

Design Considerations for Gate Driver Active Gate Control: Voltage Peak Suppression and Turn-off Loss

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Background

- xEV traction inverter
- Efficiency
- SiC MOSFET

SiC MOSFET Switching

Lower gate resistance

→ Fast switching
 → Higher di/dt
 → Voltage overshoot ↑

Higher gate resistance

→ Slow switching
 → Lower di/dt
 → Switching loss ↑

Active Gate Control

Adjustable gate resistance control

Conventional control (single resistance)

Adjustable gate resistance control

Adjustable Control Method Considering the Operating Condition

Temperature dependence

- Miller plateau varies with junction temperature and load current
- Optimal t_{off_delay} should be selected considering the operation conditions

12Ω → 30Ω

T_j = 25°C

12Ω → 30Ω

T_j = 140°C

T_j=25°C → optimal t_{off_delay} = 160ns

t _{off_delay}	140 ns	160 ns	180 ns	200 ns	
V _{ds,peak} [V]	940	940	955	1011	-
E _{off} [mJ]	143.3	127.4	105.3	80.6	-

Operating Conditions

V_{ds} = 830V,
I_{ds} = 1000A,
t_{off_delay} = 140ns – 220ns

T_j=140°C → optimal t_{off_delay} = 180ns

t _{off_delay}	140 ns	160 ns	180 ns	200 ns	220 ns
V _{ds,peak} [V]	-	926	926	947	997
E _{off} [mJ]	-	153.4	139.3	115.9	91.8

Load current dependence

I_{ds}=600A → Optimal t_{off_delay} = 200ns

t _{off_delay}	140 ns	160 ns	180 ns	200 ns	220 ns
V _{ds,peak} [V]	925	926	927	927	959
E _{off} [mJ]	79.1	75.2	70.5	56.6	44.3

I_{ds}=1000A → Optimal t_{off_delay} = 160ns

t _{off_delay}	140 ns	160 ns	180 ns	200 ns	
V _{ds,peak} [V]	940	940	955	1011	-
E _{off} [mJ]	143.3	127.4	105.3	80.6	-

Operating Conditions

V_{ds} = 830V,
T_j = 25°C,
t_{off_delay} = 140ns – 220ns

Conclusion

- Adjustable gate resistance control reduces E_{off} without increasing overshoot
- Optimal t_{off_delay} must be aligned with the end of the Miller plateau, which varies with junction temperature and load current.
- The proposed scheme provides a practical and scalable solution for SiC MOSFET-based xEV traction inverters.