GaN Systems

TRANSFORMING THE WORLD

WITH SMALLER, LOWER COST, MORE EFFICIENT POWER ELECTRONICS

Power Systems Design

Get Going with GaN

pcim EUROPE

GaN Systems company overview

Market leader for GaN power transistors

- GaN-on-Silicon transistors for the power conversion market
- Industry’s most extensive & highest-performance products
  - Enhancement mode devices
  - 100V & 650V devices; industry-best performance

Global company with decades of experience in GaN

- Parts shipping overnight from Mouser since 2014
- World-class fabless manufacturing and advanced packaging
- HQ and R&D in Ottawa, Canada
- Sales & App. Eng. in Germany, Japan, China, Taiwan, Korea, USA


CANADA


SILICON VALLEY


DETROIT


GERMANY


TAIWAN


CHINA


KOREA


JAPAN

Why GaN ?

- **Smaller size** — **2x to 10x**
- **Lighter weight** — **2x to 8x**
- **Lower power loss** — **2x to 6x**
- **BoM cost reduction** — **10% to 20%**
- **System cost reduction** — **10% to 30%**

Power Supply with Silicon

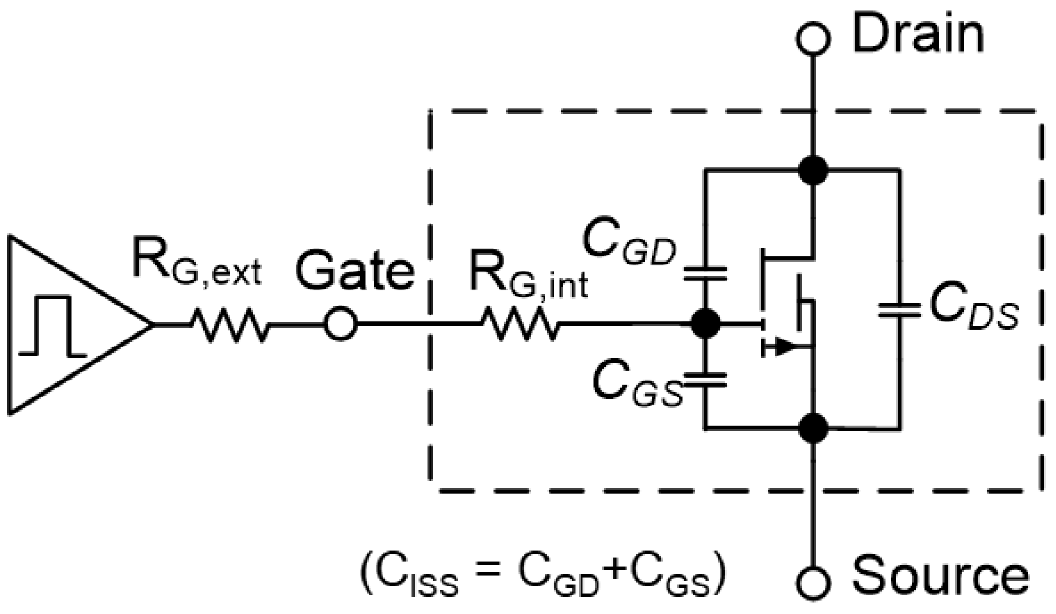
Power Supply with GaN

You know the benefits. Is it difficult? How is it done?

Designing with GaN is straight-forward

GaN Systems

- GaN is a super-fast FET
  - It's not difficult
  - It's not new
- Similarities to a Silicon MOSFET
  - True enhancement-mode, normally off
  - Voltage driven: driver charges/discharges C_{ISS}
  - Supply Gate leakage I_{GSS} only
  - Easy slew rate control by R_G
  - Easily driven by Si gate driver chip
- Differences
  - Much Lower Q_G: lower drive loss; faster switching
  - Higher gain and lower V_{GS}: +5 or +6V gate bias to turn on
  - Lower $V_{G(th)}$: +1.5V



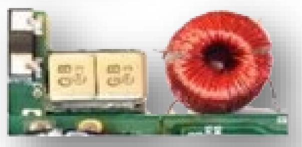
How to get the most advantage for your system

Higher frequency

Magnetics get smaller … capacitors too

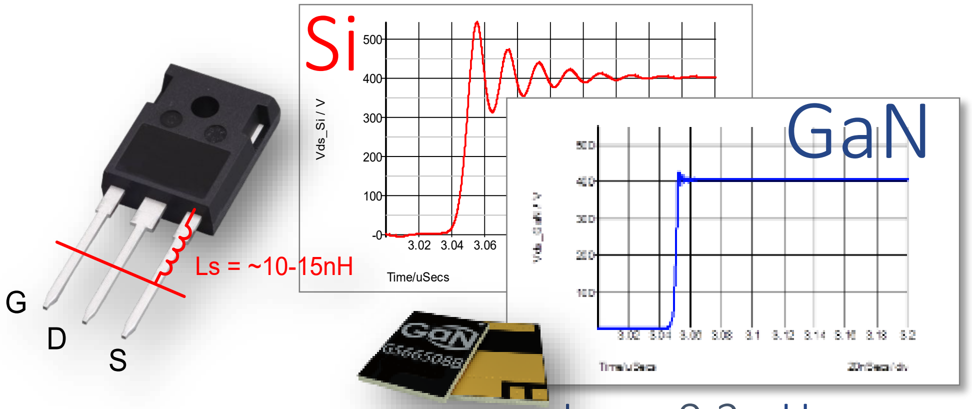
100 kHz
7 W/in^3

500 kHz
30 W/in^3



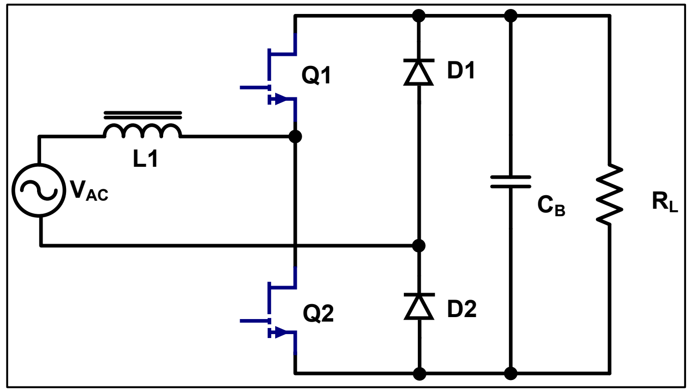
4x smaller

EMI filtering reduced



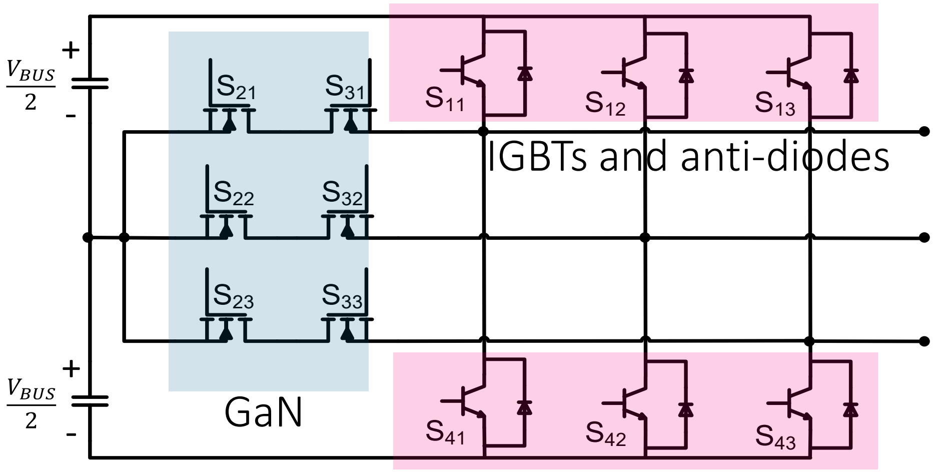
Best topologies

Bridgeless Totem Pole



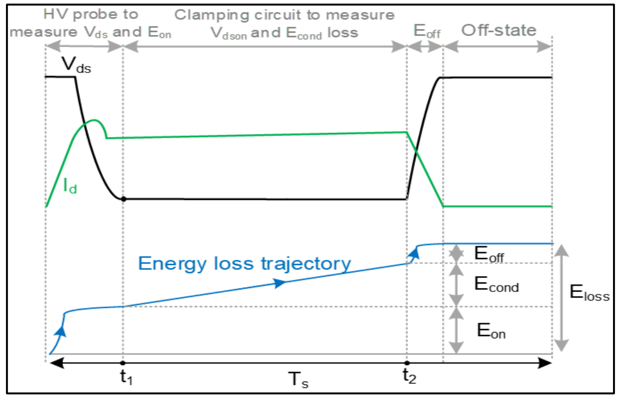
- More efficient, Lower cost
- Simpler, part count reduced 33%

T-type traction inverter



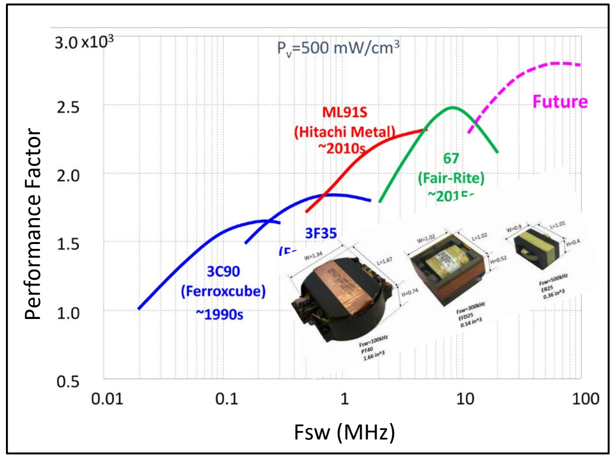
Best components

Gate Driver



- Maximize performance with gate driver that has high CMTI, high dV/dt immunity

Magnetics



- Select magnetics with low AC core-loss to minimize power loss

Resulting in power systems that are …

Smaller size | **Better performance** | **Even better performance**

How to get the info ?

GaN Systems

- Layout
- Gate Driver
- Paralleling
- Thermals
- EMI
- Dynamic Rdson

GaN Systems

PRODUCTS ▾ DESIGN CENTER ▾ MARKETS ▾ NEWS ✉ EN ▾

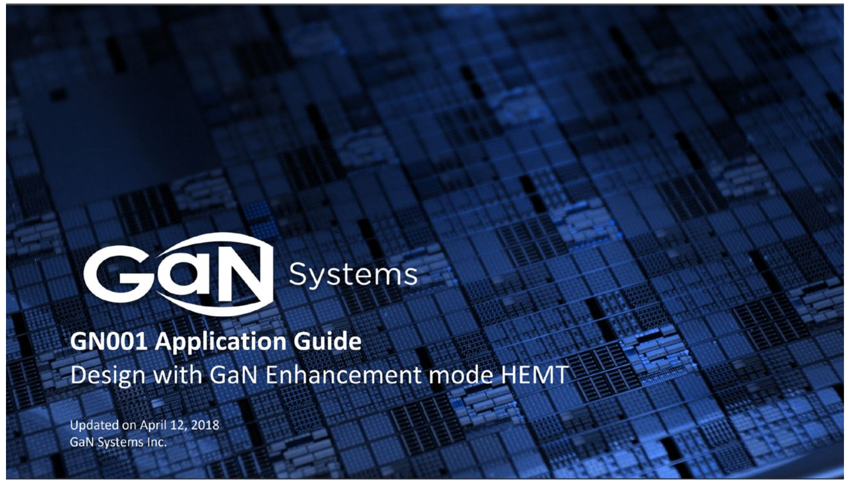
Application Notes

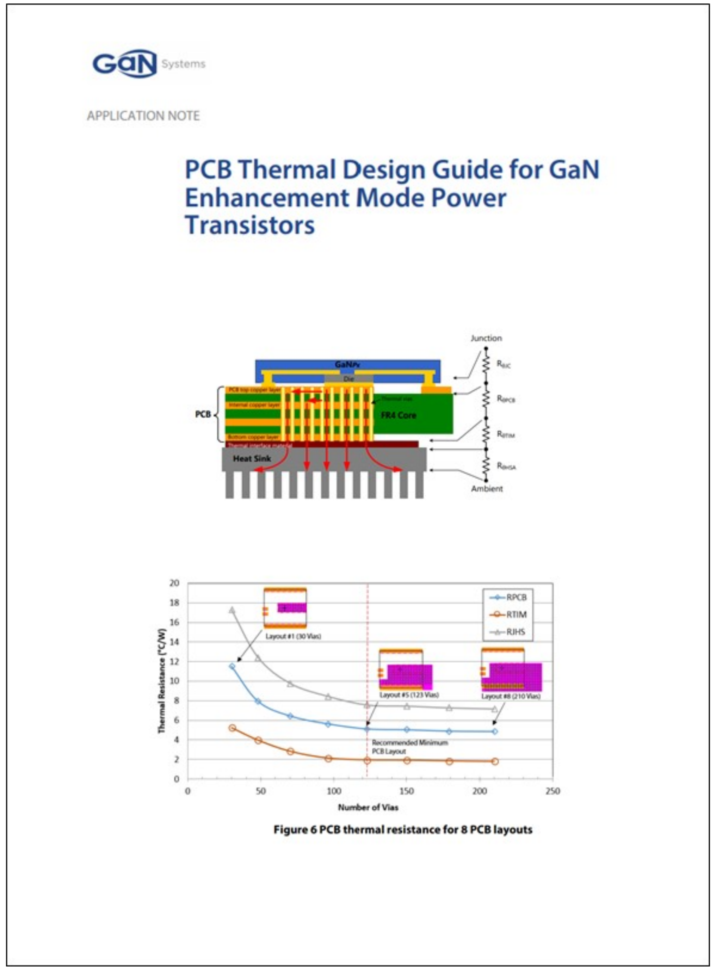
Our unique portfolio of GaN power transistors enables the design of smaller, lower cost, more efficient power systems that are free from the limitations of yesterday's silicon. Our application guides and design examples will help you understand and get the most out of GaN Systems' technology.

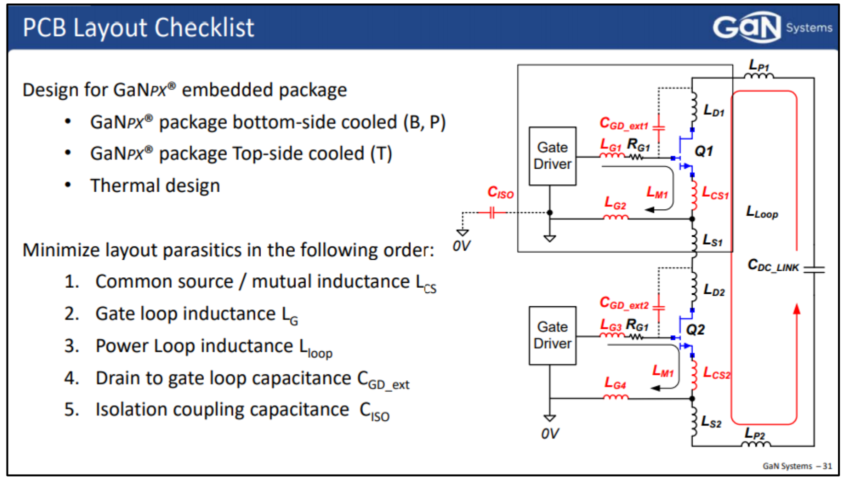
Document #	Title
GN001	Design with GaN Enhancement mode HEMT
GN001 日本語	エンハンスメントモードGaN-HEMTを用いたデザイン
GN002	Thermal Design for Top-Side Cooled GaN*PX*® packaged Devices
GN003	Measurement Techniques for High-Speed GaN E-HEMTs
GN004	Design considerations of paralleled GaN HEMT
GN005	PCB Thermal Design Guide for GaN Enhancement Mode Power Transistors
GN006	SPICE model for GaN HEMT usage guidelines and example
GN007	Modeling Thermal Behavior of GaN*PX*® packages Using RC Thermal SPICE Models
GN008	GaN Switching Loss Simulation Using LTSpice
GN009	PCB Layout Considerations with GaN E-HEMTs
GN010	EZDrive℠ Solution for GaN Systems E-HEMTs

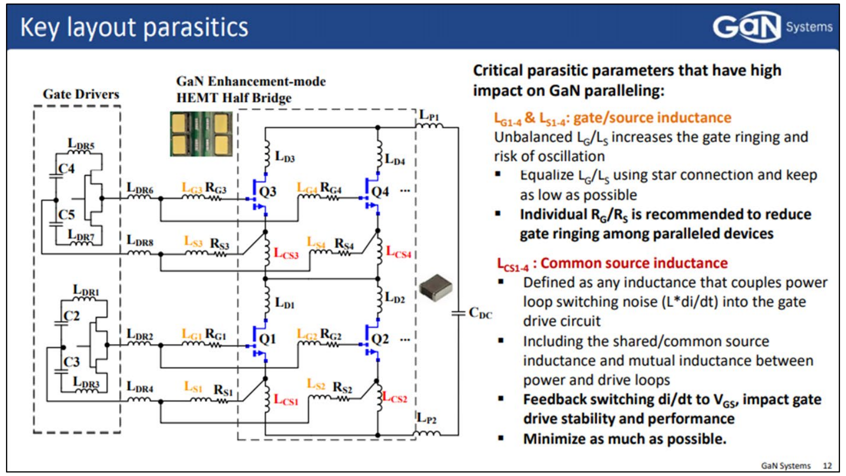
Layout, Parasitics, Thermals

- Circuit design
  - Control noise coupling from power to gate drive loop
  - Mitigate gate ringing/oscillations
- Minimizing parasitics
  - 5 step list including guidance on loop inductance and loop capacitance
- Layout best practice
  - 5 key areas to maximize performance









Drivers and Controllers

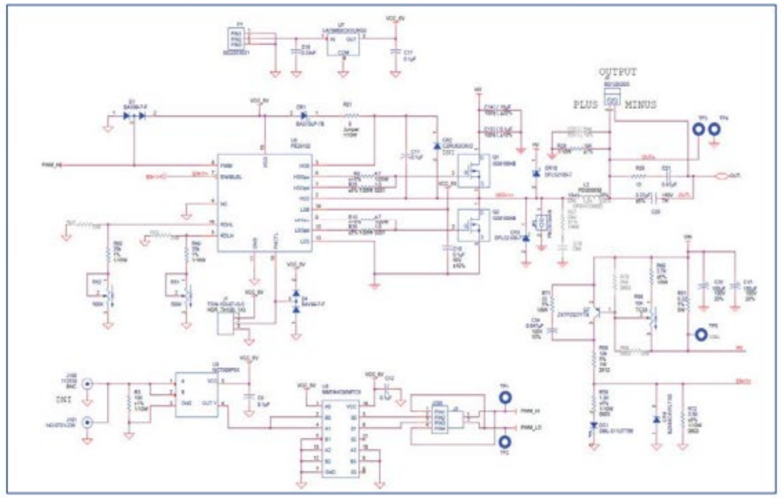
GaN Systems

- Validated list of drivers and controllers
- Half bridge and Full Bridge
- Design examples included

100V half bridge GaN driver – PE29102

pSemi A Murata Company · GaN Systems

PE29102 - 60V Half Bridge GaN driver, optimized for high frequency applications:
- Class D Audio, DC/DC, wireless power charging



GS61004B-EVBCD

100V GaN E-HEMT Full Bridge Evaluation Board, optimized for Class D Amplifiers

For more details on the GS61004B-EVBCD evaluation board, visit: http://gansystems.com/design-center/evaluation-boards/

Recommended GaN driver/controller ICs

GaN Systems

The following drivers have been verified by GaN Systems and are recommended for use with our GaN E-HEMTs:

Configurations	Gate Driver/Controller IC		Design resources
650V Half/Full Bridge: 1. DC/DC: LLC, PSFB, Sync Boost/Buck 2. AC/DC: Totem pole PFC, Active Clamp Flyback 3. Inverter, motor drive	SILICON LABS	**Si8271** – Single; **Si8273/4/5** – HB/Dual -GB (0-6V) or –AB (-3/+6V)	Si827x Datasheet Si8271 demo board (GS66508T) IMS evaluation board User Guide
	ANALOG DEVICES	**ADuM4121ARIZ** (0-6V Drive) **ADuM4121BRIZ** (-3/+6V Drive)	ADuM4121 Datasheet
	BROADCOM	**ACPL-P346** Use -4/+6V gate drive	ACPL-P346 Datasheet ACPL-P346 Evaluation Board with GS66508T
80-100V Half/Full bridge 1. 48V DC/DC 2. 48V POL 3. Sync. Buck/Boost 4. Class D Audio 5. Wireless Power Transfer	TEXAS INSTRUMENTS	**LM5113(NRND):** 100V, max 5MHz **LMG1205:** 80V/5A HB Driver	LM5113 Datasheet LMG1205 Datasheet
	pSemi	**PE29101:** 100V, 48V DC/DC, 33MHz **PE29102:** 60V, Class D Audio, WPT, 40MHz	PE29100 Datasheet PE20102 Datasheet PE29102 Demo board (GS61004B)
	UPI	UPI Semi GaN FET drivers: **uP1966A**: Dual-Channel GaN driver	uP1966A GaN Driver Ultra High Speed 80V HB Driver for GaN Application

Recommended GaN driver/controller ICs

GaN Systems

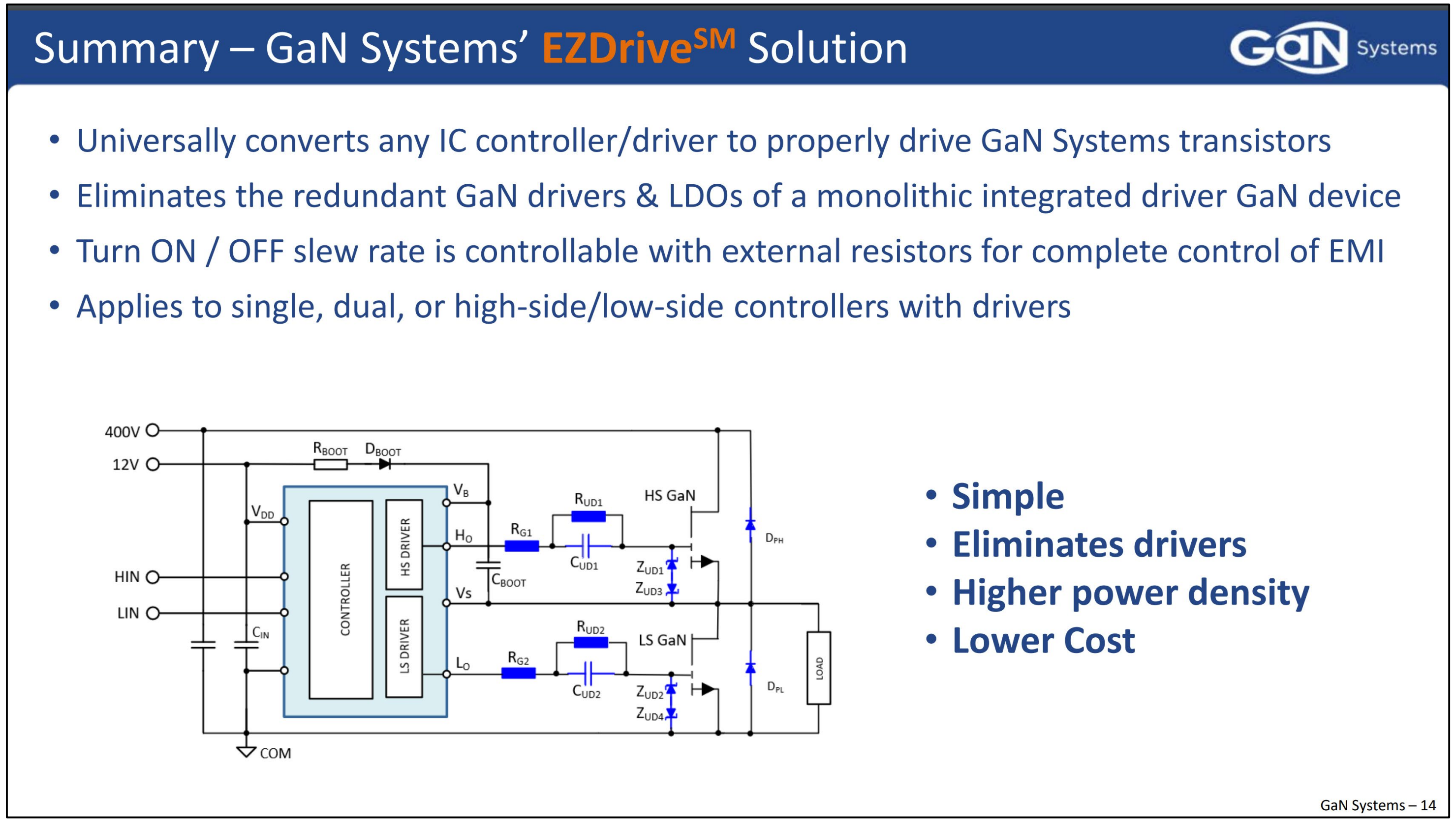
Configurations	Gate Driver/Controller IC		Design resources
Low side non-isolated driver for 650V/100V GaN*: 1. Flyback, Push-pull 2. Forward 3. Boost PFC 4. Secondary SR 5. Class E P/A	TEXAS INSTRUMENTS	**LM5114/UCC27511:** Single Channel, 4A, 5-6V drive **UCC27611:** w/ internal LDO (5V)	LM5114 Datasheet UCC2751x Datasheet
	UPI	**uP1964**: Internal LDO for 6V drive	uP1964 Datasheet
	Other GaN compatible drivers	**IXD609SI:** Single, 6V drive, high drive current (9A) **FAN3122/TC4422:** Single, 6V drive, high drive current (9A) **FAN3223/4/5:** Dual 4A, 6V drive, for push-pull or SR application	
Sync Buck DC/DC (100V GaN): 1. 48V-12V DC/DC	ANALOG DEVICES	**LTC7800:** 60V, Sync. Step-Down Controller (up to 2.2MHz, w/ integrated GaN compatible drivers)	LTC7800 Datasheet
Secondary side Rectification (100V GaN): 1. High frequency LLC 2. Flyback	ON Semiconductor	**NCP4305A**: 5V gate drive clamp, 1MHz max	NCP4305 Datasheet
	ST life.augmented	**SRK2001:** Adaptive SR controller for LLC, 5-6V drive for GaN, 500KHz max	SRK2001 Datasheet

[*] Low side non-isolated drivers can also be used on high side / half bridge configurations by combining with level-shift / signal isolators, see page 29 for design example.

Option to **eliminate** external gate driver

EZDrive™ circuit

- Use standard MOSFET controller with integrated driver to drive GaN Systems' transistors
- Low cost, easy way to implement a GaN driving circuit
- Adaptable to wide range of power levels, frequency, and LLC and PFC controllers
- The EZDrive circuit also provides design control for the optimization of efficiency and EMI

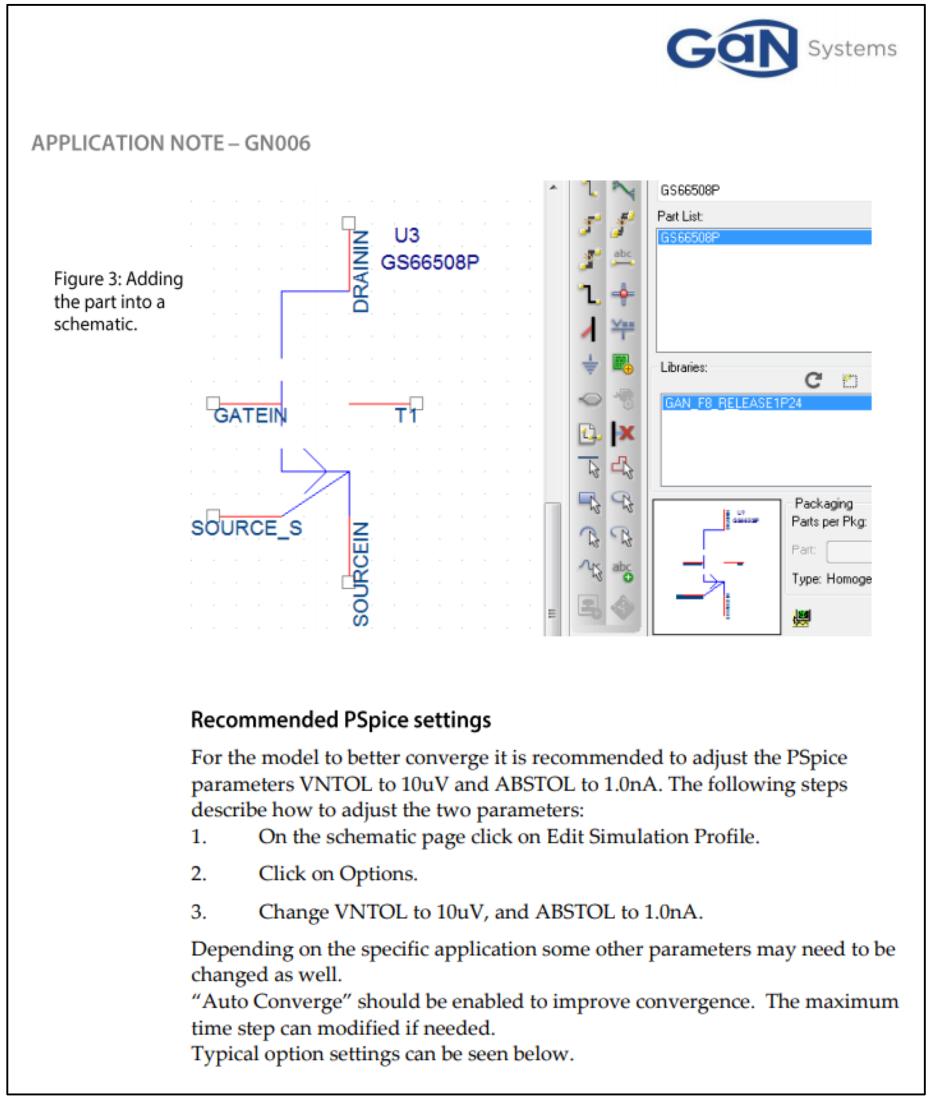


Modeling GaN devices and circuits

- Device-level simulation
  - LTspice and Pspice
  - Device characteristics (Q_g, C_{oss}/C_{iss}, IV/CV curve, E_{on}/E_{off})
  - Simple system simulation
  - Capability to observe parasitic effect on switching performance

- System-level simulation
  - PLECS
  - Simplify the switching transient
  - Observe converter operating waveforms
  - Accommodate complicated device-based, system-level simulation and analysis

Spice


GaN Systems

APPLICATION NOTE – GN006

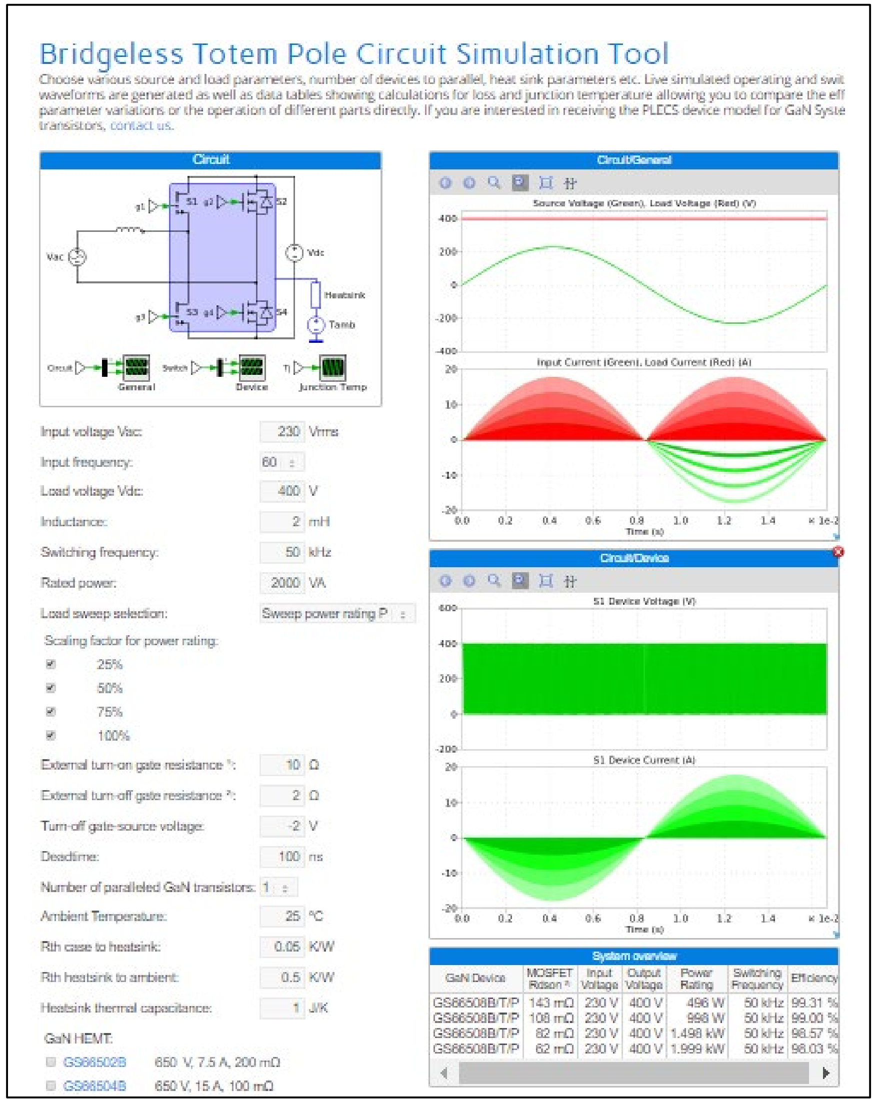
Figure 3: Adding the part into a schematic.

Recommended PSpice settings

For the model to better converge it is recommended to adjust the PSpice parameters VNTOL to 10uV and ABSTOL to 1.0nA. The following steps describe how to adjust the two parameters:

1. On the schematic page click on Edit Simulation Profile.
2. Click on Options.
3. Change VNTOL to 10uV, and ABSTOL to 1.0nA.

Depending on the specific application some other parameters may need to be changed as well.
"Auto Converge" should be enabled to improve convergence. The maximum time step can modified if needed.
Typical option settings can be seen below.



Dynamic Rds(on)

GaN Systems

- Clear analysis presented at PCIM
  - Define what it is
  - How to test
  - Measure the loss
  - Quantify the impact

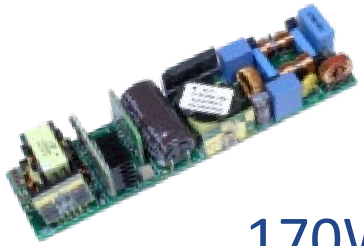
- Conclusion
  - Power loss due to dynamic Rds is insignificant in total system power loss
  - Total system power loss: GaN outperforms silicon by a wide margin

Evaluation Kits and Reference Designs

1.5-2.5kW Half bridge power stage
and universal motherboard

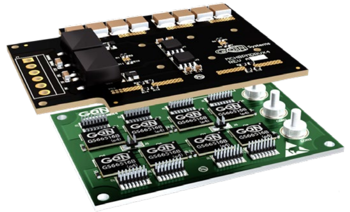
3 kW bridgeless
totem pole PFC

2-7 kW Insulated Metal Substrate
Configurable Full/Half Bridge

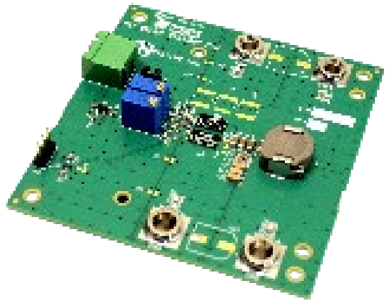


170W AC/DC PFC/LLC

14 kW Insulated Metal Substrate
Reference Design

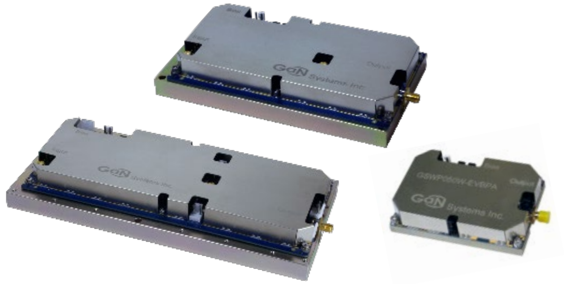


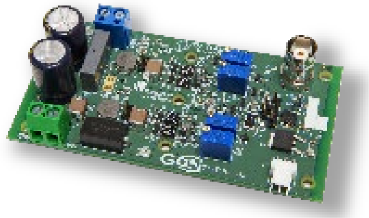
Buck Converter with
5MHz GaN Driver



EZDrive™ Eval Kit

50W, 100W to 300W+
Wireless Power Transfer
Power Amplifiers

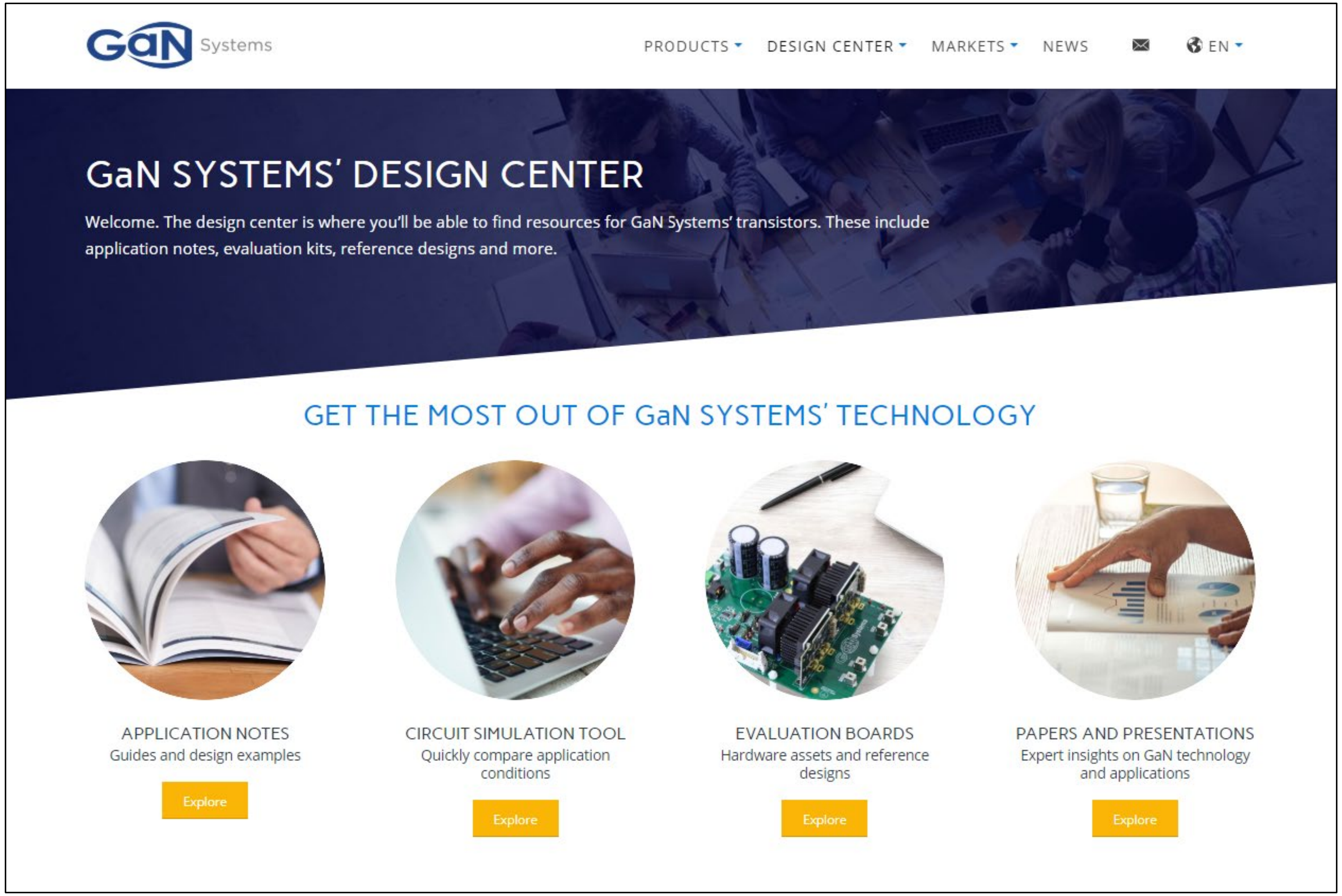




Full Bridge optimized
for Class D Amplifier

GaN Design Center

- GaN is not difficult
  - Many similarities to MOSFET
  - Differences require attention to detail but no new concepts
- Many resources available
  - Easy to find
  - Easy to use
  - GaN Systems applications engineering team to help



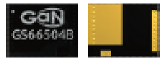
Join the wave - revolutionize your power electronics

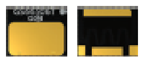
GaN Systems

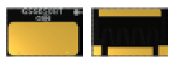
Broadest line of Products

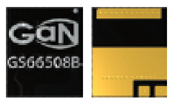
650 V GaN

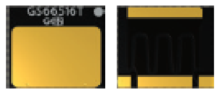

GS66502B
7.5 A, 200 mΩ
6.6 x 5.0 mm

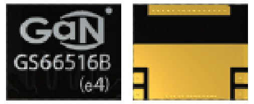

GS66504B
15 A, 100 mΩ
6.6 x 5.0 mm

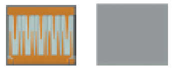

GS66506T
22 A, 67 mΩ
5.6 x 4.5 mm

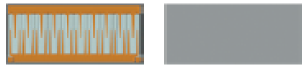

GS66508T
30 A, 50 mΩ
7.0 x 4.5 mm

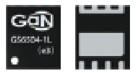

GS66508B
30 A, 50 mΩ
8.4 x 7.0 mm

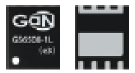

GS66516T
60 A, 25 mΩ
9.0 x 7.6 mm

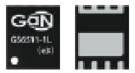

GS66516B
60 A, 25 mΩ
11.0 x 9.0 mm


GS-065-080-1-D1
80 A, 18 mΩ
6.6 x 5.6 mm


GS-065-150-1-D1
150 A, 10 mΩ
12.7 x 5.6 mm


GS-065-004-1-L
3.5 A, 500 mΩ
5.0 x 6.0 mm


GS-065-008-1-L
8 A, 225 mΩ
5.0 x 6.0 mm


GS-065-011-1-L
11 A, 150 mΩ
5.0 x 6.0 mm

100 V GaN

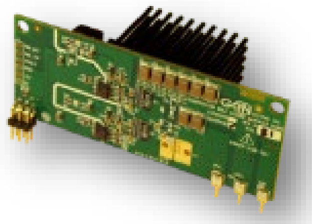

GS61004B
45 A, 15 mΩ
4.6 x 4.4 mm

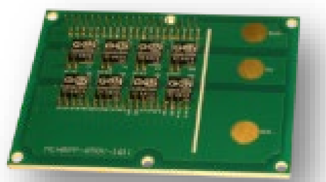

GS61008P
90 A, 7 mΩ
7.6 x 4.6 mm

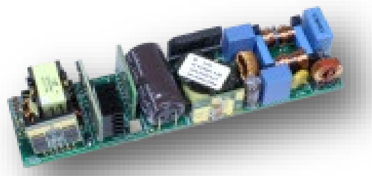

GS61008T
90 A, 7 mΩ
7.0 x 4.0 mm


GS-010-120-1-P
120 A, 5 mΩ
7.6 x 4.6 mm

Many Eval Kits & Reference Designs


Half bridge power stage


High power Paralleling


High density PFC/LLC


650 V test kit


3 kW bridgeless totem pole PFC


300 W wireless power transfer

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