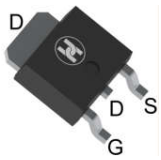
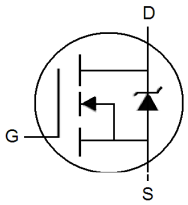
650V Silicon Carbide Power MOSFET

Key Performance Parameters		
Parameter	**Value**	**Unit**
V_{DSS}	650	V
$R_{DS(ON)max.}$ V_{GS}=15V	390	mΩ
$R_{DS(ON)typ.}$ V_{GS}=15V	300	mΩ
I_D	10.5	A
Q_G	8.8	nC



TO-252



EQUIVA ENT 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-condictioning
- E-bike charger

Maximum Ratings For MOSFET (T_{VJ}= 25˚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 $T_{VJ(max)}$	10.5	A	T_C = 25 ℃
		8.5		Tc = 100℃
I_{DM}	Peak Drain Current, tp Limited by $T_{VJ(max)}$	18	A	T_C = 25 ℃
$V_{GS, max}$	Gate-Source Max Voltage	-10/22	V	
$V_{GS, op}$	Gate-Source Operate Voltage	0/15	V	
E_{AS}	Single Pulse Avalanche Energy	17	mJ	L=0.5 mH, I_{AS}=8.4 A , V_{DD}=50V, V_{GS}=15
P_{tot}	Power Dissipation for $R_{th(j-c,typ.)}$	57	W	T_C = 25℃

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	℃	
T_{SOLD}	Soldering Temperature, Wave Soldering only Allowed at Leads 1.6mm from Case for 10s		260		℃	

650V Silicon Carbide Power MOSFET

MOSFET Characteristics (T_{VJ}= 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 μA	
$V_{GS(th)}$	Gate Threshold Voltage	2.7	3.5		V	V_{DS} = V_{GS}, I_D = 3.5mA	T_{VJ} = 25 ℃
			2.5				T_{VJ} = 175 ℃
I_{DSS}	Drain-Source Leakage Current		0.1	10	μA	V_{GS} = 0 V, V_{DS} = 650 V	T_{VJ} = 25 ℃
			1				T_{VJ} = 175 ℃
I_{GSS}	Gate-Source Leakage Current			250	nA	V_{GS} = 22 V, V_{DS} = 0 V	T_{VJ} = 25 ℃
I_{SGS}	Source-Gate Leakage Current			250	nA	V_{GS} = -10 V, V_{DS} = 0 V	T_{VJ} = 25 ℃
$R_{DS(on)}$	Drain-Source On-State Resistance		300	390	mΩ	V_{GS} = 15 V, I_D = 5 A	T_{VJ} = 25 ℃
			321				T_{VJ} = 175 ℃
g_{fs}	Transconductance		3.5		S	V_{DS} = 20 V, I_D = 5A	
$R_{G(int)}$	Internal Gate Resistance		26		Ω	f = 1MHz, V_{AC} = 25 mV	
C_{iss}	Input Capacitance		228		pF	V_{GS} = 0 V, V_{DS} = 400 V, f = 1MHz	
C_{oss}	Output Capacitance		17		pF		
C_{rss}	Reverse Transfer Capacitance		1.4		pF		
Q_{GS}	Gate to Source Charge		3.3		nC	V_{GS} = 0/15 V , V_{DS} = 400V, I_D =5 A	
Q_{GD}	Gate to Drain Charge		1.2		nC		
Q_G	Total Gate Charge		8.8		nC		

Dynamic MOSFET Characteristics (T_{VJ}= 25˚C unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit	Testing Conditions	
$t_{d(on)}$	Turn−On Delay Time		6.3		ns	V_{GS}= 0/15V L=600uH V_{DS} = 400 V, I_D = 4 A, $R_{G(on)}$ = 4.3 Ω, $R_{G(off)}$ = 4.3 Ω	T_{VJ} = 25 ℃
			6.1				T_{VJ} = 175 ℃
t_r	Rise Time		17.4		ns		T_{VJ} = 25 ℃
			13.3				T_{VJ} = 175 ℃
$t_{d(off)}$	Turn−Off Delay Time		14.3		ns		T_{VJ} = 25 ℃
			17.4				T_{VJ} = 175 ℃
t_f	Fall Time		14.8		ns		T_{VJ} = 25 ℃
			14.9				T_{VJ} = 175 ℃
E_{on}	Turn−On Switching Loss		35.1		μJ		T_{VJ} = 25 ℃
			33.4				T_{VJ} = 175 ℃
E_{off}	Turn−Off Switching Loss		3.02		μJ		T_{VJ} = 25 ℃
			3.07				T_{VJ} = 175 ℃
E_{tot}	Total Switching Energy		38.1		μJ		T_{VJ} = 25 ℃
			36.5				T_{VJ} = 175 ℃

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

Maximum Ratings For Body Diode (T_{VJ}= 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 $T_{VJ(max)}$	10.5	A	T_C = 25 ℃
		5.5	A	T_C = 100 ℃
I_{SM}	Peak Reverse Drain Current, tp Limited by $T_{VJ(max)}$	17.5	A	T_C = 25 ℃

650V Silicon Carbide Power MOSFET

Body Diode Characteristics (T_{VJ}= 25˚C unless otherwise specified)

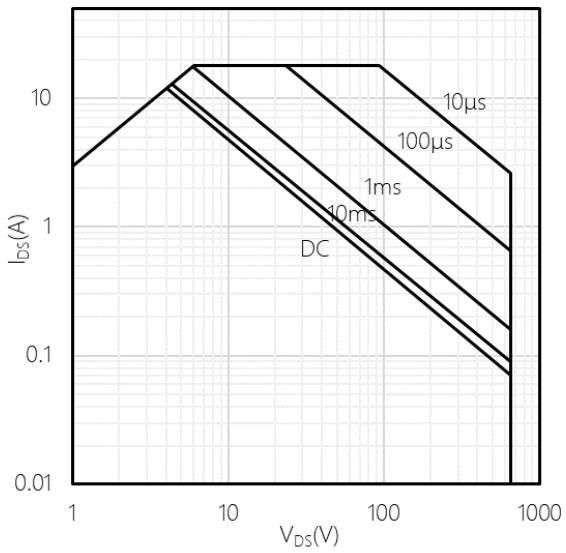
Symbol	Parameter	Min.	Typ.	Max.	Unit	Testing Conditions	
V_{SD}	Body Diode Forward Voltage		3.5		V	V_{GS} = 0 V, I_{SD} = 2.5A	T_{VJ} = 25 ℃
			3.0				T_{VJ} = 175 ℃
I_{rrm}	Peak Reverse Recovery Current		4.5		A	V_{DS} = 400 V, V_{GS} = 0 V,I_{SD} =4 A, di/dt = 1.2kA/μs	T_{VJ} = 25 ℃
			5.4				T_{VJ} = 175 ℃
Q_{rr}	Reverse Recovery Charge		25		nC		T_{VJ} = 25 ℃
			28				T_{VJ} = 175 ℃
t_{rr}	Reverse Recovery Time		9.2		ns		T_{VJ} = 25 ℃
			8.6				T_{VJ} = 175 ℃
E_{rr}	Reverse Recovery Energy		0.71		μJ		T_{VJ} = 25 ℃
			0.22				T_{VJ} = 175 ℃

650V Silicon Carbide Power MOSFET

Typical Performances

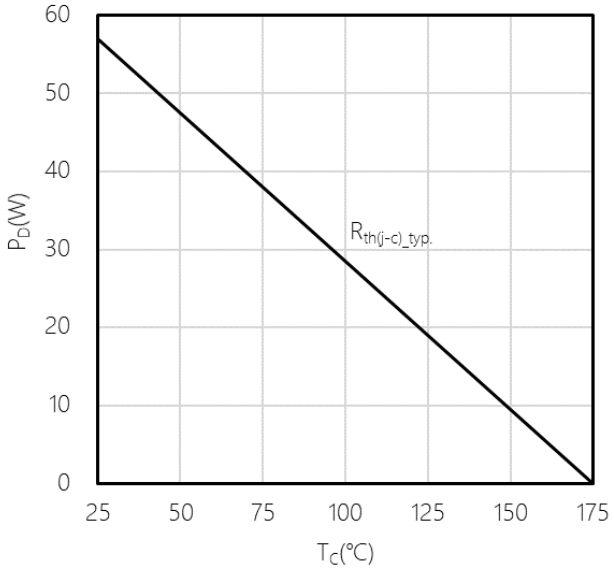
Safe operating area (SOA)

$R_{th(j-c)}$ =3.1 °C/W, Single Pulse, T_{VJ} = 25°C



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

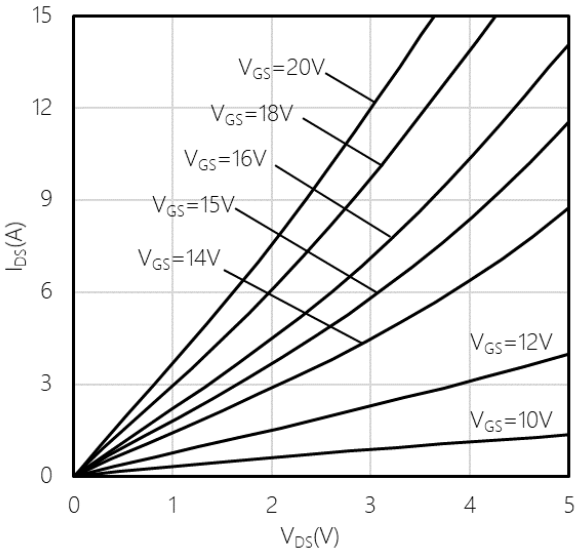
$P_D = f(T_C)$



Typical output characteristic, V_{GS} as parameter

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

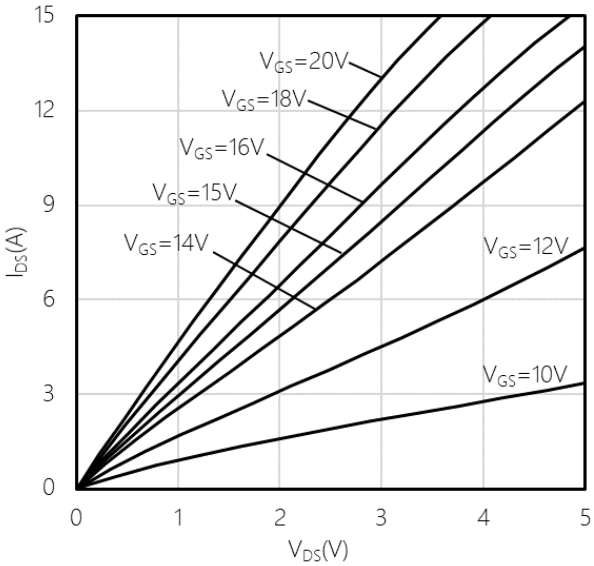
T_{VJ} = -55 ℃



Typical output characteristic, V_{GS} as parameter

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

T_{VJ} = 25 ℃

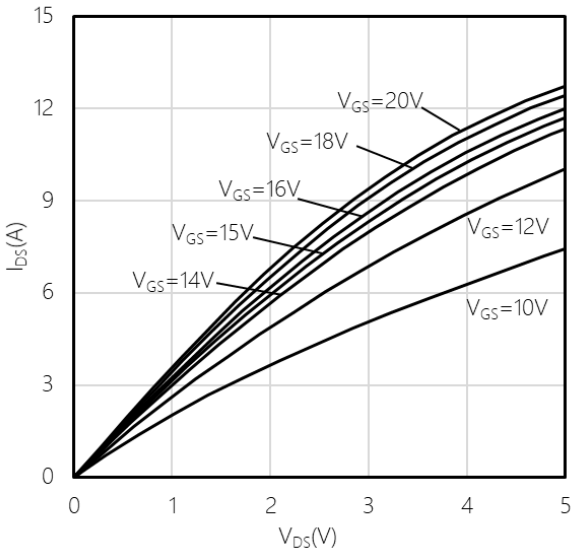


650V Silicon Carbide Power MOSFET

Typical output characteristic, V_{GS} as parameter

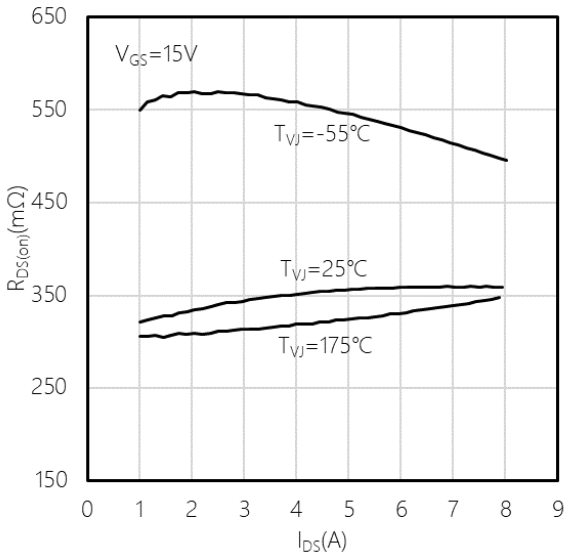
$I_{DS} = f(V_{DS})$

$T_{VJ} = 175°C$



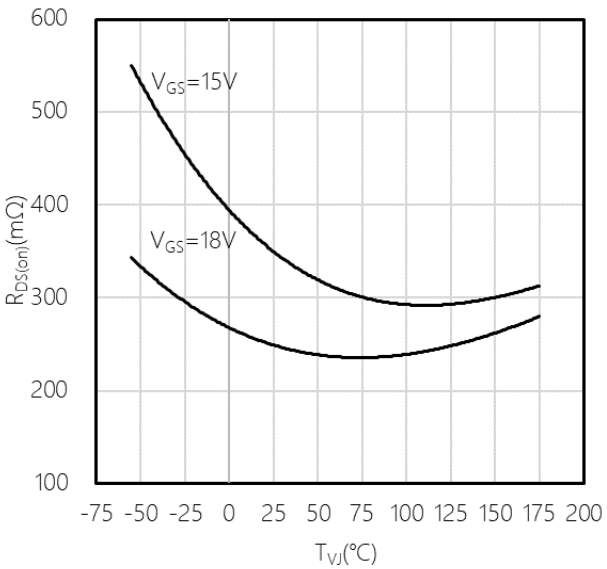
Typical on-state resistance as a function of drain current

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



Typical on-state resistance as a function of temperature

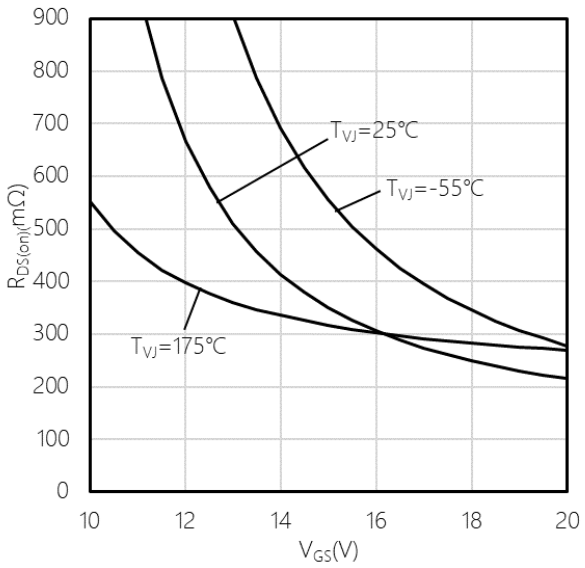
$R_{DS(on)} = f(T_{VJ})$, $I_{DS} = 4$ A



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

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

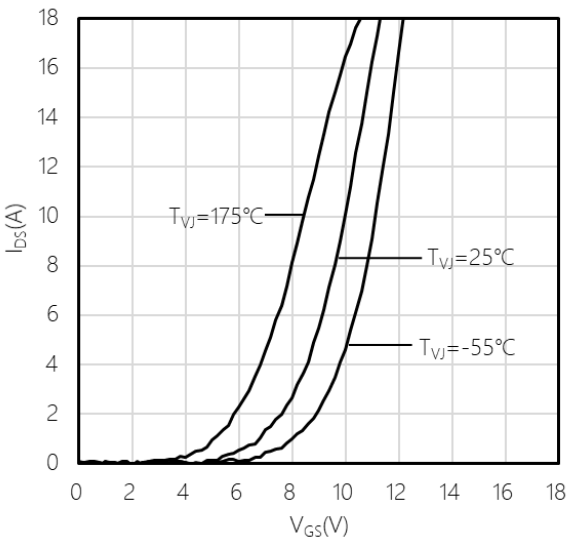
$I_{DS} = 4$ A



Typical transfer characteristic

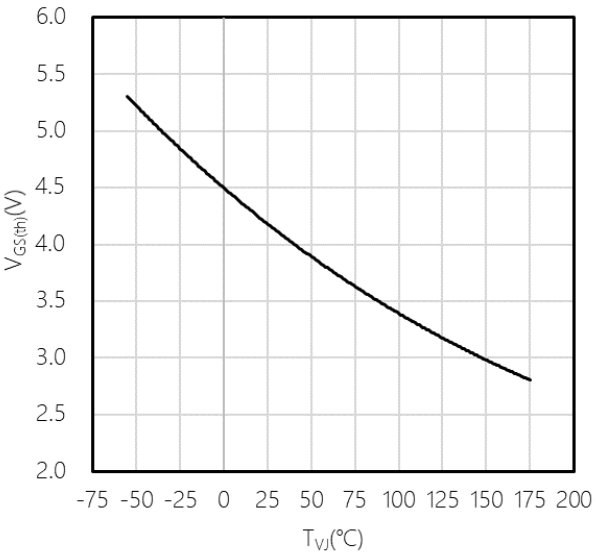
I_{DS} = f(V_{GS})

V_{DS}= 20 V



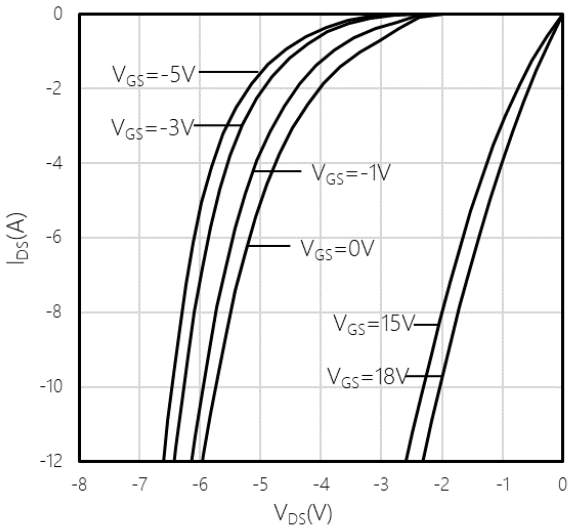
Typical gate-source threshold voltage as a function of junction temperature

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



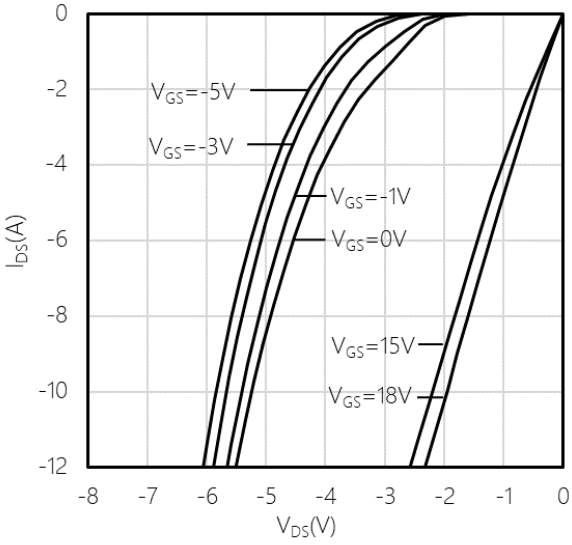
Typical reverse drain current as function of reverse drain voltage, V_{GS} as parameter

I_{DS} = f(V_{DS}), T_{VJ} = -55 °C



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

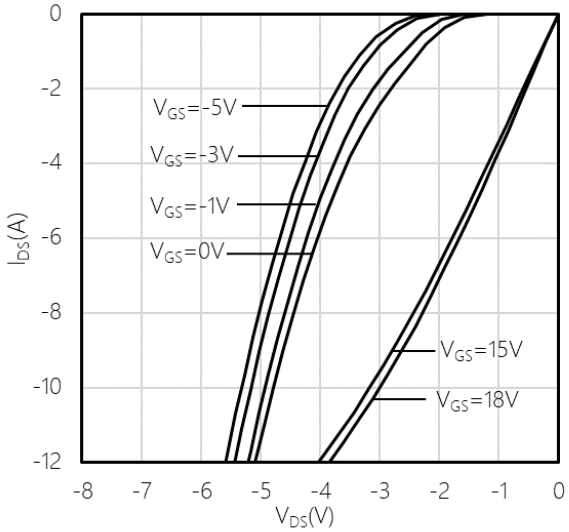
I_{DS} = f(V_{DS}), T_{VJ} = 25 °C



650V Silicon Carbide Power MOSFET

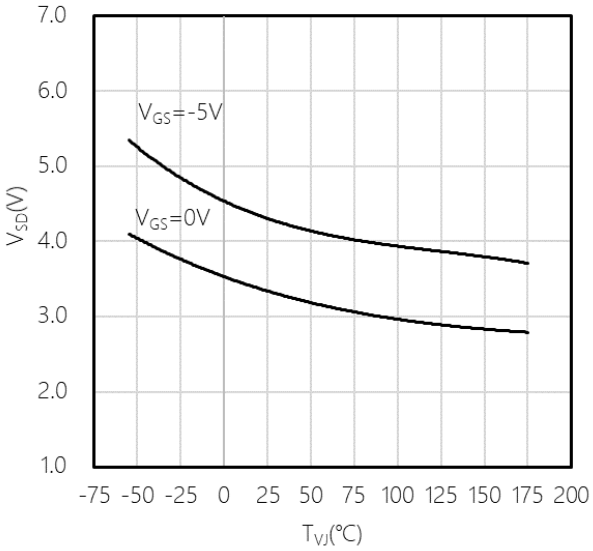
Typical reverse drain current as function of reverse drain voltage, V_{GS} as parameter

$I_{DS} = f(V_{DS})$, T_{VJ} = 175 °C



Typical reverse drain voltage as function of junction temperature

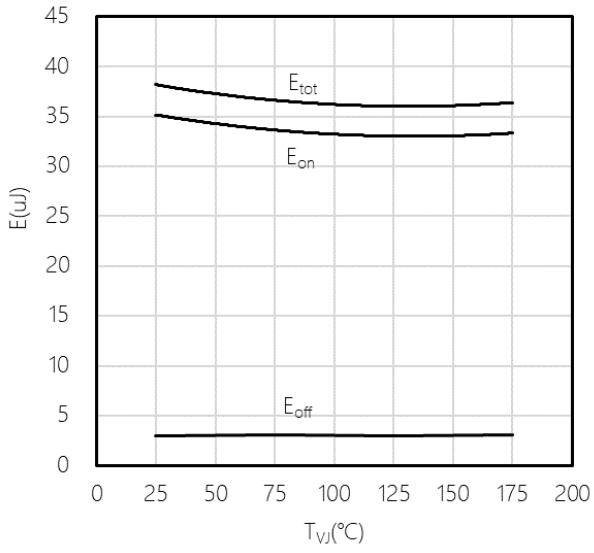
$V_{SD} = f(T_{VJ})$, I_{SD} = 2 A



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

$E = f(T_{VJ})$

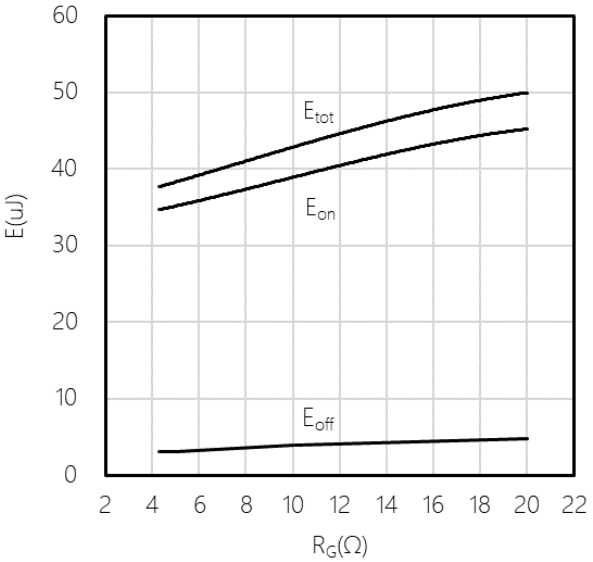
V_{DS} = 400 V, $R_{G(ext)}$ = 4.3 Ω, V_{GS} = 0/15 V, I_{DS} =4 A



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} = 4 A, T_{VJ} = 25 °C, V_{DS} = 400 V

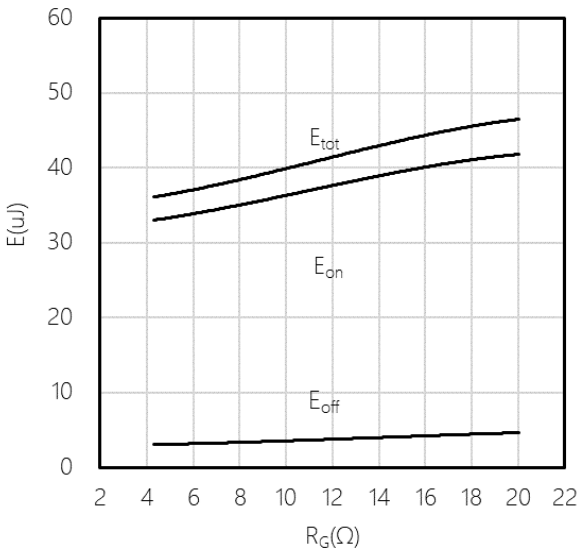


650V Silicon Carbide Power MOSFET

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

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

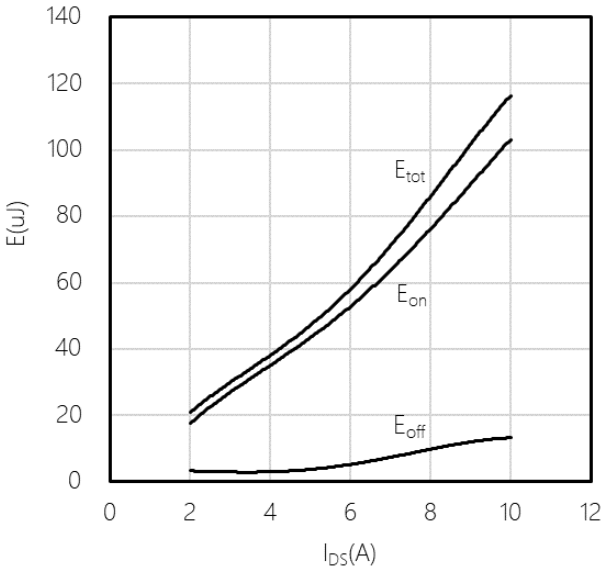
V_{GS} = 0/15 V, I_{DS} = 4 A, T_{VJ} = 175 °C, V_{DS} = 400 V



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

E = f(I_{DS})

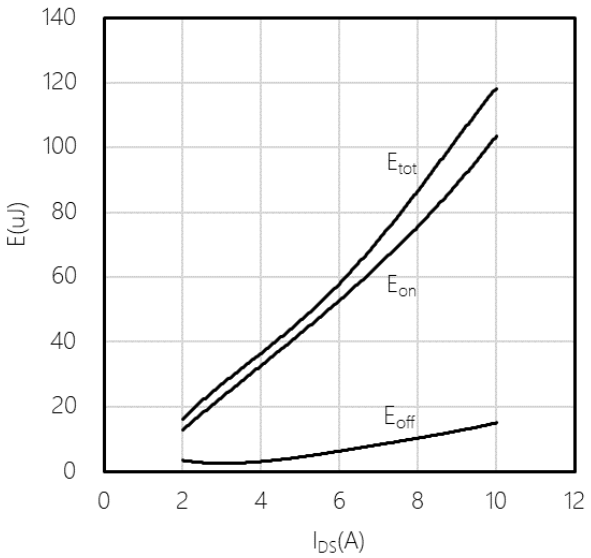
V_{GS} = 0/15 V, $R_{G(ext)}$ = 4.3 Ω, T_{VJ} = 25 °C, V_{DS} = 400 V



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

E = f(I_{DS})

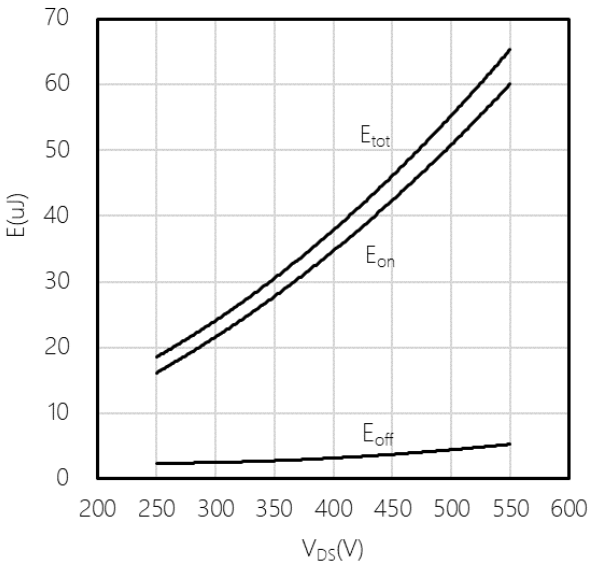
V_{GS} = 0/15 V, $R_{G(ext)}$ = 4.3 Ω, T_{VJ} = 175 °C, V_{DS} = 400 V



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

E = f(V_{DS})

V_{GS} = 0/15 V, $R_{G(ext)}$ = 4.3 Ω, T_{VJ} = 25 °C, I_{DS} =4 A

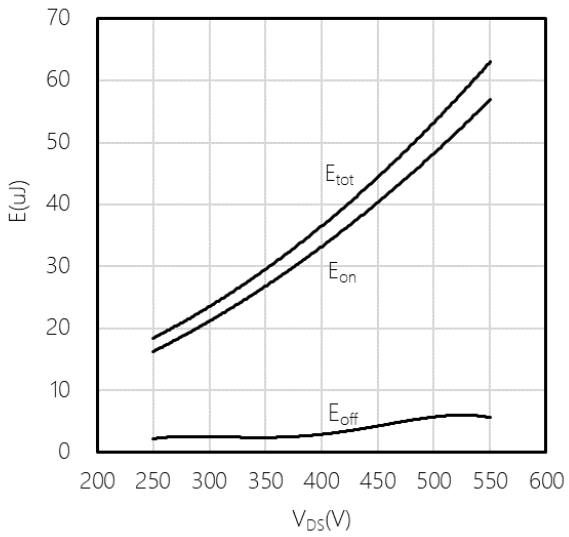


650V Silicon Carbide Power MOSFET

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

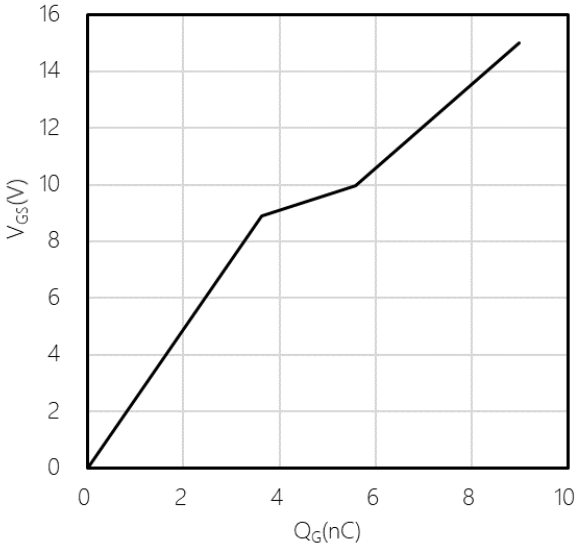
E = f(V_{DS})

V_{GS} = 0/15 V, $R_{G(ext)}$ =4.3 Ω, T_{VJ} = 175 °C, I_{DS} = 4 A



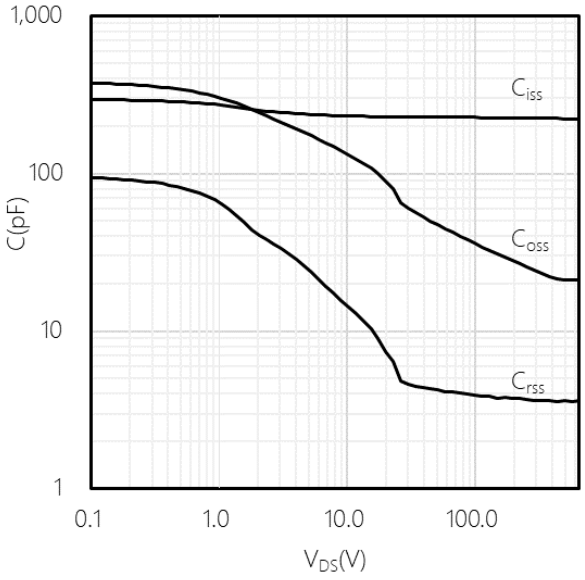
Typical gate charge

V_{GS} =f(Q_G), I_{DS} = 4 A, V_{DS} = 400V turn-on pulse



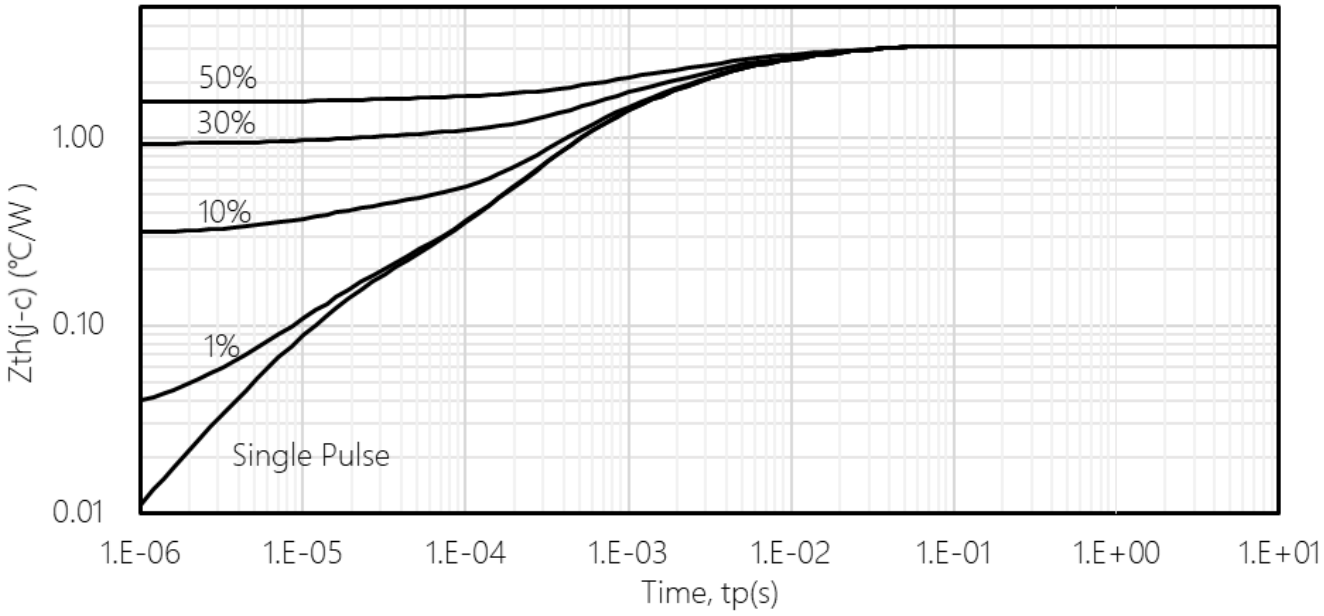
Typical capacitance as a function of drain-source voltage

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



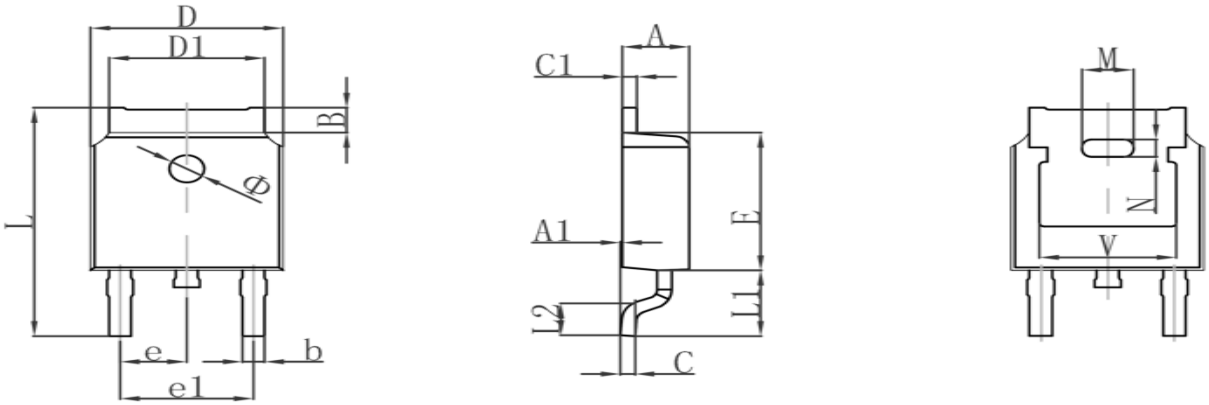
Transient thermal resistance (MOSFET)

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



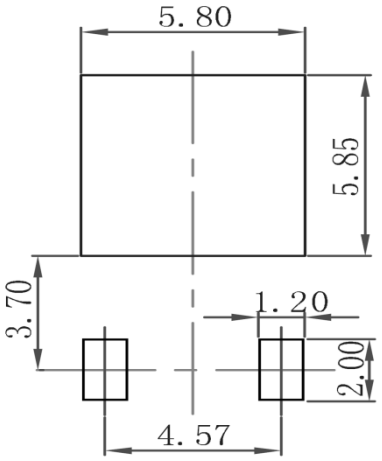
650V Silicon Carbide Power MOSFET

TO-252 PACKAGE OUTLINE DIMENSIONS



Symbol	DimensionsIn Millimeters		DimensionsIn 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

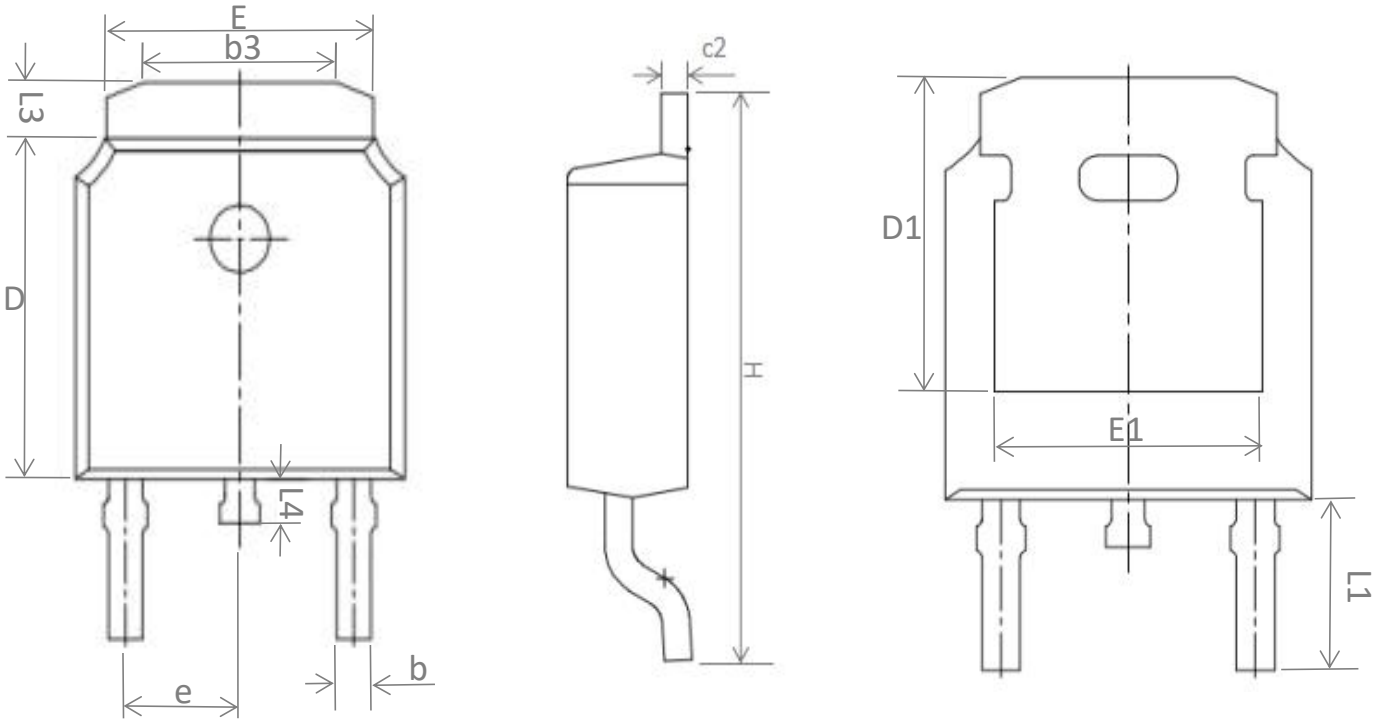


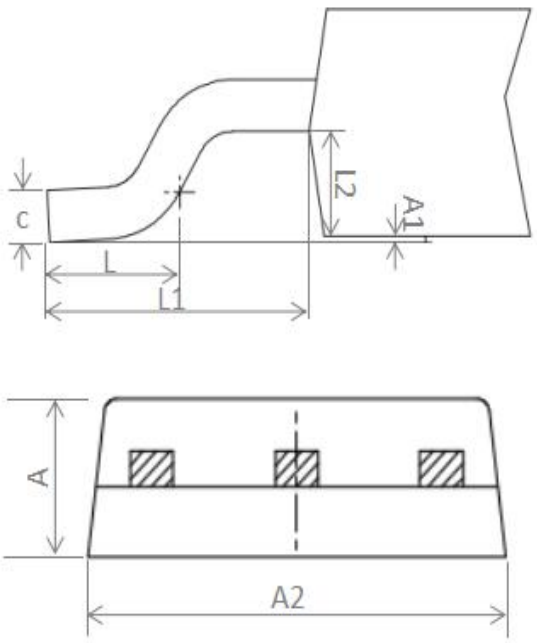
Note:

1. Controlling dimension: in millimeters
2. General tolerance: ±0.05mm
3. The pad layout is for reference purposes only

650V Silicon Carbide Power MOSFET

TO-252 PACKAGE OUTLINE DIMENSIONS



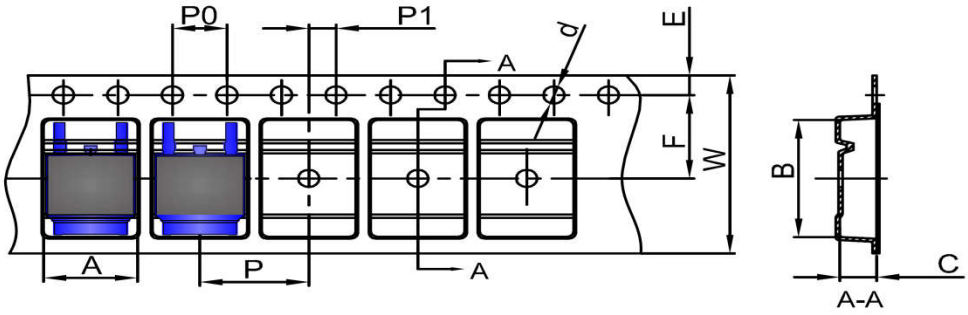


SYMBOL	Spec (mm)
A	2.3±0.1
A1	0-0.15
A2	6.6±0.1
b	0.67±0.1
b3	3.85±0.2
c	0.508±0.1
c2	0.508±0.1
D	6.1±0.15
D1	5.249±0.15
E	5.334±0.15
E1	4.826±0.15
e	2.286REF
H	10.0±0.2
L	1.5±0.15
L1	2.888±0.2
L2	0.9-1.1
L3	1.0REF
L4	0.9±0.2

650V Silicon Carbide Power MOSFET

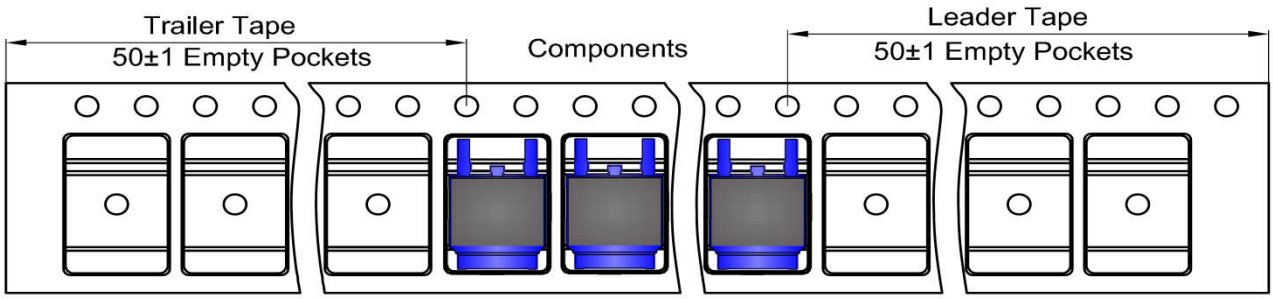
TO-252 TAPE AND REEL

TO-252 Embossed Carrier Tape

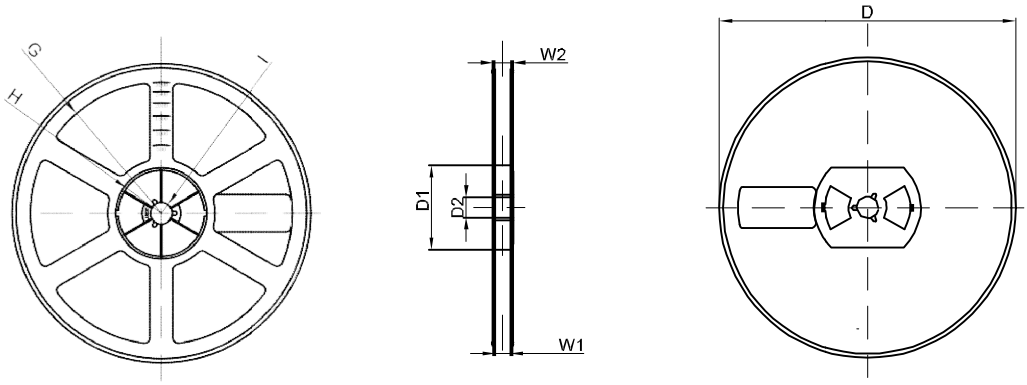


	DIMENSIONS ARE IN MILLIMETER									
TYPE	A	B	C	d	E	F	P0	P	P1	W
TO-252	6.90	10.50	2.70	Ø1.55	1.75	7.50	4.00	8.00	2.00	16.00
TOLERANCE	±0.1	±0.1	±0.1	±0.1	±0.1	±0.1	±0.1	±0.1	±0.1	±0.1

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