MOSFET

Metall Oxide Semiconductor Field Effect Transistor

CoolMOS E6

650V CoolMOS^{TM} E6 Power Transistor
IPx65R600E6

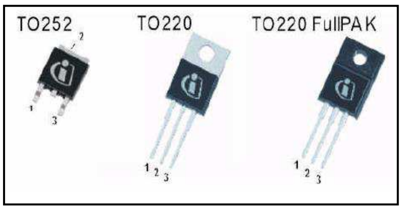
Data Sheet

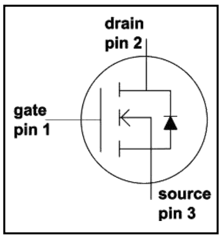
Rev. 2.3, 2018-02-28

Power Management & Multimarket

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™ DE series combines the experience of the leading SJ MOSFET supplier with high class innovation. The resulting 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 F O M R dson*Qg and E oss
- Very high commutation ruggedness
- Easy to use/drive
- JEDEC[1] qualified, Pb-free plating, available in Halogen free mold compound [2]

Applications

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

Please note: For MOSFET paralleling the use o fferrite 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
$R_{DS(on),\ max}$	0.6	Ω
$Q_{G,\ typ}$	23	nC
$I_{D,\ pulse}$	18	A
E_{oss} @ 400V	2	µJ
Body diode di/dt	500	A/µs

Type / Ordering Code	Package	Marking	Related links
IPD65R600E6	PG-TO252	65E6600	IFX CoolMOS Webpage IFX Design tools
IPP65R600E6	PG-TO220		
IPA65R600E6	PG-TO220 FullPAK		

1) J-STD20 and JESD22
2) For PG-TO252: non-Halogen free (OPN: IPD65R600E6BT); Halogen free (OPN: IPD65R600E6AT)

Table of Contents

2 Maximum ratings

At T_j = 25 °C, unless otherwise specified.

Table 2 Maximum ratings

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Continuous drain current [1]	I_D	–	–	7.3	A	T_C = 25°C
		–	–	4.6		T_C = 100°C
Pulsed drain current [2]	$I_{D, pulse}$	–	–	18		T_C = 25°C
Averlanche energy, single pulse	E_{AS}	–	–	142	mJ	I_D = 1.3A; V_{DD} = 50V; T_C = 25°C (see Table 11)
Averlanche energy, repetitive	E_{AR}	–	–	0.21		I_D=1.3 A, V_{DD}=50V
Avalanche current, repetitive	I_{AR}	–	–	1.3	A	
MOSFET dv/dt ruggedness	dv/dt	–	–	50	V/ns	V_{DS}=0…480 V
Gate source voltage	V_{GS}	-20	–	20	V	static
		-30		30		AC (f >1 Hz)
Power dissipation for Non FullPAK	P_{tot}	–	–	63	W	T_C = 25°C
Power dissipation for FullPAK	P_{tot}	–	–	28	W	T_C = 25°C
Operating and storage temperature	T_j, T_{stg}	-55	–	150	°C	
Mounting torque TO-220		–	–	60	Ncm	M3 and M3.5 screws
Mounting torque TO-220 FullPAK		–	–	50		M2.5 Screws
Continous diode forward current	I_S	–	–	6.3	A	T_C = 25°C
Diode pulse current [2]	$I_{S, pulsed}$	–	–	18	A	T_C = 25°C
Reverse diode dv/dt [3]	dv/dt	–	–	15	V/ns	V_{DS}=0…480 V, $I_{SD} \leq I_D$, T_C = 125°C (see table 22)
Maxumum diode commutation speed [3]	di_f/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 TO-220 (IPP65R600E6)

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction-case	R_{thJC}	–	–	2.0	°C/W	
Thermal resistance, junction-ambient	R_{thJA}	–	–	62		leaded
Soldering temperature, wavesoldering only allowed at leads	T_{sold}	–	–	260	°C	1.6mm (0.063 in.) from case for 10 s

Table 4 Thermal characteristics TO-220 FullPAK (IPA65R600E6)

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		leaded
Soldering temperature, wavesoldering only allowed at leads	T_{sold}	–	–	260	°C	1.6mm (0.063 in.) from case for 10 s

Table 5 Thermal characteristics TO-252 (IPD65R600E6)

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction-case	R_{thJC}	–	–	2.0	°C/W	
Thermal resistance, junction-ambient	R_{thJA}	–	–	62		SMD version, device on PCB, minimal footprint
			35			SMD version, device on PCB, 6cm² cooling area[1)]
Soldering temperature, wave- &reflowsoldering only allowed	T_{sold}	–	–	260	°C	Reflow MSL1

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

4 Electrical characteristics

Electrical characteristics, at T_j=25°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}= 0V, I_D= 1.0mA
Gate threshold voltage	$V_{GS(th)}$	2.5	3	3.5		V_{DS}= V_{GS}, I_D= 0.21mA
Zero gate Voltage drain current	I_{DSS}	–	–	1	µA	V_{DS}=600 V, V_{GS}=0V, T_j=25°C
		–	10	–		V_{DS}=600 V, V_{GS}=0V, T_j=150°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	0.6	Ω	V_{GS}= 10V, I_D=2.1A, T_j= 25°C
		–	1.40	–		V_{GS}= 10V, I_D=2.1A, T_j= 150°C
Gate resistance	R_G	–	10.5	–	Ω	f= 1MHz, open drain

Table7 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	–		
Effective output capacitance, energy related[1)]	$C_{o(er)}$	–	21	–		V_{GS}= 0V, V_{DS}=0…480V
Effective output capacitance, time related[2)]	$C_{o(tr)}$	–	88	–		I_D= const V_{GS}= 0V, V_{DS}=0…480 V
Turn- on delay time	$t_{d(on)}$	–	10	–	ns	V_{DD}=400 V V_{GS}=13 V, I_D=3.2A, R_G= 6.8 Ω (see table 20)
Rise time	t_r	–	8	–		
Turn- off delay time	$t_{d(off)}$	–	64	–		
Fall time	t_f	–	11	–		

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}	–	2.75	–	nC	V_{DD}= 480V, I_D= 3.2A, V_{GS}=0 to 10 V
Gate to drain charge	Q_{GD}	–	12	–		
Gate charge, total	Q_G	–	23			
Gate plateau voltage	$V_{plateau}$	–	5.5	–	V	

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°C
Reverse recovery time	t_{rr}	–	270	–	ns	V_R=400 V, I_F=3.2A, diF/d_t=100 A/µs (see table 22)
Reverse recovery charge	Q_{rr}	–	2.0	–	nC	
Peak reverse recovery current	I_{rrm}	–	13	–	A	

5 Electrical characteristics diagrams

Table 10

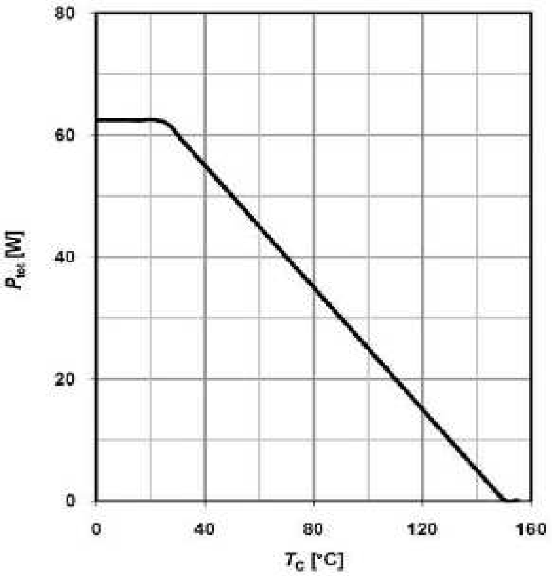
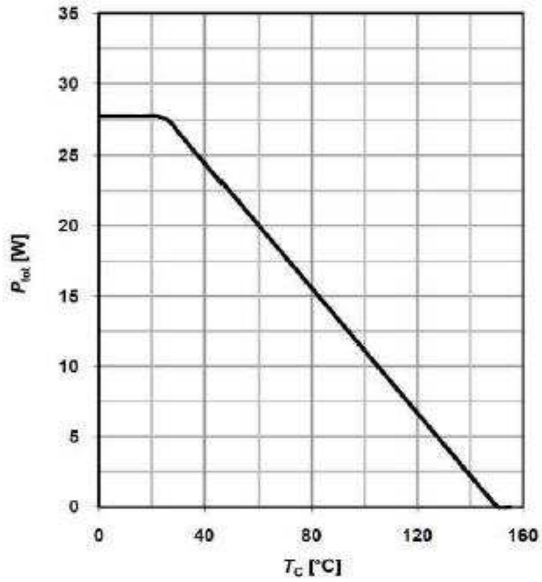
<table>
<tr><th>Power dissipation
Non FullPAK</th><th>Power dissipation
FULLPAK</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>$P_{tot} = f(T_C)$</td><td>$P_{tot} = f(T_C)$</td></tr>
</table>

Table 11

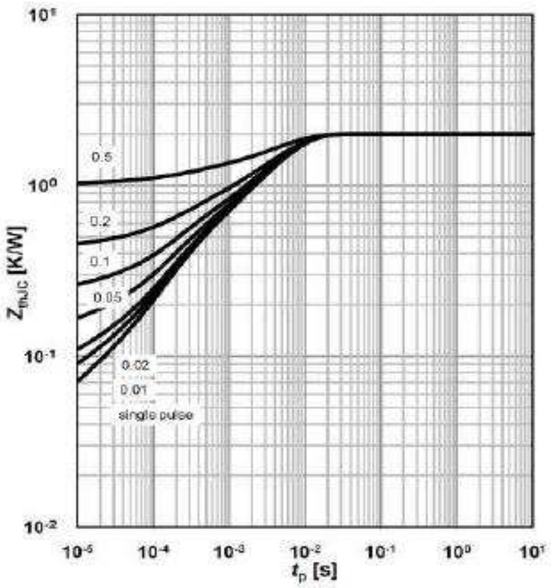
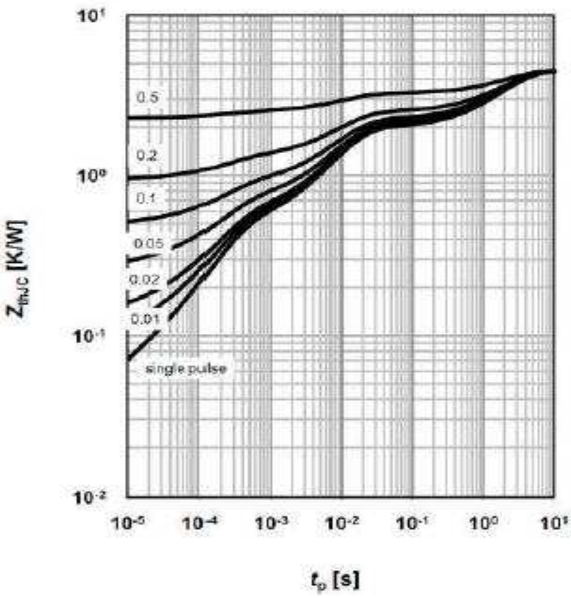
<table>
<tr><th>Max. transient thermal impedance
Non FullPAK</th><th>Max. transient thermal impedance
Non FullPAK</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>$Z_{(thJC)}=f(tp)$; parameter: $D=t_p/T$</td><td>$Z_{(thJC)}=f(tp)$; parameter: $D=t_p/T$</td></tr>
</table>

Table 12

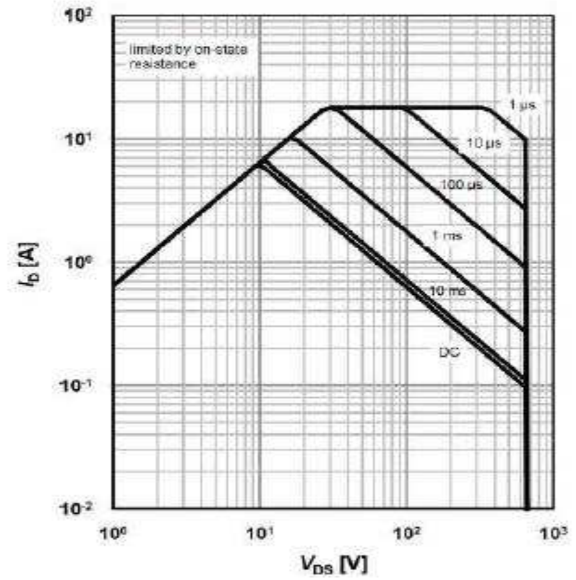
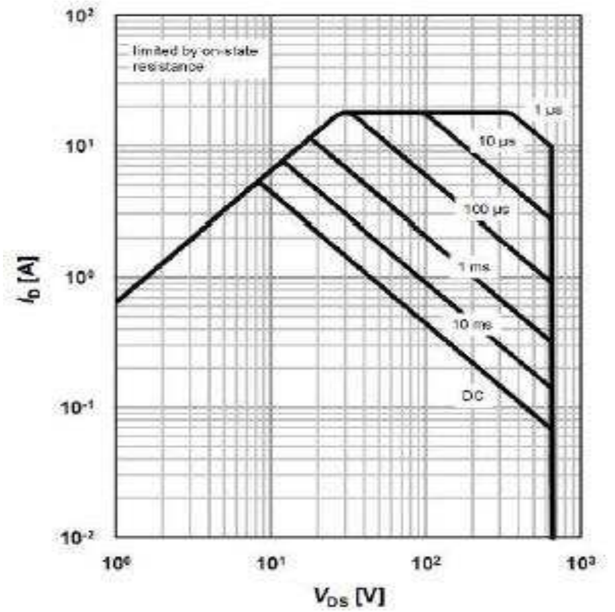
Safe operating area T_C=25°C Non FullPAK	Safe operating area T_C=25°C FullPAK
	
I_D=f(V_{DS}); T_C=25°C; V_{GS} > 7V; D=0; parameter t_p	I_D=f(V_{DS}); T_C=25°C; V_{GS} > 7V; D=0; parameter t_p

Table 13

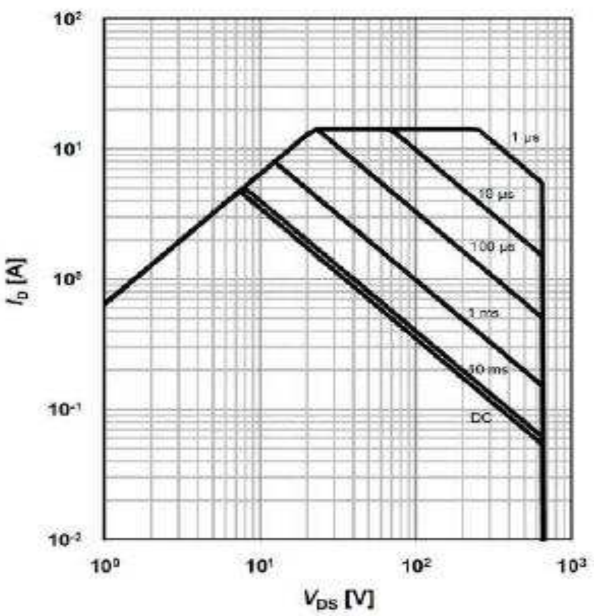
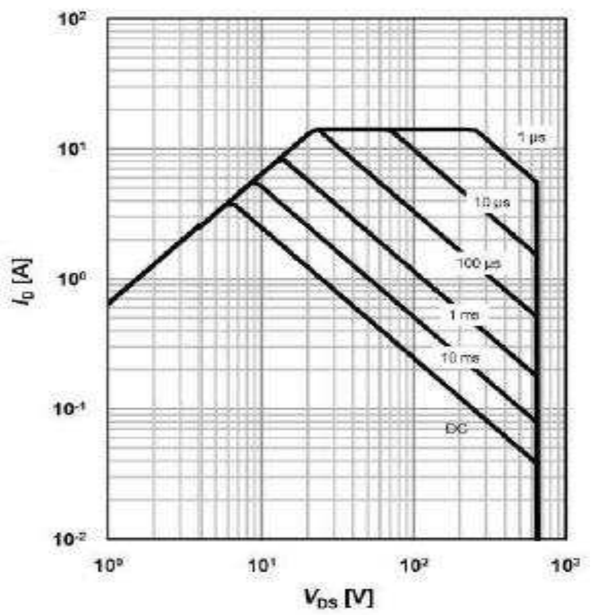
Safe operating area T_C=80°C Non FullPAK	Safe operating area T_C=80°C FullPAK
	
I_D=f(V_{DS}); T_C=80°C; V_{GS} > 7V; D=0; parameter t_p	I_D=f(V_{DS}); T_C=80°C; V_{GS} > 7V; D=0; parameter t_p

Table 14

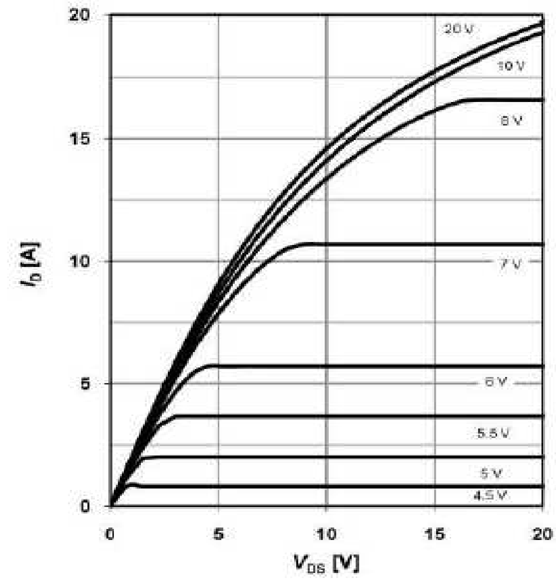
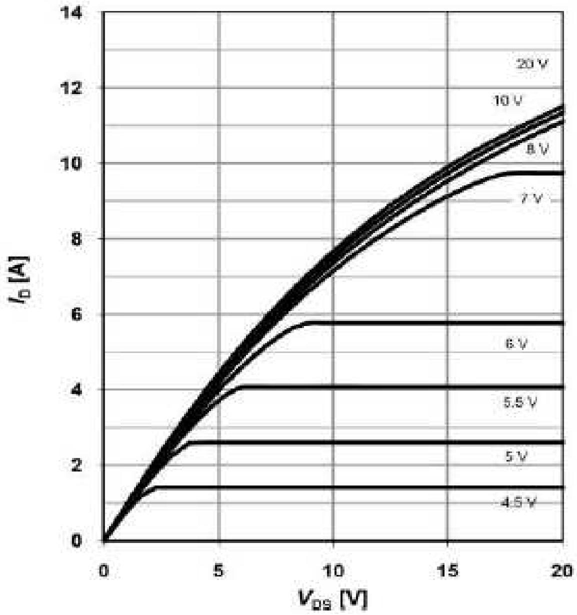
Typ. output characteristics T_C=25°C	Typ. output characteristics T_C=125°C
	
I_D=f(V_{DS}); T_j=25°C; parameter: V_{GS}	*I_D=f(V_{DS}); T_j=125°C; parameter: V_{GS}*

Table 15

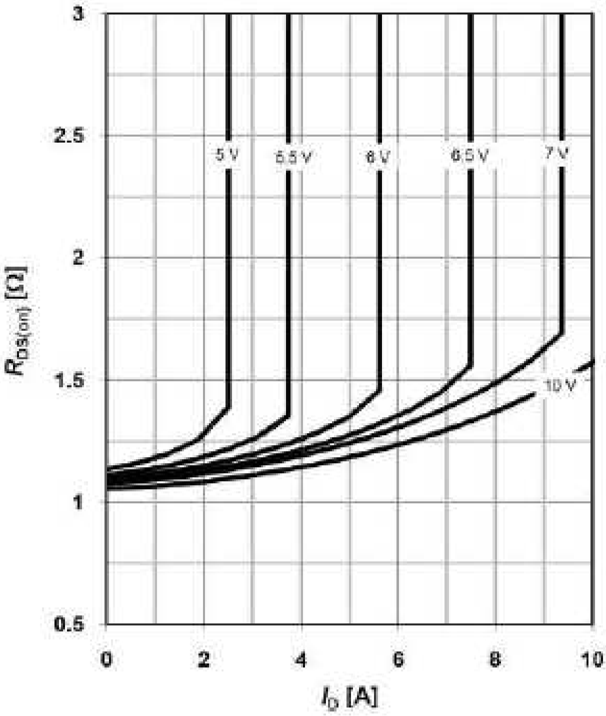
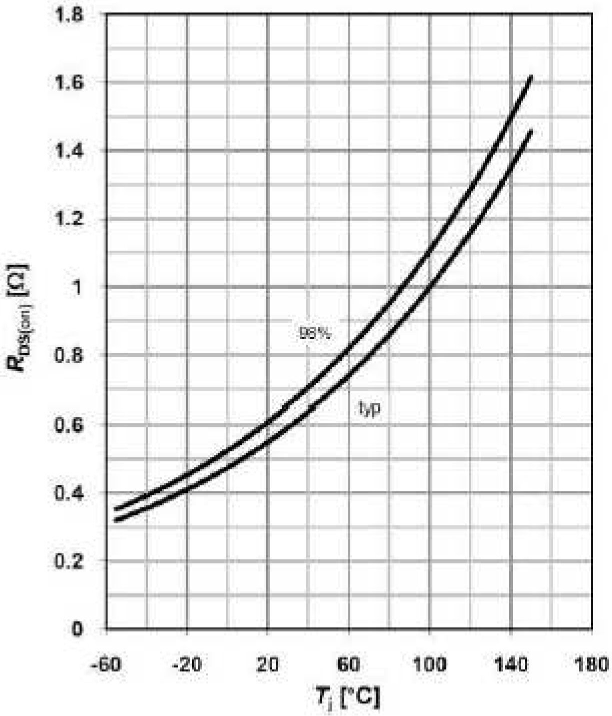
Typ. drain-source on-state resistance	Drain-source on-state resistance
	
$R_{DS(on)}$=f(I_D); T_j=125 °C; parameter: V_{GS}	*$R_{DS(on)}$= f(T_j); I_D=4.9A; V_{GS}=10V*

Table 16

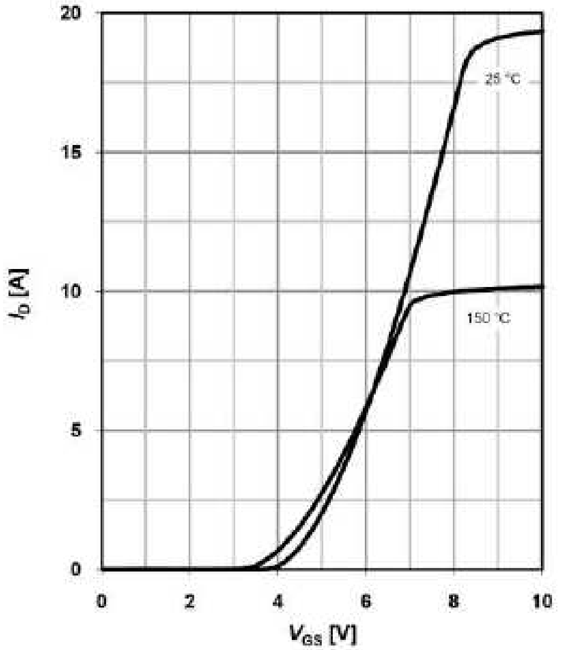
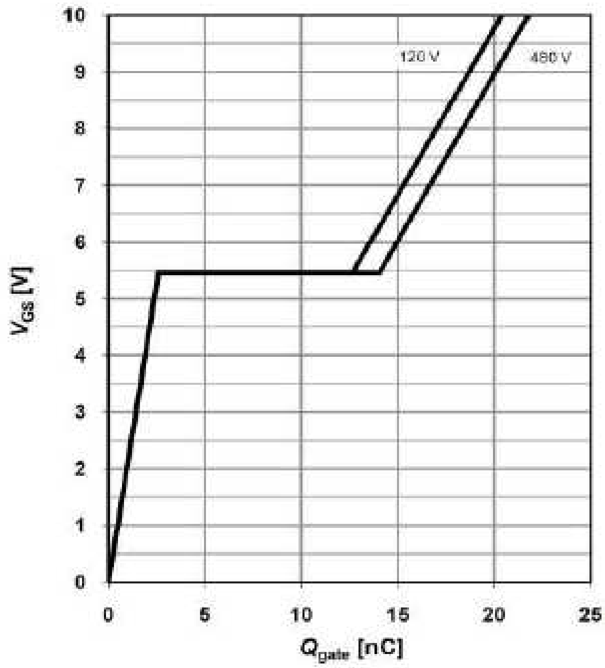
<table>
<tr><th>Typ. transfer characteristics</th><th>Typ. gate charge</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>I_D=f(V_{GS}); V_{DS}=20V</td><td>V_{GS}=f(Q_{gate}), I_D=4.9 A pulsed</td></tr>
</table>

Table 17

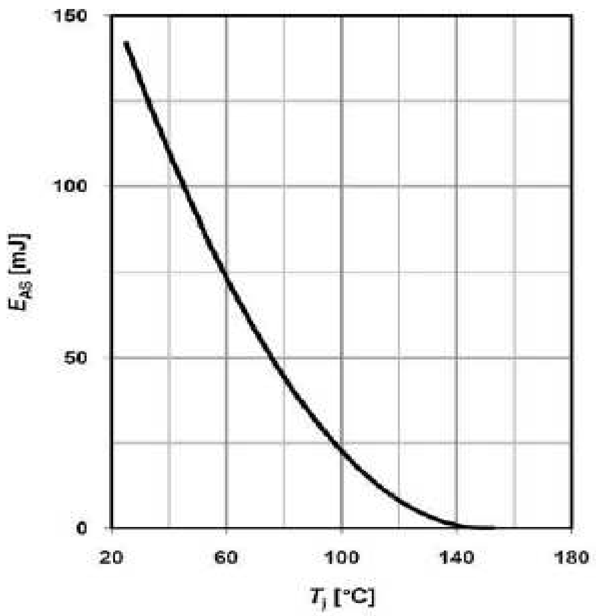
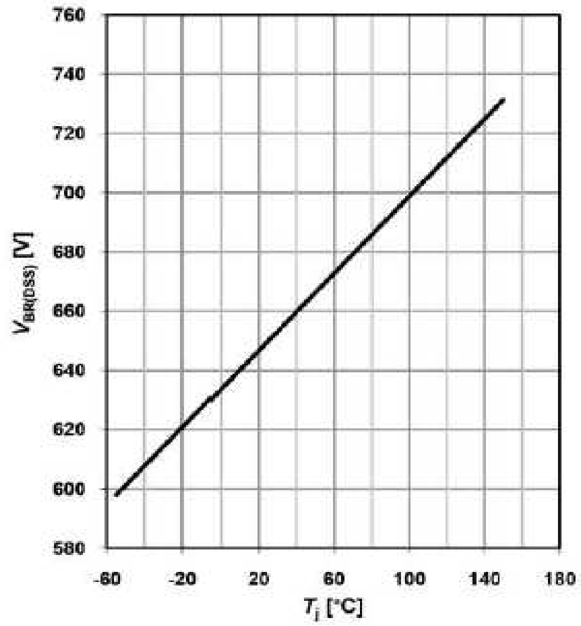
<table>
<tr><th>Avalanche energy</th><th>Drain-source breakdown voltage</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>E_{AS}=f(T_j); I_D=1.8 A; V_{DD}=50 V</td><td>$V_{BR(DSS)}$=f(T_j); I_D=1.0 mA</td></tr>
</table>

Table 18

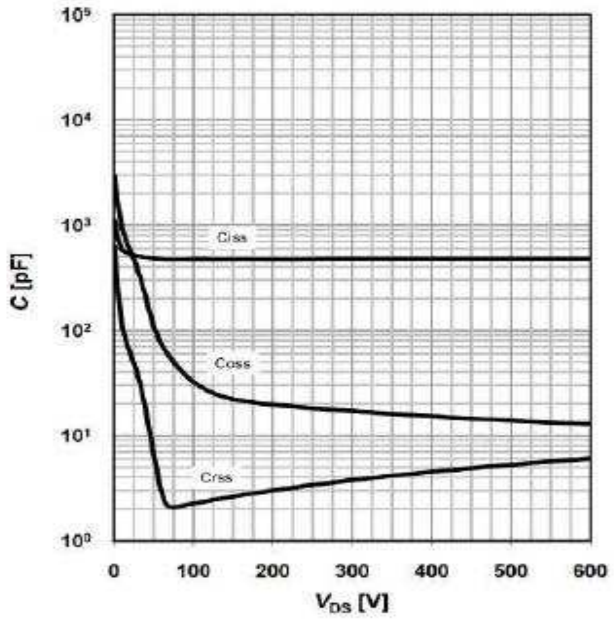
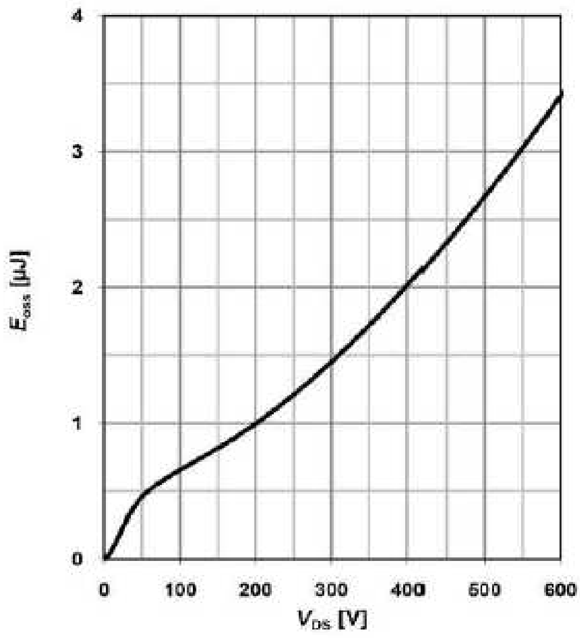
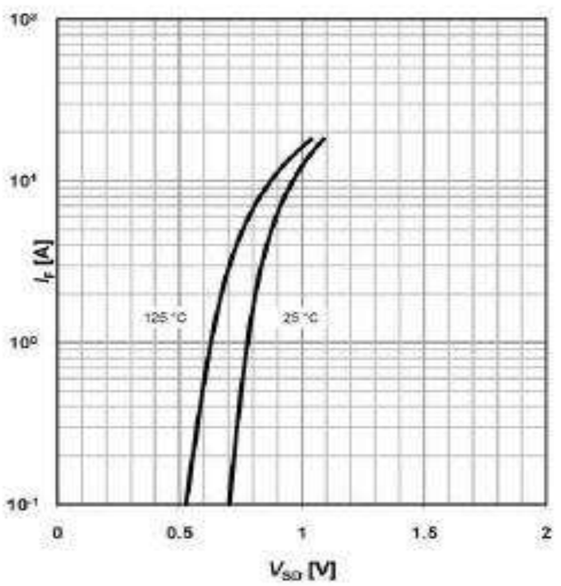
Typ. capacitances	**Typ. C_{OSS} stored energy**
	
$C=f(V_{DS})$; V_{GS}= 0 V; f=1 MHz	*$E_{OSS}=f(V_{DS})$*

Table 19

Forward characteristics of reverse diode

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

6 Test circuits

Table 20 Switching times test circuit and waveform for inductive load

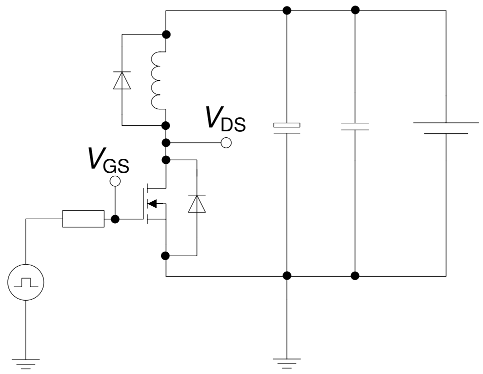
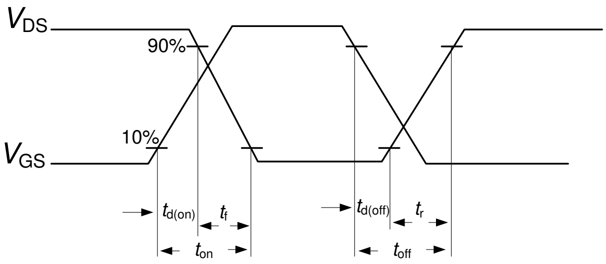
Switching times test circuit for inductive load	Switching time waveform
	

Table 11

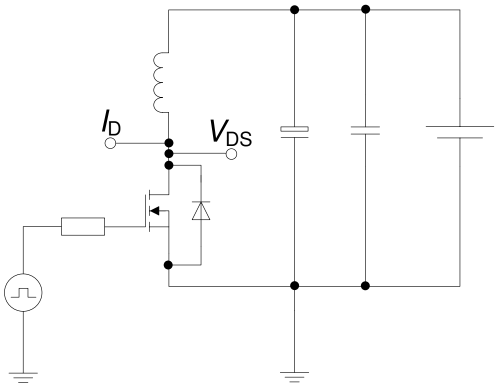
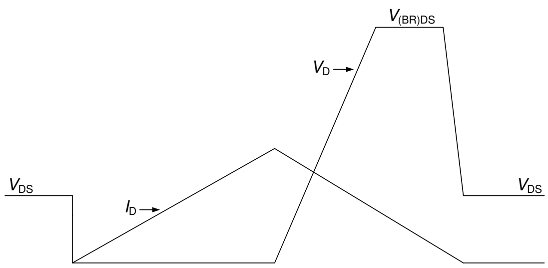
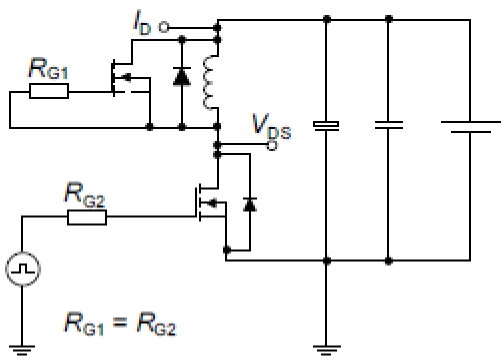
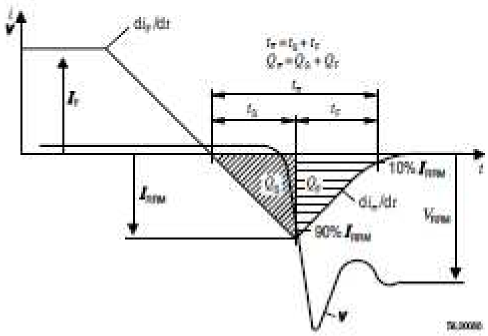
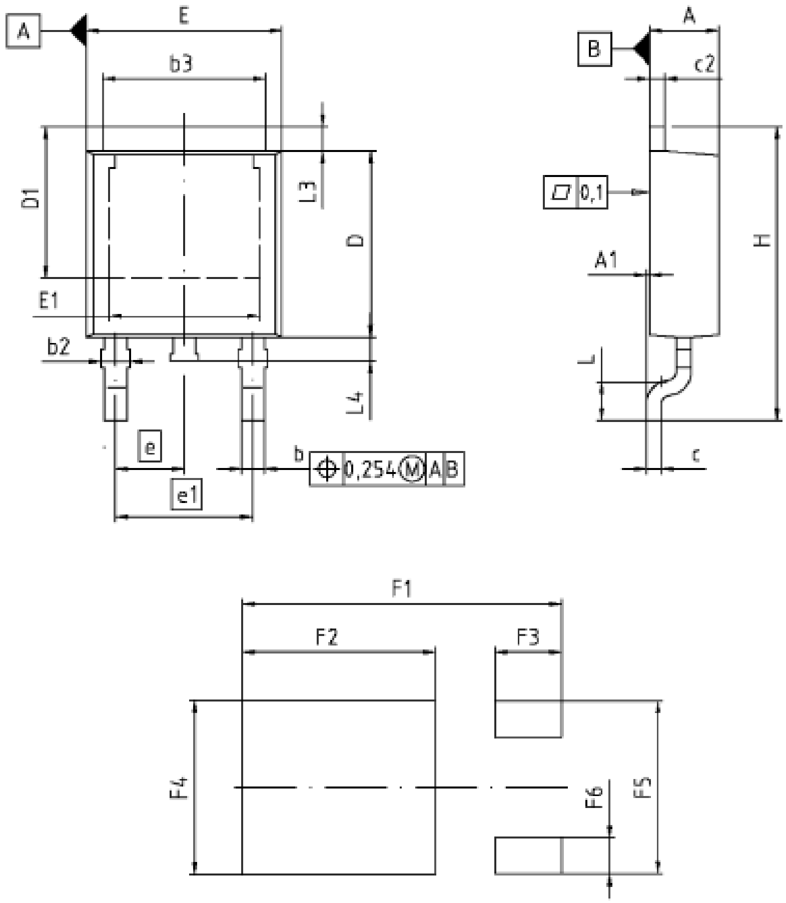
Unclamped inductive load test circuit	Unclamped inductive waveform
	

Table 22

Test circuit for diode characteristics	Diode recovery waveform
	

7 Package outlines



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	5.21	0.185	0.205
e	2.29		0.090	
e1	4.57		0.180	
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	10.50	10.70	0.413	0.421
F2	6.30	6.50	0.248	0.256
F3	2.10	2.30	0.083	0.091
F4	5.70	5.90	0.224	0.232
F5	5.66	5.86	0.223	0.231
F6	1.10	1.30	0.043	0.051

DOCUMENT NO.
Z8B00003328

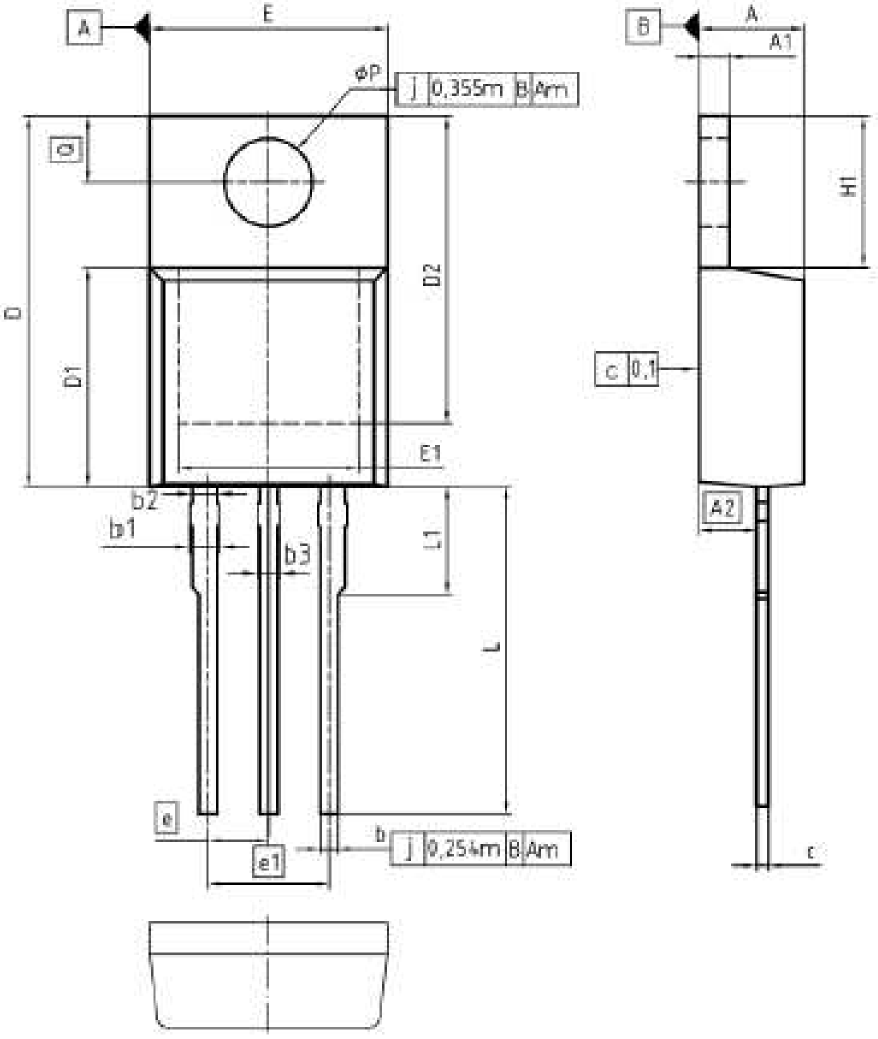
SCALE 0 2.0 4mm

EUROPEAN PROJECTION

ISSUE DATE
19-10-2007

REVISION
03

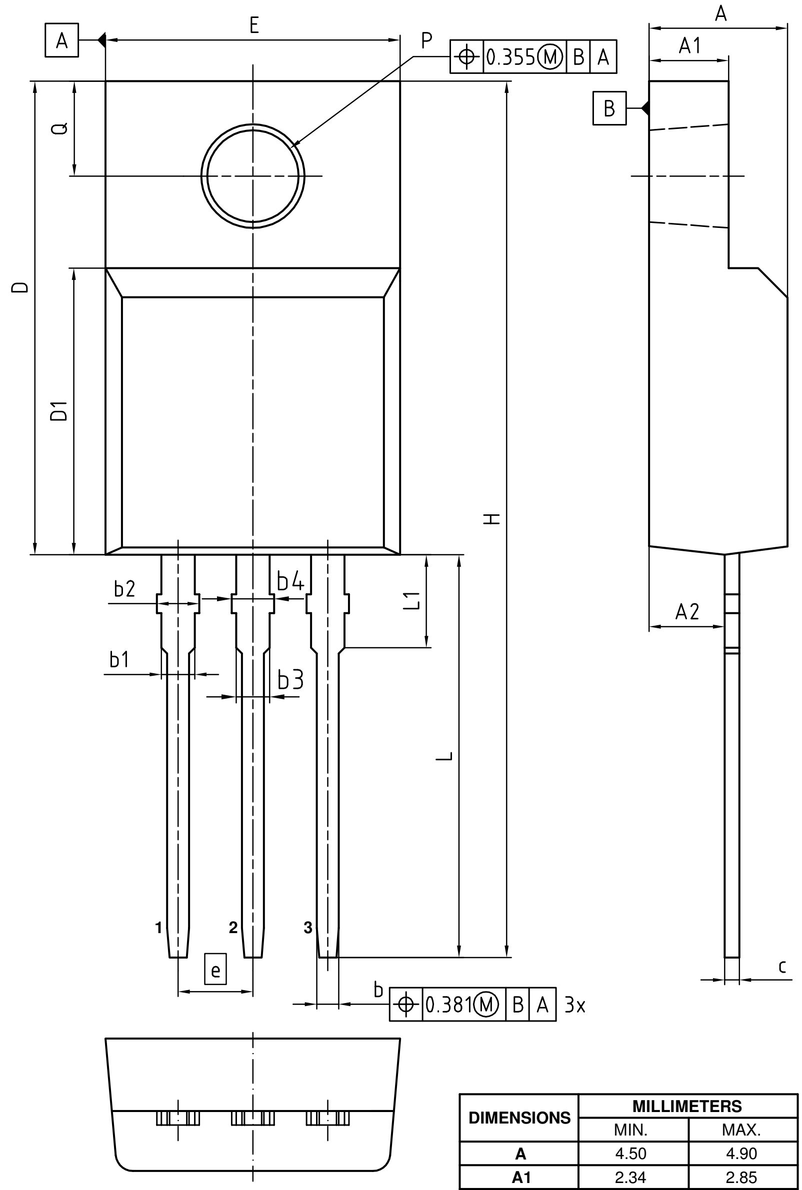
Figure 1 Outlines TO-252,, dimensions in mm/inches



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
øP	3.60	3.89	0.142	0.153
Q	2.60	3.00	0.102	0.118

DOCUMENT NO. Z8B00003318
SCALE 0 2.5 5mm
EUROPEAN PROJECTION
ISSUE DATE 23-08-2007
REVISION 05

Figure 2 Outlines TO220, dimensions in mm/inches



NOTES:
ALL DIMENSIONS REFER TO JEDEC STANDARD TO-281
AND DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS
OR GATE BURRS
GATE BURRS ARE LESS THAN 0.5 mm

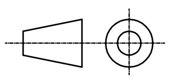
DIMENSIONS	MILLIMETERS	
	MIN.	MAX.
A	4.50	4.90
A1	2.34	2.85
A2	2.42	2.86
b	0.65	0.90
b1	0.95	1.38
b2	0.95	1.51
b3	0.65	1.38
b4	0.65	1.51
c	0.40	0.63
D	15.67	16.15
D1	8.97	9.83
E	10.00	10.65
e	2.54	
H	28.70	29.75
L	12.78	13.75
L1	2.83	3.45
øP	3.00	3.30
Q	3.15	3.50

DOCUMENT NO.
Z8B00003319

REVISION
07

SCALE 5:1
0 1 2 3 4 5mm

EUROPEAN PROJECTION



ISSUE DATE
27.01.2017

Figure 3 Outlines TO220 FullPAK, dimensions in mm

Revision History

IPx65R600E6

Revision: 2018-03-04, Rev. 2.3

Previous Revision		
Revision	Date	Subjects (major changes since last revision)
2.2	2016-08-04	Revised TO220 Full PAK package drawing on page 16
2.3	2018-03-04	Outline PG-TO-220 FullPAK update

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

Published by
Infineon Technologies AG
81726 München, Germany

Information
For further information on technology, delivery terms and conditions and prices please contact your 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.