Improve DC-DC Flyback Converter Efficiency Using eGaN FETs

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DC-DC converter designers can achieve low cost at low power densities by using flyback converters and enhancement mode gallium nitride transistors. To evaluate the performance of eGaN FETs in a flyback converter, two different converter designs were created and compared to MOSFET equivalent versions of the same design. Both converters were targeted at Power over Ethernet (PoE) low power (13 W) Powered Device (PD) applications. The first of these two converters was aimed at small size; the second design was aimed at high efficiency.

Both of the converter designs were based as close as possible on the controller manufacturers' suggested circuits. As the driver requirements for eGaN FETs are somewhat different to traditional MOSFET's, it was necessary to add discrete external drivers to the eGaN converter versions as shown in figure 1.

The MOSFET and eGaN FET devices used for each of the converters are listed in table 1.

SMALL SIZE 13 W FLYBACK CONVERTER

Figure 2 on the following page shows an implementation of a 48 V to 5 V, 13 W PoE-PD flyback converter utilizing the LT1725 IC from Linear Technology [1] which is a general purpose flyback controller. The datasheet for the LT1725 specifies a maximum operating frequency of 250 kHz, however, in this implementation the frequency was adjusted to 400 kHz to show the higher frequency advantages of the eGaN FET.

Both eGaN FET and MOSFET-based converter efficiencies for operation at 300 kHz and 400 kHz are shown in figure 3. The MOSFET (FDS2582, 150 V, 66 mΩ [2]) is compared to an EPC1012 die (200 V, 100 mΩ [3]). It can be seen that the eGaN FET efficiency results are consistently about 2% higher than the MOSFET converter for all but heavy load despite a 50% higher $R_{DS(ON)}$. In fact, the eGaN FET efficiency at 400 kHz is still higher than the equivalent MOSFET 300 kHz version over most of the load range.

Waveforms in figure 4 shows eGaN FET gate and drain operation at 400 kHz, as well as the converter's output voltage.

	Part Number	V_{DS} (V)	I_D (A)	$R_{DS(ON)}$ (mΩ)	Q_G (nC)	Q_{GD} (nC)	Rectifier Figure of Merit	Switching Figure of Merit
Primary MOSFET	FDS2582	150	4.1	66	19	4.4	1254	290
Primary eGaN FET	EPC1012	200	3	100	1.9	0.9	190	90
S/R MOSFET	SIR464	40	50	4.2	28.2	9	118	38
S/R eGaN FET	EPC1015	40	33	4	11.5	2.2	46	9

Table 1: Comparison of MOSFETs and eGaN FETs used in the flyback converters

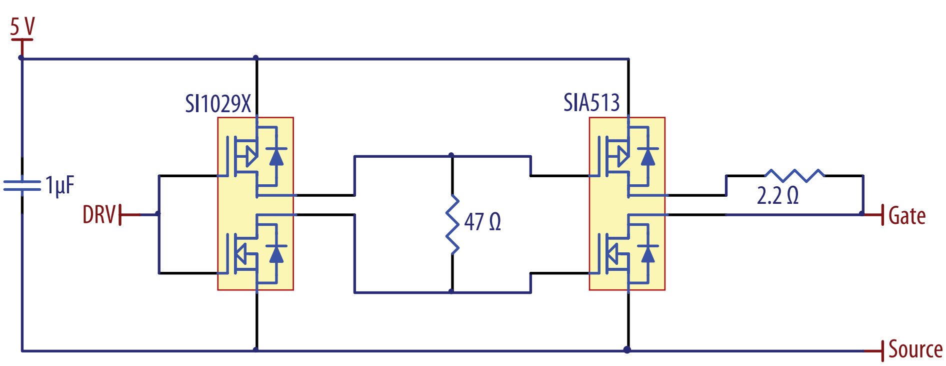

Figure 1: Discrete gate driver circuit used in eGaN flyback controllers.

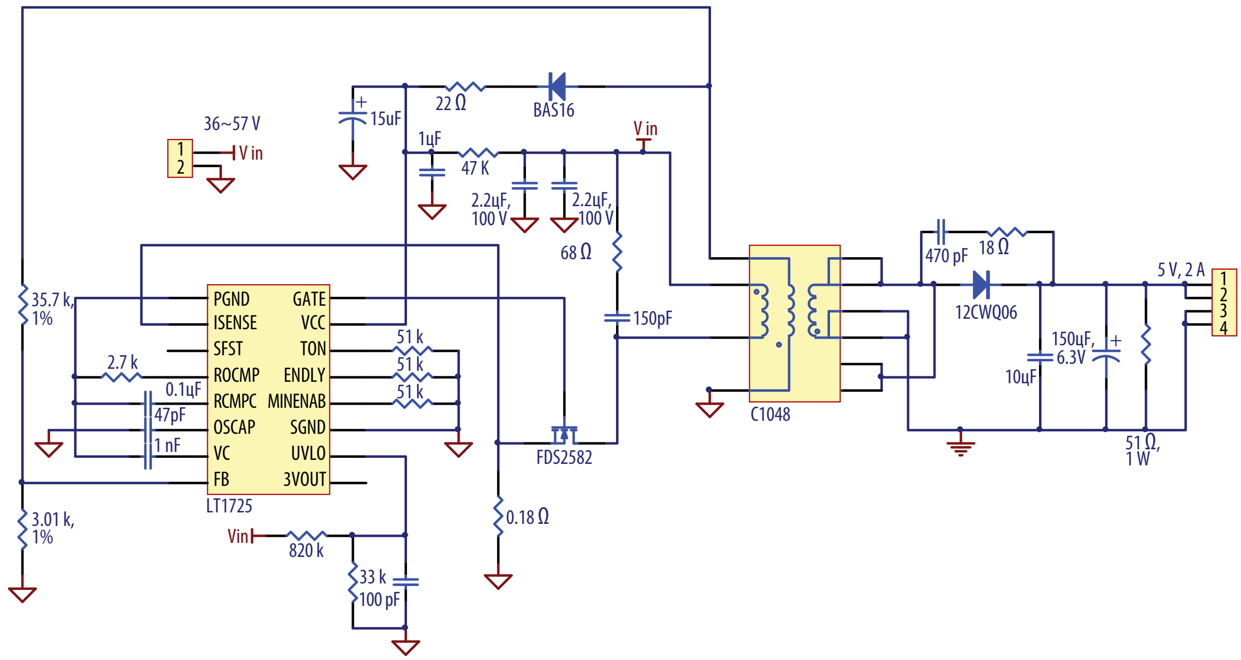

Figure 2: LT1725-based 48 V to 5 V, 13 W PoE flyback converter.

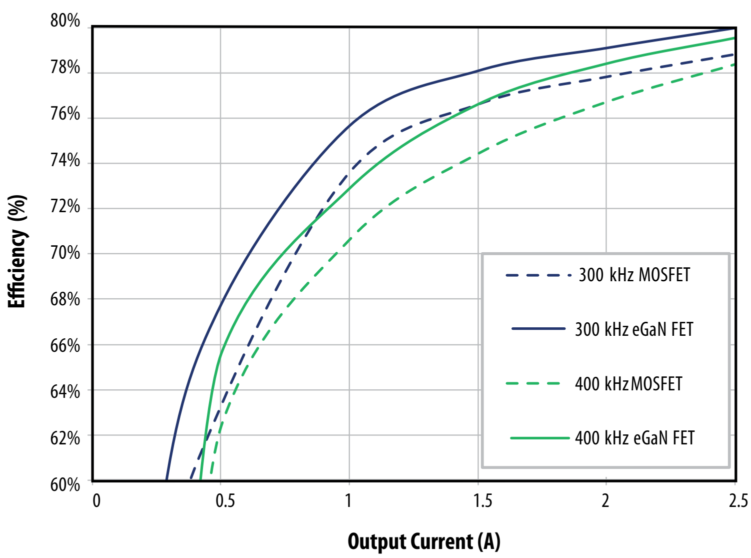

Figure 3: Efficiency comparison of eGaN FETs vs. MOSFETs for a 48 V to 5 V, 13 W flyback converter.

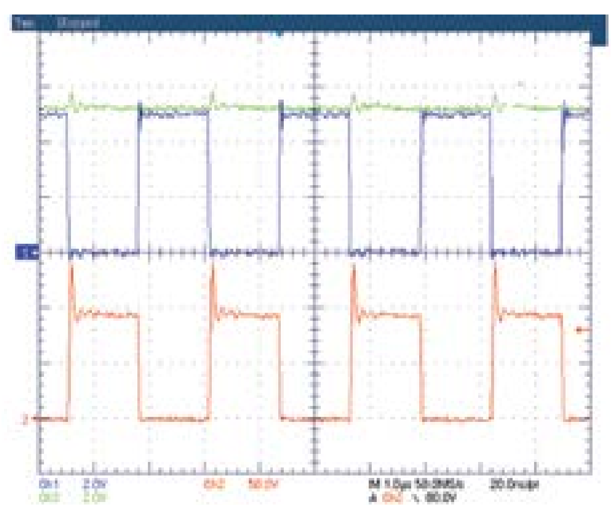

Figure 4: LT1725 eGaN FET Gate and Drain waveforms (f=400 kHz, V_{IN}=48 V, V_{OUT}=5 V, I_{OUT}= 2.5 A) CH1: eGaN FET Gate drive, CH2: eGaN FET Drain, CH3: Converter output voltage.

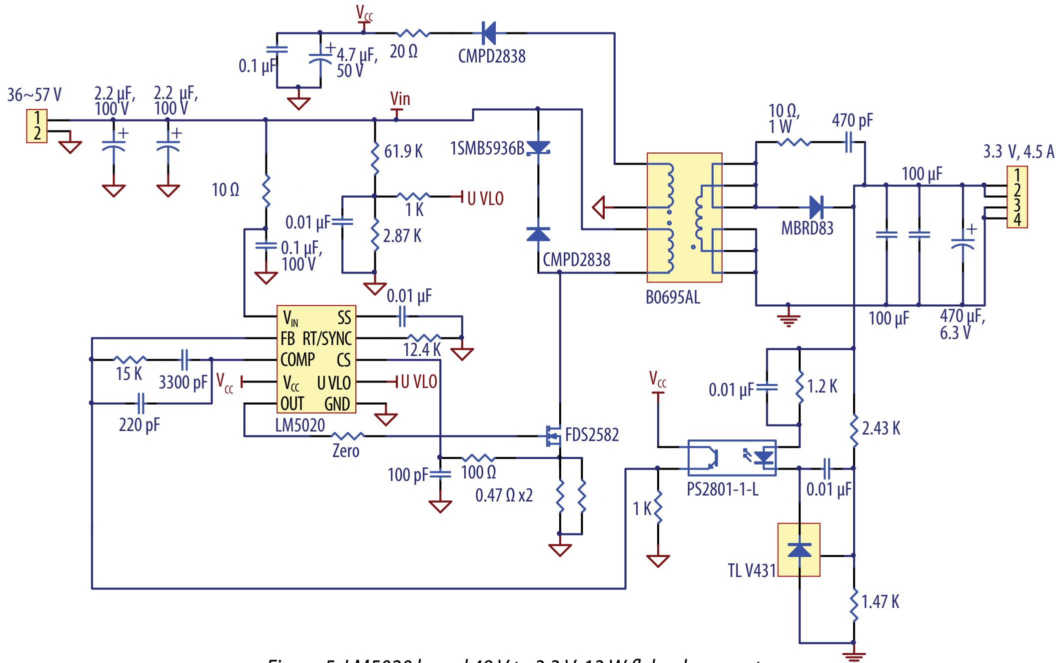

Figure 5: LM5020 based 48 V to 3.3 V, 13 W flyback converter.

HIGH EFFICIENCY 13 W FLYBACK CONVERTER

Figure 5 shows the schematic of the flyback converter using the LM5020 from National Semiconductor [4]. This circuit is virtually identical to the application given in the LM5020 datasheet. The converter efficiency was measured at 300 kHz and 500 kHz and the results are shown in figure 6. It can be seen that the 300 kHz MOSFET converter and eGaN FET converter efficiency results are almost identical despite a 50% higher $R_{DS(ON)}$ for the eGaN FET compared to the MOSFET. This is a result derived from the eGaN FETs' lower switching loss.

Note how little the drop in efficiency for the eGaN FET solution is when the switching frequency is increased to 500 kHz. The drop in efficiency is about 0.5% for the eGaN FET-based solution versus about 2% for the MOSFET solution. Waveforms in figure 7 show eGaN FET gate and drain voltage at 500 kHz, as well as the converter's output voltage.

SUMMARY

In this paper, two eGaN FET-based 13 W flyback converters were built and evaluated side by side with standard MOSFET designs. One was optimized for small size, and the other was optimized for high efficiency. In both cases, eGaN FET flyback converters showed higher efficiencies and the potential of reducing system costs over their MOSFET counterparts.

REFERENCES:

[1] http://cds.linear.com/docs/Datasheet/1725fa.pdf
[2] thttp://www.fairchildsemi.com/ds/FD%2FFDS2582.pdf
[3] http://epc-co.com/epc/documents/datasheets/EPC1012_datasheet_final.pdf
[4] http://www.national.com/ds/LM/LM5020.pdf

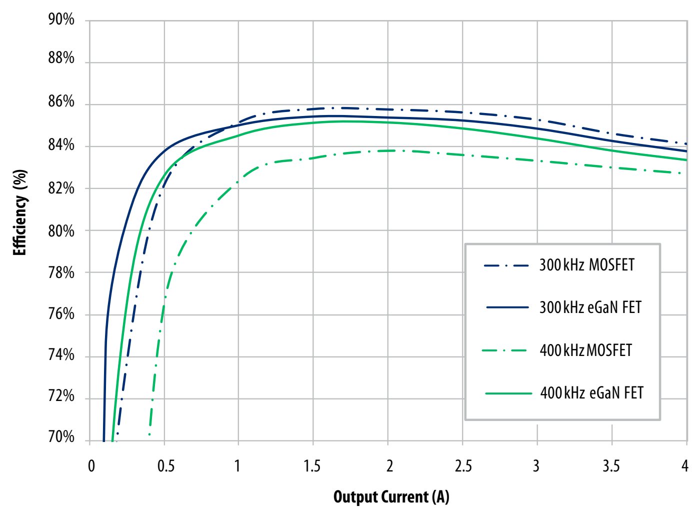

Figure 6: Efficiency comparison of eGaN FET vs MOSFET for 48 V to 3.3 V, 13 W flyback converter.

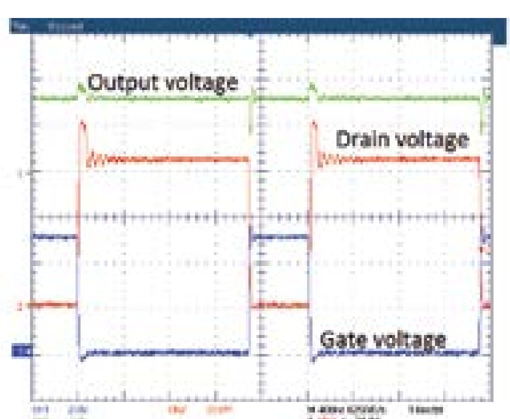

Figure 7: LM5020 waveforms (f=500 kHz, V_{IN}=48 V, V_{OUT}=3.1V, I_{OUT}= 4 A).