

# TRANSFORMING THE WORLD

WITH SMALLER, LOWER COST, MORE EFFICIENT POWER ELECTRONICS

**GaN Systems Overview** 

January 2020



## There's a revolution occurring in Power Electronics



More computing



More electronics



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Systems

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More people







### **The Challenge**

Build systems that use less materials & waste less energy ... so all 7B people can use

### **The Solution**

Better power electronics by using **better power transistors** 

# **Power Transistors**



### **20 YEAR CYCLES OF INNOVATION**



# GaN is growing across many markets





Large, heavy, and Ecodesign directive for higher efficiency Inefficient and approaching 5% of global power usage Storage needed for Distributed Energy (ESS) Inefficient and 30% of worldwide electricity usage Government reduced  $CO_2 \&$  high MPG regulations

# **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 to >2000 customers since 2014
- World-class fabless manufacturing and advanced packaging
- HQ and R&D in Ottawa, Canada. Ops HQ in Taiwan.
- Sales & App. Eng. in Germany, Japan, China, Taiwan, Korea, USA



# GaN Systems leads the shift in power electronics Gan Systems







Power Supply with Silicon

Power Supply with GaN

#### **GaN SYSTEMS OUTPERFORMS OTHER TRANSISTORS**

- 13X better than best Silicon
- ♠ 6X better that best SiC
- ♣ 3X better than other GaN

#### **CUSTOMERS ACHIEVE IMPROVED SYSTEMS**

- Efficiency
- Size
- Weight
- Lower system cost

4x lower losses

- 4x smaller
- 4x lighter
- 10% to 20%

CONFIDENTIAL

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# **Product Portfolio**





**"T" Top-side Cooling** Simpler thermal design for hard-switching applications

### "B" & "P" Bottom-side Cooling

Compact solution for lower power designs

### "D" Die

Optimized for wire bonding. Suitable for power module applications

### "L" 5x6 PDFN

A cost effective solution for low power designs

# A superior device in a superior package

### Island Technology<sup>®</sup> die design

- Lateral active region
- Vertical current collection
- Islands, not fingers

- Faster switching
- Smaller die
- Higher yield
- Higher current (>50A)







### GaNPX<sup>®</sup> package design

- Thick copper
- Embedded GaN die
- No wire bonds
- Source Sense (SS) pad
- Low R<sub>ds(on)</sub>
- Low thermal impedance
- Ultra low inductance
- Differential  $V_{GS}$

- Higher operating current
- More Power/Die Area
- More Power/Package Area
- Minimized gate ringing at high switching frequency

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# GaN Systems Performance Advantages vs Si & Sic Gan Systems

- Figure of Merit is 30x better than the best IGBTs, 13x the best SJ MOSFET, 6x the best SiC
- Island Technology<sup>®</sup> enables enables smaller die, faster switching, high current and high yields
- GaNPX<sup>®</sup> packaging enables faster switching, more current, ultra-low inductance, small size
- In use at switching frequencies up to 100MHz
- Similar gate drive to MOSFET, easier than SiC
- GaN is easy to parallel, SiC is very difficult to parallel reliably
- GaN-on-Si potential for cost parity with Silicon. SiC will remain costly.

Parameter	Symbol	Units	650V MOSFET	600V IGBT	900V SiC	650V GaN Systems GS66508T
Switching Energy	E <sub>ON</sub> /E <sub>OFF</sub>	μJ	Not avail	940/440	47/17	29/8
FOM	$Q_{G}^{*}R_{DS(on)}$	nC*mΩ	4480	10725	1976	358
Inductance	L <sub>SOURCE</sub>	nH	2	12	5	0.2
Reverse Recovery	Q <sub>RR</sub>	nC	10000	320	135	Zero

### Island Technology®



### GaNPX<sup>®</sup> package



GaN System's E-HEMT delivers highest performance and lowest cost

# It's happening now ... the GaN Systems timeline Gan Systems



### FOCUSED GaN DEVELOPMENT... CHANGES THE FUTURE OF THE \$15B POWER TRANSISTOR MARKET

# Growing list of Companies show GaN advantage Gan Systems



https://gansystems.com/gan-application-examples/

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# Fast growing customer base





### **Computer charger**

4x smaller 3x lighter 40 W/in<sup>3</sup>

### Solar ESS 2x smaller 3x lighter Eliminated fan



### Data Center server power supply



50% higher power density 20% lower P<sub>loss</sub>

# Industrial applications are smaller with GaN



### **EV** inverter

5x smaller 3x lighter 50% lower P<sub>loss</sub> 3-phase AC Power Converter 10x smaller 8x lighter





### **AC/DC Converter**

2x smaller3x more power6x density increase

Systems

Gan

# **On-board charger customer**









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# Market leaders confirm the value of GaN



Source: APEC Conference 2019

# GaN vs SiC – Power loss and junction temperature



Synchronous buck DC/DC system (400-200V, 900W, 200 kHz, Tamb=25°C)

**GON** Systems

# Take full advantage of GaN – Tools and Resources Gan Systems



# Take full advantage of GaN – Evaluation Boards

GS665MB-EVB Motherboard + GS665xxDB-EVB Daughterboard Half bridge power stage

### GSP65MB-EVB

+ GSP65RxxHB-EVB 2-7 kW Insulated Metal Substrate Configurable Full/Half Bridge Evaluation kit

#### GSP665x-EVBIMS2

2-6 kW Insulated Metal Substrate Configurable Full/Half Bridge Evaluation kit



1.2kW Bridgeless Totem Pole Power Factor Correction Evaluation Board







#### **GSWPT-EVBSKY**

Dual-mode wireless charging pad supporting AirFuel's Magnetic Resonant MR and WPC's Qi charging standards. Fully documented reference design.



Systems

#### GSWP050W-EVBPA GSWP100W-EVBPA GSWP300W-EVBPA

50W, 100W to 300W+ Wireless Power Transfer Power Amplifier Evaluation Kits

**GS61008P-EVBHF** Buck Converter with 40MHz GaN Driver

<u>GS65011-EVBEZ</u> EZDrive<sup>®</sup> open loop boost evaluation board





# Take full advantage of GaN – Evaluation Boards



GS-EVB-HB-66508B-ON1NEW650V, ultra-small form factor Half Bridge power stageIn partnership with On Semi.25mm x 25mm Half Bridge power stageOn Semi NCP51820 driver and GS66508B E-HEMT.Ideal for high density / cost sensitive applications.





#### GS-EVB-LID-500W-OS



High power LiDAR Reference Design

In partnership with Osram. Ultrafast laser driver with a high-power, 500W, multi-channel Surface Mount (SMT) laser for LiDAR (Light detection and ranging) systems.



In partnership with

OSRAM

# Take full advantage of GaN – Evaluation Boards

**Class D Amplifier** 

#### **RELEASE FEBRUARY 2020**

#### GS-EVB-AUD-AMP1-GS - Class D Audio Amplifier Reference Design

#### Features

- Bridge-Tied Load Output Topology
- Easy Integration w/ Companion GaN SMP
- On-Board Power Management w/Aux Supplies

#### Performance

- 200W per Channel into 8 ohms
- 300W per Channel into 4 ohms
- > 108dB SNR and Dynamic Range
- < 0.01% THD+N (8Ω, 1W, 20Hz to 20kHz)
- 20Hz-20kHz +/-0.5dB Frequency Response (8Ω)

### GS-EVB-AUD-SMPS1-GS Switch Mode Power Supply for Audio Amplifier

#### Features

- Complete Stand-alone Dual-Rail LLC SMPS
- 400W Continuous Duty, 550W Peak Power
- GaN PFC and Half-Bridge LLC Topology

#### Performance

- Graceful Handling of Complex and Lower Impedance Loads
- Fully-Regulated, Split-Rail Outputs
- No heatsinking, no cooling, reduced system size
- EMI/EMC friendly

#### **RELEASE FEBRUARY 2020**

#### GS-EVB-ACDC-300W-ON

#### Ultra high power density 300W AC/DC SMPS

World's highest power density 300W AC/DC design Complete system reference design

Suitable for applications requiring ultra-high power density (UHPD): AC-DC adapters for HDTV power supplies, gaming notebook, console adapters, industrial and medical devices.

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# MARKET LEADERS ARE BOUGHT INTO GaN



### **GaN IN AUTOMOTIVE**



### **BMW i Ventures**

BMW i Ventures Leads Strategic Investment in GaN Systems



Mirai Fund, Toyota Motor Company, invests in GaN Systems

### **GaN IN POWER SUPPLIES**



Delta becomes Strategic Investor in GaN Systems



## **STRATEGICALLY PARTNERED WITH ...**





to support Aerospace & Defense

to give customers more choices for GaN

### GaN SYSTEMS TODAY

### **#1 in GaN**

- Highest current; broadest voltages
- Best electrical performance
- Best die & best package
- Most widely used by customers

### Shipping since 2014

- Offices in 7 countries
- Parts shipping to >2000 customers

### **Customer Successes**

- AC Adapters
- Wireless Power and Charging
- Datacenter Server and Rack Power
- Solar Inverter and ESS
- Motor Drives
- Automotive OBC & Traction Inverter



CONSUMER















INDUSTRIAL



#### TRANSPORTATION









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# **GaN Systems**

# **GS-EVB-LID-500W-OS 500W LiDAR Evaluation Board**



#### In Partnership



#### **TECHNICAL HIGHLIGHTS**

- 500W, multi-channel Surface Mount (SMT) Laser for LiDAR systems
- Ultrafast laser driver



#### **FEATURES**

- Fan-less, self-powered design. No external DC supplies required
- Minimal external components due to high level of integration with SA4041 controller
- High Efficiency across wide load range
- Scalable to higher power with magnetics / GaN E-HEMT selection

https://gansystems.com/design-center/evaluation-boards/



# GS-EVB-HB-66508B-ON1 650V, Ultra-Small Half Bridge





25mm x 25mm Layout

#### **TECHNICAL HIGHLIGHTS**

650V, ultra-small form factor Half Bridge power stage

#### **TARGET APPLICATIONS**

Off-line power converter topologies

- LLC
- Phase-shifted full-bridge
- Totem Pole PFC
- Aactive clamp flyback and forward
- Dual active-bridge
- Phi-2
- High voltage synchronous buck

#### **FEATURES**

- 25mm x 25mm Half Bridge power stage
- On Semi NCP51820 driver
- GaN Systems' GS66508B E-HEMTs
- Ideal for high density / cost sensitive applications

Systems

CON

### **GS65011-EVBEZ - EZDrive™ Open Loop Boost EVB**

A low-cost, easy way to drive GaN System's E-HEMTs using a standard MOSFET controller with integrated driver. Adaptable to any power level, any frequency, and any LLC and PFC controller.



Application Considerations	Silicon MOSFETs	GaN Systems EZDrive	Monolithic integrated GaN driver
Total BoM Cost	$\checkmark$	1	×
Choice of devices to optimize design	$\checkmark$	✓	×
Use controller driver, eliminate redundancy	$\checkmark$	~	x
EMI control	$\checkmark$	~	×
Power density	×	1	1

https://gansystems.com/design-center/evaluation-boards/



CON

### GS1200BTP-EVB 1.2kW Bridgeless Totem Pole PFC EVB







#### **TECHNICAL HIGHLIGHTS**

- Universal AC input (85 V- 264 V)
- 1.2 kW continuous output power @ 240 V (600 W @ 85 V)
- 385 V<sub>DC</sub> regulated bus output voltage. (firmware adjustable)
- Full load efficiency > (99%), PF > 0.99
- Low THD (< 3%) with option for further optimization

#### **FEATURES**

- Fan-less, self-powered design. No external DC supplies required
- Minimal external components due to high level of integration with SA4041 controller
- High Efficiency across wide load range
- Scalable to higher power with magnetics / GaN E-HEMT selection
   <a href="https://gansystems.com/design-center/evaluation-boards/">https://gansystems.com/design-center/evaluation-boards/</a>



### **GSP665x-EVB - High Power IMS 2 Evaluation Kit**



#### **Configurable Platform**



IMS 2

Gate Driver Mother Board GSP665HPMB-EVBIMS2



IMS 2 GaN Half Bridge (1 or 2 per mother board) GSP66516HB-EVBIMS2 GSP66508HB-EVBIMS2



Configurable Mid-Level Power (1 – 6 kW)

#### **PURPOSE**

Designed for expediting development cycles and demonstrating an optimized thermal and electrical design at low cost.

#### **TECHNICAL OVERVIEW**

- High-performance, high power density
- Horizontal Implementation of Insulated Metal Substrate (IMS) PCB
- Motherboard
  - Configurable: 1 or 2 half bridges or 1 full bridge circuit + more
  - Optimized layout for minimizing parasitic elements
- IMS II Half bridge boards
  - Enhanced thermal design
  - Low system thermal impedance
  - Robust mechanical design
  - GSP66516HB-EVBIMS2 = 650V / 60A / 25m $\Omega$
  - GSP66508HB-EVBIMS2 = 650V / 30A / 50mΩ
- Low manufacturing cost
- Scalable & flexible

https://gansystems.com/design-center/evaluation-boards/



# 650V Half Bridge EVBs COMPARISON

650V Universal MB + DC		IMS Eval Platform – Vertical	IMS2 Eval Platform –Horizontal	
			New Service Se	
KEY USE	<ul> <li>Characterizing GaN E-HEMT performance</li> <li>Easy to probe signals and compare different E-HEMTs</li> </ul>	<ul> <li>With configurable motherboard, good for real applications and circuits</li> <li>IMS modules help expedite system level prototyping</li> </ul>	<ul> <li>With configurable motherboard, good for real applications and circuits.</li> <li>IMS help expedite system level prototyping</li> <li>Requires gate drive circuit design on main board.</li> </ul>	
POWER LEVEL	• Low power (< 2 kW)	<ul> <li>High power: up to 7 kW</li> <li>REF design scalable to higher power</li> </ul>	<ul><li>High power, up to 6 kW</li><li>REF design scalable to higherpower</li></ul>	
HALF BRIDGE MODULE	<ul> <li>Driver + GaN E-HEMTs on a PCB</li> <li>Vertical orientation</li> </ul>	<ul> <li>Driver + GaN E-HEMTS on an IMS board</li> <li>Vertical orientation</li> </ul>	<ul> <li>GaN E-HEMTs on an IMS board</li> <li>Driver cct on the main PCB</li> <li>Horizontal, low profile layout, <u>optimized performance</u>!</li> </ul>	
COOLING	• Forced air with heatsink	<ul> <li>Forced air with heatsink</li> <li>IMS board effective for thermals and cost</li> </ul>	<ul> <li>Forced air or cold plate</li> <li>Hermetically sealed PSUs</li> <li>IMS directly coupled to heatsink or cold plate</li> </ul>	
TYPICAL APPLICATIONS	• For characterizing GaN E-HEMTs	<ul> <li>Industrial PFC</li> <li>Motor drive</li> <li>Server data center – PFC and DC/DC</li> <li>Telecom power</li> </ul>	<ul> <li>Automotive OBC</li> <li>Automotive DC/DC</li> <li>Datacenter – low profile, i.e 1U</li> <li>ESS</li> </ul>	

Q: What are you using the EVB for?

Q: How are you cooling your system?

Q: What power level is your application?

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