

MOSFET

Metal Oxide Semiconductor Field Effect Transistor

CoolMOS™ P6

600V CoolMOS™ P6 Power Transistor
IPx60R380P6

Data Sheet

Rev. 2.2
Final

1 Description

CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. CoolMOS™ P6 series combines the experience of the leading SJ MOSFET supplier with high class innovation. The offered devices provide all benefits of a fast switching SJ MOSFET while not sacrificing ease of use. Extremely low switching and conduction losses make switching applications even more efficient, more compact, lighter and cooler.

Features

- Increased MOSFET dv/dt ruggedness
- 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 industrial grade applications according to JEDEC (J-STD20 and JESD22)

Applications

PFC stages, hard switching PWM stages and resonant switching stages for e.g. PC Silverbox, Adapter, LCD & PDP TV, Lighting, Server, Telecom and UPS.

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

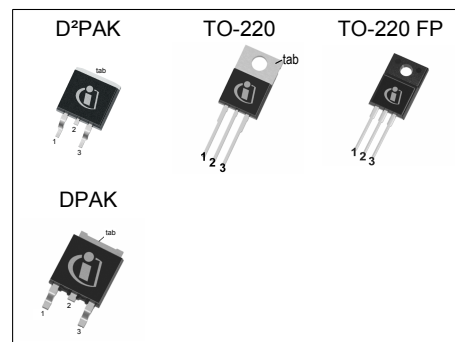


Table 1 Key Performance Parameters

Parameter	Value	Unit
$V_{DS} @ T_{j,max}$	650	V
$R_{DS(on),max}$	380	mΩ
$Q_{g,typ}$	19	nC
$I_{D,pulse}$	29	A
$E_{oss@400V}$	2.7	μJ
Body diode di/dt	500	A/μs

Type / Ordering Code	Package	Marking	Related Links
IPB60R380P6	PG-TO 263	6R380P6	see Appendix A
IPP60R380P6	PG-TO 220		
IPA60R380P6	PG-TO 220 FullPAK		
IPD60R380P6	PG-TO 252		

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2 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	-	-	10.6 6.7	A	$T_C=25^\circ\text{C}$ $T_C=100^\circ\text{C}$
Pulsed drain current ²⁾	$I_{D,pulse}$	-	-	29	A	$T_C=25^\circ\text{C}$
Avalanche energy, single pulse	E_{AS}	-	-	210	mJ	$I_D=1.8\text{A}$; $V_{DD}=50\text{V}$; see table 12
Avalanche energy, repetitive	E_{AR}	-	-	0.32	mJ	$I_D=1.8\text{A}$; $V_{DD}=50\text{V}$; see table 12
Avalanche current, repetitive	I_{AR}	-	-	1.8	A	-
MOSFET dv/dt ruggedness	dv/dt	-	-	100	V/ns	$V_{DS}=0\dots400\text{V}$
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-220, TO-252, TO-263	P_{tot}	-	-	83	W	$T_C=25^\circ\text{C}$
Power dissipation (FullPAK) TO-220FP	P_{tot}	-	-	31	W	$T_C=25^\circ\text{C}$
Storage temperature	T_{stg}	-55	-	150	$^\circ\text{C}$	-
Operating junction temperature	T_j	-55	-	150	$^\circ\text{C}$	-
Mounting torque (Non FullPAK) TO-220	-	-	-	60	Ncm	M3 and M3.5 screws
Mounting torque (FullPAK) TO-220FP	-	-	-	50	Ncm	M2.5 screws
Continuous diode forward current	I_S	-	-	9.2	A	$T_C=25^\circ\text{C}$
Diode pulse current ²⁾	$I_{S,pulse}$	-	-	29	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 10
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 10
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 $T_{j,max}$. Maximum duty cycle $D=0.75$

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

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

3 Thermal characteristics

Table 3 Thermal characteristics (Non FullPAK) TO-220

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}	-	-	1.5	°C/W	-
Thermal resistance, junction - ambient	R_{thJA}	-	-	62	°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 (FullPAK) TO-220FP

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}	-	-	4	°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 5 Thermal characteristics TO-252, TO-263

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}	-	-	1.5	°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 MSL1

4 Electrical characteristics

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

Table 6 Static characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Drain-source breakdown voltage	$V_{(BR)DSS}$	600	-	-	V	$V_{GS}=0V$, $I_D=1mA$
Gate threshold voltage	$V_{(GS)th}$	3.5	4.0	4.5	V	$V_{DS}=V_{GS}$, $I_D=0.32mA$
Zero gate voltage drain current	I_{DSS}	-	-	1	μA	$V_{DS}=600$, $V_{GS}=0V$, $T_j=25^\circ\text{C}$ $V_{DS}=600$, $V_{GS}=0V$, $T_j=150^\circ\text{C}$
Gate-source leakage current	I_{GSS}	-	-	100	nA	$V_{GS}=20V$, $V_{DS}=0V$
Drain-source on-state resistance	$R_{DS(on)}$	-	0.342 0.889	0.380 -	Ω	$V_{GS}=10V$, $I_D=3.8A$, $T_j=25^\circ\text{C}$ $V_{GS}=10V$, $I_D=3.8A$, $T_j=150^\circ\text{C}$
Gate resistance	R_G	-	7.8	-	Ω	$f=1MHz$, open drain

Table 7 Dynamic characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	C_{iss}	-	877	-	pF	$V_{GS}=0V$, $V_{DS}=100V$, $f=1MHz$
Output capacitance	C_{oss}	-	42	-	pF	$V_{GS}=0V$, $V_{DS}=100V$, $f=1MHz$
Effective output capacitance, energy related ¹⁾	$C_{o(er)}$	-	33	-	pF	$V_{GS}=0V$, $V_{DS}=0...400V$
Effective output capacitance, time related ²⁾	$C_{o(tr)}$	-	135	-	pF	$I_D=\text{constant}$, $V_{GS}=0V$, $V_{DS}=0...400V$
Turn-on delay time	$t_{d(on)}$	-	12	-	ns	$V_{DD}=400V$, $V_{GS}=13V$, $I_D=4.8A$, $R_G=3.4\Omega$; see table 11
Rise time	t_r	-	6	-	ns	$V_{DD}=400V$, $V_{GS}=13V$, $I_D=4.8A$, $R_G=3.4\Omega$; see table 11
Turn-off delay time	$t_{d(off)}$	-	33	-	ns	$V_{DD}=400V$, $V_{GS}=13V$, $I_D=4.8A$, $R_G=3.4\Omega$; see table 11
Fall time	t_f	-	7	-	ns	$V_{DD}=400V$, $V_{GS}=13V$, $I_D=4.8A$, $R_G=3.4\Omega$; see table 11

Table 8 Gate charge characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate to source charge	Q_{gs}	-	5.4	-	nC	$V_{DD}=400V$, $I_D=4.8A$, $V_{GS}=0$ to $10V$
Gate to drain charge	Q_{gd}	-	7	-	nC	$V_{DD}=400V$, $I_D=4.8A$, $V_{GS}=0$ to $10V$
Gate charge total	Q_g	-	19	-	nC	$V_{DD}=400V$, $I_D=4.8A$, $V_{GS}=0$ to $10V$
Gate plateau voltage	$V_{plateau}$	-	6.1	-	V	$V_{DD}=400V$, $I_D=4.8A$, $V_{GS}=0$ 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 400V

²⁾ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 400V

Table 9 Reverse diode characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Diode forward voltage	V_{SD}	-	0.9	-	V	$V_{GS}=0V$, $I_F=4.8A$, $T_j=25^{\circ}C$
Reverse recovery time	t_{rr}	-	232	-	ns	$V_R=400V$, $I_F=4.8A$, $di_F/dt=100A/\mu s$; see table 10
Reverse recovery charge	Q_{rr}	-	2.1	-	μC	$V_R=400V$, $I_F=4.8A$, $di_F/dt=100A/\mu s$; see table 10
Peak reverse recovery current	I_{rrm}	-	17	-	A	$V_R=400V$, $I_F=4.8A$, $di_F/dt=100A/\mu s$; see table 10

5 Electrical characteristics diagrams

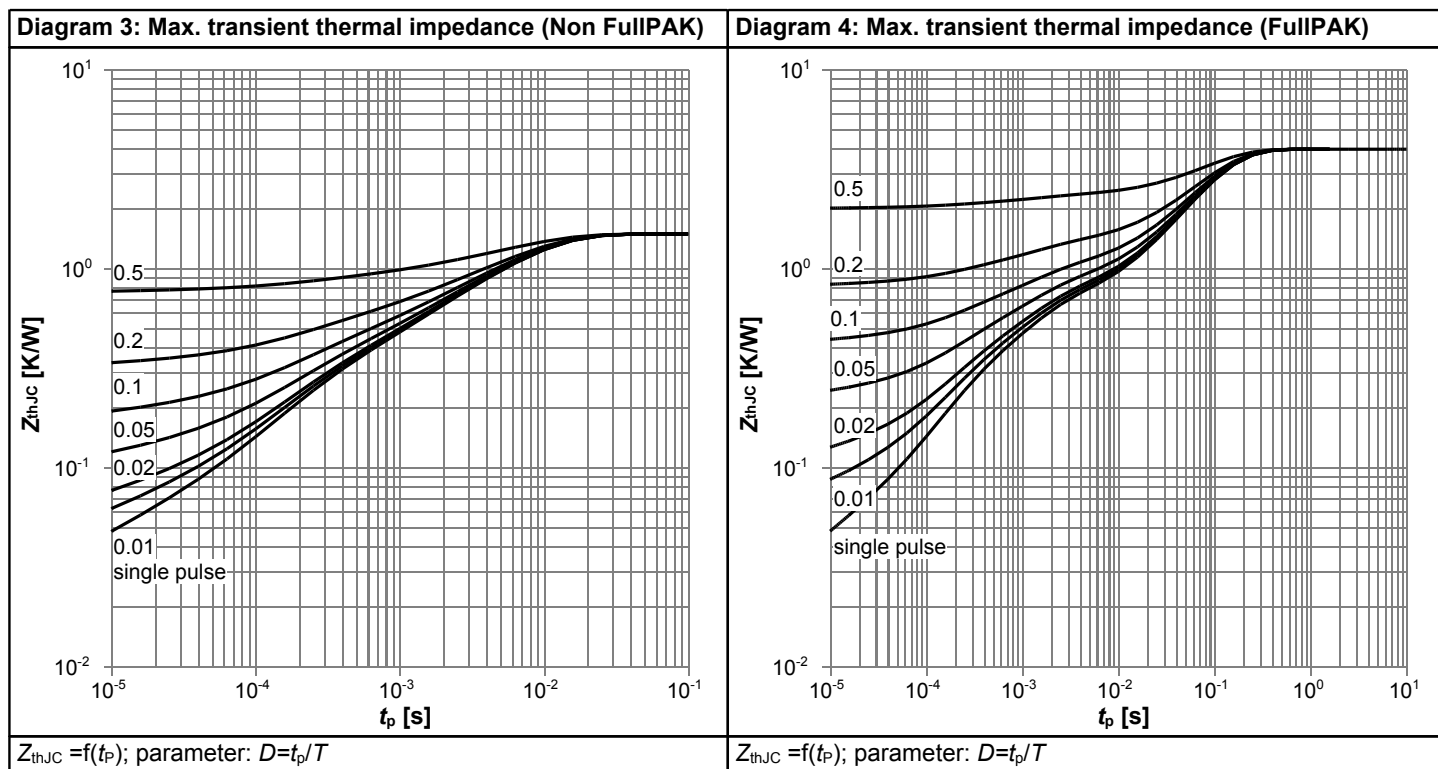
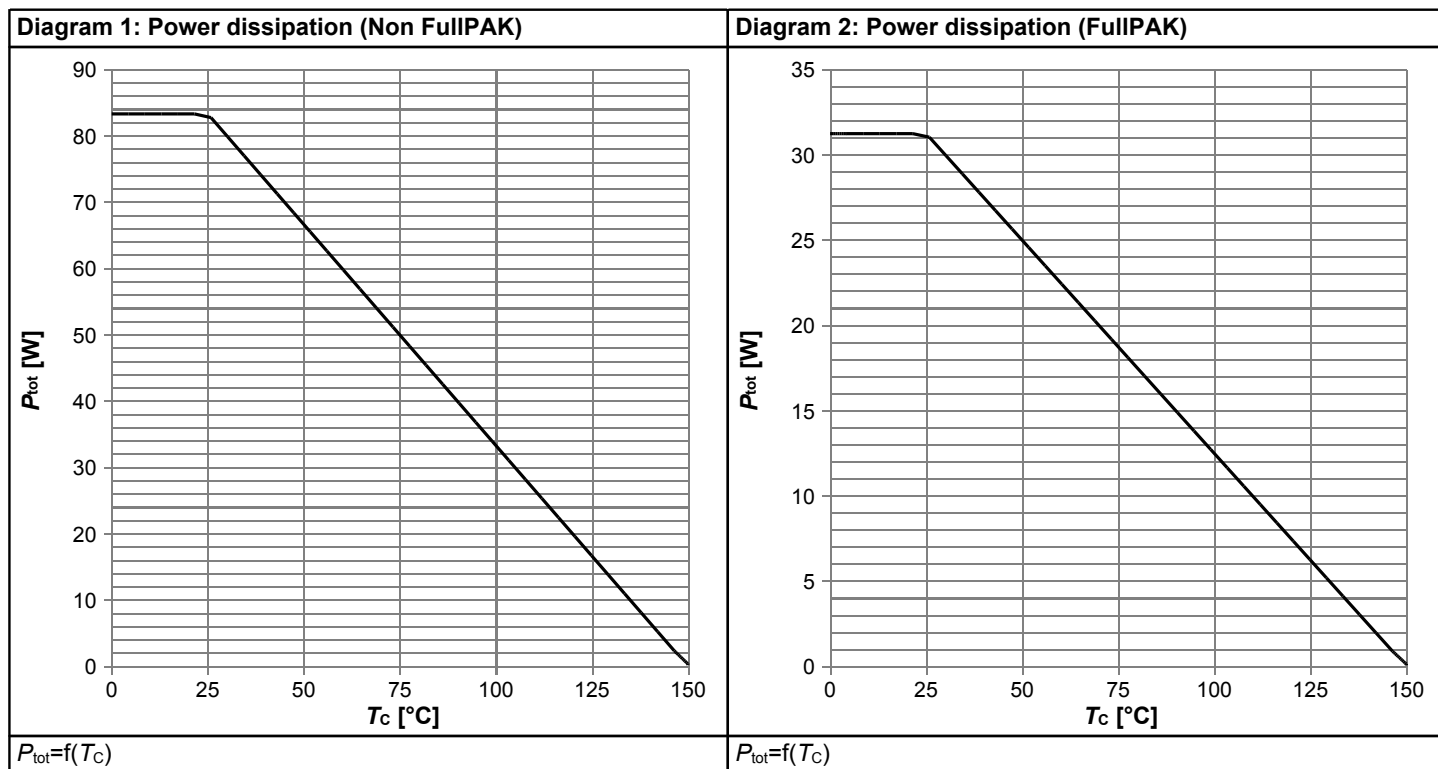
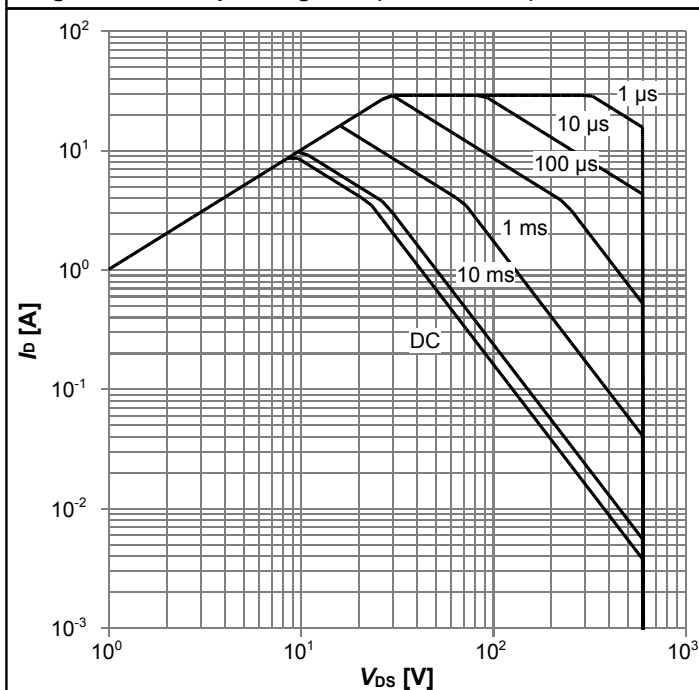
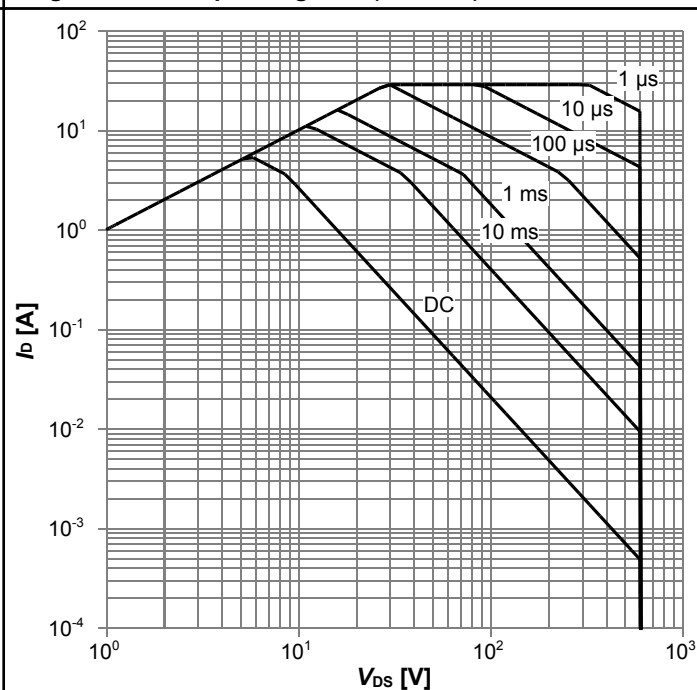


Diagram 5: Safe operating area (Non FullPAK)



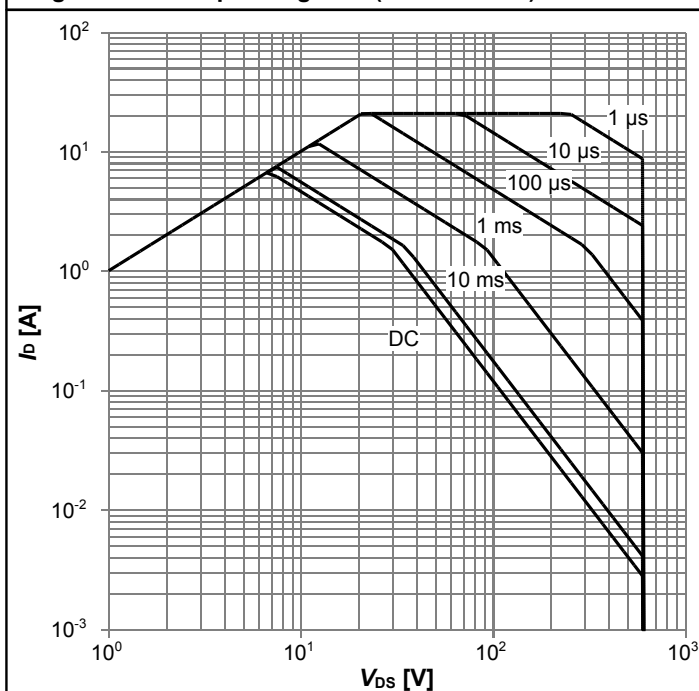
$I_D=f(V_{DS})$; $T_C=25\text{ °C}$; $D=0$; parameter: t_p

Diagram 6: Safe operating area (FullPAK)



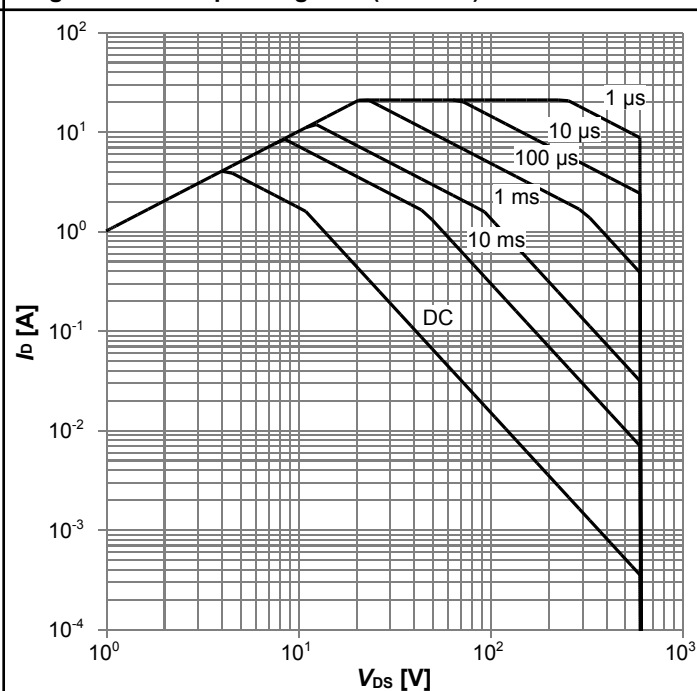
$I_D=f(V_{DS})$; $T_C=25\text{ °C}$; $D=0$; parameter: t_p

Diagram 7: Safe operating area (Non FullPAK)



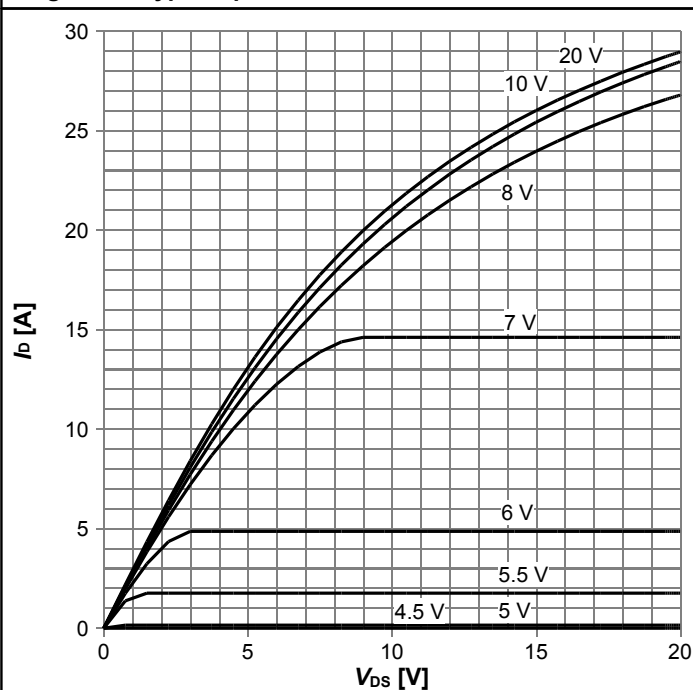
$I_D=f(V_{DS})$; $T_C=80\text{ °C}$; $D=0$; parameter: t_p

Diagram 8: Safe operating area (FullPAK)



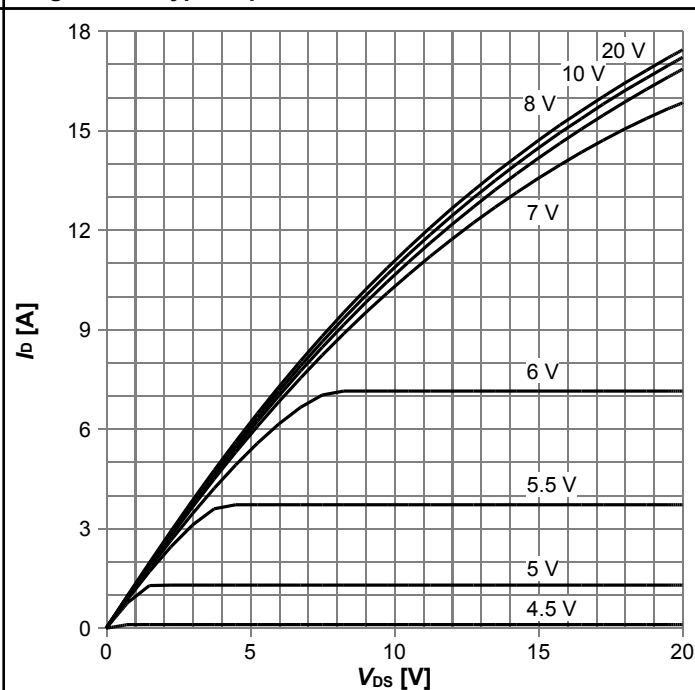
$I_D=f(V_{DS})$; $T_C=80\text{ °C}$; $D=0$; parameter: t_p

Diagram 9: Typ. output characteristics



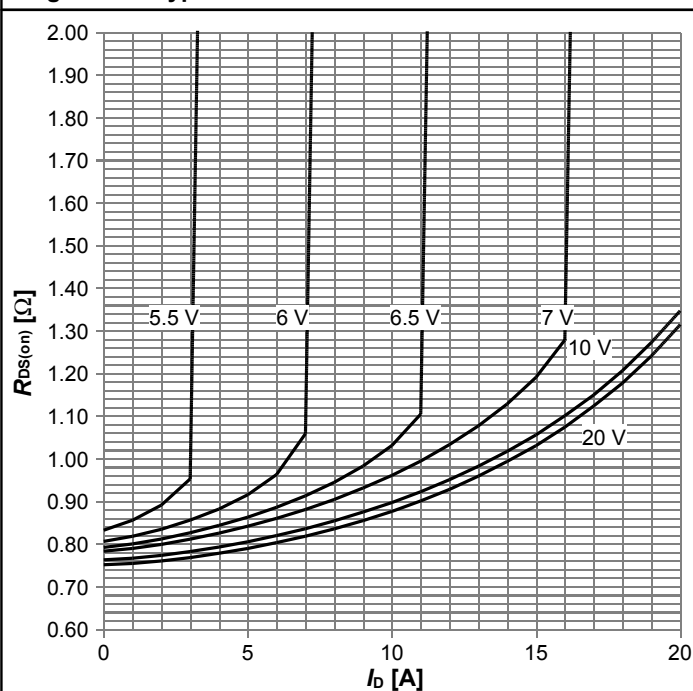
$I_D = f(V_{DS})$; $T_j = 25^\circ\text{C}$; parameter: V_{GS}

Diagram 10: Typ. output characteristics



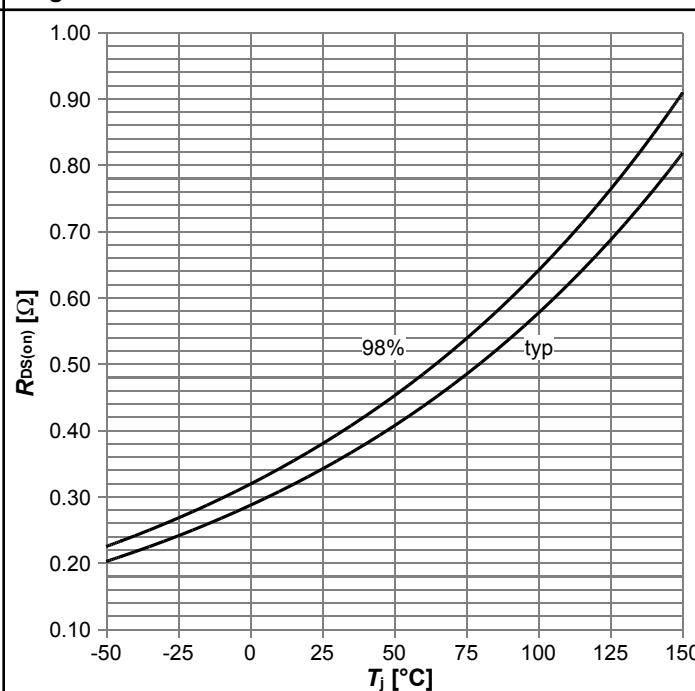
$I_D = f(V_{DS})$; $T_j = 125^\circ\text{C}$; parameter: V_{GS}

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



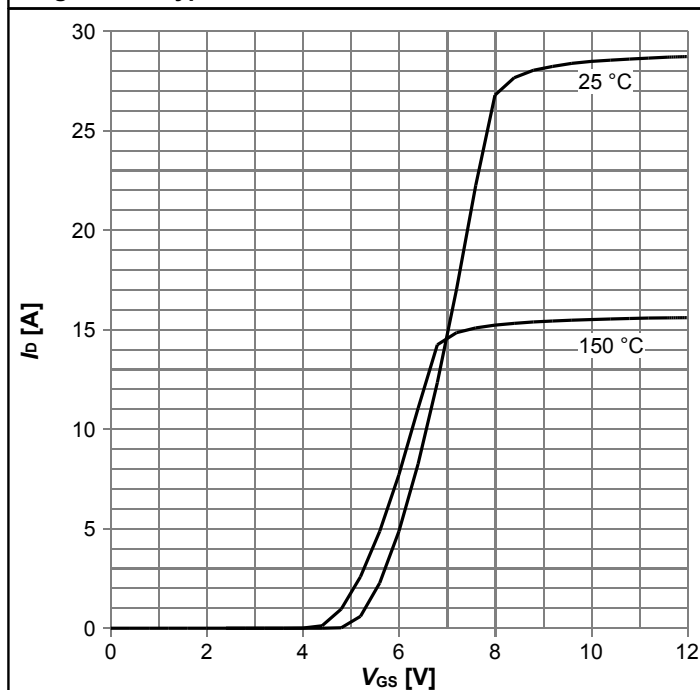
$R_{DS(on)} = f(I_D)$; $T_j = 125^\circ\text{C}$; parameter: V_{GS}

Diagram 12: Drain-source on-state resistance



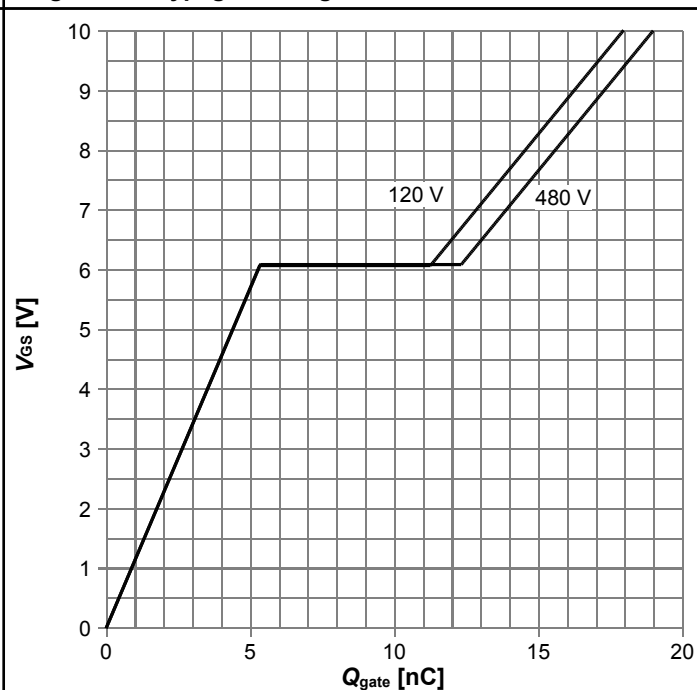
$R_{DS(on)} = f(T_j)$; $I_D = 3.8\text{ A}$; $V_{GS} = 10\text{ V}$

Diagram 13: Typ. transfer characteristics



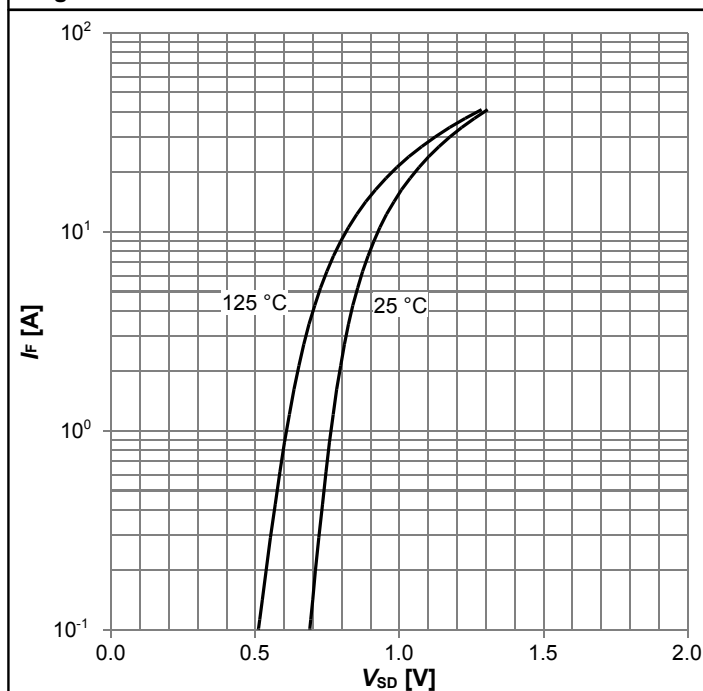
$I_D = f(V_{GS})$; $V_{DS} = 20V$; parameter: T_j

Diagram 14: Typ. gate charge



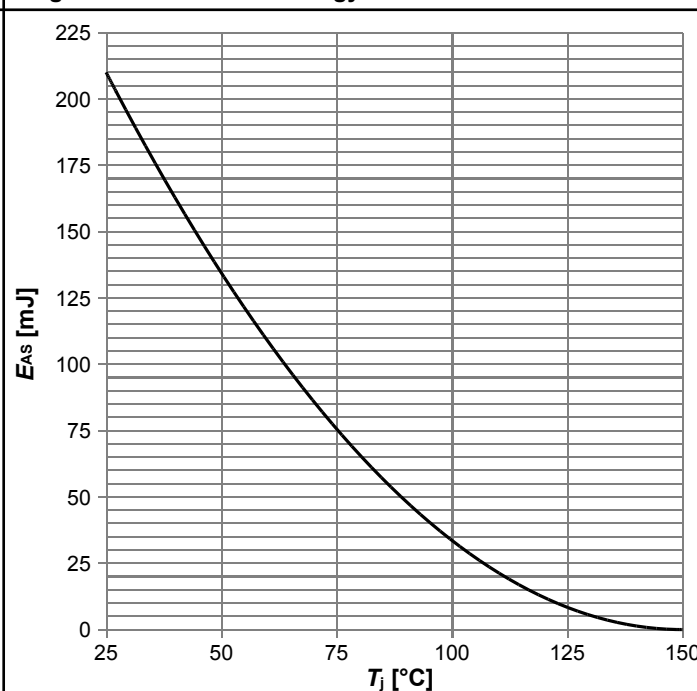
$V_{GS} = f(Q_{gate})$; $I_D = 4.8 A$ pulsed; parameter: V_{DD}

Diagram 15: Forward characteristics of reverse diode



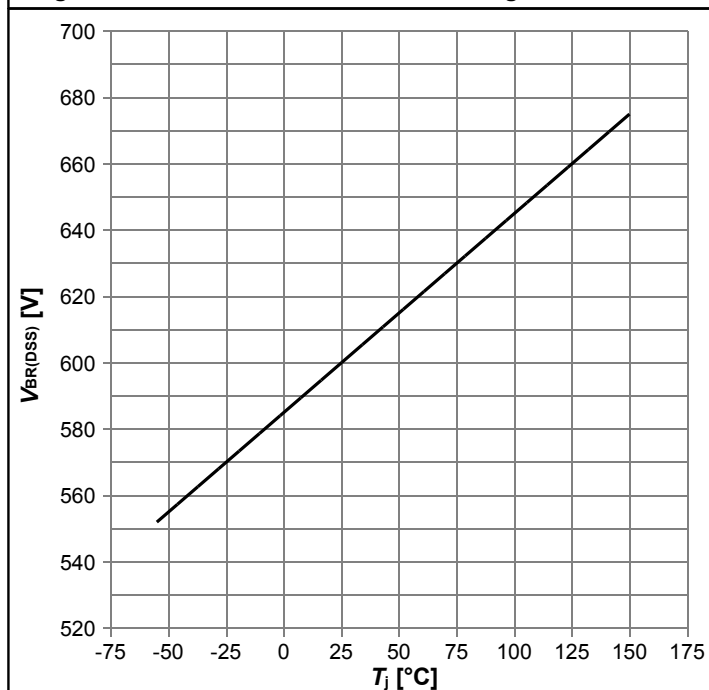
$I_F = f(V_{SD})$; parameter: T_j

Diagram 16: Avalanche energy



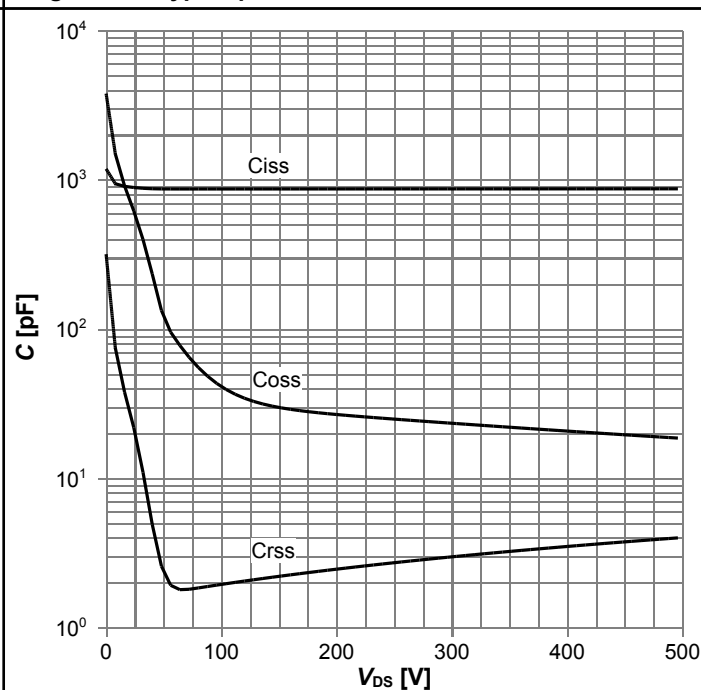
$E_{AS} = f(T_j)$; $I_D = 1.8 A$; $V_{DD} = 50 V$

Diagram 17: Drain-source breakdown voltage



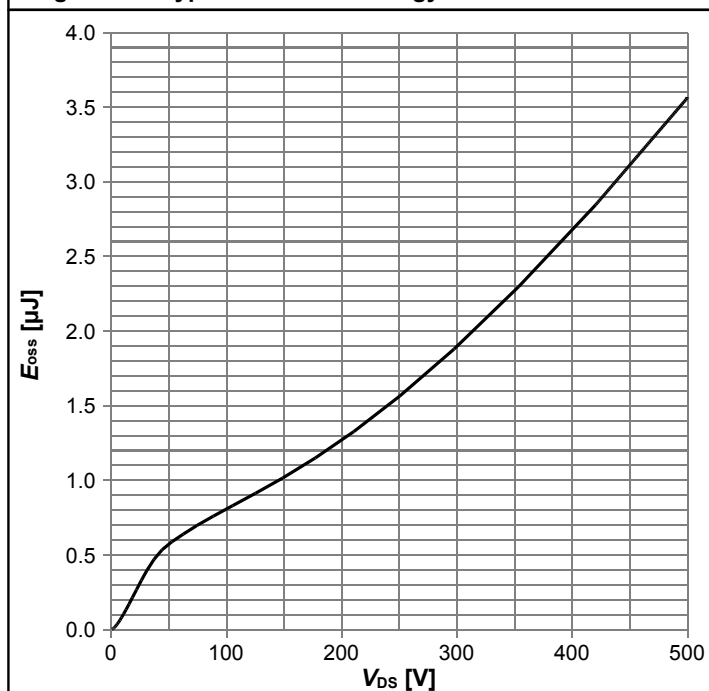
$$V_{BR(DSS)} = f(T_j); I_D = 1 \text{ mA}$$

Diagram 18: Typ. capacitances



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

Diagram 19: Typ. Coss stored energy



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

6 Test Circuits

Table 10 Diode characteristics

Test circuit for diode characteristics $R_{g1} = R_{g2}$	Diode recovery waveform $t_{rr} = t_F + t_S$ $Q_{rr} = Q_F + Q_S$
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Table 11 Switching times

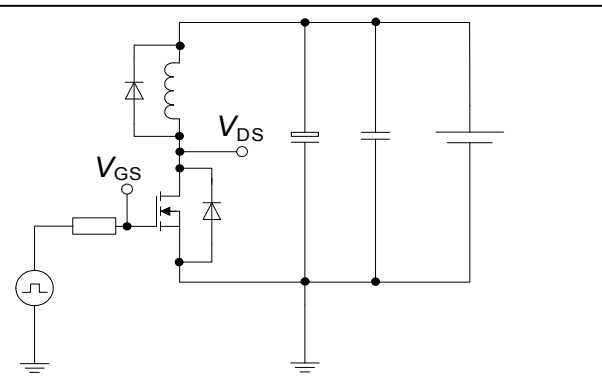
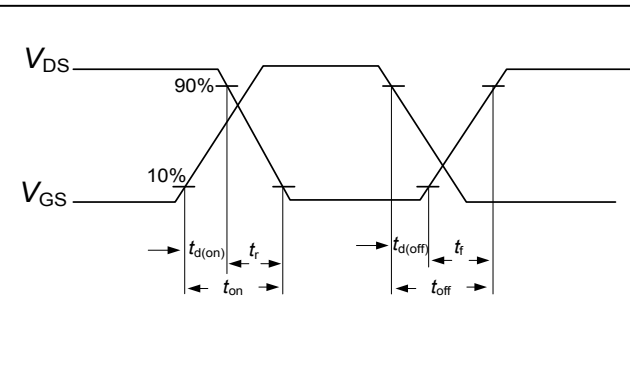
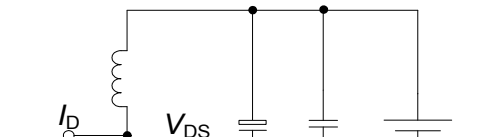
Switching times test circuit for inductive load	Switching times waveform
 The circuit diagram illustrates a MOSFET switching an inductive load. A pulse generator is connected to the gate of the MOSFET through a resistor, with the gate voltage labeled V_{GS}. The MOSFET's drain is connected to an inductive load (represented by an inductor and a diode in parallel) and a DC voltage source. The drain voltage V_{DS} is measured across the load. The load is connected to ground.	 The timing diagram shows the switching waveforms for V_{DS} and V_{GS}. The gate voltage V_{GS} transitions from a low level to a high level (turn-on) and back to low (turn-off). The drain voltage V_{DS} transitions from a high level to a low level (turn-on) and back to high (turn-off). The diagram defines the following switching times: $t_{d(on)}$: Delay time from the start of V_{GS} rise to 10% of V_{GS} to the start of V_{DS} fall. t_r: Rise time of V_{GS} from 10% to 90%. t_{on}: Total turn-on time from the start of V_{GS} rise to the start of V_{DS} fall. $t_{d(off)}$: Delay time from the start of V_{GS} fall to 10% of V_{GS} to the start of V_{DS} rise. t_f: Fall time of V_{GS} from 90% to 10%. t_{off}: Total turn-off time from the start of V_{GS} fall to the start of V_{DS} rise.

Table 12 Unclamped inductive load

Unclamped inductive load test circuit	Unclamped inductive waveform
	

7 Package Outlines

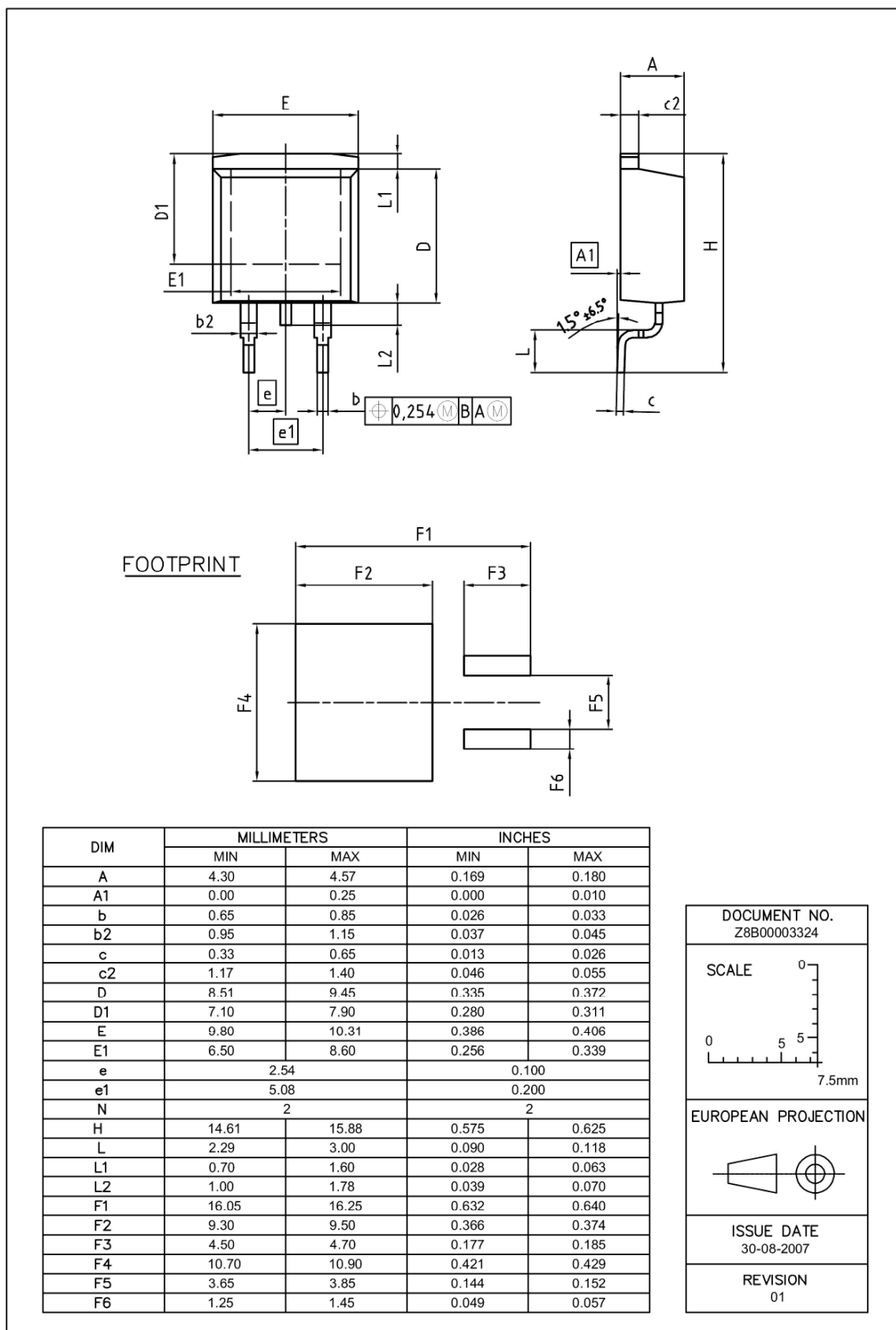


Figure 1 Outline PG-TO 263, dimensions in mm/inches

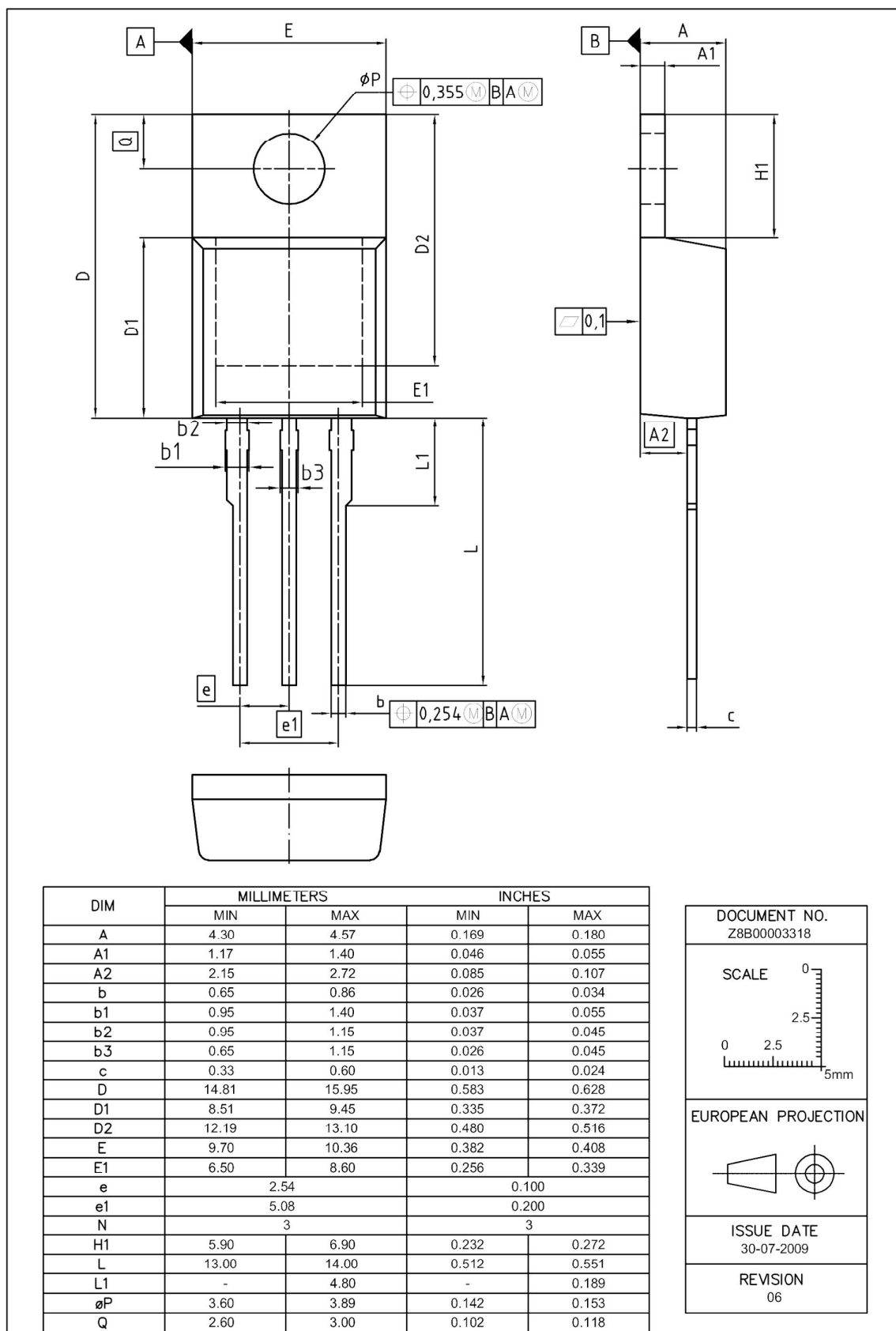
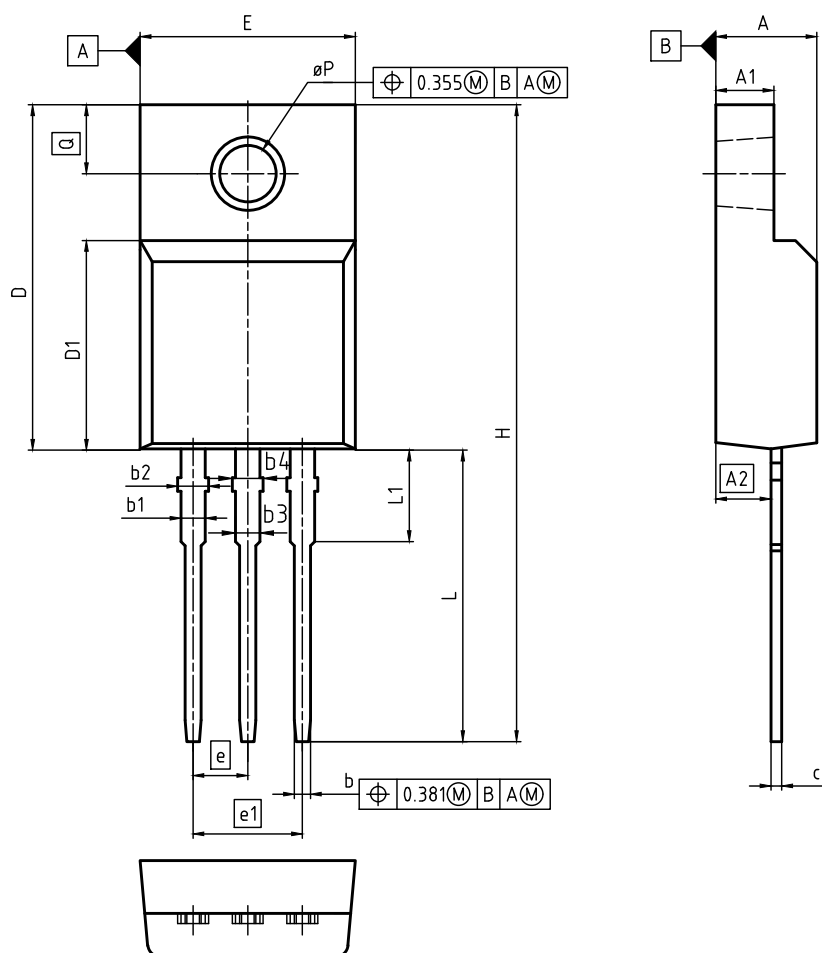


Figure 2 Outline PG-TO 220, dimensions in mm/inches



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.50	4.90	0.177	0.193
A1	2.34	2.85	0.092	0.112
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	0.95	1.51	0.037	0.059
b3	0.65	1.38	0.026	0.054
b4	0.65	1.51	0.026	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	2.95	3.38	0.116	0.133
Q	3.15	3.50	0.124	0.138

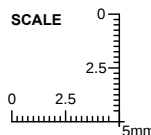
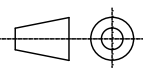
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ISSUE DATE 05-05-2014
REVISION 04

Figure 3 Outline PG-TO 220 FullIPAK, dimensions in mm/inches

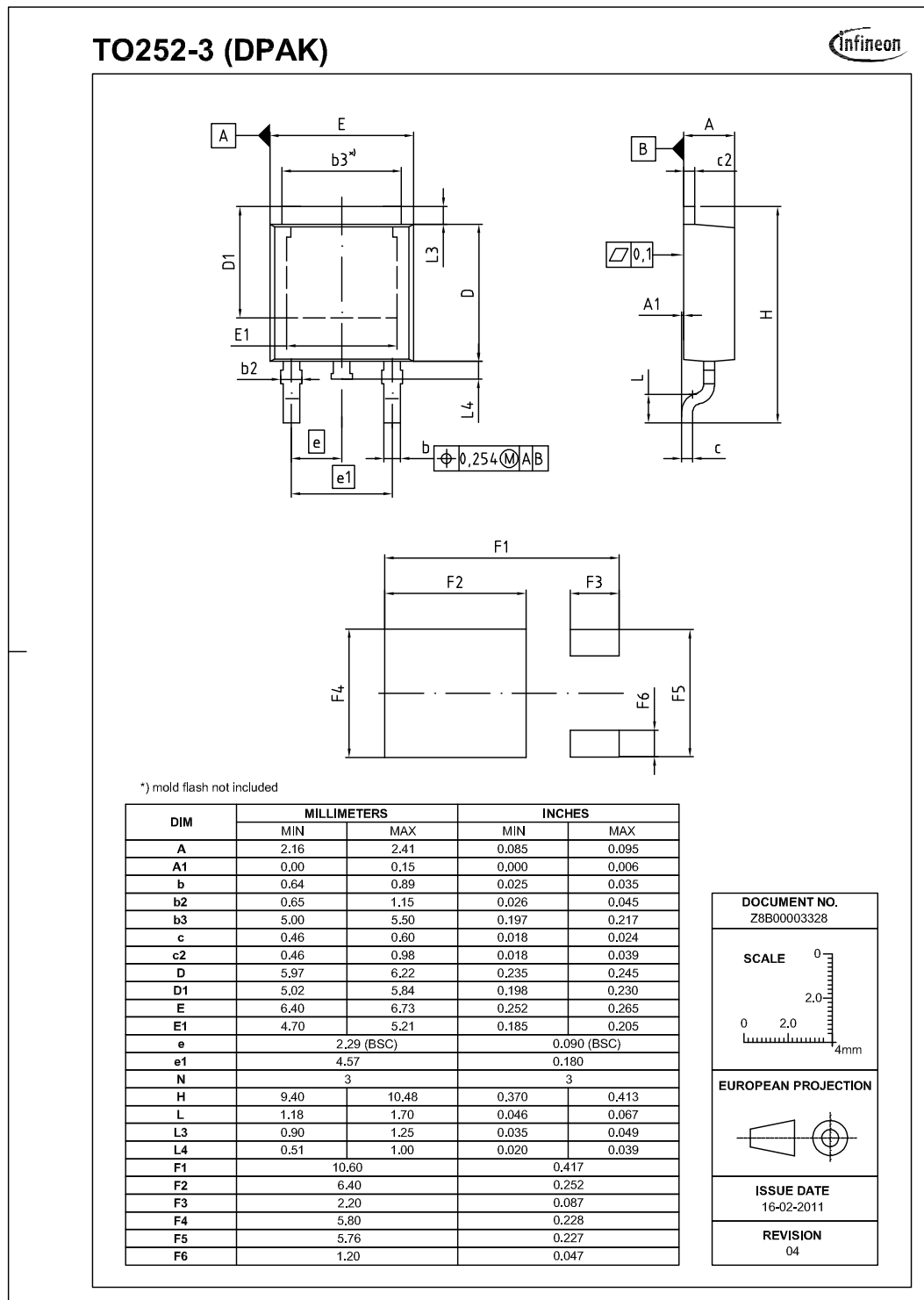


Figure 4 Outline PG-TO 252, dimensions in mm/inches

8 Appendix A

Table 13 Related Links

- IFX CoolMOS™ P6 Webpage: www.infineon.com
- IFX CoolMOS™ P6 application note: www.infineon.com
- IFX CoolMOS™ P6 simulation model: www.infineon.com
- IFX Design tools: www.infineon.com

Revision History

IPB60R380P6, IPP60R380P6, IPA60R380P6, IPD60R380P6

Revision: 2015-07-10, Rev. 2.2

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.0	2013-12-05	Release of final version
2.1	2013-12-05	Release of multi-package datasheet
2.2	2015-07-10	PG-TO 263 package added

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The Infineon Technologies component described in this Data Sheet may be used in life-support devices or systems and/or automotive, aviation and aerospace applications or systems only with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support, automotive, aviation and aerospace device or system or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.

Компания «Life Electronics» занимается поставками электронных компонентов импортного и отечественного производства от производителей и со складов крупных дистрибьюторов Европы, Америки и Азии.

С конца 2013 года компания активно расширяет линейку поставок компонентов по направлению коаксиальный кабель, кварцевые генераторы и конденсаторы (керамические, пленочные, электролитические), за счёт заключения дистрибьюторских договоров

Мы предлагаем:

- Конкурентоспособные цены и скидки постоянным клиентам.
- Специальные условия для постоянных клиентов.
- Подбор аналогов.
- Поставку компонентов в любых объемах, удовлетворяющих вашим потребностям.
- Приемлемые сроки поставки, возможна ускоренная поставка.
- Доставку товара в любую точку России и стран СНГ.
- Комплексную поставку.
- Работу по проектам и поставку образцов.
- Формирование склада под заказчика.
- Сертификаты соответствия на поставляемую продукцию (по желанию клиента).
- Тестирование поставляемой продукции.
- Поставку компонентов, требующих военную и космическую приемку.
- Входной контроль качества.
- Наличие сертификата ISO.

В составе нашей компании организован Конструкторский отдел, призванный помогать разработчикам, и инженерам.

Конструкторский отдел помогает осуществить:

- Регистрацию проекта у производителя компонентов.
- Техническую поддержку проекта.
- Защиту от снятия компонента с производства.
- Оценку стоимости проекта по компонентам.
- Изготовление тестовой платы монтаж и пусконаладочные работы.



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