

# MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## CoolMOS E6

650V CoolMOS™ E6 Power Transistor  
IPx65R380E6

## Data Sheet

Rev. 2.1, 2013-07-31  
Final

Industrial & Multimarket

## 1 Description

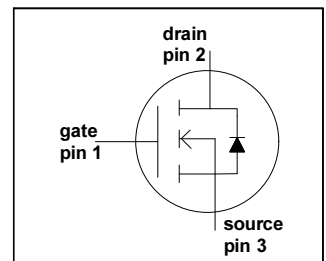
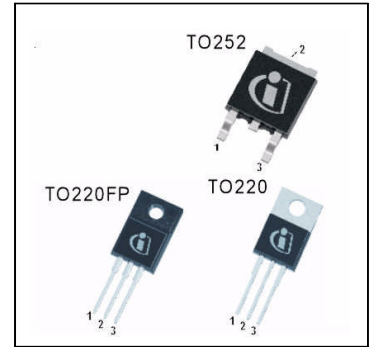
CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. CoolMOS™ E6 series combines the experience of the leading SJ MOSFET supplier with high class innovation. The resulting devices provide 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 FOM  $R_{DS(on)} \cdot Q_g$  and  $E_{oss}$
- Very high commutation ruggedness
- Easy to use/drive
- JEDEC<sup>1)</sup> qualified, Pb-free plating, available in Halogen free mold compound<sup>2)</sup>

### 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
$R_{DS(on),max}$	0.38	$\Omega$
$Q_{g,typ}$	39	nC
$I_{D,pulse}$	29	A
$E_{oss} @ 400V$	2.8	$\mu J$
Body diode $di/dt$	500	A/ $\mu s$

Type / Ordering Code	Package	Marking	Related Links
IPD65R380E6	PG-TO252	65E6380	<a href="#">IFX CoolMOS Webpage</a> <a href="#">IFX Design tools</a>
IPP65R380E6	PG-TO220		
IPA65R380E6	PG-TO220 FullPAK		

1) J-STD20 and JESD22

2) For PG-TO252: non-Halogen free (OPN: IPD65R380E6BT); Halogen free (OPN: IPD65R380E6AT)

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## 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 <sup>1)</sup>	$I_D$	-	-	10.6	A	$T_C = 25\text{ °C}$
				6.7		$T_C = 100\text{ °C}$
Pulsed drain current <sup>2)</sup>	$I_{D,pulse}$	-	-	29	A	$T_C = 25\text{ °C}$
Avalanche energy, single pulse	$E_{AS}$	-	-	215	mJ	$I_D = 1.8\text{ A}, V_{DD} = 50\text{ V}$ (see table 21)
Avalanche energy, repetitive	$E_{AR}$	-	-	0.32		$I_D = 1.8\text{ A}, V_{DD} = 50\text{ V}$
Avalanche current, repetitive	$I_{AR}$	-	-	1.8	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 Non FullPAK	$P_{tot}$	-	-	83	W	$T_C = 25\text{ °C}$
Power dissipation for FullPAK	$P_{tot}$	-	-	31	W	$T_C = 25\text{ °C}$
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
Continuous diode forward current	$I_S$	-	-	9.2	A	$T_C = 25\text{ °C}$
Diode pulse current <sup>2)</sup>	$I_{S,pulse}$	-	-	29	A	$T_C = 25\text{ °C}$
Reverse diode dv/dt <sup>3)</sup>	dv/dt	-	-	15	V/ns	$V_{DS} = 0 \dots 480\text{ V}, I_{SD} \leq I_D,$ $T_j = 125\text{ °C}$ (see table 22)
Maximum diode commutation speed <sup>3)</sup>	di/dt			500		A/ $\mu\text{s}$

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**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	-	1.5	°C/W	leaded
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 TO-220FullPAK**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	-	4.0	°C/W	leaded
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 TO-252**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	-	1.5	°C/W	SMD version, device on PCB, minimal footprint
Thermal resistance, junction - ambient	$R_{thJA}$	-	-	62		
				35		
Soldering temperature, wave- & reflowsoldering allowed	$T_{sold}$	-	-	260	°C	reflow MSL1

1) Device on 40mm\*40mm\*1.5 epoxy PCB FR4 with 6cm<sup>2</sup> (one layer, 70µm thick) copper area for drain connection. PCB is vertical without air stream cooling.

## 4 Electrical characteristics

Electrical characteristics, at  $T_J=25\text{ °C}$ , 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		$V_{DS}=V_{GS}$ , $I_D=0.32\text{ mA}$
Zero gate voltage drain current	$I_{DSS}$	-	-	1	$\mu\text{A}$	$V_{DS}=600\text{ V}$ , $V_{GS}=0\text{ V}$ , $T_J=25\text{ °C}$
		-	10	-		$V_{DS}=600\text{ V}$ , $V_{GS}=0\text{ V}$ , $T_J=150\text{ °C}$
Gate-source leakage current	$I_{GSS}$	-	-	100	nA	$V_{GS}=20\text{ V}$ , $V_{DS}=0\text{ V}$
Drain-source on-state resistance	$R_{DS(on)}$	-	0.34	0.38	$\Omega$	$V_{GS}=10\text{ V}$ , $I_D=3.2\text{ A}$ , $T_J=25\text{ °C}$
		-	0.89	-		$V_{GS}=10\text{ V}$ , $I_D=3.2\text{ A}$ , $T_J=150\text{ °C}$
Gate resistance	$R_G$	-	7.5	-	$\Omega$	$f=1\text{ MHz}$ , open drain

**Table 7 Dynamic characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition	
		Min.	Typ.	Max.			
Input capacitance	$C_{iss}$	-	710	-	pF	$V_{GS}=0\text{ V}$ , $V_{DS}=100\text{ V}$ , $f=1\text{ MHz}$	
Output capacitance	$C_{oss}$	-	41	-			
Effective output capacitance, energy related <sup>1)</sup>	$C_{o(er)}$	-	32	-			$V_{GS}=0\text{ V}$ , $V_{DS}=0\dots480\text{ V}$
Effective output capacitance, time related <sup>2)</sup>	$C_{o(tr)}$	-	140	-			$I_D=\text{constant}$ , $V_{GS}=0\text{ V}$ $V_{DS}=0\dots480\text{ V}$
Turn-on delay time	$t_{d(on)}$	-	10	-	ns	$V_{DD}=400\text{ V}$ , $V_{GS}=13\text{ V}$ , $I_D=4.9\text{ A}$ , $R_G=3.4\text{ }\Omega$ (see table 20)	
Rise time	$t_r$	-	7	-			
Turn-off delay time	$t_{d(off)}$	-	57	-			
Fall time	$t_f$	-	8	-			

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	$Q_{gs}$	-	4	-	nC	$V_{DD}=480\text{ V}$ , $I_D=4.9\text{ A}$ , $V_{GS}=0\text{ to }10\text{ V}$
Gate to drain charge	$Q_{gd}$	-	20	-		
Gate charge total	$Q_g$	-	39	-		
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	$V_{GS}=0\text{ V}$ , $I_F=4.9\text{ A}$ , $T_j=25\text{ °C}$
Reverse recovery time	$t_{rr}$	-	280	-	ns	$V_R=400\text{ V}$ , $I_F=4.9\text{ A}$ , $di_F/dt=100\text{ A}/\mu\text{s}$ (see table 22)
Reverse recovery charge	$Q_{rr}$	-	2.8	-	$\mu\text{C}$	
Peak reverse recovery current	$I_{rrm}$	-	17	-	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: $D = t_p / T$



Electrical characteristics diagrams

Table 12

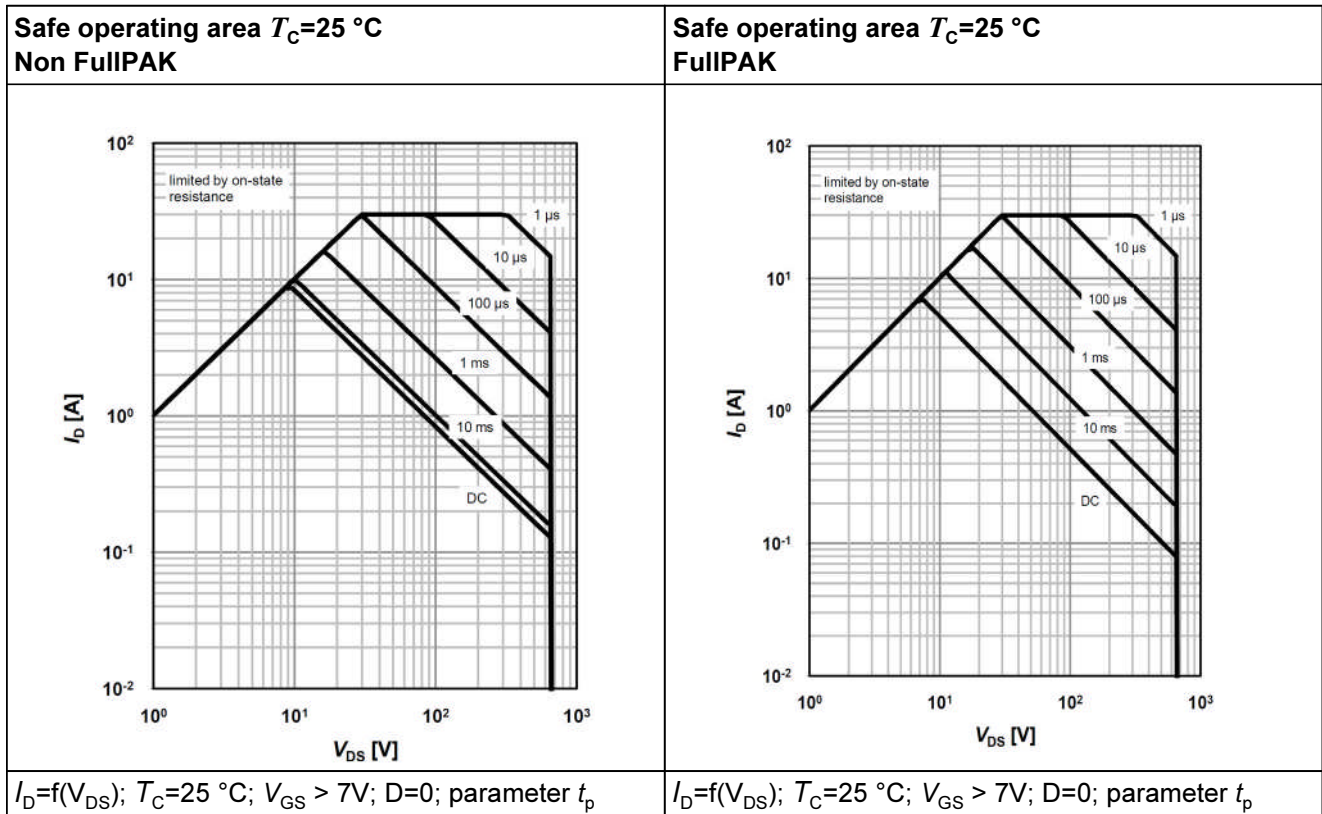


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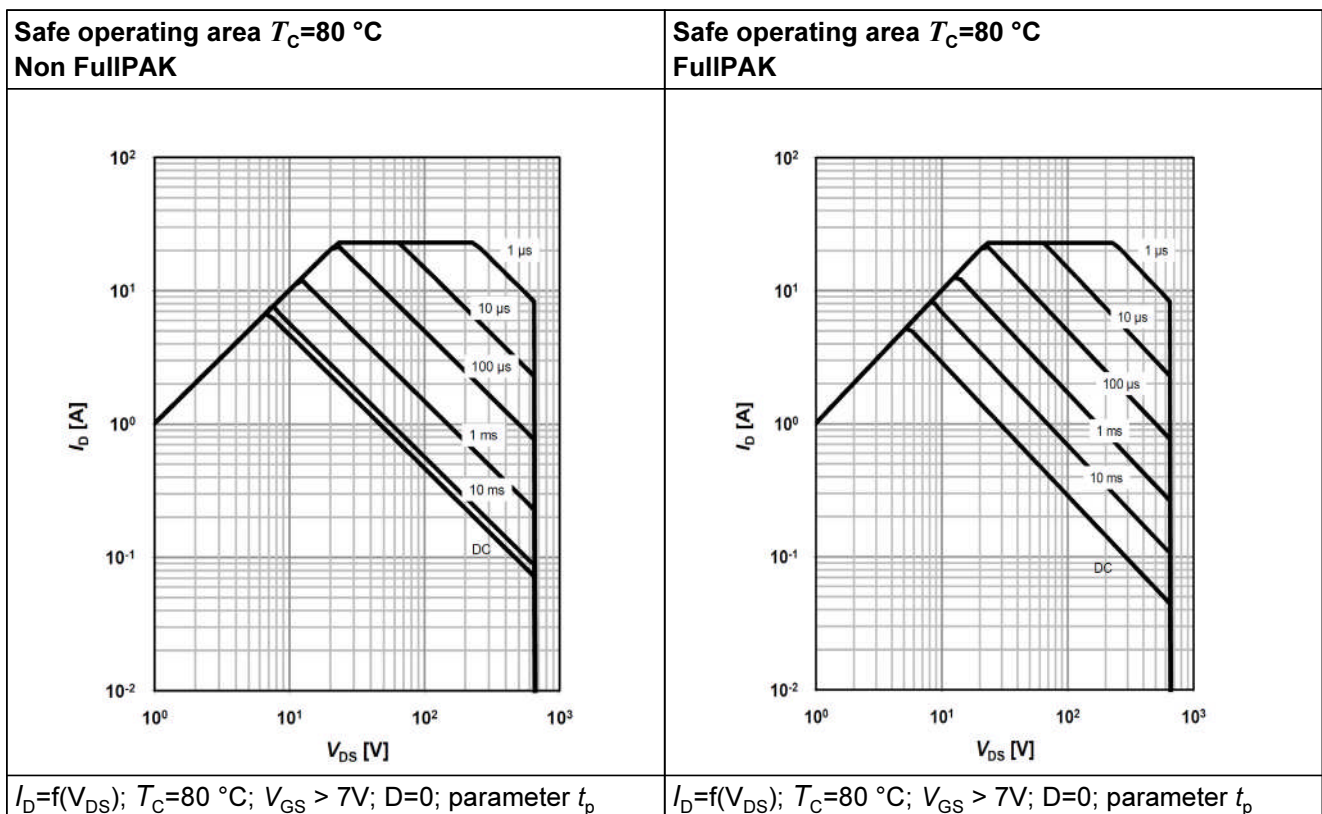


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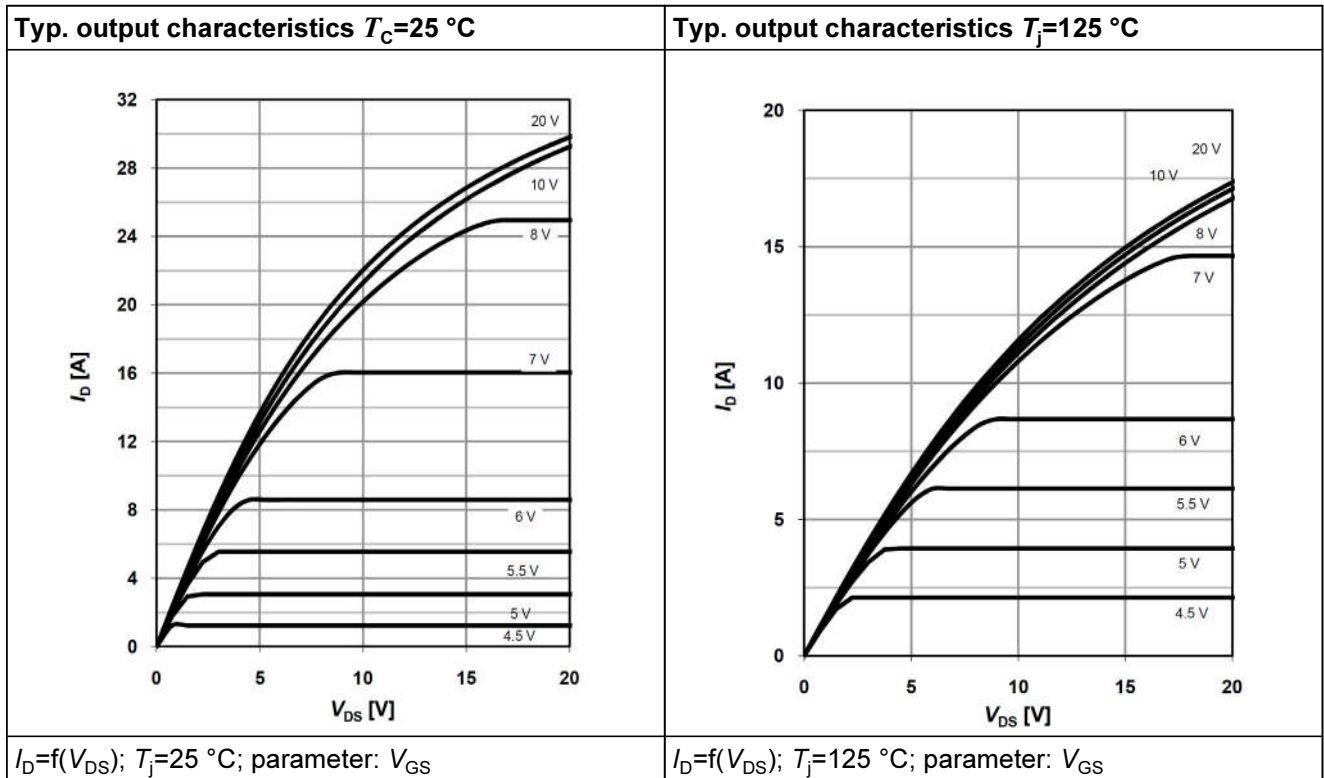


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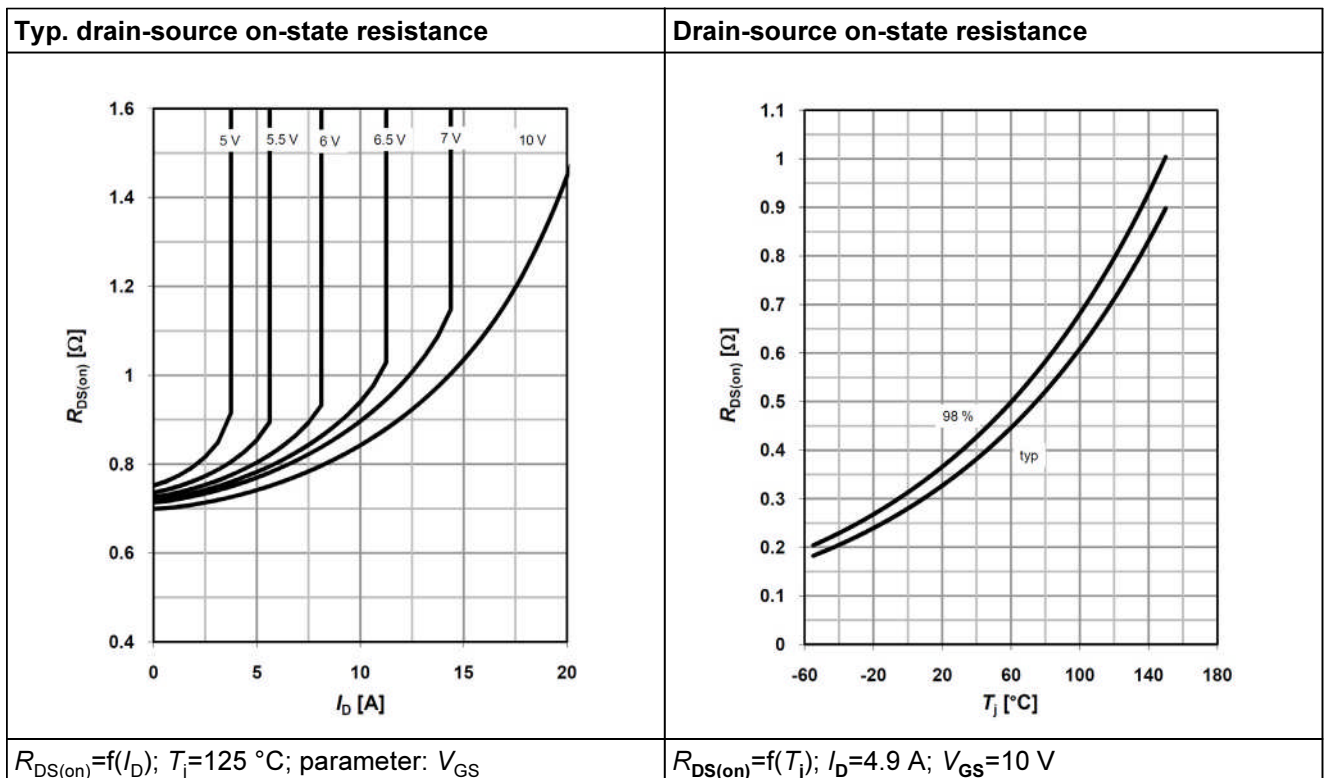


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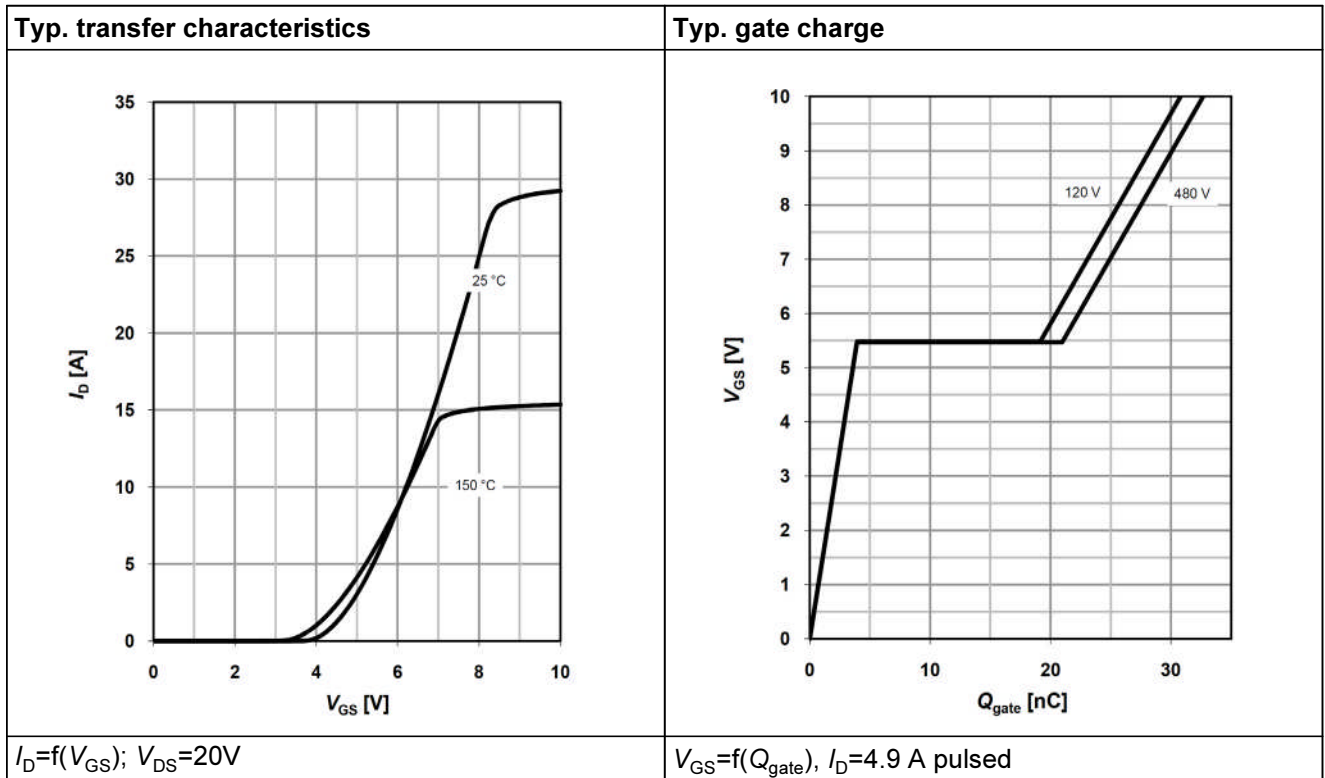


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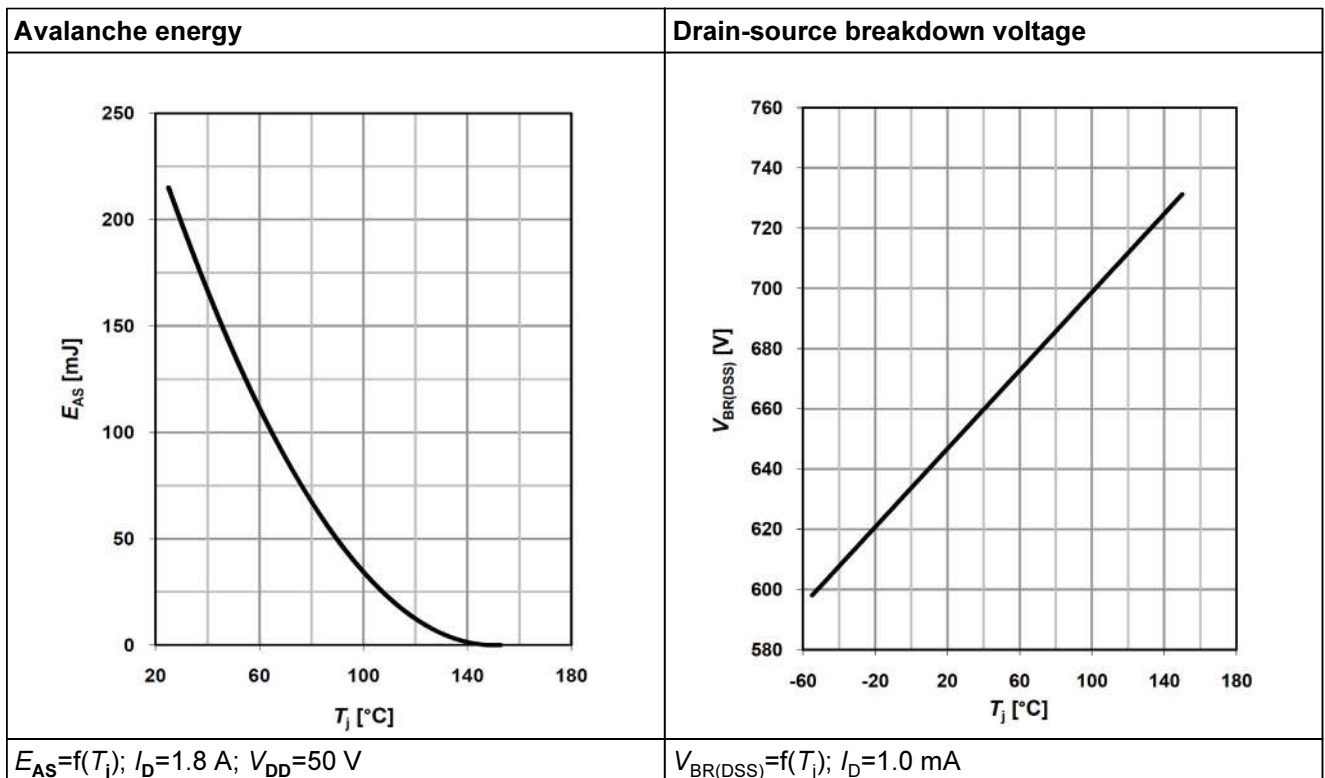


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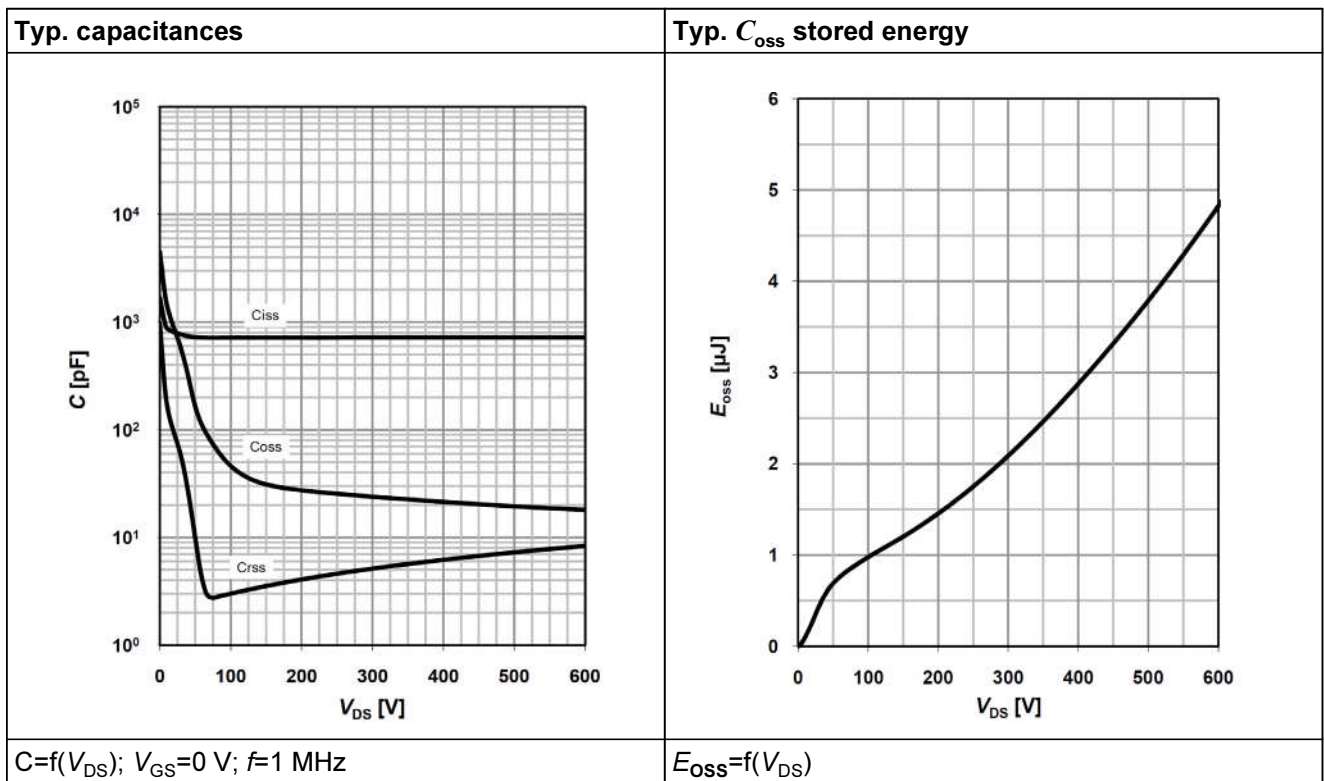
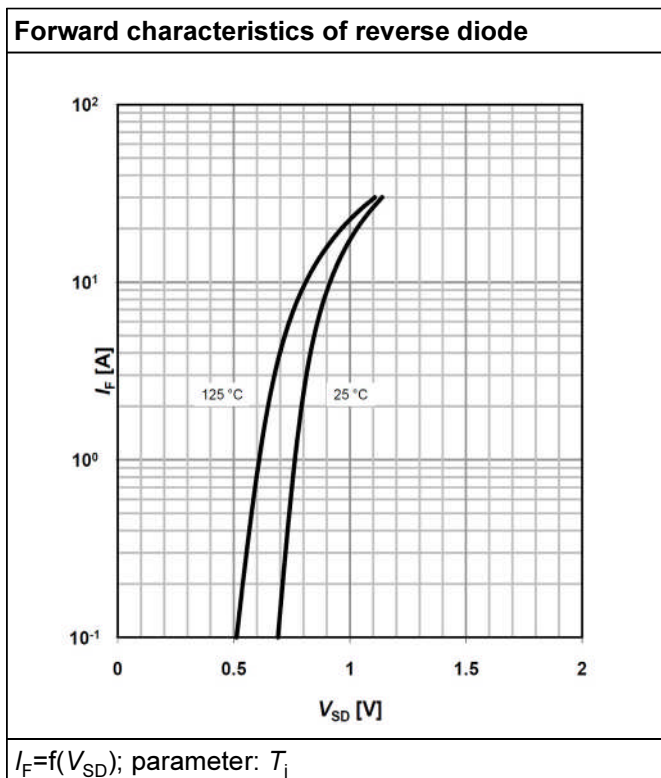


Table 19



## 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

## 7 Package outlines

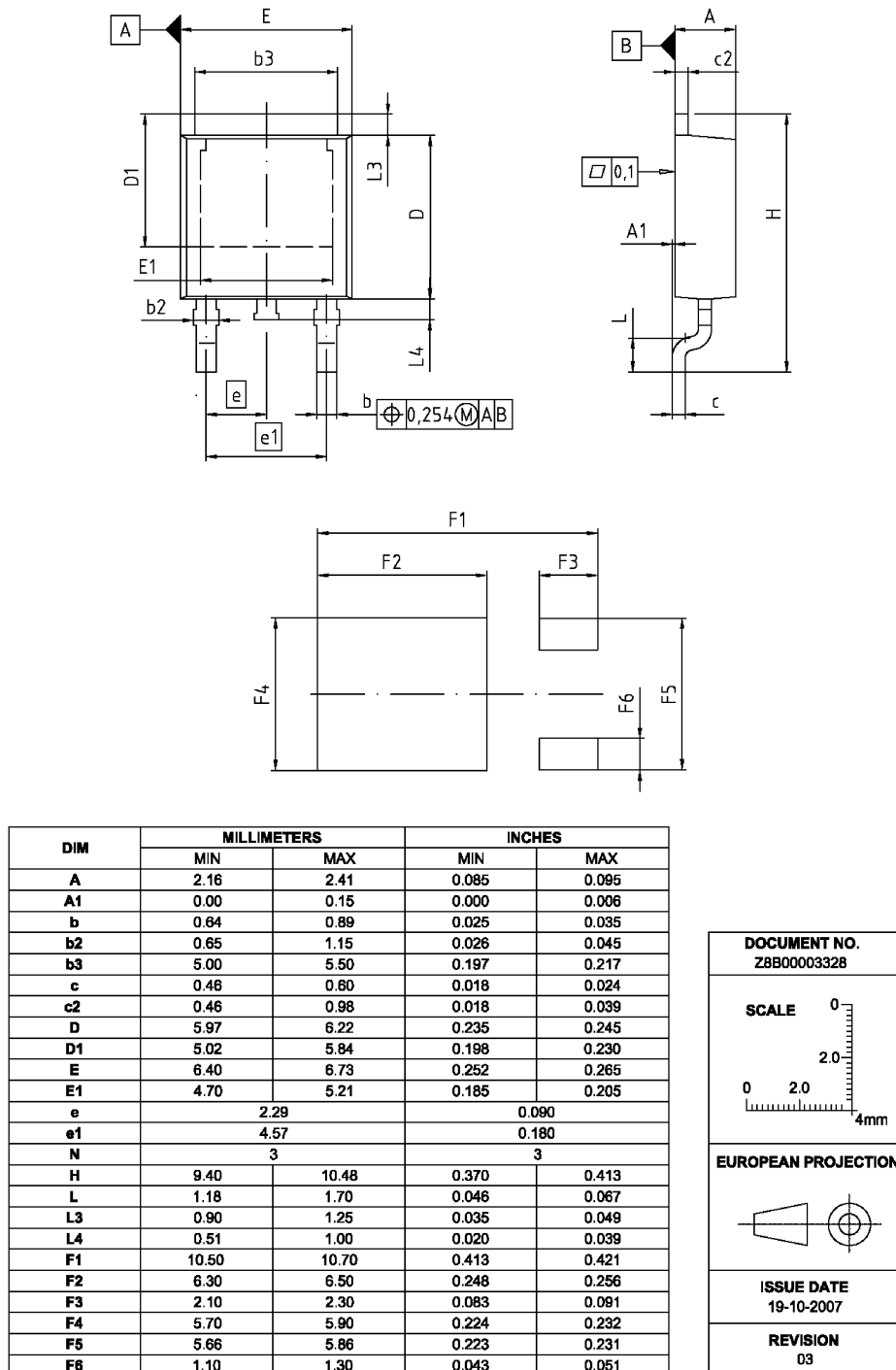
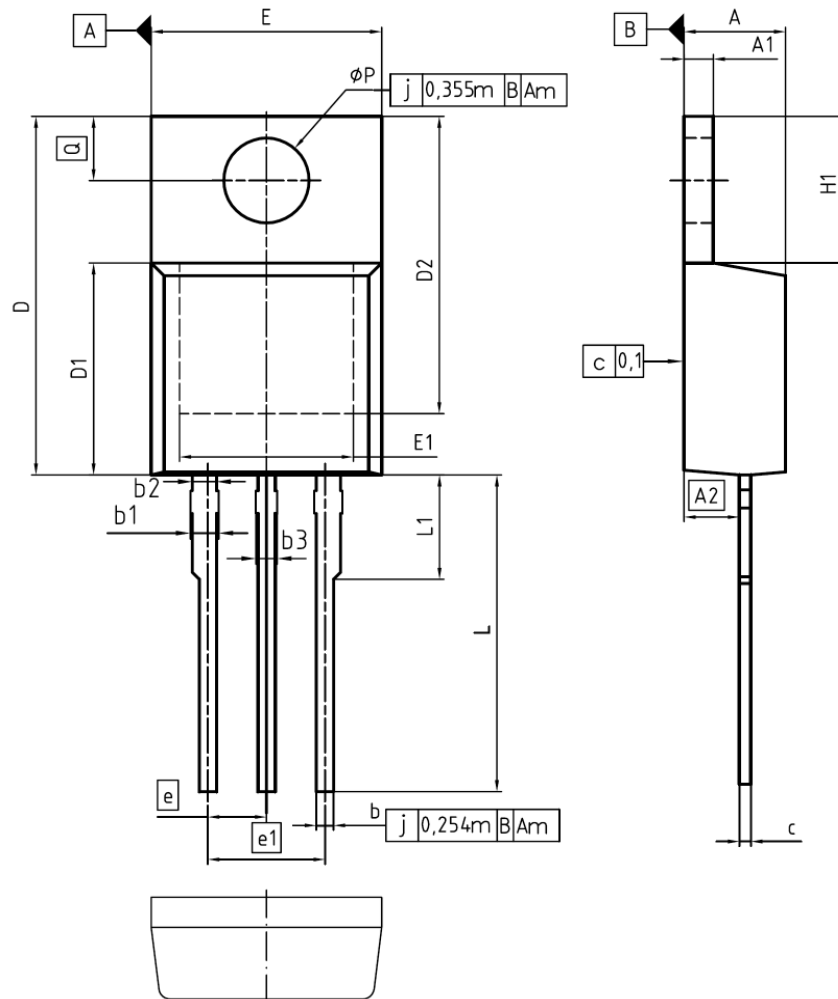


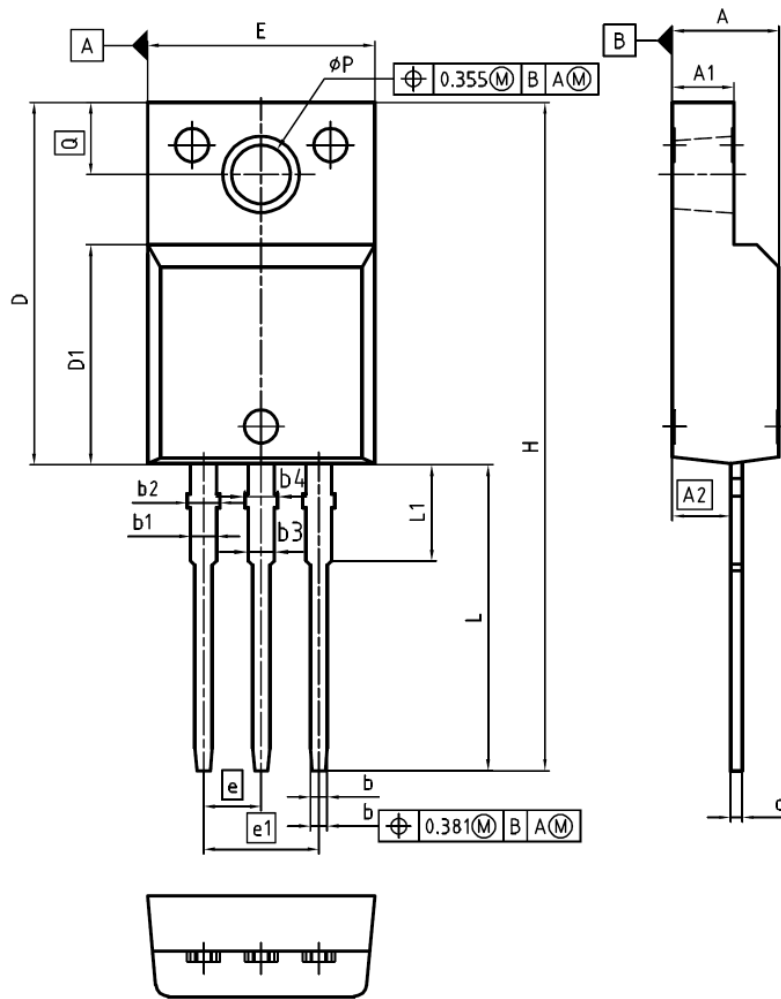
Figure 1 Outlines TO-252, dimensions in mm/inches



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
phi P	3.60	3.89	0.142	0.153
Q	2.60	3.00	0.102	0.118

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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

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03

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



## 8 Revision History

Revision History: 2013-07-31, Rev. 2.1

Previous Revision: 2.0

Revision	Subjects (major changes since last revision)
2.0	Release of final data sheet
2.1	Update halogen free mold compound status of PG-TO252 package

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