

eGaN® FETs Deliver the Performance of GaN at the Price of Silicon

New family of eGaN FETs has superior performance, smaller size, high reliability, and a lower price.



Alex Lidow PhD, Johan Strydom, PhD, Efficient Power Conversion Corporation

Power transistors made using gallium nitride (GaN) instead of silicon have been in production for several years. GaN-based transistors can be found in over 1,000 designs in applications such as envelope tracking for 4G/LTE base stations, LiDAR systems for autonomous vehicles, Class-D audio systems, satellites, automotive lighting, wireless power transmitters, AC-DC and DC-DC power supplies, to name just a few. The designers of the earliest applications were driven to GaN based on the faster speeds that could be achieved when switching power. Faster switching can translate into smaller size, higher efficiency, and lower system cost. GaN transistors switch ten times faster than silicon devices. In order to get this enhanced performance, customers paid a premium price for the state-of-the-art in power transistors.

NOW THAT IS CHANGING...

A new line of eGaN FETs is now available that are not only much faster and smaller than power MOSFETs with similar on-resistance and voltage ratings, but these new transistors are priced favorably at comparable volumes. This is the first time in 60 years that there has been a non-silicon technology that has both superior performance and price compared with their silicon-based counterpart. It's not a fluke; since launching in 2010, EPC has been manufacturing GaN devices with steadily improving performance.

Those devices opened up entirely new markets for products in medical, automotive, consumer, and telecommunications that would not exist but for the improved performance enabled by GaN. These are fun applications, like virtual reality glasses and advanced gaming features. They are applications designed to add great convenience to our lives, like wireless power and autonomous vehicles. But most significantly, they are life-changing applications, like mobile communications in developing countries, colonoscopies-in-a-pill, and wireless heart pumps that dramatically improve the quality of life for those using them.

Benefiting from the learning curve of the last five years, the cost of producing GaN devices has dropped to substantially lower than the cost to produce silicon devices, and EPC is bringing that benefit to the consumer with this new family of devices.

To illustrate this performance and cost advantage the EPC2035 and the EPC2036 are shown in table 1. The power MOSFETs used for comparison were selected based on having roughly comparable maximum rated on-resistance ($R_{DS(on)}$) and having the same maximum rated breakdown voltage ($V_{DS(max)}$). Note that the indicators of switching speed, Q_{OSS} , Q_{GD} , and Q_G , are also shown in this table for comparison (Lower values are better). Likewise, the capacitances are significantly less for the GaN devices than for their counterpart MOSFETs. Device area is also shown for comparison. Finally, in the far right columns are comparisons of low, mid, and high volume pricing as indicated on the Digi-Key web site.

Device	V_{DS} (max)	$R_{DS(on)}$ (max)	Q_{OSS} (typ @50% BV)	Q_{GD} (typ @50% BV)	Q_G (typ @5 V)	C_{ISS} (typ)	C_{RSS} (typ @50% BV)	C_{OSS} (typ @50% BV)	Device Area	Price Comparison		
										1Ku	10Ku	100Ku
EPC2035	60 V	45 mΩ	3 nC	0.16 nC	1.2 nC	100 pF	1.6 pF	60 pF	0.81 mm ²	\$0.360	\$0.293	\$0.230
MOSFET A	60 V	35 / 42 mΩ	7 nC	3.5 nC	19 nC	985 pF	50 pF	90 pF	19.11 mm ²	\$0.382	\$0.313	\$0.285
EPC2036	100 V	73 mΩ	3.9 nC	0.17 nC	0.7 nC	75 pF	0.7 pF	50 pF	0.81 mm ²	\$0.376	\$0.306	\$0.240
MOSFET B	100 V	56 / 88 mΩ	6.5 nC	1.3 nC	2.8 nC	301 pF	3.6 pF	70 pF	32.5 mm ²	\$0.396	\$0.324	\$0.295

Table 1: Comparison of electrical specification and pricing between eGaN FETs and MOSFETs

EXPERIMENTAL RESULTS:

To evaluate the performance of these small, cost-competitive parts, consider a low-current high-voltage buck converter application. In this example, two EPC2035s were used to create 48 V to 5 V DC-DC point of load (POL) converter using the LM5113 as driver. Shown in Figure 1 are the typical waveforms when operating at a switching frequency of 1 MHz and an output current of 4 A. The hard-switching edge rise-time on the switch-node voltage is shown to be around 1.3 ns - an average of over 30 V/ns! Also of note is that despite the extremely fast switching, there is minimal voltage overshoot (10%) at the completion of the transition with a ringing frequency of 500 MHz, resulting from a power loop inductance of only 2 nH.

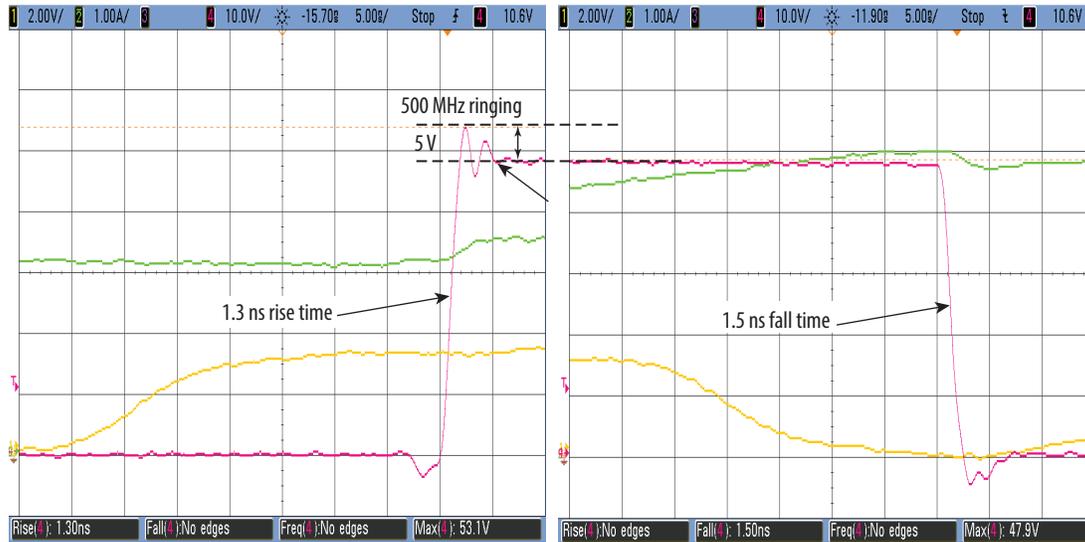


Figure 1: Typical Waveforms for EPC9049 $V_{IN} = 48\text{ V}$ to $5\text{ V}/4\text{ A}$ (1000 kHz) Buck converter showing rising and falling edges, CH1: (V_{PWM}) Input logic signal – CH2: (I_{OUT}) Output inductor current – CH4: (V_{OUT}) Switch node voltage

SUMMARY:

With this new family of eGaN FETs, the design engineer can realize lower cost, superior switching speeds, and a smaller final product when designing with these parts. The last barrier to the widespread adoption of GaN transistors as silicon MOSFET replacements has fallen.