Bi-Directional GaN Power ICs open up new possibilities in off-grid applications

Alfred Hesener Senior Director Industrial & Consumer 17th, April 2024



Navitas Electrify Our World™



Navitas Company Confidential 2024

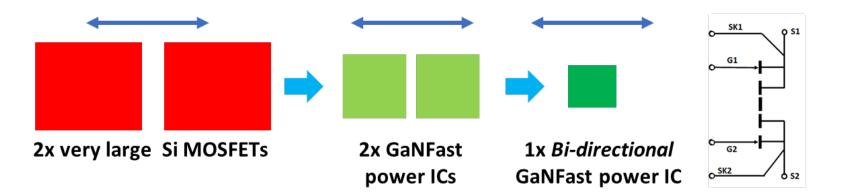




- Bi-Directional power switches in GaN technology
- Technology comparison
- New topologies:
 - Vienna rectifier
 - Current-source inverter
 - Solid state circuit breaker
- Summary

World's First Bi-Directional GaNFast[™] Power IC





4x smaller than SiC Bi-Bi-directional FET, 3x smaller than two Uni-directional GaN, 9x smaller than Silicon

- Traditional power semis (MOSFETS, IGBTS) are uni-directional (one-way conduction or isolation)
- Several topologies need bi-directional power flow control complex and difficult to control
- Bi-directional GaNFast power ICs are the smallest, most efficient, lowest system cost solution
 - Optimized for fast switching, AC voltage applications
 - Enable 'previously-impractical' topologies
 - Integrated circuitry ensures reliability
- Applications: Power supplies, Industrial, Solar, Energy storage, Motor drives
- Mass Production Target: 2024

Bi-Directional GaNFast[™] Power IC Navitas GaN Power ICs Unlock the Next Level of Performance

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Feature	Impact		Benefit
Very low switching losses	Reduce losses by >20% over SiC, >50% over Si		Small / no heatsink, easier thermal design, higher reliability
Very high switching frequency possible	Very small / planar magnetic components		Reduced size and system cost
Precise switch timing with low latency and dead time	Improved control loop performance, low EMI		Smaller EMI filter → system cost improvement
High voltage ratings	High robustness against transient overvoltages		Lower field failure rate, surge robustness
Integrated substrate clamp	Reduced dynamic on- resistance drift		Repeatable performance
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Extended Technology Comparison*



Switch Configuration	Description	Chip area / Size / Complexity	Number of Components	ON-state Voltage Drop	Switching Loss	Switching Frequency	Gate Control Complexity
	Diode bridge + asymmetric IGBT	Very high	5	3.5V [2 diodes + 1 IGBT]	High	16kHz	Low
$\begin{array}{c} \mathbf{Q}_{1} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{Q}_{2} \\ \mathbf{C} \stackrel{\mathbf{C}}{=} & \mathbf{C} \stackrel{\mathbf{G}}{=} & \mathbf{Q}_{2} \\ \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{Q}_{2} \\ \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{Q}_{2} \\ \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} \\ \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} \\ \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} \\ \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} \\ \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} \\ \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} \\ \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} \\ \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} \\ \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} \\ \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} & \mathbf{G} \stackrel{\mathbf{G}}{=} \\ \mathbf{G} \stackrel{\mathbf{G}$	Asymmetric IGBT + freewheeling diodes	Very high	4	2.5V [1 diode + 1 IGBT]	High	16kHz	Low
	Back-to-back reverse-blocking IGBTs	High	2	2.0V [1 symmetric IGBT]	Very high	8kHz	Medium
	Si power MOSFETs + JBS diodes	High	4	1.25V [1 diode + 1 MOSFET]	Low	60kHz	Low
	Back-to-back SiC power MOSFETs + antiparallel and series JBS diodes	Very high	6	1.25V [1 diode + 1 MOSFET]	Low	100kHz	Medium
	Four-terminal SiC monolithic BiDFET	Medium	1	0.5V [1 BiDFET]	Low	100kHz+	Medium
	Monolithic bi-directional GaN power IC	Lowest	1	0.5V [1 Bi-directional GaN power IC]	Lowest	500kHz+	Medium

* See "Baliga et.al.: The BiDFET Device and Its Impact on Converters", IEEE Power Electronics Magazine, March 2023

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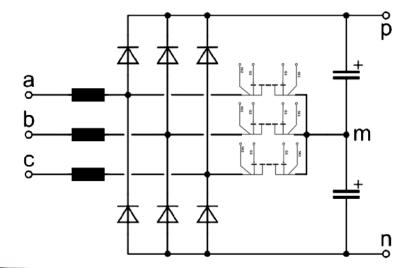




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Bi-Directional GaNFast™ Power IC in Vienna Converter

- Input: Universal AC, output: 800V (+/- 400 V)
- Switching frequency: 100 kHz
- Using GaNFast[™] Bi-directional GaN in TOLT
- Very high efficiency and low complexity

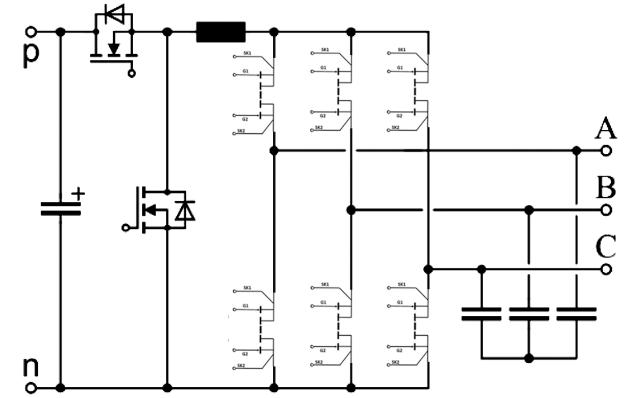


* See "Huber, Kolar: Monolithic bi-directional power transistors", IEEE Power Electronics Magazine, March 2023

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Bi-Directional GaNFast[™] Power IC in Current Source Inverter

- Inherently sinusoidal output
- Very high switching frequency possible through further reduction of the switching losses
- Bi-directional power flow
- Potential to optimize motor size and cost, through lower inductance





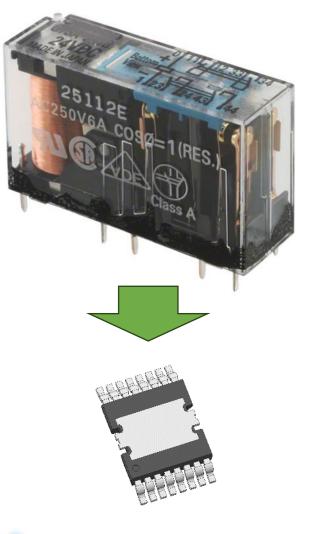
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Bi-Directional GaNFast™ Power IC in Circuit Breakers

• Replacing electromechanical switches with a solid-state switch

Significant advantages for <u>critical</u> applications:

- No arcing
- No degradation from vibration or shock
- Much smaller size and weight
- Fast response time
- No moving parts \rightarrow better reliability, switch cycles
- Handles AC or DC
- Low power remote control



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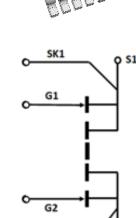
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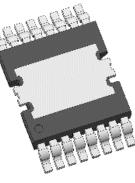
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Summary

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 - Optimized for fast switching, AC voltage applications
 - Enable 'previously-impractical' topologies
 - Integrated circuitry ensures reliability

Navitas' GaNFast[™] Bi-directional offers convincing solutions to enable new topologies for better performance and system cost savings







Discover more at navitassemi.com

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