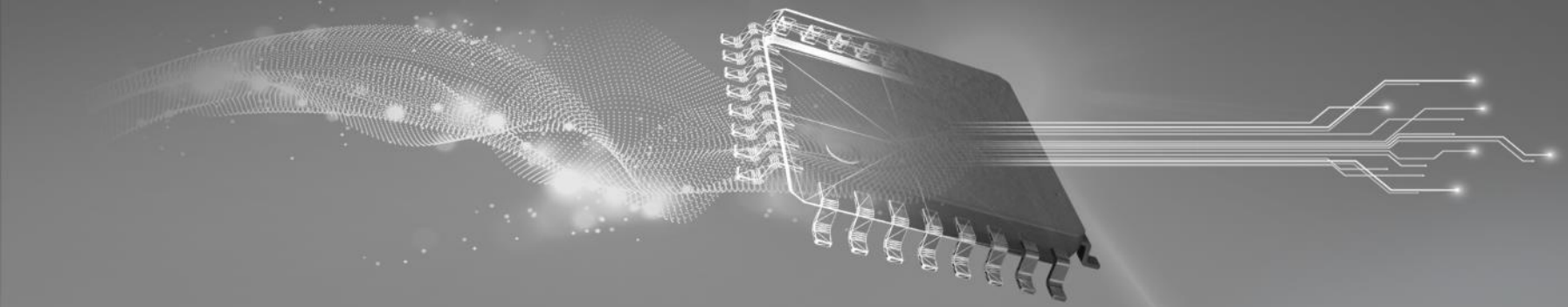
TI TECH DAYS



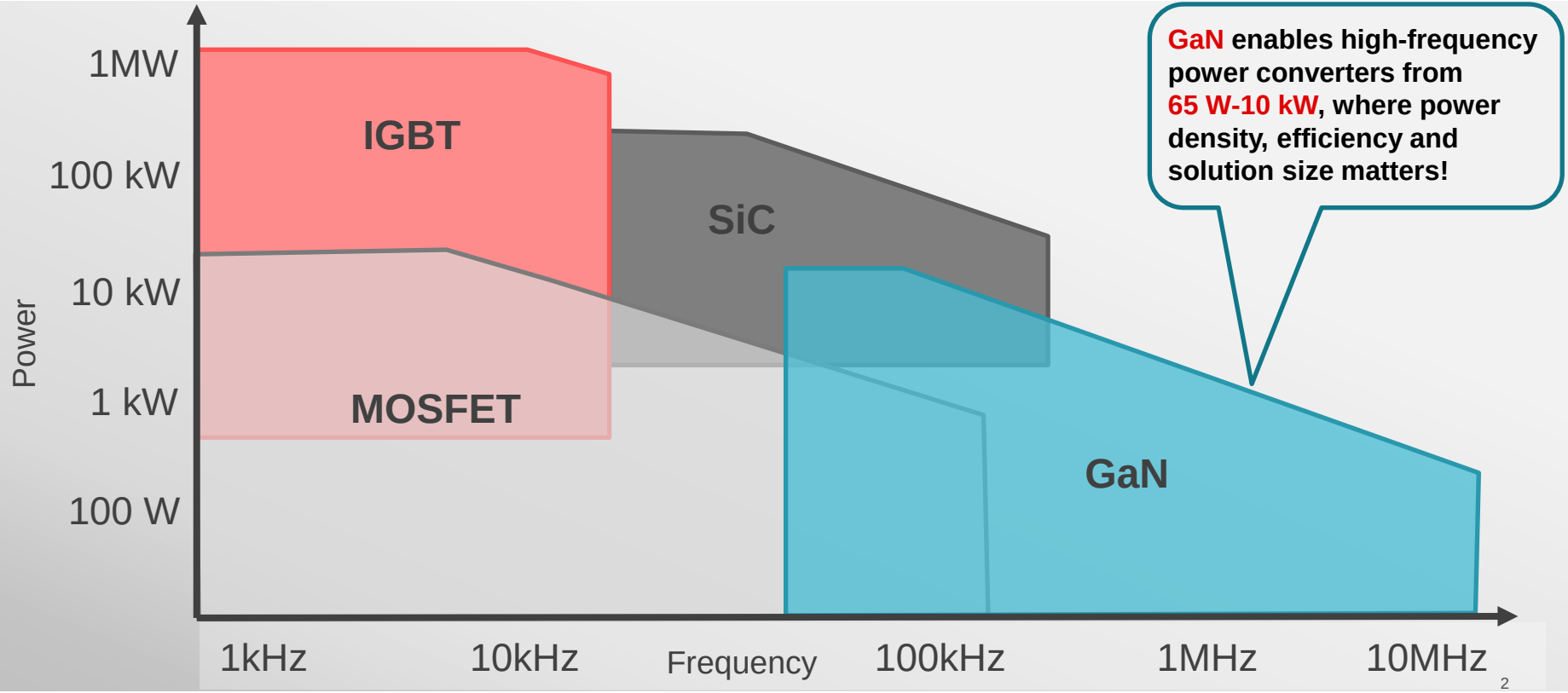
Gallium nitride: Understanding TI’s portfolio and how to use it to enhance industrial designs

Fei Yang

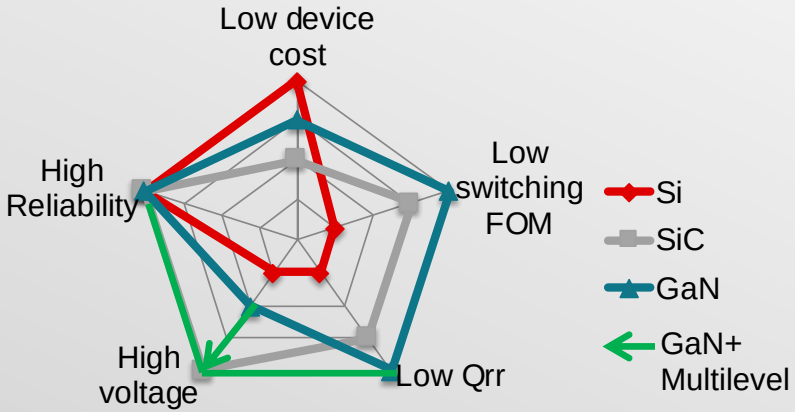
High Voltage Power - GaN Applications Engineer

Texas Instruments

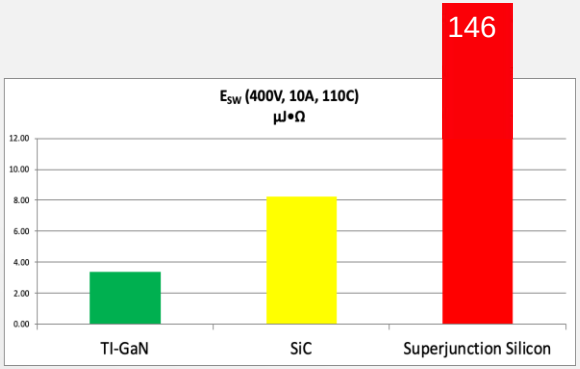
GaN vs. other power devices

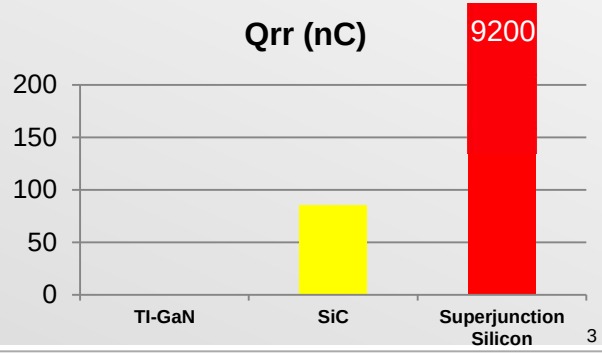


GaN comparison to Si and SiC



GaN offers the best overall cost and performance





GaN applications: from watts to kWs

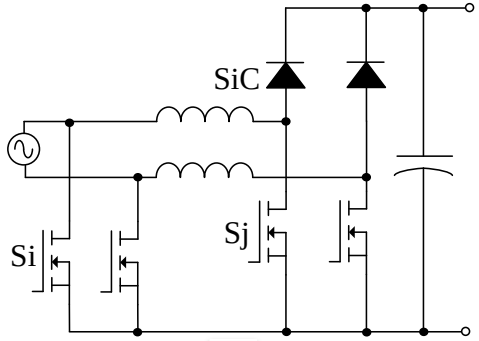
	GaN applications		Why TI GaN	
65 W-4 kW	**AC/DC PSU** • Server, telecom and 5G PSU • Industrial power AC/DC • USB Type-C®, DTV, gaming		**>2X higher density vs. Superjunction** LMG3410R150, LMG3410R070, LMG3410R050, LMG3422R030	• 99%-efficient PFC • MHz HV DC/DC • TI analog and digital controllers
<2k W	**Robotics** • Robots and cobots • Industrial transport • Factory automation		**No cooling fans and 85% smaller heatsinks** LMG3410R050, LMG3422R030	• 99%-efficient inverters • No cooling fan • Integration of drive and motor
>5 kW	**Grid** • Energy storage • Solar energy and UPS • Grid test and measurement		**3X higher density vs IGBT and 1.25X vs. SiC** LMG3410R050, LMG3422R030	• Multi-level topologies • 3-Phase grid and >900 V DC Bus • Scalable
3.3-22 kW	**Automotive** • Onboard charger • HV isolated DC/DC converter		**50% lower cost than SiC** LMG352xR030-Q1	• Up to 2.2 MHz switching frequency • Support for 400/800 V battery • AECQ-100 Grade 1

Using GaN in: AC/DC PSU designs

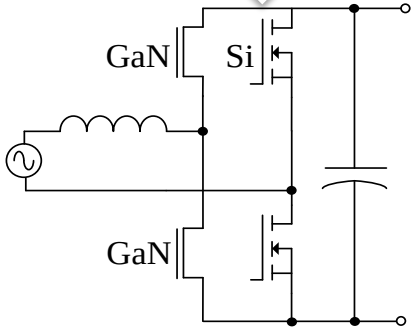
2 kW silicon PFC

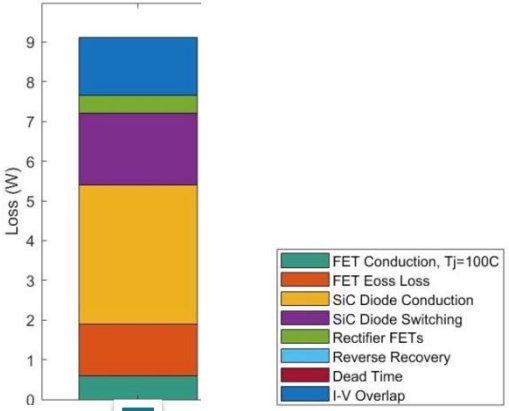
2.8x higher density

2 kW GaN PFC

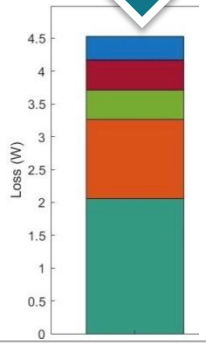


40% reduction in component count



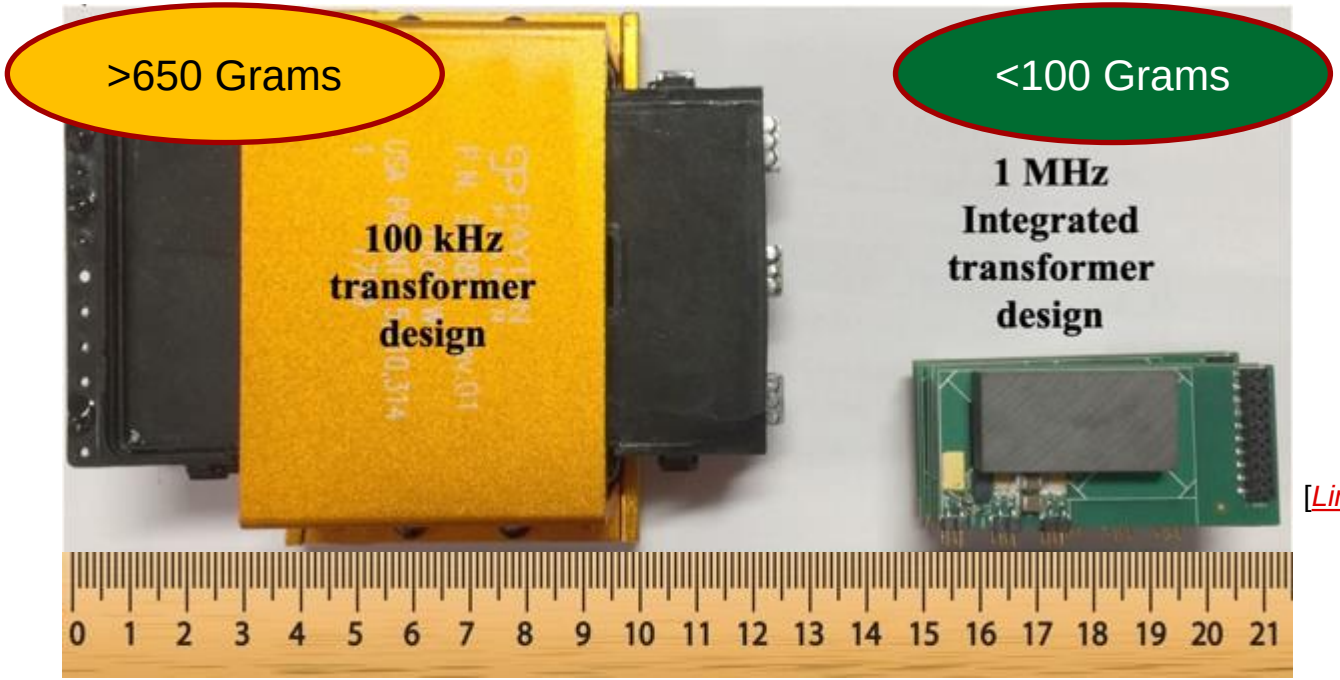


50% lower losses



Reducing power magnetics size with GaN

Compared with 100 kHz LLC design, the 1 kW transformer is 6X smaller



[*Link to PMP20637*]

Using GaN in: servo drive designs

Silicon servo drive @ 1.5 kW

Cooling Area: ***Fan*** + 145 x 82 x 42 mm

- **75% reduction factory floor cabinets**
- **90% less power and communication cabling**
- **85% smaller heatsink and NO FAN**

- **in 6 axis robotic system*

Integrated GaN drive @ 1.2 kW

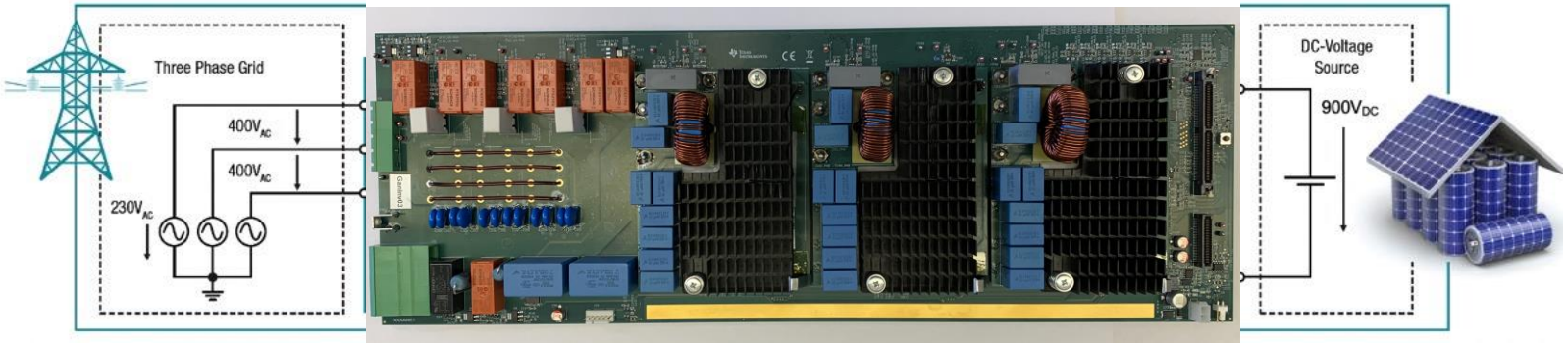
Cooling Area: ***No fan:*** 80 x 46 x 20 mm

Using GaN in: three-phase grid applications

900 V - 5 kW Bi-directional AC/DC converter with TI GaN

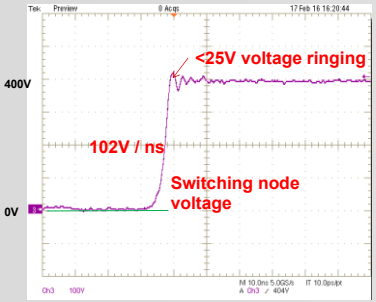
- 3X power density improvement over IGBT
- 1.25X power density improvement over SiC – at a lower solution cost

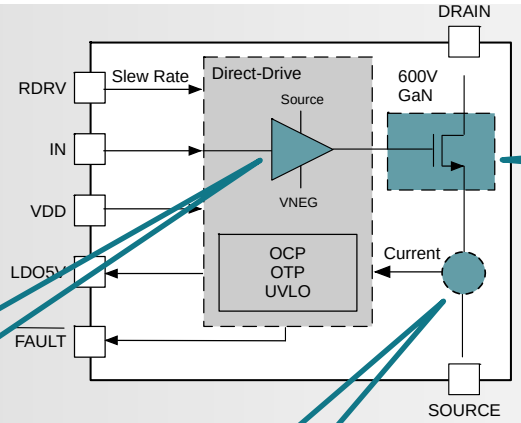
Typical operating conditions	IGBT	SiC	TI GaN
Frequency (kHz)	20	100	**140**
Open frame power density (W/in^3)	73	170	**211**
Efficiency (%)	98.3	98.9	**99.2**



470 mm x 162 mm x 51 mm

Driver and protection integration: why is it important?

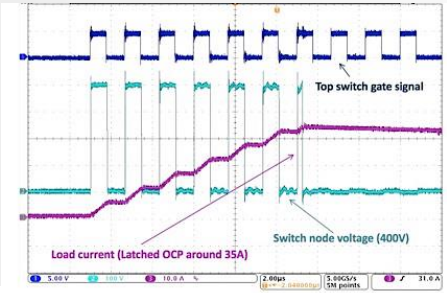




600-V GaN FETs
150 mΩ
70 mΩ
50 mΩ
30 mΩ

Integrated driver cuts losses by 50% compared to discrete GaN

<100 ns short-circuit protection with zero external components



Integration simplifies BOM and cost

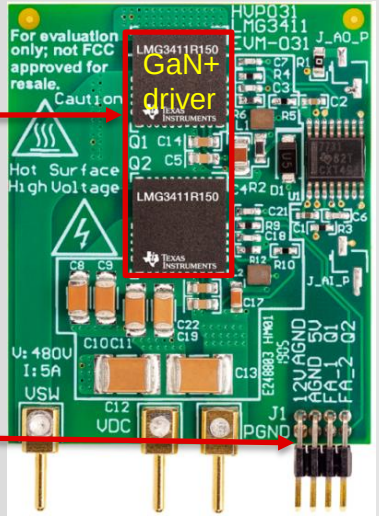
TI GaN

Discrete GaN

FETs + driver + protection

Min area: 24x29mm

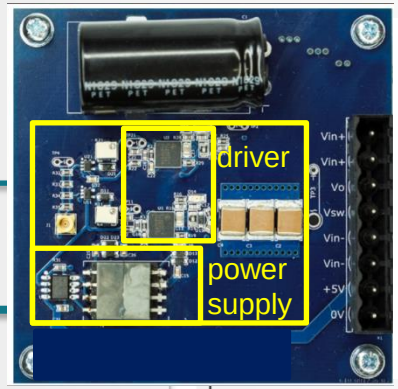
Only single 12-V unregulated supply needed

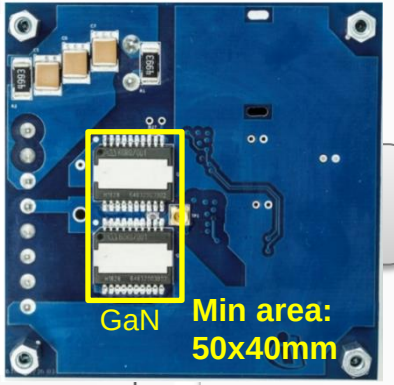


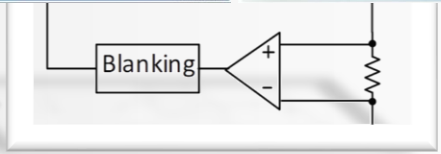
Gate drive circuitry

External power supply needed

External protection needed



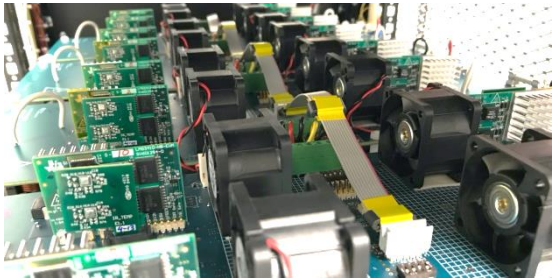




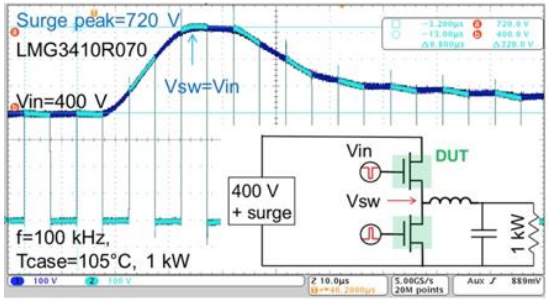
TI GaN: lifetime reliability

Multi-kW lifetime testing

- >40 million hours and >5 GWhr of energy converted
- <1 FIT over 10-year life
- ZERO field returns



Self-protected in extreme conditions



- Designed to withstand 720-V surge and lightning
- <100 ns short-circuit protection
- Thermal protection to 150ºC
- Digital fault reporting for system diagnostics

LMG341x portfolio: GaN FET + integrated driver

Power delivery			Motor Drives, FAC, BA	OBCs and energy storage	
ACF	PFC	LLC	Inverter	Bi-directional AC/DC, Multi-level	

65 W – 100 W → 400 W – 3 kW → 5 kW – 11.6 kW

150mΩ	70 mΩ	50 mΩ	30 mΩ
LMG341xR150	LMG341xR070	LMG341xR050 LMG342xR050	LMG342xR030

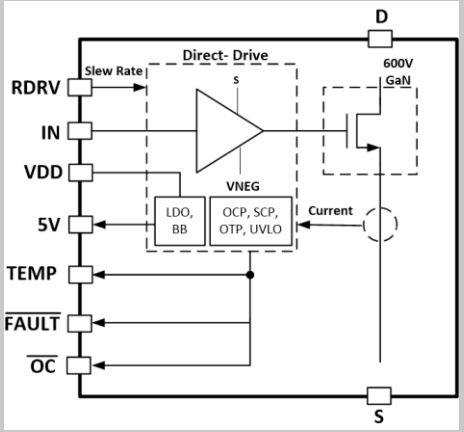
- 600-V GaN FETs
- Fully integrated protection with fault alert and integrated gate driver
- 100% TI-owned manufacturing, supply and cost

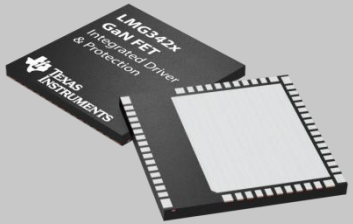
LMG342x: next-generation 600-V GaN FETs with integrated driver + protection

Features

- **50mΩ, and 30mΩ** $R_{DS(on)}$ Drain to Source
- **Integrated GaN gate driver:**
  - TI direct-driver technology switches the GaN directly
  - Internal buck-boost generates negative drive voltage
  - **>200 V/ns CMTI** and **2.2 MHz** switching frequency
  - Only single **7.5-19 V** unregulated supply needed
  - 5V LDO to power external isolator
- **Ideal diode mode** Reduces third quadrant losses by 66%
- **External resistor sets drive strength (RDRV pin):**
  - **30 V/ns to 150 V/ns** adjustability
  - No compromise in gate-drive inductance
- **Fault monitoring and protection:**
  - Cycle-by-Cycle over-current protection (<100 nS)
  - Latched short circuit protection (<100 ns)
  - Over-temperature protection
  - UVLO protection
- **Reporting:**
  - Variable duty cycle PWM **temperature reporting**
  - Fault indication

Functional block diagram and package





12x12mm QFN
(Thermal pad connected to source)

- **50mΩ:** LMG342xR050
- **30mΩ:** LMG342xR030

Samples and EVM available now

Additional resources

Technical content

Direct-drive configuration for GaN devices

[Link]

GaN drives energy efficiency to the next level

[Link]

Half the space, double the power: How gallium nitride is revolutionizing robotics, renewable energy, telecom and more

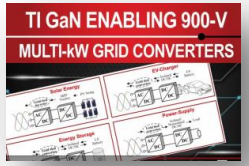
[Link]

Training videos

[Link]

[Link]

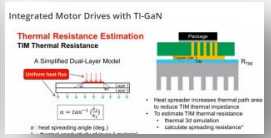
[Link]



[Link]

[Link]

Motor Drive Training



[Link]

Design tools

GaN reference designs

[99% efficient 3-phase inverter]

[1MHz 1.6kW CrM Totem Pole PFC]

[Bidirectional 3.3kW CCM Totem Pole PFC]

GaN plug-in daughter cards

[LMG3411R150 Daughter Card]

[LMG3411R070 Daughter Card]

[LMG3411R050 Daughter Card]

[GaN Buck-Boost Motherboard]

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