

650V Silicon Carbide Power MOSFET
Features

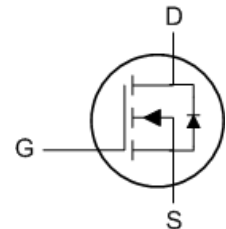
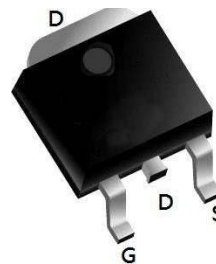
- Revolutionary semiconductor material Silicon Carbide
- High blocking voltage with low on-resistance
- High-speed switching with very low switching losses
- High-speed and high robust intrinsic body diode
- Optimized package with separate driver source pin

Product Summary


BVDSS	RDSON	ID
650V	260mΩ	15.5A

Applications

- LED Driver
- PD charger
- PC adapter
- Air-conditioning
- E-bike charger

TO252-3L Pin Configuration

Maximum Ratings For MOSFET ($T_{VJ} = 25^{\circ}\text{C}$ unless otherwise specified)

Symbol	Parameter	Value	Unit	Testing Conditions
V_{DS}	Drain-Source Voltage	650	V	
I_D	Continuous DC Drain Current for $R_{th(j-c,typ.)}$, Limited by $T_{VJ(max)}$	15.5	A	$T_C = 25^{\circ}\text{C}$
		11		$T_C = 100^{\circ}\text{C}$
I_{DM}	Peak Drain Current, tp Limited by $T_{VJ(max)}$	25	A	$T_C = 25^{\circ}\text{C}$
$V_{GS, max}$	Gate-Source Max Voltage	-10/22	V	
$V_{GS, op}$	Gate-Source Operate Voltage	0/15	V	
E_{AS}	Single Pulse Avalanche Energy	25	mJ	$L=0.5\text{ mH}$, $I_{AS}=10\text{ A}$, $V_{DD}=50\text{ V}$, $V_{GS}=15\text{ V}$
P_{tot}	Power Dissipation for $R_{th(j-c,typ.)}$	67	W	$T_C = 25^{\circ}\text{C}$

Package Values

Symbol	Parameter	Min.	Typ.	Max.	Unit	Testing Conditions
$R_{th(j-c)}$	MOSFET/Body Diode Junction-Case Thermal Resistance		2.23	2.67	K/W	
T_{VJ} , T_{STG}	Operating Junction and Storage Temperature	-55		175	$^{\circ}\text{C}$	
T_{SOLD}	Soldering Temperature, Wave Soldering only Allowed at Leads 1.6mm from Case for 10s		260		$^{\circ}\text{C}$	

650V Silicon Carbide Power MOSFET
MOSFET Characteristics ($T_{VJ} = 25^{\circ}\text{C}$ unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit	Testing Conditions	
$V_{(BR)DSS}$	Drain-Source breakdown voltage	650			V	$I_D = 100\ \mu\text{A}$	
$V_{GS(th)}$	Gate Threshold Voltage	3.2	4.1	5	V	$V_{DS} = V_{GS}, I_D = 10\ \text{mA}$	$T_{VJ} = 25^{\circ}\text{C}$
			2.9				$T_{VJ} = 175^{\circ}\text{C}$
I_{DSS}	Drain-Source Leakage Current		0.1	20	μA	$V_{GS} = 0\ \text{V}, V_{DS} = 650\ \text{V}$	$T_{VJ} = 25^{\circ}\text{C}$
			0.5				$T_{VJ} = 175^{\circ}\text{C}$
I_{GSS}	Gate-Source Leakage Current			250	nA	$V_{GS} = 22\ \text{V}, V_{DS} = 0\ \text{V}$	$T_{VJ} = 25^{\circ}\text{C}$
I_{SGS}	Source-Gate Leakage Current			250	nA	$V_{GS} = -10\ \text{V}, V_{DS} = 0\ \text{V}$	$T_{VJ} = 25^{\circ}\text{C}$
$R_{DS(on)}$	Drain-Source On-State Resistance		260	300	m Ω	$V_{GS} = 15\ \text{V}, I_D = 5\ \text{A}$	$T_{VJ} = 25^{\circ}\text{C}$
			231				$T_{VJ} = 175^{\circ}\text{C}$
g_{fs}	Transconductance		3.6		S	$V_{DS} = 20\ \text{V}, I_D = 5\ \text{A}$	
$R_{G(int)}$	Internal Gate Resistance		25.5		Ω	$f = 1\text{MHz}, V_{AC} = 25\ \text{mV}$	
C_{iss}	Input Capacitance		294		pF	$V_{GS} = 0\ \text{V}, V_{DS} = 650\ \text{V}, f = 1\text{MHz}$	
C_{oss}	Output Capacitance		25		pF		
C_{rss}	Reverse Transfer Capacitance		4		pF		
Q_{GS}	Gate to Source Charge		4.3		nC	$V_{GS} = 0/15\ \text{V}, V_{DS} = 400\text{V}, I_D = 5\ \text{A}$	
Q_{GD}	Gate to Drain Charge		1.6		nC		
Q_G	Total Gate Charge		12.5		nC		

Dynamic MOSFET Characteristics ($T_{VJ} = 25^{\circ}\text{C}$ unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit	Testing Conditions	
$t_{d(on)}$	Turn-On Delay Time		6.6		ns	$V_{GS} = 0/15V$ $L = 600\mu H$ $V_{DS} = 400\text{ V}, I_D = 5\text{ A},$ $R_{G(on)} = 2.2\ \Omega, R_{G(off)} = 2.2\ \Omega$	$T_{VJ} = 25\text{ }^{\circ}\text{C}$
			6.0				$T_{VJ} = 175\text{ }^{\circ}\text{C}$
t_r	Rise Time		18.3		ns		$T_{VJ} = 25\text{ }^{\circ}\text{C}$
			14.2				$T_{VJ} = 175\text{ }^{\circ}\text{C}$
$t_{d(off)}$	Turn-Off Delay Time		17.7		ns		$T_{VJ} = 25\text{ }^{\circ}\text{C}$
			21.3				$T_{VJ} = 175\text{ }^{\circ}\text{C}$
t_f	Fall Time		32.1		ns		$T_{VJ} = 25\text{ }^{\circ}\text{C}$
			35.6				$T_{VJ} = 175\text{ }^{\circ}\text{C}$
E_{on}	Turn-On Switching Loss		43.2		μJ		$T_{VJ} = 25\text{ }^{\circ}\text{C}$
			40.7				$T_{VJ} = 175\text{ }^{\circ}\text{C}$
E_{off}	Turn-Off Switching Loss		5.5		μJ		$T_{VJ} = 25\text{ }^{\circ}\text{C}$
			5.2				$T_{VJ} = 175\text{ }^{\circ}\text{C}$
E_{tot}	Total Switching Energy		48.7		μJ		$T_{VJ} = 25\text{ }^{\circ}\text{C}$
			45.9				$T_{VJ} = 175\text{ }^{\circ}\text{C}$

Note: E_{on}/E_{off} result is with body diode.

Maximum Ratings For Body Diode ($T_{VJ} = 25^{\circ}\text{C}$ unless otherwise specified)

Symbol	Parameter	Value	Unit	Testing Conditions
V_{DSS}	Drain-Source Voltage	650	V	
I_S	Continuous DC Source Current, Limited by $T_{VJ(max)}$	12	A	$T_C = 25^{\circ}\text{C}$
		7	A	$T_C = 100^{\circ}\text{C}$
I_{SM}	Peak Reverse Drain Current, tp Limited by $T_{VJ(max)}$	23	A	$T_C = 25^{\circ}\text{C}$

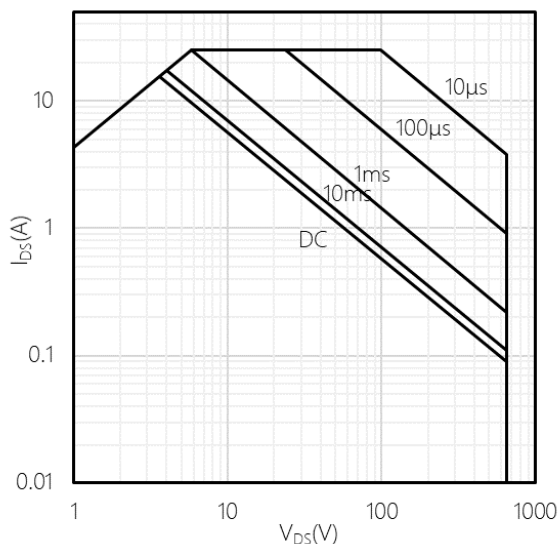
650V Silicon Carbide Power MOSFET
Body Diode Characteristics ($T_{VJ} = 25^{\circ}\text{C}$ unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit	Testing Conditions	
V _{SD}	Body Diode Forward Voltage		3.3		V	V _{GS} = 0 V, I _{SD} = 2.5 A	T _{VJ} = 25 °C
			2.8				T _{VJ} = 175 °C
I _{rrm}	Peak Reverse Recovery Current		5.8		A	V _{DS} = 400 V, V _{GS} = -0 V, I _{SD} = 5 A, di/dt = 1.6kA/μs	T _{VJ} = 25 °C
			6.2				T _{VJ} = 175 °C
Q _{rr}	Reverse Recovery Charge		32.6		nC		T _{VJ} = 25 °C
			36.1				T _{VJ} = 175 °C
t _{rr}	Reverse Recovery Time		9.9		ns		T _{VJ} = 25 °C
			9.4				T _{VJ} = 175 °C
E _{rr}	Reverse Recovery Energy		0.31		μJ		T _{VJ} = 25 °C
			0.39				T _{VJ} = 175 °C

Typical Performances

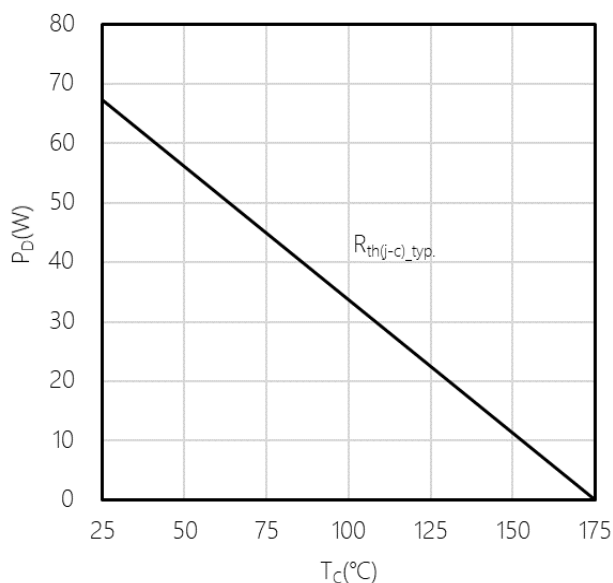
Safe operating area (SOA)

$R_{th(j-c)} = 2.67\text{ }^{\circ}\text{C/W}$, Single Pulse, $T_{vj} = 25^{\circ}\text{C}$



Power dissipation as a function of case temperature limited by bond wire

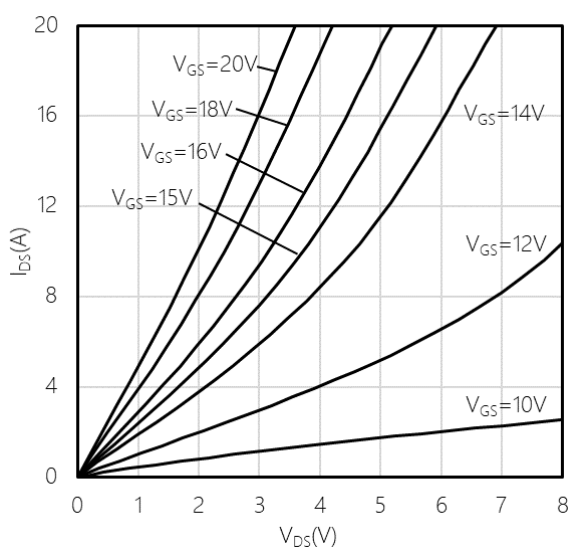
$P_D = f(T_C)$



Typical output characteristic, V_{GS} as parameter

$I_{DS} = f(V_{DS})$

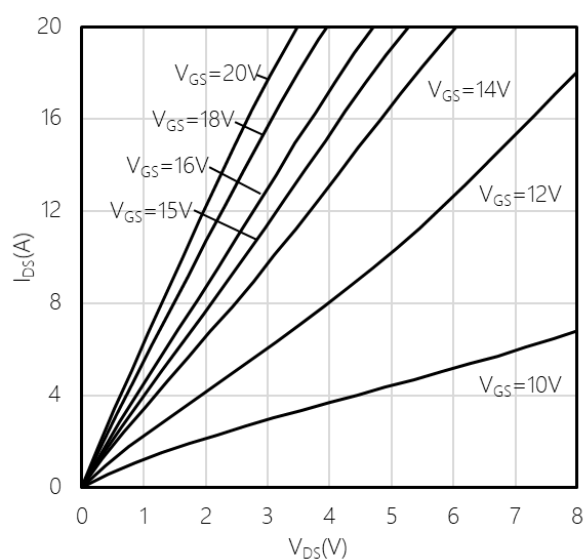
$T_{vj} = -55\text{ }^{\circ}\text{C}$



Typical output characteristic, V_{GS} as parameter

$I_{DS} = f(V_{DS})$

$T_{vj} = 25\text{ }^{\circ}\text{C}$

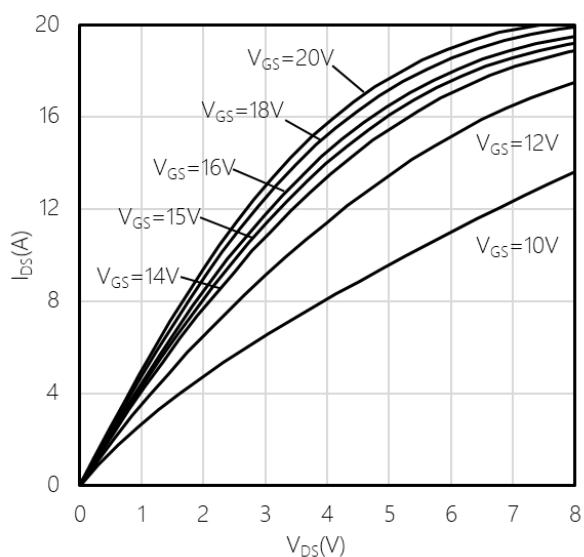


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Typical output characteristic, V_{GS} as parameter

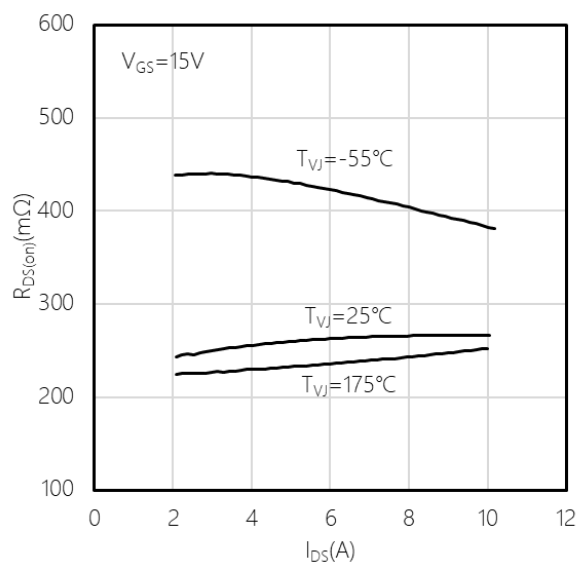
$$I_{DS} = f(V_{DS})$$

$$T_{VJ} = 175^{\circ}\text{C}$$



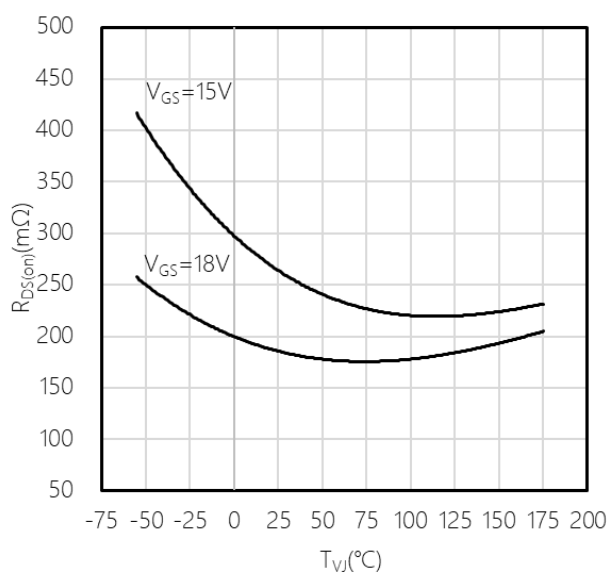
Typical on-state resistance as a function of drain current

$$R_{DS(on)} = f(I_{DS}), V_{GS} = 18\text{V}$$



Typical on-state resistance as a function of temperature

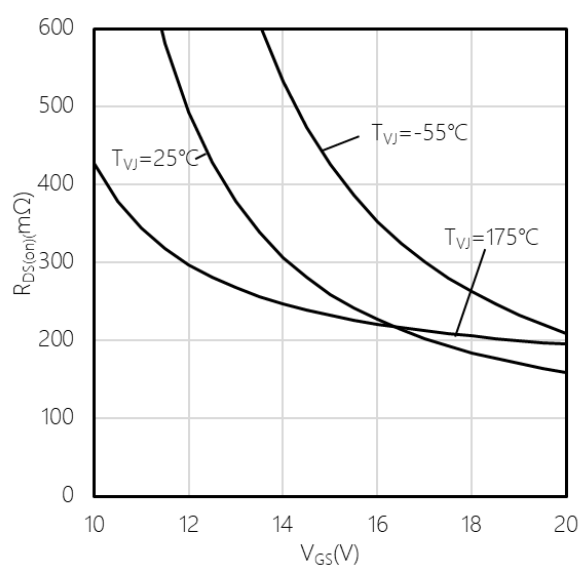
$$R_{DS(on)} = f(T_{VJ}), I_{DS} = 5\text{ A}$$



Typical on-state resistance as a function of V_{GS}

$$R_{DS(on)} = f(V_{GS})$$

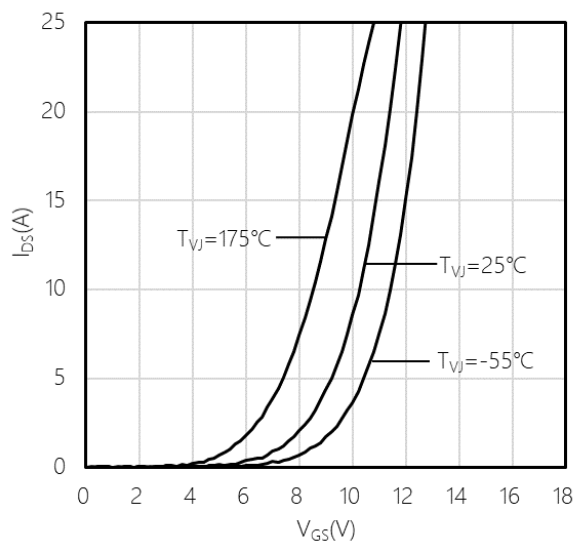
$$I_{DS} = 5\text{ A}$$



Typical transfer characteristic

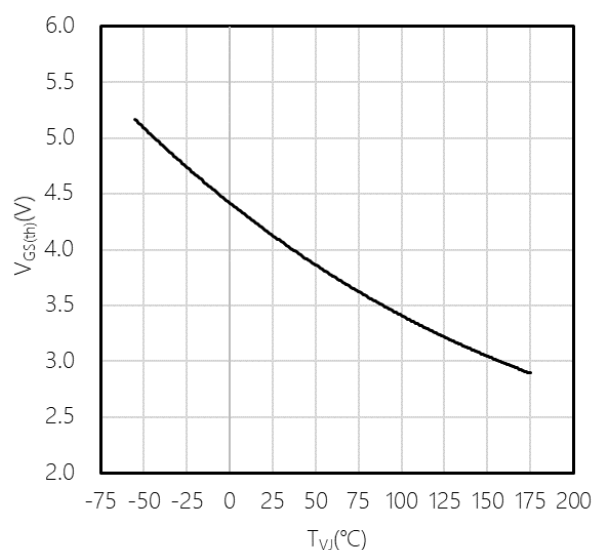
$$I_{DS} = f(V_{GS})$$

$$V_{DS} = 20 \text{ V}$$



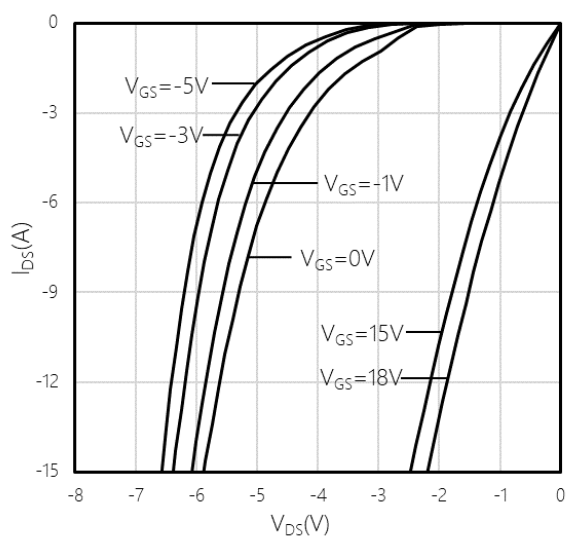
Typical gate-source threshold voltage as a function of junction temperature

$$V_{GS(th)} = f(T_{VJ}), I_{DS} = 10 \text{ mA}$$



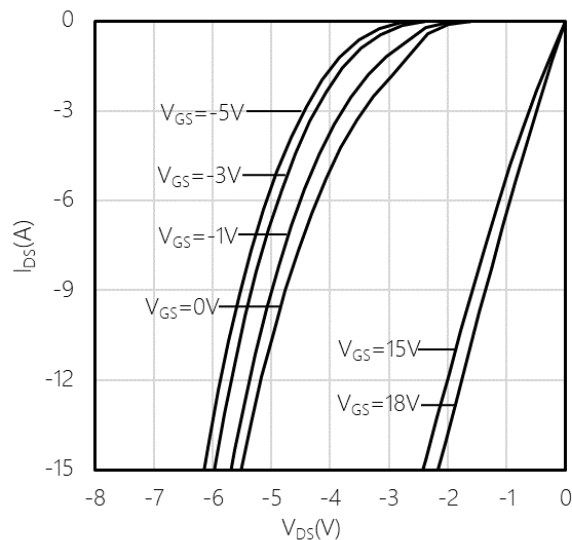
Typical reverse drain current as function of reverse drain voltage, V_{GS} as parameter

$$I_{DS} = f(V_{DS}), T_{VJ} = -55^{\circ}\text{C}$$



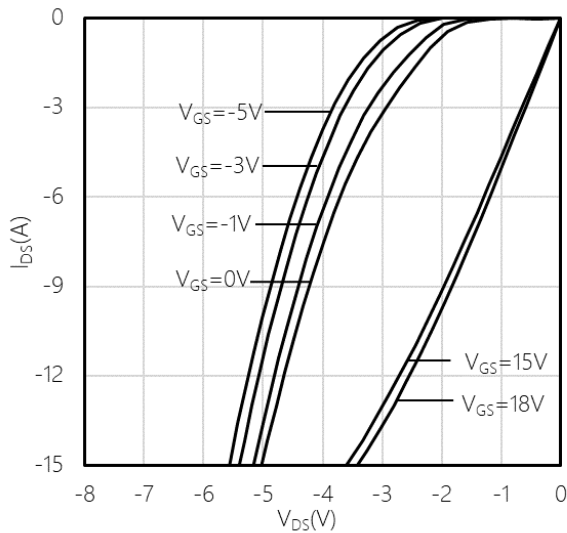
Typical reverse drain current as function of reverse drain voltage, V_{GS} as parameter

$$I_{DS} = f(V_{DS}), T_{VJ} = 25^{\circ}\text{C}$$



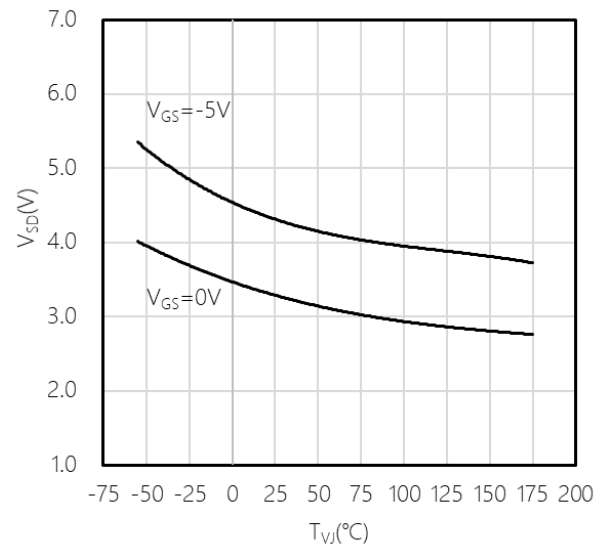
Typical reverse drain current as function of reverse drain voltage, V_{GS} as parameter

$I_{DS} = f(V_{DS}), T_{VJ} = 175^\circ\text{C}$



Typical reverse drain voltage as function of junction temperature

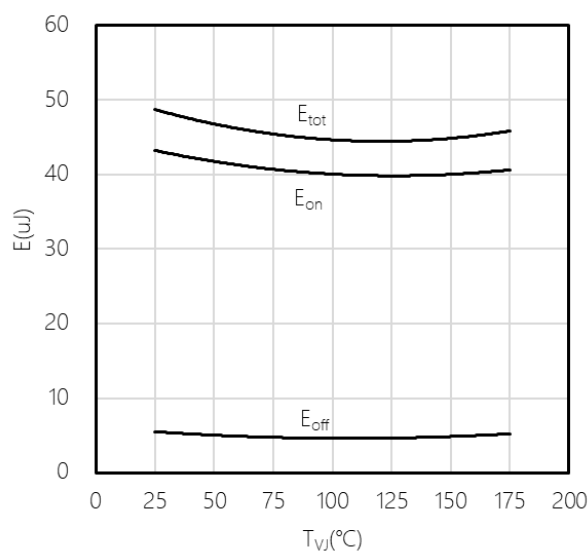
$V_{SD} = f(T_{VJ}), I_{SD} = 2.5\text{ A}$



Typical switching energy as a function of junction temperature, 2nd device own body diode: $V_{GS} = -5\text{ V}$

$E = f(T_{VJ})$

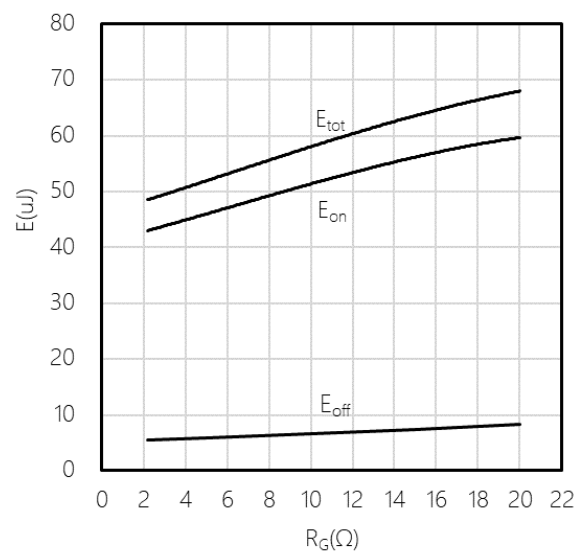
$V_{DS} = 400\text{ V}, R_{G(\text{ext})} = 2.2\ \Omega, V_{GS} = 0/15\text{ V}, I_{DS} = 5\text{ A}$



Typical switching energy losses as a function of gate resistance, 2nd device own body diode: $V_{GS} = -5\text{ V}$

$E = f(R_{G(\text{ext})})$

$V_{VGS} = 0/15\text{ V}, I_{DS} = 5\text{ A}, T_{VJ} = 25^\circ\text{C}, V_{DS} = 400\text{ V}$

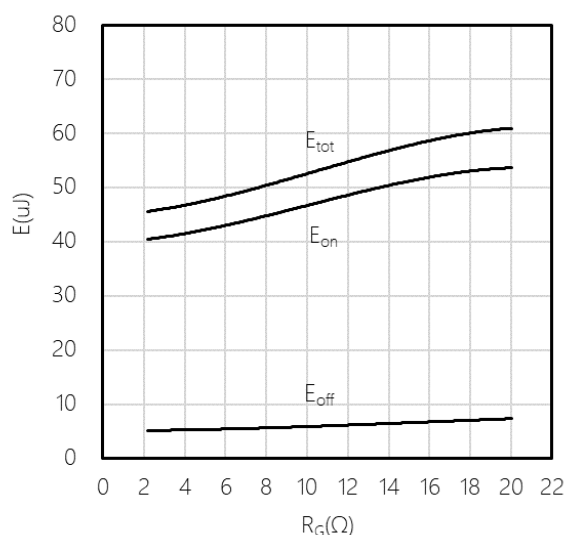


650V Silicon Carbide Power MOSFET

Typical switching energy losses as a function of gate resistance, 2nd device own body diode: $V_{GS} = 0$ V

$$E = f(R_{G(ext)})$$

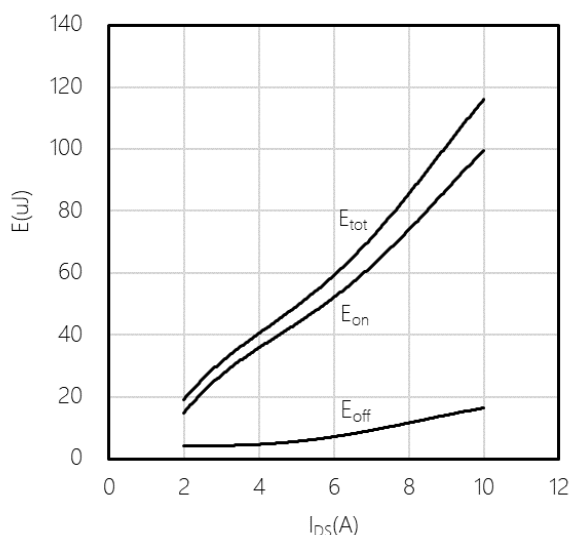
$V_{GS} = 0/15$ V, $I_{DS} = 5$ A, $T_{VJ} = 175$ °C, $V_{DS} = 400$ V



Typical switching energy losses as a function of I_{DS} , 2nd device own body diode: $V_{GS} = 0$ V

$$E = f(I_{DS})$$

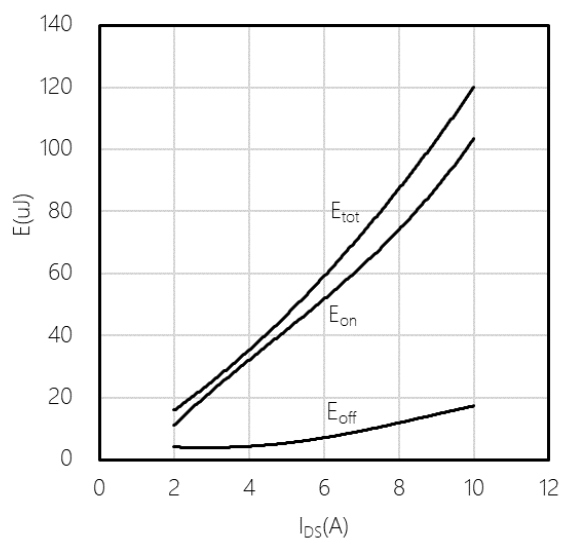
$V_{GS} = 0/15$ V, $R_{G(ext)} = 2.2$ Ω, $T_{VJ} = 25$ °C, $V_{DS} = 400$ V



Typical switching energy losses as a function of I_{DS} , 2nd device own body diode: $V_{GS} = 0$ V

$$E = f(I_{DS})$$

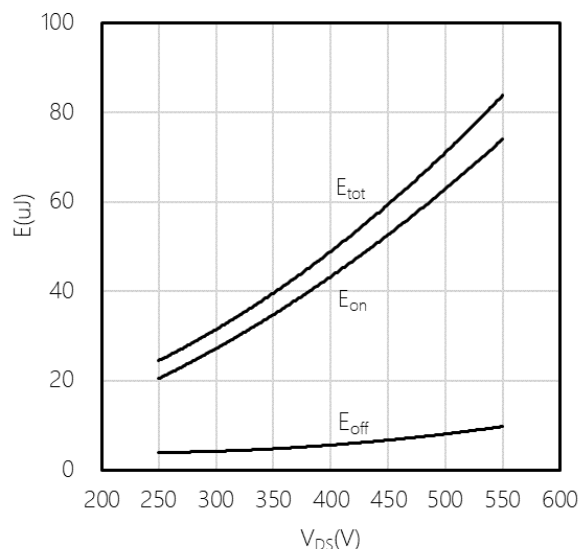
$V_{GS} = 0/15$ V, $R_{G(ext)} = 2.2$ Ω, $T_{VJ} = 175$ °C, $V_{DS} = 400$ V



Typical switching energy losses as a function of V_{DS} , 2nd device own body diode: $V_{GS} = 0$ V

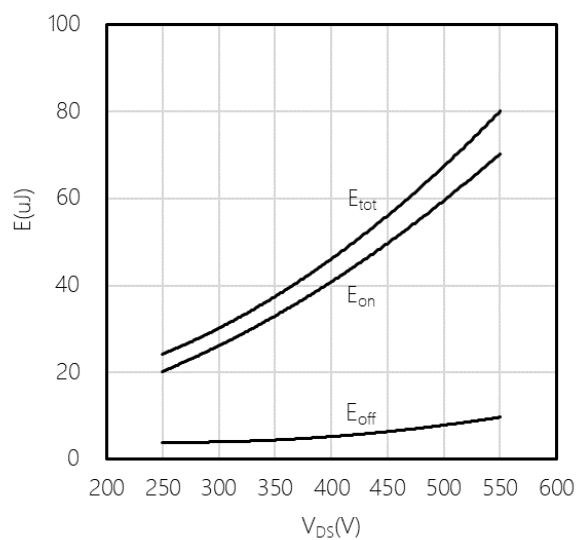
$$E = f(V_{DS})$$

$V_{GS} = 0/15$ V, $R_{G(ext)} = 2.2$ Ω, $T_{VJ} = 25$ °C, $I_{DS} = 5$ A

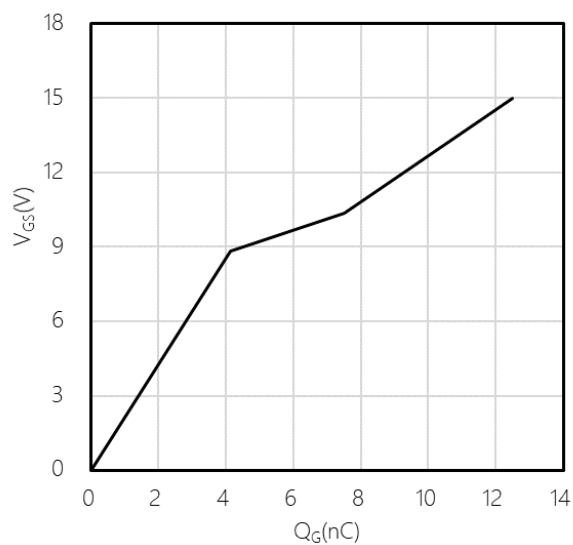
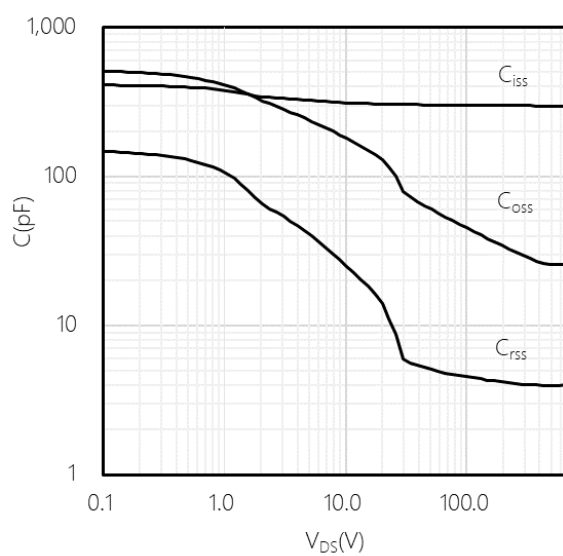


650V Silicon Carbide Power MOSFET
Typical switching energy losses as a function of V_{DS} ,
2nd device own body diode: $V_{GS} = 0\text{ V}$

$$E = f(V_{DS})$$

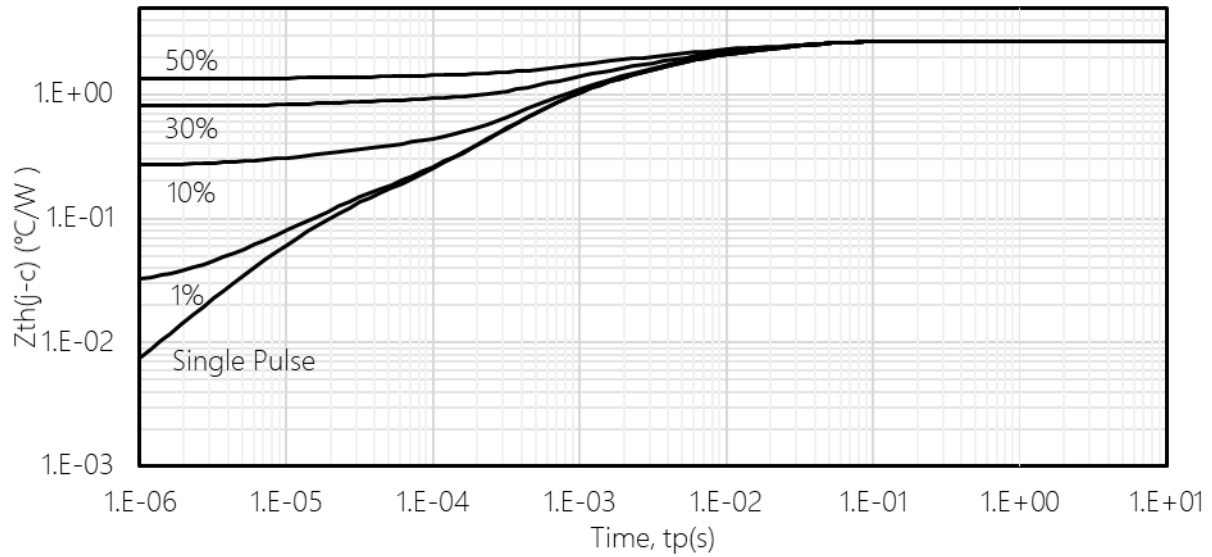
 $V_{VGS} = 0/15\text{ V}$, $R_{G(ext)} = 2.2\ \Omega$, $T_{VJ} = 175\ ^\circ\text{C}$, $I_{DS} = 5\text{ A}$

Typical gate charge
 $V_{GS} = f(Q_G)$, $I_{DS} = 5\text{ A}$, $V_{DS} = 400\text{ V}$

turn-on pulse


Typical capacitance as a function of drain-source voltage
 $C = f(V_{DS})$, $V_{GS} = 0\text{ V}$, $f = 1\text{ MHz}$


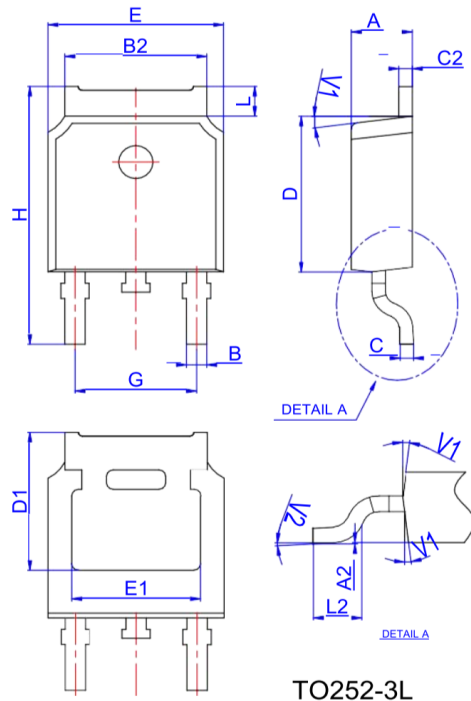
Transient thermal resistance (MOSFET)

$(Z_{th(j-c,max)} = f(t_p), \text{ Parameter } D = t_p/T$



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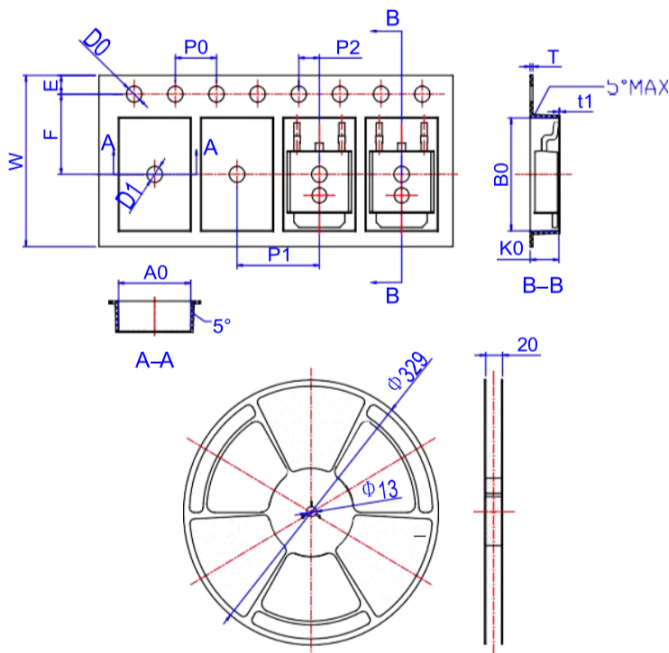
Package Dimensions



TO252-3L

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	2.10		2.50	0.083		0.098
A2	0		0.10	0		0.004
B	0.66		0.86	0.026		0.034
B2	5.18		5.48	0.202		0.216
C	0.40		0.60	0.016		0.024
C2	0.44		0.58	0.017		0.023
D	5.90		6.30	0.232		0.248
D1	5.30REF			0.209REF		
E	6.40		6.80	0.252		0.268
E1	4.63			0.182		
G	4.47		4.67	0.176		0.184
H	9.50		10.70	0.374		0.421
L	1.09		1.21	0.043		0.048
L2	1.35		1.65	0.053		0.065
V1		7°			7°	
V2	0°		6°	0°		6°

Reel Specification-TO252-3L



Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
W	15.90	16.00	16.10	0.626	0.630	0.634
E	1.65	1.75	1.85	0.065	0.069	0.073
F	7.40	7.50	7.60	0.291	0.295	0.299
D0	1.40	1.50	1.60	0.055	0.059	0.063
D1	1.40	1.50	1.60	0.055	0.059	0.063
P0	3.90	4.00	4.10	0.154	0.157	0.161
P1	7.90	8.00	8.10	0.311	0.315	0.319
P2	1.90	2.00	2.10	0.075	0.079	0.083
A0	6.85	6.90	7.00	0.270	0.271	0.276
B0	10.45	10.50	10.60	0.411	0.413	0.417
K0	2.68	2.78	2.88	0.105	0.109	0.113
T	0.24		0.27	0.009		0.011
t1	0.10			0.004		
10P0	39.80	40.00	40.20	1.567	1.575	1.583