Driving eGaN® FETs in High Performance Power Conversion Systems

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Agenda

• Overview of EPC eGaN® FET technology

• The opportunity to improve efficiency and performance

• Future Products

• Conclusions
Overview of eGaN FET Technology
eGaN FET Structure

- AlGaN Electron Generating Layer
- Dielectric
- Two Dimensional Electron Gas (2DEG)
- Aluminum Nitride Isolation Layer
- GaN
eGaN FET Structure
eGaN FET Line Grid Array “Package”
Flip Chip Assembly

HEATSINK

SILICON

Aluminum Nitride

Active GaN Device Region

Solder Bumps

COPPER TRACES

PRINTED CIRCUIT BOARD
GaN vs Si and SiC

- **Breakdown Voltage (V)**
- **Ron (Ωmm²)**

**Graph**
- Points labeled: IRF4127, IRF068N10N, EPC1010, EPC1001
- Lines denote different technologies:
  - GaN Limit
  - SiC Limit
  - Si Limit

**Breakdown Voltage (V)**
- 100V
- 200V

**Ron (Ωmm²)**
- 10⁻⁴
- 10⁻³
- 10⁻²
- 10⁻¹
- 10⁰
- 10¹
- 10²
- 10³
- 10⁴
eGaN Figure of Merit

FOM = \( R_{\text{dson}} \times Q_g \) (200V)
High Frequency Capabilities

EPC1012 Maximum Gain Vs Frequency

Gain (dB) vs Frequency [MHz]
High Frequency Capabilities

EPC1012, Vds = 80V, 500MHz
Measured

Gain [dB]

Pout/[W]
The Opportunity to Improve DC-DC Efficiency
Topologies Explored

Buck Converter

Full Bridge Isolated Converter
Buck Converter

Advantage:
• High power density and high efficiency

Figure 7 – Buck converter with an input voltage of 48 VDC and output voltage of 1.2 VDC
Efficiency vs Frequency

1.2 Vout / 5A

Efficiency (%) vs Switching Frequency (kHz)

- MOSFET @ 12Vin
- MOSFET @ 24Vin
- MOSFET @ 48Vin
- eGaN FET @ 12Vin
- eGaN FET @ 24Vin
- eGaN FET @ 48Vin
Buck Size Comparison

A 24V-1.2V Buck converter was built with both with eGaN FETs and state-of-the-art silicon power MOSFETs.
Buck Size Comparison

184 mm²
A 24V-1.2V Buck converter with eGaN FETs is 50% smaller and has 30% less power losses at 800 kHz.
Isolated Full Bridge Converter

Advantage:
• Isolation and high power density at high power

- 36~75 V
- ~53 V
- ~48 V
- 12 V
- 15 A
- 180 W
- 700 W
- 2-phase
Isolated Full Bridge Converter

Efficiency comparison @ 12 V_{OUT}
eGaN FET @ 333 kHz vs MOSFET @ 250 kHz
Isolated Full Bridge Converter
PoE-PSE Full Bridge Converter

Efficiency vs. Output Current (A)

- 38 V eGaN FET
- 38 V MOSFET
- 48 V eGaN FET
- 48 V MOSFET
- 60 V eGaN FET
- 60 V MOSFET

- 140 kHz MOSFET
- 250 kHz eGaN FET

550 W, 700 W, 98% efficiency
PoE-PSE Full Bridge Converter

Efficiency vs. Output Current (A) for different input voltages:
- 38 V Two phase
- 38 V Single phase
- 48 V Two phase
- 48 V Single phase
- 60 V Two phase
- 60 V Single phase
PoE-PSE Full Bridge Converter
Integrated Gate Driver Solution

LM5113 from National Semiconductor

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EPC Product Plans
Beyond 600 Volts

EPC’s eGaN FET products will extend to 600V in 2011 and to 900V and 1200V in 2012 if there is adequate customer interest.
Beyond Discrete Devices

**Driver On Board**

Discrete FET with Driver

Full-Bridge with Driver and Level Shift
Conclusions

• eGaN® technology opens up options for improving overall system efficiency.

• eGaN FETs demonstrated significant performance improvement

• eGaN technology will enable even higher power density and cost reductions through higher levels of integration.
The end of the road for silicon.....

is the beginning of the eGaN FET journey!