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Switching speed controllable GaN FET

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Abstract

This work introduces our latest combined GaN FET technology released to the market. Based on the advantages of a new structure design of the driving circuit integrated, the new device gets the benefits of high efficiency, high switching frequency and low EMI problem. These features make the device ideal fit for QR flyback topology, supporting the trend for compacted high power-density quick-charger and PD adapters.

Index Terms—Cascode structure, gallium nitride (GaN) highelectron-mobility transistor (HEMT), Quasi-Resonant Flyback, EMI.

1 Introduction

In switching power supply applications, gallium nitride(GaN) high electron-mobility transistor (HEMT), provides the best FOM. It can work at the highest switching frequency, achieving high power density. Especially in the field of mobile phone fast charging and PD adapter, GaN HEMT excellent high-frequency characteristics reduce the transformer size, and its higher conversion efficiency also supports a smaller size of the adapter for heat dissipation. However, in the quasi-resonant(QR) flyback converter, the turn-on speed of the primary side main switch will lead to extremely high voltage spikes on the secondary side FET (Fig1), causing break down risk and bad EMI performance. See Fig1,The turn-on can be reduced by increasing the resistance R10 of PWM controller driving circuit or device Gate resistance, but it will cause the delay of the driving signal, and the distortion driving waveform, resulting in the efficiency drop and seriously limit the increase of switching frequency. This method introduces a new type of GaN device that does not rely on the grid driving circuit, and can adjust the turn-on speed. It realizes the distortion-free driving waveform and the improvement of EMI performance, gives the high-frequency performance of gallium nitride devices, and realizes the design of high power density PD adapter.

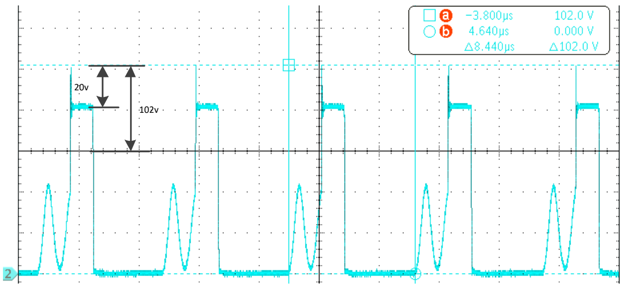

Fig. 1. Stress of Second side Synchronous Rectification MOSFET (SSR FET)

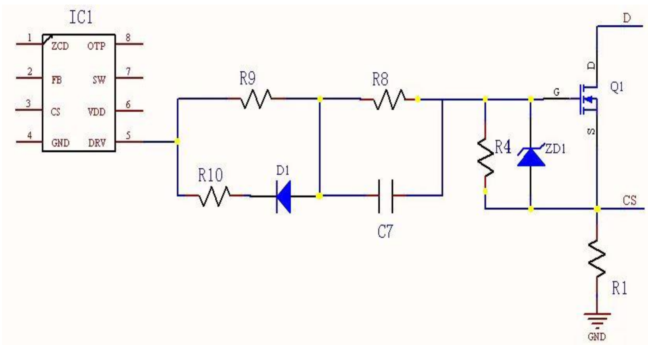

Fig. 2. Typical drive circuit of E-mode GaN device

Increasing R10 of driving circuit could make lower stress of SSR FET, but it causes long delay of driving signal, see Fig 3. To make the turn on slew rate below 5V/ns, it cause as long as 150ns turn on delay, which cause lower efficiency

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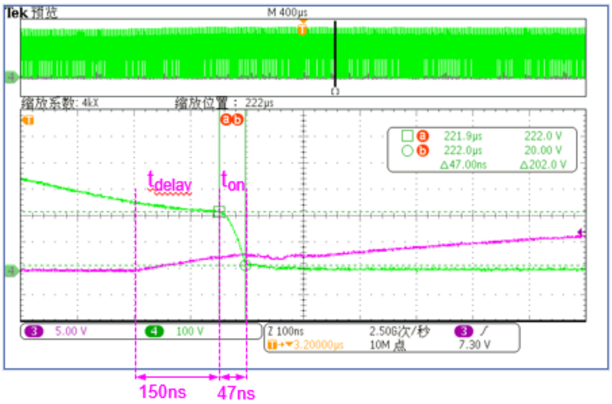

Fig. 3. Turn on delay of GaN by increase Rg

2 Turn on speed controllable device by Cascode GaN

The Cascode GaN device driving signal is received by the Low side Silicon MOSFET, while turn on speed is affected by the highside GaN HEMT. That means adjusting the GaN HEMT parameters could get on-off speed controlled with no any change of the driving signal. Adding resistance in series to the Gate of GaN HEMT, we can get the HEMT slew rate decreased both in turning on and off. Fig.5. shows the Cascode GaN device turn on at zero current in QR Flyback converter. The switching loss mainly contributed by turn off loss. So we need fast turn off and slow turn on. With by-pass diode of the speed control resistor, it makes the device fast turn off.

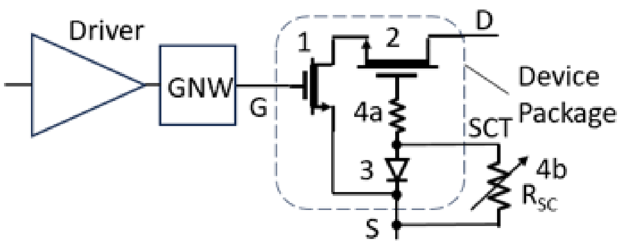

Fig. 4. Additional Resistance for turn on speed control

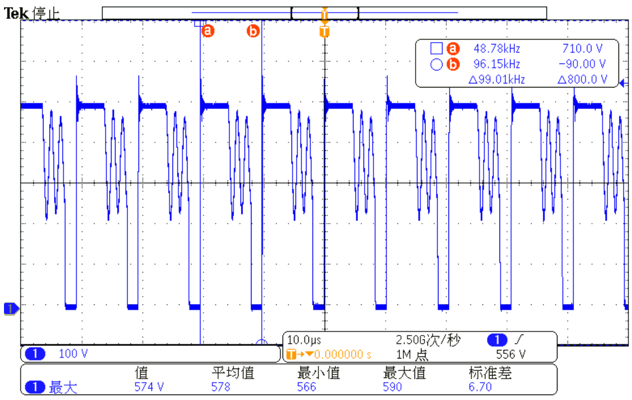

Fig. 5. Voltage of primary GaN FET

2.1 Performance evaluation of Speed controllable Cascode GaN

With speed controllable GaN, the driving circuit only need 2 resistors, making the design cost effective. Fig.6. The turn-on delay only 15ns with 30ohm Rg of the driver. It can make the SSR FET around zero spike of voltage stress Fig.8. the CE performance also improved over 6dB margin.Fig.9 Fig 10.

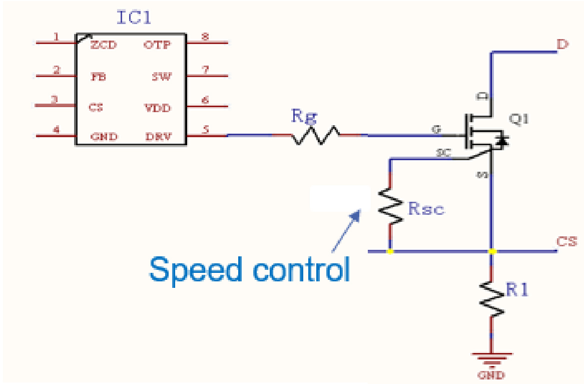

Fig. 6. Typical circuit of speed controllable GaN

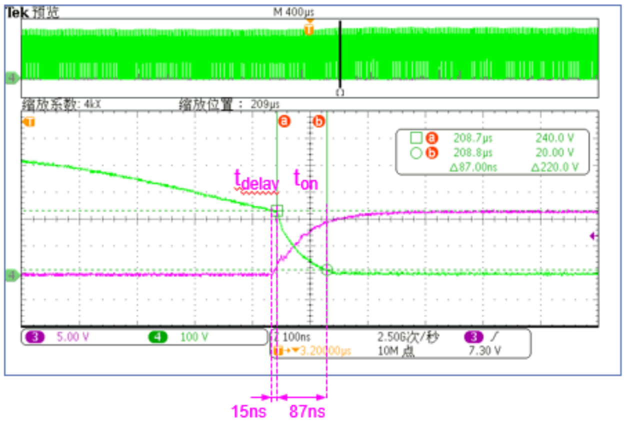

Fig. 7. Turn-on delay of speed controllable GaN

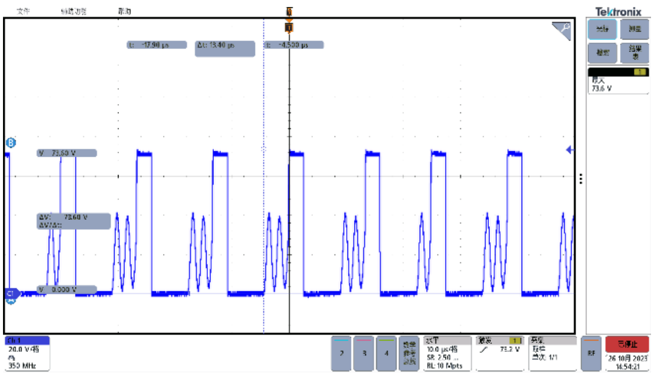

Fig. 8. Stress of SSR FET

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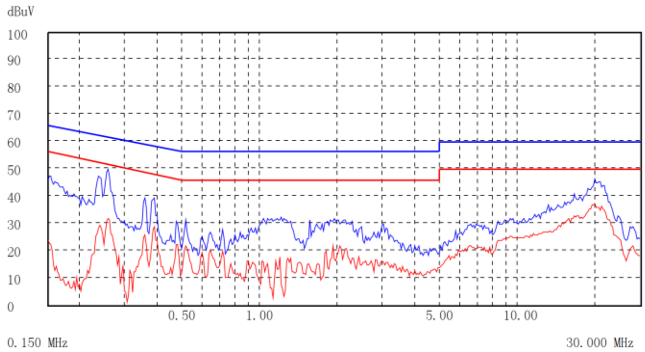

Fig. 9. CE of speed controllable Cascode GaN

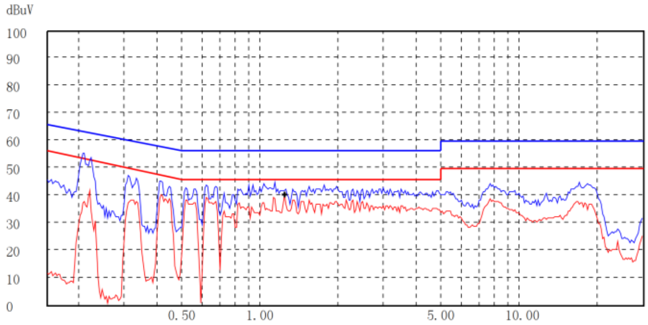

Fig. 10.CE of normal Cascode GaN

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