

MOSFET

Metal Oxide Semiconductor Field Effect Transistor

CoolMOS™ P6

600V CoolMOS™ P6 Power Transistor
IPx60R160P6

Data Sheet

Rev. 2.1
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.

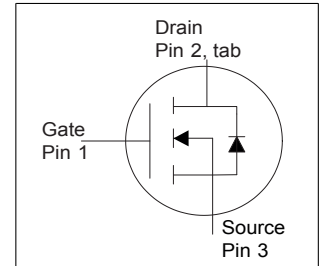
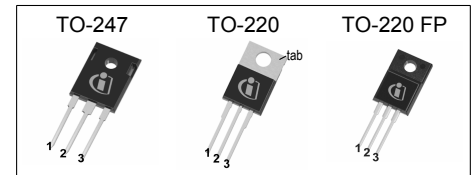


Table 1 Key Performance Parameters

Parameter	Value	Unit
$V_{DS} @ T_{j,max}$	650	V
$R_{DS(on),max}$	160	$m\Omega$
$Q_{g,typ}$	44	nC
$I_{D,pulse}$	68	A
$E_{oss@400V}$	5.7	μJ
Body diode di/dt	500	A/ μs

Type / Ordering Code	Package	Marking	Related Links
IPW60R160P6	PG-TO 247	6R160P6	see Appendix A
IPP60R160P6	PG-TO 220		
IPA60R160P6	PG-TO 220 FullPAK		

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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	-	-	23.8 15.0	A	$T_C=25^\circ\text{C}$ $T_C=100^\circ\text{C}$
Pulsed drain current ²⁾	$I_{D,pulse}$	-	-	68	A	$T_C=25^\circ\text{C}$
Avalanche energy, single pulse	E_{AS}	-	-	497	mJ	$I_D=4.1\text{A}$; $V_{DD}=50\text{V}$; see table 10
Avalanche energy, repetitive	E_{AR}	-	-	0.75	mJ	$I_D=4.1\text{A}$; $V_{DD}=50\text{V}$; see table 10
Avalanche current, repetitive	I_{AR}	-	-	4.1	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 Hz)
Power dissipation (Non FullPAK) TO-220, TO-247	P_{tot}	-	-	176	W	$T_C=25^\circ\text{C}$
Power dissipation (FullPAK) TO-220FP	P_{tot}	-	-	34	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, TO-247	-	-	-	60	Ncm	M3 and M3.5 screws
Mounting torque (FullPAK) TO-220FP	-	-	-	50	Ncm	M2.5 screws
Continuous diode forward current	I_S	-	-	20.6	A	$T_C=25^\circ\text{C}$
Diode pulse current ²⁾	$I_{S,pulse}$	-	-	68	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 8
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 8
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, TO-247

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}	-	-	0.71	°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}	-	-	3.67	°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

4 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	$V_{GS}=0V$, $I_D=1mA$
Gate threshold voltage	$V_{(GS)th}$	3.5	4.0	4.5	V	$V_{DS}=V_{GS}$, $I_D=0.75mA$
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	$R_{DS(on)}$	-	0.144 0.374	0.160 -	Ω	$V_{GS}=10V$, $I_D=9A$, $T_j=25^\circ\text{C}$ $V_{GS}=10V$, $I_D=9A$, $T_j=150^\circ\text{C}$
Gate resistance	R_G	-	1.6	-	Ω	$f=1MHz$, open drain

Table 6 Dynamic characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	C_{iss}	-	2080	-	pF	$V_{GS}=0V$, $V_{DS}=100V$, $f=1MHz$
Output capacitance	C_{oss}	-	89	-	pF	$V_{GS}=0V$, $V_{DS}=100V$, $f=1MHz$
Effective output capacitance, energy related ¹⁾	$C_{o(er)}$	-	72	-	pF	$V_{GS}=0V$, $V_{DS}=0...400V$
Effective output capacitance, time related ²⁾	$C_{o(tr)}$	-	313	-	pF	$I_D=\text{constant}$, $V_{GS}=0V$, $V_{DS}=0...400V$
Turn-on delay time	$t_{d(on)}$	-	12.5	-	ns	$V_{DD}=400V$, $V_{GS}=13V$, $I_D=11.3A$, $R_G=1.7\Omega$; see table 9
Rise time	t_r	-	7.6	-	ns	$V_{DD}=400V$, $V_{GS}=13V$, $I_D=11.3A$, $R_G=1.7\Omega$; see table 9
Turn-off delay time	$t_{d(off)}$	-	40	-	ns	$V_{DD}=400V$, $V_{GS}=13V$, $I_D=11.3A$, $R_G=1.7\Omega$; see table 9
Fall time	t_f	-	5.8	-	ns	$V_{DD}=400V$, $V_{GS}=13V$, $I_D=11.3A$, $R_G=1.7\Omega$; see table 9

Table 7 Gate charge characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate to source charge	Q_{gs}	-	13	-	nC	$V_{DD}=400V$, $I_D=11.3A$, $V_{GS}=0$ to $10V$
Gate to drain charge	Q_{gd}	-	15	-	nC	$V_{DD}=400V$, $I_D=11.3A$, $V_{GS}=0$ to $10V$
Gate charge total	Q_g	-	44	-	nC	$V_{DD}=400V$, $I_D=11.3A$, $V_{GS}=0$ to $10V$
Gate plateau voltage	$V_{plateau}$	-	6.1	-	V	$V_{DD}=400V$, $I_D=11.3A$, $V_{GS}=0$ 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 8 Reverse diode characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Diode forward voltage	V_{SD}	-	0.9	-	V	$V_{GS}=0V$, $I_F=11.3A$, $T_j=25^{\circ}C$
Reverse recovery time	t_{rr}	-	350	-	ns	$V_R=400V$, $I_F=11.3A$, $di_F/dt=100A/\mu s$; see table 8
Reverse recovery charge	Q_{rr}	-	5.3	-	μC	$V_R=400V$, $I_F=11.3A$, $di_F/dt=100A/\mu s$; see table 8
Peak reverse recovery current	I_{rrm}	-	28	-	A	$V_R=400V$, $I_F=11.3A$, $di_F/dt=100A/\mu s$; see table 8

5 Electrical characteristics diagrams

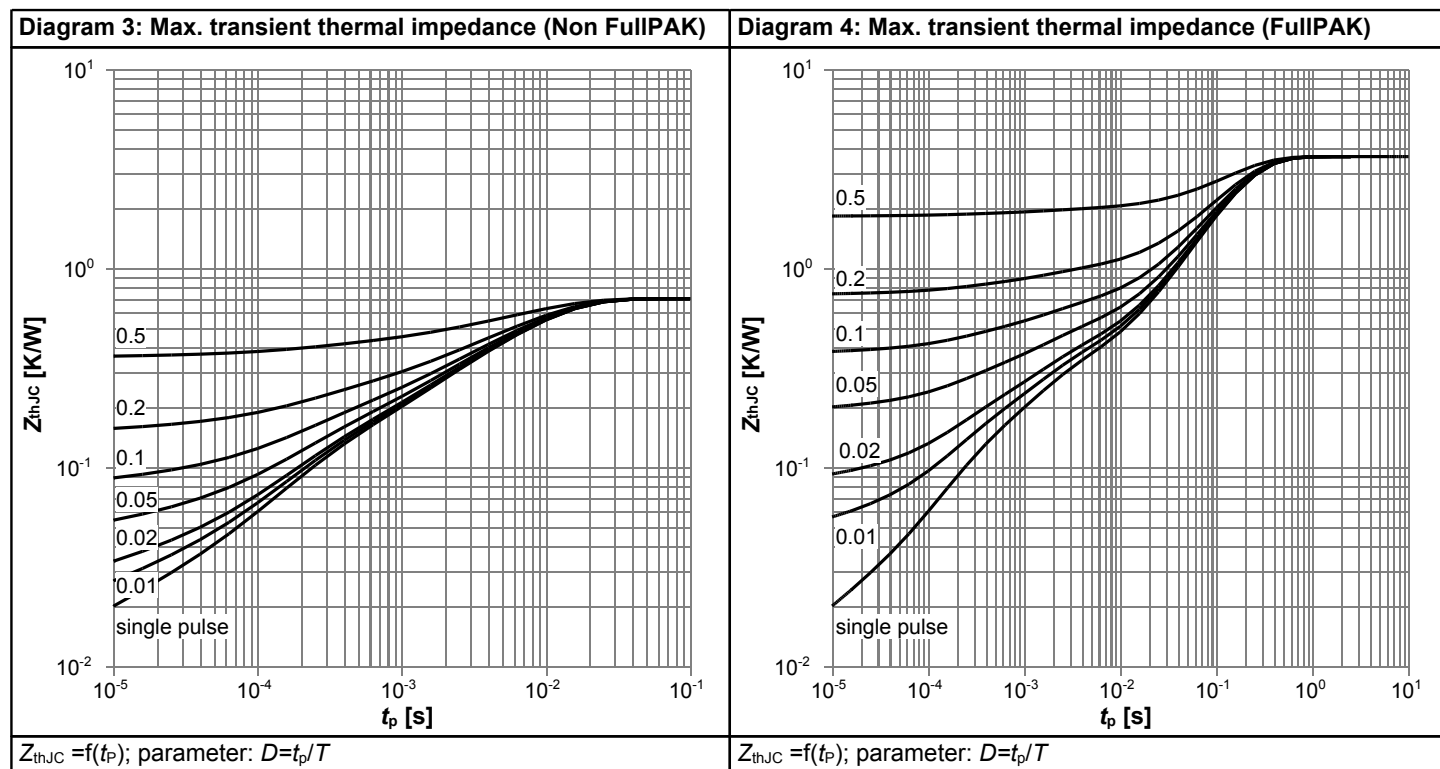
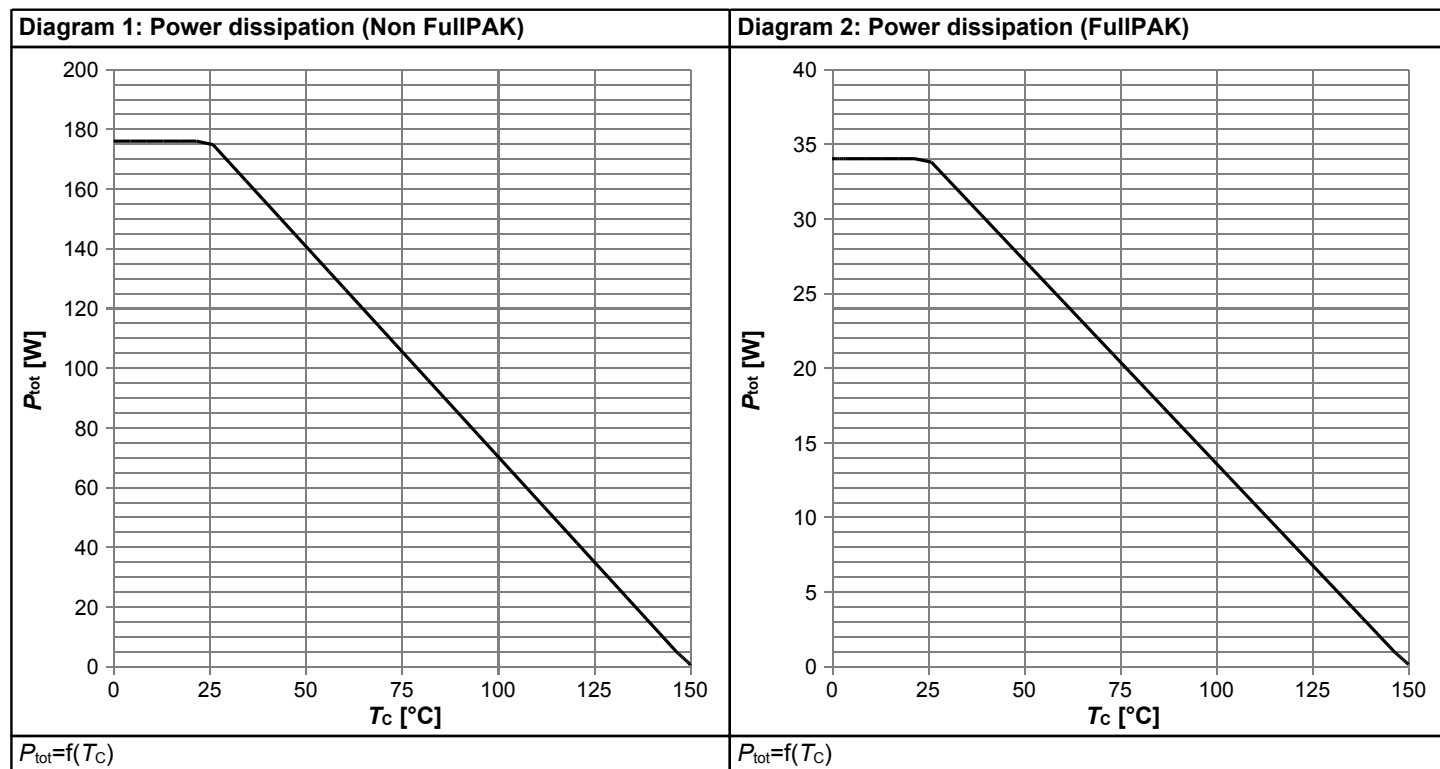
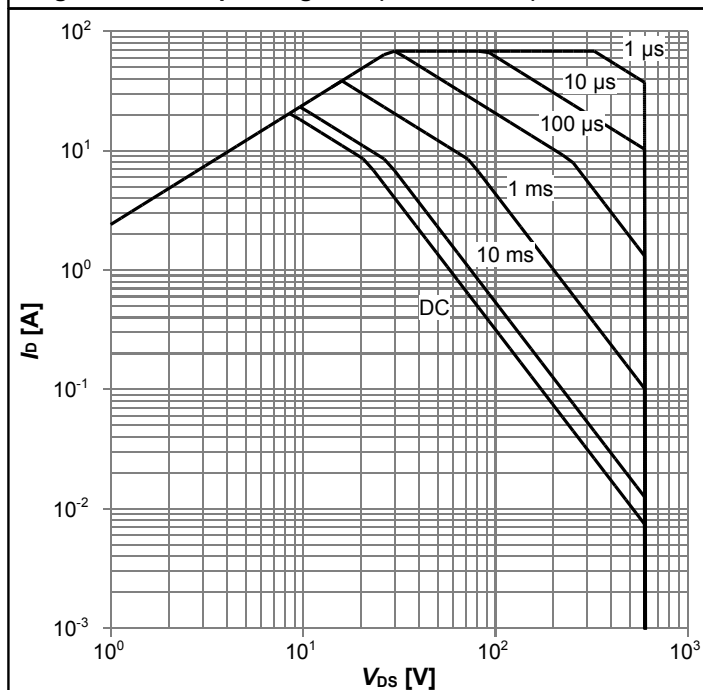
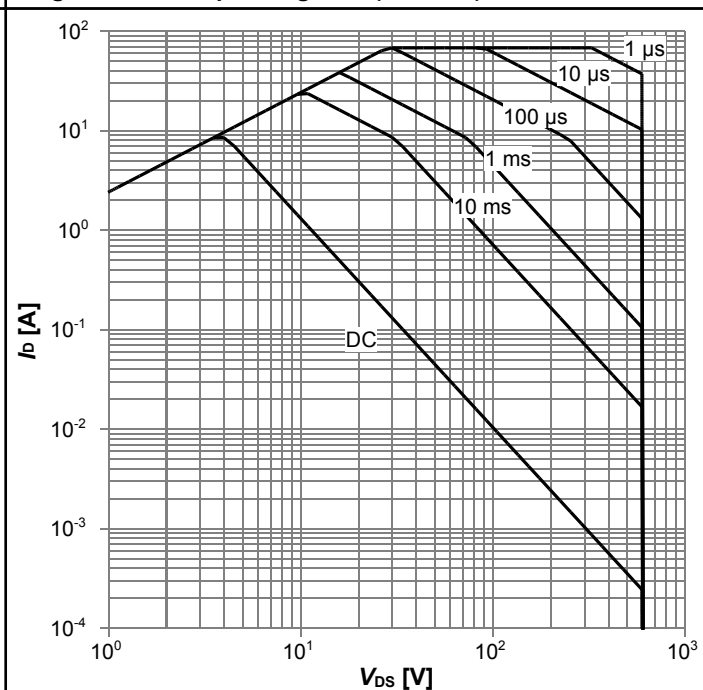


Diagram 5: Safe operating area (Non FullPAK)



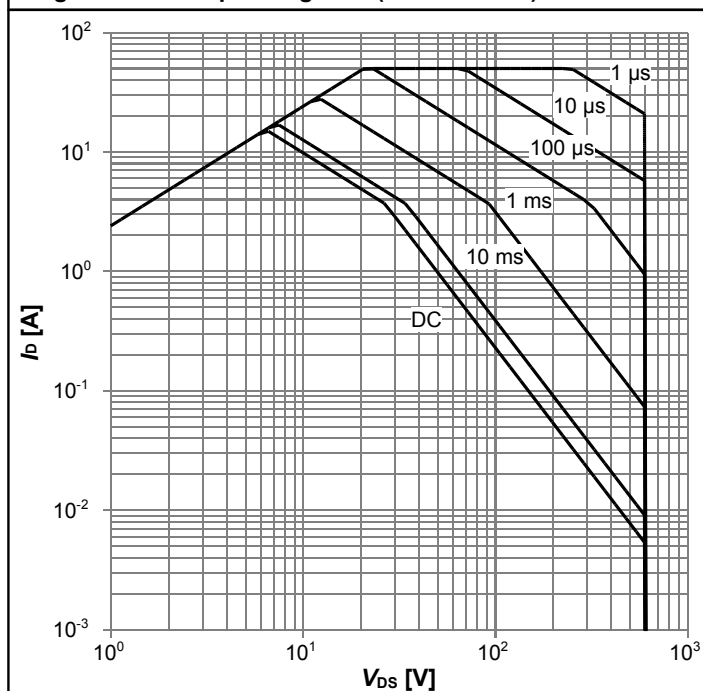
$I_D=f(V_{DS})$; $T_C=25\text{ °C}$; $D=0$; parameter: t_p

Diagram 6: Safe operating area (FullPAK)



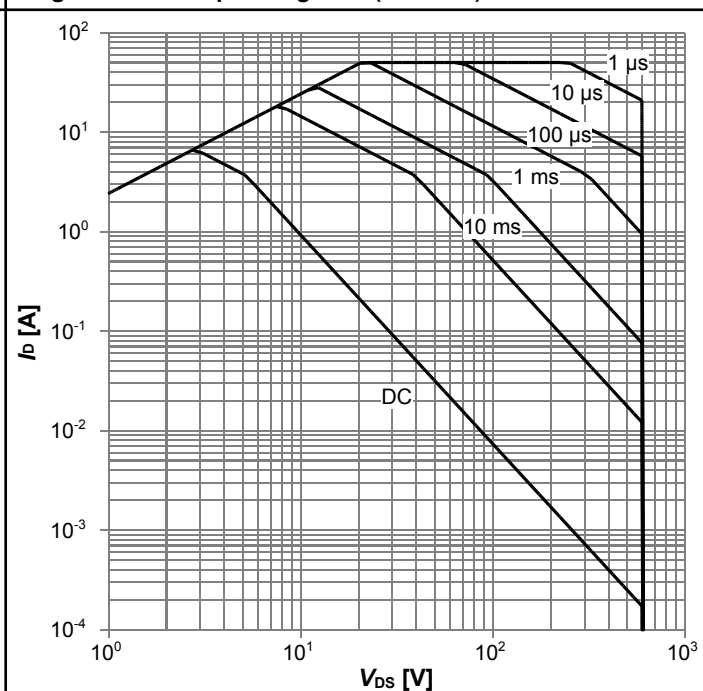
$I_D=f(V_{DS})$; $T_C=25\text{ °C}$; $D=0$; parameter: t_p

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

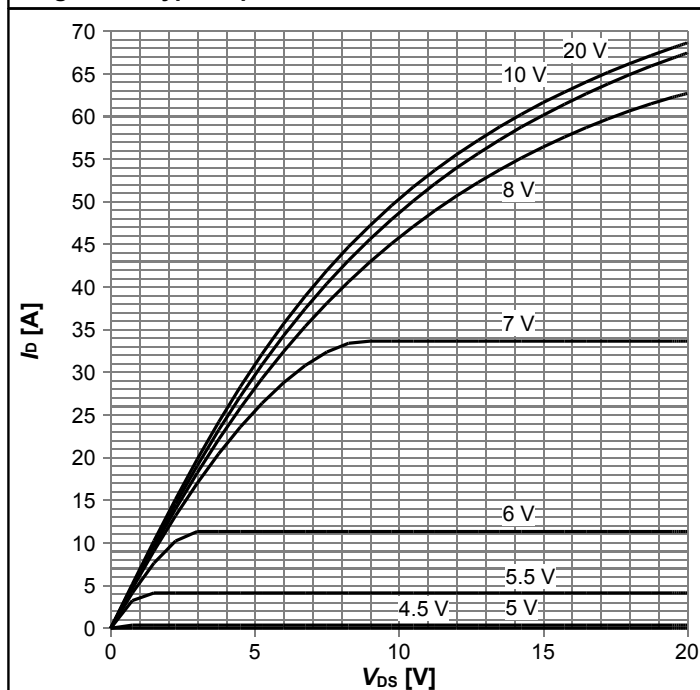

 $I_D = f(V_{DS}); T_J = 25^\circ\text{C}; \text{parameter: } V_{GS}$

Diagram 10: Typ. output characteristics

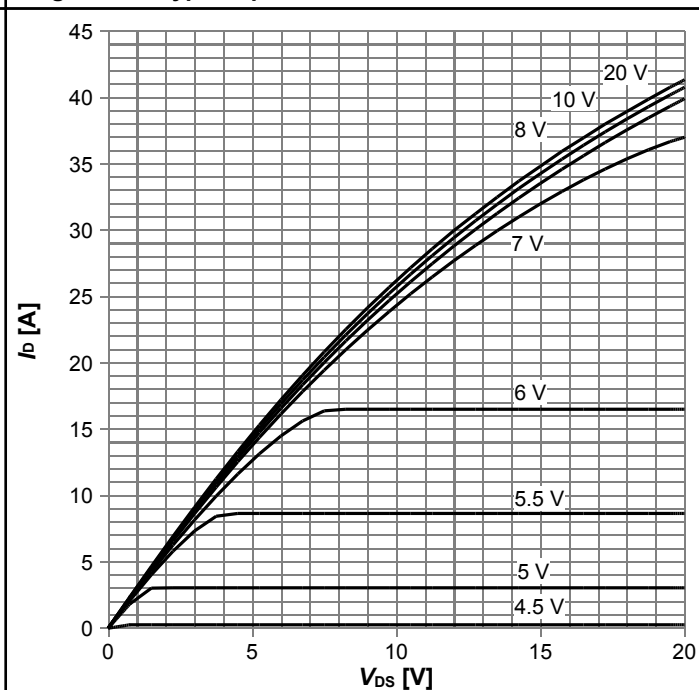

 $I_D = f(V_{DS}); T_J = 125^\circ\text{C}; \text{parameter: } V_{GS}$

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

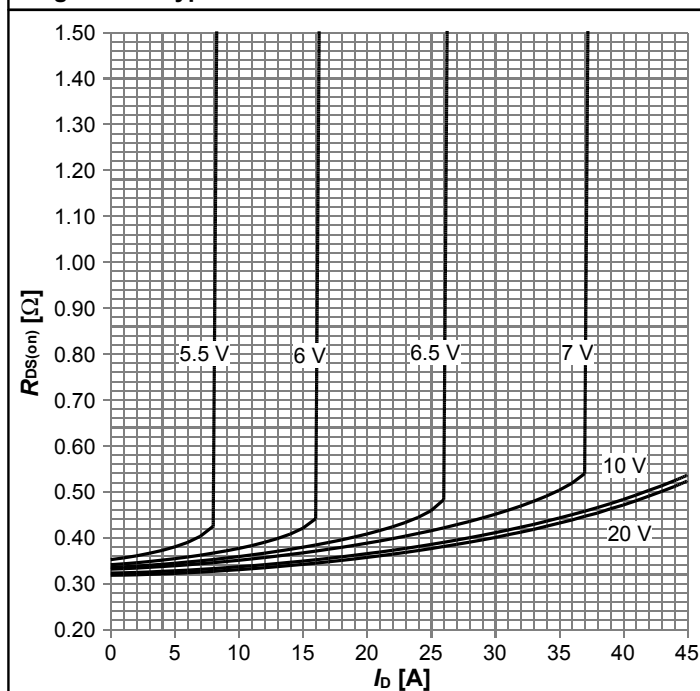

 $R_{DS(on)} = f(I_D); T_J = 125^\circ\text{C}; \text{parameter: } V_{GS}$

Diagram 12: Drain-source on-state resistance

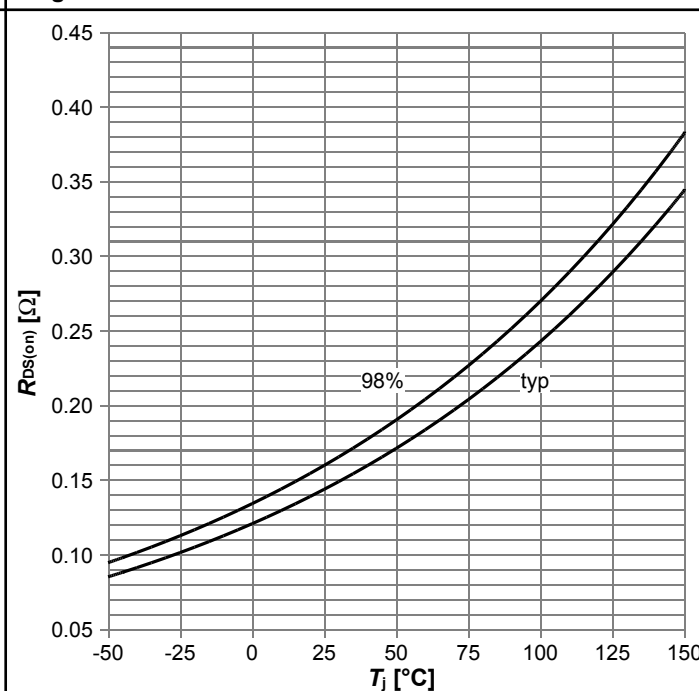
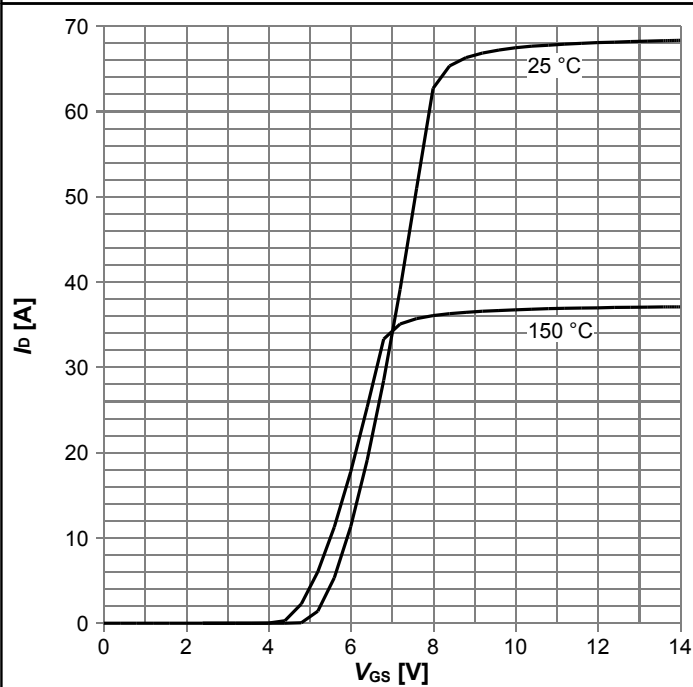
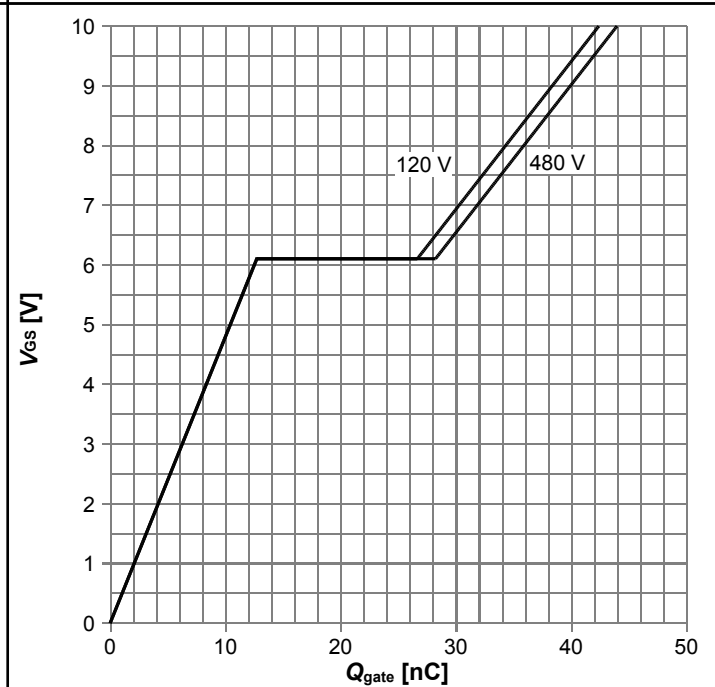

 $R_{DS(on)} = f(T_J); I_D = 9.0\text{ A}; V_{GS} = 10\text{ V}$

Diagram 13: Typ. transfer characteristics



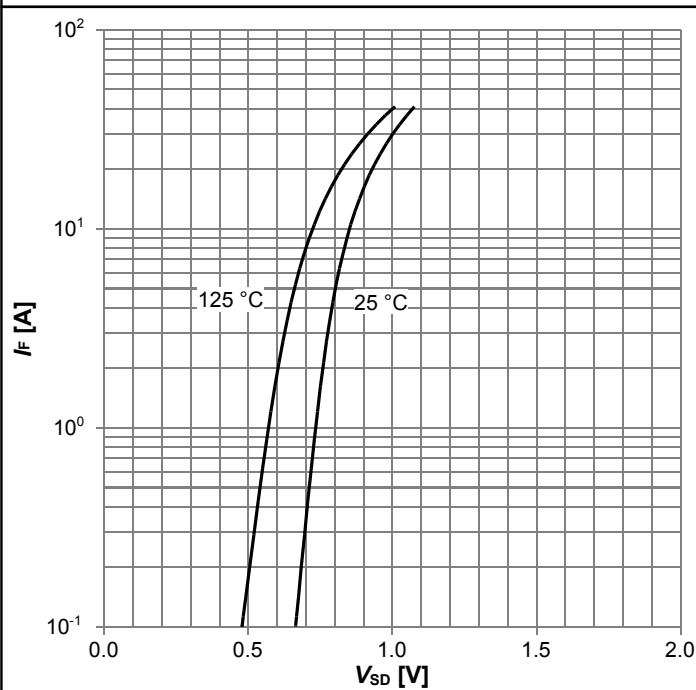
$I_D = f(V_{GS})$; $V_{DS} = 20V$; parameter: T_j

Diagram 14: Typ. gate charge



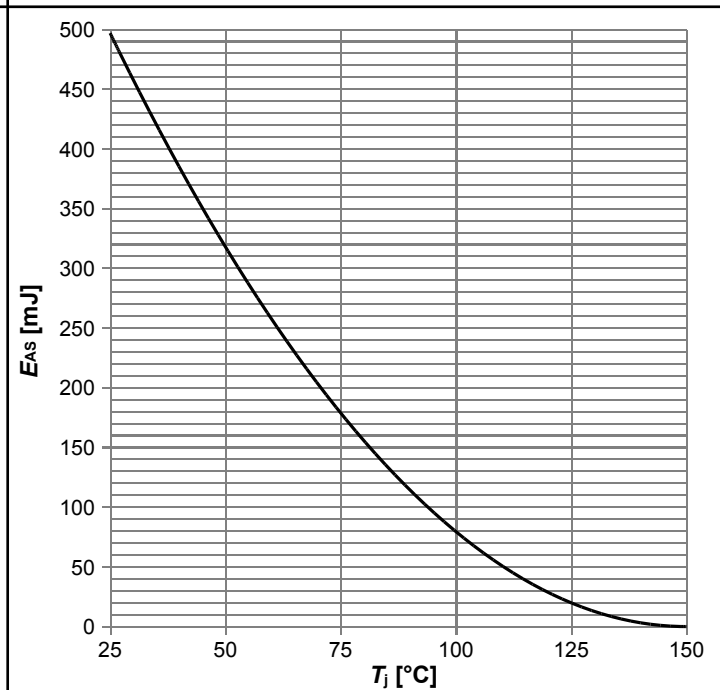
$V_{GS} = f(Q_{gate})$; $I_D = 11.3 A$ pulsed; parameter: V_{DD}

Diagram 15: Forward characteristics of reverse diode



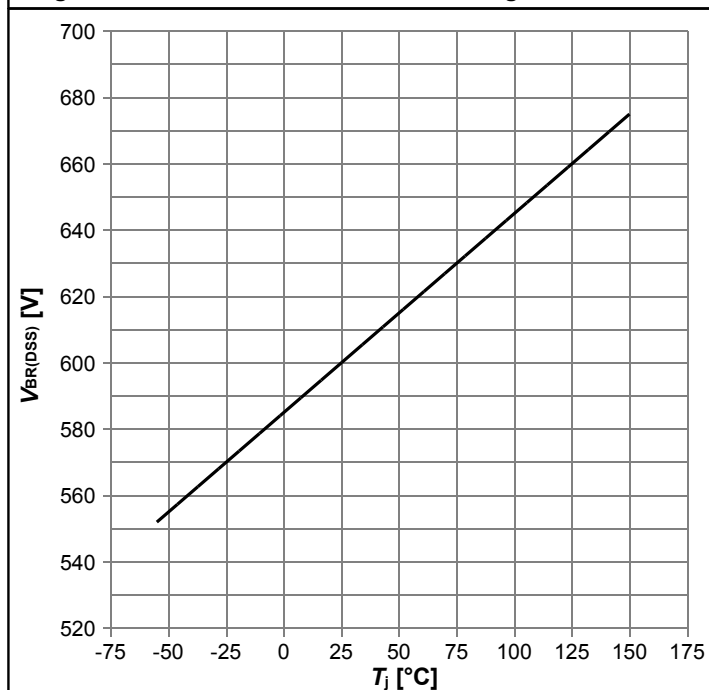
$I_F = f(V_{SD})$; parameter: T_j

Diagram 16: Avalanche energy



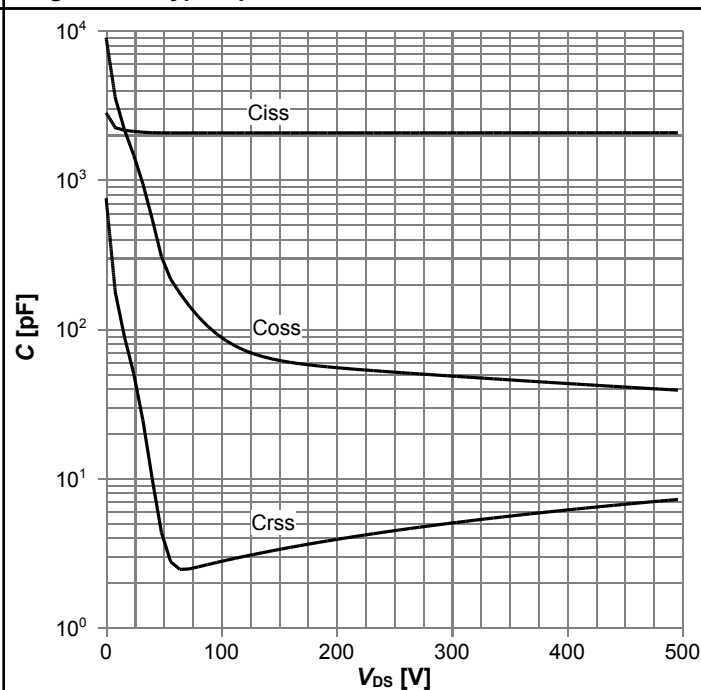
$E_{AS} = f(T_j)$; $I_D = 4.1 A$; $V_{DD} = 50 V$

Diagram 17: Drain-source breakdown voltage



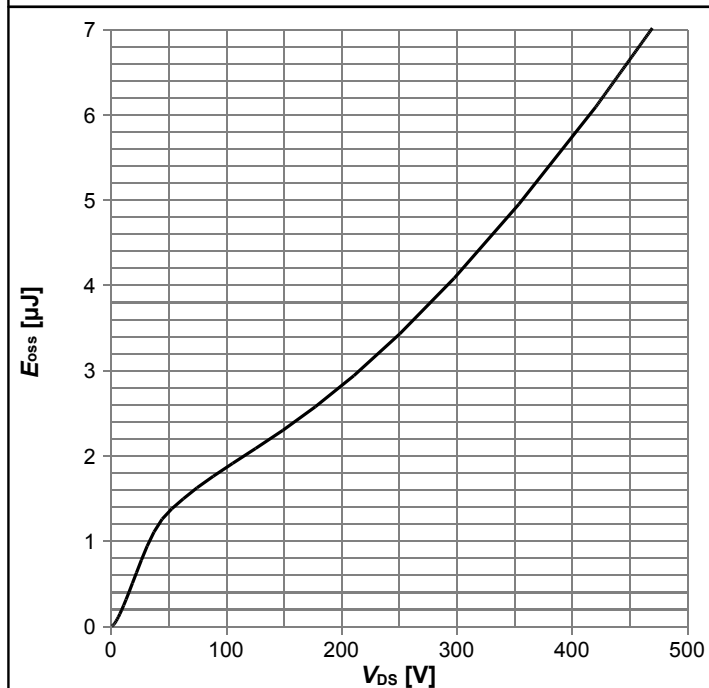
$$V_{BR(DSS)} = f(T_j); I_D = 1 \text{ mA}$$

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 9 Diode characteristics

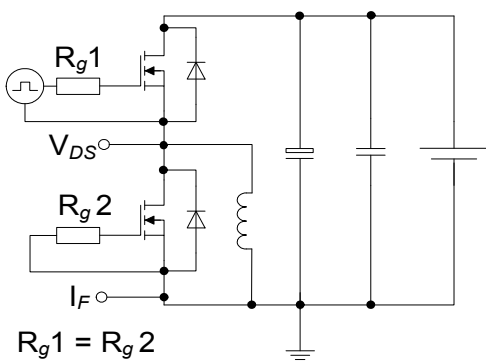
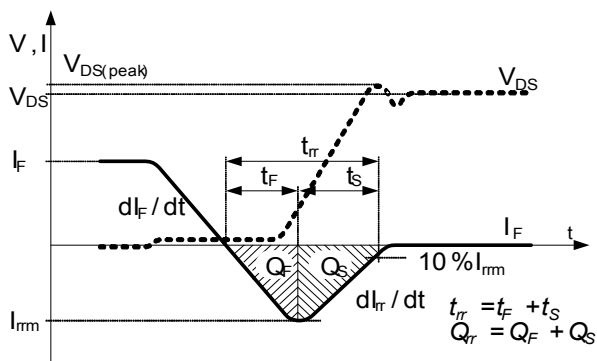
Test circuit for diode characteristics	Diode recovery waveform
 $R_{g1} = R_{g2}$	 $t_{rr} = t_{fr} + t_{tr}$ $Q_{rr} = Q_F + Q_S$

Table 10 Switching times

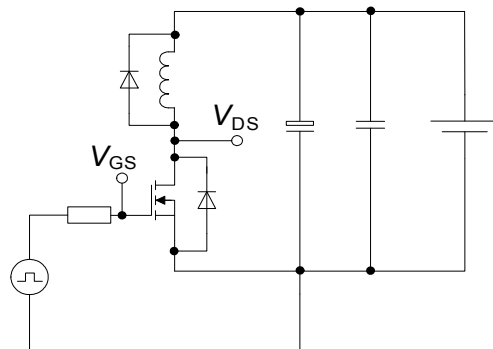
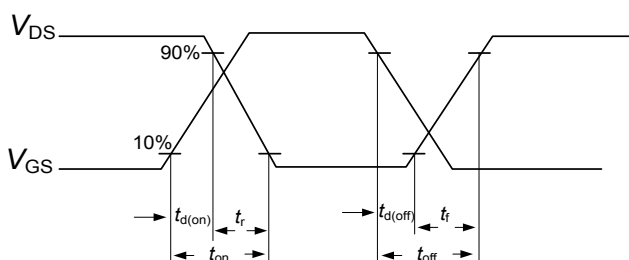
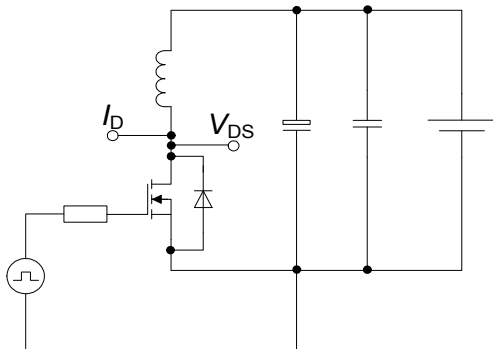
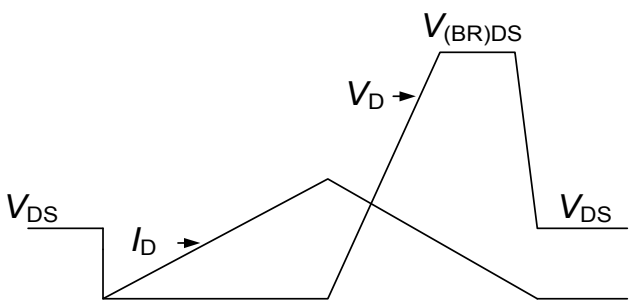
Switching times test circuit for inductive load	Switching times waveform
	

Table 11 Unclamped inductive load

Unclamped inductive load test circuit	Unclamped inductive waveform
	

7 Package Outlines

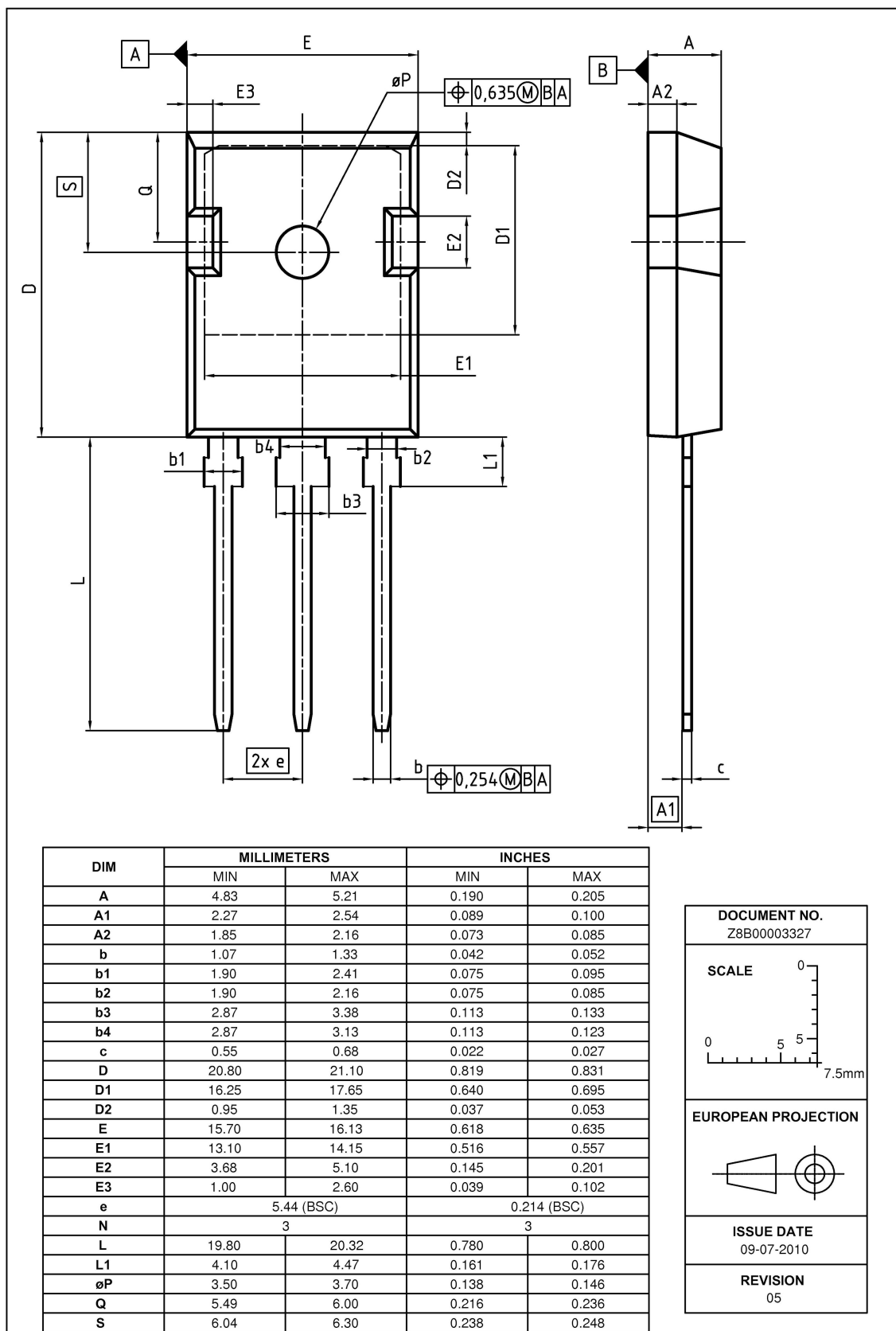


Figure 1 Outline PG-TO 247, dimensions in mm/inches

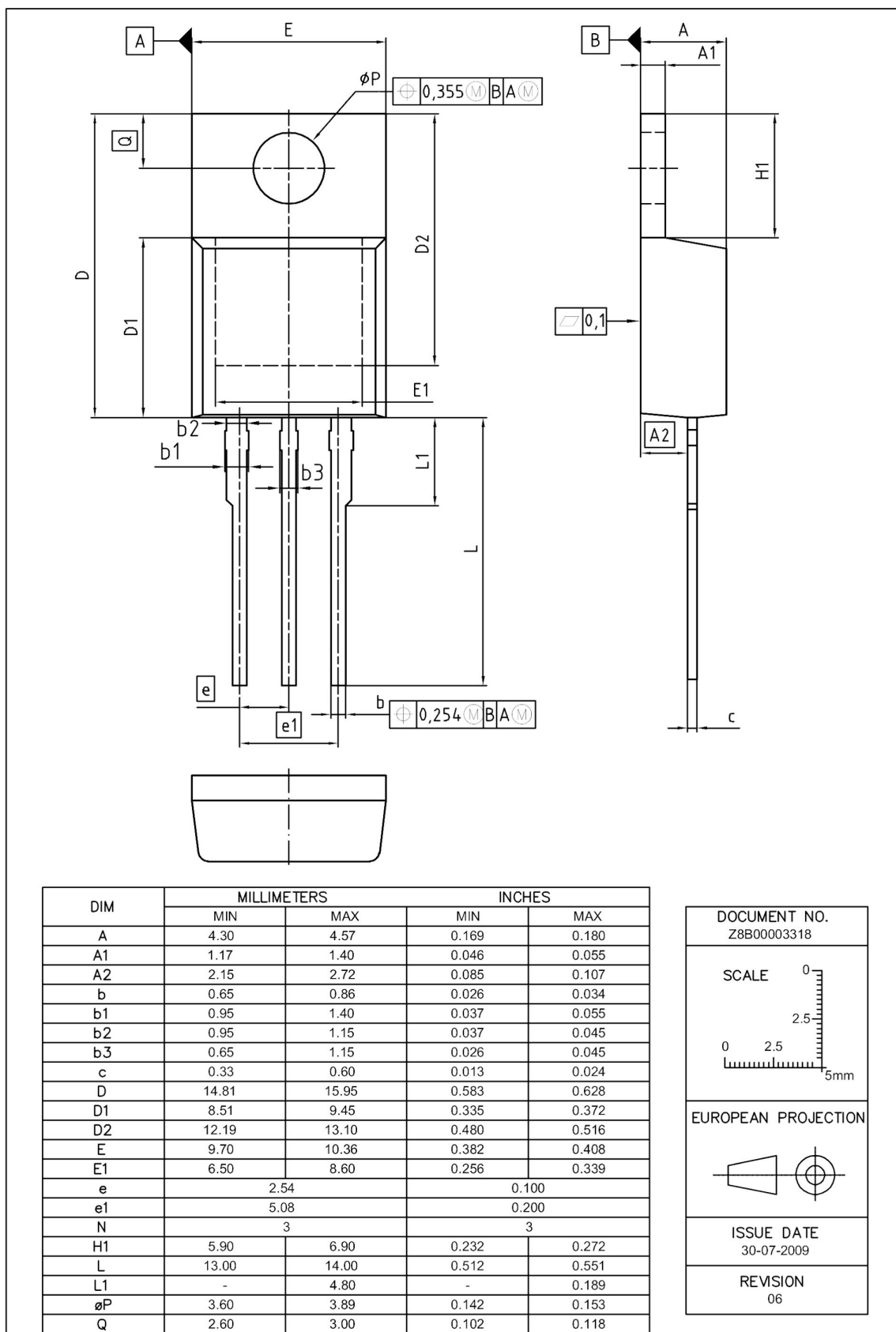


Figure 2 Outline PG-TO 220, dimensions in mm/inches

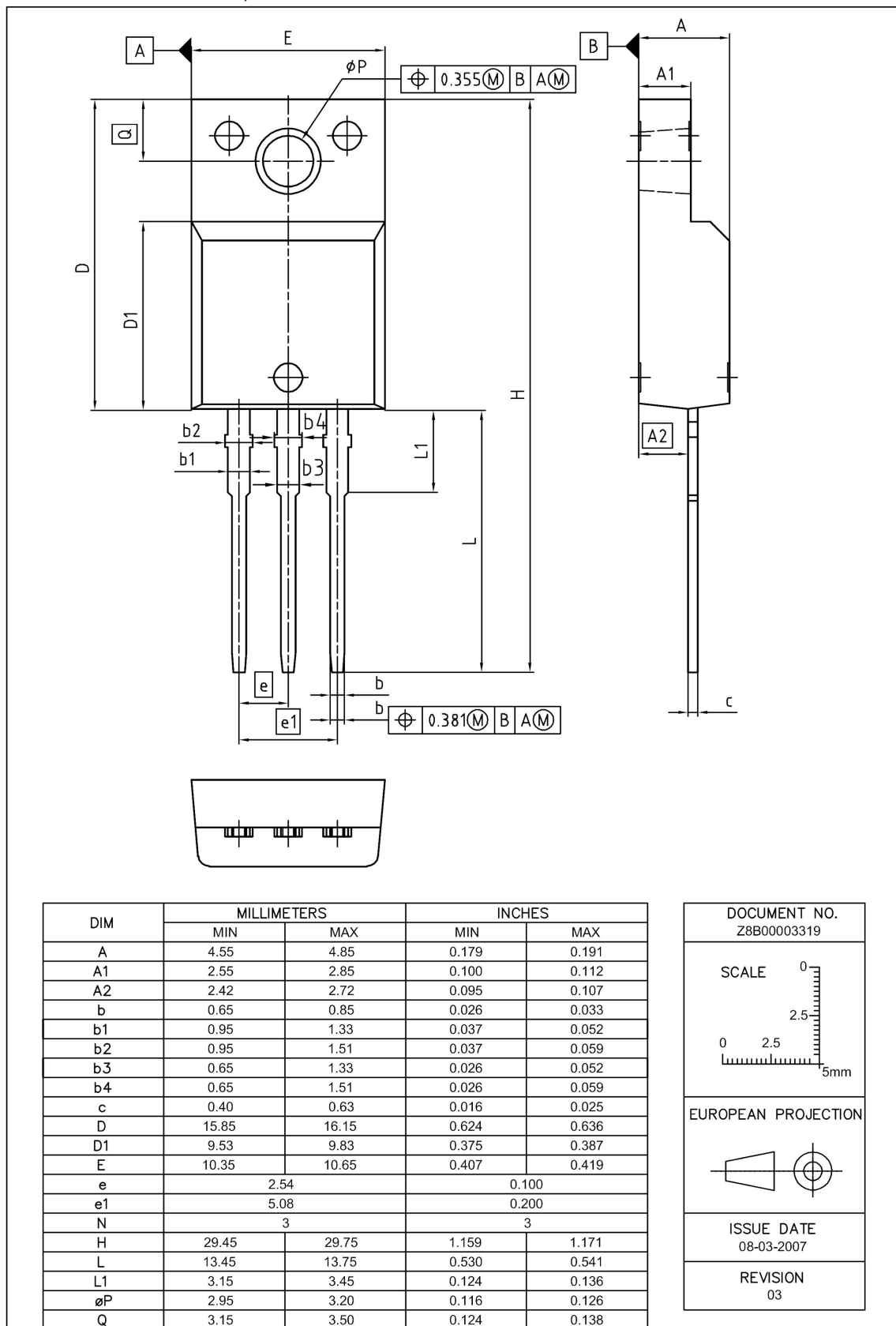


Figure 3 Outline PG-TO 220 FullPAK, dimensions in mm/inches

8 Appendix A

Table 12 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

IPW60R160P6, IPP60R160P6, IPA60R160P6

Revision: 2013-12-05, Rev. 2.1

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.0	2013-12-04	Release of final version
2.1	2013-12-05	Release of multi-package datasheet

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