

# 650V 65mΩ Silicon Carbide Power MOSFET

## Features

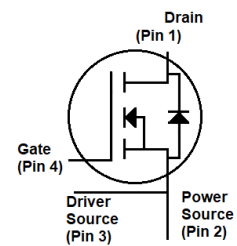
- High blocking voltage with low on-resistance
- High switching speed with low capacitance
- Very fast and robust intrinsic body diode with low reverse recovery
- Very low switching losses
- Excellent avalanche ruggedness
- RoHS compliant

## Benefits

- Greater system efficiency
- Reduced cooling requirements
- Increased power density
- Increased system switching frequency
- Easy to parallel and simple to drive

## Potential Applications

- Solar inverters
- Uninterrupted power supplies
- Switch mode power supplies
- Motor drives



Package Type: TO-247-4L



## Description

The Sanan Semiconductor 650V/65mΩ silicon carbide power MOSFET uses advanced SiC MOSFET technology with low on-resistance, low switching losses, and a high operation temperature of 175°C. It is suitable for use in high frequency circuits and provides a reduction in overall system size, increased efficiency and increased switching frequency. It has been widely used in applications including solar inverters, uninterrupted power supplies, switch mode power supplies, and motor drives. Using RoHS compliant components, it is qualified for use in industrial application.

## Product Specifications

Device	V <sub>DS</sub>	I <sub>D</sub> (25°C)	R <sub>(DS)on</sub>	Marking
SMS0650065M	650V	41A	65mΩ	MS0650065M

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**Table 1. Maximum Ratings**

(T<sub>C</sub> = 25°C, unless otherwise specified)

Parameter	Symbol	Value	Unit	Test conditions
Drain-source voltage	V <sub>DSmax</sub>	650	V	V <sub>GS</sub> = 0V, I <sub>D</sub> = 100μA
Gate-source voltage, max. transient voltage	V <sub>GSmax</sub>	-10/+25		t <sub>p</sub> ≤ 0.5us, D < 1%
Gate-source voltage, max. static voltage	V <sub>GSmax</sub>	-8/+22		
Gate-source voltage	V <sub>GSop</sub>	-5/+18		Recommended operation values
Continuous drain current	I <sub>D</sub>	41	A	V <sub>GS</sub> = 18V
		29		V <sub>GS</sub> = 18V, T <sub>C</sub> = 100°C
Pulsed drain current	I <sub>D(pulse)</sub>	103	A	Pulse width t <sub>p</sub> limited by T <sub>jmax</sub>
Power dissipation	P <sub>tot</sub>	179	W	
Operating junction temperature	T <sub>j</sub>	-55~175	°C	
Storage temperature	T <sub>stg</sub>	-55~175	°C	
Soldering temperature	T <sub>L</sub>	260	°C	1.6mm from case for 10s
Mounting torque	M	0.7	Nm	M3 screw

**Table 2. Thermal Resistances**

Parameter	Symbol	Values			Unit	Test condition
		Min.	Typ.	Max.		
Thermal resistance from junction to case	R <sub>th(j-c)</sub>	/	0.70	/	°C/W	
Thermal resistance from junction to ambient	R <sub>th(j-a)</sub>	/	/	40	°C/W	

**Table 3. Static Electrical Characteristics**

(T<sub>j</sub> = 25°C, unless otherwise specified)

Parameter	Symbol	Values			Unit	Test conditions
		Min.	Typ.	Max.		
Drain-source breakdown voltage	V <sub>(BR)DSS</sub>	650	/	/	V	V <sub>GS</sub> = 0V, I <sub>D</sub> = 100μA
Gate threshold voltage	V <sub>GS(th)</sub>	1.8	2.8	4.2		V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 4mA
		/	2.0	/		V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 4mA, T <sub>j</sub> = 175°C
Drain-source leakage current	I <sub>DSS</sub>	/	1	50	μA	V <sub>DS</sub> = 650V, V <sub>GS</sub> = 0V
Gate-source leakage current	I <sub>GSS</sub>	/	1	250	nA	V <sub>GS</sub> = 18V, V <sub>DS</sub> = 0V
Drain-source on-state resistance	R <sub>DS(on)</sub>	/	80	/	mΩ	V <sub>GS</sub> = 15V, I <sub>D</sub> = 12A
		/	65	85		V <sub>GS</sub> = 18V, I <sub>D</sub> = 12A
		/	80	/		V <sub>GS</sub> = 18V, I <sub>D</sub> = 12A, T <sub>j</sub> = 175°C
Transconductance	g <sub>fs</sub>	/	13	/	S	V <sub>DS</sub> = 20V, I <sub>D</sub> = 20A
		/	11	/		V <sub>DS</sub> = 20V, I <sub>D</sub> = 20A, T <sub>j</sub> = 175°C
Internal gate resistance	R <sub>G(int)</sub>	/	3.5	/	Ω	f = 1MHz, V <sub>AC</sub> = 25mV

**Table 4. Dynamic Electrical Characteristics**

(T<sub>j</sub> = 25°C, unless otherwise specified)

Parameter	Symbol	Values			Unit	Test conditions
		Min.	Typ.	Max.		
Input capacitance	C <sub>iSS</sub>	/	996	/	pF	V <sub>GS</sub> = 0V, V <sub>DS</sub> = 600V, f = 1MHz, V <sub>AC</sub> = 25mV
Output capacitance	C <sub>oss</sub>	/	99	/		
Reverse transfer capacitance	C <sub>rSS</sub>	/	1.6	/		
C <sub>oss</sub> stored energy	E <sub>oss</sub>	/	22	/	μJ	
Gate to source charge	Q <sub>GS</sub>	/	13	/	nC	V <sub>DD</sub> = 400V, V <sub>GS</sub> = -5/+18V, I <sub>D</sub> = 12A, I <sub>GS</sub> = 1mA
Gate to drain charge	Q <sub>GD</sub>	/	12	/		
Total gate charge	Q <sub>G</sub>	/	42	/		

**Table 5. Switching Characteristics**

( $T_j = 25^\circ\text{C}$ , unless otherwise specified)

Parameter	Symbol	Values			Unit	Test conditions	
		Min.	Typ.	Max.			
Turn-on delay time	$t_{d(on)}$	/	9	/	ns	$V_{DD} = 400\text{V}$ , $V_{GS} = -5/+18\text{V}$ , $I_D = 12\text{A}$ , $R_{G(ext)} = 4\Omega$ , $L = 110\mu\text{H}$	
Rise time	$t_r$	/	10	/			
Turn-off delay time	$t_{d(off)}$	/	20	/			
Fall time	$t_f$	/	13	/			
Turn-on switching energy	$E_{on}$	/	23	/	$\mu\text{J}$		
Turn-off switching energy	$E_{off}$	/	5	/			
Turn-on delay time	$t_{d(on)}$	/	7	/	ns		$V_{DD} = 400\text{V}$ , $V_{GS} = -5/+18\text{V}$ , $I_D = 12\text{A}$ , $R_{G(ext)} = 4\Omega$ , $L = 110\mu\text{H}$ $T_j = 175^\circ\text{C}$
Rise time	$t_r$	/	10	/			
Turn-off delay time	$t_{d(off)}$	/	24	/			
Fall time	$t_f$	/	14	/			
Turn-on switching energy	$E_{on}$	/	22	/	$\mu\text{J}$		
Turn-off switching energy	$E_{off}$	/	5	/			

**Table 6. Reverse SiC Diode Characteristics**

( $T_j = 25^\circ\text{C}$ , unless otherwise specified)

Parameter	Symbol	Values			Unit	Test conditions
		Min.	Typ.	Max.		
Diode forward voltage	$V_{SD}$	/	4.2	/	V	$V_{GS} = -5V, I_{SD} = 12A$
		/	3.7	/		$V_{GS} = -5V, I_{SD} = 12A,$ $T_j = 175^\circ\text{C}$
Continuous diode forward current	$I_S$	/	/	41	A	$V_{GS} = -5V, T_C = 25^\circ\text{C}$
Diode pulse current	$I_{S, pulse}$	/	/	103	A	$V_{GS} = -5V$ , pulse width $t_p$ limited by $T_{jmax}$
Reverse recovery time	$t_{rr}$	/	13	/	ns	$V_{GS} = -5V, I_{SD} = 12A,$ $V_R = 400V,$ $di/dt = 1.31kA/\mu s$
Reverse recovery charge	$Q_{rr}$	/	0.14	/	$\mu\text{C}$	
Peak reverse recovery current	$I_{rrm}$	/	18	/	A	

**Electrical Characteristic Diagrams**

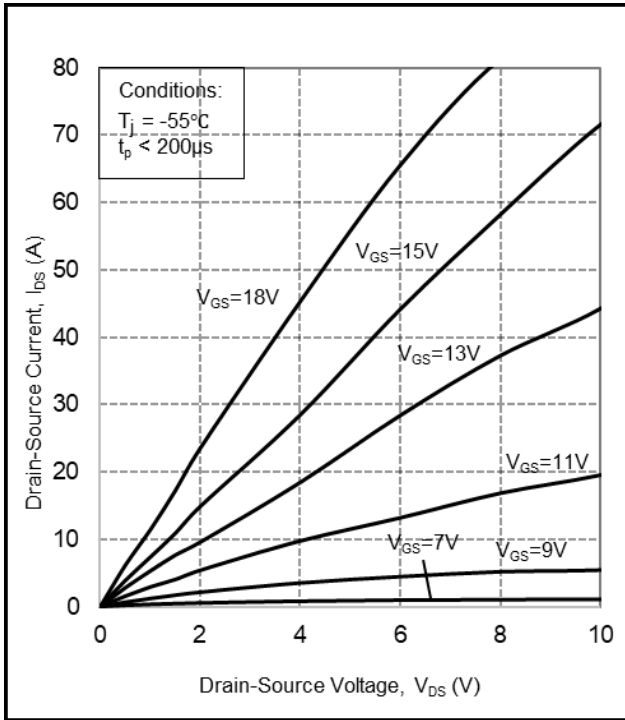


Figure 1. Output characteristics at  $T_j = -55^\circ\text{C}$

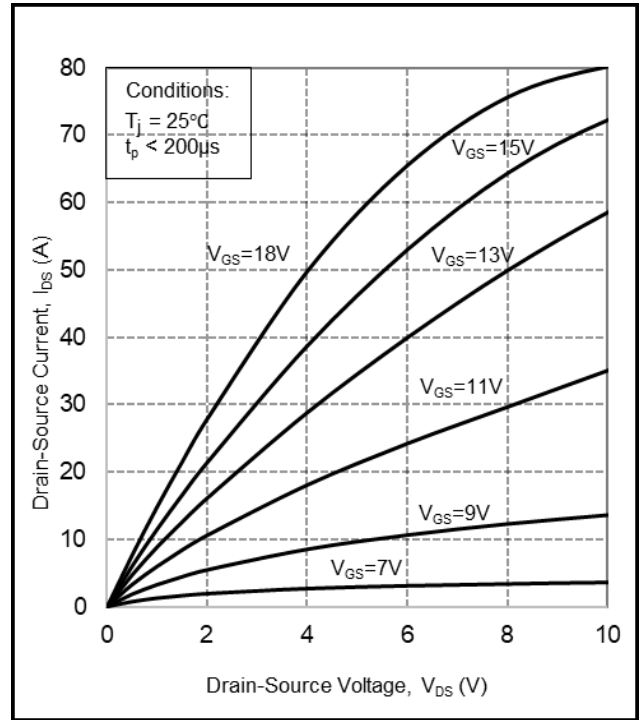


Figure 2. Output characteristics at  $T_j = 25^\circ\text{C}$

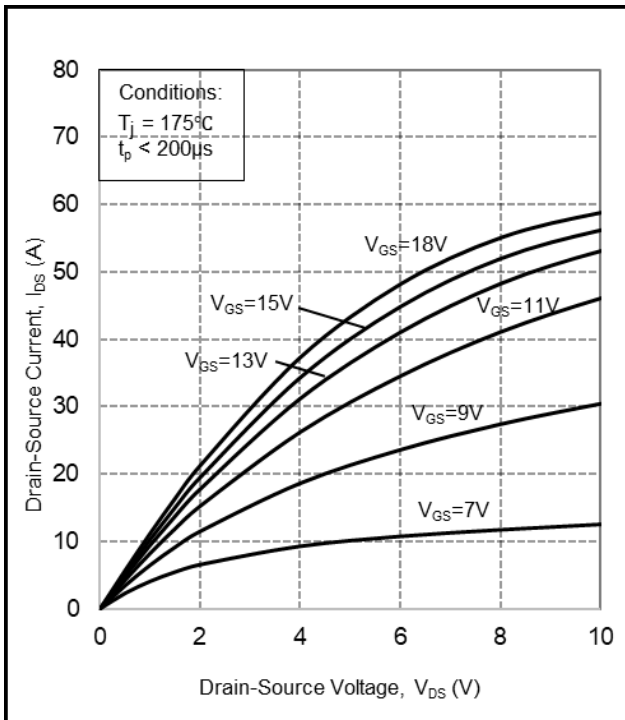


Figure 3. Output characteristics at  $T_j = 175^\circ\text{C}$

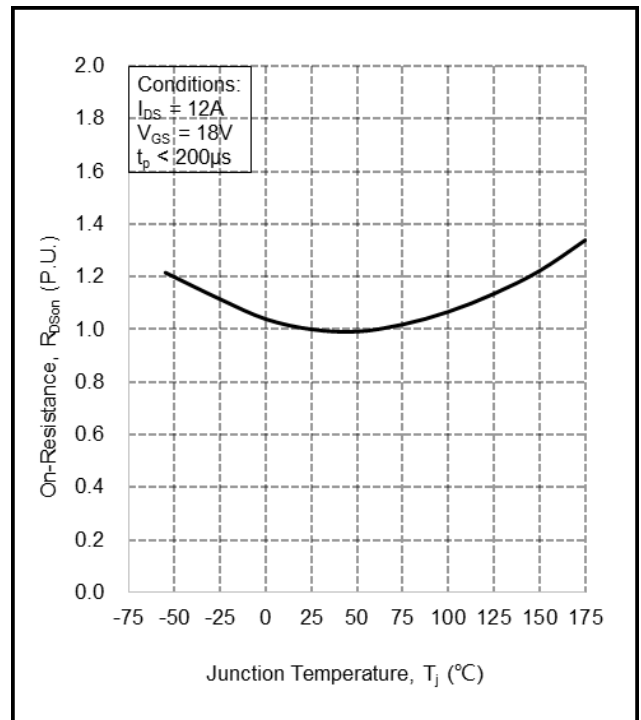


Figure 4. Normalized on-resistance vs. temperature

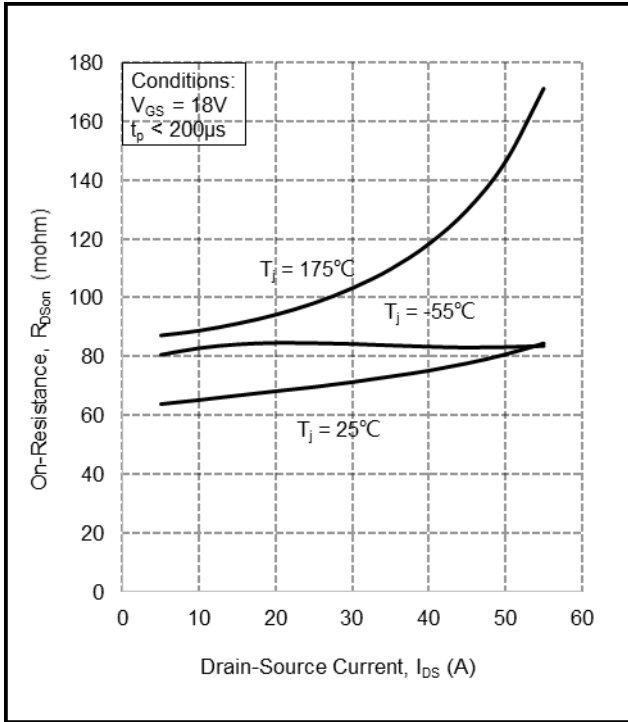


Figure 5. On-resistance vs. drain current for various temperatures

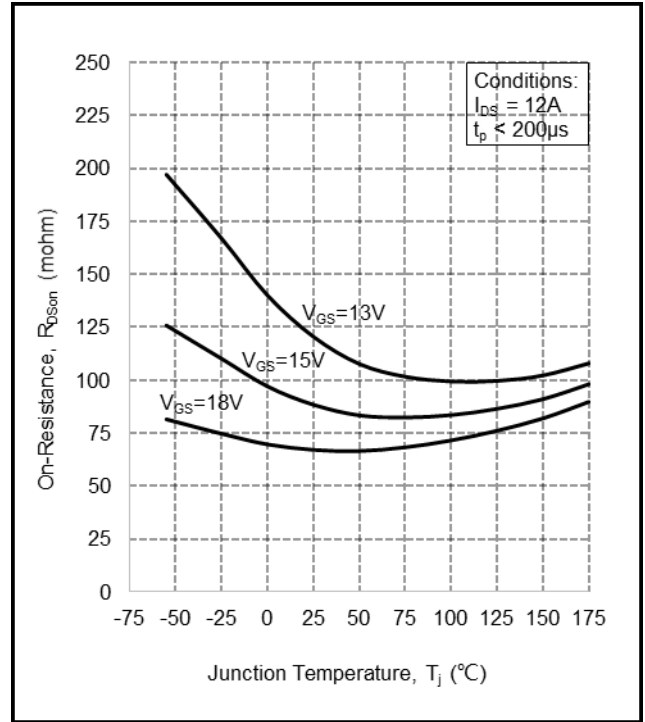


Figure 6. On-resistance vs. temperature for various gate voltages

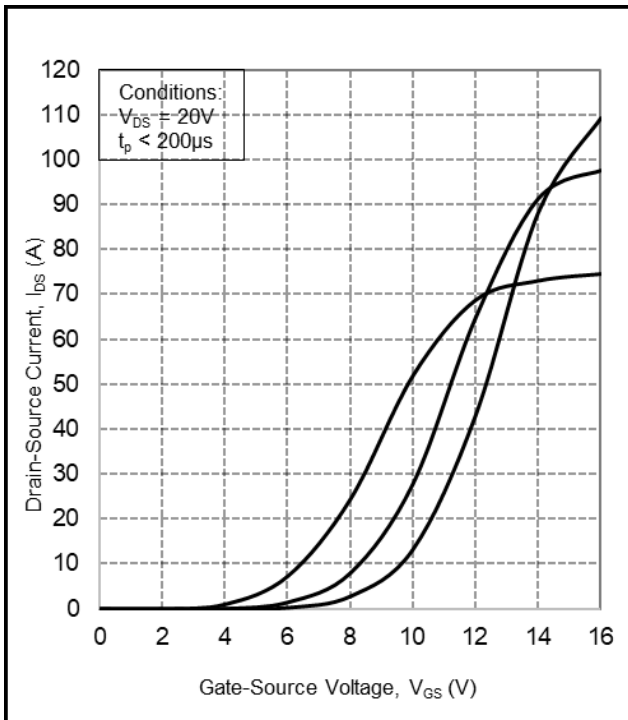


Figure 7. Transfer characteristic for various junction temperatures

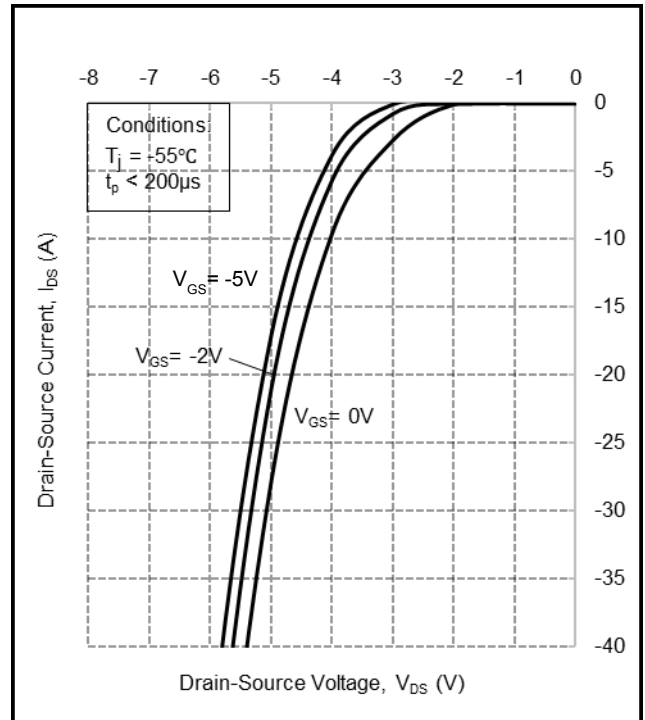


Figure 8. Body diode characteristic at  $T_j = -55^\circ\text{C}$



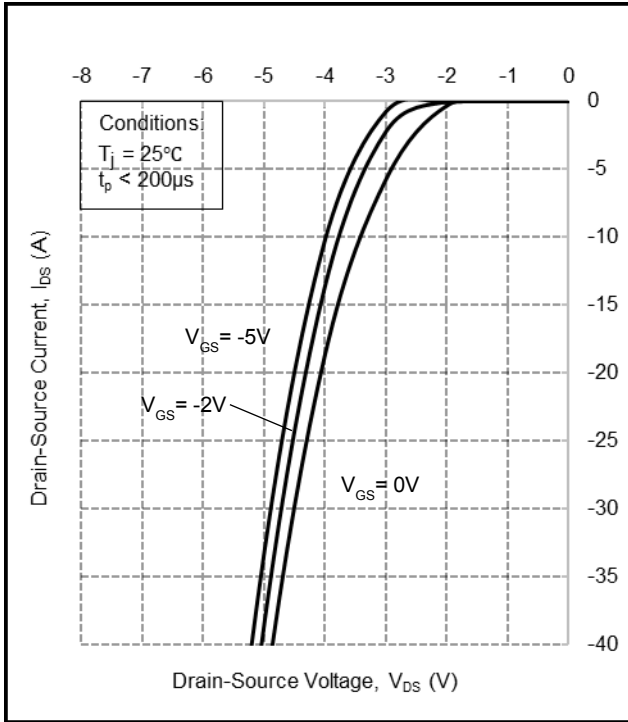


Figure 9. Body diode characteristic at  $T_j = 25^\circ\text{C}$

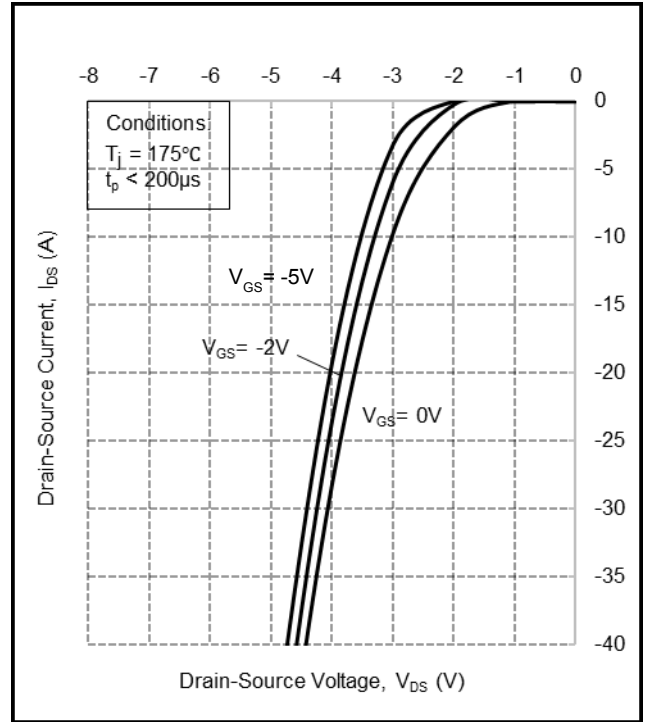


Figure 10. Body diode characteristic at  $T_j = 175^\circ\text{C}$

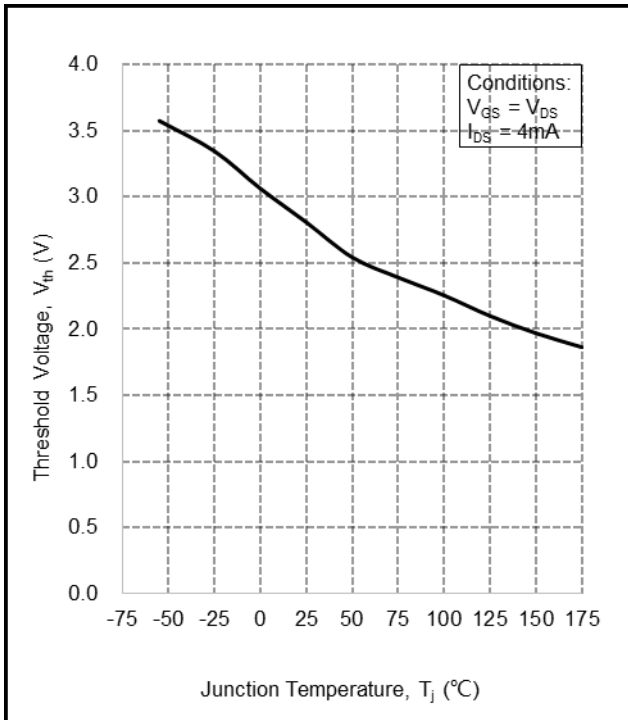


Figure 11. Threshold voltage vs. temperature

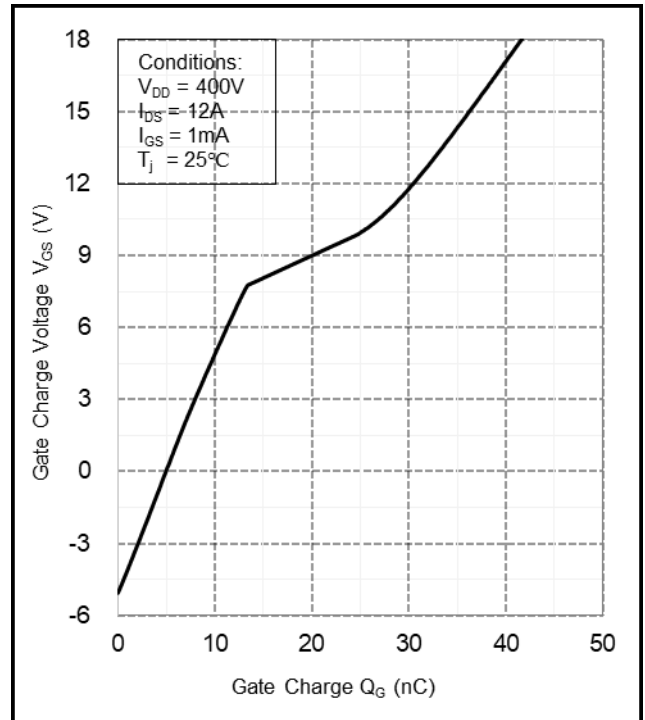


Figure 12. Gate Charge Characteristic

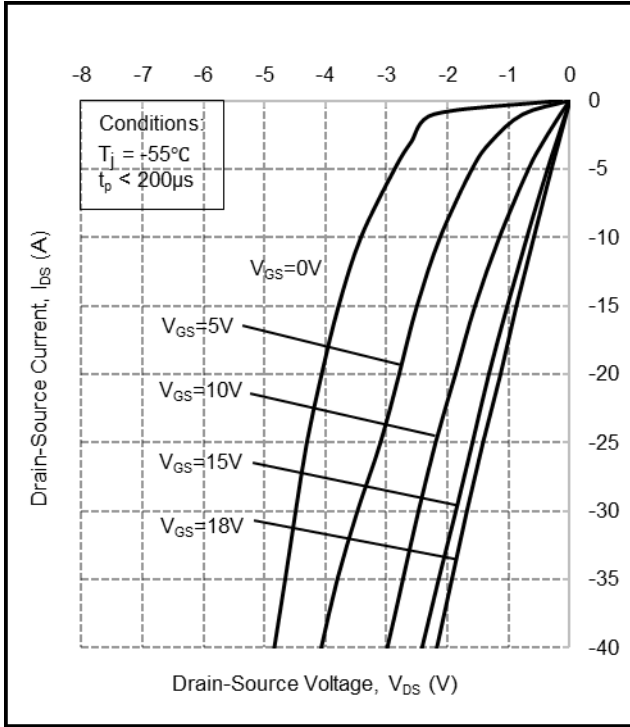


Figure 13. 3rd quadrant characteristic at  $T_j = -55^\circ\text{C}$

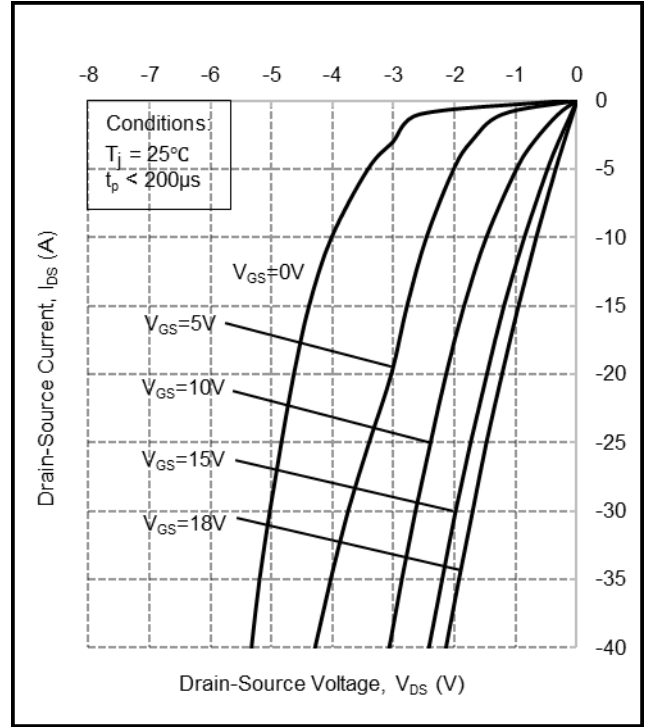


Figure 14. 3rd quadrant characteristic at  $T_j = 25^\circ\text{C}$

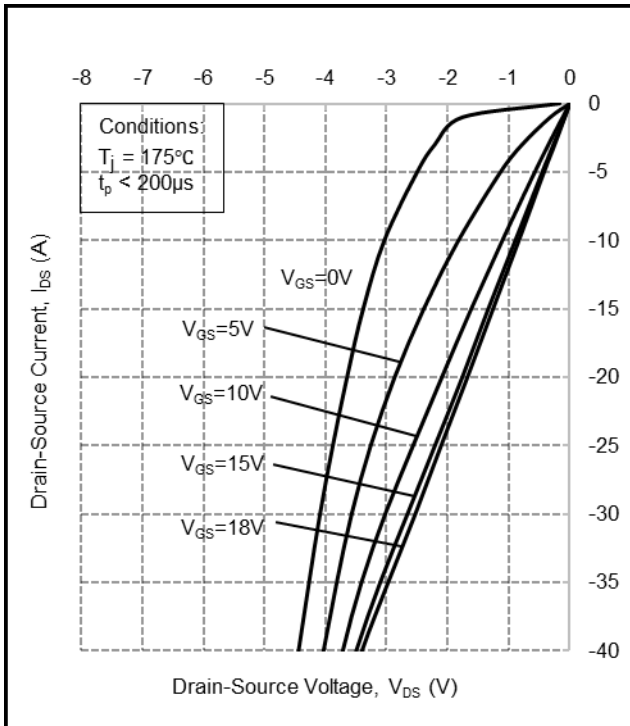


Figure 15. 3rd quadrant characteristic at  $T_j = 175^\circ\text{C}$

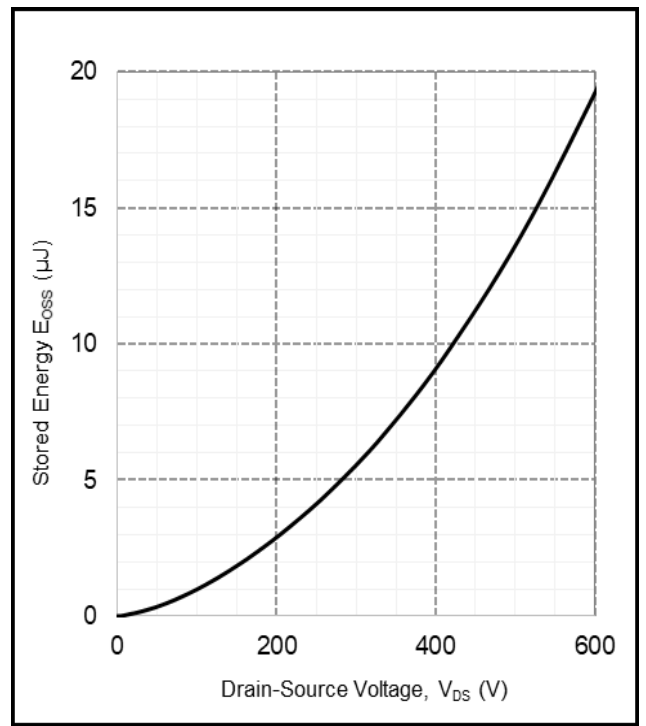


Figure 16. Output capacitor stored energy

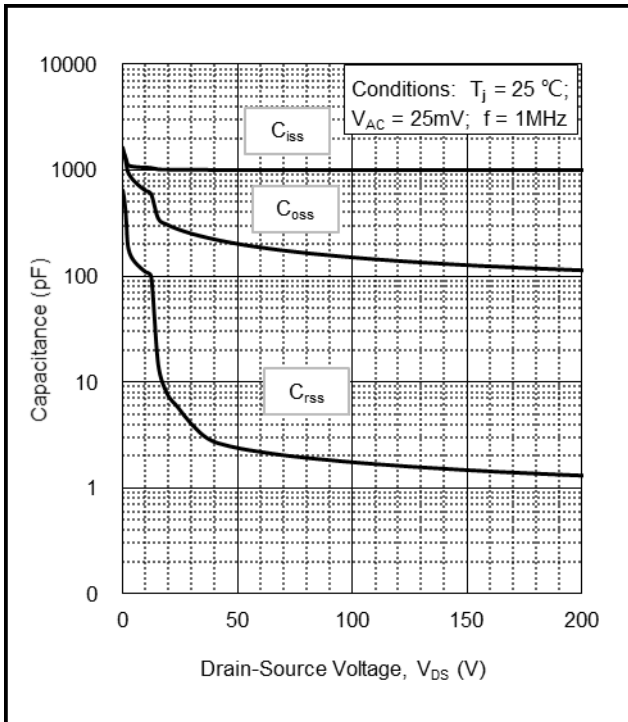


Figure 17. Capacitance vs. drain-source voltage (0 - 200V)

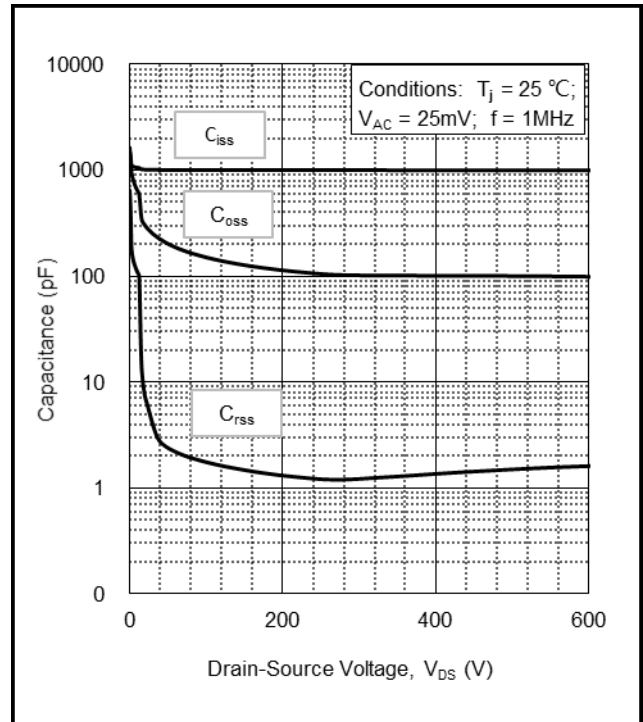


Figure 18. Capacitance vs. drain-source voltage (0 - 600V)

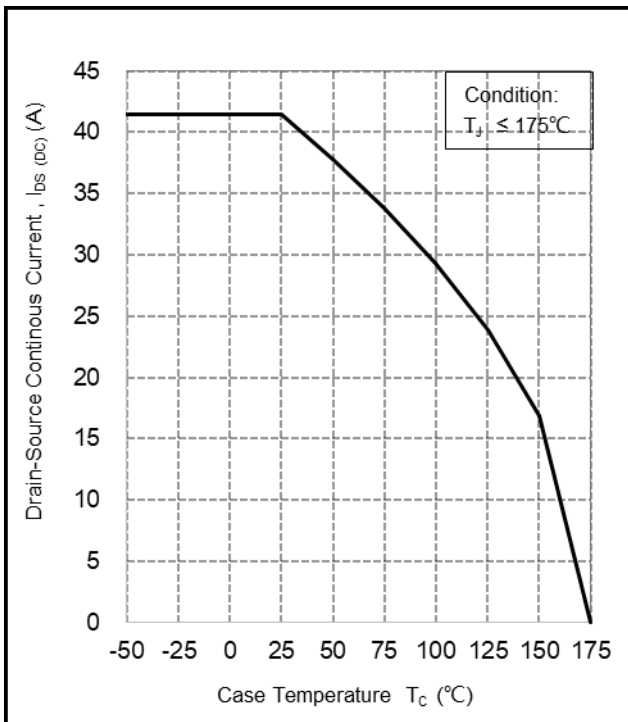


Figure 19. Continuous drain current derating vs. temperature

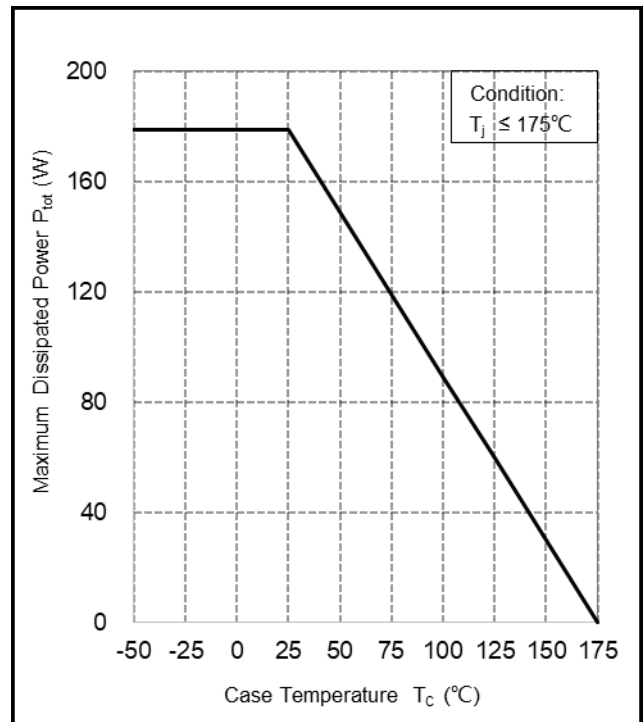


Figure 20. Maximum power dissipation derating vs. temperature

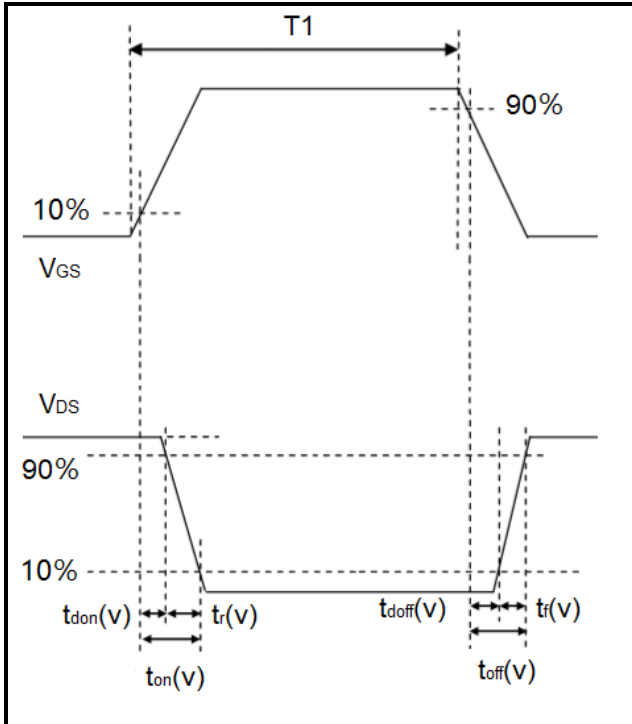


Figure 21. Switching times definition

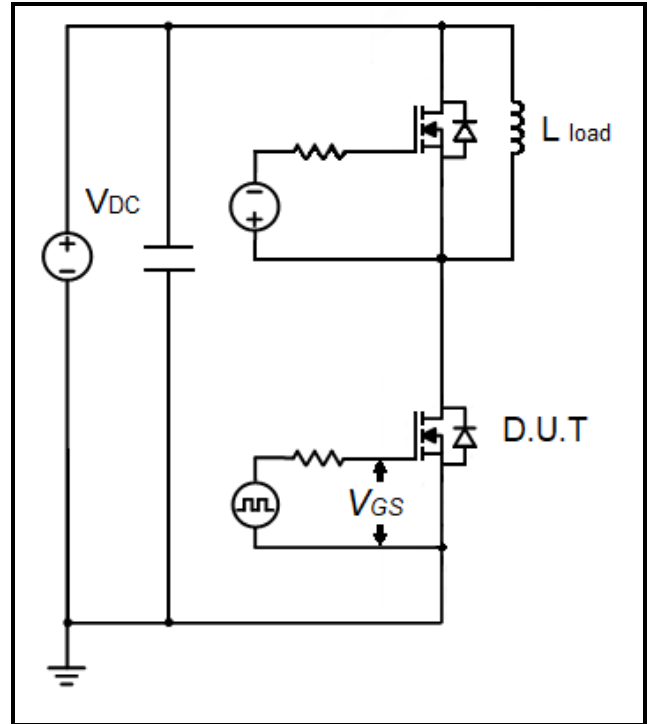
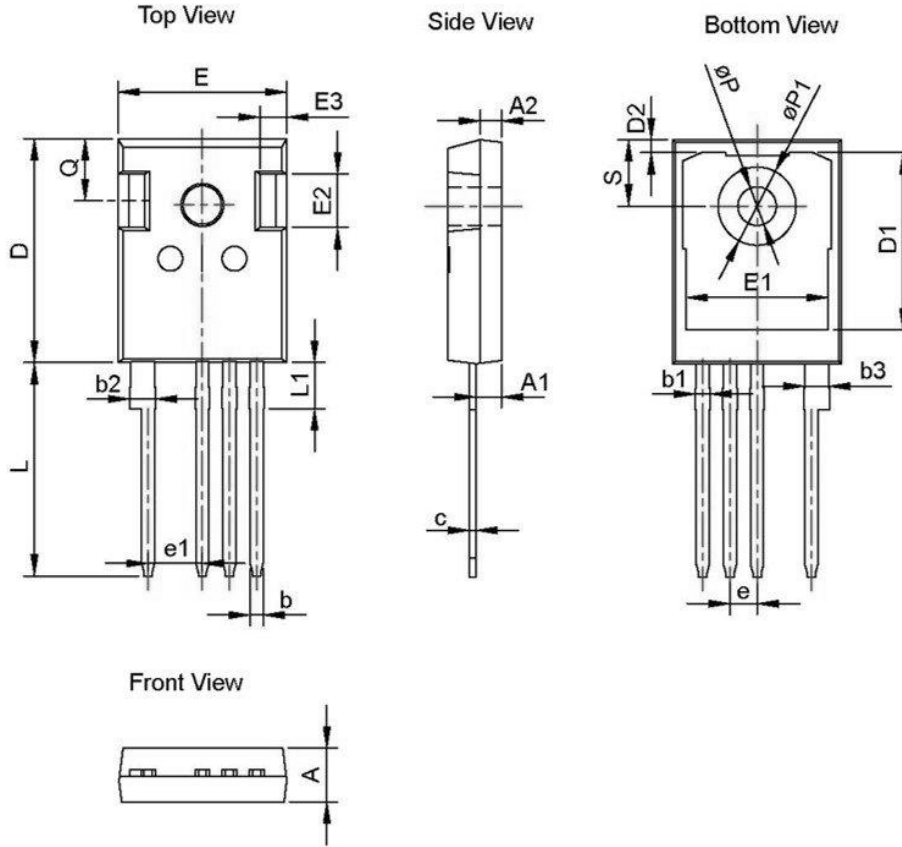


Figure 22. Clamped inductive switching waveform test circuit

**Package Information**

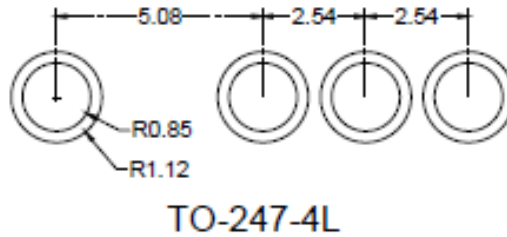


Dimension unit: [mm]			
Symbol	Min	Nom	Max
A	4.80	5.00	5.20
A1	2.21	2.41	2.61
A2	1.85	2.00	2.15
b	1.11	1.21	1.36
b1	1.11	1.37	1.57
b2	2.24	2.40	2.60
b3	2.11	2.21	2.36
c	0.51	0.60	0.75
D	20.70	20.90	21.30
D1	15.92	16.22	16.52
D2	1.00	1.20	1.35
E	15.50	15.80	16.10
E1	13.00	13.30	13.60
E2	4.80	5.00	5.20
E3	2.30	2.50	2.70
e	2.54 BSC		
e1	5.08 BSC		

Dimension unit: [mm]			
Symbol	Min	Nom	Max
L	19.62	19.92	20.22
L1	-	-	4.30
$\phi P$	3.40	3.60	3.80
$\phi P_1$	-	-	7.30
Q	5.40	5.80	6.20
S	6.20 BSC		

## Recommended Solder Pad Layout

Note: All dimensions are in mm



## Ordering Information

Part number	SMS0650065M-ISATH
Package	TO-247-4L
Unit quantity	300 EA
Packing type	Tube

## Important Notices – Read Carefully

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