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Switching Behavior Investigation of 1200V CoolSiC^{TM} MOSFET G2 Discrete

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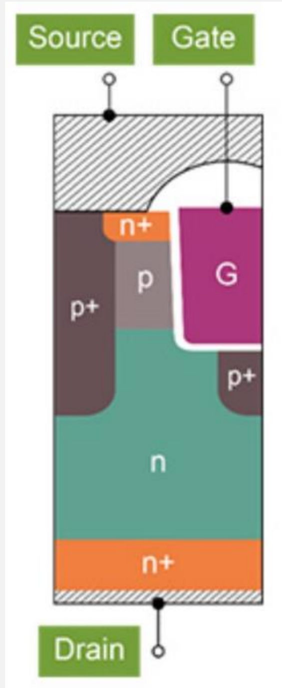
■ Introduction



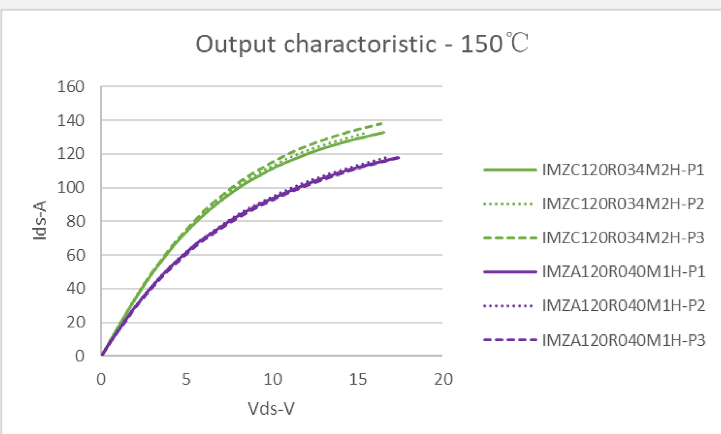
The power electronics industry demands high performance power semiconductors with elevated power density. In response to these requirements, Infineon has introduced CoolSiC^{TM} G2 MOSFET, featuring an optimized vertical structure and cell design. The CoolSiC™ MOSFET 1200 V G2 employs a vertical trench cell structure, carefully designed with multiple optimized parameters. These design enhancements yield the best on-state resistance – $R_{DS(on)}$ * A – without compromising reliability.

In comparison to planar devices, CoolSiC^{TM} MOSFET G2 exhibits advantages in hard switching due to its low switching loss. This advantage becomes more pronounced as the switching frequency increases. To investigate the behavior of the CoolSiC^{TM} MOSFET G2, a comparative study was conducted using G1 IMZA120R040M1H and G2 IMZC120R034M2H.

■ Static characteristic evaluation

$R_{DS(on)}$ of SiC MOSFET consists of channel resistance, JFET resistance, and drift zone resistance. Channel resistance exhibits a negative temperature dependence, whereas JFET and drift zone resistance displays a positive temperature dependence. Hence, total $R_{DS(on)}$-T_j coefficient is determined by ratio of three parts. CoolSiC^{TM} MOSFET G2 features an optimized channel quality, which results in a lower channel resistance value and proportion in the total on-resistance, it is expected that for G2 the $R_{DS(on)}$-T_j coefficient increases compared to G1.

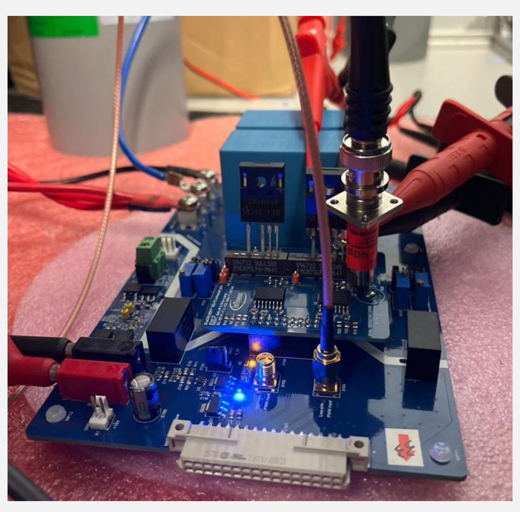
Output characteristics test of both parts was conducted. At low current range, e.g. Ids<20A, G1 and G2 show similar on-voltage. As Ids increase, on-voltage of G2 is significantly lower than G1. Moreover, G2 shows higher saturation current than G1, which means G2 will have higher short circuit current, hence shorter short circuit withstand time than G1.



Output characteristic

■ Double pulse test platform

Switching characteristic of power device is usually verified by double pulse test. Shunt resistor was used for accurate current measurement, and PMK BUMLE BEE high voltage probe was usd for V_{DS} due to its high bandwidth.



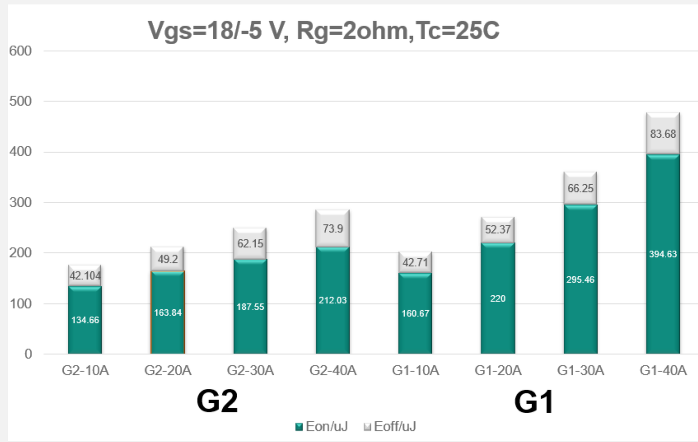
Test platform setup

Equipment	Model
Oscilloscope	Lecroy HDO6104
Waveform Generator	Lecroy Arbstudio 1104
Current	SDN414 Shunt-0.1 ohm
Voltage Probe	V_{DS}: PMK BUMBLE BEE
	V_{GS}: Cybertek P1300
Demo Board	EVAL-PS-DP-MAIN-M5
Test Condition	Input: 800V DC
	Ambient temperature-25℃

■ Switching loss investigation

● Loss comparison between G1 and G2

Switching behavior of G1 and G2 was investigated. Total loss of the G2 is lower than G1 across the entire current range. The difference in switching loss became more pronounced at higher current ratings.



Switching loss comparison

● Negative Vgs reduces turn off loss

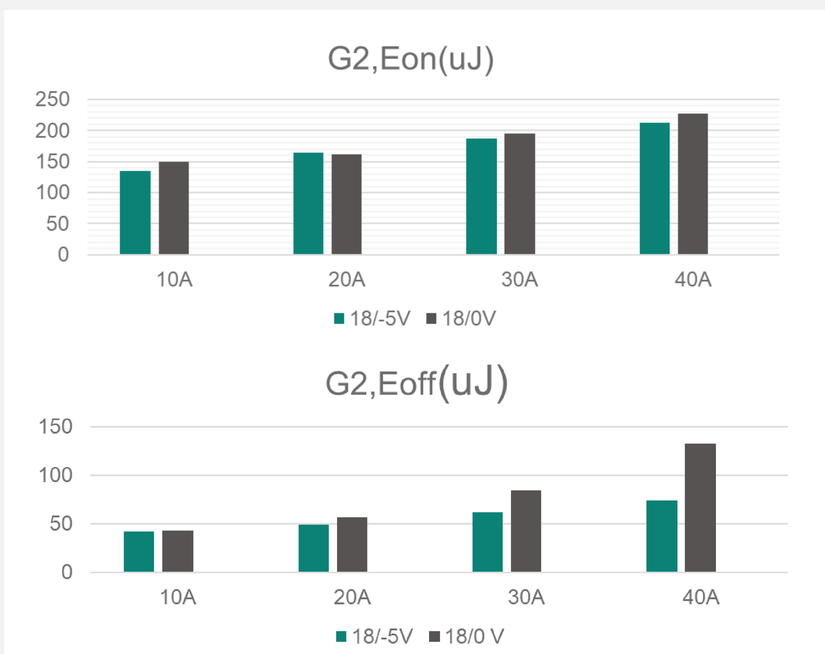
Using a turn-off voltage of -5 V instead of 0 V resulted in a significant reduction in turn-off loss, particularly at high gate resistor values and load currents.

☐ Rg=2Ω, various I_D

When a gate resistor of 2 Ω was used, the turn-off loss of the G2 device at I_D=40A was reduced by 44% when a turn-off voltage of -5 V was applied, compared to a turn-off voltage of 0 V.

☐ Various Rg, I_D=20A

When the drain current was maintained at 20 A and the gate resistor was increased, a 44% reduction in turn-off loss was observed when a gate resistor of 10 Ω was used.

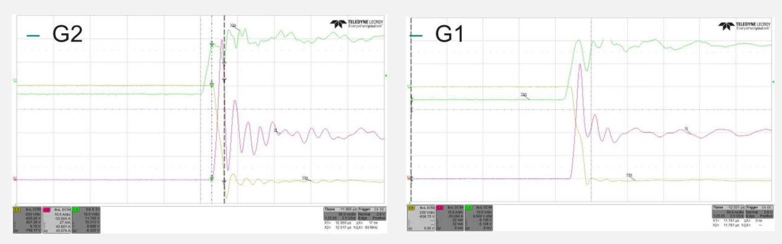


Switching loss at different I_D

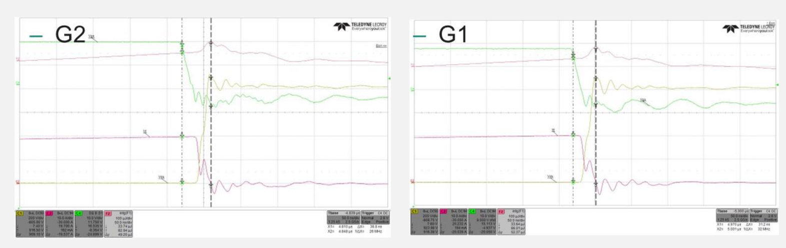
Switching loss at different Rg

● Switching waveform

During the swithing transient, the G2 device exhibits more pronounced oscillations compared to the G1 device, which can be attributed to its higher di/dt and dv/dt characteristics. However, despite these increased oscillations, the G2 device's switching behavior remains well-controlled.



Turn on transient



Turn off transient

■ Conclusion

With its optimized vertical structure and cell design, CoolSiC^{TM} G2 MOSFET achieves the lowest $R_{DS(on)}$*A in the industry. Additionally, the device exhibits advantages in hard switching by achieving low switching loss. The double pulse test results confirm the G2 device IMZC120R034M2H shows switching loss reduction of up to 40% compared to G1 IMZA120R040M1H . Furthermore, the influence of turn-off voltage on switching loss was investigated, and the results show a significant reduction in turn-off loss when using a turn-off voltage of -5 V, especially at high current condition and large gate resistor is used.