Power GaN FETs

Performance, efficiency, reliability

nexperia

EFFICIENCY WINS.

Building on proven processes

From product concept and design to manufacturing and sales, getting the smallest details right helps the world's most demanding industries make quality and efficiency gains. Key to Nexperia's success has been a strong commitment to meet and even go beyond the stringent quality standards our customers demand, and this standard level also applies to our development of power GaN FETs.

Whether that is internationally recognized standards for quality (ISO 9000), the environment (ISO 14001), health and safety (ISO 45001 / OHSAS 18001) or industry specific (IATF 16949), all our customers benefit from products that are built on proven zero defect, six-sigma and safe-launch processes. Owning our own industrial front-end and assembly infrastructure ensures we can control every aspect, so you can expect the same level of service and response as you already experience across the Nexperia portfolio to be applied to our GaN FET offering.

Any new technology requires an increased level of confidence, this is why we also do application and technology specific quality and reliability testing within the development of all GaN FETs.

Automotive grade
As an established supplier into the automotive industry our rigorous attention to detail and commitment to automotive quality yields sub-part-per-million (sub-ppm) failure rates across our existing portfolio of Discretes, MOSFETs and Analog & Logic ICs. We extend our AEC-Q101 qualification into our GaN FETs development.

GaN-on-Si: Power and efficiency in one package

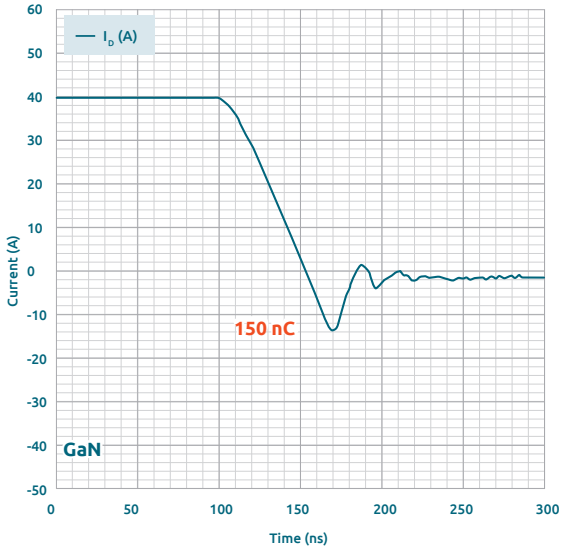
Power conversion efficiency is a key growth driver in electronics but there is often a trade-off between density and efficiency.

When it comes to getting very high efficiency and high-power density, then 650 V GaN-on-Si FETs offer an ideal solution. These devices allow high frequency operation with high breakdown voltages and high current carrying capabilities. A substantially lower switching figure of merit ($R_{DS(on)}$ x Q_{GD}) and reverse recovery charge (Q_{rr}), enable the high switching frequencies while delivering lower dissipation and more efficient power conversion.

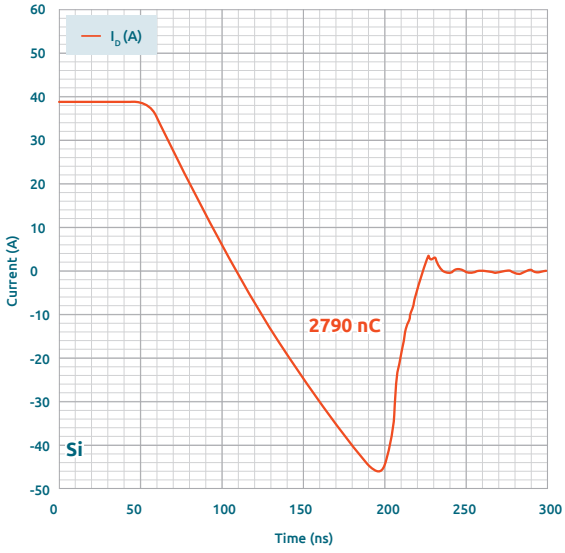
Features and benefits

- Ultra low reverse recovery loss
- Easy simple gate drive (0 V to +10 V or 12 V)
- Robust gate oxide quality (+ - 20 V capability)
- High gate threshold voltage (+4 V) for very good gate bounce immunity
- Integrated very low V_F body diode. No external antiparallel diode required
- Bidirectional topology. Reverse conduction capability
- Easy to control slew rate for turn on and turn off
- Large transient voltage capability (725V)

Low reverse recovery loss compared to silicon devices, same test circuit



GAN041-650WSB
Reverse turn-off, 41 mΩ
400 V, 40 A, 800 A/µs, Q_{rr}= 150 nC



Si MOSFET
Reverse turn-off, 41 mΩ
400 V, 40 A, 800 A/µs, Q_{rr}= 2790 nC

GaN-on-Si: the process game changer

Compound or III-V semiconductors, such as GaN, often offer performance benefits compared to Silicon (Si). For example GaN is mechanically stable, has a wide bandgap with high heat capacity and comparable thermal conductivity. However, III-V semiconductors tend to be more costly to process. Growing thick GaN epitaxial layers on large diameter Si substrate is a recent breakthrough. It reduces costs per wafer to a competitive level for power applications and allows processing in existing 200 mm fabs.

Where performance counts

Efficient power use is a key industrial challenge and a driver for innovation. Societal pressure and legislation are demanding increasing efficiencies in power conversion and control. For some applications power conversion efficiency and power density are critical for market adoption. Prime examples include the trend towards automotive electrification and the high-voltage communications and industrial infrastructure sectors. GaN FETs enable smaller, faster, cooler, lighter systems, with lower overall system cost.

Powering the IoT infrastructure

Providing us with the always on cloud connectivity, processing power and storage we demand takes a lot of power. Very efficient high-end power supplies are needed to deliver the reduced power losses in **industrial automation, data centres,** and **telecommunications infrastructure.** That is why the improved density and efficient power conversion offered by GaN-on-Si is critical.

Electrification of the powertrain

With every gram of CO_2 exhaust being vital in today's cars, it is driving the move to vehicle electrification. From hybrids through to full electric vehicles, electrification of the powertrain is expected to dominate power semiconductor market growth in the next two decades. The power density and efficiency of GaN-on-Si will play a leading role in this space, specifically for **on-board chargers (EV charging), DC/DC converters** and **motor drive traction inverters (xEV traction inverters).**

Partnering with Ricardo to develop GaN-based EV inverter design

GaN FET technology leads to systems with greater efficiencies at lower costs. With improved thermal performance and simpler switching topologies, leading to greater range for electric vehicles. GaN is now on the brink of replacing silicon based IGBTs and SiC as the preferred technology for the traction inverters used in plug-in hybrids or full battery electric cars.

That is why we have partnered with renowned automotive engineering consulting company Ricardo, to produce a technology demonstrator for an EV inverter based on our GaN technology.

Solutions

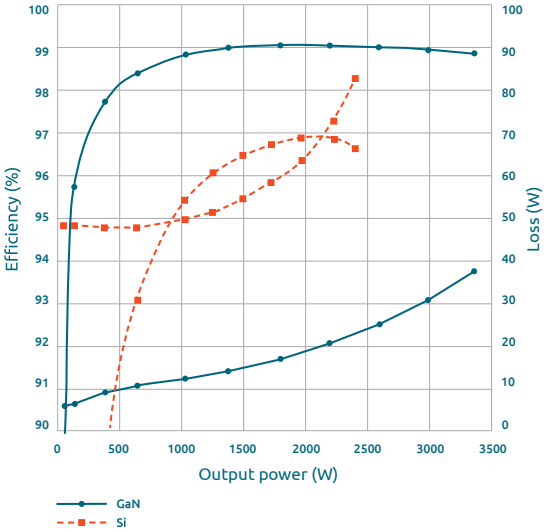
Power GaN FETs demonstrate superior performance in various solutions:

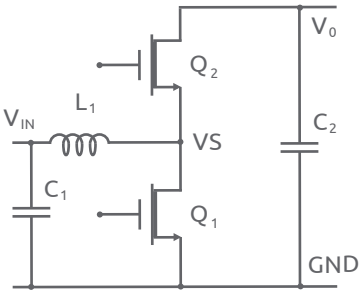
- Hard switching for AC/DC Totem pole PFC applications
- LLC phase shift full-bridge (resonant or fixed frequency) for soft-switching applications
- All DC/AC inverter topologies
- AC/AC matrix converters using bidirectional switches

GaN FET half-bridge

GaN FET half-bridge

Power GaN FETs with their ultra-low Q_{rr} and very fast switching transitions can reduce switching losses to offer the highest efficiencies. Switching applications can benefit from GaN FETs, and whether AC/DC, DC/DC or DC/AC multi-phase inverters, the half-bridge configuration is an integral part of these solutions.

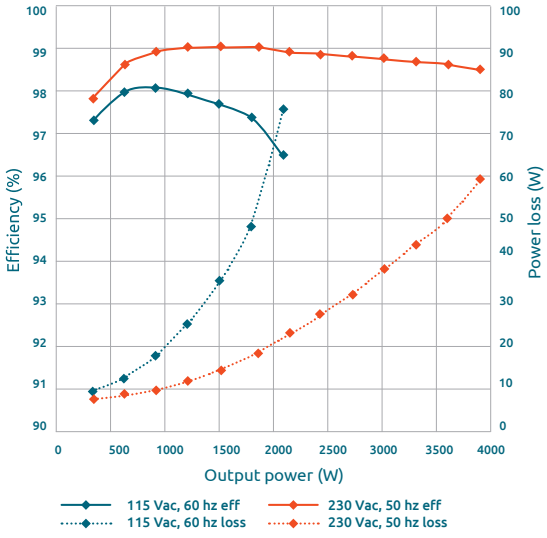


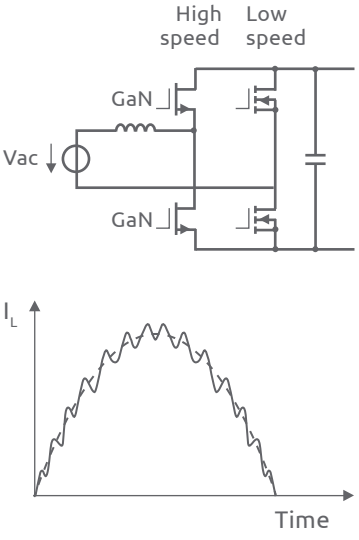


Totem pole PFC

GaN FET totem pole PFC

Power GaN FETs out perform all other devices in hard-switching applications using totem pole topologies to improve performance whilst reducing component count by 50 %. Lower component count reduces cost, improves power density, whilst increasing overall system reliability. Improved overall system power efficiency has the secondary effect of reducing the requirement for expensive cooling systems and the related operating costs in closed environments.





Products

Nexperia's current GaN FET products and development roadmap are focused on delivering reliable products to support both automotive and IoT infrastructure applications. Our GaN process technology is based on our robust and proven production processes which now generates industry leading power GaN FETs.

Features and benefits:

- Easy gate drive, low $R_{DS(on)}$, fast switching
- Excellent body diode (Low V_F), low Q_{rr}
- High ruggedness
- Low dynamic $R_{DS(on)}$
- Stable switching
- Rugged gate bounce immunity (V_{th} ~ 4 V)

GAN063-650WSA – Power GaN FET 650V		
	V_{DS}	650 V
	V_{TDS}	800 V
	$R_{DS(on)}$ max	60 mΩ
	$R_{DS(on)}$ typ	50 mΩ
	Package	TO-247 (SOT429)
	E_{OSS}	15 µJ @ 400 V
	Q_{rr}	125 nC @ 400 V -1000 A/µS

GAN041-650WSB – Power GaN FET 650 V		
	V_{DS}	650 V
	V_{TDS}	725 V
	$R_{DS(on)}$ max	41 mΩ
	$R_{DS(on)}$ typ	35 mΩ
	Package	TO-247 (SOT429)
	E_{OSS}	17 µJ @ 400 V
	Q_{rr}	150 nC @ 400 V -1000 A/µS

Both products are available now
Visit *www.nexperia.com/gan-fets* for datasheets, samples, and design support tools

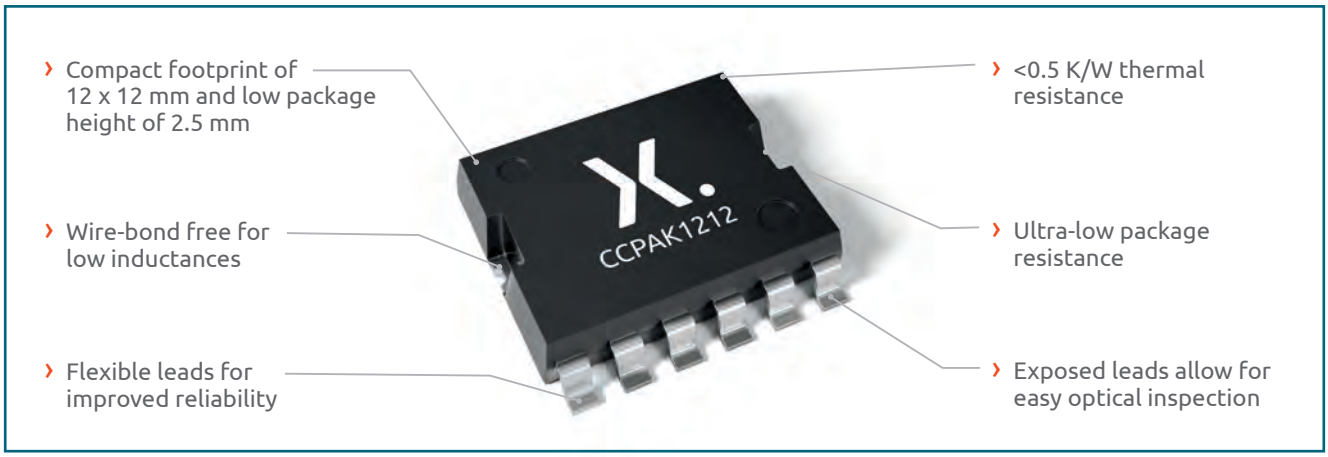
Developing for the future:

We remain focused on the development of very high-reliability high-quality power GaN FETs, with continued development in:

- Automotive qualification
- 900 V and upwards
- Half-bridge package solutions
- Clip-bond packaging (CCPAK)
- Bare die

CCPAK

As the innovators of copper-clip package technology, Nexperia brings almost 20 years experience of producing high-quality high-robustness SMD packaging to its GaN FET portfolio. Adopting proven technology, CCPAK gives industry-leading performance in a truly innovative package. Wire-bond free for optimized thermal and electrical performance, and simplified design of cascode configuration to eliminate the need for complicated drivers and controls.



Features and benefits

Innovative copper-clip technology

- 3x lower inductances than industry-standard packages for lower switching losses and EMI
- Higher reliability vs wire-bond solution

Manufacturability & robustness

- Flexible leads for temp cycling reliability
- Flexible gull winged leads for robust board level reliability
- Compatible with SMD soldering and AOI

Thermal performance

- Low $R_{th(j\text{-}mb)}$ typ (<0.5 K/W) for optimal cooling
- 175 ºC T_j max

Two cooling options

- Bottom-side cooling (CCPAK1212)
- Top-side cooling (CCPAK1212i)

Plan for qualifications

- AEC-Q101
- MSL1
- Halogen free

Target applications

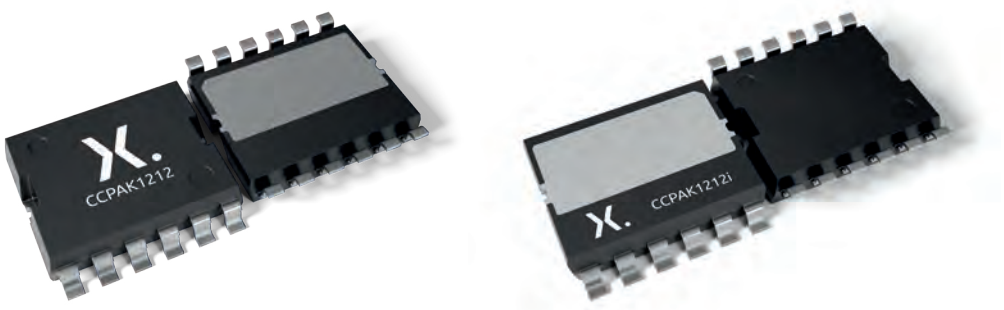
Industrial

- Power supplies for Titanium grade rack mounted telecoms
- Power supplies for 5G and data centres
- Industrial vehicle charging
- Solar (PV) inverter
- AC servo drive/Frequency inverters

Automotive EV

- On board charging
- DC/DC converters
- Traction inverters

For added flexibility in designs and to further improve heat dissipation, CCPAK is available in both top-side cooling, and traditional bottom-side cooling design. The first in the portfolio of GaN SMD packages, the CCPAK1212 and CCPAK1212i has a compact footprint of 12 x 12 mm and low package height of 2.5 mm.



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