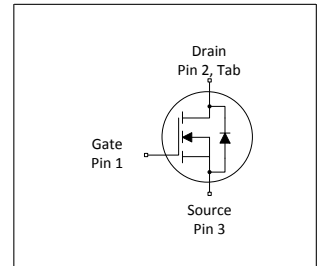


MOSFET

600V CoolMOS™ CE Power Transistor

CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. CoolMOS™ CE is a price-performance optimized platform enabling to target cost sensitive applications in Consumer and Lighting markets by still meeting highest efficiency standards. The new series provides all benefits of a fast switching Superjunction MOSFET while not sacrificing ease of use and offering the best cost down performance ratio available on the market.



Features

- Extremely low losses due to very low FOM $R_{DS(on)} \cdot Q_g$ and E_{oss}
- Very high commutation ruggedness
- Easy to use/drive
- Pb-free plating, Halogen free mold compound
- Qualified for standard grade applications

Applications

PFC stages, hard switching PWM stages and resonant switching stages for e.g. PC Silverbox, Adapter, LCD & PDP TV and indoor lighting.

Please note: Note1: For MOSFET paralleling the use of ferrite beads on the gate or separate totem poles is generally recommended.

*Note2: *6R650CE is Full PAK marking only*



Table 1 Key Performance Parameters

Parameter	Value	Unit
$V_{DS} @ T_{j,max}$	650	V
$R_{DS(on),max}$	650	mΩ
I_d	9.9	A
$Q_{g,typ}$	20.5	nC
$I_{D,pulse}$	19	A
$E_{oss}@400V$	1.9	μJ

Type / Ordering Code	Package	Marking	Related Links
IPD60R650CE	PG-TO 252	60S650CE / 6R650CE*	see Appendix A
IPA60R650CE	PG-TO 220 FullPAK		

Table of Contents

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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	-	-	9.9 6.2	A	$T_C=25^\circ\text{C}$ $T_C=100^\circ\text{C}$
Pulsed drain current ²⁾	$I_{D,pulse}$	-	-	19	A	$T_C=25^\circ\text{C}$
Avalanche energy, single pulse	E_{AS}	-	-	133	mJ	$I_D=1.3\text{A}$; $V_{DD}=50\text{V}$; see table 11
Avalanche energy, repetitive	E_{AR}	-	-	0.20	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}	-	-	82	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	A	$T_C=25^\circ\text{C}$
Diode pulse current ²⁾	$I_{S,pulse}$	-	-	19	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} , $T_C=25^\circ\text{C}$, $t=1\text{min}$

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	$^\circ\text{C/W}$	-
Thermal resistance, junction - ambient	R_{thJA}	-	-	80	$^\circ\text{C/W}$	leaded
Soldering temperature, wavesoldering only allowed at leads	T_{sold}	-	-	260	$^\circ\text{C}$	1.6mm (0.063 in.) from case for 10s

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_θ

Table 4 Thermal characteristics TO-252

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}	-	-	1.52	°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 6cm ² (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	$V_{(BR)DSS}$	600	-	-	V	$V_{GS}=0\text{V}$, $I_D=0.25\text{mA}$
Gate threshold voltage	$V_{(GS)th}$	2.5	3.0	3.5	V	$V_{DS}=V_{GS}$, $I_D=0.2\text{mA}$
Zero gate voltage drain current	I_{DSS}	-	-	1	μA	$V_{DS}=600$, $V_{GS}=0\text{V}$, $T_j=25^\circ\text{C}$ $V_{DS}=600$, $V_{GS}=0\text{V}$, $T_j=150^\circ\text{C}$
Gate-source leakage current	I_{GSS}	-	-	100	nA	$V_{GS}=20\text{V}$, $V_{DS}=0\text{V}$
Drain-source on-state resistance	$R_{DS(on)}$	-	0.54 1.40	0.65 -	Ω	$V_{GS}=10\text{V}$, $I_D=2.4\text{A}$, $T_j=25^\circ\text{C}$ $V_{GS}=10\text{V}$, $I_D=2.4\text{A}$, $T_j=150^\circ\text{C}$
Gate resistance	R_G	-	10	-	Ω	$f=1\text{MHz}$, open drain

Table 6 Dynamic characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	C_{iss}	-	440	-	pF	$V_{GS}=0\text{V}$, $V_{DS}=100\text{V}$, $f=1\text{MHz}$
Output capacitance	C_{oss}	-	30	-	pF	$V_{GS}=0\text{V}$, $V_{DS}=100\text{V}$, $f=1\text{MHz}$
Effective output capacitance, energy related ¹⁾	$C_{o(er)}$	-	21	-	pF	$V_{GS}=0\text{V}$, $V_{DS}=0\dots480\text{V}$
Effective output capacitance, time related ²⁾	$C_{o(tr)}$	-	88	-	pF	$I_D=\text{constant}$, $V_{GS}=0\text{V}$, $V_{DS}=0\dots480\text{V}$
Turn-on delay time	$t_{d(on)}$	-	10	-	ns	$V_{DD}=400\text{V}$, $V_{GS}=13\text{V}$, $I_D=3\text{A}$, $R_G=6.8\Omega$; see table 10
Rise time	t_r	-	8	-	ns	$V_{DD}=400\text{V}$, $V_{GS}=13\text{V}$, $I_D=3\text{A}$, $R_G=6.8\Omega$; see table 10
Turn-off delay time	$t_{d(off)}$	-	58	-	ns	$V_{DD}=400\text{V}$, $V_{GS}=13\text{V}$, $I_D=3\text{A}$, $R_G=6.8\Omega$; see table 10
Fall time	t_f	-	11	-	ns	$V_{DD}=400\text{V}$, $V_{GS}=13\text{V}$, $I_D=3\text{A}$, $R_G=6.8\Omega$; see table 10

Table 7 Gate charge characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate to source charge	Q_{GS}	-	2.5	-	nC	$V_{DD}=480\text{V}$, $I_D=3\text{A}$, $V_{GS}=0$ to 10V
Gate to drain charge	Q_{gd}	-	10.5	-	nC	$V_{DD}=480\text{V}$, $I_D=3\text{A}$, $V_{GS}=0$ to 10V
Gate charge total	Q_g	-	20.5	-	nC	$V_{DD}=480\text{V}$, $I_D=3\text{A}$, $V_{GS}=0$ to 10V
Gate plateau voltage	V_{plateau}	-	5.4	-	V	$V_{DD}=480\text{V}$, $I_D=3\text{A}$, $V_{GS}=0$ 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	$V_{GS}=0V, I_F=3A, T_j=25^\circ C$
Reverse recovery time	t_{rr}	-	250	-	ns	$V_R=400V, I_F=3A, di_F/dt=100A/\mu s$; see table 9
Reverse recovery charge	Q_{rr}	-	2.1	-	μC	$V_R=400V, I_F=3A, di_F/dt=100A/\mu s$; see table 9
Peak reverse recovery current	I_{rrm}	-	16	-	A	$V_R=400V, I_F=3A, di_F/dt=100A/\mu s$; see table 9

4 Electrical characteristics diagrams

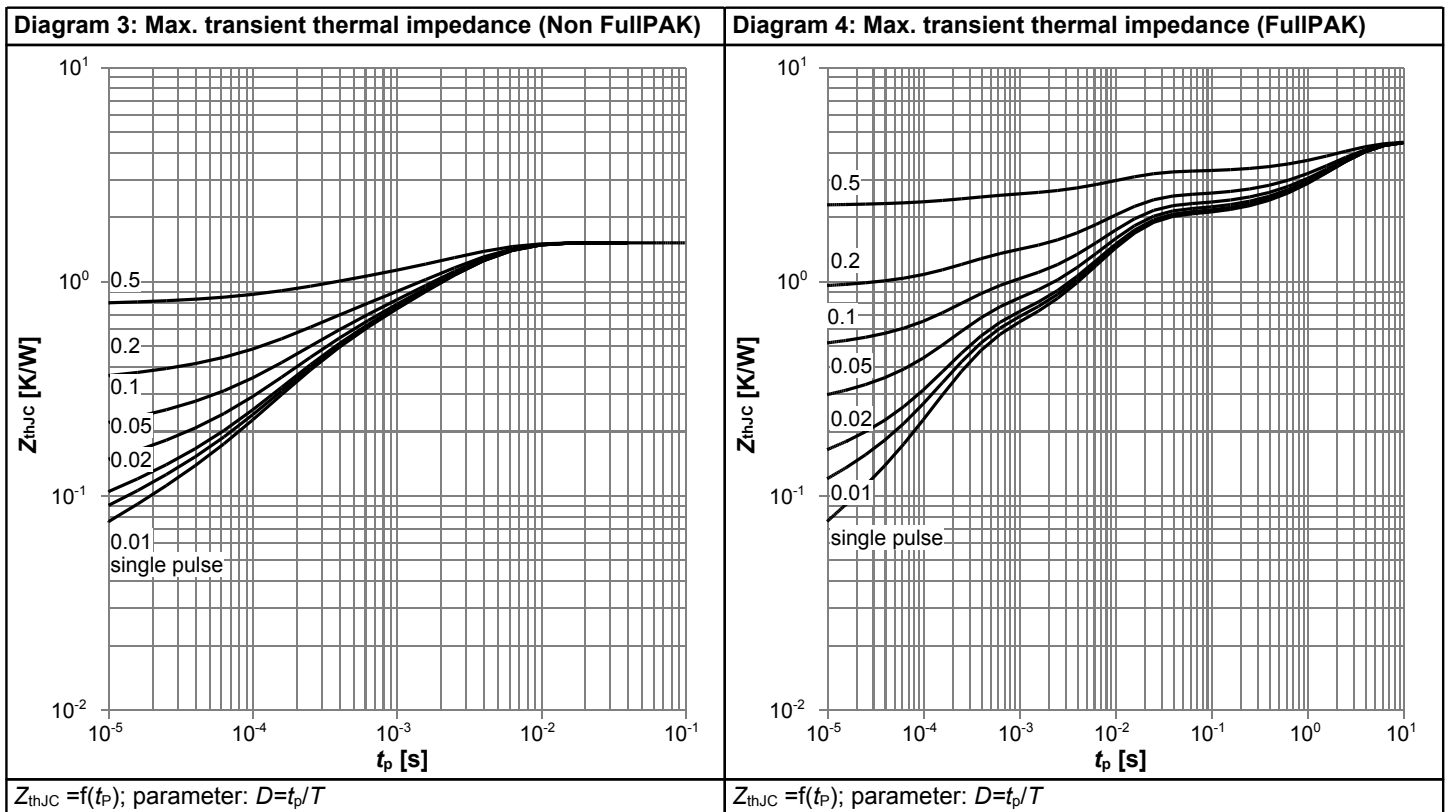
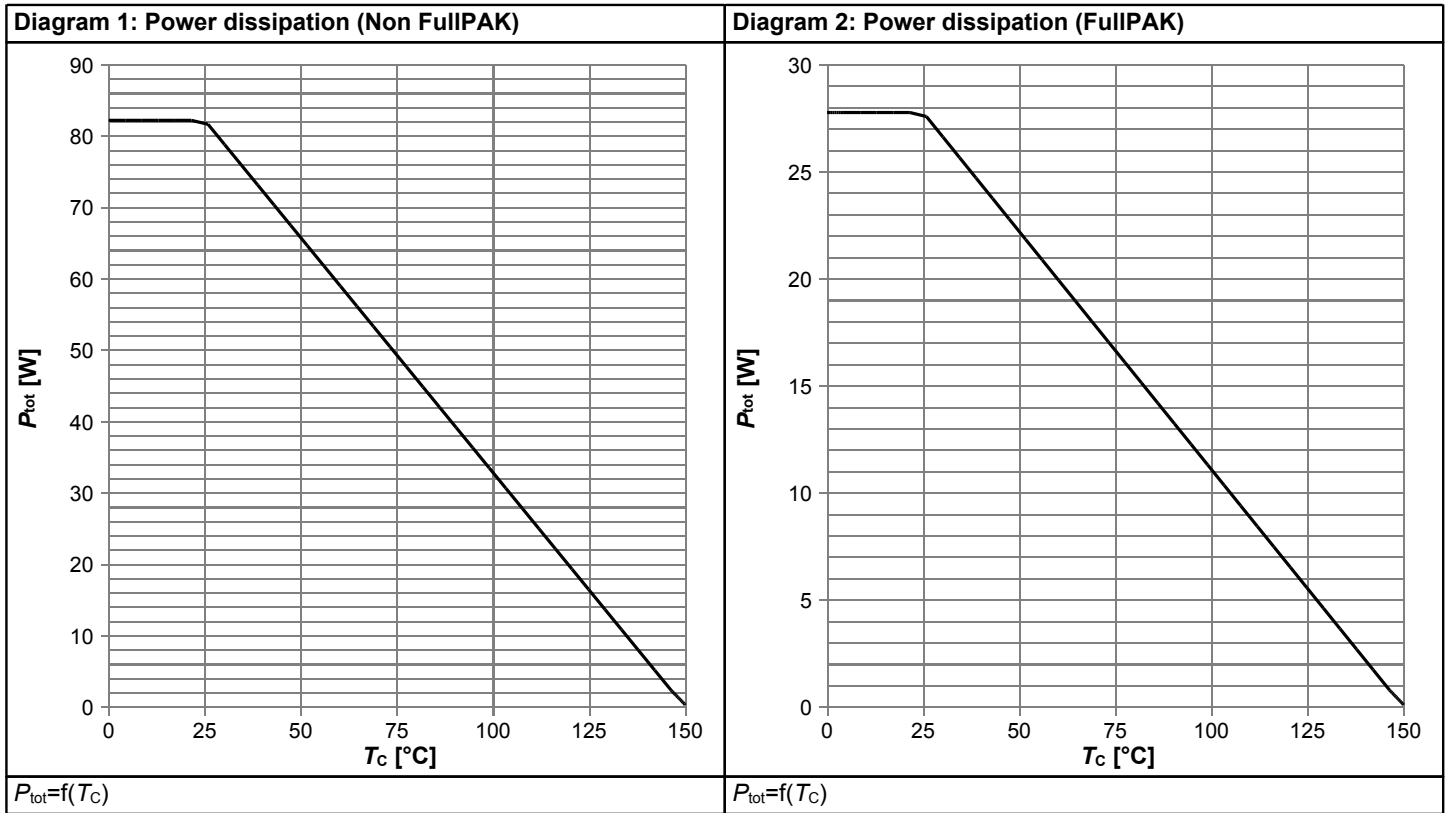
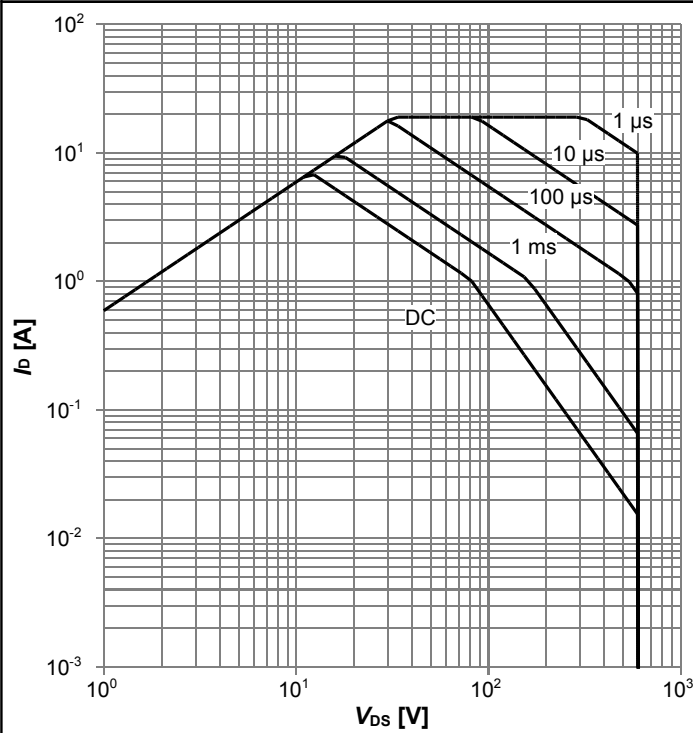
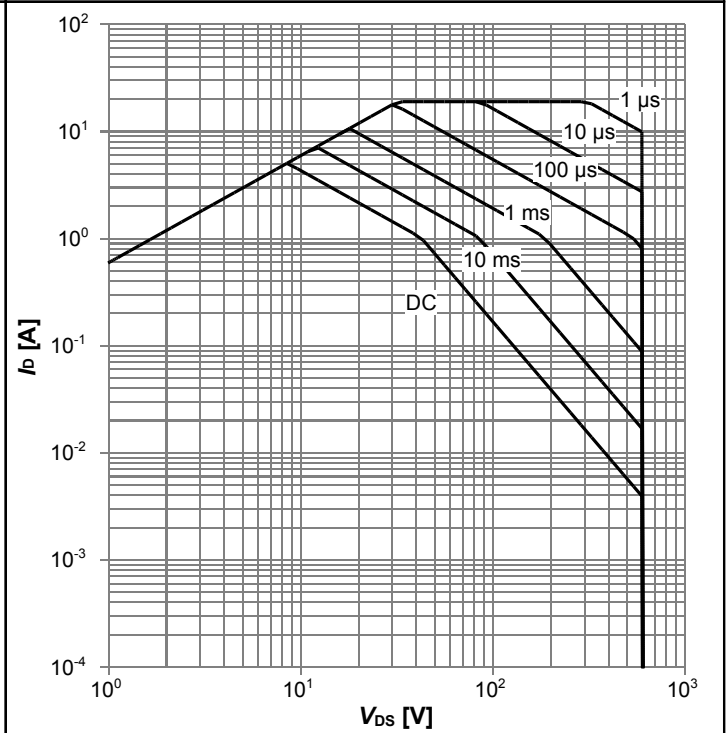


Diagram 5: Safe operating area (Non FullIPAK)



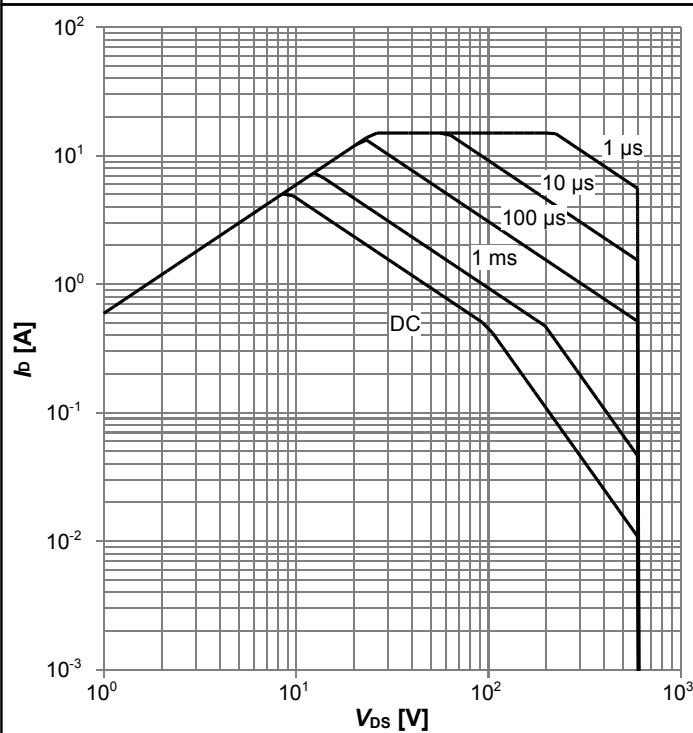
$I_b=f(V_{Ds}); T_C=25\text{ °C}; D=0; \text{parameter: } t_p$

Diagram 6: Safe operating area (FullIPAK)



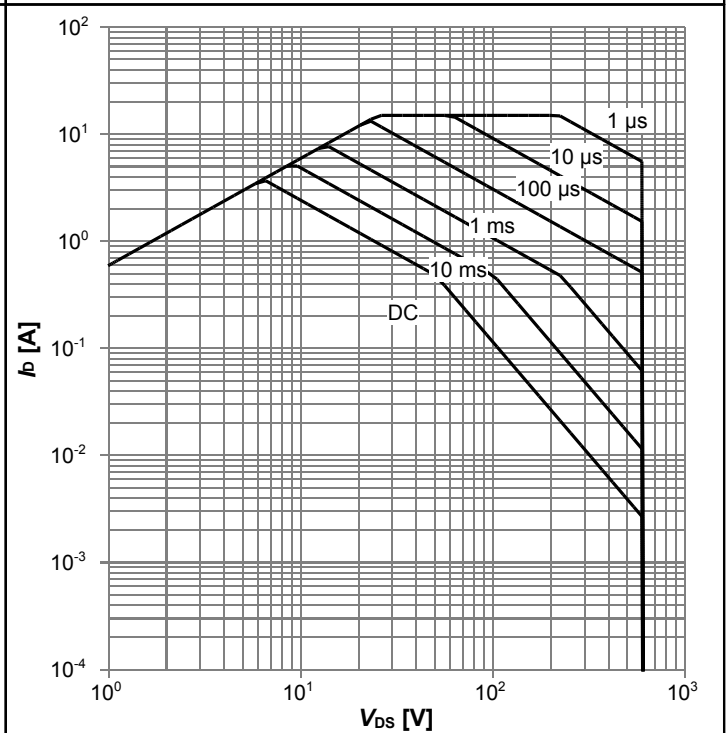
$I_b=f(V_{Ds}); T_C=25\text{ °C}; D=0; \text{parameter: } t_p$

Diagram 7: Safe operating area (Non FullIPAK)



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

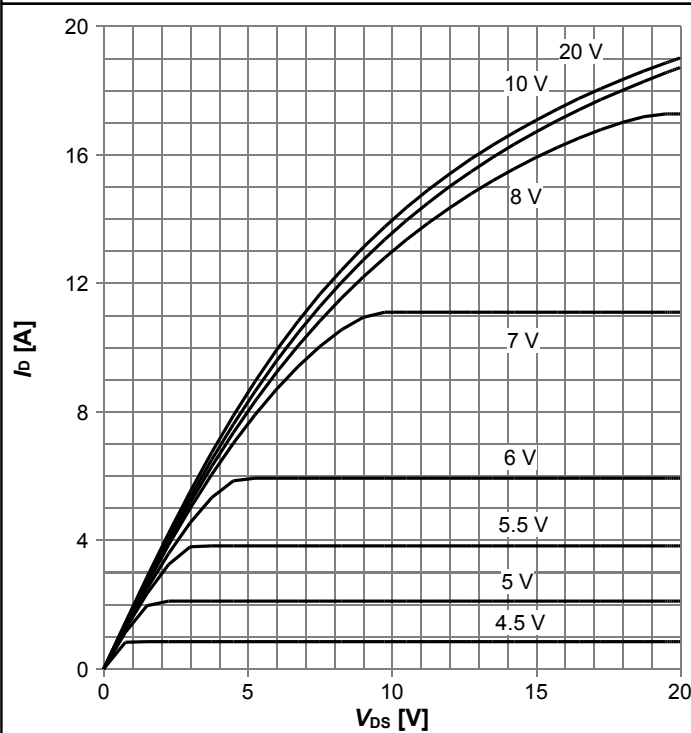
Diagram 8: Safe operating area (FullIPAK)



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

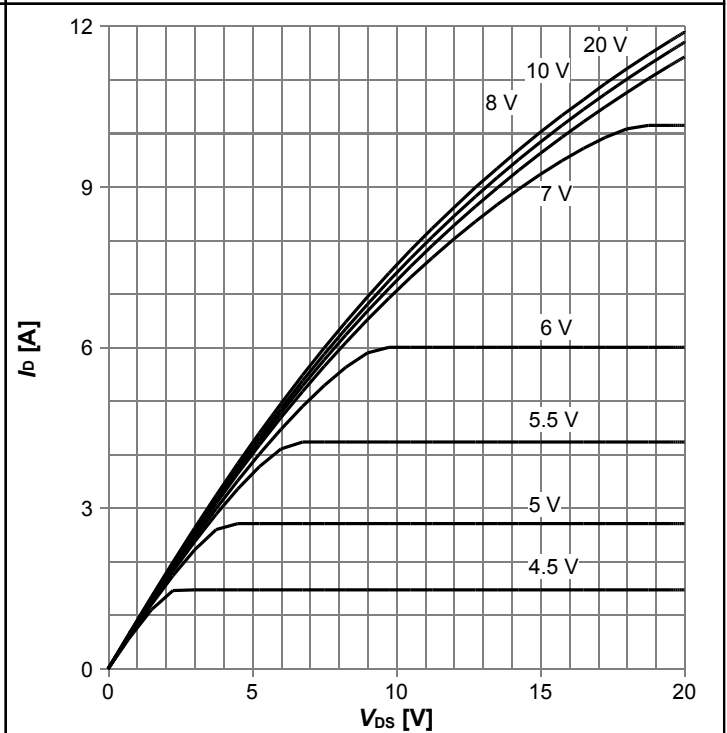
600V CoolMOS™ CE Power Transistor
IPD60R650CE, IPA60R650CE

Diagram 9: Typ. output characteristics



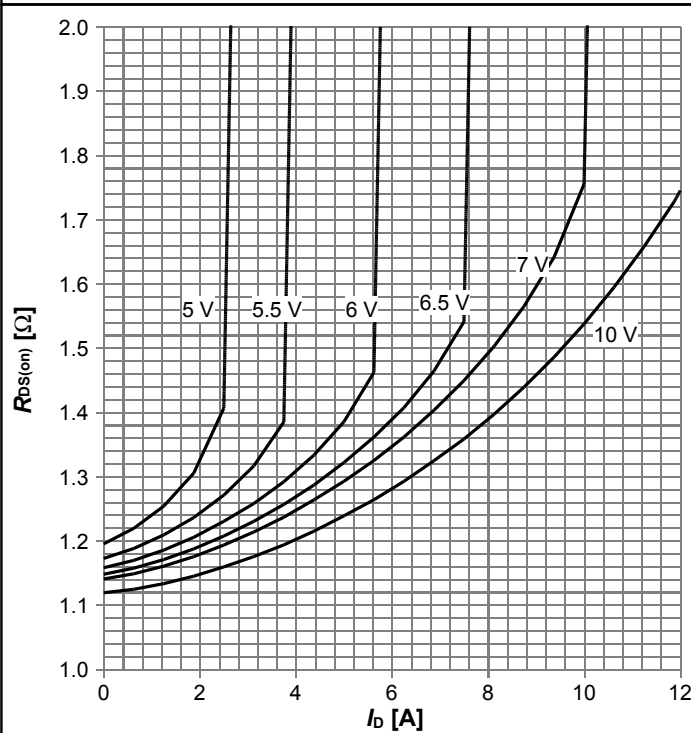
$I_D=f(V_{DS})$; $T_j=25\text{ °C}$; parameter: V_{GS}

Diagram 10: Typ. output characteristics



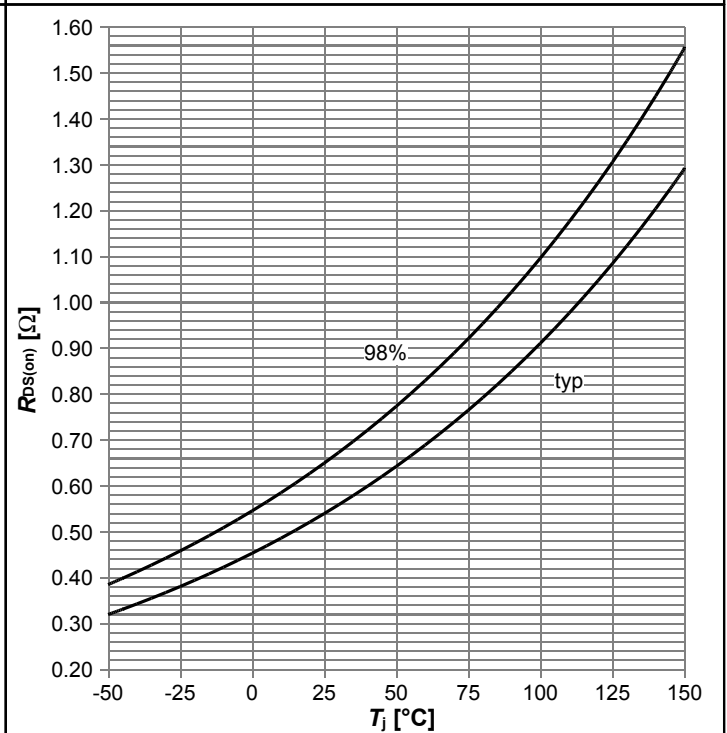
$I_D=f(V_{DS})$; $T_j=125\text{ °C}$; parameter: V_{GS}

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



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

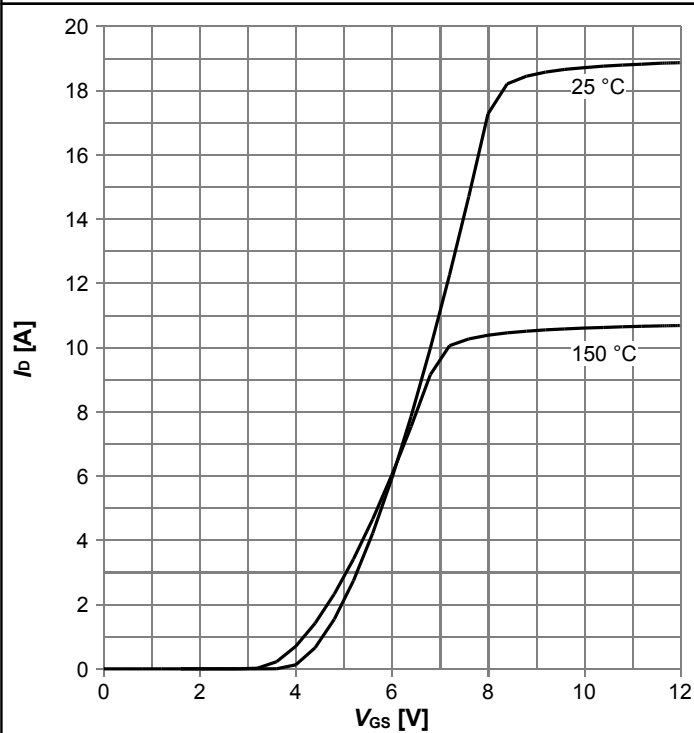
Diagram 12: Drain-source on-state resistance



$R_{DS(on)}=f(T_j)$; $I_D=2.4\text{ A}$; $V_{GS}=10\text{ V}$

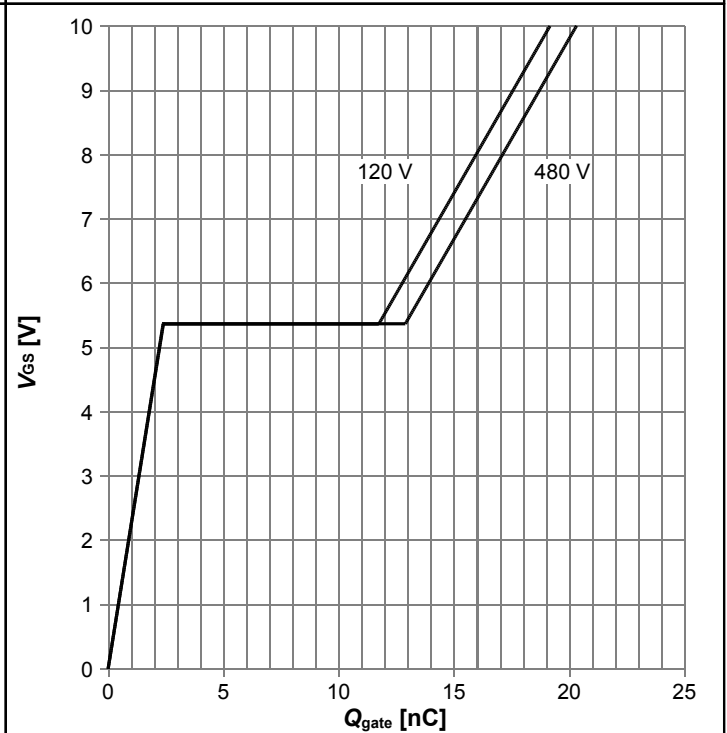
600V CoolMOS™ CE Power Transistor
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Diagram 13: Typ. transfer characteristics



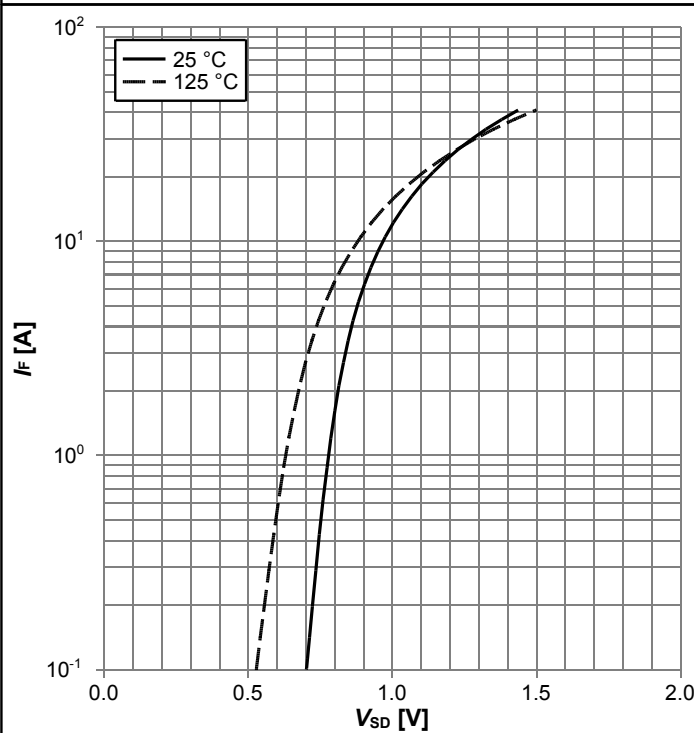
$I_D = f(V_{GS}); V_{DS} = 20V; \text{parameter: } T_j$

Diagram 14: Typ. gate charge



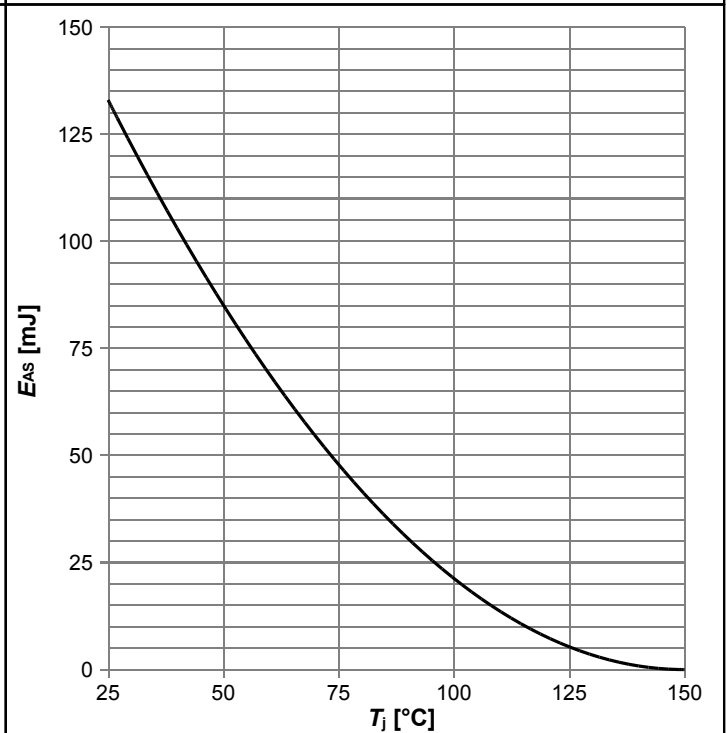
$V_{GS} = f(Q_{gate}); I_D = 3.0 \text{ A pulsed}; \text{parameter: } V_{DD}$

Diagram 15: Forward characteristics of reverse diode



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

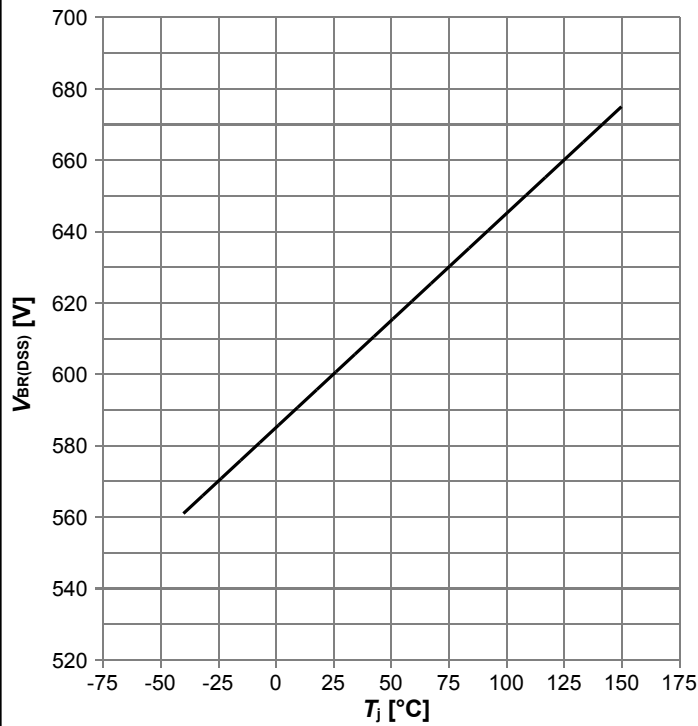
Diagram 16: Avalanche energy



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

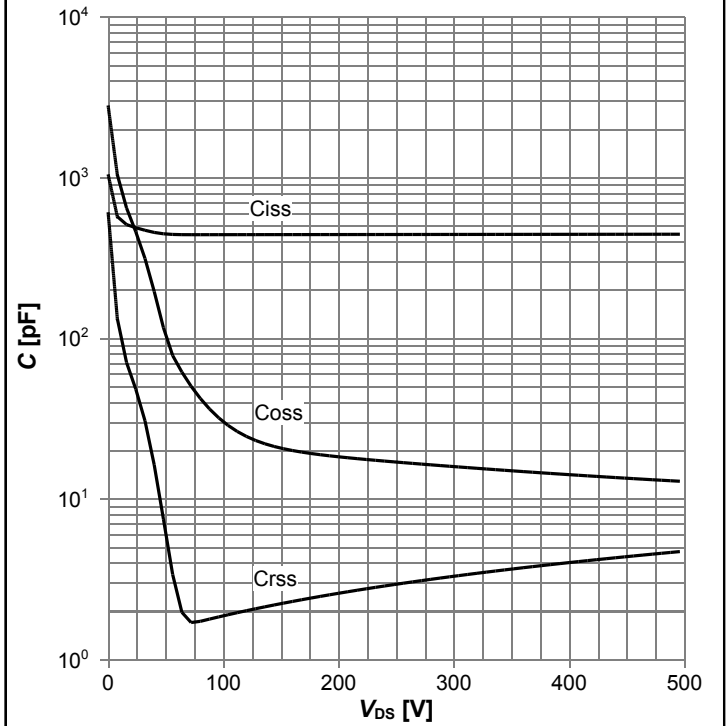
600V CoolMOS™ CE Power Transistor
IPD60R650CE, IPA60R650CE

Diagram 17: Drain-source breakdown voltage



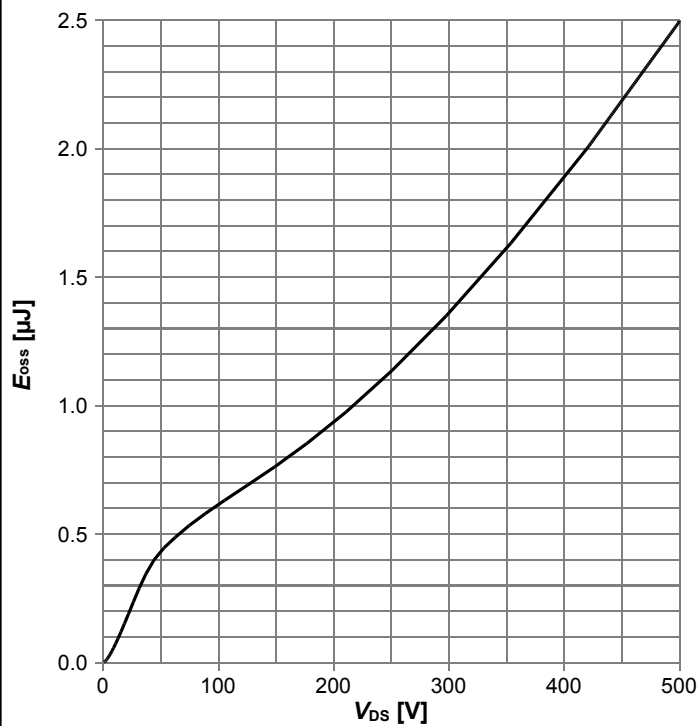
$V_{BR(DSS)}=f(T_j); I_D=0.25 \text{ mA}$

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

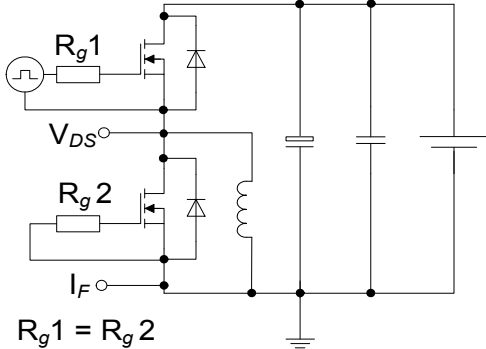
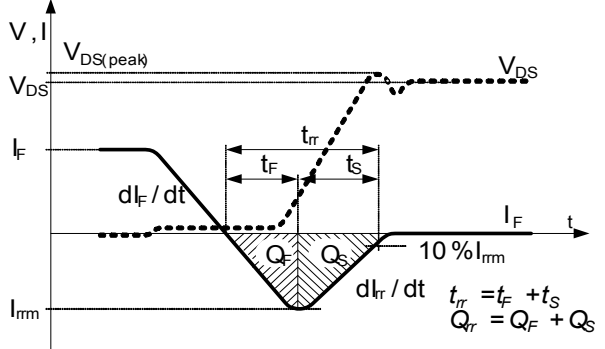
Test circuit for diode characteristics	Diode recovery waveform
 <p>$R_{g1} = R_{g2}$</p>	 <p>$t_{tr} = t_F + t_S$ $Q_{tr} = Q_F + Q_S$</p>

Table 10 Switching times

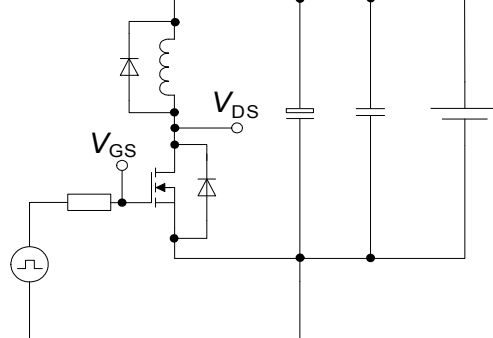
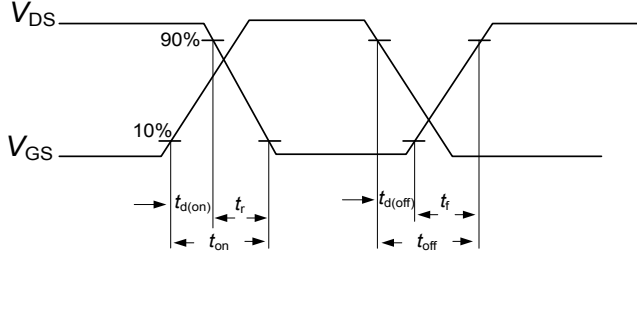
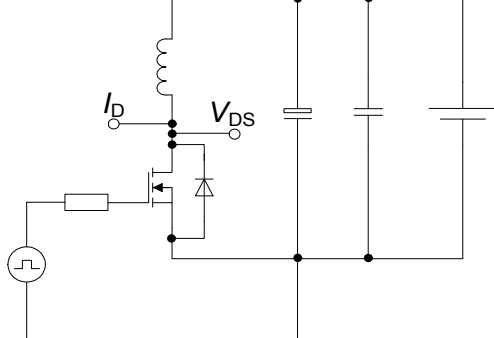
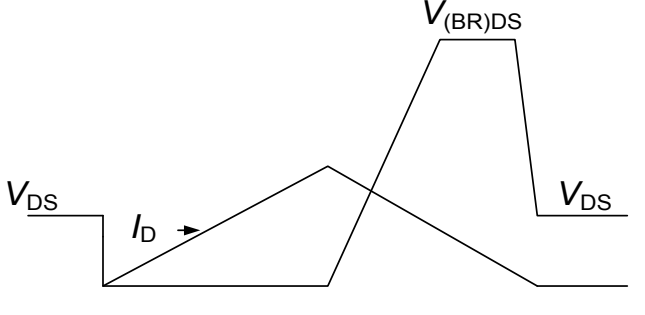
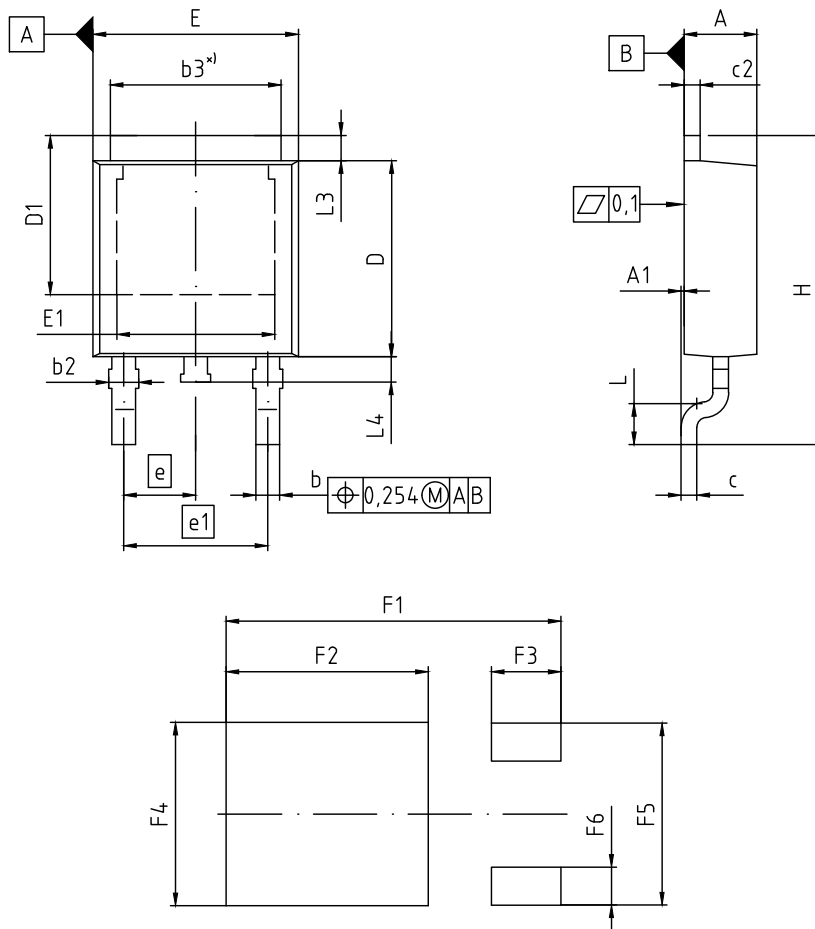
Switching times test circuit for inductive load	Switching times waveform
	

Table 11 Unclamped inductive load

Unclamped inductive load test circuit	Unclamped inductive waveform
	

6 Package Outlines



*) mold flash not included

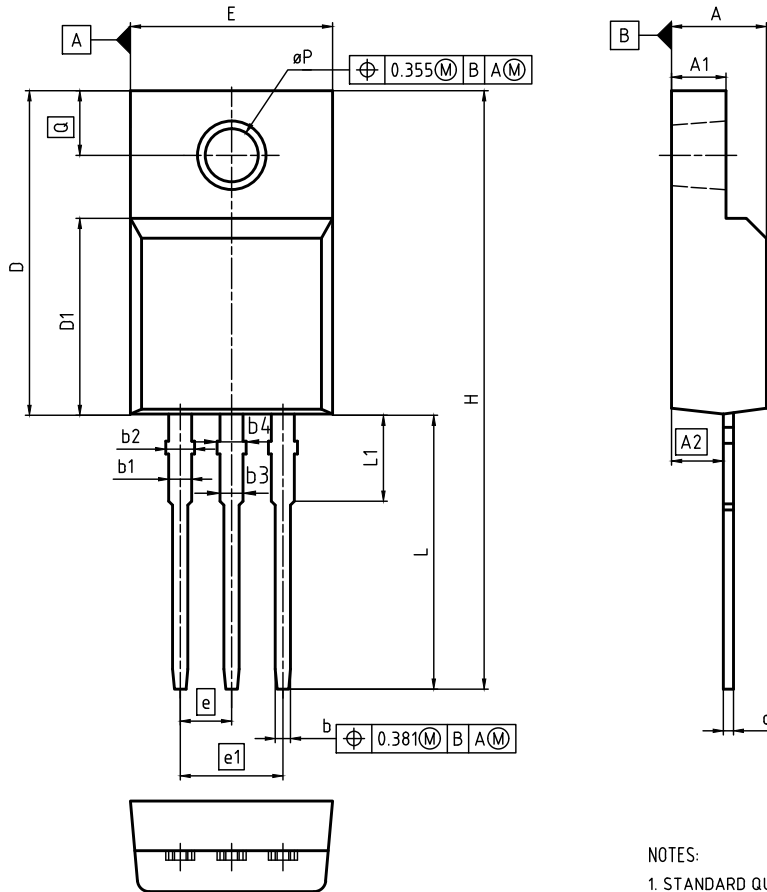
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.16	2.41	0.085	0.095
A1	0.00	0.15	0.000	0.006
b	0.64	0.89	0.025	0.035
b2	0.65	1.15	0.026	0.045
b3	5.00	5.50	0.197	0.217
c	0.46	0.60	0.018	0.024
c2	0.46	0.98	0.018	0.039
D	5.97	6.22	0.235	0.245
D1	5.02	5.84	0.198	0.230
E	6.40	6.73	0.252	0.265
E1	4.70	5.60	0.185	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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SCALE 0 2.0 4mm
EUROPEAN PROJECTION
ISSUE DATE 01-09-2015
REVISION 05

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

600V CoolMOS™ CE Power Transistor

IPD60R650CE, IPA60R650CE



NOTES:

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

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

DOCUMENT NO.
Z8B00181328

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

IPx60R650CE

Revision: 2018-04-11, Rev. 2.3

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.0	2014-09-25	Release of final version
2.1	2016-03-31	Modified Id, Rthjc. Modified SOA and Zthjc curves
2.2	2016-08-08	Added Full PAK marking on page 1, revised Full PAK package drawing on page 14 and changed TO252 package solder reflow rating to MSL3 on page 4
2.3	2018-04-11	Updated package naming in Table 2, line 10 (T0-252)

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