smaller PCB footprint
- Lower system costs (BOM)
- Less assembly steps in production
- Lower manufacturing costs
- Possibility to increase power

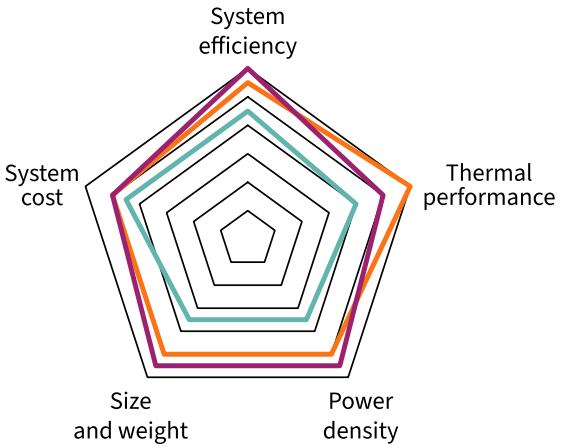
Robotics and drones (motor drives)

Motor control for robotic and drone applications is typically based on B6 inverters Silicon MOSFETs.

Device level



System level



Si

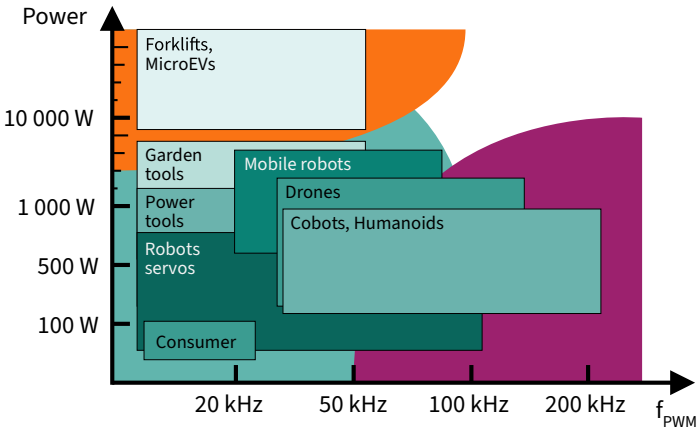
- Preferred for designs, no size restrictions or temperature concerns
- Best fit for **mainstream designs** in a wide range of applications

SiC

- Preferred for designs combing high-power and high-temperature operation
- Best fit for premium designs at high power such as forklifts and microEVs

GaN

- Preferred for high power density, size and weight requirements
- Best fit for **premium designs** in commercial drone, cobot and humanoid



Benefits of high switching frequency

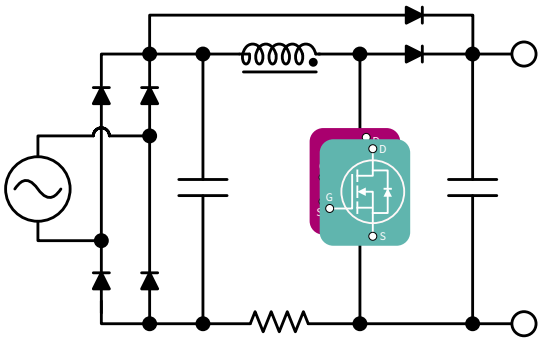
- Decrease inverter size and weight (capacitors)
- Increase battery life
- Low audible noise
- GaN further improves benefits
  - System efficiency (inverter and motor losses)
  - Lower operating temperature
  - Smooth and controllable dV/dt for low EMI
  - Integration of PCB with motor

Si SiC GaN

Lighting

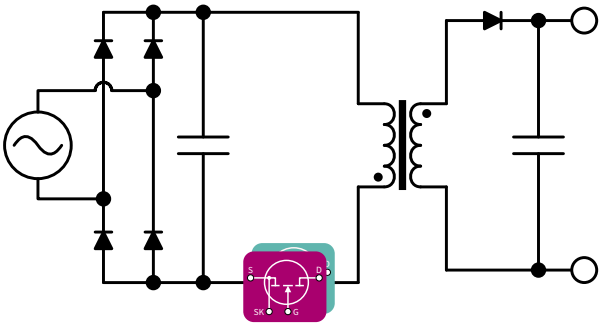
AC/DC (PFC)

Boost CCM



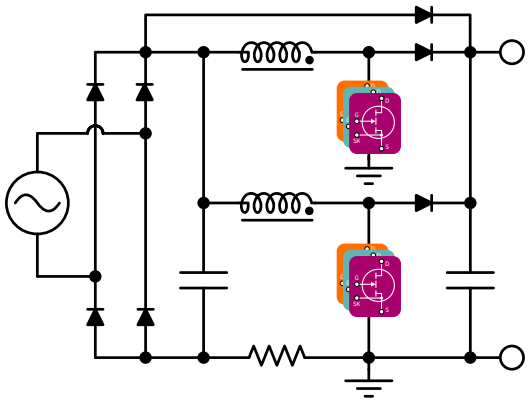
- Flexible output voltage
- Easy to access PFC inductors
- Simple control
- No isolation

Flyback



- Isolated
- Output voltage fixed by turn ratio at the transformer

Interleaved boost

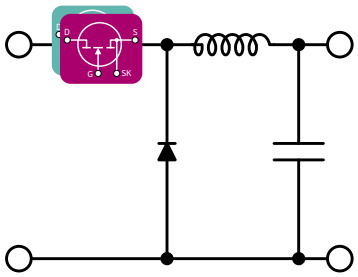


- Best for higher power
- Higher efficiency than simple boost PFC
- Reduced input current ripple

Si SiC GaN

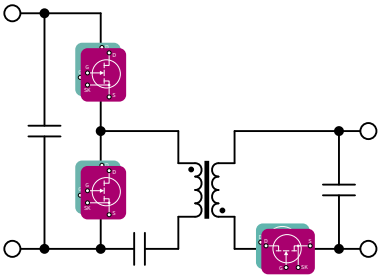
DC/DC

Buck



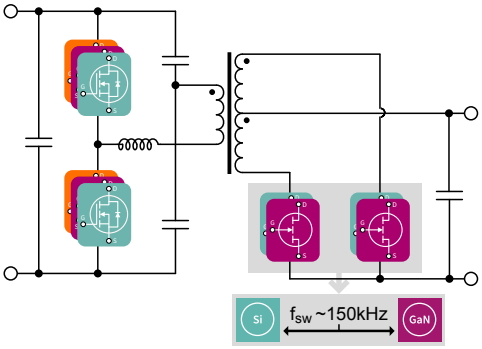
- Best for low power and cost optimized designs
- Simple control
- No galvanic isolation
- Low component count

Hybrid flyback



- Higher efficiency
- Higher power capability
- Simple control

LLC



- Best for variable loads
- Ease to achieve high efficiency and high power density
- Wide-range output voltage possible
- GaN on secondary for high power density
- Wide bandgap on the primary side for higher power and higher power density

Si SiC GaN

Support

Discover our broad offering of power switches based on silicon, silicon carbide, and gallium nitride.

Si	SiC	GaN
– Product families ranging from 15 V to 1.2 kV – Evaluation boards and reference designs for quick and easy prototyping – Simulation models	– Product families ranging from 400 V to 3.3 kV – Evaluation boards and reference designs for quick and easy prototyping – Simulation models	– Product families ranging from 40 V to 700 V – Evaluation boards and reference designs for quick and easy prototyping – Simulation models
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