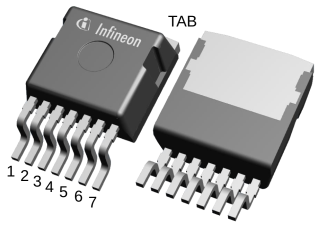
Final datasheet

CoolSiC™ 1200 V SiC Trench MOSFET : Silicon Carbide MOSFET



Halogen-free

Green

Lead-free

RoHS

Features

- V_{DSS} = 1200 V at T_{vj} = -55...175°C
- I_{DDC} = 38 A at T_C = 25°C
- $R_{DS(on)}$ = 60 mΩ at V_{GS} = 20 V, T_{vj} = 25°C
- New performance-optimized chip technology (Gen1p) with improved R_{DSon}* A
- Best in class switching energy for lower switching losses and reduced cooling efforts
- Lowest device capacitances for higher switching speeds and higher power density
- A combination of low C_{rss}/C_{iss} ratio and high $V_{GS(th)}$ to avoid parasitic turn-on and enable unipolar gate driving
- Reduced total gate charge Q_G for lower driving power and losses
- Increased recommended turn-on voltage ($V_{GS(on)}$ = 20 V) for lower $R_{DS(on)}$
- .XT die attach technology for best in class thermal performance
- Low package stray inductance for faster and cleaner switching
- Sense (Kelvin) source pin for better gate control and reduced switching losses
- Creepage distance of 5.8 mm (material group II) to fit 800 V applications
- SMT package for automated assembly and reduced system costs

Potential applications

- On-board charger
- DC/DC converter
- Auxiliary drives

Product validation

- Qualified for Automotive Applications. Product Validation according to AEC-Q100/101

Description

Pin definition:

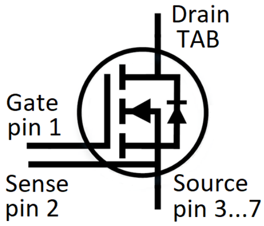
• Pin 1 - Gate

• Pin 2 - Kelvin sense contact

• Pin 3…7 - Source

• Tab - Drain

Note: The source and sense pins are not exchangeable, their exchange might lead to malfunction



Type	Package	Marking
AIMBG120R060M1	PG-TO263-7-U01	AS60MM1

Table of contents

1 Package

Table 1 Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Storage temperature	T_{stg}		-55		150	°C
Soldering temperature	T_{sold}				260	°C
MOSFET/body diode thermal resistance, junction-case[1)]	$R_{th(j-c)}$			0.57	0.74	K/W

1) not subject to production test - verified by design/characterization

2 MOSFET

Table 2 Maximum rated values

Parameter	Symbol	Note or test condition		Values	Unit
Drain-source voltage[1)]	V_{DSS}	T_{vj} = -55...175 °C		1200	V
Continuous DC drain current for $R_{th(j-c,max)}$, limited by $T_{vj(max)}$[2)]	I_{DDC}	V_{GS} = 20 V	T_c = 25 °C	38	A
			T_c = 100 °C	27	
Peak drain current, t_p limited by $T_{vj(max)}$[2)]	I_{DM}	V_{GS} = 20 V		97	A
Gate-source voltage, max. transient voltage[3)]	V_{GS}	$t_p \leq 0.5$ µs, $D < 0.01$		-10...25	V
Gate-source voltage, max. static voltage[3)]	V_{GS}			-5...23	V
Avalanche energy, single pulse	E_{AS}	I_D = 10 A, V_{DD} = 50 V, L = 3.6 mH		180	mJ
Power dissipation, limited by $T_{vj(max)}$[2)]	P_{tot}		T_c = 25 °C	202	W
			T_c = 100 °C	101	

1) Tested at Tvj=25°C, verified by design/characterization over full temperature range
2) not subject to production test - verified by design/characterization
3) **Important note:** The selection of positive and negative gate-source voltages impacts the long-term behavior of the device. The design guidelines described in Application Note AN2018-09 must be considered to ensure sound operation of the device over the planned lifetime.

Table 3 Recommended values

Parameter	Symbol	Note or test condition	Values	Unit
Recommended turn-on gate voltage	$V_{GS(on)}$		20	V
Recommended turn-off gate voltage	$V_{GS(off)}$		0	V

Table 4 **Characteristic values**

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Drain-source on-state resistance	$R_{DS(on)}$	$I_D = 13$ A	$T_{vj} = 25$ °C, $V_{GS(on)} = 20$ V		60	75	mΩ
			$T_{vj} = 100$ °C, $V_{GS(on)} = 20$ V		84		
			$T_{vj} = 175$ °C, $V_{GS(on)} = 20$ V		120		
			$T_{vj} = 25$ °C, $V_{GS(on)} = 18$ V		65		
Gate-source threshold voltage	$V_{GS(th)}$	$I_D = 4.3$ mA, $V_{DS} = V_{GS}$ (tested after 1 ms pulse at $V_{GS} = 20$ V)	$T_{vj} = 25$ °C	3.7	4.4	5.1	V
			$T_{vj} = 175$ °C		3.6		
Zero gate-voltage drain current	I_{DSS}	$V_{DS} = 1200$ V, $V_{GS} = 0$ V	$T_{vj} = 25$ °C		0.3	13	µA
			$T_{vj} = 175$ °C		10		
Gate leakage current	I_{GSS}	$V_{DS} = 0$ V	$V_{GS} = 25$ V			100	nA
			$V_{GS} = -10$ V			-100	
Forward transconductance	g_{fs}	$I_D = 13$ A, $V_{DS} = 20$ V			8.1		S
Short-circuit withstand time[2)]	t_{SC}	$V_{DD} \leq 800$ V, $V_{DS,peak} < 1200$ V, $T_{vj(start)} = 25$ °C, $R_{G,ext} = 2\ \Omega$	$V_{GS(on)} = 20$ V		1.5		µs
			$V_{GS(on)} = 18$ V		2		
			$V_{GS(on)} = 15$ V		2.5		
Internal gate resistance	$R_{G,int}$	$f = 1$ MHz, $V_{AC} = 25$ mV			4		Ω
Input capacitance	C_{iss}	$V_{DS} = 800$ V, $V_{GS} = 0$ V, $f = 100$ kHz, $V_{AC} = 25$ mV			880		pF
Output capacitance	C_{oss}	$V_{DS} = 800$ V, $V_{GS} = 0$ V, $f = 100$ kHz, $V_{AC} = 25$ mV			43		pF
Reverse transfer capacitance	C_{rss}	$V_{DS} = 800$ V, $V_{GS} = 0$ V, $f = 100$ kHz, $V_{AC} = 25$ mV			2		pF
C_{oss} stored energy	E_{oss}	$V_{DS} = 800$ V, $V_{GS} = 0$ V, $f = 100$ kHz, $V_{AC} = 25$ mV			18		µJ
Total gate charge	Q_G	$V_{DD} = 800$ V, $I_D = 13$ A, $V_{GS} = 0/20$ V, turn-on pulse			32		nC
Plateau gate charge	$Q_{GS(pl)}$	$V_{DD} = 800$ V, $I_D = 13$ A, $V_{GS} = 0/20$ V, turn-on pulse			8		nC
Gate-to-drain charge	Q_{GD}	$V_{DD} = 800$ V, $I_D = 13$ A, $V_{GS} = 0/20$ V, turn-on pulse			5		nC
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 800$ V, $I_D = 13$ A, $V_{GS} = 0/20$ V, $R_{G,ext} = 2\ \Omega$, $L_\sigma = 20$ nH, diode: body diode at $V_{GS} = 0$ V	$T_{vj} = 25$ °C		6.2		ns
			$T_{vj} = 175$ °C		6.2		

(table continues...)

Table 4 **(continued) Characteristic values**

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Rise time	t_r	V_{DD} = 800 V, I_D = 13 A, V_{GS} = 0/20 V, $R_{G,ext}$ = 2 Ω, L_σ = 20 nH, diode: body diode at V_{GS} = 0 V	T_{vj} = 25 °C		5.4		ns
			T_{vj} = 175 °C		6.4		
Turn-off delay time	$t_{d(off)}$	V_{DD} = 800 V, I_D = 13 A, V_{GS} = 0/20 V, $R_{G,ext}$ = 2 Ω, L_σ = 20 nH, diode: body diode at V_{GS} = 0 V	T_{vj} = 25 °C		13		ns
			T_{vj} = 175 °C		13.9		
Fall time	t_f	V_{DD} = 800 V, I_D = 13 A, V_{GS} = 0/20 V, $R_{G,ext}$ = 2 Ω, L_σ = 20 nH, diode: body diode at V_{GS} = 0 V	T_{vj} = 25 °C		8		ns
			T_{vj} = 175 °C		8.5		
Turn-on energy	E_{on}	V_{DD} = 800 V, I_D = 13 A, V_{GS} = 0/20 V, $R_{G,ext}$ = 2 Ω, L_σ = 20 nH, diode: body diode at V_{GS} = 0 V	T_{vj} = 25 °C		79.3		µJ
			T_{vj} = 175 °C		113.3		
Turn-off energy	E_{off}	V_{DD} = 800 V, I_D = 13 A, V_{GS} = 0/20 V, $R_{G,ext}$ = 2 Ω, L_σ = 20 nH, diode: body diode at V_{GS} = 0 V	T_{vj} = 25 °C		31.5		µJ
			T_{vj} = 175 °C		30.7		
Total switching energy	E_{tot}	V_{DD} = 800 V, I_D = 13 A, V_{GS} = 0/20 V, $R_{G,ext}$ = 2 Ω, L_σ = 20 nH, diode: body diode at V_{GS} = 0 V	T_{vj} = 25 °C		110.8		µJ
			T_{vj} = 175 °C		144		
Virtual junction temperature	T_{vj}			-55		175	°C

***Note**:* *Characteristics at T_{vj} = 25°C, unless otherwise specified.*

3 Body diode (MOSFET)

Table 5 **Maximum rated values**

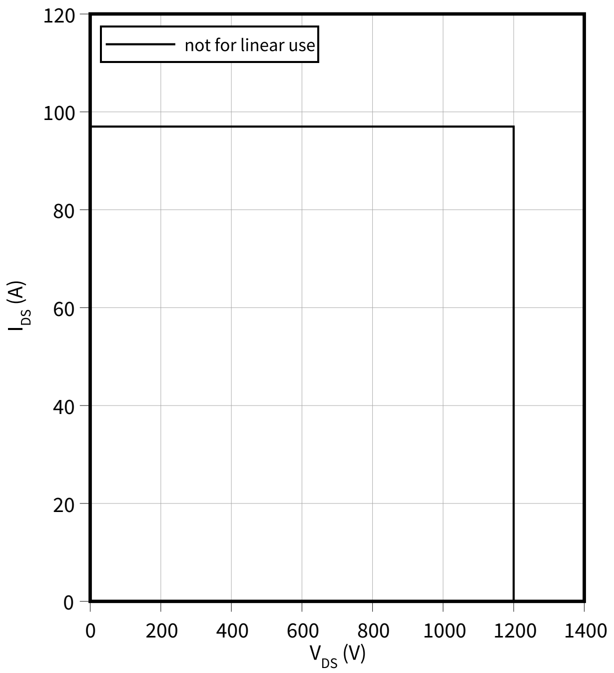
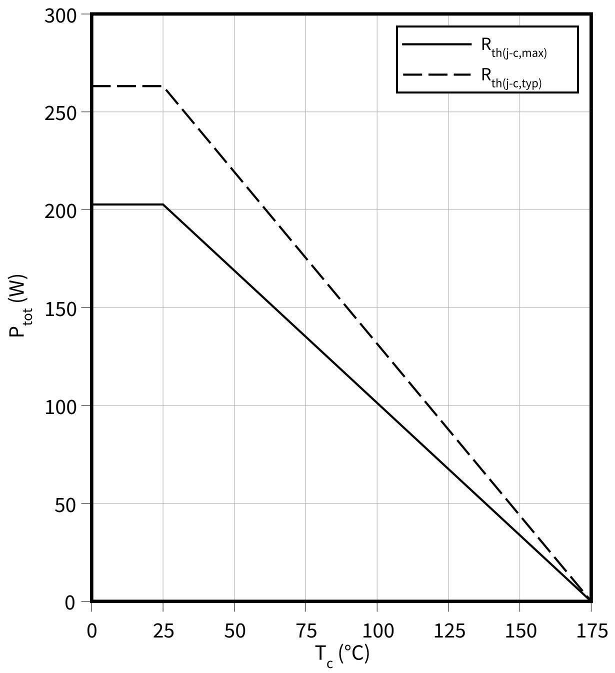
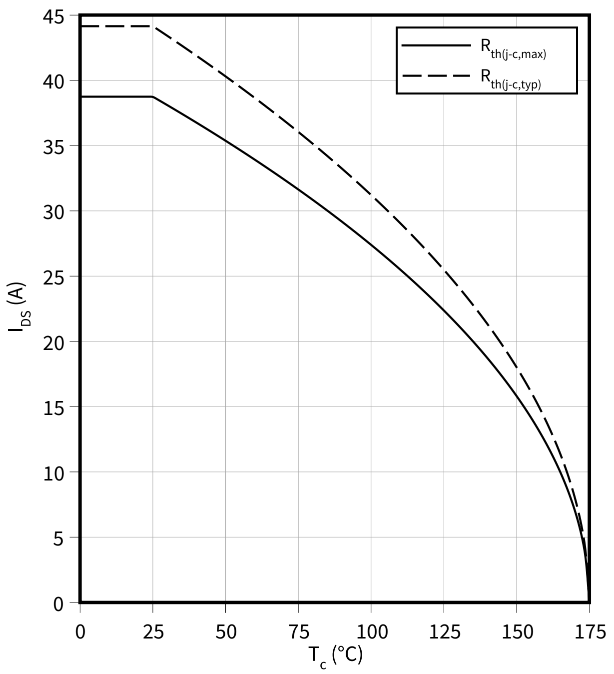
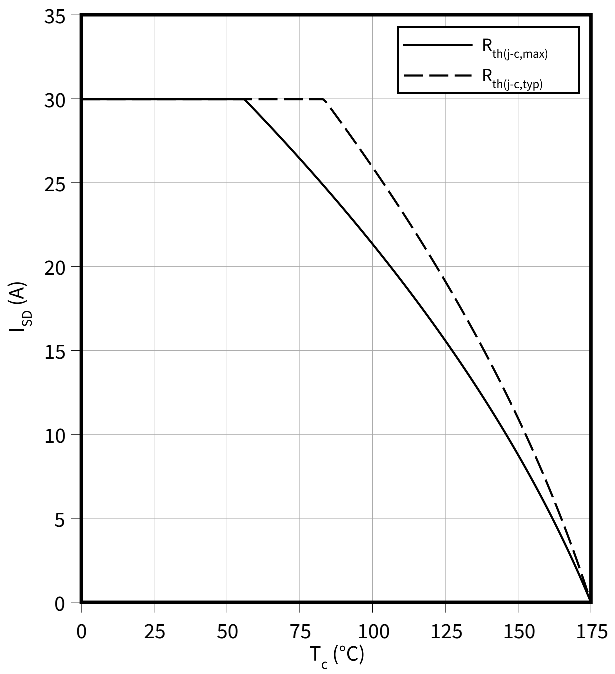
Parameter	Symbol	Note or test condition		Values	Unit
Drain-source voltage[1)]	V_{DSS}	T_{vj} = -55...175 °C		1200	V
Continuous reverse drain current for $R_{th(j-c,max)}$, limited by $T_{vj(max)}$[2)]	I_{SDC}	V_{GS} = 0 V	T_c = 25 °C	30	A
			T_c = 100 °C	21	
Peak reverse drain current, t_p limited by $T_{vj(max)}$[2)]	I_{SM}	V_{GS} = 0 V		30	A

1) Tested at Tvj=25°C, verified by design/characterization over full temperature range
2) not subject to production test - verified by design/characterization

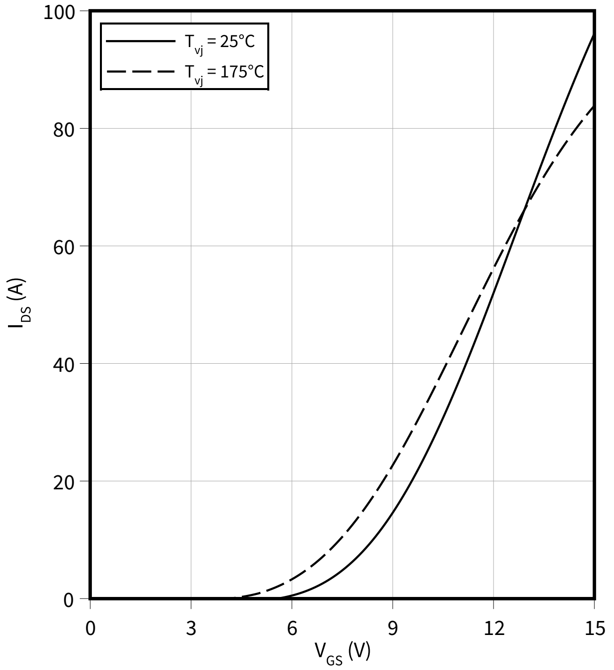
Table 6 **Characteristic values**

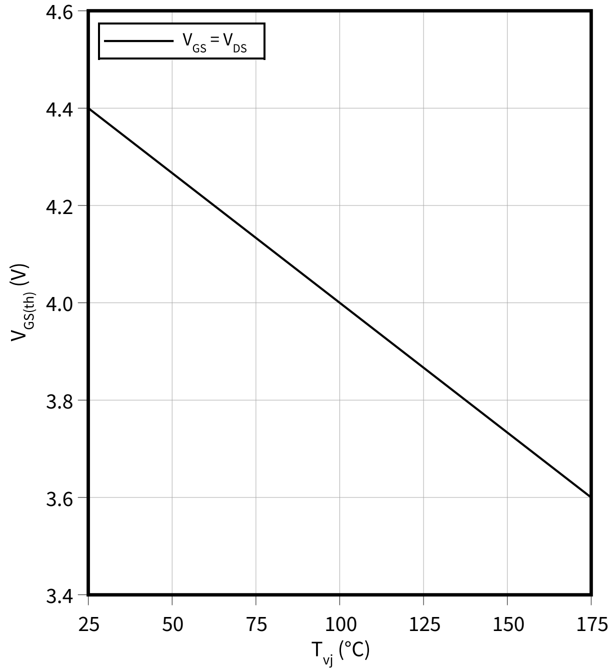
Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Drain-source reverse voltage	V_{SD}	I_{SD} = 13 A, V_{GS} = 0 V	T_{vj} = 25 °C		3.9	5	V
			T_{vj} = 100 °C		3.8		
			T_{vj} = 175 °C		3.7		
MOSFET forward recovery charge	Q_{fr}	V_{DD} = 800 V, I_{SD} = 13 A, V_{GS} = 0 V, $-di_{SD}/dt$ = 2000 A/µs, Q_{fr} includes also Q_C	T_{vj} = 25 °C		106		nC
			T_{vj} = 175 °C		207		
MOSFET peak forward recovery current	I_{frm}	V_{DD} = 800 V, I_{SD} = 13 A, V_{GS} = 0 V, $-di_{SD}/dt$ = 2000 A/µs, Q_{fr} includes also Q_C	T_{vj} = 25 °C		7.8		A
			T_{vj} = 175 °C		10.1		
Virtual junction temperature	T_{vj}			-55		175	°C

4 Characteristics diagrams

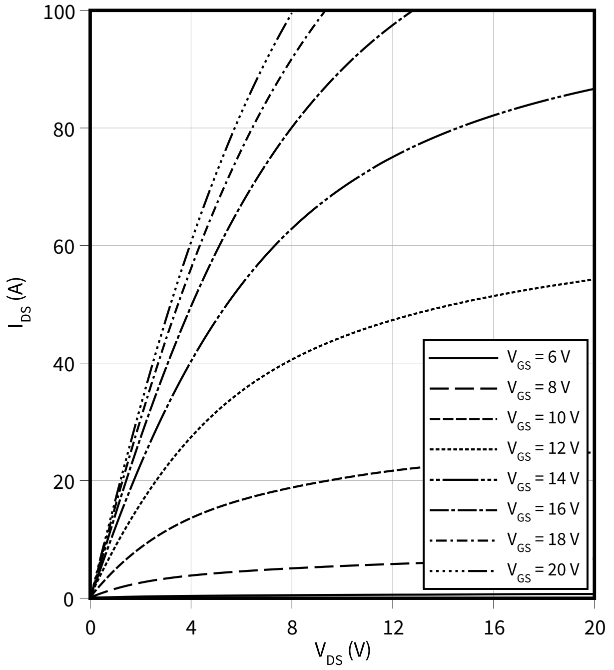
Reverse bias safe operating area (RBSOA) $I_{DS} = f(V_{DS})$ $T_{vj} \leq 175$ °C, $V_{GS} = 0/20$ V, $T_c = 25$ °C	**Power dissipation as a function of case temperature** $P_{tot} = f(T_c)$
	
Maximum DC drain to source current as a function of case temperature $I_{DS} = f(T_c)$	**Maximum source to drain current as a function of case temperature** $I_{SD} = f(T_c)$ $V_{GS} = 0$ V
	

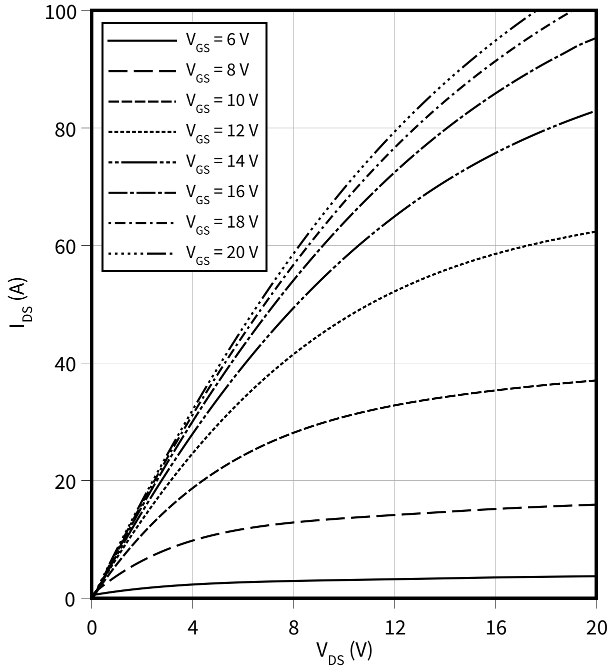
Typical transfer characteristic $I_{DS} = f(V_{GS})$ $V_{DS} = 20$ V, $t_p = 20$ µs	**Typical gate-source threshold voltage as a function of junction temperature** $V_{GS(th)} = f(T_{vj})$ $I_D = 4.3$ mA



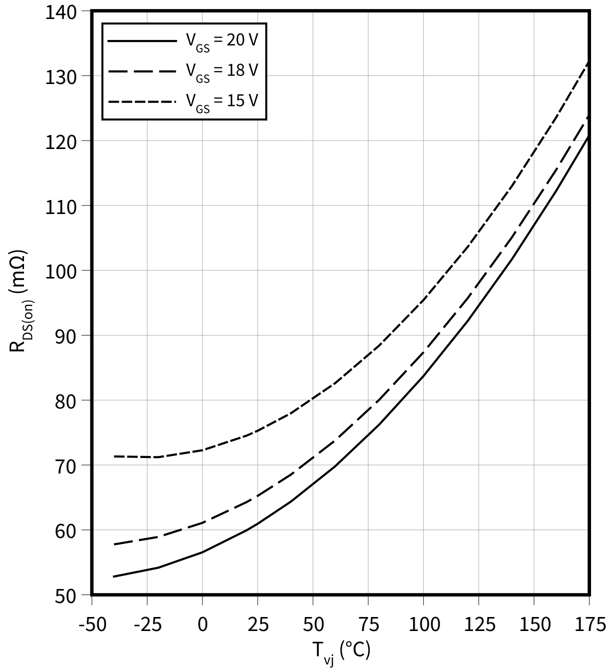


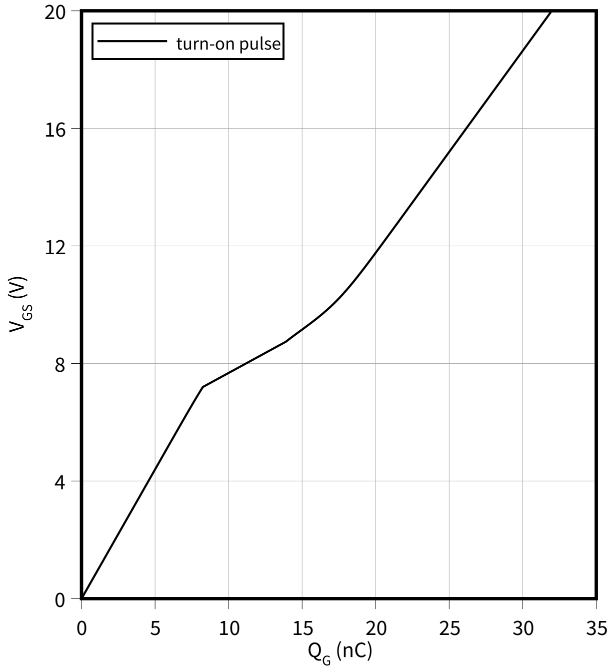
Typical output characteristic, V_{GS} as parameter $I_{DS} = f(V_{DS})$ $T_{vj} = 25$ °C, $t_p = 20$ µs	**Typical output characteristic, V_{GS} as parameter** $I_{DS} = f(V_{DS})$ $T_{vj} = 175$ °C, $t_p = 20$ µs



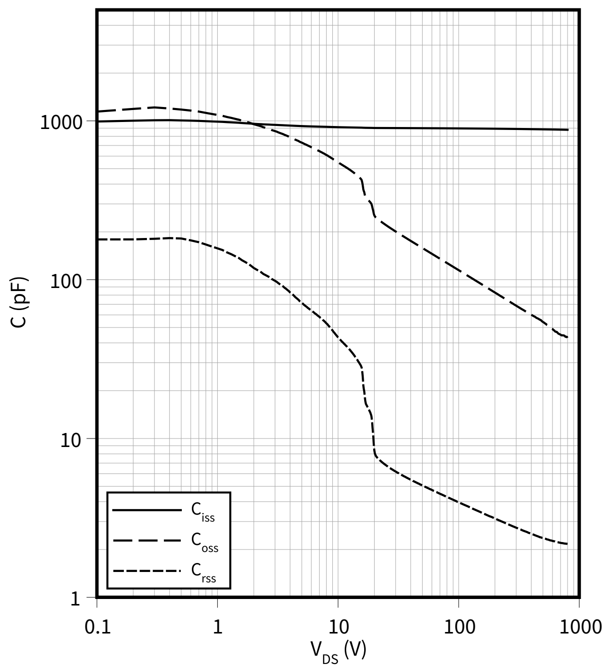


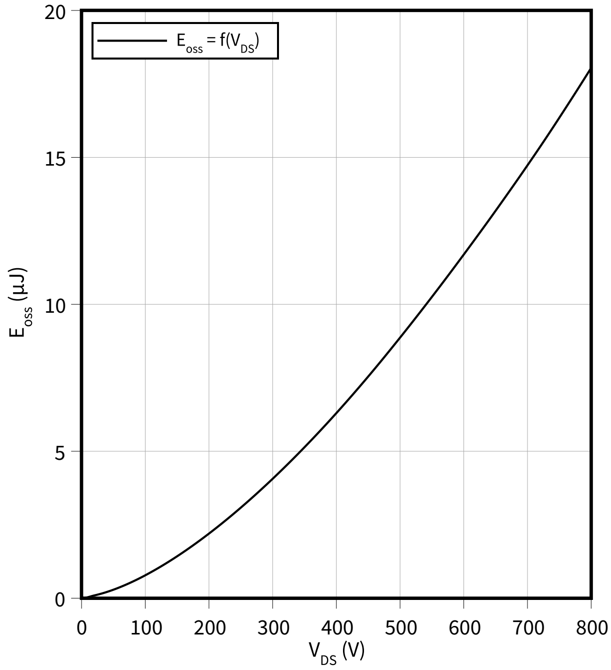
Typical on-state resistance as a function of junction temperature $R_{DS(on)} = f(T_{vj})$ $I_D = 13$ A	**Typical gate charge** $V_{GS} = f(Q_G)$ $I_D = 13$ A, $V_{DS} = 800$ V





Typical capacitance as a function of drain-source voltage $C = f(V_{DS})$ f = 100 kHz, $V_{GS} = 0$ V	**Typical C_{oss} stored energy** $E_{oss} = f(V_{DS})$ f = 100 kHz, $V_{GS} = 0$ V

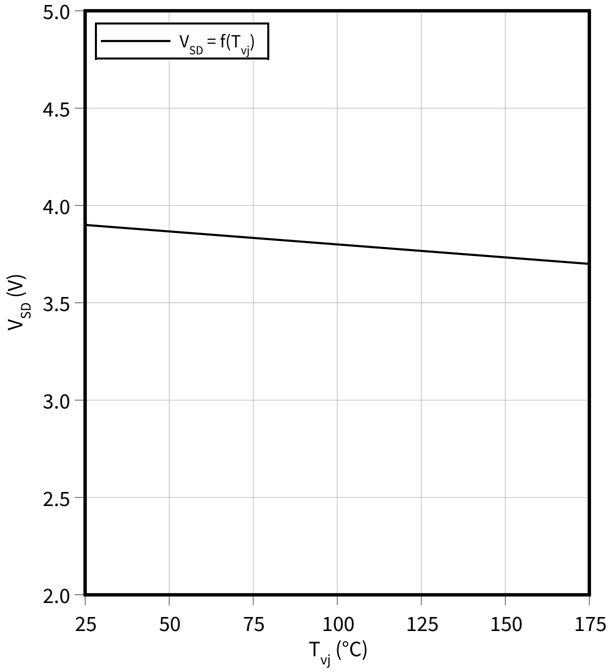




Typical reverse drain voltage as function of junction temperature

$V_{SD} = f(T_{vj})$

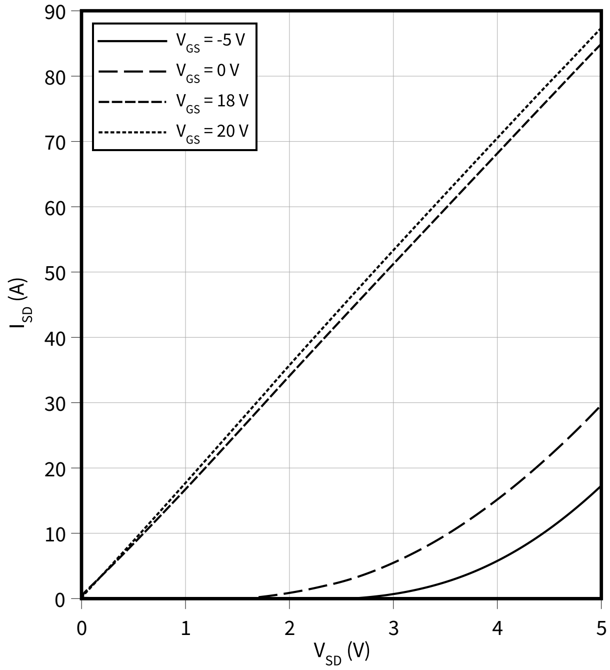
$I_{SD} = 13$ A, $V_{GS} = 0$ V



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

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

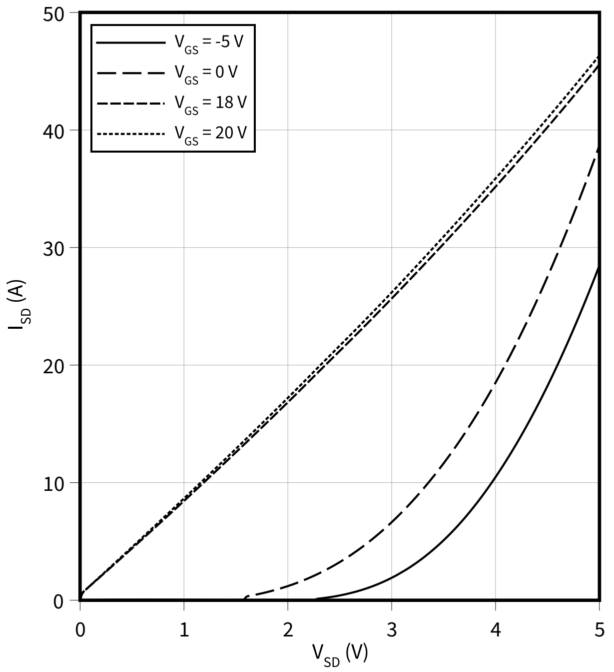
$T_{vj} = 25$ °C, $t_p = 20$ µs



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

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

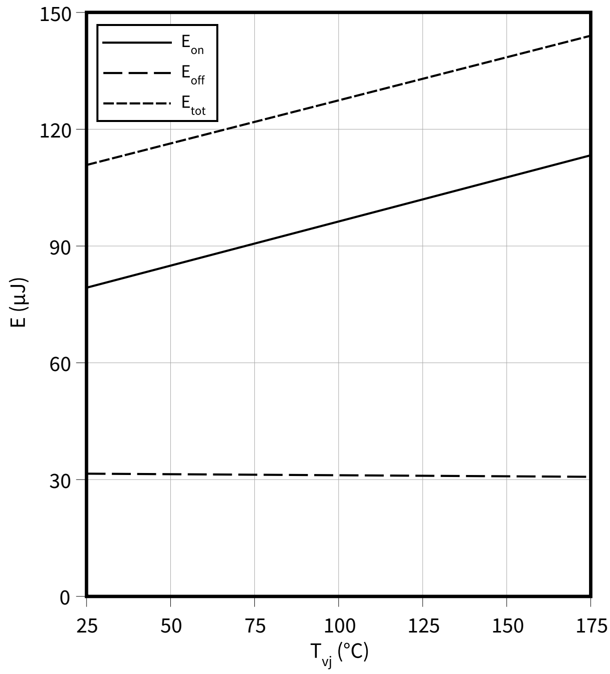
$T_{vj} = 175$ °C, $t_p = 20$ µs



Typical switching energy as a function of junction temperature, test circuit in Fig. F, 2nd device own body diode: $V_{GS} = 0$ V

$E = f(T_{vj})$

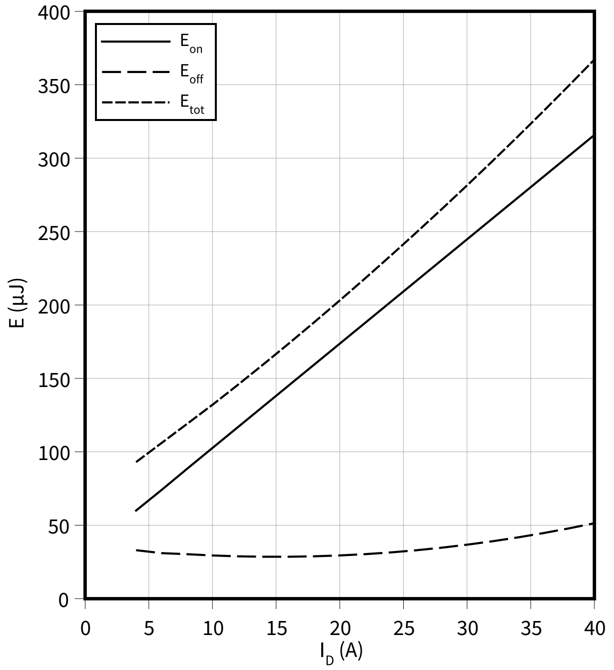
$V_{GS} = 0/20$ V, $I_D = 13$ A, $R_{G,ext} = 2$ Ω, $V_{DD} = 800$ V



Typical switching energy as a function of drain current, test circuit in Fig. F, 2nd device own body diode: V_{GS} = 0 V

$E = f(I_D)$

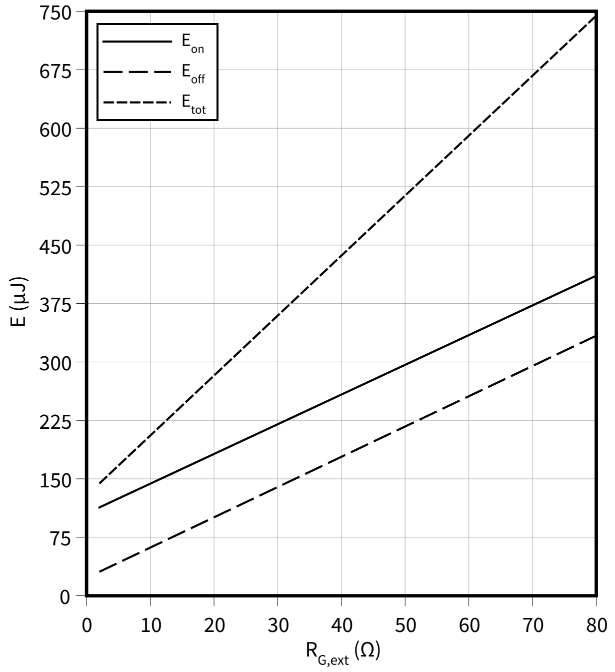
V_{GS} = 0/20 V, T_{vj} = 175 °C, $R_{G,ext}$ = 2 Ω, V_{DD} = 800 V



Typical switching energy as a function of gate resistance, test circuit in Fig. F, 2nd device own body diode: V_{GS} = 0 V

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

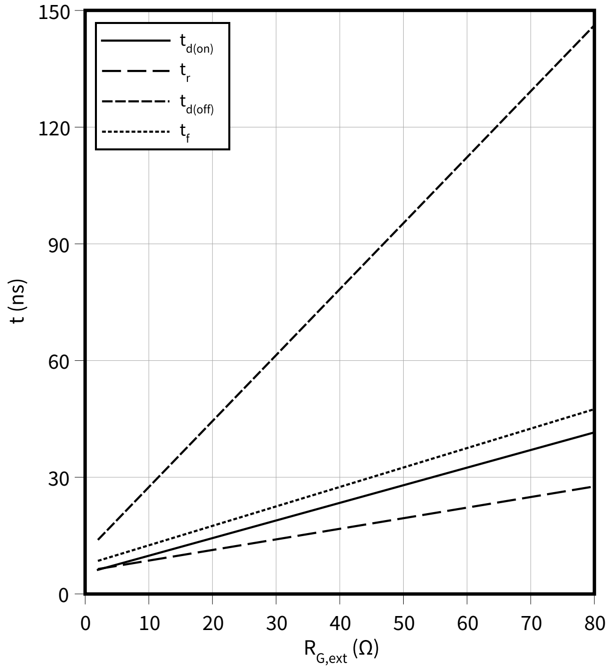
V_{GS} = 0/20 V, I_D = 13 A, T_{vj} = 175 °C, V_{DD} = 800 V



Typical switching times as a function of gate resistance, test circuit in Fig. F, 2nd device own body diode: V_{GS} = 0 V

$t = f(R_{G,ext})$

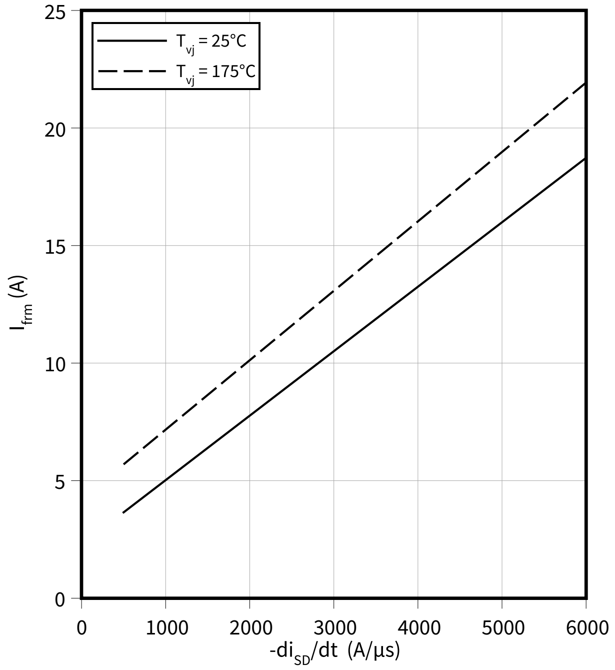
V_{GS} = 0/20 V, I_D = 13 A, T_{vj} = 175 °C, V_{DD} = 800 V



Typical MOSFET peak forward recovery current as a function of reverse drain current slope

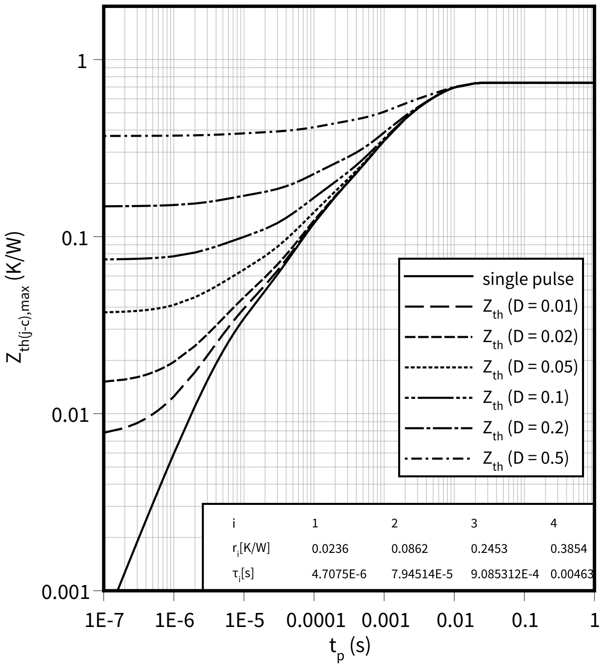
$I_{frm} = f(-di_{SD}/dt)$

V_{GS} = 0/20 V, I_{SD} = 13 A, V_{DD} = 800 V

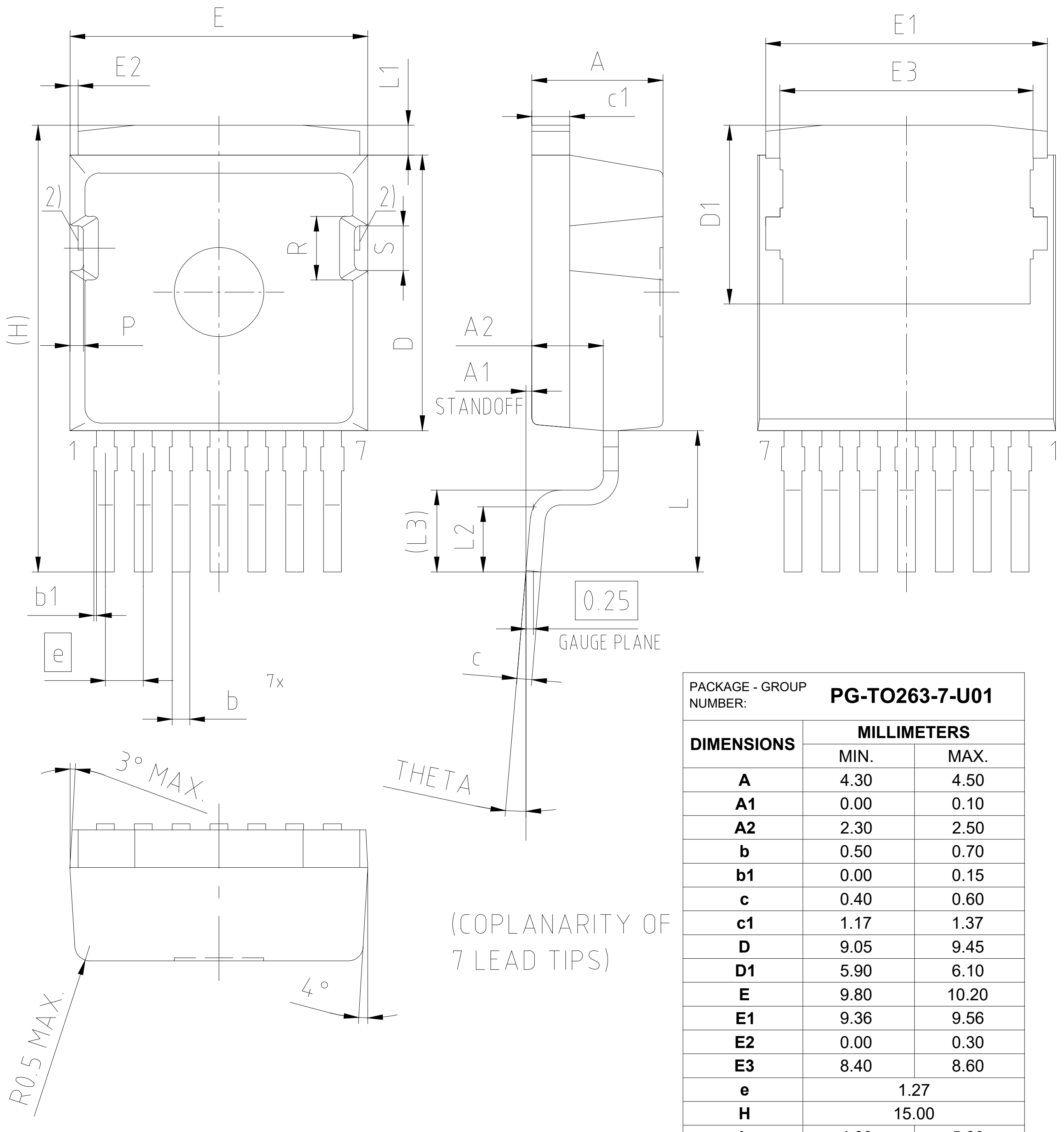


Max. transient thermal impedance (MOSFET/diode)

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



5 Package outlines



PACKAGE - GROUP NUMBER:	PG-TO263-7-U01	
DIMENSIONS	**MILLIMETERS**	
	MIN.	MAX.
A	4.30	4.50
A1	0.00	0.10
A2	2.30	2.50
b	0.50	0.70
b1	0.00	0.15
c	0.40	0.60
c1	1.17	1.37
D	9.05	9.45
D1	5.90	6.10
E	9.80	10.20
E1	9.36	9.56
E2	0.00	0.30
E3	8.40	8.60
e	1.27	
H	15.00	
L	4.20	5.20
L1	0.70	1.30
L2	1.70	2.30
L3	2.70	
P	0.35	0.55
R	2.03	2.23
S	1.40	1.60
THETA	0.00°	8.00°

NOTES:
1) ALL METAL SURFACES TIN PLATED EXCEPT AREA OF CUT
2) MOLD FILLING IS ACCEPTABLE AT THIS AREA

Figure 1

6 Testing conditions

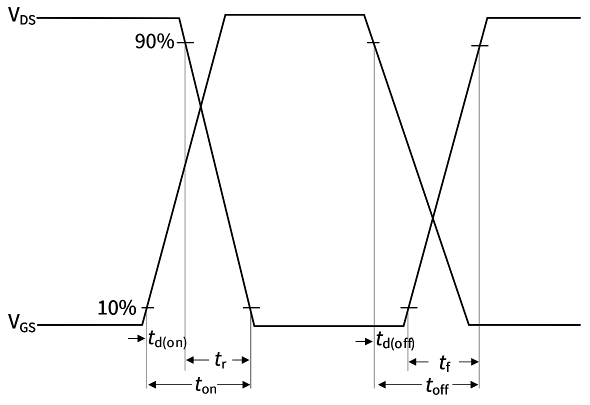


Figure A. **Definition of switching times**

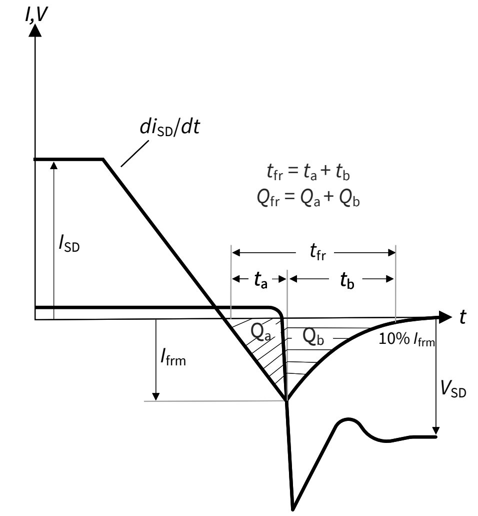


Figure B. **Definition of body diode switching characteristics**

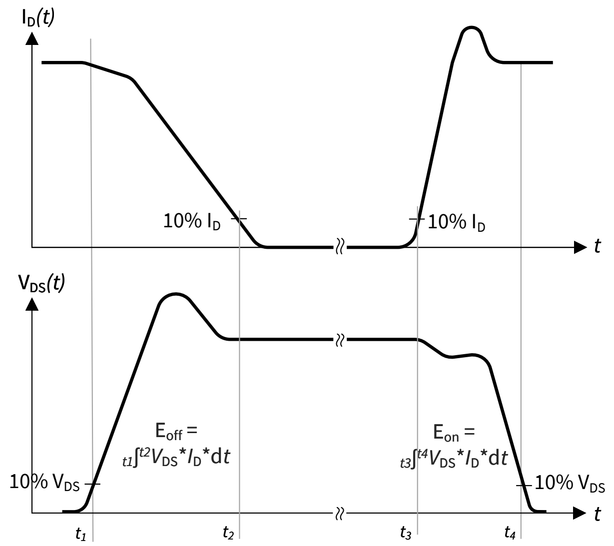


Figure C. **Definition of switching losses**

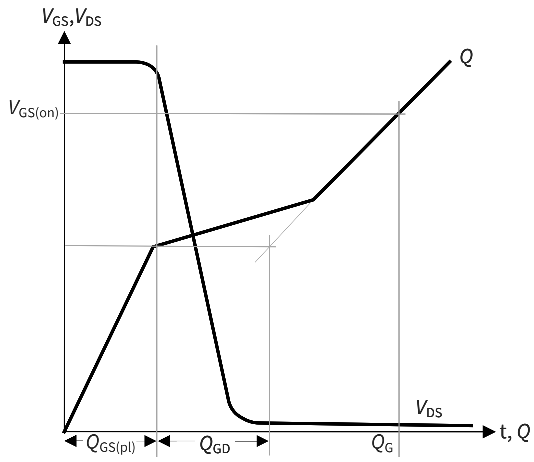


Figure D. **Definition of QGD**

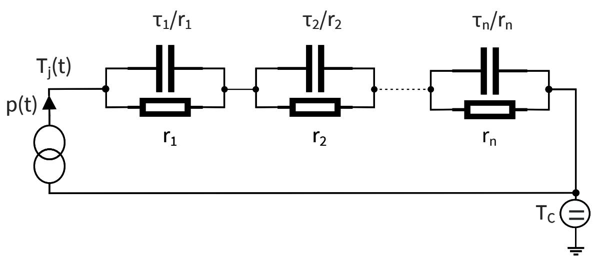


Figure E. **Thermal equivalent circuit**

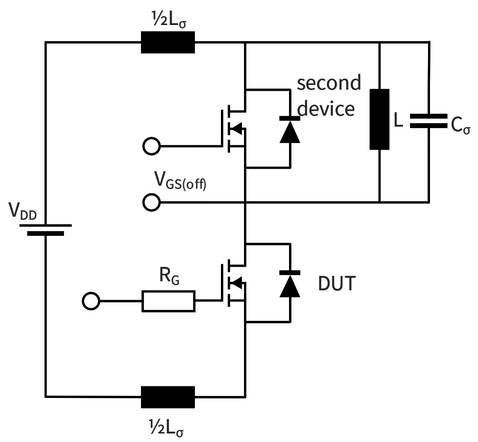


Figure F. **Dynamic test circuit**
Parasitic inductance L_σ,
Parasitic capacitor C_σ,

Figure 2

Revision history

Document revision	Date of release	Description of changes
0.10	2022-12-08	Preliminary datasheet
0.20	2022-12-09	Update of "Drain-source on-state resistance", value '**Max.**' for 25°C, in Table 4 "Characteristic values"
1.00	2023-05-16	Final datasheet
1.10	2024-04-02	Updated table values: Vgsth, Idss, gfs, tdon, tr, tdoff, tf, Eon, Eoff, Etot,Qfr, Ifrm Updated graphs: IDS = f(VGS), VGS(th) = f(Tvj), IDS = f(VDS), RDS(on) = f(Tvj), ISD = f(VSD), E = f(Tvj), E = f(RG,ext), t = f(RG,ext), Ifrm = f(-diSD/dt) Added new graphs: E = f(ID), Eoss = f(VDS) No change to the product, new values based on additional characterization
1.20	2024-11-12	Updated features: “Minimal creepage distance 5.85mm (material group II) to fit 800V applications without coating” changed to “Creepage distance of 5.8mm (material group II) to fit 800V applications” Updated package from PG-TO263-7-HV-ND5.8 to PG-TO263-7-U01

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