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1 Maximum ratings

at $T_j = 25^\circ\text{C}$, unless otherwise specified

Table 2 Maximum ratings

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Continuous drain current ¹⁾	I_D	-	-	10.1 6.4	A	$T_C=25^\circ\text{C}$ $T_C=100^\circ\text{C}$
Pulsed drain current ²⁾	$I_{D,pulse}$	-	-	18	A	$T_C=25^\circ\text{C}$
Avalanche energy, single pulse	E_{AS}	-	-	142	mJ	$I_D=1.3\text{A}$; $V_{DD}=50\text{V}$; see table 11
Avalanche energy, repetitive	E_{AR}	-	-	0.21	mJ	$I_D=1.3\text{A}$; $V_{DD}=50\text{V}$; see table 11
Avalanche current, repetitive	I_{AR}	-	-	1.3	A	-
MOSFET dv/dt ruggedness	dv/dt	-	-	50	V/ns	$V_{DS}=0\dots480\text{V}$
Gate source voltage (static)	V_{GS}	-20	-	20	V	static;
Gate source voltage (dynamic)	V_{GS}	-30	-	30	V	AC ($f>1\text{ Hz}$)
Power dissipation (Non FullPAK) TO-252	P_{tot}	-	-	86	W	$T_C=25^\circ\text{C}$
Storage temperature	T_{stg}	-40	-	150	$^\circ\text{C}$	-
Operating junction temperature	T_j	-40	-	150	$^\circ\text{C}$	-
Continuous diode forward current	I_S	-	-	7.1	A	$T_C=25^\circ\text{C}$
Diode pulse current ²⁾	$I_{S,pulse}$	-	-	18	A	$T_C=25^\circ\text{C}$
Reverse diode dv/dt ³⁾	dv/dt	-	-	15	V/ns	$V_{DS}=0\dots400\text{V}$, $I_{SD}\leq I_S$, $T_j=25^\circ\text{C}$ see table 9
Maximum diode commutation speed	di/dt	-	-	500	A/ μs	$V_{DS}=0\dots400\text{V}$, $I_{SD}\leq I_S$, $T_j=25^\circ\text{C}$ see table 9
Power dissipation (FullPAK) TO-220FP	P_{tot}	-	-	28	W	$T_C=25^\circ\text{C}$
Mounting torque (FullPAK) TO-220FP	-	-	-	50	Ncm	M2.5 screws
Insulation withstand voltage for TO-220FP	V_{ISO}	-	-	2500	V	V_{rms} , $T_C=25^\circ\text{C}$, $t=1\text{min}$

¹⁾ Limited by $T_{j,max}$. TO252 equivalent, Maximum duty cycle $D=0.50$

²⁾ Pulse width t_p limited by $T_{j,max}$

³⁾ Identical low side and high side switch with identical R_G

2 Thermal characteristics

Table 3 Thermal characteristics (FullPAK) TO-220FP

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}	-	-	4.5	°C/W	-
Thermal resistance, junction - ambient	R_{thJA}	-	-	80	°C/W	leaded
Soldering temperature, wavesoldering only allowed at leads	T_{sold}	-	-	260	°C	1.6mm (0.063 in.) from case for 10s

Table 4 Thermal characteristics TO-252

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}	-	-	1.45	°C/W	-
Thermal resistance, junction - ambient	R_{thJA}	-	-	62	°C/W	device on PCB, minimal footprint
Thermal resistance, junction - ambient for SMD version	R_{thJA}	-	35	45	°C/W	Device on 40mm*40mm*1.5mm epoxy PCB FR4 with 6cm² (one layer, 70µm thickness) copper area for drain connection and cooling. PCB is vertical without air stream cooling.
Soldering temperature, wave & reflow soldering allowed	T_{sold}	-	-	260	°C	reflow MSL3

3 Electrical characteristics

at $T_j=25^\circ\text{C}$, unless otherwise specified

Table 5 Static characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Drain-source breakdown voltage	$V_{(BR)DSS}$	650	-	-	V	$V_{GS}=0V$, $I_D=1mA$
Gate threshold voltage	$V_{(GS)th}$	2.5	3.0	3.5	V	$V_{DS}=V_{GS}$, $I_D=0.21mA$
Zero gate voltage drain current	I_{DSS}	-	-	1	μA	$V_{DS}=650$, $V_{GS}=0V$, $T_j=25^\circ\text{C}$ $V_{DS}=650$, $V_{GS}=0V$, $T_j=150^\circ\text{C}$
Gate-source leakage current	I_{GSS}	-	-	100	nA	$V_{GS}=20V$, $V_{DS}=0V$
Drain-source on-state resistance	$R_{DS(on)}$	-	0.54 1.40	0.65	Ω	$V_{GS}=10V$, $I_D=2.1A$, $T_j=25^\circ\text{C}$ $V_{GS}=10V$, $I_D=2.1A$, $T_j=150^\circ\text{C}$
Gate resistance	R_G	-	10.5	-	Ω	$f=1MHz$, open drain

Table 6 Dynamic characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	C_{iss}	-	440	-	pF	$V_{GS}=0V$, $V_{DS}=100V$, $f=1MHz$
Output capacitance	C_{oss}	-	30	-	pF	$V_{GS}=0V$, $V_{DS}=100V$, $f=1MHz$
Effective output capacitance, energy related ¹⁾	$C_{o(er)}$	-	21	-	pF	$V_{GS}=0V$, $V_{DS}=0...480V$
Effective output capacitance, time related ²⁾	$C_{o(tr)}$	-	88	-	pF	$I_D=\text{constant}$, $V_{GS}=0V$, $V_{DS}=0...480V$
Turn-on delay time	$t_{d(on)}$	-	10	-	ns	$V_{DD}=400V$, $V_{GS}=13V$, $I_D=3.2A$, $R_G=6.8\Omega$; see table 10
Rise time	t_r	-	8	-	ns	$V_{DD}=400V$, $V_{GS}=13V$, $I_D=3.2A$, $R_G=6.8\Omega$; see table 10
Turn-off delay time	$t_{d(off)}$	-	64	-	ns	$V_{DD}=400V$, $V_{GS}=13V$, $I_D=3.2A$, $R_G=6.8\Omega$; see table 10
Fall time	t_f	-	11	-	ns	$V_{DD}=400V$, $V_{GS}=13V$, $I_D=3.2A$, $R_G=6.8\Omega$; see table 10

Table 7 Gate charge characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate to source charge	Q_{gs}	-	2.75	-	nC	$V_{DD}=480V$, $I_D=3.2A$, $V_{GS}=0$ to $10V$
Gate to drain charge	Q_{gd}	-	12	-	nC	$V_{DD}=480V$, $I_D=3.2A$, $V_{GS}=0$ to $10V$
Gate charge total	Q_g	-	23	-	nC	$V_{DD}=480V$, $I_D=3.2A$, $V_{GS}=0$ to $10V$
Gate plateau voltage	$V_{plateau}$	-	5.5	-	V	$V_{DD}=480V$, $I_D=3.2A$, $V_{GS}=0$ to $10V$

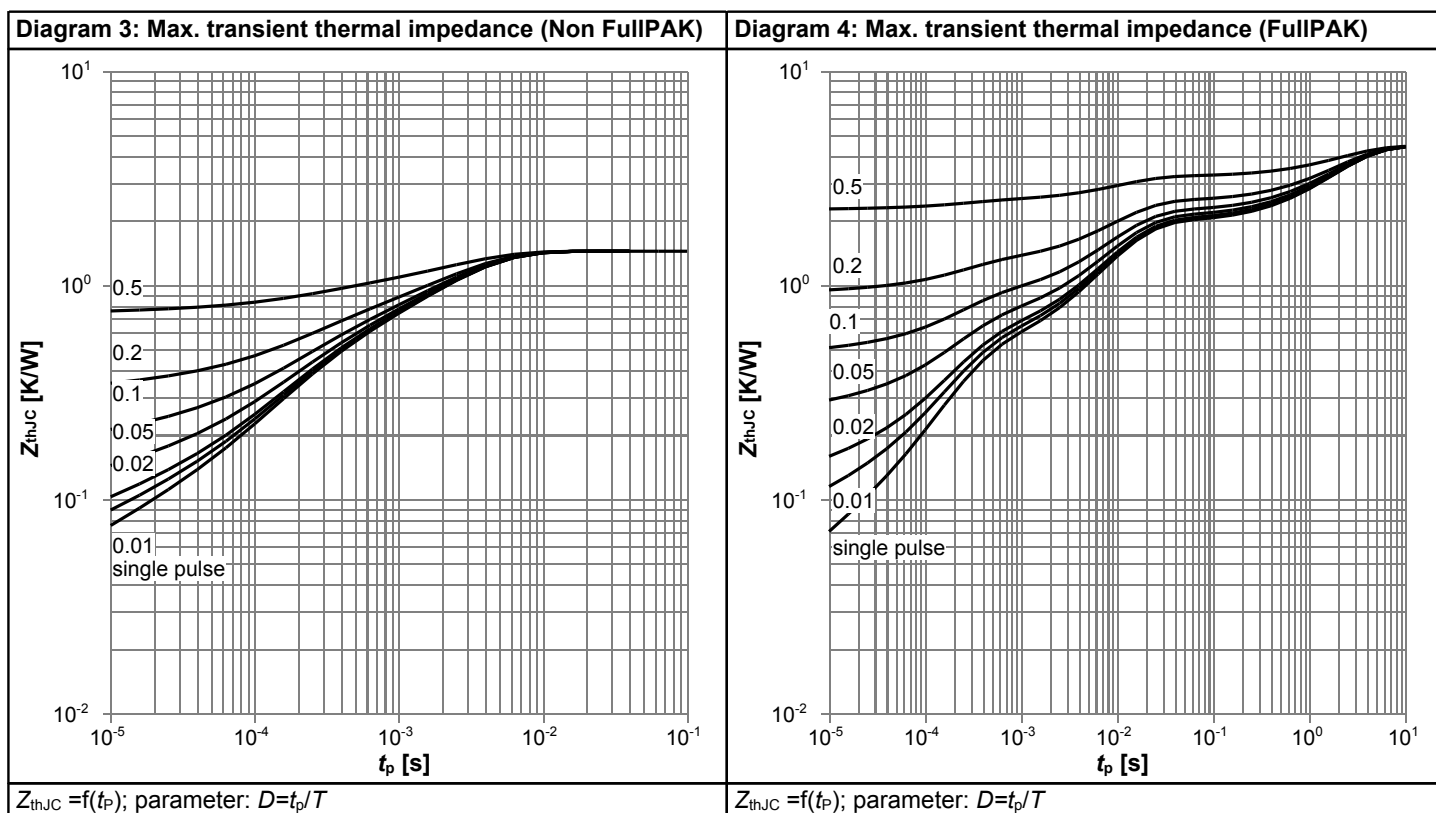
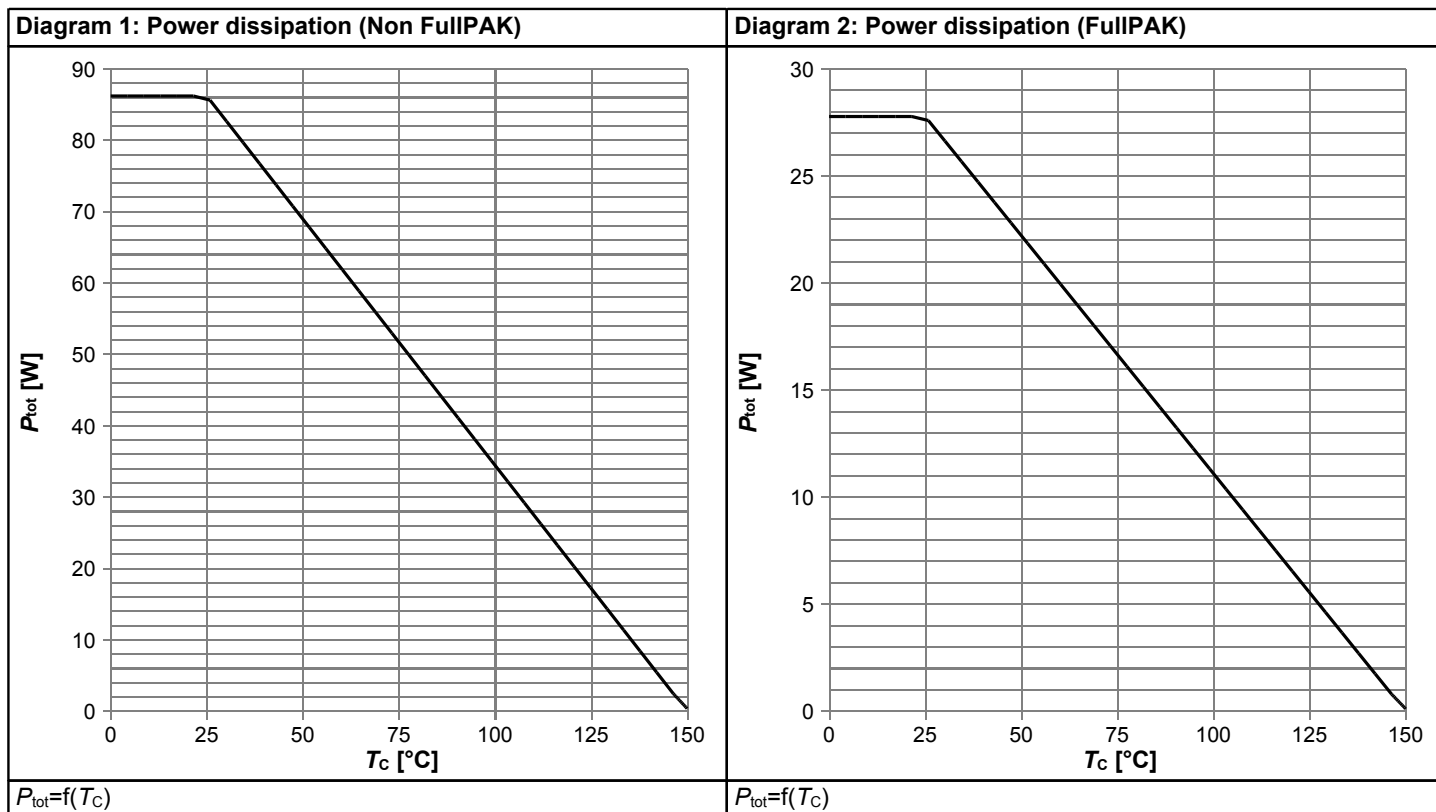
¹⁾ $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% $V_{o(BR)DSS}$

²⁾ $C_{o(tr)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% $V_{o(BR)DSS}$

Table 8 Reverse diode characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Diode forward voltage	V_{SD}	-	0.9	-	V	$V_{GS}=0V$, $I_F=3.2A$, $T_J=25^{\circ}C$
Reverse recovery time	t_{rr}	-	270	-	ns	$V_R=400V$, $I_F=3.2A$, $di_F/dt=100A/\mu s$; see table 9
Reverse recovery charge	Q_{rr}	-	2	-	μC	$V_R=400V$, $I_F=3.2A$, $di_F/dt=100A/\mu s$; see table 9
Peak reverse recovery current	I_{rrm}	-	13	-	A	$V_R=400V$, $I_F=3.2A$, $di_F/dt=100A/\mu s$; see table 9

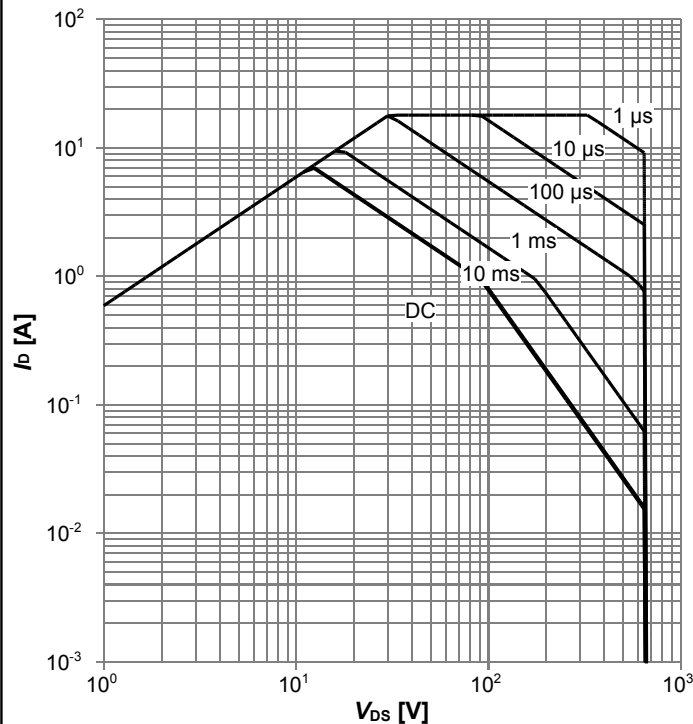
4 Electrical characteristics diagrams



650V CoolMOS™ CE Power Transistor

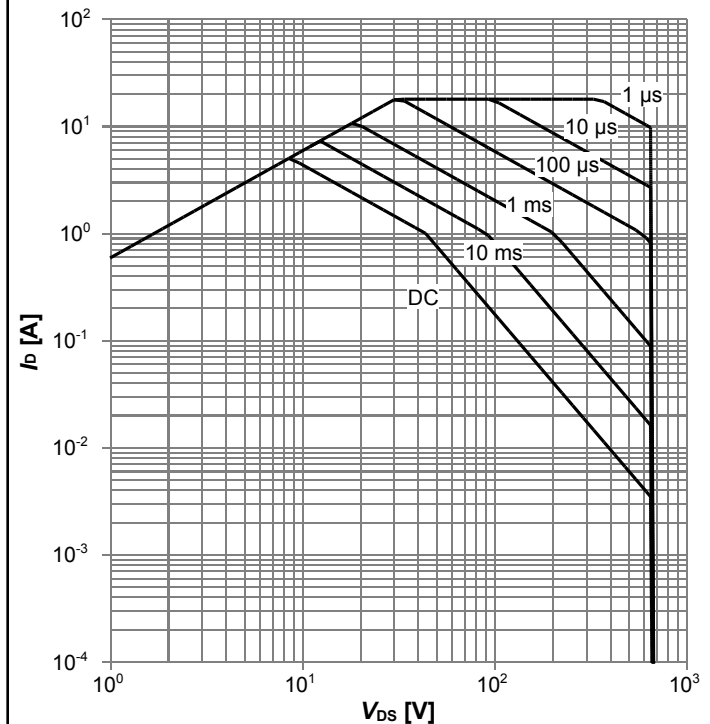
IPD65R650CE, IPA65R650CE

Diagram 5: Safe operating area (Non FullPAK)



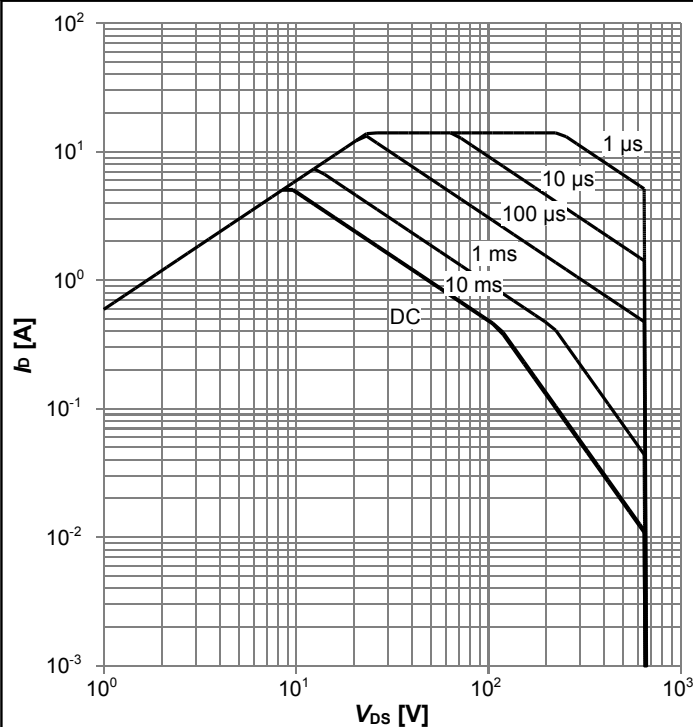
$I_D=f(V_{DS})$; $T_C=25\text{ °C}$; $D=0$; parameter: t_p

Diagram 6: Safe operating area (FullPAK)



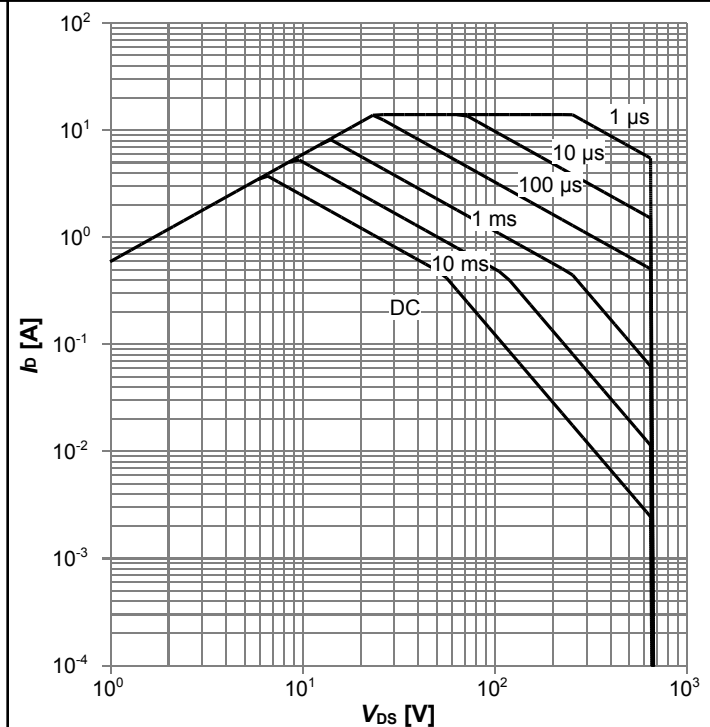
$I_D=f(V_{DS})$; $T_C=25\text{ °C}$; $D=0$; parameter: t_p

Diagram 7: Safe operating area (Non FullPAK)



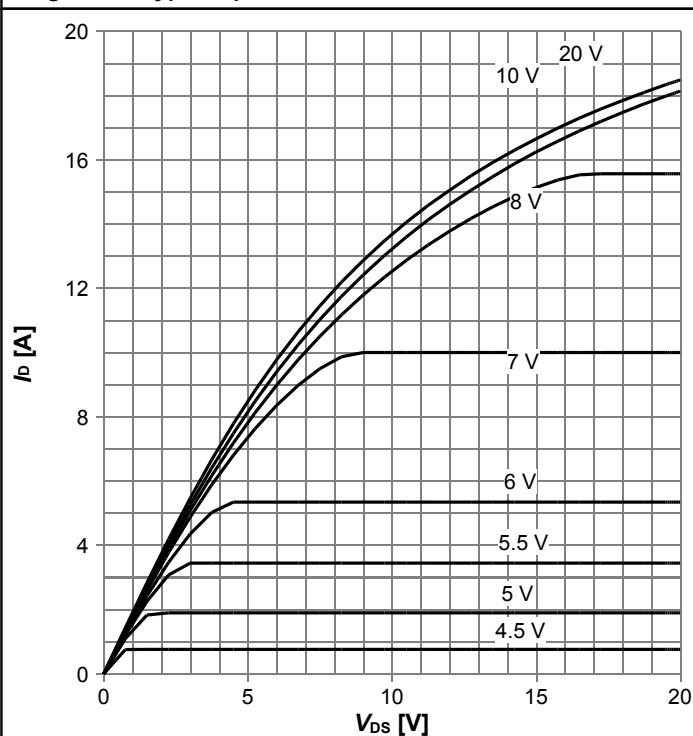
$I_D=f(V_{DS})$; $T_C=80\text{ °C}$; $D=0$; parameter: t_p

Diagram 8: Safe operating area (FullPAK)



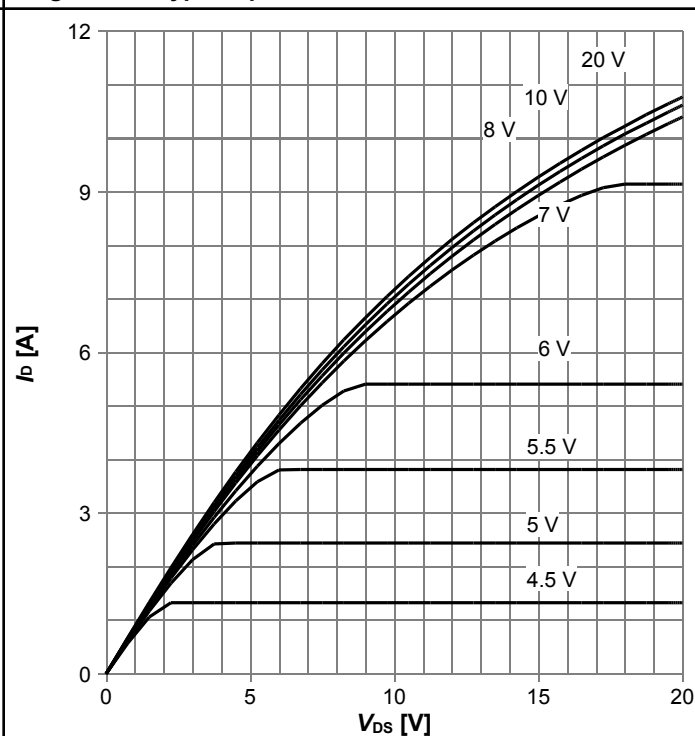
$I_D=f(V_{DS})$; $T_C=80\text{ °C}$; $D=0$; parameter: t_p

Diagram 9: Typ. output characteristics



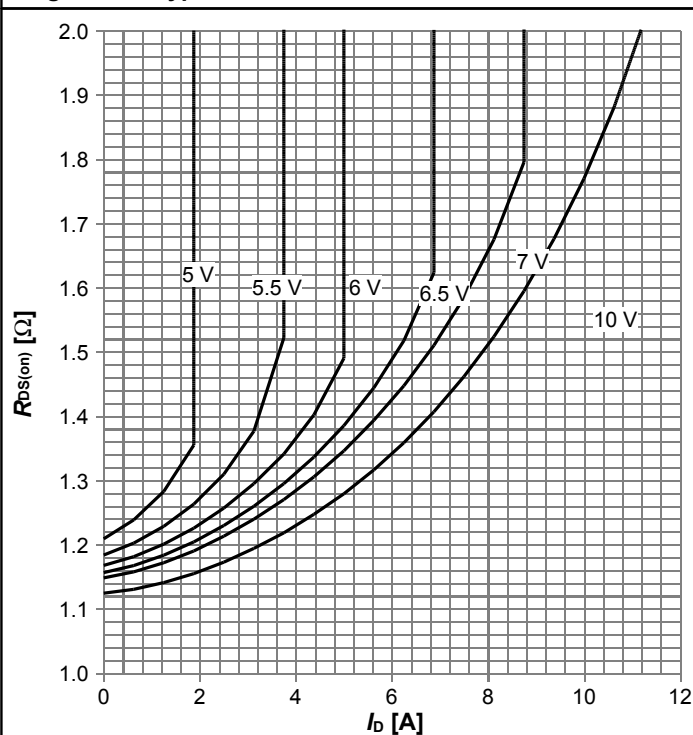
$I_D = f(V_{DS})$; $T_j = 25\text{ °C}$; parameter: V_{GS}

Diagram 10: Typ. output characteristics



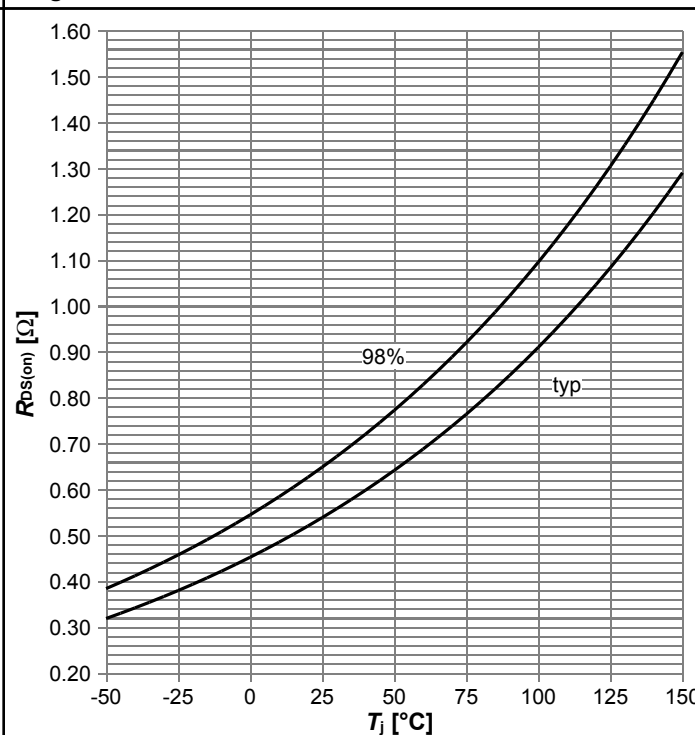
$I_D = f(V_{DS})$; $T_j = 125\text{ °C}$; parameter: V_{GS}

Diagram 11: Typ. drain-source on-state resistance



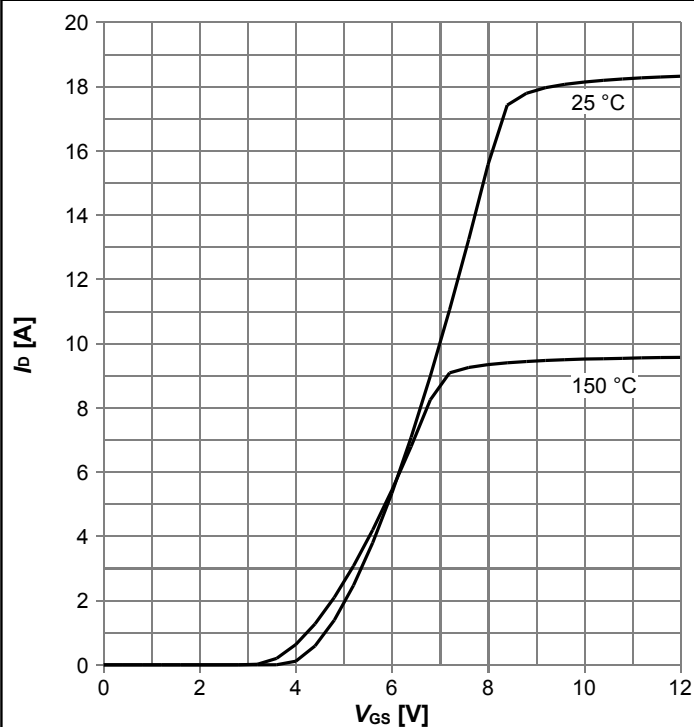
$R_{DS(on)} = f(I_D)$; $T_j = 125\text{ °C}$; parameter: V_{GS}

Diagram 12: Drain-source on-state resistance



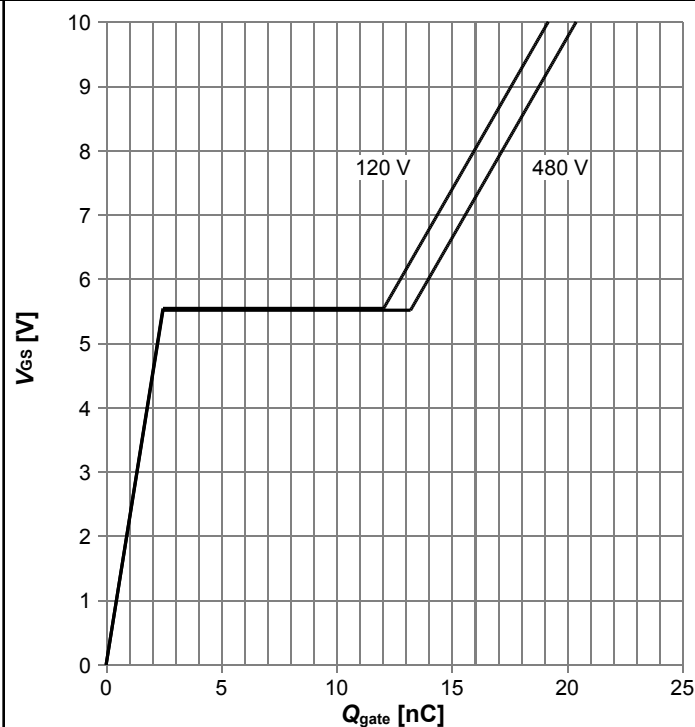
$R_{DS(on)} = f(T_j)$; $I_D = 2.1\text{ A}$; $V_{GS} = 10\text{ V}$

Diagram 13: Typ. transfer characteristics



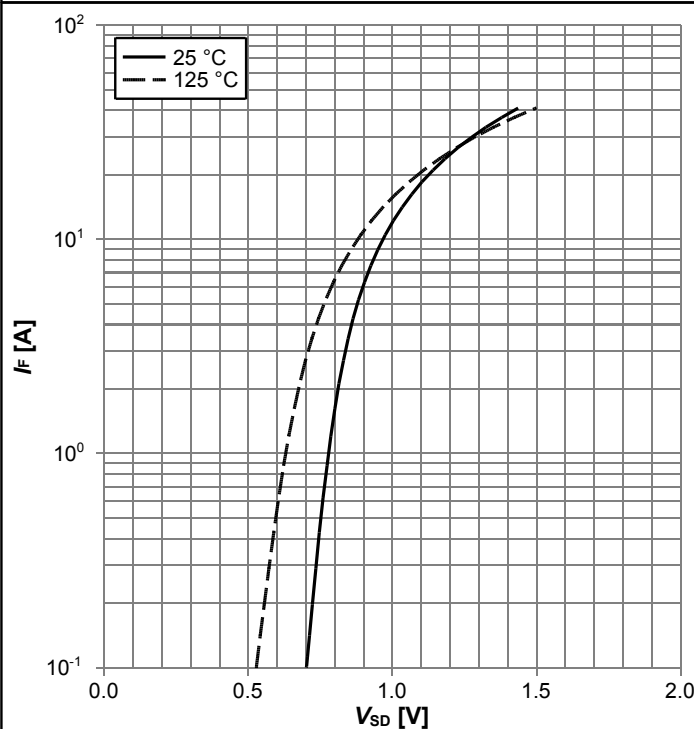
$I_D = f(V_{GS})$; $V_{DS} = 20V$; parameter: T_j

Diagram 14: Typ. gate charge



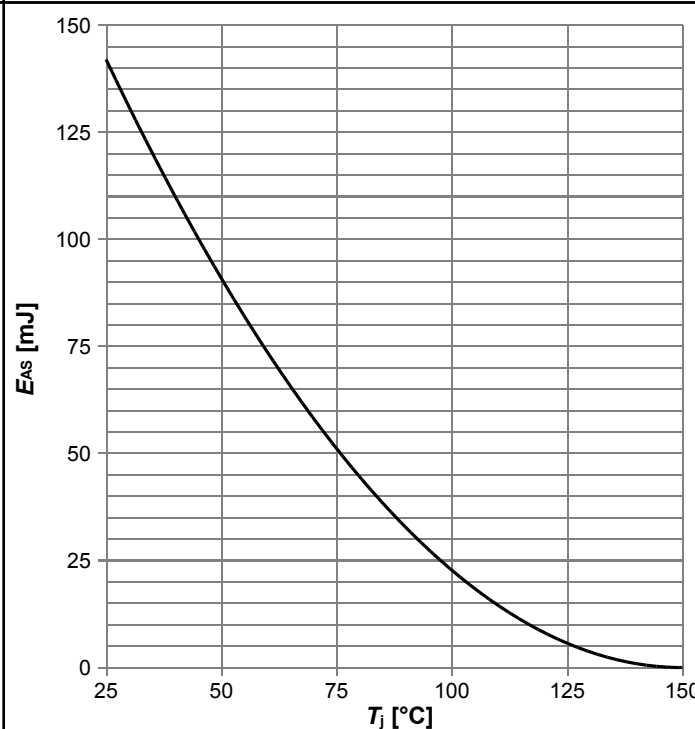
$V_{GS} = f(Q_{gate})$; $I_D = 3.2$ A pulsed; parameter: V_{DD}

Diagram 15: Forward characteristics of reverse diode



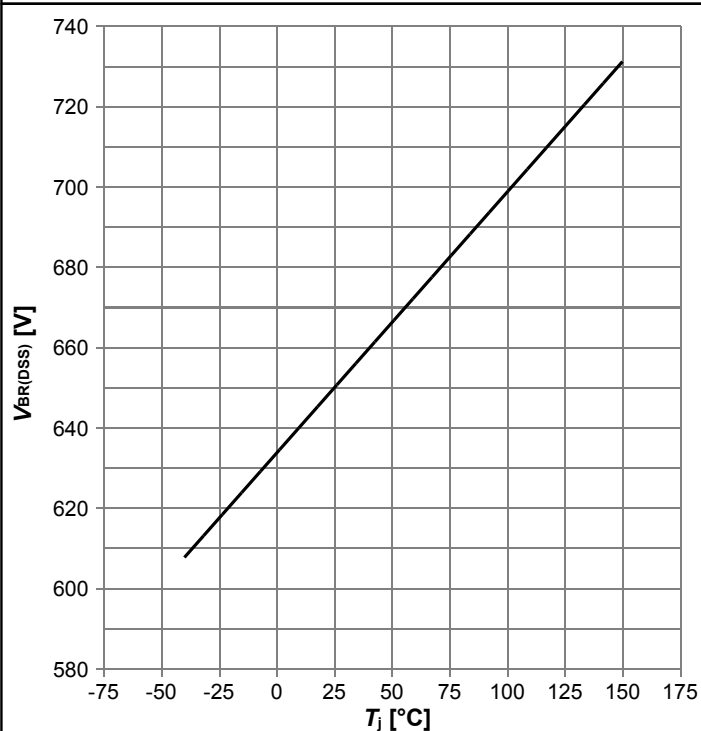
$I_F = f(V_{SD})$; parameter: T_j

Diagram 16: Avalanche energy



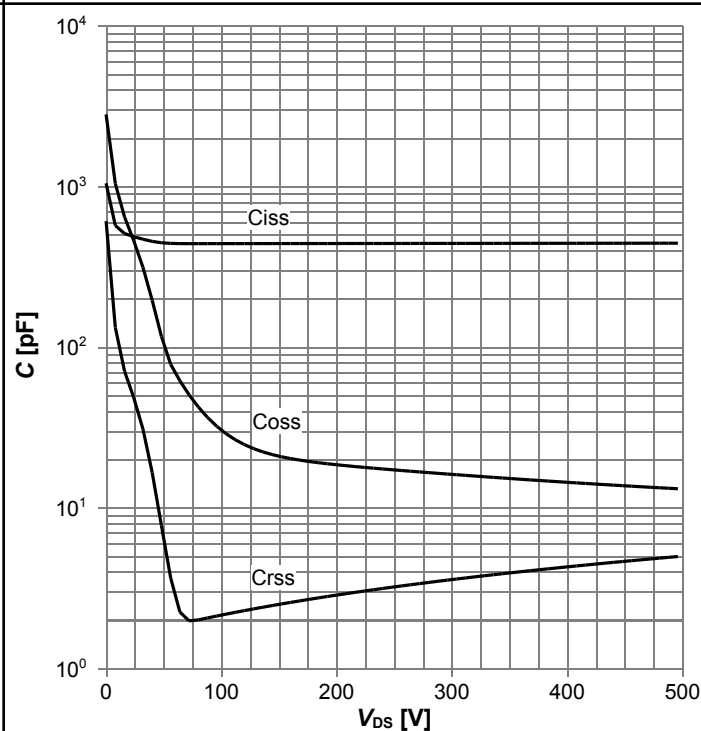
$E_{AS} = f(T_j)$; $I_D = 1.3$ A; $V_{DD} = 50$ V

Diagram 17: Drain-source breakdown voltage



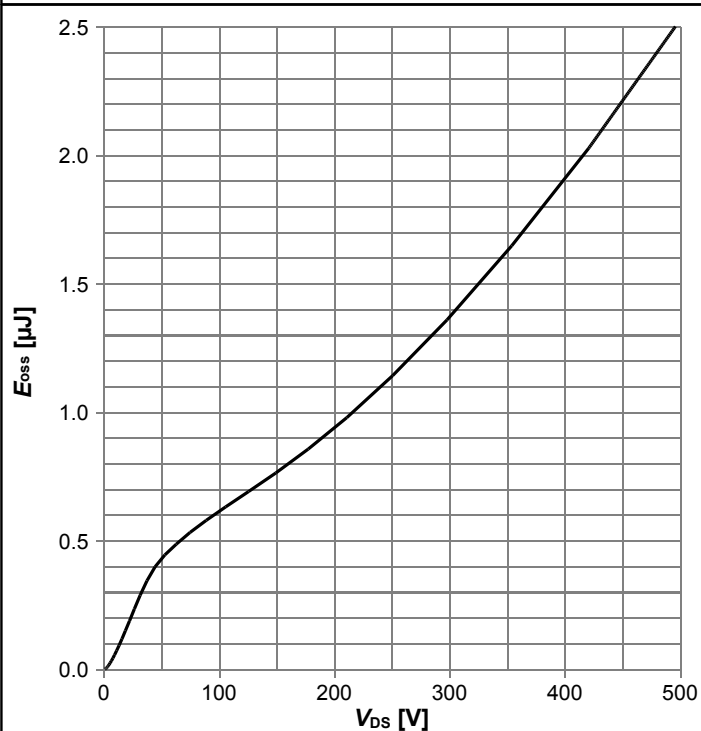
$V_{BR(DSS)} = f(T_j); I_D = 1.0 \text{ mA}$

Diagram 18: Typ. capacitances



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

Diagram 19: Typ. Coss stored energy



$E_{oss} = f(V_{DS})$

5 Test Circuits

Table 9 Diode characteristics

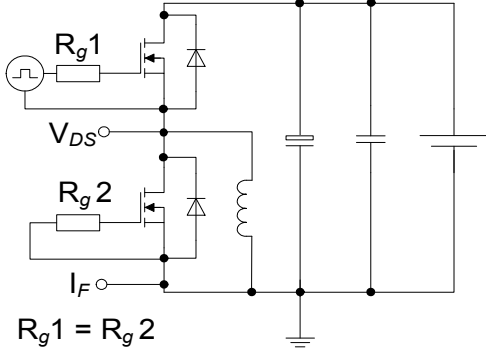
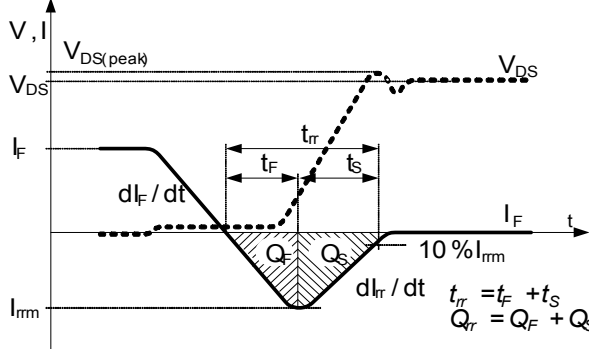
Test circuit for diode characteristics	Diode recovery waveform
 $R_{g1} = R_{g2}$	 $t_{tr} = t_F + t_S$ $Q_{rr} = Q_F + Q_S$

Table 10 Switching times

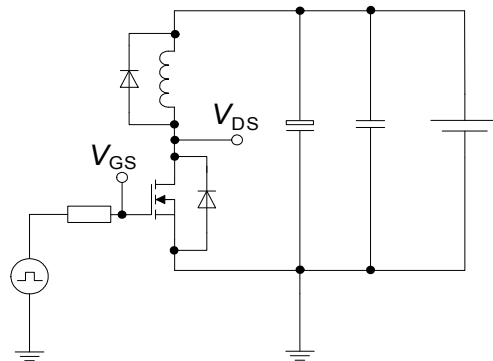
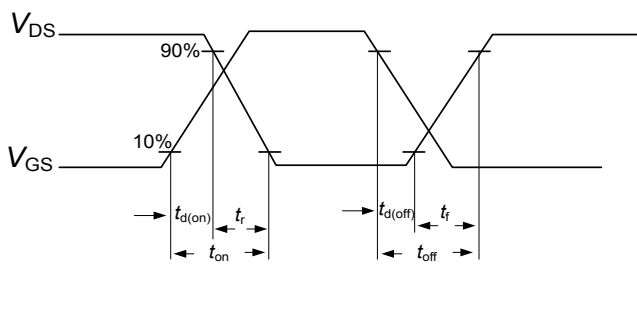
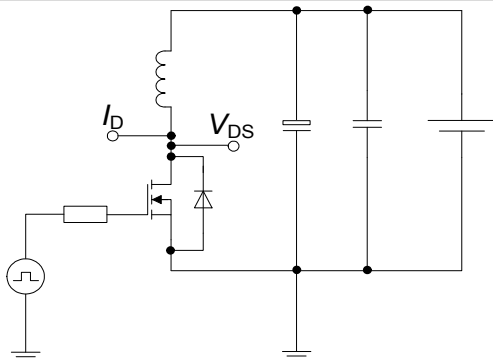
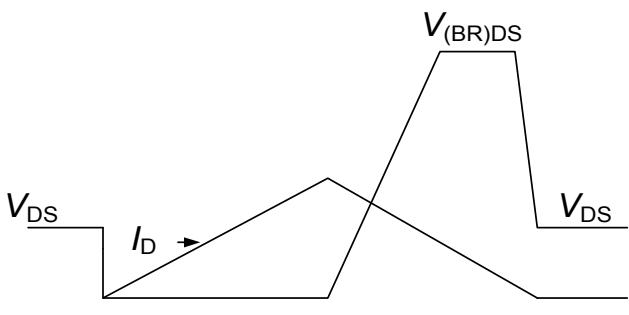
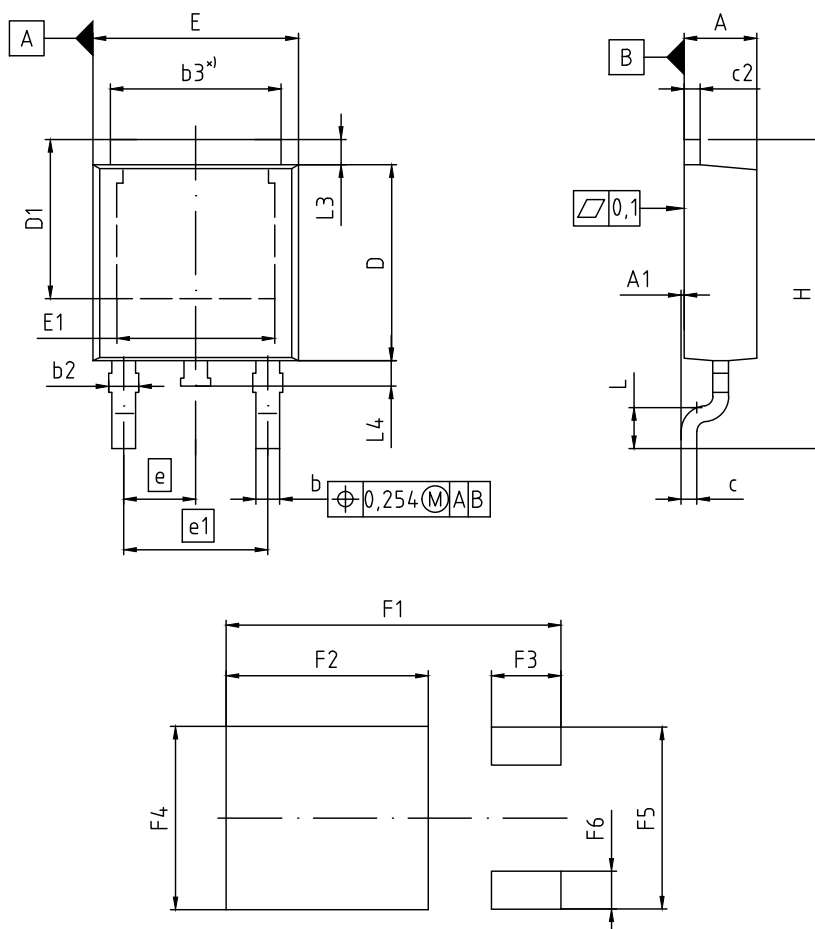
Switching times test circuit for inductive load	Switching times waveform
	

Table 11 Unclamped inductive load

Unclamped inductive load test circuit	Unclamped inductive waveform
	

6 Package Outlines

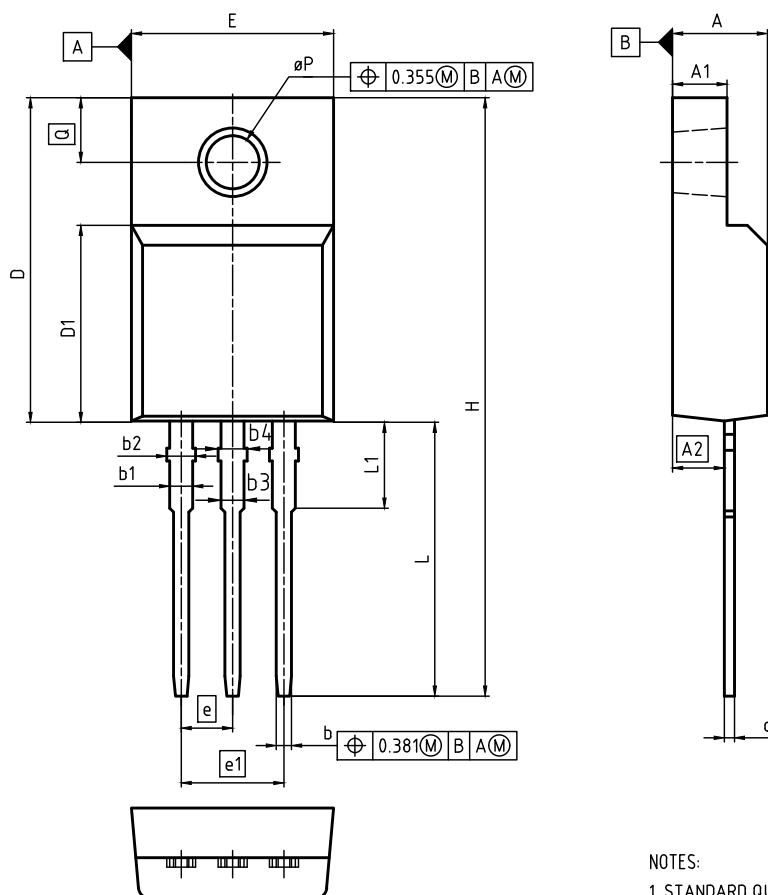


*) mold flash not included

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.16	2.41	0.085	0.095
A1	0.00	0.15	0.000	0.006
b	0.64	0.89	0.025	0.035
b2	0.65	1.15	0.026	0.045
b3	5.00	5.50	0.197	0.217
c	0.46	0.60	0.018	0.024
c2	0.46	0.98	0.018	0.039
D	5.97	6.22	0.235	0.245
D1	5.02	5.84	0.198	0.230
E	6.40	6.73	0.252	0.265
E1	4.70	5.60	0.185	0.220
e	2.29 (BSC)		0.090 (BSC)	
e1	4.57 (BSC)		0.180 (BSC)	
N	3		3	
H	9.40	10.48	0.370	0.413
L	1.18	1.70	0.046	0.067
L3	0.90	1.25	0.035	0.049
L4	0.51	1.00	0.020	0.039
F1	10.60		0.417	
F2	6.40		0.252	
F3	2.20		0.087	
F4	5.80		0.228	
F5	5.76		0.227	
F6	1.20		0.047	

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EUROPEAN PROJECTION
ISSUE DATE 01-09-2015
REVISION 05

Figure 1 Outline PG-TO 252, dimensions in mm/inches



DIMENSIONS DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.50	4.90	0.177	0.193
A1	2.34	2.80	0.092	0.110
A2	2.42	2.86	0.095	0.113
b	0.65	0.90	0.026	0.035
b1	0.95	1.38	0.037	0.054
b2	1.20	1.50	0.047	0.059
b3	0.65	1.38	0.026	0.054
b4	1.20	1.50	0.047	0.059
c	0.40	0.63	0.016	0.025
D	15.67	16.15	0.617	0.636
D1	8.97	9.83	0.353	0.387
E	10.00	10.65	0.394	0.419
e	2.54 (BSC)		0.100 (BSC)	
e1	5.08		0.200	
N	3		3	
H	28.70	29.75	1.130	1.171
L	12.78	13.75	0.503	0.541
L1	2.83	3.45	0.111	0.136
øP	3.00	3.38	0.118	0.133
Q	3.15	3.50	0.124	0.138

NOTES:

1. STANDARD QUALITY GRADE
2. ALL DIMENSIONS REFER TO JEDEC STANDARD TO-281 NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS

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SCALE
EUROPEAN PROJECTION
ISSUE DATE 29-04-2016
REVISION 01

Figure 2 Outline PG-TO 220 FullPAK, dimensions in mm/inches

7 Appendix A

Table 12 Related Links

- IFX CoolMOS™ CE Webpage: www.infineon.com
- IFX CoolMOS™ CE application note: www.infineon.com
- IFX CoolMOS™ CE simulation model: www.infineon.com
- IFX Design tools: www.infineon.com

Revision History

IPD65R650CE, IPA65R650CE

Revision: 2016-12-07, Rev. 2.4

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.3	2016-07-21	Rev. 2.1 - Modified Id, Rthjc, SOA, Zthjc curves. Rev 2.2 - Revised Full PAK package drawing, Rev 2.3 - Added Full PAK marking in page 1
2.4	2016-12-07	Changed solder reflow data fromMSL1 to MSL3 on page 4

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