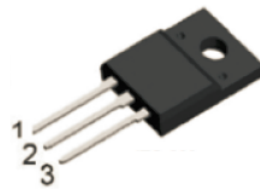
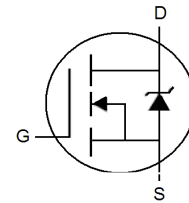


650V Silicon Carbide Power MOSFET

Key Performance Parameters		
Parameter	Value	Unit
V_{DSS}	650	V
$R_{DS(ON)max. V_{GS}=15V}$	215	mΩ
$R_{DS(ON)typ. V_{GS}=15V}$	180	mΩ
I_D	19.5	A
Q_G	15.3	nC



TO-220F



EQUIVALENT CIRCUIT

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

Applications

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

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

Symbol	Parameter	Value	Unit	Testing Conditions
V_{DSS}	Drain-Source Voltage	650	V	
I_D	Continuous DC Drain Current for $R_{th(j-c,typ.)}$, Limited by $T_{VJ(max)}$	19.5	A	$T_C = 25^\circ\text{C}$
		13.5		$T_C = 100^\circ\text{C}$
I_{DM}	Peak Drain Current, t_p Limited by $T_{VJ(max)}$	34	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	33.4	mJ	$L=0.5\text{mH}$, $I_{AS}=11.5\text{A}$, $V_{DD}=50\text{V}$, $V_{GS}=15\text{V}$
P_{tot}	Power Dissipation for $R_{th(j-c,typ.)}$	76	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		1.98	2.37	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 (TVJ= 25°C unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit	Testing Conditions	
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	650			V	$I_D = 100 \mu A$	
$V_{GS(th)}$	Gate Threshold Voltage	3.2	3.9	5.0	V	$V_{DS} = V_{GS}, I_D = 10 \text{ mA}$	$T_{VJ} = 25^\circ C$
			2.8				$T_{VJ} = 175^\circ C$
I_{DSS}	Drain-Source Leakage Current		0.1	20	μA	$V_{GS} = 0 \text{ V}, V_{DS} = 650 \text{ V}$	$T_{VJ} = 25^\circ C$
			5				$T_{VJ} = 175^\circ C$
I_{GSS}	Gate-Source Leakage Current			250	nA	$V_{GS} = 22 \text{ V}, V_{DS} = 0 \text{ V}$	$T_{VJ} = 25^\circ C$
I_{SGS}	Source-Gate Leakage Current			250	nA	$V_{GS} = -10 \text{ V}, V_{DS} = 0 \text{ V}$	$T_{VJ} = 25^\circ C$
$R_{DS(on)}$	Drain-Source On-State Resistance		180	215	m Ω	$V_{GS} = 15 \text{ V}, I_D = 7 \text{ A}$	$T_{VJ} = 25^\circ C$
			164				$T_{VJ} = 175^\circ C$
g_{fs}	Transconductance		4.3		S	$V_{DS} = 20 \text{ V}, I_D = 7 \text{ A}$	
$R_{G(int)}$	Internal Gate Resistance		31		Ω	$f = 1\text{MHz}, V_{AC} = 25 \text{ mV}$	
C_{iss}	Input Capacitance		418		pF	$V_{GS} = 0 \text{ V}, V_{DS} = 650 \text{ V}, f = 1\text{MHz}$	
C_{oss}	Output Capacitance		33		pF		
C_{rss}	Reverse Transfer Capacitance		4.3		pF		
Q_{GS}	Gate to Source Charge		5.5		nC	$V_{GS} = 0 / 15 \text{ V}, V_{DD} = 400 \text{ V}, I_D = 7 \text{ A}$	
Q_{GD}	Gate to Drain Charge		2.6		nC		
Q_G	Total Gate Charge		15.3		nC		

Dynamic MOSFET Characteristics (TVJ= 25°C unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit	Testing Conditions	
$t_{d(on)}$	Turn-On Delay Time		29.2		ns	$V_{GS} = 0/15\text{ V}$, $L=600\text{ }\mu\text{H}$ $V_{DD} = 400\text{ V}$, $I_D = 7\text{ A}$, $R_{G(on)}$ $= 2.2\text{ }\Omega$, $R_{G(off)} = 2.2\text{ }\Omega$	$T_{VJ} = 25\text{ }^{\circ}\text{C}$
			27.6				$T_{VJ} = 175\text{ }^{\circ}\text{C}$
t_r	Rise Time		11.7		ns		$T_{VJ} = 25\text{ }^{\circ}\text{C}$
			10.8				$T_{VJ} = 175\text{ }^{\circ}\text{C}$
$t_{d(off)}$	Turn-Off Delay Time		46.1		ns		$T_{VJ} = 25\text{ }^{\circ}\text{C}$
			43.1				$T_{VJ} = 175\text{ }^{\circ}\text{C}$
t_f	Fall Time		16.5		ns		$T_{VJ} = 25\text{ }^{\circ}\text{C}$
			13.3				$T_{VJ} = 175\text{ }^{\circ}\text{C}$
E_{on}	Turn-On Switching Loss		67.8		μJ		$T_{VJ} = 25\text{ }^{\circ}\text{C}$
			67.5				$T_{VJ} = 175\text{ }^{\circ}\text{C}$
E_{off}	Turn-Off Switching Loss		15.0		μJ		$T_{VJ} = 25\text{ }^{\circ}\text{C}$
			10.5				$T_{VJ} = 175\text{ }^{\circ}\text{C}$
E_{tot}	Total Switching Energy		82.8		μJ		$T_{VJ} = 25\text{ }^{\circ}\text{C}$
			78.0				$T_{VJ} = 175\text{ }^{\circ}\text{C}$

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

Maximum Ratings For Body Diode (TVJ= 25°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 $T_{VJ(max)}$	13.5	A	$T_C = 25^\circ C$
		7.7	A	$T_C = 100^\circ C$
I_{SM}	Peak Reverse Drain Current, tp Limited by $T_{VJ(max)}$	29.5	A	$T_C = 25^\circ C$

650V Silicon Carbide Power MOSFET
Body Diode Characteristics (TVJ= 25°C unless otherwise specified)

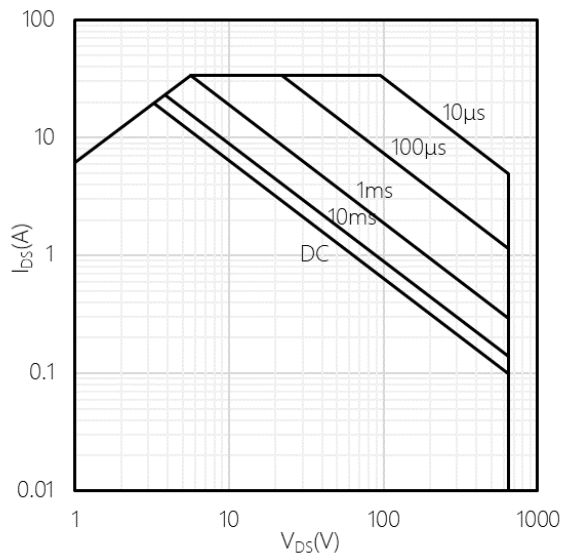
Symbol	Parameter	Min.	Typ.	Max.	Unit	Testing Conditions	
V _{SD}	Body Diode Forward Voltage		3.3		V	V _{GS} = 0 V, I _{SD} = 3.5 A	T _{VJ} = 25 °C
			2.8				T _{VJ} = 175 °C
I _{rrm}	Peak Reverse Recovery Current		6.9		A	V _{DS} = 400 V, V _{GS} = 0 V, I _{SD} = 7 A, di/dt = 2 kA/μs	T _{VJ} = 25 °C
			5.8				T _{VJ} = 175 °C
Q _{rr}	Reverse Recovery Charge		68		nC		T _{VJ} = 25 °C
			82				T _{VJ} = 175 °C
t _{rr}	Reverse Recovery Time		26		ns		T _{VJ} = 25 °C
			27				T _{VJ} = 175 °C
E _{rr}	Reverse Recovery Energy		5.0		μJ		T _{VJ} = 25 °C
			7.2				T _{VJ} = 175 °C

650V Silicon Carbide Power MOSFET

Typical Performances

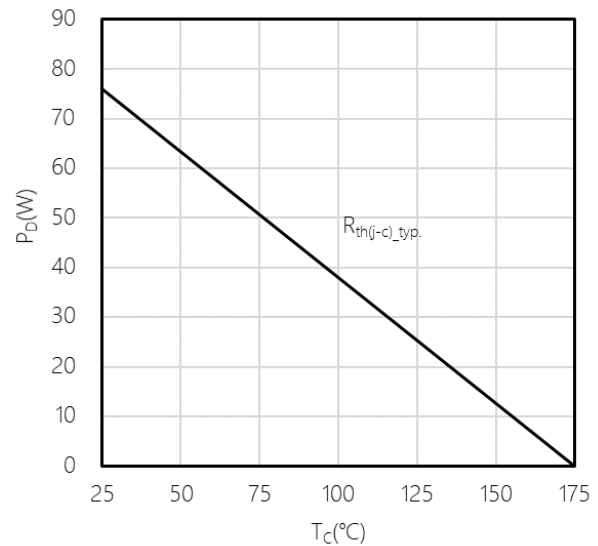
Safe operating area (SOA)

$R_{th(j-c)} = 2.37 \text{ }^{\circ}\text{C/W}$, Single Pulse, $T_{vj} = 25^{\circ}\text{C}$



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

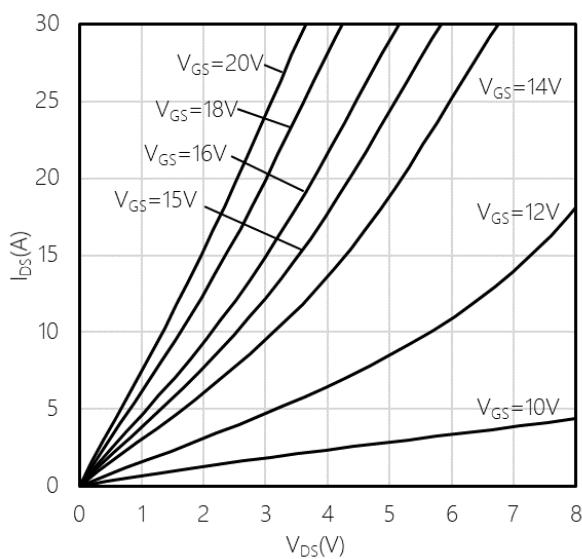
$$P_D = f(T_C)$$



Typical output characteristic, V_{GS} as parameter

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

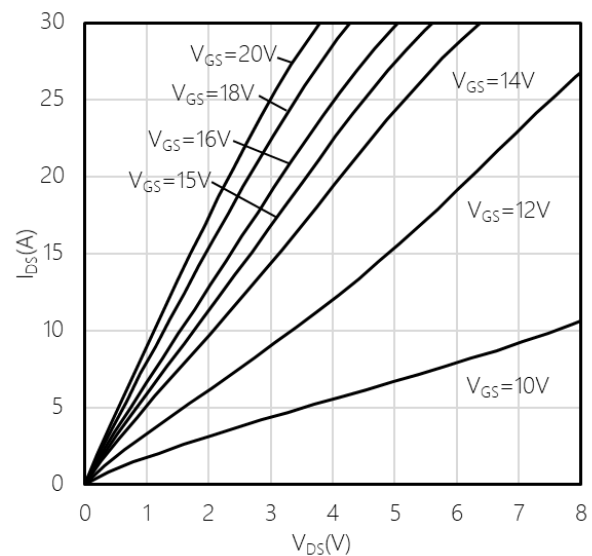
$T_{vj} = -55^{\circ}\text{C}$



Typical output characteristic, V_{GS} as parameter

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

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

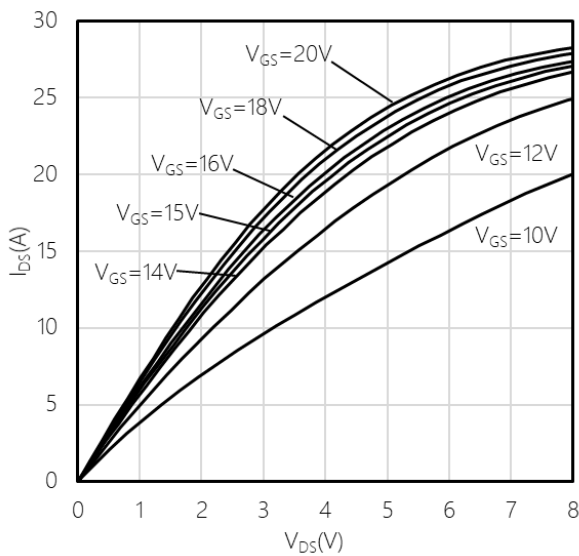


650V Silicon Carbide Power MOSFET

Typical output characteristic, V_{GS} as parameter

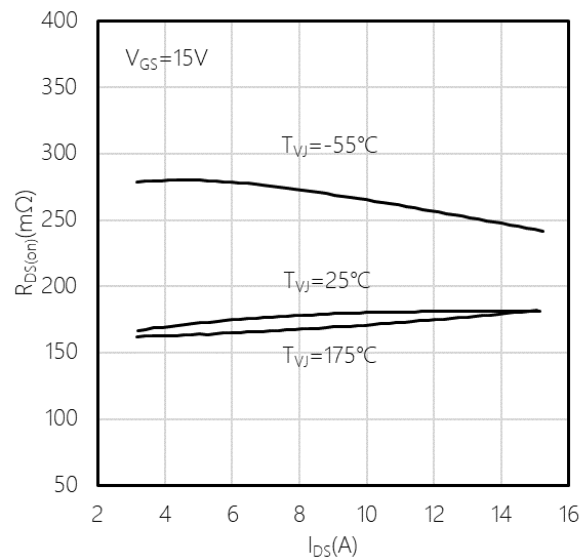
$$I_{DS} = f(V_{DS})$$

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



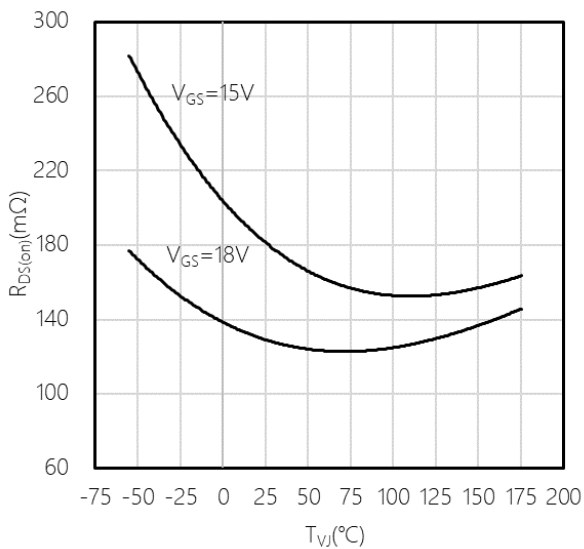
Typical on-state resistance as a function of drain current

$$R_{DS(on)} = f(I_{DS}), V_{GS} = 15\text{V}$$



Typical on-state resistance as a function of temperature

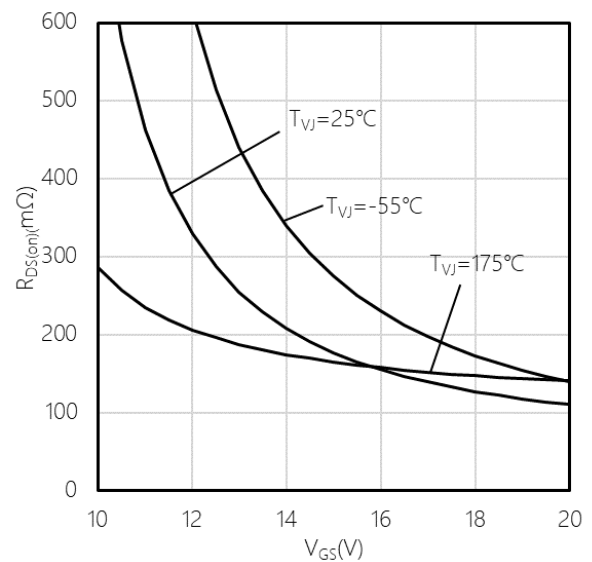
$$R_{DS(on)} = f(T_{VJ}), I_{DS} = 7\text{ A}$$



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

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

$$I_{DS} = 7\text{ A}$$

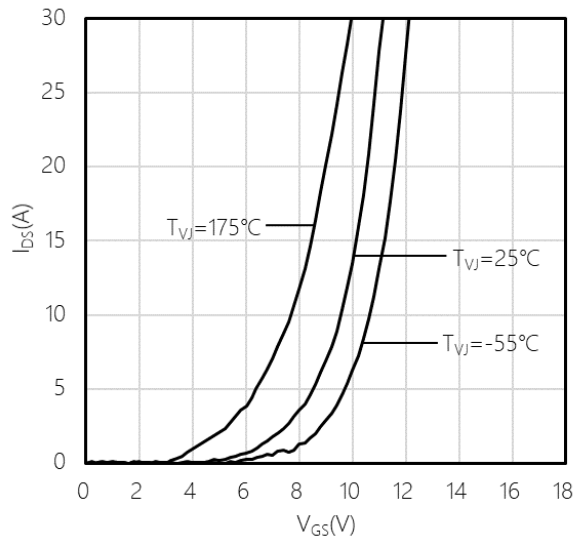


650V Silicon Carbide Power MOSFET

Typical transfer characteristic

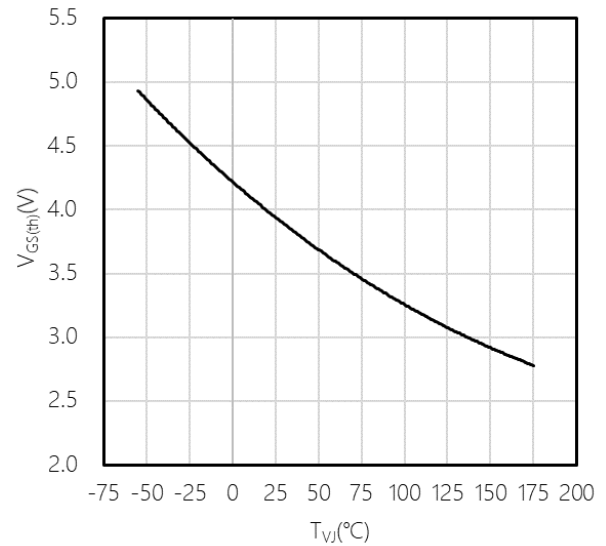
$$I_{DS} = f(V_{GS})$$

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



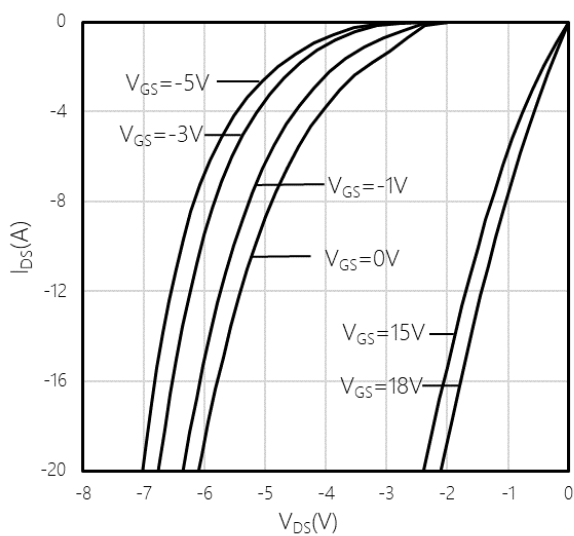
Typical gate-source threshold voltage as a function of junction temperature

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



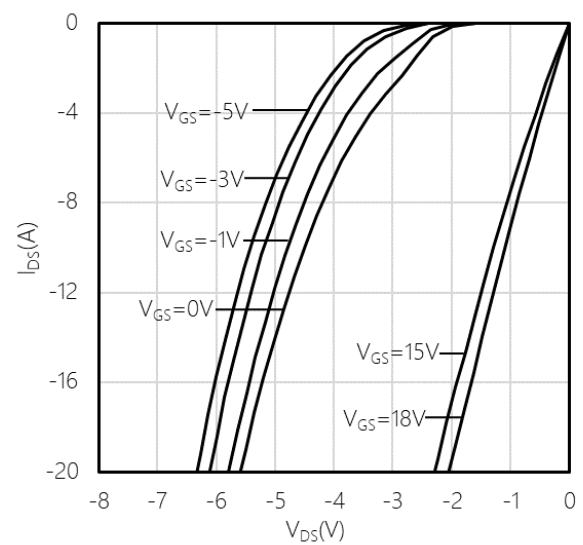
Typical reverse drain current as function of reverse drain voltage, V_{GS} as parameter

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



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

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

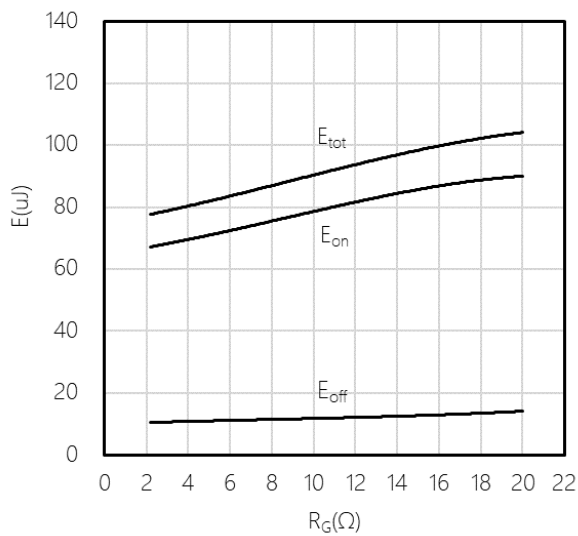


650V Silicon Carbide Power MOSFET

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

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

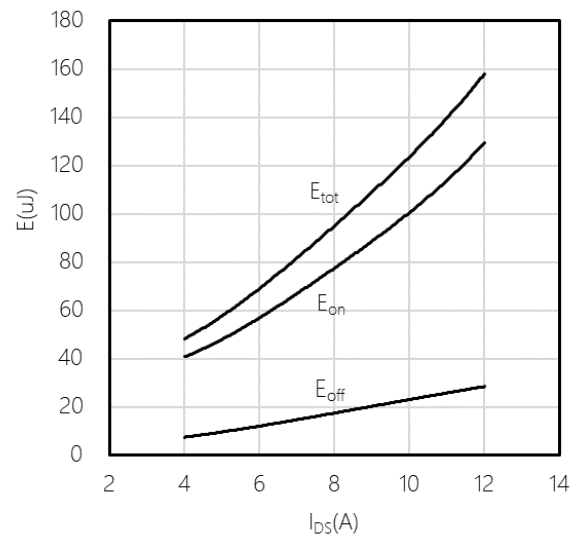
$V_{GS} = 0/15$ V, $I_{DS} = 7$ A, $T_{VJ} = 175$ °C, $V_{DS} = 400$ V



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

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

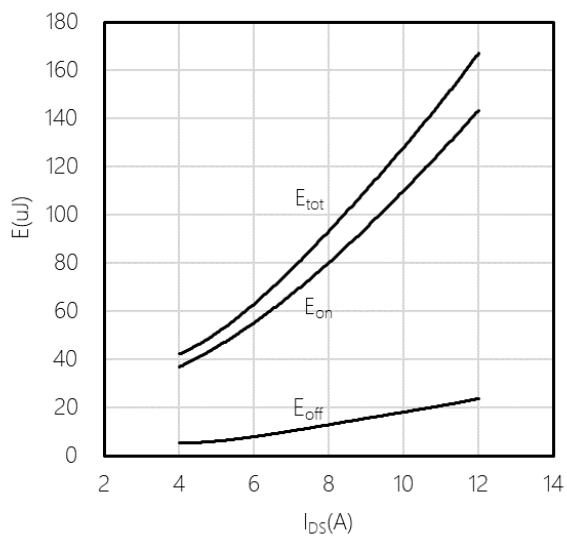
$V_{GS} = 0/15$ V, $R_{G(ext)} = 2.2$ Ω, $T_{VJ} = 25$ °C, $V_{DS} = 400$ V



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

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

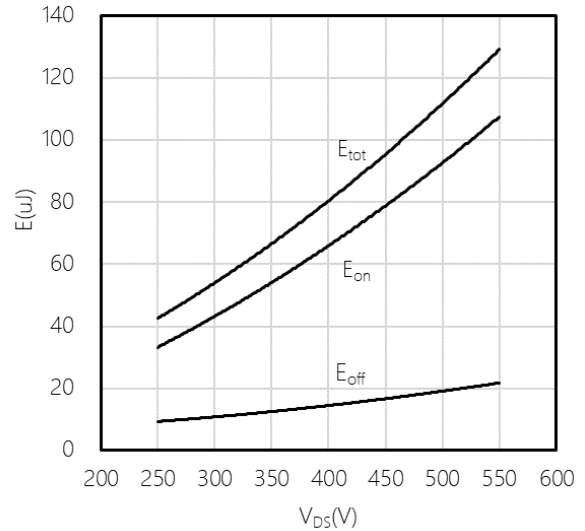
$V_{GS} = 0/15$ V, $R_{G(ext)} = 2.2$ Ω, $T_{VJ} = 175$ °C, $V_{DS} = 400$ V



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

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

$V_{GS} = 0/15$ V, $R_{G(ext)} = 2.2$ Ω, $T_{VJ} = 25$ °C, $I_{DS} = 7$ A

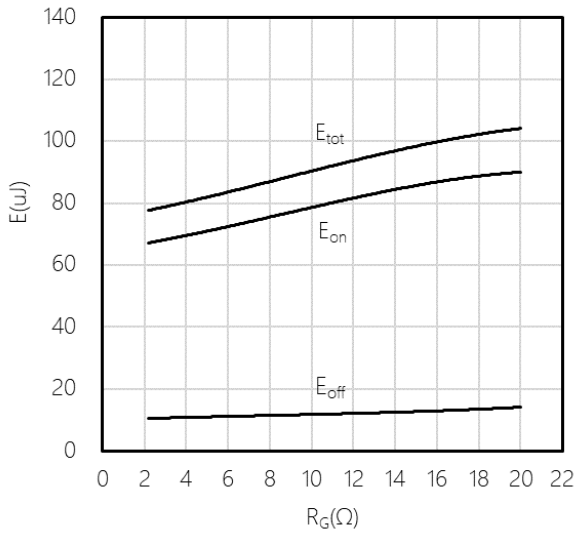


650V Silicon Carbide Power MOSFET

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

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

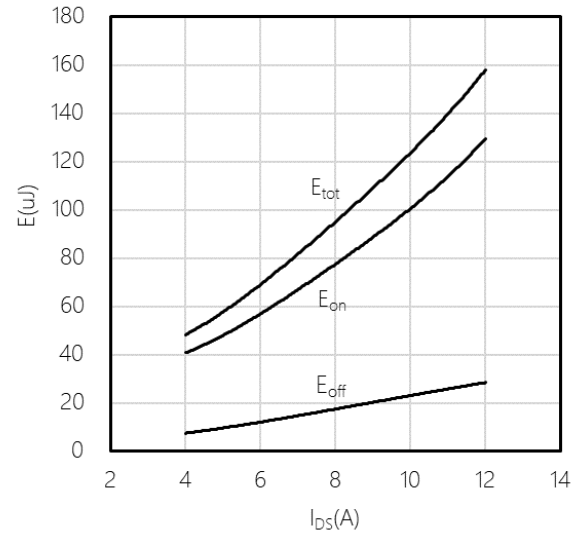
$V_{GS} = 0/15$ V, $I_{DS} = 7$ A, $T_{VJ} = 175$ °C, $V_{DS} = 400$ V



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

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

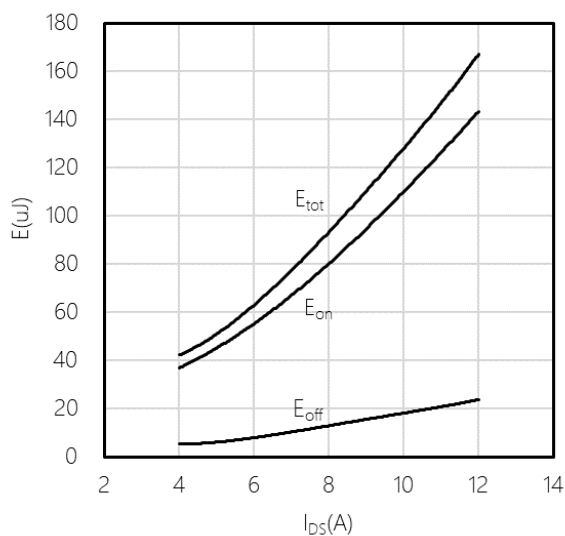
$V_{GS} = 0/15$ V, $R_{G(ext)} = 2.2$ Ω , $T_{VJ} = 25$ °C, $V_{DS} = 400$ V



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

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

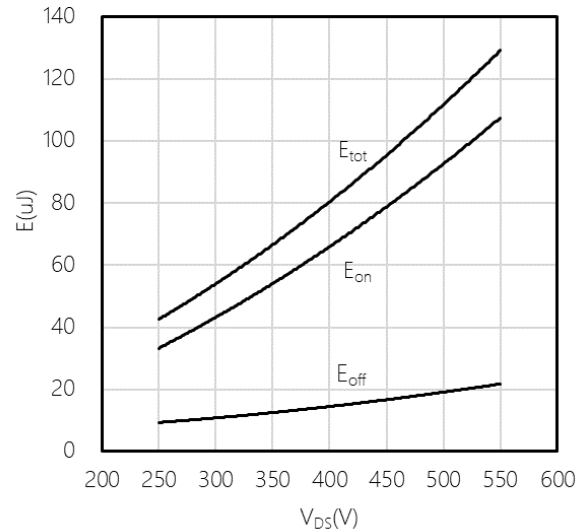
$V_{GS} = 0/15$ V, $R_{G(ext)} = 2.2$ Ω , $T_{VJ} = 175$ °C, $V_{DS} = 400$ V



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

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

$V_{GS} = 0/15$ V, $R_{G(ext)} = 2.2$ Ω , $T_{VJ} = 25$ °C, $I_{DS} = 7$ A



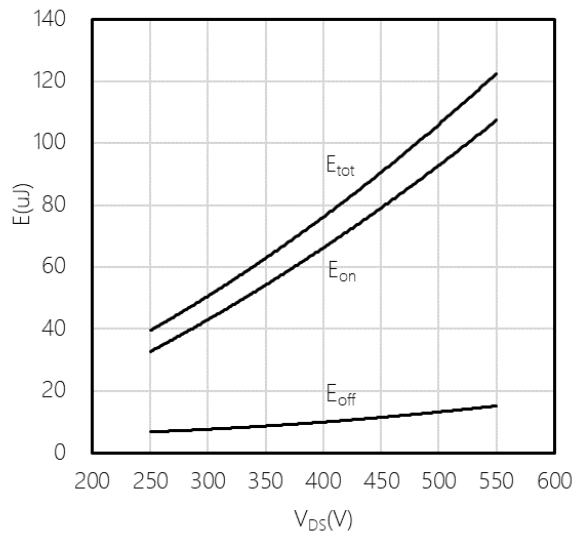
650V Silicon Carbide Power MOSFET

Typical switching energy losses as a function of V_{DS} ,

2nd device own body diode: $V_{GS} = -5\text{ V}$

$E = f(V_{DS})$

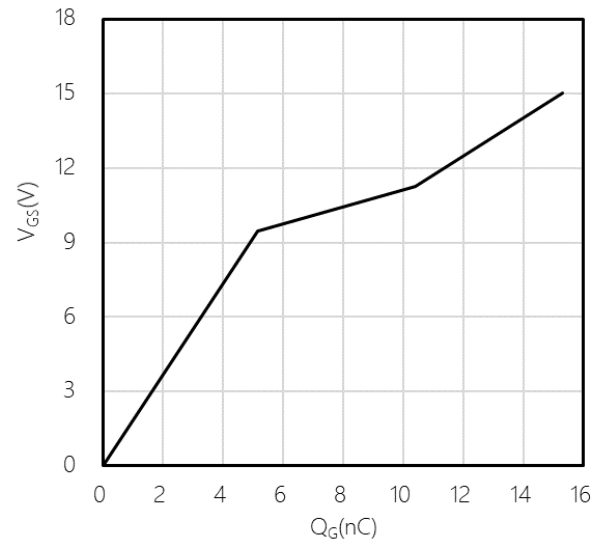
$V_{GS} = 0/15\text{ V}$, $R_{G(ext)} = 2.2\ \Omega$, $T_{VJ} = 175\ ^\circ\text{C}$, $I_{DS} = 7\text{ A}$



Typical gate charge

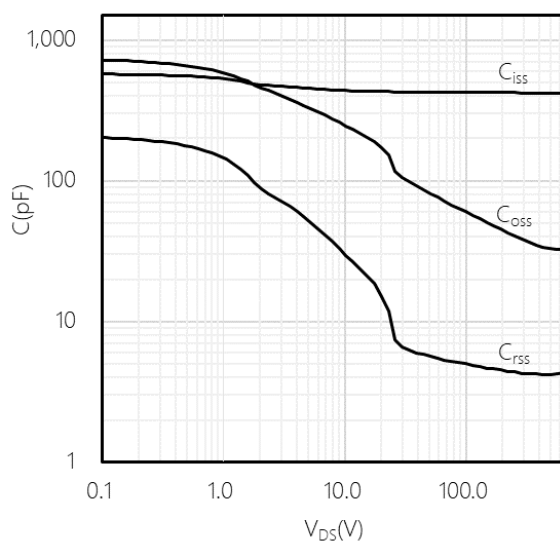
$V_{GS} = f(Q_G)$, $I_{DS} = 7\text{ A}$, $V_{DS} = 400\text{ V}$

turn-on pulse



Typical capacitance as a function of drain-source voltage

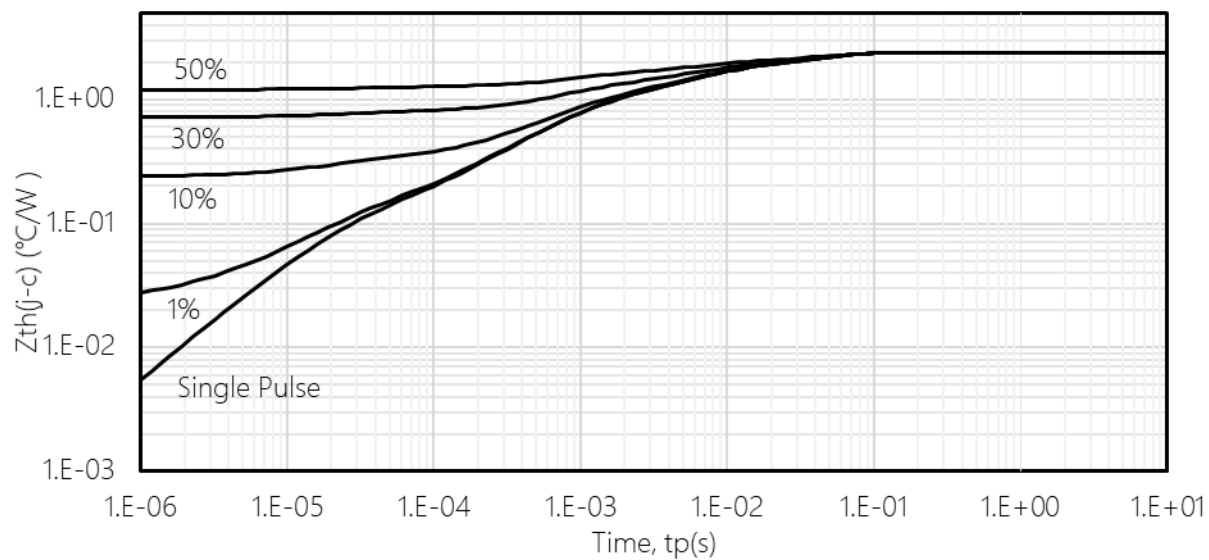
$C = f(V_{DS})$, $V_{GS} = 0\text{ V}$, $f = 1\text{ MHz}$



650V Silicon Carbide Power MOSFET

Transient thermal resistance (MOSFET)

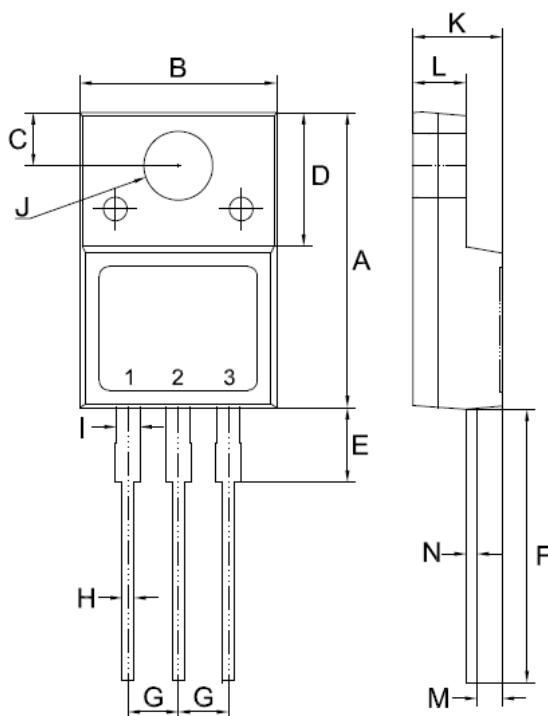
$(Z_{th(j-c,max)} = f(t_p), \text{Parameter } D = t_p/T$



650V Silicon Carbide Power MOSFET

Package Dimensions

TO-220F Mechanical Drawing



TO-220F		
Unit:mm		
DIM	MIN	MAX
A	14.50	15.50
B	9.50	10.50
C	2.50	2.90
D	6.30	7.30
E	3.30	4.30
F	13.00	14.00
G	2.35	2.75
H	0.30	0.90
I	0.90	1.50
J	3.20	3.80
K	4.24	4.84
L	2.52	2.92
M	1.09	1.49
N	0.47	0.64