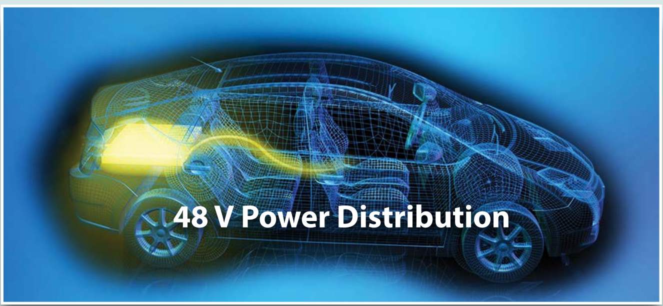
eGaN® FETs and ICs for Automotive DC-DC Applications

EFFICIENT POWER CONVERSION

Automotive electronics can now take full advantage of the improved efficiency, speed, smaller size, and lower cost of enhancement-mode gallium nitride (eGaN®) devices. Already, several large applications where GaN has significant advantages over the aging silicon MOSFET have emerged, particularly at the 48 V input node.



48 V_{IN} to 12 V_{OUT} for mild hybrid power

12 – 24 V_{IN} to 3.3 V_{OUT} for Infotainment

48 V_{IN} to 12 V_{OUT} for Mild Hybrid Power

By 2025, one of every 10 vehicles sold worldwide will be a 48 V mild hybrid. 48 V systems boost fuel efficiency ~ 10-15% delivering 4X the power without increasing engine size, and carbon-dioxide emissions by 25%[1].

The need for 48 V bus power distribution becomes increasingly evident with all the new power hungry electronically driven functions and features appearing on the latest cars. For example: Electric start-stop, electric steering, electric suspension, electric turbo-supercharging, variable speed air conditioning to name just a few.

And now, with the emergence of autonomous vehicles, additional demands from systems such as lidar, radar, camera, and ultrasonic sensors, are placed upon the power distribution system. These require high performance graphic processors to gather, interpret, integrate, and to make sense of it all. These processors are very power hungry and put an additional burden on traditional automotive 12 V electrical distribution buses.

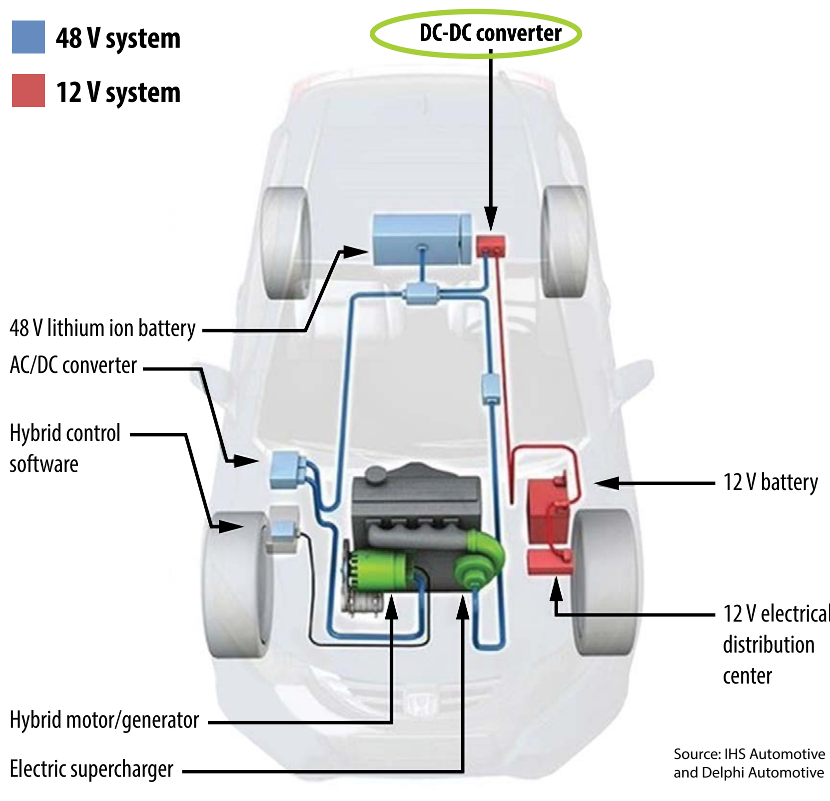


Figure 1. Representation of 48 V mild hybrid system

Why GaN?

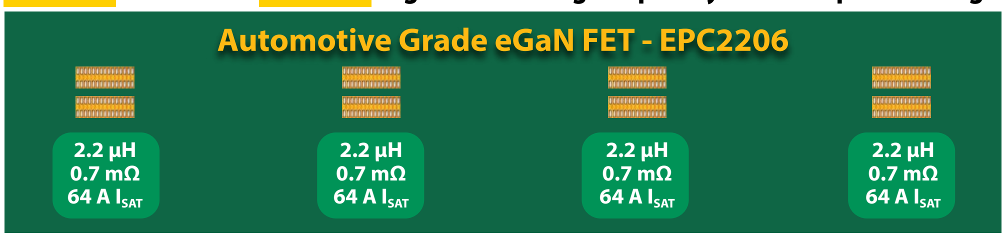
For 48 V bus systems, GaN technology increases the efficiency, shrinks the size, and reduces system cost. Due to the fast switching speed GaN-based solutions can operate at 250 kHz per phase as oppose to 125 kHz per phase for traditional MOSFET solutions. As an example, in a 3 kW 48 V to 12 V DC-DC converter, this higher switching frequency results in the reduction from a five-phase system to a four-phase system, reducing both size and cost. As seen in figure 2 the GaN-based solution is 35% smaller, results in 10 W lower inductor DCR losses, AND reduces cost of the system by about 20% over the MOSFET solution.

GaN is ... *SMALLER*

MOSFET Solution at 125kHz: 5-Phase design required for 250A (inductor limited)

H = 46 mm
L = 163 mm
Area = 75 cm²

GaN FET Solution at 250 kHz: Higher switching frequency allows 4-phase design



H = 38 mm
L = 130 mm
Area = 49 cm²

35% Smaller, 10 W Lower Inductor DCR Loss

Figure 2. Solution size comparison of eGaN FET vs. silicon MOSFET in a 48 V to 12 V, 3 kW system

GaN is ... *MORE EFFICIENT*

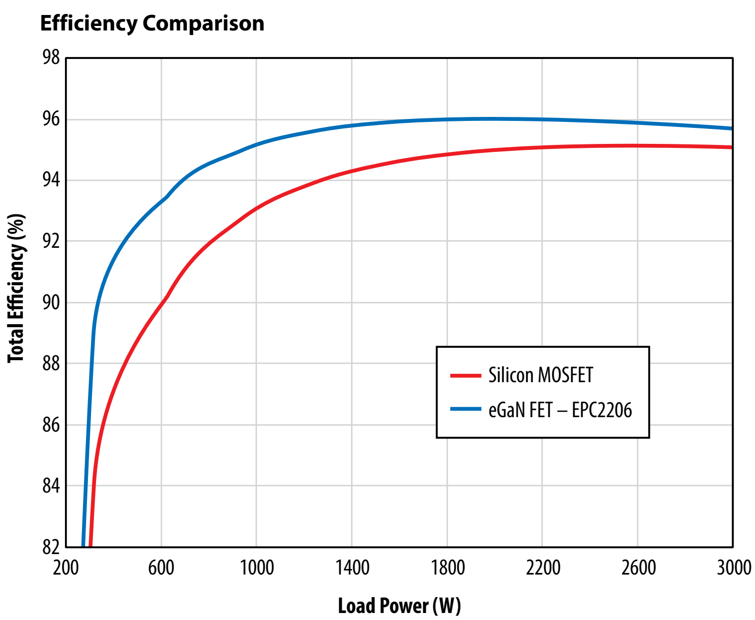


Figure 3. Efficiency and cost comparison of eGaN FET vs. silicon MOSFET in a 48 V to 12 V, 3 kW system

GaN is ... *LOWER COST*

Costs	Solutions	
	MOSFET	eGaN
Inductor Cost MOSFET = 5 per GaN FET = 4 per	$5.50	**$4.40**
FET Cost MOSFET = 10 per GaN FET = 8 per	$10.30	**$9.90**
Driver Cost MOSFET = 5 per GaN FET = 4 per	$2.50	**$2.00**
PCB Cost (estimate at $0.025/cm²)	$1.88	**$1.23**
Housing Cost (add. for larger MOSFET solution)	$2.00*	**-**
Total DC-DC Converter Sub-Cost	**$22.20**	**$17.50**

*estimate

12 – 24 V_{IN} to 3.3 V_{OUT} for Infotainment

Worldwide shipments of in-vehicle infotainment systems are expected to exceed 183 million units by the year 2022 (Statista). Modern infotainment systems contain many advance features such a touch screen capability, Bluetooth communications, digital and high-definition TV, satellite radio, GPS navigation, and even gaming. These systems put additional demand on the vehicles power system.

Why GaN?

GaN devices are much smaller in size and have less capacitance when compared to silicon MOSFETs. The superior figure of merit (FOM) of GaN transistors compared to state-of-the-art silicon MOSFETs allows designers to operate systems at much higher create systems that are smaller, more efficient, run cooler, and cost less. (Figure 4)

As an example of how this improvement in FOM translates to performance, a system with 12 V to 24 V input range and 3.3 V output was built to compare 100 V eGaN FETs against Si MOSFET solution. Both converters were operated to 10 A at 2 MHz. At 12 V input, the eGaN solution is nearly 5% higher peak efficiency and 2 W lower power loss. At 24 V input, the eGaN solution provides a nearly 7% higher peak efficiency and 3.1 W lower power loss. (Figure 5)

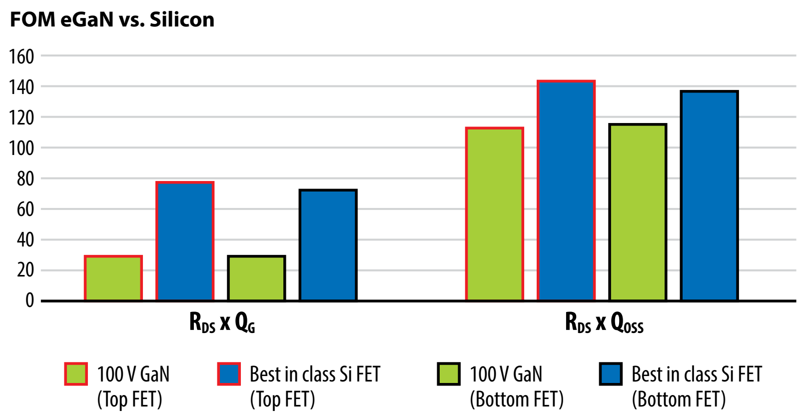


Figure 4. Figure of Merit (FOM) eGaN FET vs. Silicon MOSFET

GaN is ... *MORE EFFICIENT*

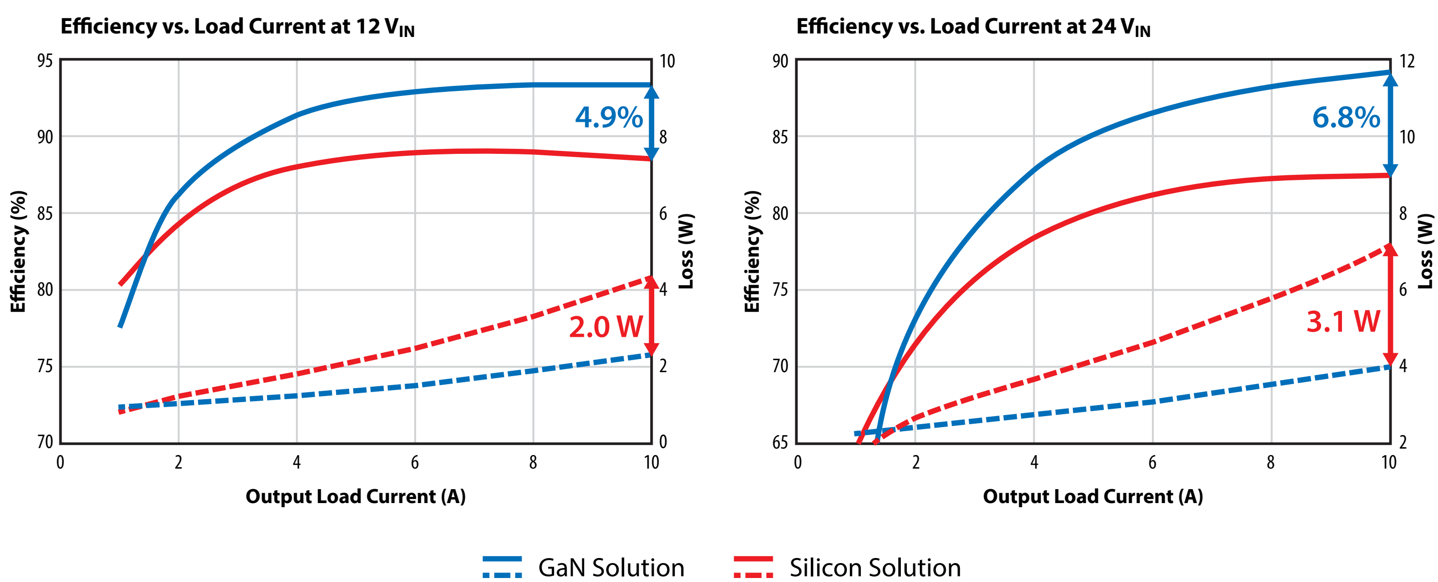


Figure 5. Efficiency and power loss comparison of eGaN FET vs. Silicon MOSFET

GaN is ... *COOLER*

Despite the significantly smaller size of the eGaN FET, the higher efficiency and lower power loss allows the GaN-based solution to run cooler than the larger MOSFET solution. Figure 6 shows the thermal performance of both boards operating at 24 V input, 3.3 V output, 2 MHz, with no airflow and no heatsink. The hotspot in the GaN-Based solution board is a 10°C lower than the silicon board.

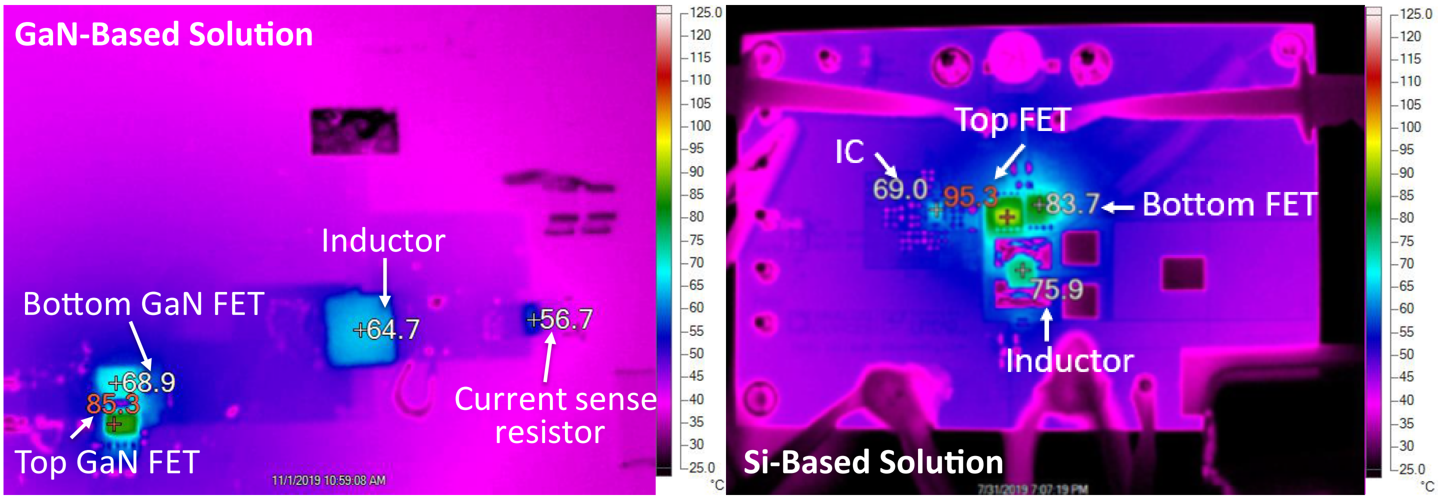
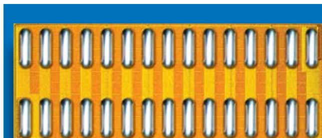
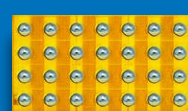


Figure 6. Thermal performance comparison of eGaN FET vs. silicon MOSFET

	 6.05 mm x 2.3 mm	 2 mm x 3.5 mm	 1.5 mm x 2.5 mm
Parameter	**EPC2206 (@ 5 V_{GS})**	**EPC2053* (@ 5 V_{GS})**	**EPC2045* (@ 5 V_{GS})**
V_{DS}	80 (AEC-Q101)	100	100
$R_{DS(on)}$ typ	1.8 mΩ	3.2 mΩ	5.6 mΩ
$R_{DS(on)}$ max	2.2 mΩ	4 mΩ	7 mΩ
Q_G typ @ 50 V_{DS}	15 nC	12 nC	5.9 nC
Q_{GD} typ @ 50 V_{DS}	3 nC	1.5 nC	0.8 nC
Q_{OSS} typ @ 50 V_{DS}	72 nC	43 nC	25 nC
Q_{RR} typ	0 nC	0 nC	0 nC
Device Size	13.9 mm^2	7 mm^2	3.75 mm^2
Development Board	EPC90122	EPC9093	EPC9078

* AEC versions in development. Contact EPC for more information

EPC
EFFICIENT POWER CONVERSION

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