

MOSFET

Metal Oxide Semiconductor Field Effect Transistor

CoolMOS C6

650V CoolMOS™ C6 Power Transistor
IPx65R190C6

Data Sheet

Rev. 2.0, 2011-05-09
Final

Industrial & Multimarket

650V CoolMOS™ C6 Power Transistor

IPA65R190C6, IPB65R190C6
IPI65R190C6, IPP65R190C6
IPW65R190C6

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™ C6 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

- 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
- JEDEC¹⁾ qualified, Pb-free plating, Halogen free

Applications

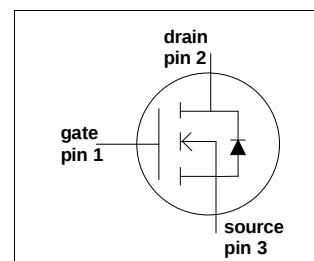
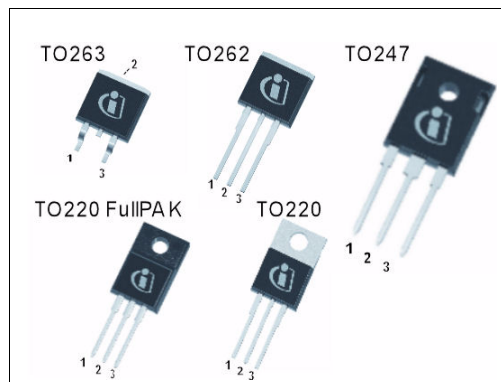
PFC stages, hard switching PWM stages and resonant switching PWM stages for e.g. PC Silverbox, Adapter, LCD & PDP TV, Lighting, Server, Telecom and UPS.

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
$V_{DS} @ T_{j,max}$	700	V
$R_{DS(on),max}$	0.19	Ω
$Q_{g,typ}$	73	nC
$I_{D,pulse}$	66	A
$E_{oss} @ 400V$	5.9	μJ
Body diode di/dt	500	A/ μs

Type / Ordering Code	Package	Marking	Related Links
IPW65R190C6	PG-TO247	65C6190	IFX CoolMOS Webpage IFX Design tools
IPB65R190C6	PG-TO263		
IPI65R190C6	PG-TO262		
IPP65R190C6	PG-TO220		
IPA65R190C6	PG-TO220 FullPAK		



1) J-STD20 and JESD22

Table of Contents

1	Description	2
	Table of Contents	3
2	Maximum ratings	4
3	Thermal characteristics	5
4	Electrical characteristics	6
5	Electrical characteristics diagrams	8
6	Test circuits	13
7	Package outlines	14
8	Revision History	19

2 Maximum ratings

at $T_j = 25\text{ °C}$, unless otherwise specified.

Table 2 Maximum ratings

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Continuous drain current ¹⁾	I_D	-	-	20.2	A	$T_C = 25\text{ °C}$
				12.8		$T_C = 100\text{ °C}$
Pulsed drain current ²⁾	$I_{D,pulse}$	-	-	66	A	$T_C = 25\text{ °C}$
Avalanche energy, single pulse	E_{AS}	-	-	485	mJ	$I_D = 3.5\text{ A}, V_{DD} = 50\text{ V}$
Avalanche energy, repetitive	E_{AR}	-	-	0.73		$I_D = 3.5\text{ A}, V_{DD} = 50\text{ V}$
Avalanche current, repetitive	I_{AR}	-	-	3.5	A	
MOSFET dv/dt ruggedness	dv/dt	-	-	50	V/ns	$V_{DS} = 0 \dots 480\text{ V}$
Gate source voltage	V_{GS}	-20	-	20	V	static
		-30		30		AC ($f > 1\text{ Hz}$)
Power dissipation for TO-220, TO-247, TO-262, TO-263	P_{tot}	-	-	151	W	$T_C = 25\text{ °C}$
Power dissipation for TO-220 FullPAK	P_{tot}	-	-	34		
Operating and storage temperature	T_j, T_{stg}	-55	-	150	°C	
Mounting torque TO-220, TO-247		-	-	60	Ncm	M3 and M3.5 screws
Mounting torque TO-220 FullPAK				50		M2.5 screws
Continuous diode forward current	I_S	-	-	17.5	A	$T_C = 25\text{ °C}$
Diode pulse current ²⁾	$I_{S,pulse}$	-	-	66	A	$T_C = 25\text{ °C}$
Reverse diode dv/dt ³⁾	dv/dt	-	-	15	V/ns	$V_{DS} = 0 \dots 400\text{ V}, I_{SD} \leq I_D, T_j = 25\text{ °C}$
Maximum diode commutation speed ³⁾	di/dt			500	A/μs	

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

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}	-	-	0.83	°C/W	leded
Thermal resistance, junction - ambient	R_{thJA}	-	-	62		
Soldering temperature, wavesoldering only allowed at leads	T_{sold}	-	-	260	°C	1.6 mm (0.063 in.) from case for 10 s

Table 4 Thermal characteristics FullPAK

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}	-	-	3.7	°C/W	leded
Thermal resistance, junction - ambient	R_{thJA}	-	-	80		
Soldering temperature, wavesoldering only allowed at leads	T_{sold}	-	-	260	°C	1.6 mm (0.063 in.) from case for 10 s

Table 5 Thermal characteristics SMD

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}	-	-	0.83	°C/W	SMD version, device on PCB, minimal footprint
Thermal resistance, junction - ambient	R_{thJA}	-	-	62		
		-	35	-		
Soldering temperature, wave- & reflow soldering allowed	T_{sold}	-	-	260	°C	reflow MSL1

1) Device on 40mm*40mm*1.5mm one layer epoxy PCB FR4 with 6cm² copper area (thickness 70µm) for drain connection. PCB is vertical without air stream cooling.

4 Electrical characteristics

Electrical characteristics, at $T_J=25\text{ °C}$, unless otherwise specified.

Table 6 Static characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Drain-source breakdown voltage	$V_{(BR)DSS}$	650	-	-	V	$V_{GS}=0\text{ V}$, $I_D=1.0\text{ mA}$
Gate threshold voltage	$V_{GS(th)}$	2.5	3	3.5		$V_{DS}=V_{GS}$, $I_D=0.73\text{ mA}$
Zero gate voltage drain current	I_{DSS}	-	-	1	μA	$V_{DS}=650\text{ V}$, $V_{GS}=0\text{ V}$, $T_J=25\text{ °C}$
		-	10	-		$V_{DS}=650\text{ V}$, $V_{GS}=0\text{ V}$, $T_J=150\text{ °C}$
Gate-source leakage current	I_{GSS}	-	-	100	nA	$V_{GS}=20\text{ V}$, $V_{DS}=0\text{ V}$
Drain-source on-state resistance	$R_{DS(on)}$	-	0.17	0.19	Ω	$V_{GS}=10\text{ V}$, $I_D=7.3\text{ A}$, $T_J=25\text{ °C}$
		-	0.44	-		$V_{GS}=10\text{ V}$, $I_D=7.3\text{ A}$, $T_J=150\text{ °C}$
Gate resistance	R_G	-	8.5	-	Ω	$f=1\text{ MHz}$, open drain

Table 7 Dynamic characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	C_{iss}	-	1620	-	pF	$V_{GS}=0\text{ V}$, $V_{DS}=100\text{ V}$, $f=1\text{ MHz}$
Output capacitance	C_{oss}	-	98	-		
Effective output capacitance, energy related ¹⁾	$C_{o(er)}$	-	65	-		$V_{GS}=0\text{ V}$, $V_{DS}=0\ldots480\text{ V}$
Effective output capacitance, time related ²⁾	$C_{o(tr)}$	-	308	-		$I_D=\text{constant}$, $V_{GS}=0\text{ V}$ $V_{DS}=0\ldots480\text{ V}$
Turn-on delay time	$t_{d(on)}$	-	13	-	ns	$V_{DD}=400\text{ V}$, $V_{GS}=13\text{ V}$, $I_D=11\text{ A}$, $R_G=3.4\text{ }\Omega$
Rise time	t_r	-	12	-		
Turn-off delay time	$t_{d(off)}$	-	133	-		
Fall time	t_f	-	10	-		

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% $V_{(BR)DSS}$

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 80% $V_{(BR)DSS}$

Table 8 Gate charge characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate to source charge	Q_{gs}	-	8.9	-	nC	$V_{DD}=480\text{ V}$, $I_D=11\text{ A}$, $V_{GS}=0\text{ to }10\text{ V}$
Gate to drain charge	Q_{gd}	-	38	-		
Gate charge total	Q_g	-	73	-		
Gate plateau voltage	$V_{plateau}$	-	5.5	-	V	

Table 9 Reverse diode characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Diode forward voltage	V_{SD}	-	0.9	-	V	$V_{GS}=0\text{ V}$, $I_F=11\text{ A}$, $T_j=25\text{ °C}$
Reverse recovery time	t_{rr}	-	410	-	ns	$V_R=400\text{ V}$, $I_F=11\text{ A}$, $di_F/dt=100\text{ A}/\mu\text{s}$
Reverse recovery charge	Q_{rr}	-	6.1	-	μC	
Peak reverse recovery current	I_{rrm}	-	28	-	A	

5 Electrical characteristics diagrams

Table 10

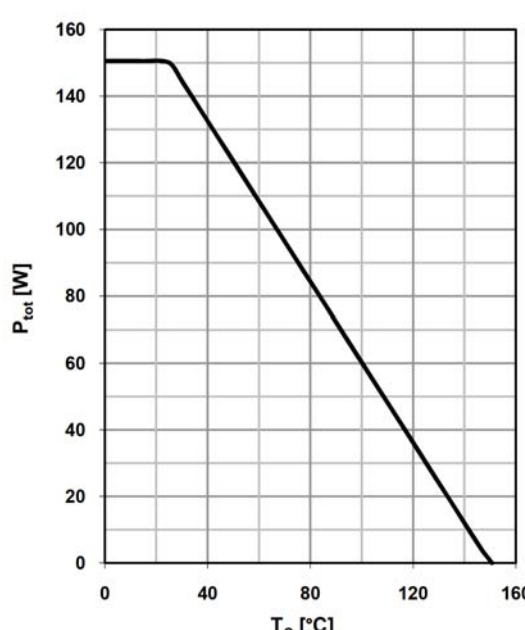
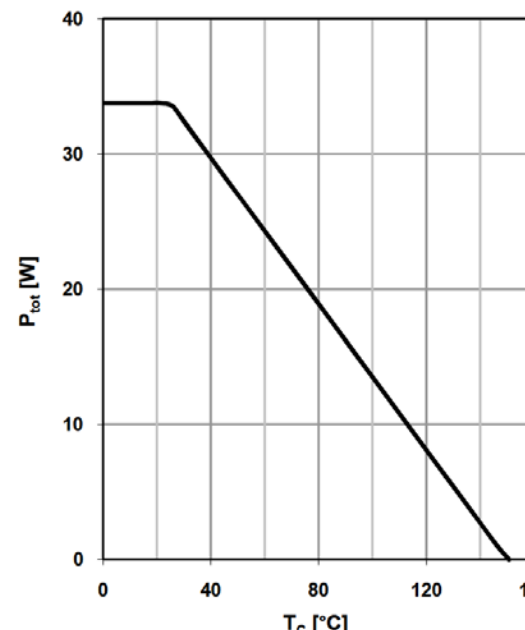
Power dissipation Non FullPAK	Power dissipation FullPAK
	
$P_{tot} = f(T_c)$	$P_{tot} = f(T_c)$

Table 11

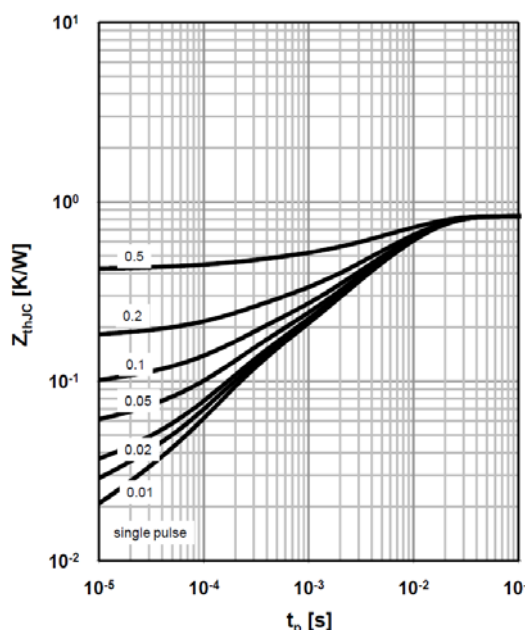
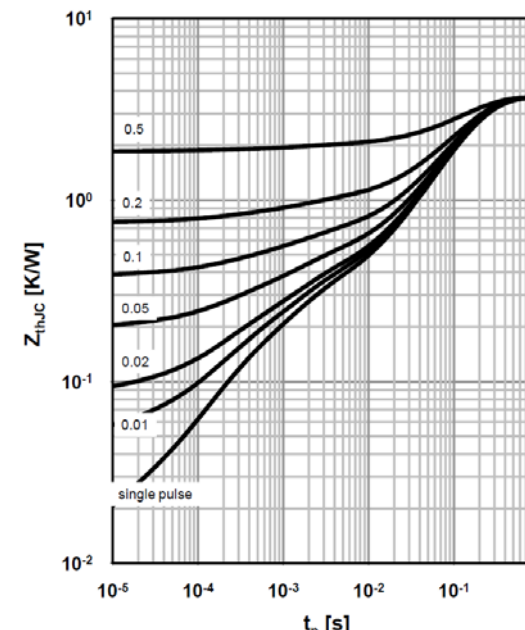
Max. transient thermal impedance Non FullPAK	Max. transient thermal impedance FullPAK
	
$Z_{(thJC)} = f(t_p)$; parameter: $D = t_p / T$	$Z_{(thJC)} = f(t_p)$; parameter: $D = t_p / T$

Table 12

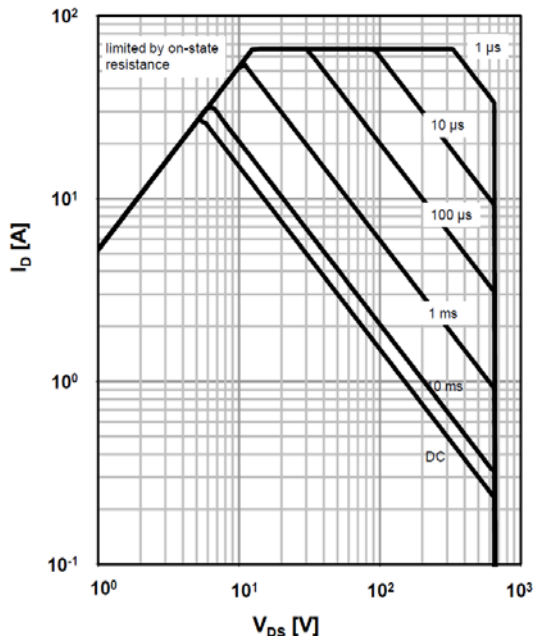
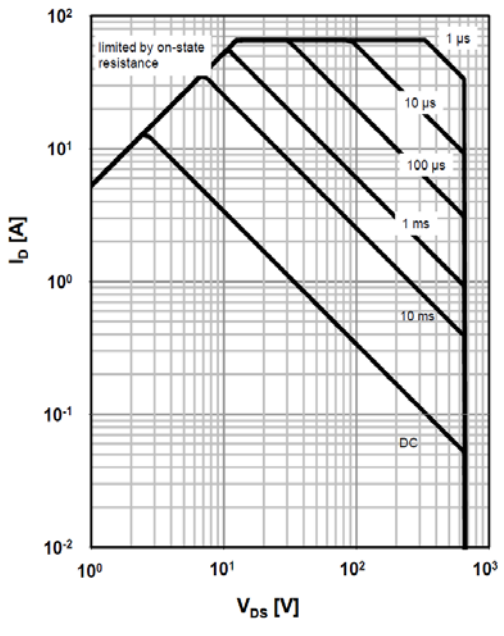
Safe operating area $T_C=25\text{ °C}$ Non FullPAK	Safe operating area $T_C=25\text{ °C}$ FullPAK
	
$I_D=f(V_{DS}); T_C=25\text{ °C}; V_{GS} > 7V; D=0; \text{parameter } t_p$	$I_D=f(V_{DS}); T_C=25\text{ °C}; V_{GS} > 7V; D=0; \text{parameter } t_p$

Table 13

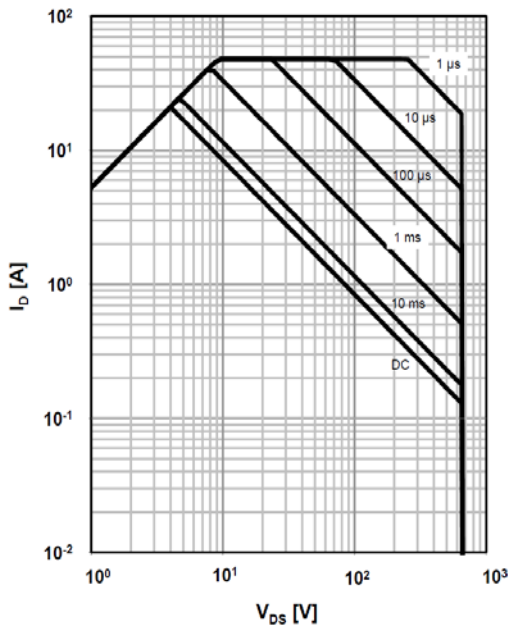
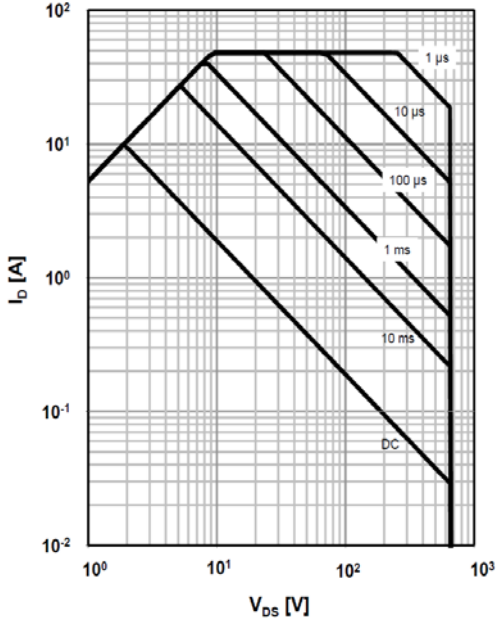
Safe operating area $T_C=80\text{ °C}$ Non FullPAK	Safe operating area $T_C=80\text{ °C}$ FullPAK
	
$I_D=f(V_{DS}); T_C=80\text{ °C}; V_{GS} > 7V; D=0; \text{parameter } t_p$	$I_D=f(V_{DS}); T_C=80\text{ °C}; V_{GS} > 7V; D=0; \text{parameter } t_p$

Table 14

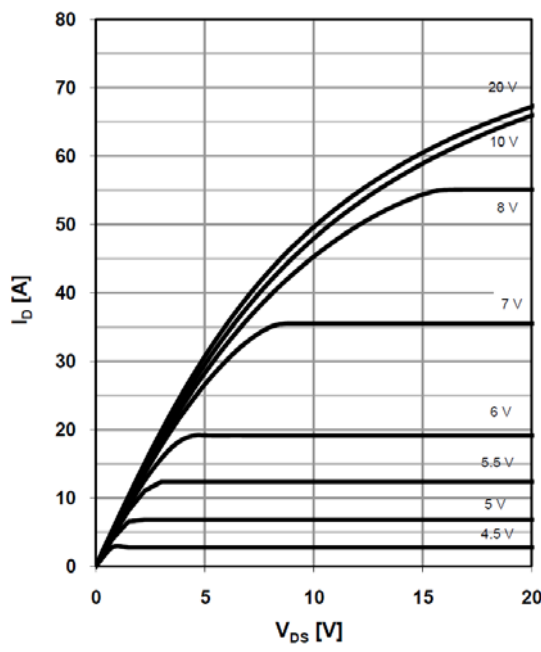
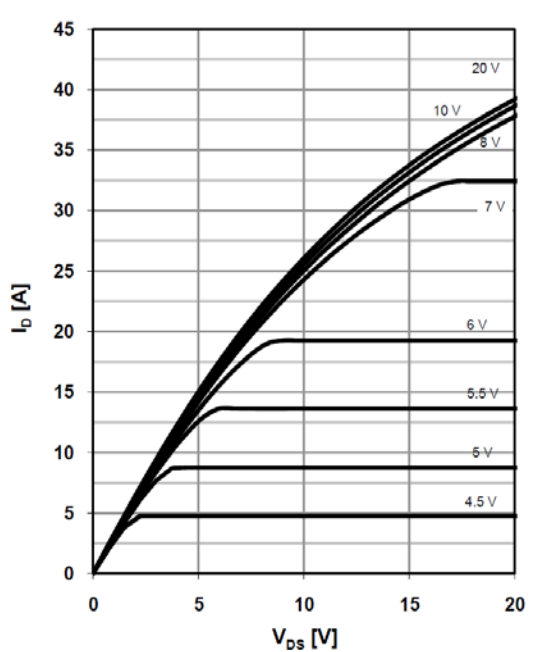
Typ. output characteristics $T_J=25\text{ }^{\circ}\text{C}$	Typ. output characteristics $T_J=125\text{ }^{\circ}\text{C}$
	
$I_D=f(V_{DS}); T_J=25\text{ }^{\circ}\text{C}; \text{parameter: } V_{GS}$	$I_D=f(V_{DS}); T_J=125\text{ }^{\circ}\text{C}; \text{parameter: } V_{GS}$

Table 15

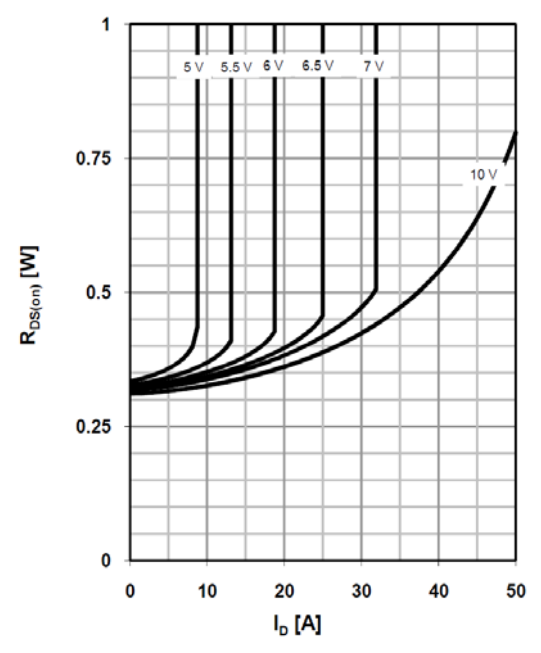
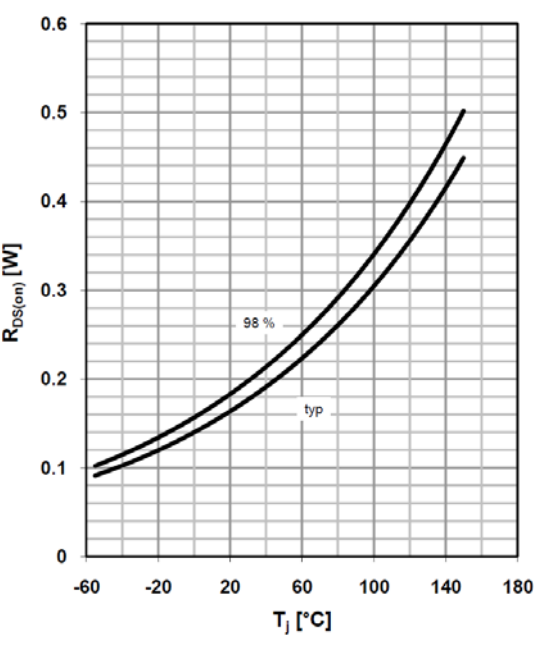
Typ. drain-source on-state resistance	Drain-source on-state resistance
	
$R_{DS(on)}=f(I_D); T_J=125\text{ }^{\circ}\text{C}; \text{parameter: } V_{GS}$	$R_{DS(on)}=f(T_J); I_D=7.3\text{ A}; V_{GS}=10\text{ V}$

Table 16

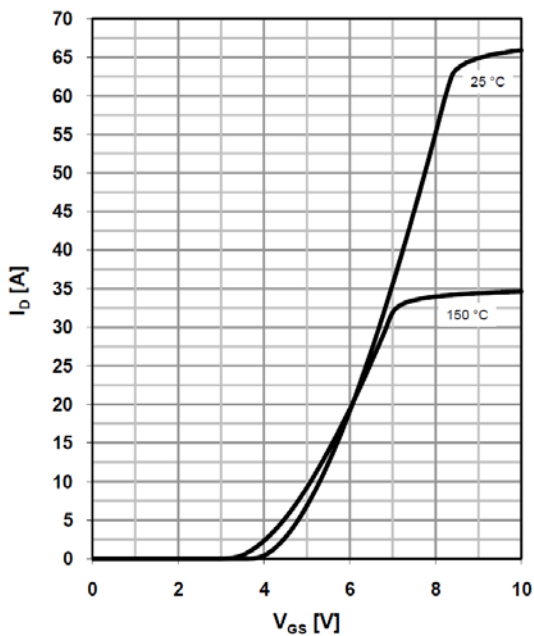
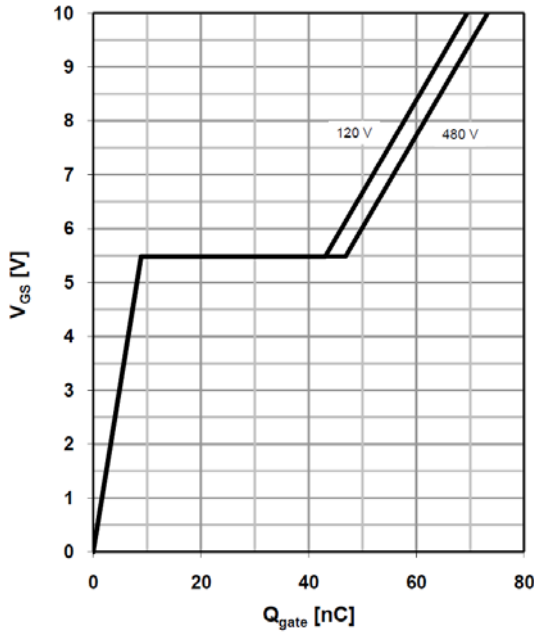
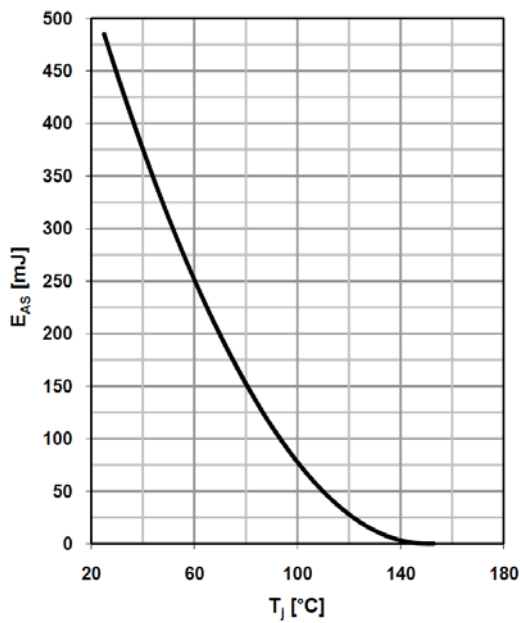
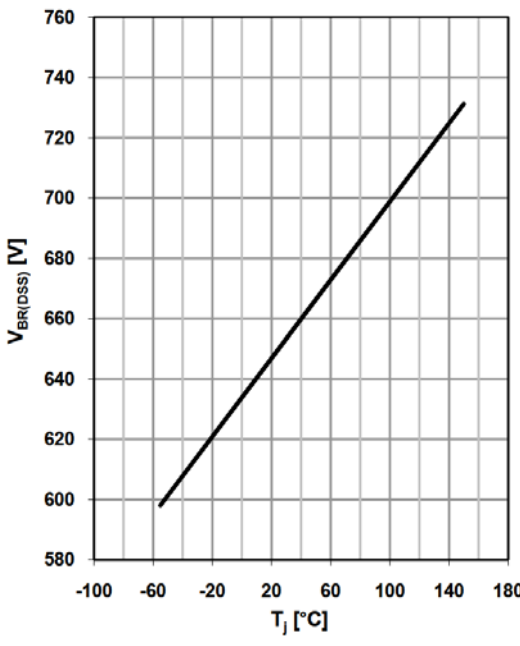
Typ. transfer characteristics	Typ. gate charge
	
$I_D = f(V_{GS}); V_{DS} = 20V$	$V_{GS} = f(Q_{gate}), I_D = 11 \text{ A pulsed}$

Table 17

Avalanche energy	Drain-source breakdown voltage
	
$E_{AS} = f(T_j); I_D = 3.5 \text{ A}; V_{DD} = 50 \text{ V}$	$V_{BR(DSS)} = f(T_j); I_D = 1.0 \text{ mA}$

Electrical characteristics diagrams

Table 18

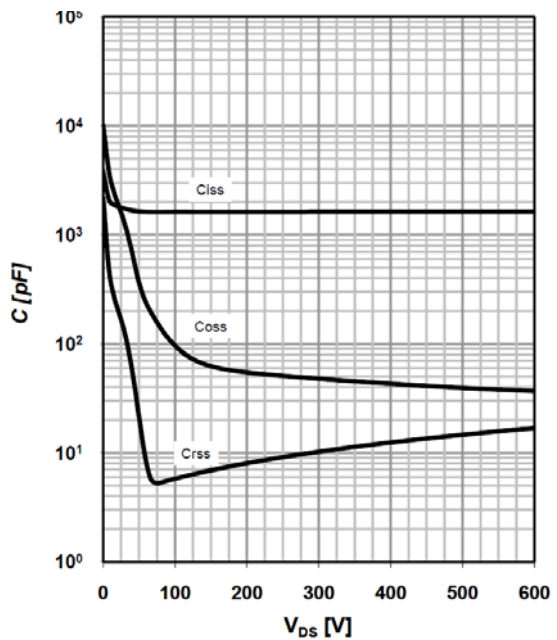
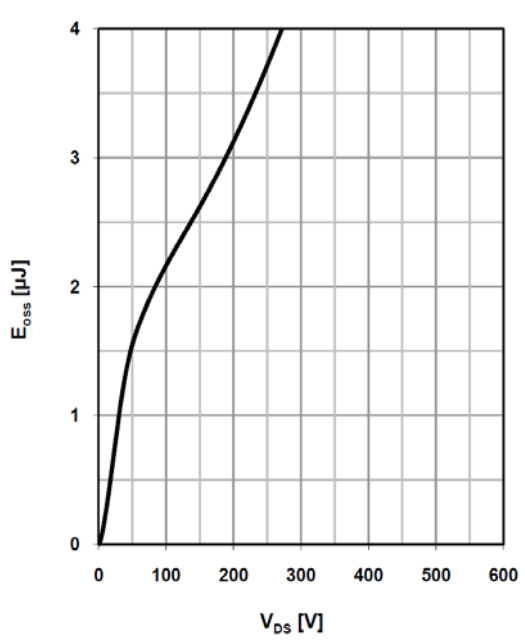
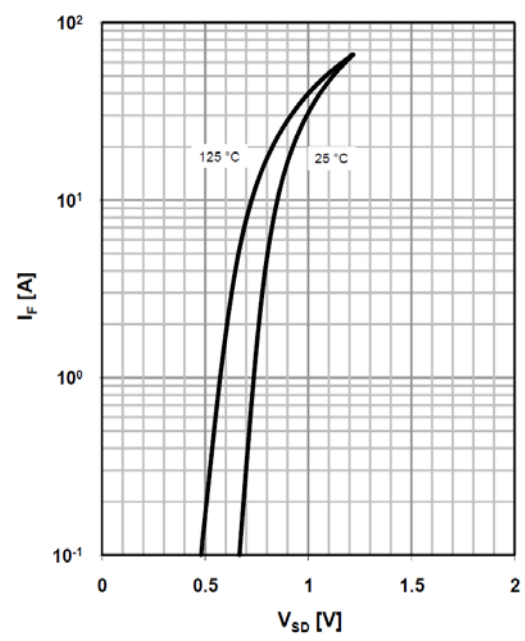
Typ. capacitances	Typ. C_{oss} stored energy
 Graph showing typical capacitances (C in pF) versus drain-source voltage (V_{DS} in V). The y-axis is logarithmic from 10^0 to 10^5. The x-axis is linear from 0 to 600 V. Three curves are shown: C_{iss} (input capacitance), C_{oss} (output capacitance), and C_{rss} (reverse transfer capacitance). C_{iss} is relatively constant around 2×10^3 pF. C_{oss} and C_{rss} decrease as V_{DS} increases, with C_{oss} being significantly higher than C_{rss}.	 Graph showing typical stored energy (E_{oss} in μJ) versus drain-source voltage (V_{DS} in V). The y-axis is linear from 0 to 4 μJ. The x-axis is linear from 0 to 600 V. The curve shows E_{oss} increasing with V_{DS}, reaching approximately 4 μJ at 300 V.
$C=f(V_{DS}); V_{GS}=0 \text{ V}; f=1 \text{ MHz}$	$E_{oss}=f(V_{DS})$

Table 19

Forward characteristics of reverse diode
 Graph showing forward current (I_F in A) versus drain-source voltage (V_{SD} in V) for the reverse diode. The y-axis is logarithmic from 10^{-1} to 10^2 A. The x-axis is linear from 0 to 2 V. Two curves are shown for different temperatures: 125°C and 25°C. The 125°C curve is shifted to the left, indicating higher current for the same voltage compared to the 25°C curve.
$I_F=f(V_{SD}); \text{ parameter: } T_j$

6 Test circuits

Table 20 Switching times test circuit and waveform for inductive load

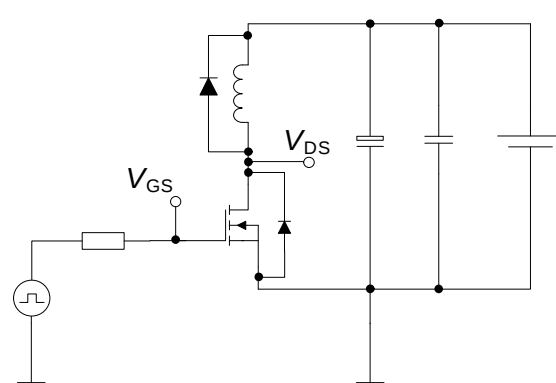
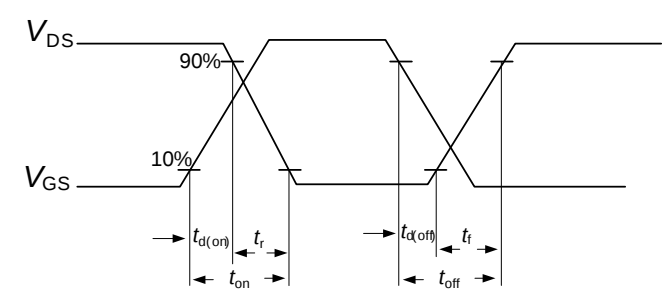
Switching times test circuit for inductive load	Switching time waveform
	

Table 21 Unclamped inductive load test circuit and waveform

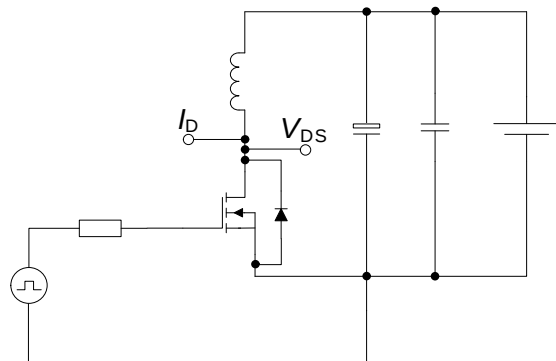
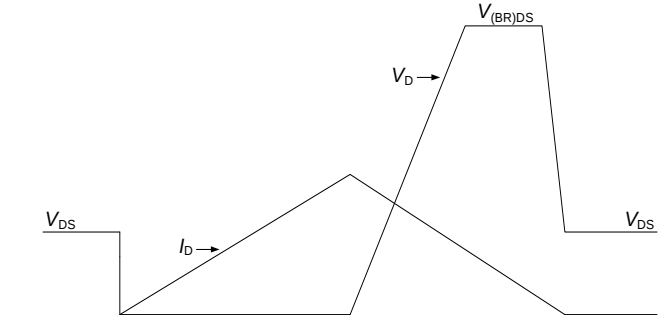
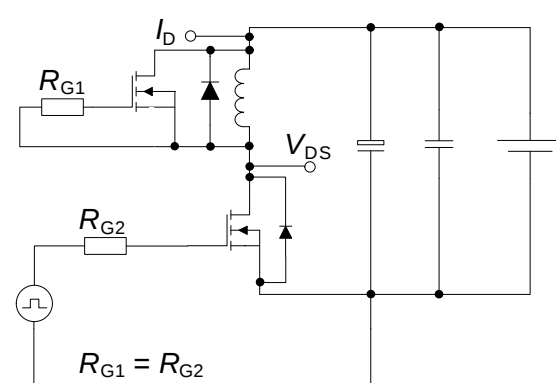
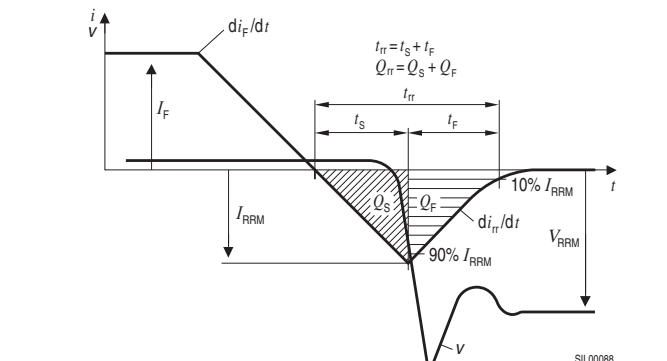
Unclamped inductive load test circuit	Unclamped inductive waveform
	

Table 22 Test circuit and waveform for diode characteristics

Test circuit for diode characteristics	Diode recovery waveform
 $R_{G1} = R_{G2}$	 $t_{rr} = t_s + t_f$ $Q_{rr} = Q_s + Q_f$

7 Package outlines

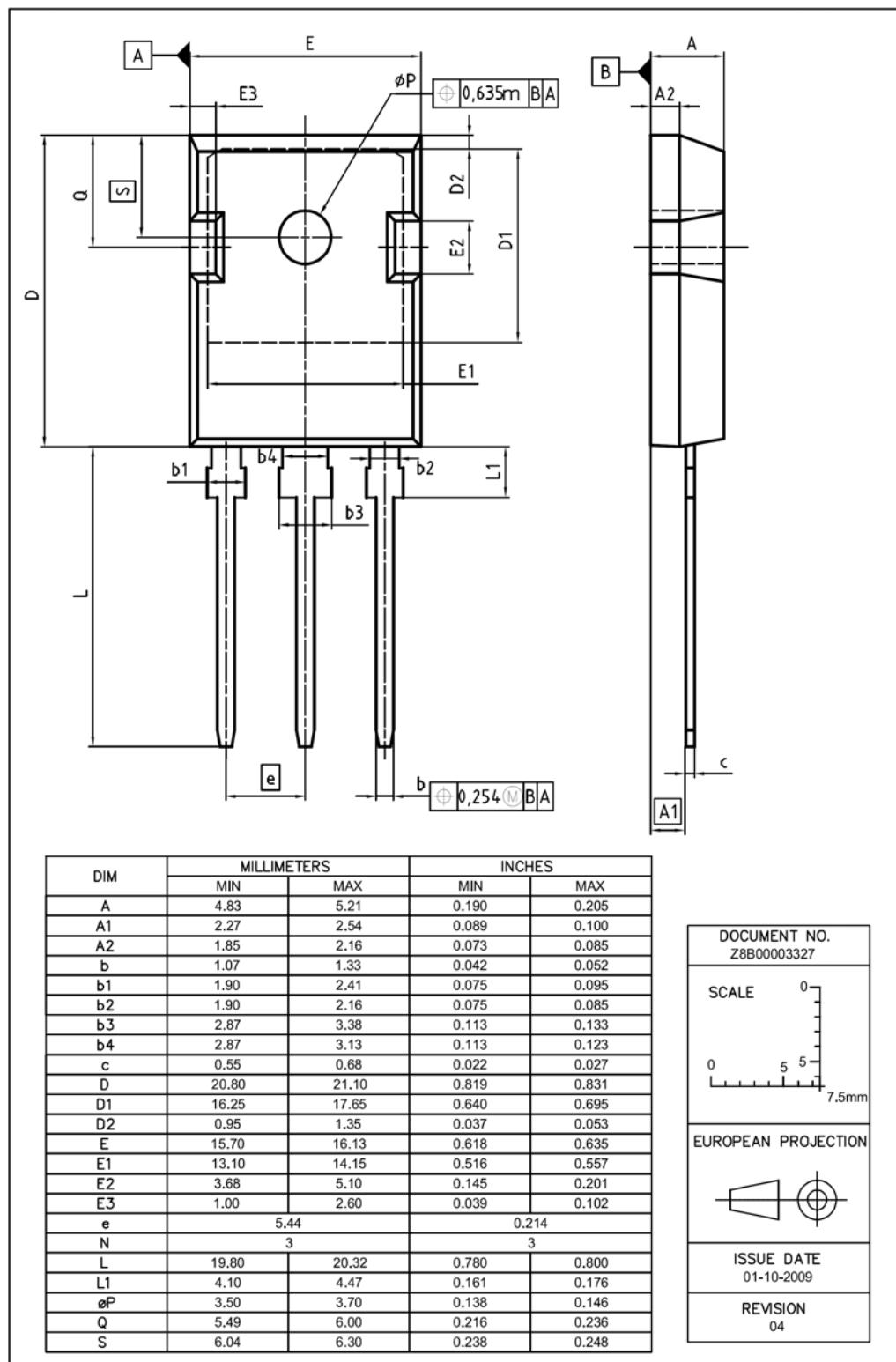
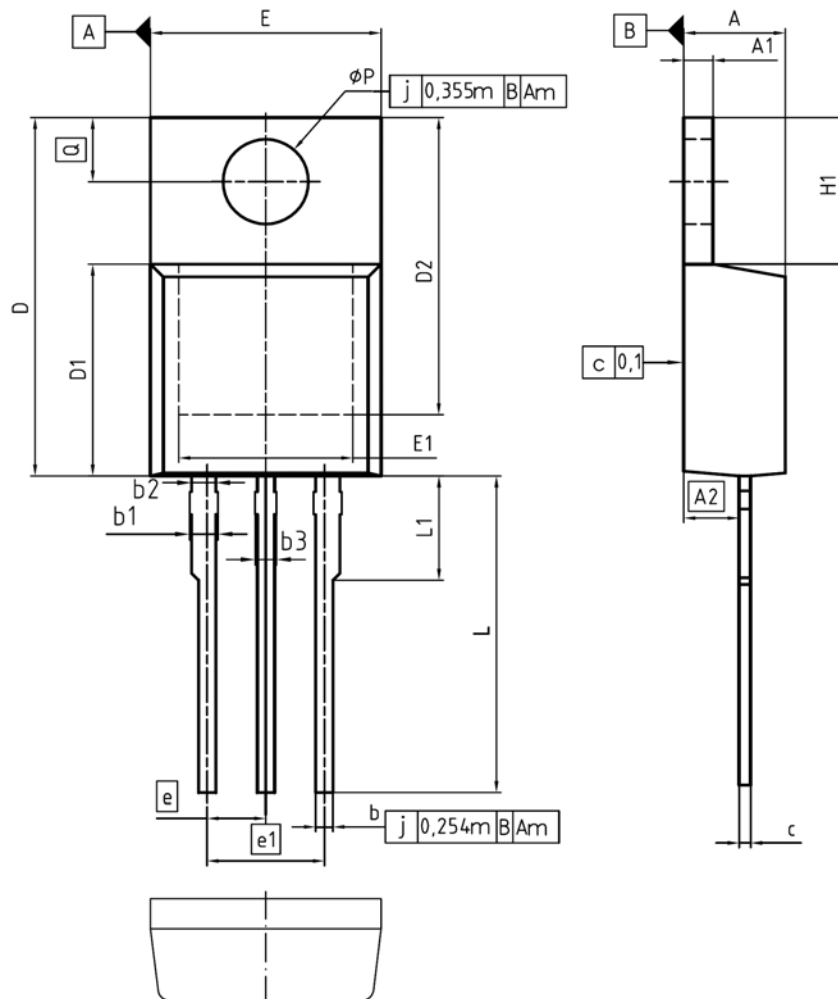


Figure 1 Outlines TO-247, dimensions in mm/inches



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.30	4.57	0.169	0.180
A1	1.17	1.40	0.046	0.055
A2	2.15	2.72	0.085	0.107
b	0.65	0.86	0.026	0.034
b1	0.95	1.40	0.037	0.055
b2	0.95	1.15	0.037	0.045
b3	0.65	1.15	0.026	0.045
c	0.33	0.60	0.013	0.024
D	14.81	15.95	0.583	0.628
D1	8.51	9.45	0.335	0.372
D2	12.19	13.10	0.480	0.516
E	9.70	10.36	0.382	0.408
E1	6.50	8.60	0.256	0.339
e	2.54		0.100	
e1	5.08		0.200	
N	3		3	
H1	5.90	6.90	0.232	0.272
L	13.00	14.00	0.512	0.551
L1	-	4.80	-	0.189
phi P	3.60	3.89	0.142	0.153
Q	2.60	3.00	0.102	0.118

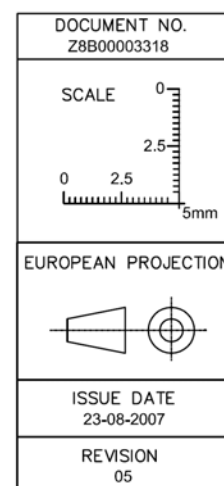
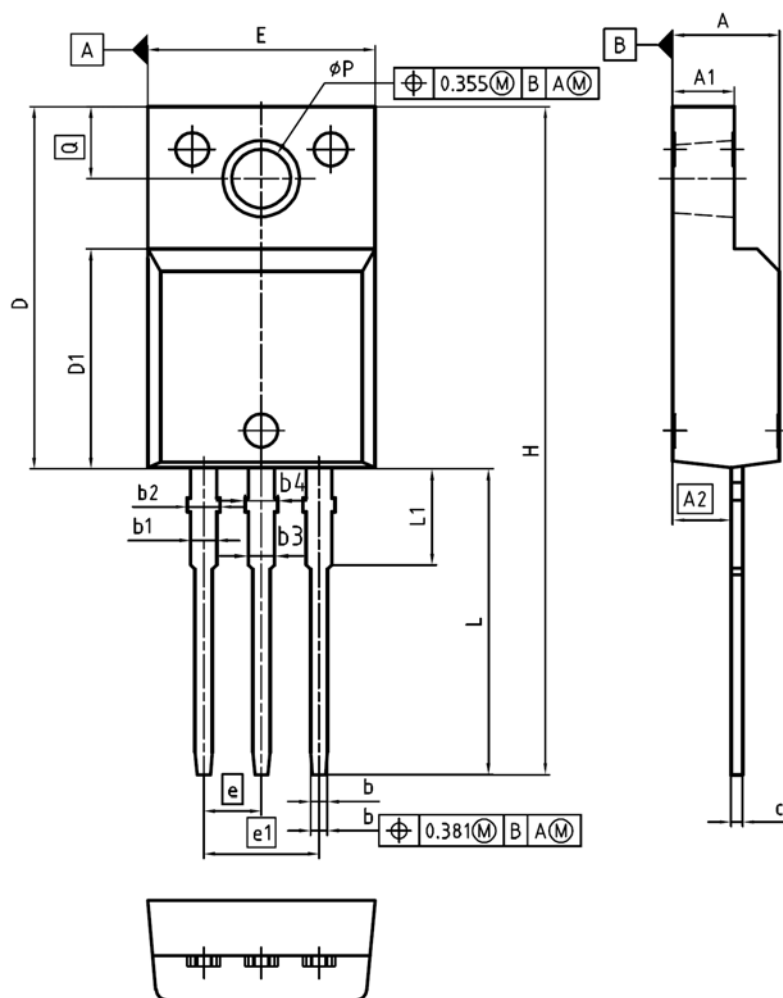


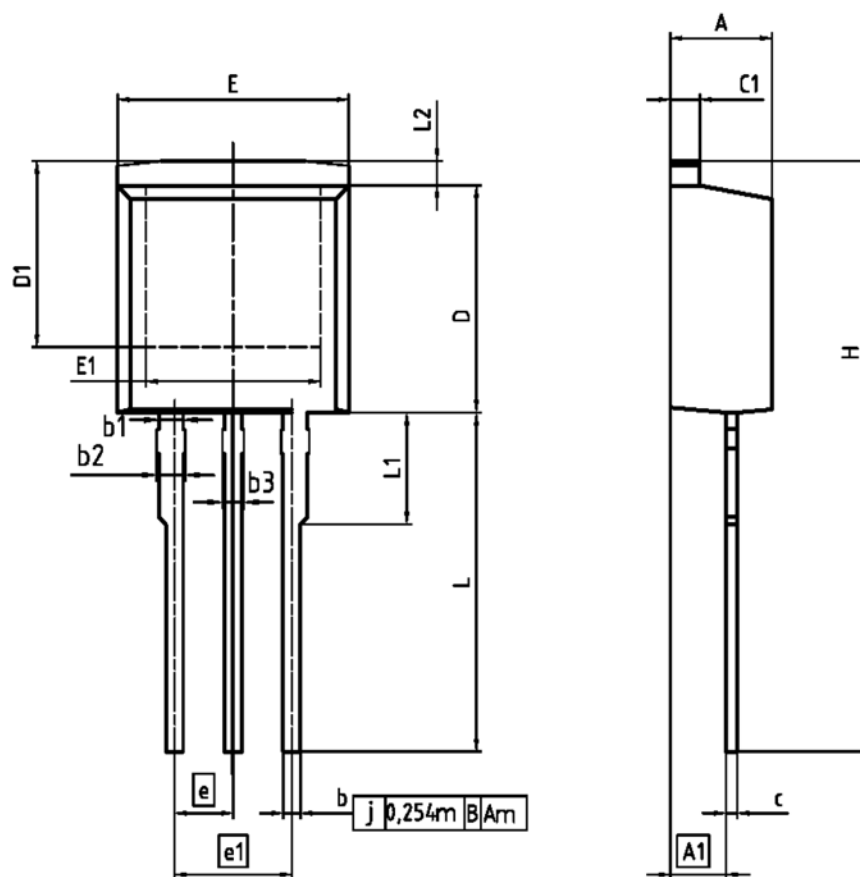
Figure 2 Outlines TO-220, dimensions in mm/inches



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.55	4.85	0.179	0.191
A1	2.55	2.85	0.100	0.112
A2	2.42	2.72	0.095	0.107
b	0.65	0.85	0.026	0.033
b1	0.95	1.33	0.037	0.052
b2	0.95	1.51	0.037	0.059
b3	0.65	1.33	0.026	0.052
b4	0.65	1.51	0.026	0.059
c	0.40	0.63	0.016	0.025
D	15.85	16.15	0.624	0.636
D1	9.53	9.83	0.375	0.387
E	10.35	10.65	0.407	0.419
e	2.54		0.100	
e1	5.08		0.200	
N	3		3	
H	29.45	29.75	1.159	1.171
L	13.45	13.75	0.530	0.541
L1	3.15	3.45	0.124	0.136
øP	2.95	3.20	0.116	0.126
Q	3.15	3.50	0.124	0.138

DOCUMENT NO. Z8B00003319
SCALE 0 2.5 5mm
EUROPEAN PROJECTION 
ISSUE DATE 08-03-2007
REVISION 03

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



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.300	4.572	0.169	0.180
A1	2.150	2.718	0.085	0.107
b	0.650	0.864	0.026	0.034
b1	0.950	1.093	0.037	0.043
b2	0.950	1.400	0.037	0.055
b3	0.850	1.118	0.026	0.044
c	0.330	0.600	0.013	0.024
c1	1.170	1.400	0.046	0.055
D	8.509	9.450	0.335	0.372
D1	6.900	-	0.272	-
E	9.700	10.363	0.382	0.408
E1	6.500	8.600	0.256	0.339
e	2.540		0.100	
e1	5.080		0.200	
N	3		3	
L	13.000	14.000	0.512	0.551
L1	-	4.800	-	0.189
L2	-	1.727	-	0.068

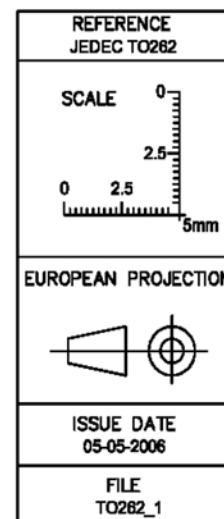
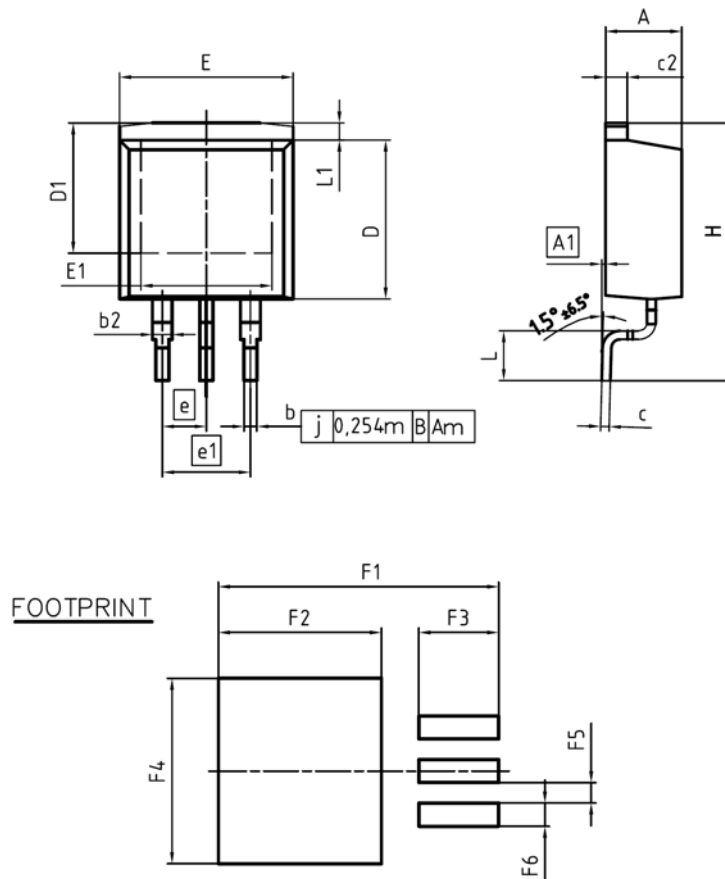


Figure 4 Outlines TO-262, dimensions in mm/inches



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.30	4.57	0.169	0.180
A1	0.00	0.25	0.000	0.010
b	0.65	0.85	0.026	0.033
b2	0.95	1.15	0.037	0.045
c	0.33	0.65	0.013	0.026
c2	1.17	1.40	0.046	0.055
D	8.51	9.45	0.335	0.372
D1	7.10	7.90	0.280	0.311
E	9.80	10.31	0.386	0.406
E1	6.50	8.60	0.256	0.339
e	2.54		0.100	
e1	5.08		0.200	
N	3		3	
H	14.61	15.88	0.575	0.625
L	2.29	3.00	0.090	0.118
L1	0.70	1.60	0.028	0.063
F1	16.05	16.25	0.632	0.640
F2	9.30	9.50	0.366	0.374
F3	4.50	4.70	0.177	0.185
F4	10.70	10.90	0.421	0.429
F5	1.10	1.30	0.043	0.051
F6	1.25	1.45	0.049	0.057

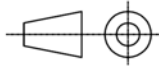
DOCUMENT NO. Z8B00003323
SCALE 0 5 5 7.5mm
EUROPEAN PROJECTION 
ISSUE DATE 30-08-2007
REVISION 01

Figure 5 Outlines TO-263, dimensions in mm/inches

8 Revision History

Revision History: 2011-05-09, Rev. 2.0

Previous Revision:

Revision	Subjects (major changes since last revision)
2.0	Release of final data sheet

We Listen to Your Comments

Any information within this document that you feel is wrong, unclear or missing at all?

Your feedback will help us to continuously improve the quality of this document.

Please send your proposal (including a reference to this document) to: erratum@infineon.com



Edition 2011-05-09

Published by

Infineon Technologies AG

81726 Munich, Germany

© 2011 Infineon Technologies AG

All Rights Reserved.

Legal Disclaimer

The information given in this document shall in no event be regarded as a guarantee of conditions or characteristics. With respect to any examples or hints given herein, any typical values stated herein and/or any information regarding the application of the device, Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind, including without limitation, warranties of non-infringement of intellectual property rights of any third party.

Information

For further information on technology, delivery terms and conditions and prices, please contact the nearest Infineon Technologies Office (www.infineon.com).

Warnings

Due to technical requirements, components may contain dangerous substances. For information on the types in question, please contact the nearest Infineon Technologies Office.

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.