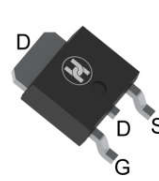
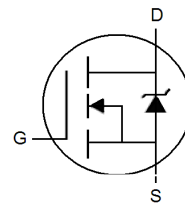


650V Silicon Carbide Power MOSFET

Key Performance Parameters		
Parameter	Value	Unit
V_{DS}	650	V
$R_{DS(ON)max. V_{GS}=15V}$	500	mΩ
$R_{DS(ON)typ. V_{GS}=15V}$	650	mΩ
I_D	7.5	A
Q_G	6.7	nC



TO-252



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
- Optimized package with separate driver source pin

Applications

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

Maximum Ratings For MOSFET (TVJ= 25°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 $T_{VJ(max)}$	7.5	A	$T_C = 25^\circ C$
		5.8		$T_C = 100^\circ C$
I_{DM}	Peak Drain Current, tp Limited by $T_{VJ(max)}$	13	A	$T_C = 25^\circ C$
$V_{GS, max}$	Gate-Source Max Voltage	-10/22	V	
$V_{GS, op}$	Gate-Source Operate Voltage	0/15	V	
E_{AS}	Single Pulse Avalanche Energy	10.2	mJ	$L=0.5\text{ mH}$, $I_{AS}=8.1\text{ A}$, $V_{DD}=50V$, $V_{GS}=15\text{ V}$
P_{tot}	Power Dissipation for $R_{th(j-c,typ.)}$	41	W	$T_C = 25^\circ C$

Package Values

Symbol	Parameter	Min.	Typ.	Max.	Unit	Testing Conditions
$R_{th(j-c)}$	MOSFET/Body Diode Junction-Case Thermal Resistance		2.6	3.1	K/W	
T_{VJ}, T_{STG}	Operating Junction and Storage Temperature	-55		175	°C	
T_{SOLD}	Soldering Temperature, Wave Soldering only Allowed at Leads 1.6mm from Case for 10s		260		°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		3.8		V	$V_{DS} = V_{GS}, I_D = 3.5 \text{ mA}$
			2.7			$T_{VJ} = 175^\circ C$
I_{DSS}	Drain-Source Leakage Current		0.1	20	μA	$V_{GS} = 0 \text{ V}, V_{DS} = 650 \text{ V}$
			3			$T_{VJ} = 175^\circ C$
I_{GSS}	Gate-Source Leakage Current			250	nA	$V_{GS} = 22 \text{ V}, V_{DS} = 0 \text{ V}$
I_{SGS}	Source-Gate Leakage Current			250	nA	$V_{GS} = -10 \text{ V}, V_{DS} = 0 \text{ V}$
$R_{DS(on)}$	Drain-Source On-State Resistance		500	650	m Ω	$V_{GS} = 15 \text{ V}, I_D = 4 \text{ A}$
			509			$T_{VJ} = 175^\circ C$
g_{fs}	Transconductance		2.6		S	$V_{DS} = 20 \text{ V}, I_D = 4 \text{ A}$
$R_{G(int)}$	Internal Gate Resistance		35		Ω	$f = 1 \text{ MHz}, V_{AC} = 25 \text{ mV}$
C_{iss}	Input Capacitance		149		pF	$V_{GS} = 0 \text{ V}, V_{DS} = 650 \text{ V}, f = 1 \text{ MHz}$
C_{oss}	Output Capacitance		11		pF	
C_{rss}	Reverse Transfer Capacitance		0.8		pF	
Q_{GS}	Gate to Source Charge		3.0		nC	$V_{GS} = 0/15 \text{ V}, V_{DS} = 400 \text{ V}, I_D = 4 \text{ A}$
Q_{GD}	Gate to Drain Charge		1.1		nC	
Q_G	Total Gate Charge		6.7		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		6.3		ns	$T_{VJ} = 25^\circ C$
			6.1			$T_{VJ} = 175^\circ C$
t_r	Rise Time		17.4		ns	$T_{VJ} = 25^\circ C$
			13.3			$T_{VJ} = 175^\circ C$
$t_{d(off)}$	Turn-Off Delay Time		14.3		ns	$T_{VJ} = 25^\circ C$
			17.4			$T_{VJ} = 175^\circ C$
t_f	Fall Time		14.8		ns	$T_{VJ} = 25^\circ C$
			14.9			$T_{VJ} = 175^\circ C$
E_{on}	Turn-On Switching Loss		35.1		μJ	$T_{VJ} = 25^\circ C$
			33.4			$T_{VJ} = 175^\circ C$
E_{off}	Turn-Off Switching Loss		3.02		μJ	$T_{VJ} = 25^\circ C$
			3.07			$T_{VJ} = 175^\circ C$
E_{tot}	Total Switching Energy		38.1		μJ	$T_{VJ} = 25^\circ C$
			36.5			$T_{VJ} = 175^\circ C$

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 $T_{VJ(max)}$	7.5	A	$T_C = 25^\circ C$
		5.8	A	$T_C = 100^\circ C$
I_{SM}	Peak Reverse Drain Current, tp Limited by $T_{VJ(max)}$	13	A	$T_C = 25^\circ C$

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

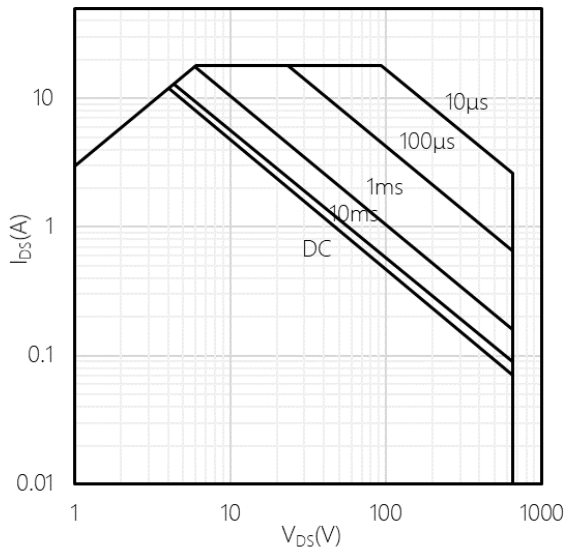
Symbol	Parameter	Min.	Typ.	Max.	Unit	Testing Conditions	
V _{SD}	Body Diode Forward Voltage		3.8		V	V _{GS} = 0 V, I _{SD} = 2A	T _{VJ} = 25 °C
			3.3				T _{VJ} = 175 °C
I _{rrm}	Peak Reverse Recovery Current		4.5		A	V _{DS} = 400 V, V _{GS} = 0 V, I _{SD} = 4 A, di/dt = 1.2kA/μs	T _{VJ} = 25 °C
			5.4				T _{VJ} = 175 °C
Q _{rr}	Reverse Recovery Charge		25		nC		T _{VJ} = 25 °C
			28				T _{VJ} = 175 °C
t _{rr}	Reverse Recovery Time		9.2		ns		T _{VJ} = 25 °C
			8.6				T _{VJ} = 175 °C
E _{rr}	Reverse Recovery Energy		0.71		μJ		T _{VJ} = 25 °C
			0.22				T _{VJ} = 175 °C

650V Silicon Carbide Power MOSFET

Typical Performances

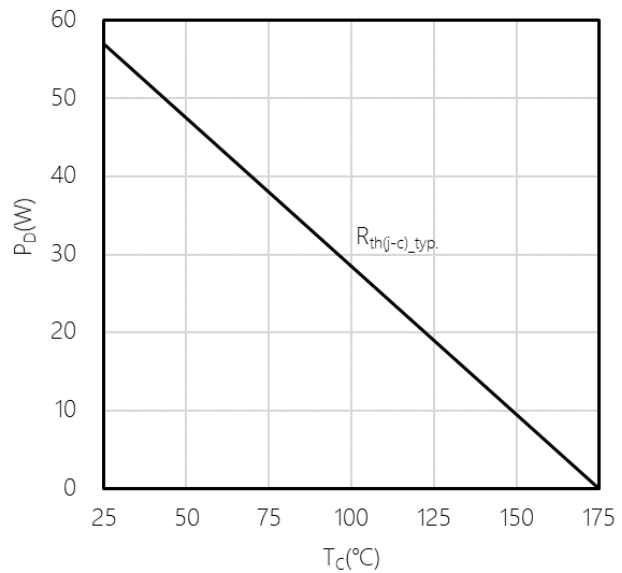
Safe operating area (SOA)

$R_{th(j-c)} = 3.1\text{ }^{\circ}\text{C/W}$, Single Pulse, $T_{vj} = 25^{\circ}\text{C}$



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

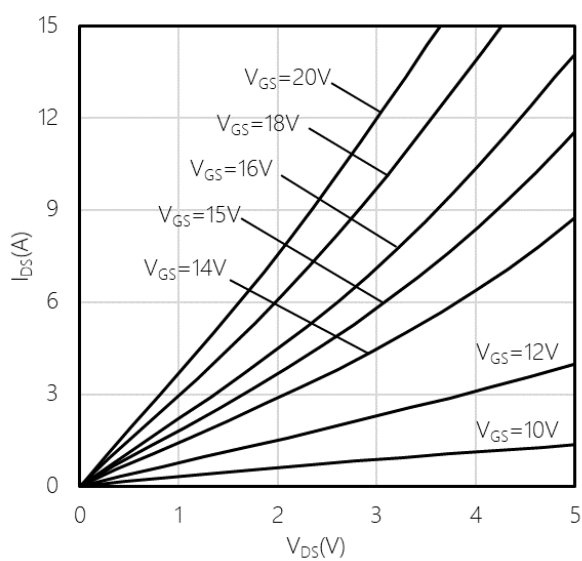
$P_D = f(T_C)$



Typical output characteristic, V_{GS} as parameter

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

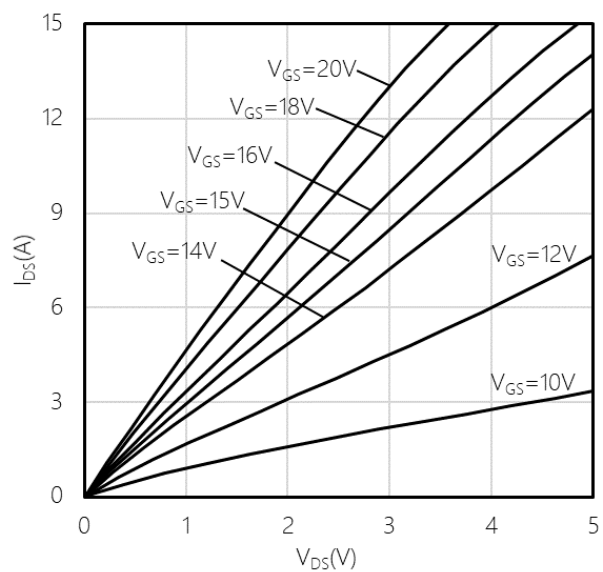
$T_{vj} = -55\text{ }^{\circ}\text{C}$



Typical output characteristic, V_{GS} as parameter

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

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

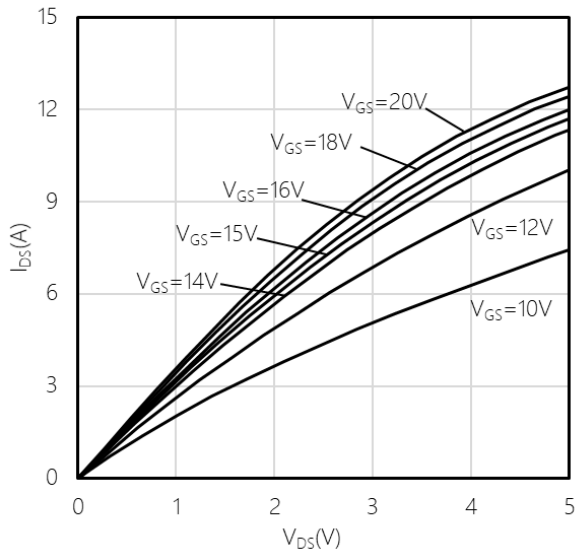


650V Silicon Carbide Power MOSFET

Typical output characteristic, V_{GS} as parameter

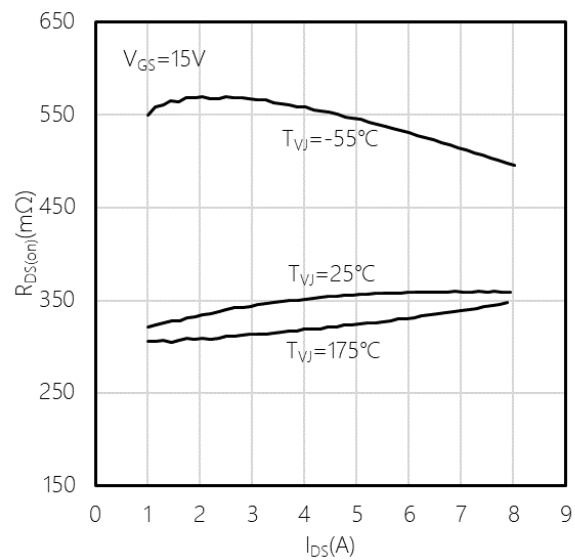
$$I_{DS} = f(V_{DS})$$

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



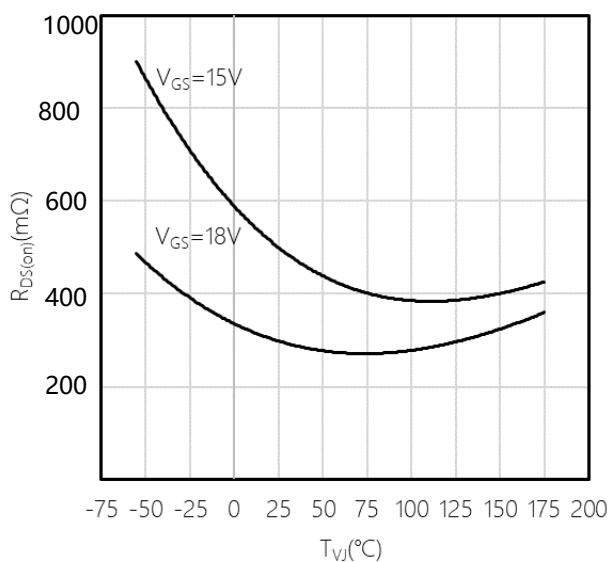
Typical on-state resistance as a function of drain current

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



Typical on-state resistance as a function of temperature

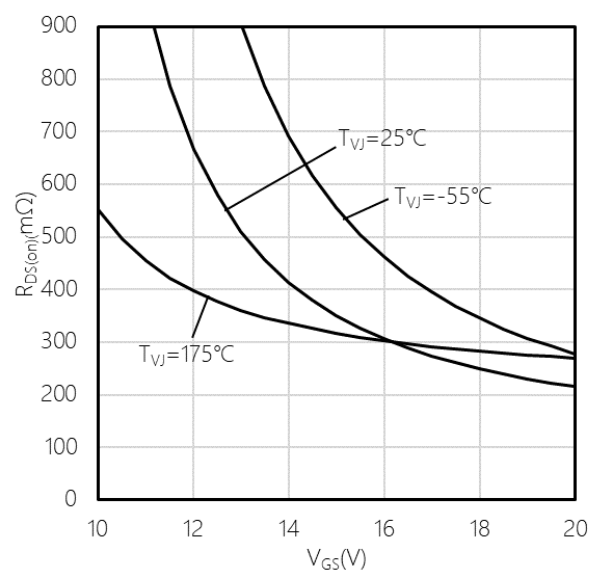
$$R_{DS(on)} = f(T_{VJ}), I_{DS} = 4\text{ A}$$



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

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

$$I_{DS} = 4\text{ A}$$

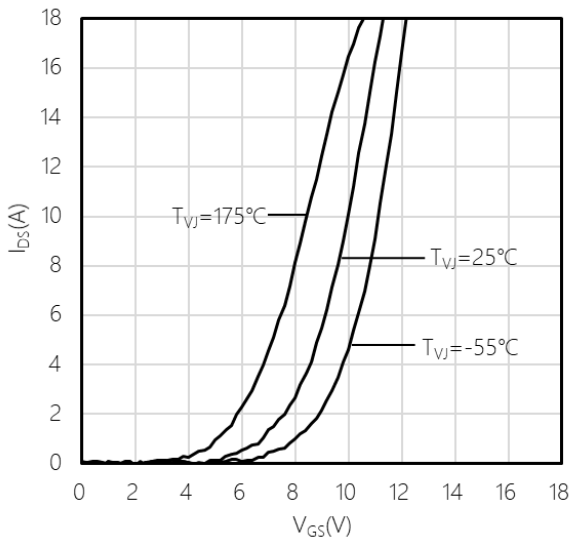


650V Silicon Carbide Power MOSFET

Typical transfer characteristic

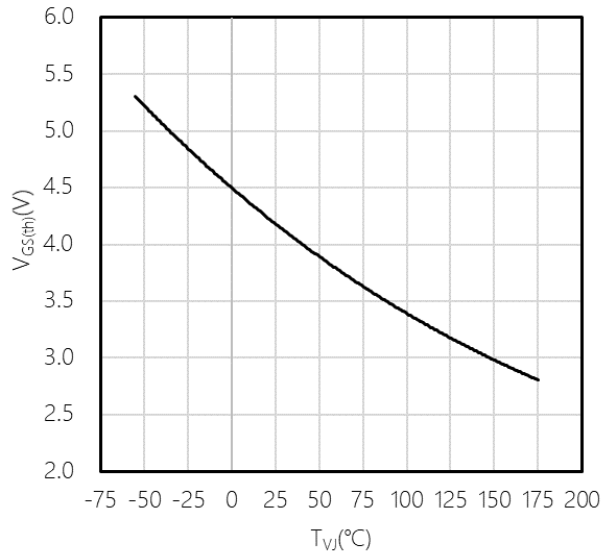
$$I_{DS} = f(V_{GS})$$

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



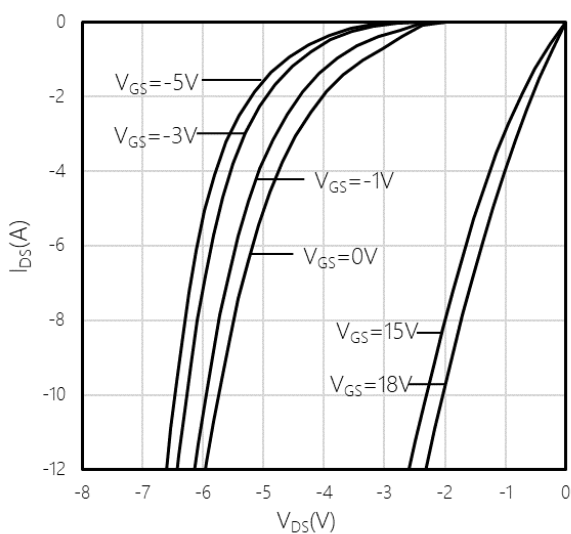
Typical gate-source threshold voltage as a function of junction temperature

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



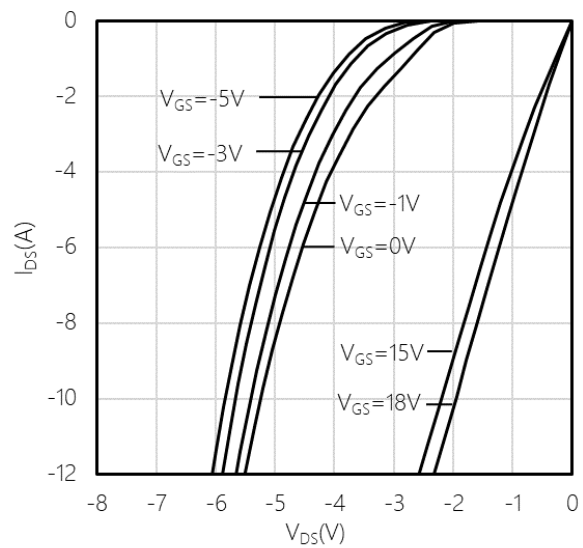
Typical reverse drain current as function of reverse drain voltage, V_{GS} as parameter

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



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

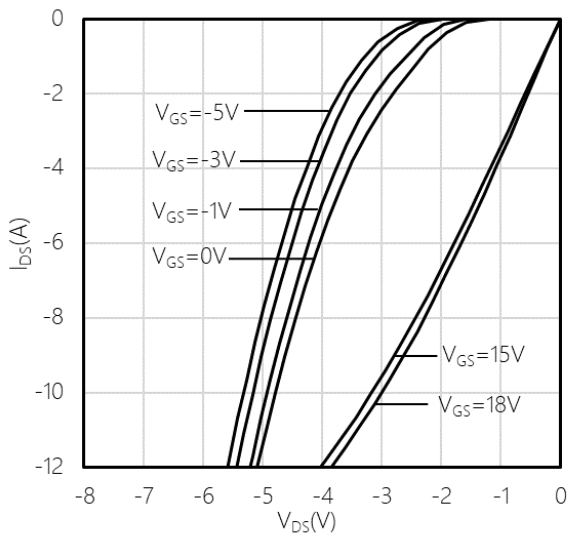
$$I_{DS} = f(V_{DS}), T_{VJ} = 25^\circ\text{C}$$



650V Silicon Carbide Power MOSFET

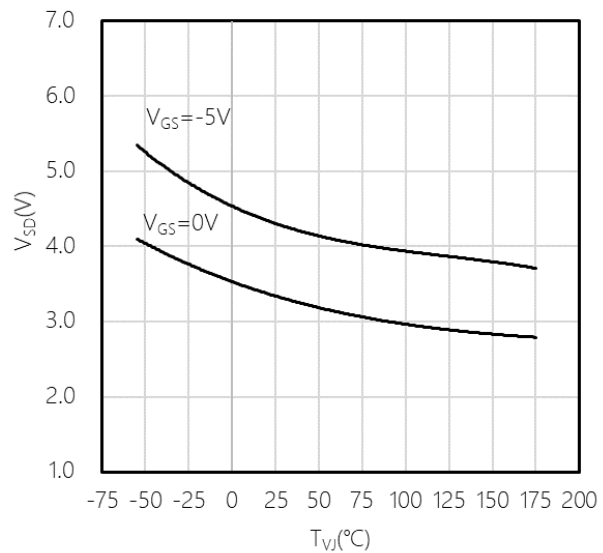
Typical reverse drain current as function of reverse drain voltage, V_{GS} as parameter

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



Typical reverse drain voltage as function of junction temperature

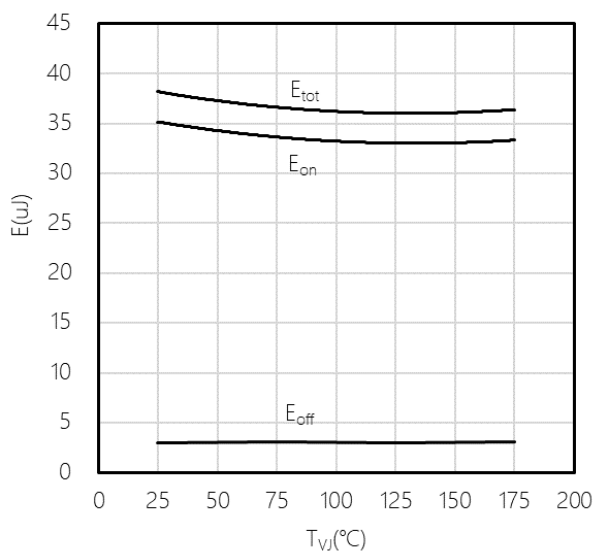
$$V_{SD} = f(T_{VJ}), I_{SD} = 2\text{ A}$$



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

$$E = f(T_{VJ})$$

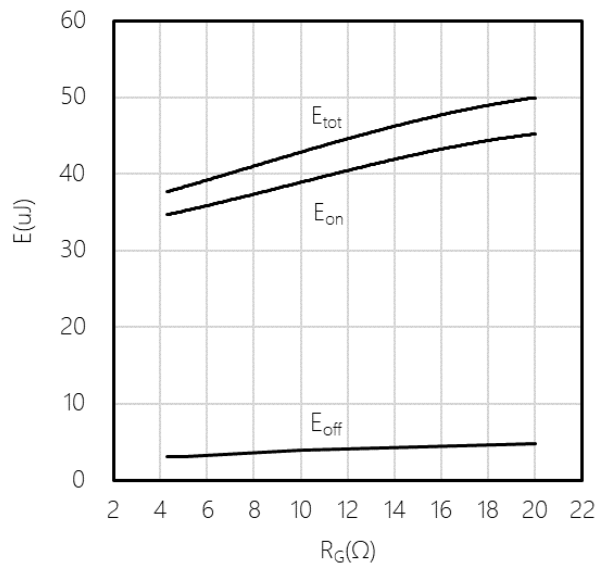
$$V_{DS} = 400\text{ V}, R_{G(ext)} = 4.3\text{ }\Omega, V_{GS} = 0/15\text{ V}, I_{DS} = 4\text{ A}$$



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

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

$$V_{GS} = 0/15\text{ V}, I_{DS} = 4\text{ A}, T_{VJ} = 25\text{ }^{\circ}\text{C}, V_{DS} = 400\text{ V}$$

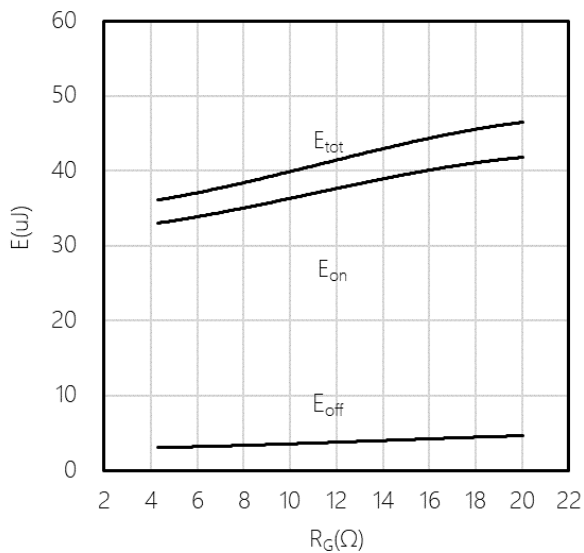


650V Silicon Carbide Power MOSFET

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

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

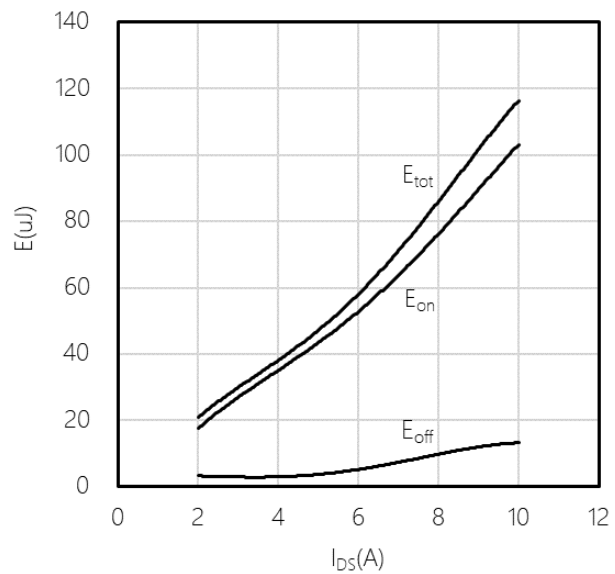
$V_{GS} = 0/15$ V, $I_{DS} = 4$ A, $T_{VJ} = 175$ °C, $V_{DS} = 400$ V



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

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

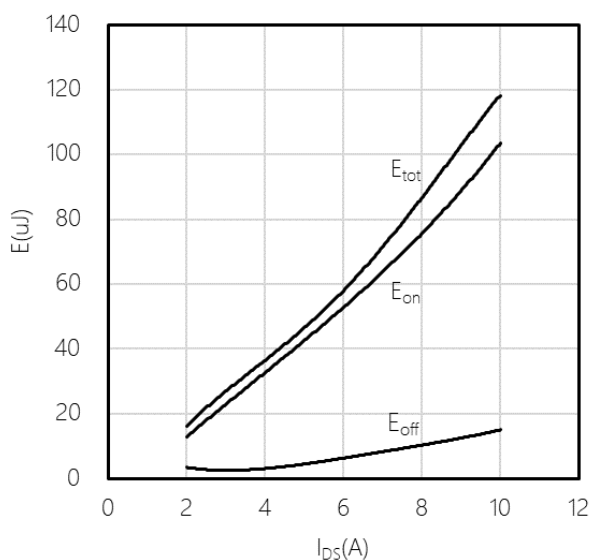
$V_{GS} = 0/15$ V, $R_{G(ext)} = 4.3$ Ω, $T_{VJ} = 25$ °C, $V_{DS} = 400$ V



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

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

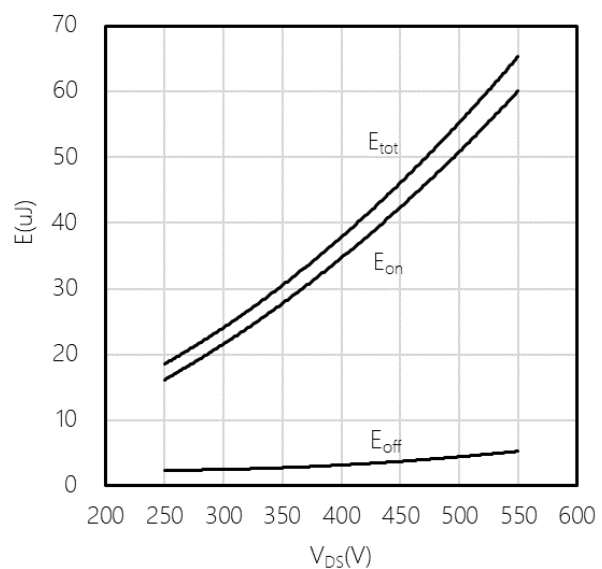
$V_{GS} = 0/15$ V, $R_{G(ext)} = 4.3$ Ω, $T_{VJ} = 175$ °C, $V_{DS} = 400$ V



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, $R_{G(ext)} = 4.3$ Ω, $T_{VJ} = 25$ °C, $I_{DS} = 4$ A



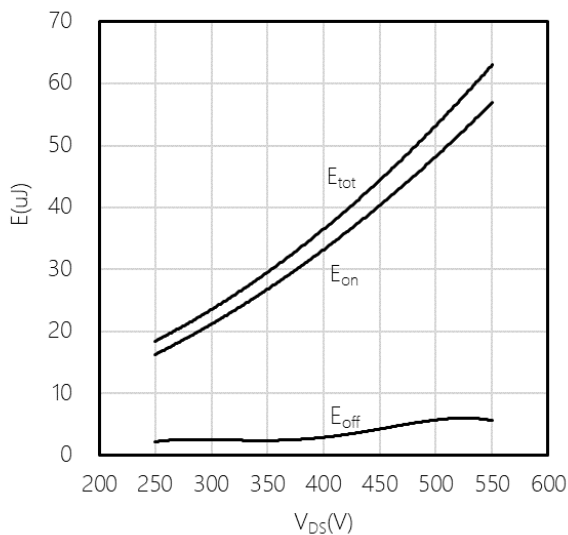
650V Silicon Carbide Power MOSFET

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

2nd device own body diode: $V_{GS} = 0\text{ V}$

$E = f(V_{DS})$

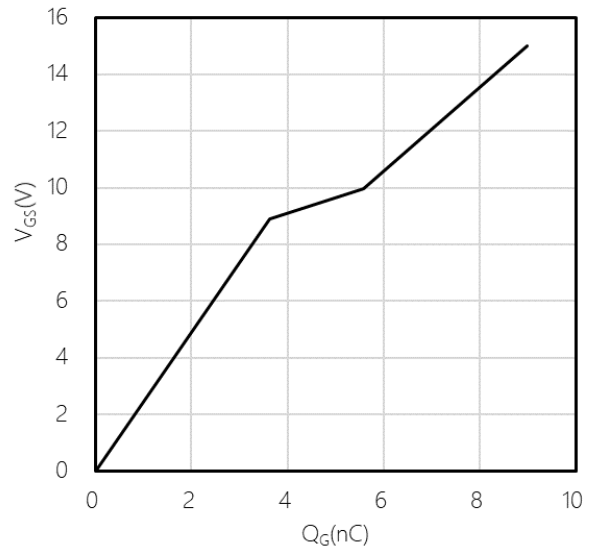
$V_{VGS} = 0/15\text{ V}$, $R_{G(ext)} = 4.3\ \Omega$, $T_{VJ} = 175\ ^\circ\text{C}$, $I_{DS} = 4\text{ A}$



Typical gate charge

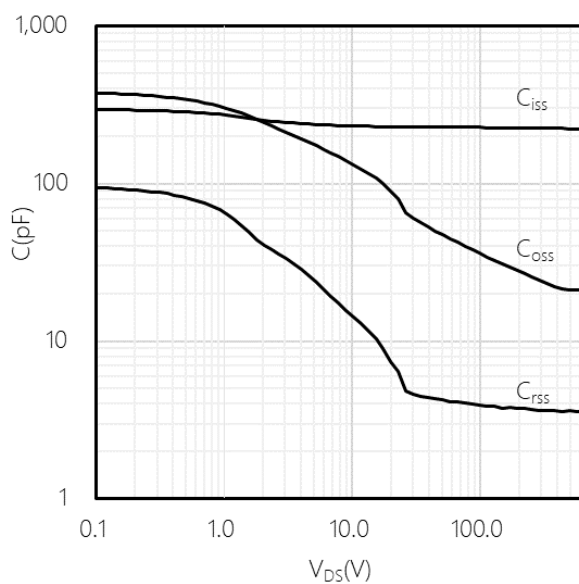
$V_{GS} = f(Q_G)$, $I_{DS} = 4\text{ A}$, $V_{DS} =$

400V turn-on pulse



Typical capacitance as a function of drain-source voltage

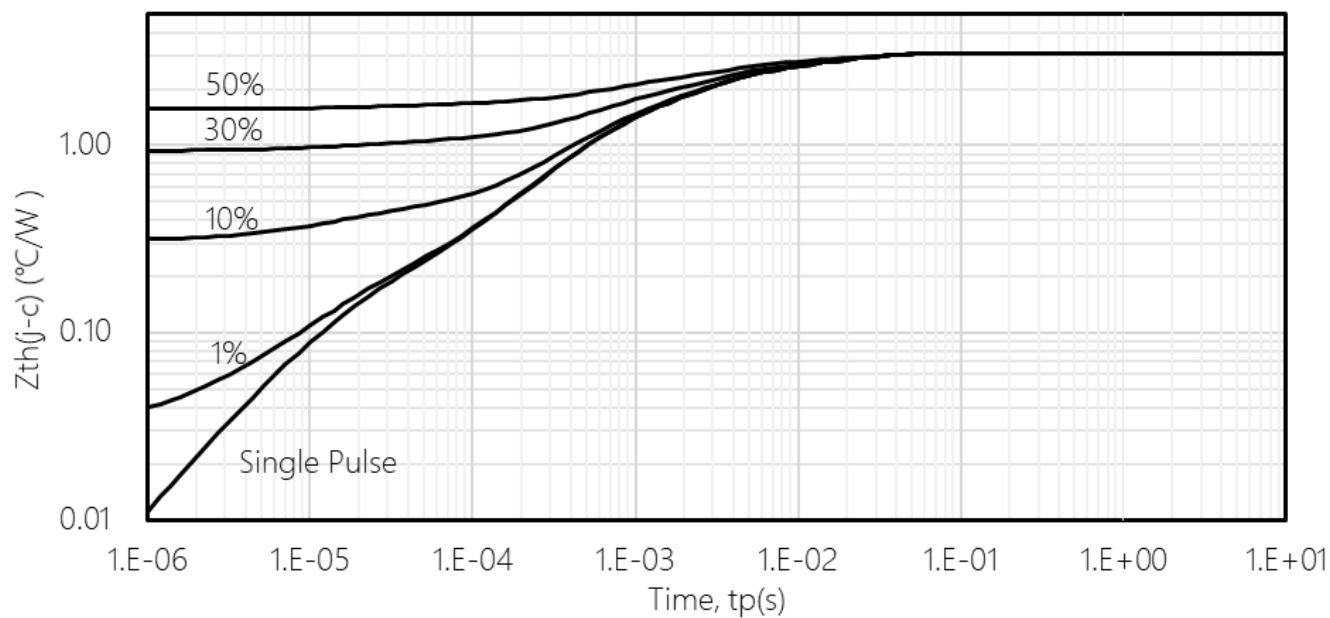
$C = f(V_{DS})$, $V_{GS} = 0\text{ V}$, $f = 1\text{ MHz}$



650V Silicon Carbide Power MOSFET

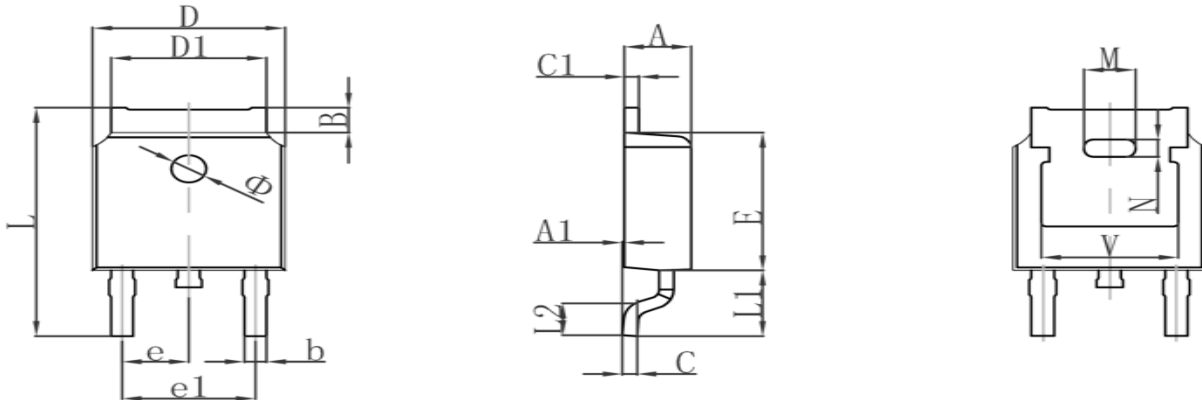
Transient thermal resistance (MOSFET)

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



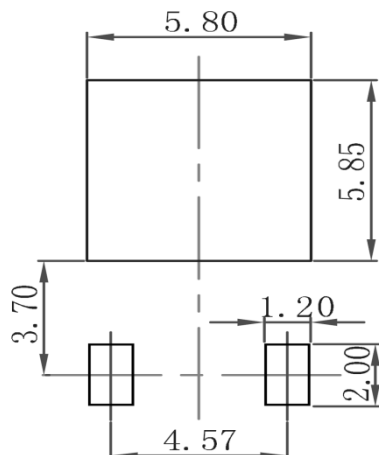
650V Silicon Carbide Power MOSFET

TO-252 PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	2.200	2.380	0.087	0.094
A1	0.000	0.100	0.000	0.004
B	0.800	1.400	0.031	0.055
b	0.710	0.810	0.028	0.032
c	0.460	0.560	0.018	0.022
c1	0.460	0.560	0.018	0.022
D	6.500	6.700	0.256	0.264
D1	5.130	5.460	0.202	0.215
E	6.000	6.200	0.236	0.244
e	2.286TYP		0.090TYP	
e1	4.327	4.727	0.170	0.186
M	1.778REF		0.070REF	
N	0.762REF		0.018REF	
L	9.800	10.400	0.386	0.409
L1	2.9REF		0.114REF	
L2	1.400	1.700	0.055	0.067
V	4.830REF		0.190REF	
Φ	1.100	1.300	0.043	0.051

TO-252 SUGGESTED PAD LAYOUT

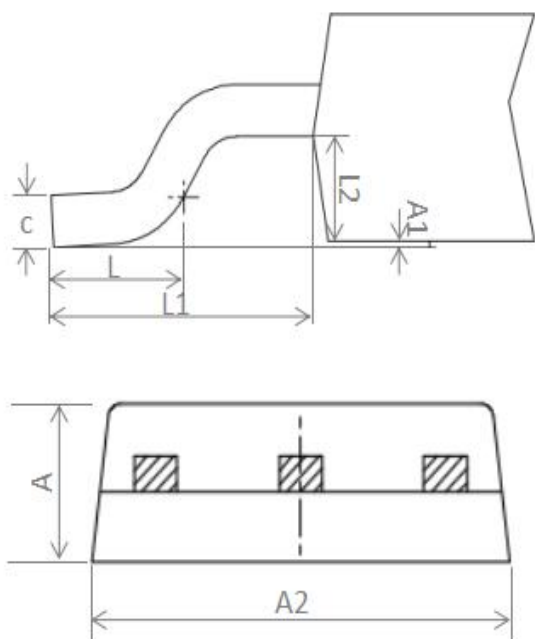
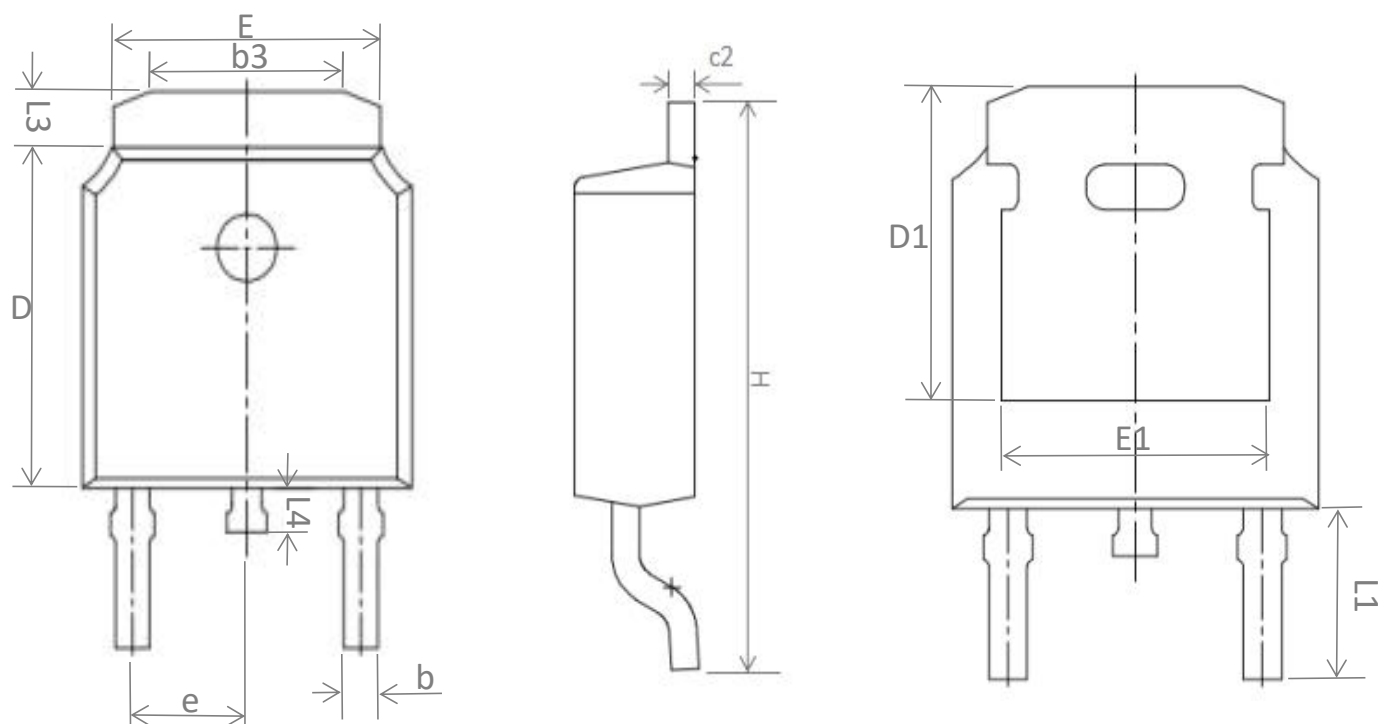


Note:

1. Controlling dimension: in millimeters
2. General tolerance: $\pm 0.05\text{mm}$
3. The pad layout is for reference purposes only

650V Silicon Carbide Power MOSFET

TO-252 PACKAGE OUTLINE DIMENSIONS

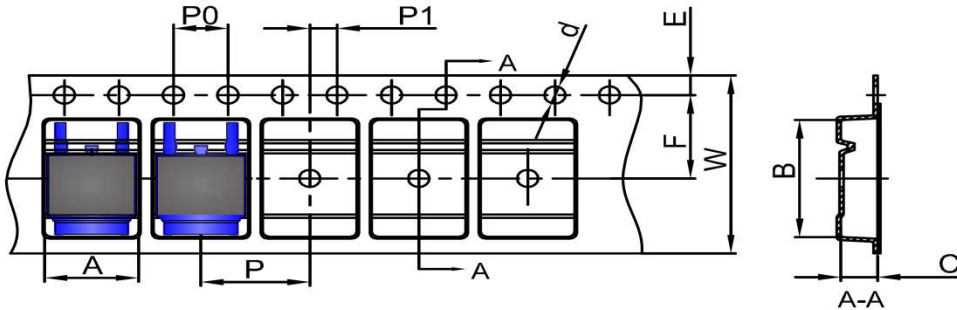


SYMBOL	Spec (mm)
A	2.3 ± 0.1
A1	0-0.15
A2	6.6 ± 0.1
b	0.67 ± 0.1
b3	3.85 ± 0.2
c	0.508 ± 0.1
c2	0.508 ± 0.1
D	6.1 ± 0.15
D1	5.249 ± 0.15
E	5.334 ± 0.15
E1	4.826 ± 0.15
e	2.286REF
H	10.0 ± 0.2
L	1.5 ± 0.15
L1	2.888 ± 0.2
L2	0.9-1.1
L3	1.0REF
L4	0.9 ± 0.2

650V Silicon Carbide Power MOSFET

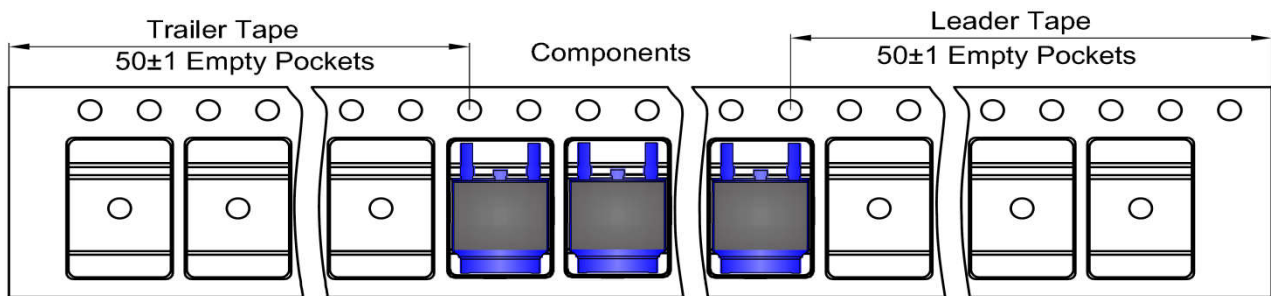
TO-252 TAPE AND REEL

TO-252 Embossed Carrier Tape

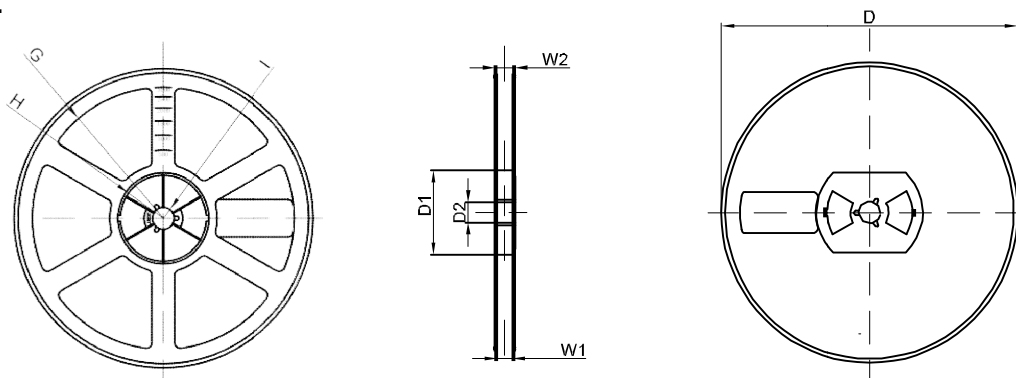


DIMENSIONS ARE IN MILLIMETER										
TYPE	A	B	C	d	E	F	P0	P	P1	W
TO-252	6.90	10.50	2.70	Ø1.55	1.75	7.50	4.00	8.00	2.00	16.00
TOLERANCE	±0.1	±0.1	±0.1	±0.1	±0.1	±0.1	±0.1	±0.1	±0.1	±0.1

TO-252 Tape Leader and Trailer



TO-252 REEL



DIMENSIONS ARE IN MILLIMETER								
REEL OPTION	D	D1	D2	G	H	I	W1	W2
13" DIA	Ø330.00	100.00	Φ21.00	R151.00	R56.00	R6.50	16.40	21.00
TOLERANCE	±2	±1	±1	±1	±1	±1	±1	±1