Design and Validation of a 1MHz Double-pulse Test (DPT) Methodology for 900V SiC MOSFET

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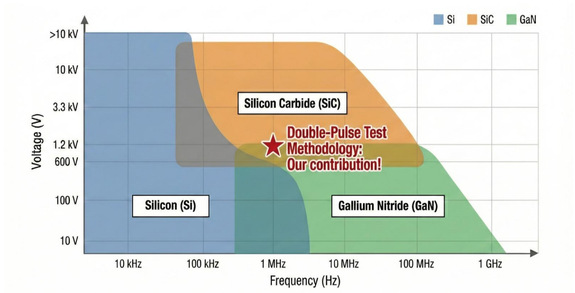
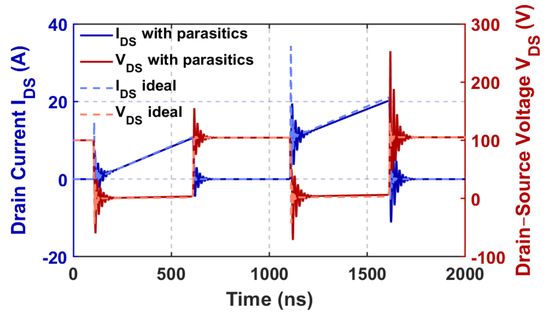
MOTIVATION

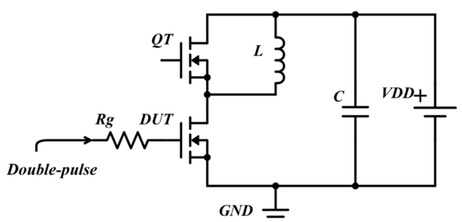
SiC MOSFET:
- faster switching; higher fs; lower switching loss
- high-voltage capability; thermal robustness



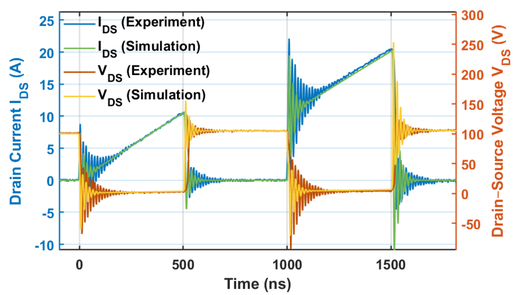
Challenge (MHz DPT):
- Parasitics: PCB/package/measurement
- Waveform distortion: extraction error

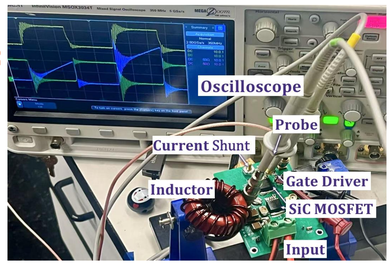


Double-pulse Test



- ringing frequency match < 5% deviation





RINGING SUPPRESSION

- An R_{dmp} is added based on a time-domain ohmic-region RLC model to suppress ringing.
- RLC model **with damping resistor**:

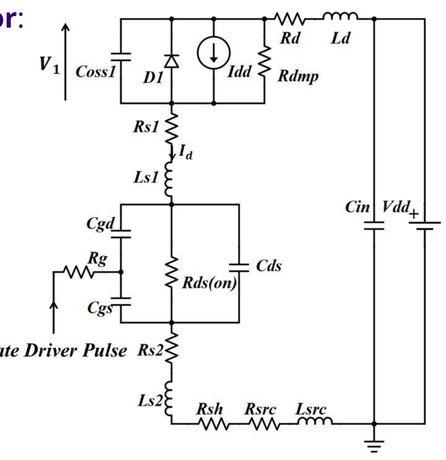
$$\frac{d^2 i_d}{dt^2} + \frac{R_\Sigma}{L_\Sigma}\frac{di_d}{dt} + \frac{1}{L_\Sigma C_{oss}}\, i_d = 0$$

$$\alpha' = \frac{1}{2}\left(\frac{R_\Sigma}{L_\Sigma} + \frac{1}{R_{dmp} C_{oss}}\right)$$

$$\omega_r' = \sqrt{\frac{1}{L_\Sigma C_{oss}}\left(1 + \frac{R_\Sigma}{R_{dmp}}\right) - \alpha'^2}$$

- Peak current (k-th oscillation):

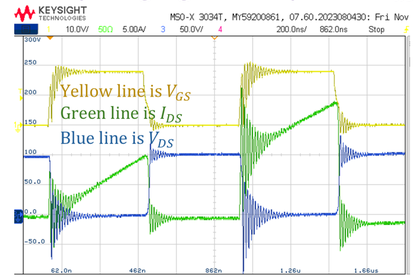
$$\Delta i_k' = \Delta i_1\, e^{-\alpha'(t_k - t_1)}\, \frac{\omega_r' \sqrt{A^2 + B^2}}{\sqrt{\omega_r'^2 + \alpha'^2}}$$

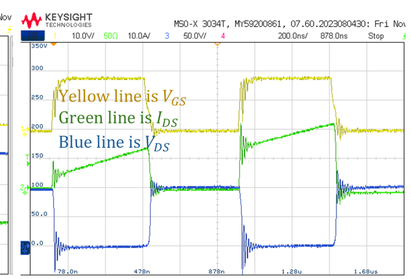


- **Trade-off:** Smaller R_{dmp} speeds ringing decay but increases turn-on bypass current and Ids stress.

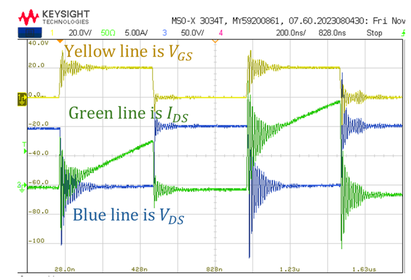
EXPERIMENTAL RESULTS

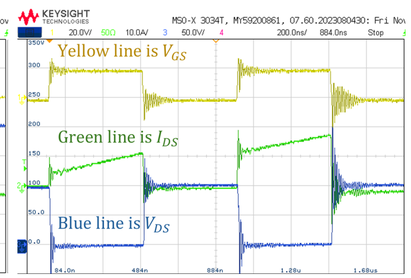
- **900 V C3M0065090J:** R_{dmp} suppresses 1 MHz commutation-loop ringing and improves I_{ds} / V_{ds} waveforms





- **1200 V AIMBG120R080M1:** validates the same approach





	C3M (w/o)	C3M (25Ω)	AIM(w/o)	AIM(25Ω)
t_f (ns)	10.0	9.2	3.2	2.4
E_{off}(μJ)	0.663	1.491	0.395	0.826
Overshoot (%)	101.0	63.7	125.0	81.4
t_r (ns)	10.8	10.8	7.6	7.6
E_{on} (μJ)	23.224	16.717	14.868	7.349
t_{rr} (ns)	8.46	6.98	6.30	5.64

CONCLUSION

Platform:
- 1 MHz DPT (900 V SiC) with low-parasitic layout

Modeling:
- VNA parasitics to LTspice

Design rule:
- time-domain ohmic-region guideline for R_{dmp}

Measured results (R_{dmp} = 25 Ω):
- >60% peak reduction; 15 to 5 cycles (900 V C3M0065090J)

Cross-device validation:
- 16 to 3 cycles on 1200 V AIMBG120R080M1
- no hardware changes