

## MOSFET

Metal Oxide Semiconductor Field Effect Transistor

### CoolMOS™ E6 600V

600V CoolMOS™ E6 Power Transistor  
IPx60R280E6

## Data Sheet

Rev. 2.2  
Final

## 600V CoolMOS™ E6 Power Transistor

IPP60R280E6, IPA60R280E6  
IPW60R280E6

### 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 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.

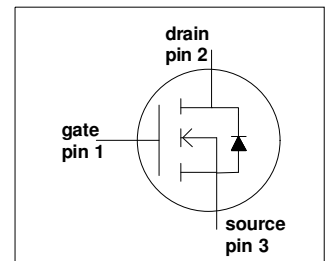
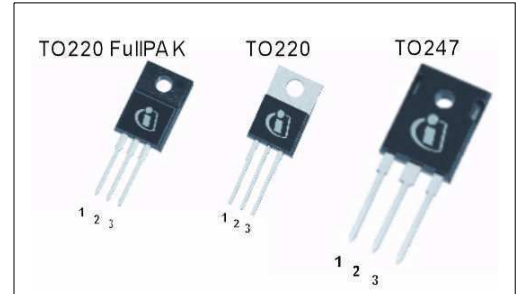
#### Features

- 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
- JEDEC<sup>1)</sup> 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
$V_{DS} @ T_{j,max}$	650	V
$R_{DS(on),max}$	0.28	$\Omega$
$Q_{g,typ}$	43	nC
$I_{D,pulse}$	40	A
$E_{oss} @ 400V$	3.7	$\mu J$
Body diode $di/dt$	500	$A/\mu s$

Type / Ordering Code	Package	Marking	Related Links
IPW60R280E6	PG-TO247	6R280E6	<a href="#">IFX CoolMOS Webpage</a> <a href="#">IFX Design tools</a>
IPP60R280E6	PG-TO220		
IPA60R280E6	PG-TO220 FullPAK		

1) J-STD20 and JESD22

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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>	$I_D$	-	-	13.8	A	$T_C = 25\text{ °C}$
				8.7		$T_C = 100\text{ °C}$
Pulsed drain current <sup>2)</sup>	$I_{D,pulse}$	-	-	40	A	$T_C = 25\text{ °C}$
Avalanche energy, single pulse	$E_{AS}$	-	-	284	mJ	$I_D = 2.4\text{ A}, V_{DD} = 50\text{ V}$ (see table 21)
Avalanche energy, repetitive	$E_{AR}$	-	-	0.43		$I_D = 2.4\text{ A}, V_{DD} = 50\text{ V}$
Avalanche current, repetitive	$I_{AR}$	-	-	2.4	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	$P_{tot}$	-	-	104	W	$T_C = 25\text{ °C}$
Power dissipation for TO-220 FullPAK	$P_{tot}$	-	-	32		
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	$I_S$	-	-	12	A	$T_C = 25\text{ °C}$
Diode pulse current <sup>2)</sup>	$I_{S,pulse}$	-	-	40	A	$T_C = 25\text{ °C}$
Reverse diode dv/dt <sup>3)</sup>	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 <sup>3)</sup>	di/dt			500	A/ $\mu$ s	(see table 22)

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 (IPP60R280E6), TO-247 (IPW60R280E6)**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	-	1.2	°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 (IPA60R280E6)**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	-	3.9	°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

## 4 Electrical characteristics

Electrical characteristics, at  $T_J=25\text{ °C}$ , 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	$V_{GS}=0\text{ V}$ , $I_D=0.25\text{ mA}$
Gate threshold voltage	$V_{GS(th)}$	2.5	3	3.5		$V_{DS}=V_{GS}$ , $I_D=0.43\text{ mA}$
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	$R_{DS(on)}$	-	0.25	0.28	$\Omega$	$V_{GS}=10\text{ V}$ , $I_D=6.5\text{ A}$ , $T_J=25\text{ °C}$
		-	0.66	-		$V_{GS}=10\text{ V}$ , $I_D=6.5\text{ A}$ , $T_J=150\text{ °C}$
Gate resistance	$R_G$	-	7	-	$\Omega$	$f=1\text{ MHz}$ , open drain

**Table 6 Dynamic characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	$C_{iss}$	-	950	-	pF	$V_{GS}=0\text{ V}$ , $V_{DS}=100\text{ V}$ , $f=1\text{ MHz}$
Output capacitance	$C_{oss}$	-	60	-		
Effective output capacitance, energy related <sup>1)</sup>	$C_{o(er)}$	-	40	-		
Effective output capacitance, time related <sup>2)</sup>	$C_{o(tr)}$	-	183	-		$I_D=\text{constant}$ , $V_{GS}=0\text{ V}$ $V_{DS}=0\dots480\text{ V}$
Turn-on delay time	$t_{d(on)}$	-	11	-	ns	$V_{DD}=400\text{ V}$ , $V_{GS}=13\text{ V}$ , $I_D=6.5\text{ A}$ , $R_G=3.4\text{ }\Omega$ (see table 20)
Rise time	$t_r$	-	9	-		
Turn-off delay time	$t_{d(off)}$	-	71	-		
Fall time	$t_f$	-	9	-		

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 7 Gate charge characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate to source charge	$Q_{gs}$	-	5	-	nC	$V_{DD}=480\text{ V}$ , $I_D=6.5\text{ A}$ , $V_{GS}=0\text{ to }10\text{ V}$
Gate to drain charge	$Q_{gd}$	-	22	-		
Gate charge total	$Q_g$	-	43	-		
Gate plateau voltage	$V_{plateau}$	-	5.4	-	V	

**Table 8 Reverse diode characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Diode forward voltage	$V_{SD}$	-	0.9	-	V	$V_{GS}=0\text{ V}$ , $I_F=6.5\text{ A}$ , $T_j=25\text{ °C}$
Reverse recovery time	$t_{rr}$	-	345	-	ns	$V_R=400\text{ V}$ , $I_F=6.5\text{ A}$ , $di_F/dt=100\text{ A}/\mu\text{s}$ (see table 22)
Reverse recovery charge	$Q_{rr}$	-	4.5	-	$\mu\text{C}$	
Peak reverse recovery current	$I_{rrm}$	-	24	-	A	

5 Electrical characteristics diagrams

Table 9

<p><b>Power dissipation</b> TO-220, TO-247, TO-262, TO-263</p>	<p><b>Power dissipation</b> TO-220 FullPAK</p>
<p><math>P_{tot} = f(T_C)</math></p>	<p><math>P_{tot} = f(T_C)</math></p>

Table 10

<p><b>Max. transient thermal impedance</b> TO-220, TO-247, TO-262, TO-263</p>	<p><b>Max. transient thermal impedance</b> TO-220 FullPAK</p>
<p><math>Z_{(thJC)} = f(t_p)</math>; parameter: <math>D = t_p / T</math></p>	<p><math>Z_{(thJC)} = f(t_p)</math>; parameter: <math>D = t_p / T</math></p>



Electrical characteristics diagrams

Table 11

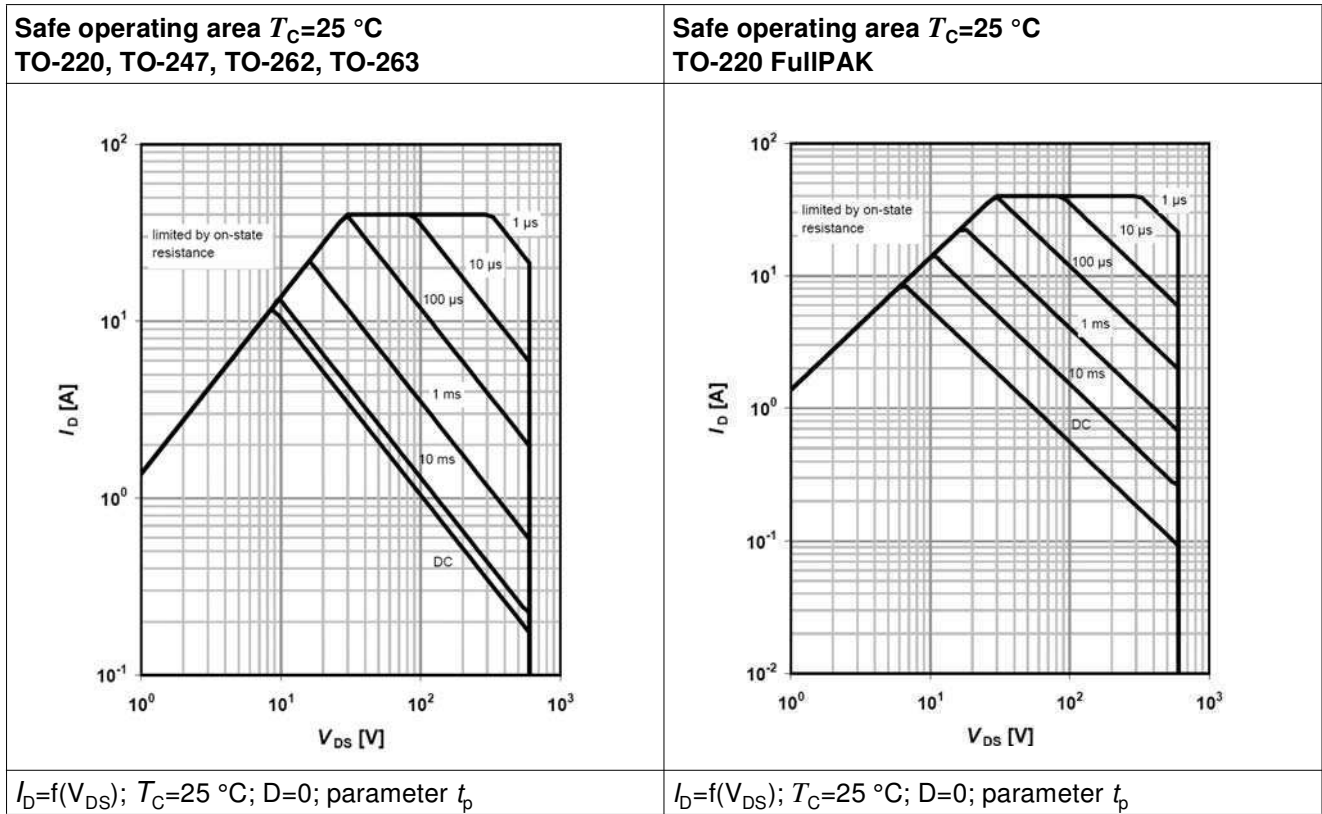


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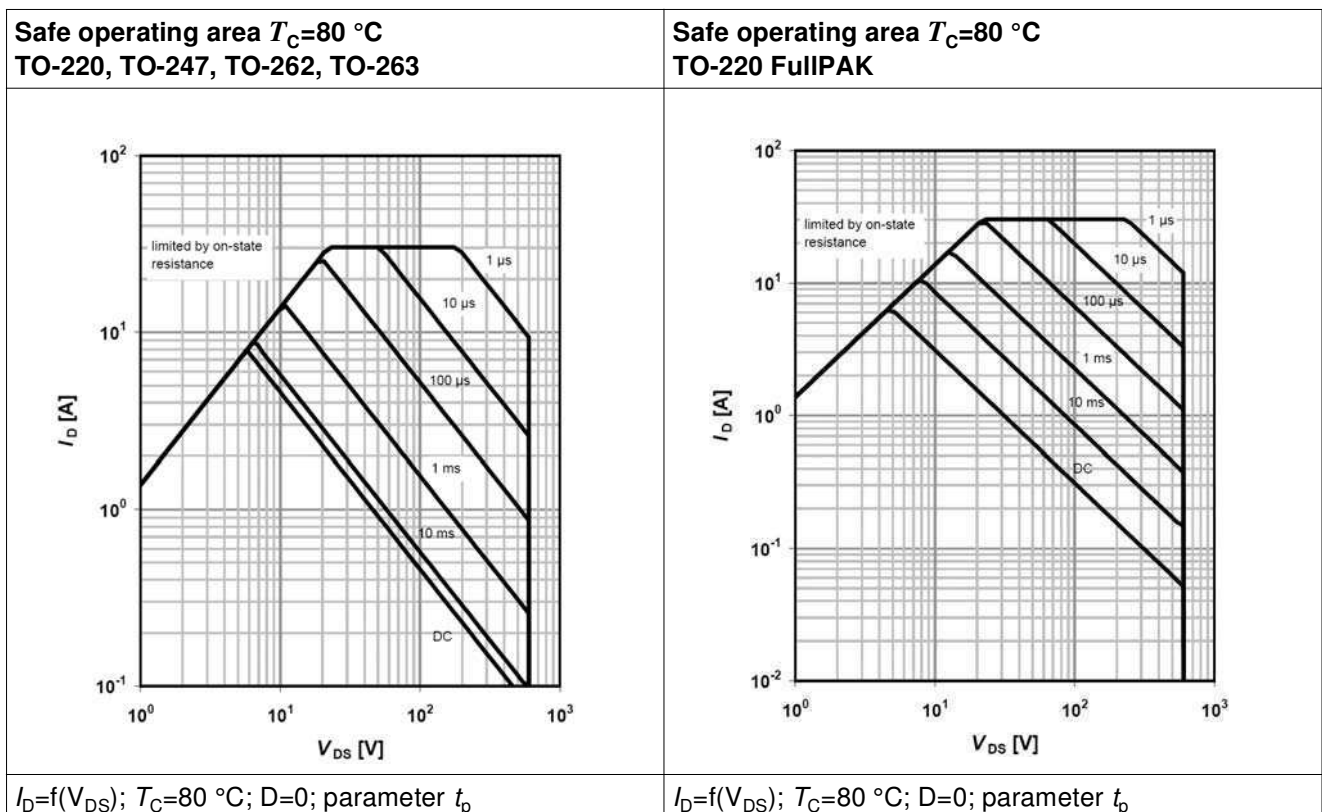


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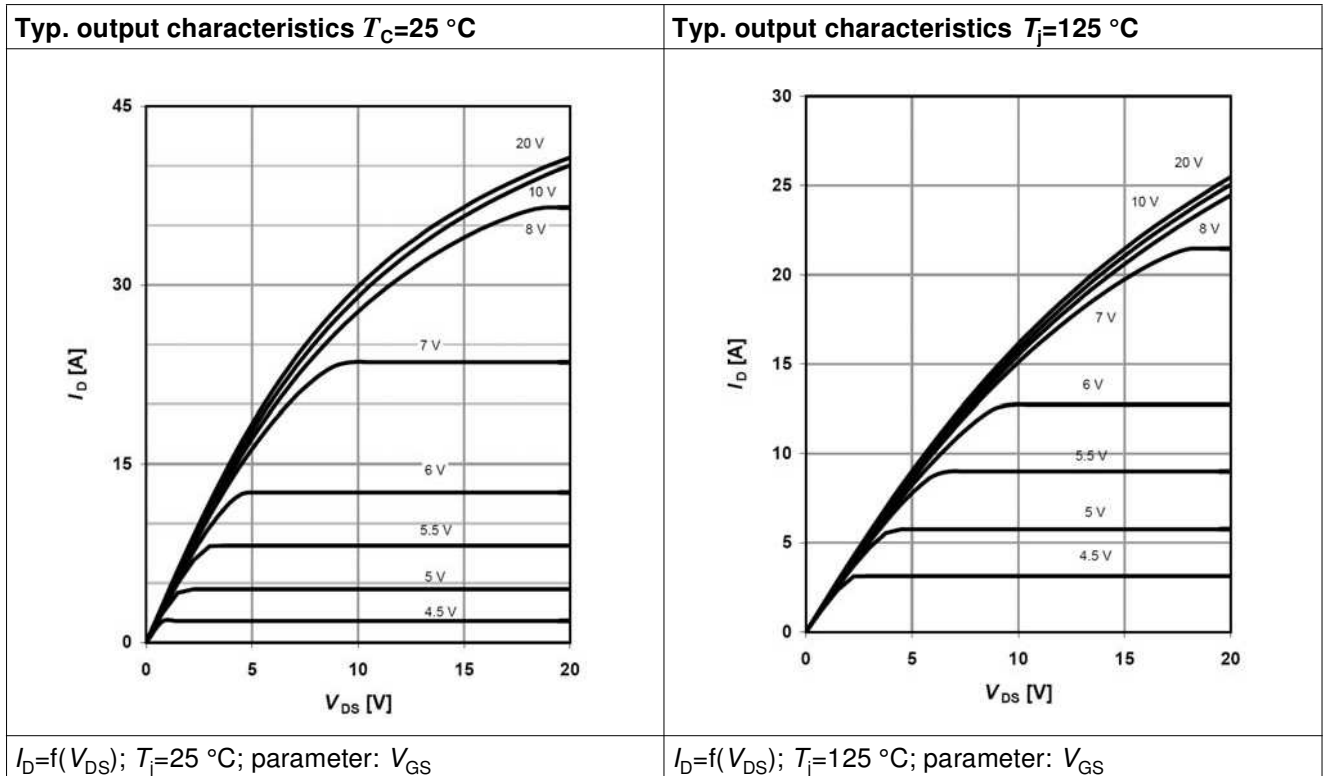


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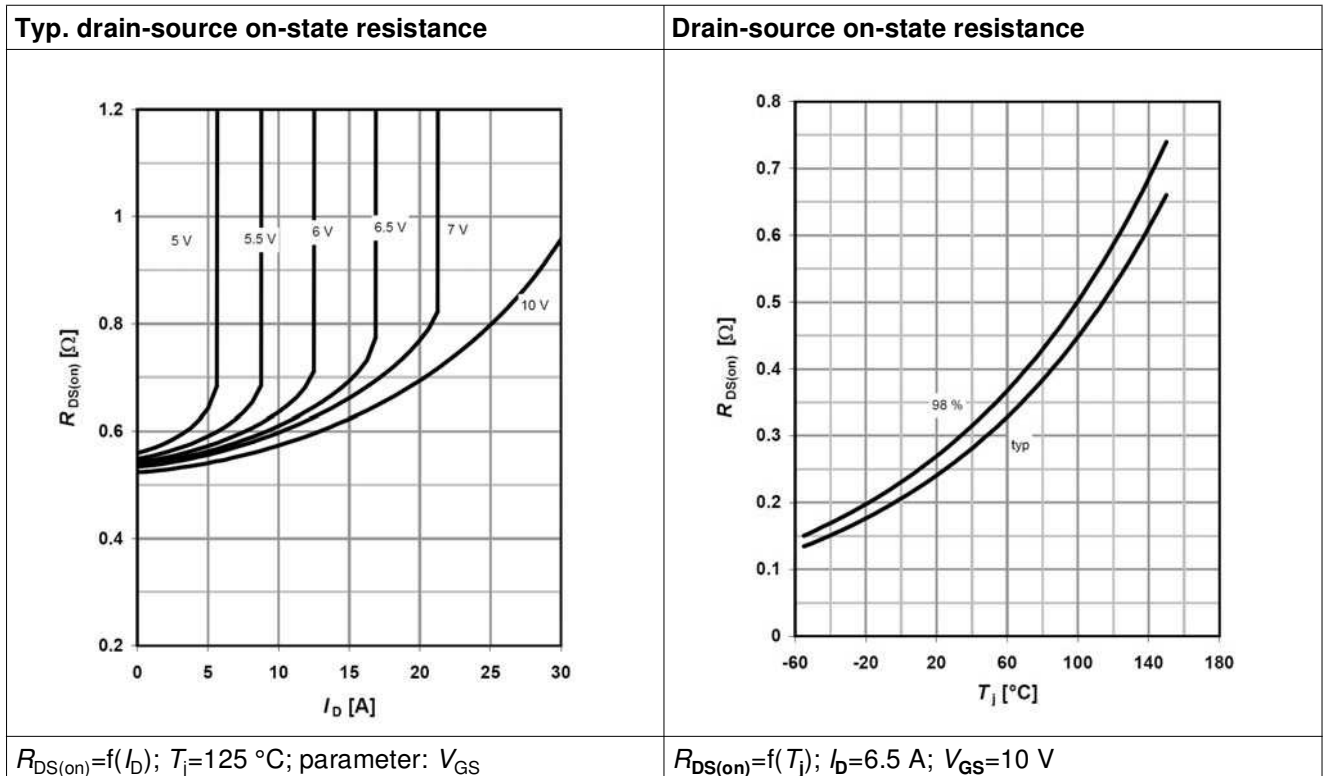


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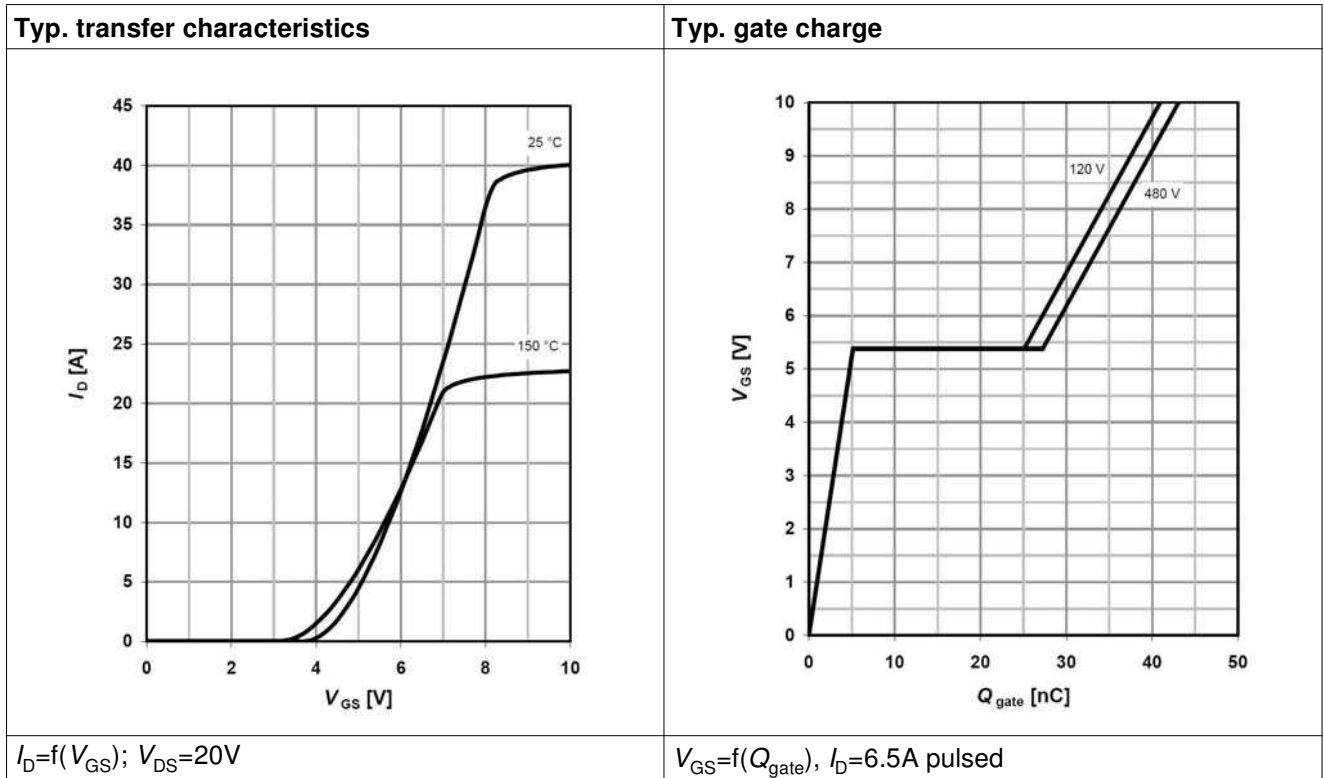


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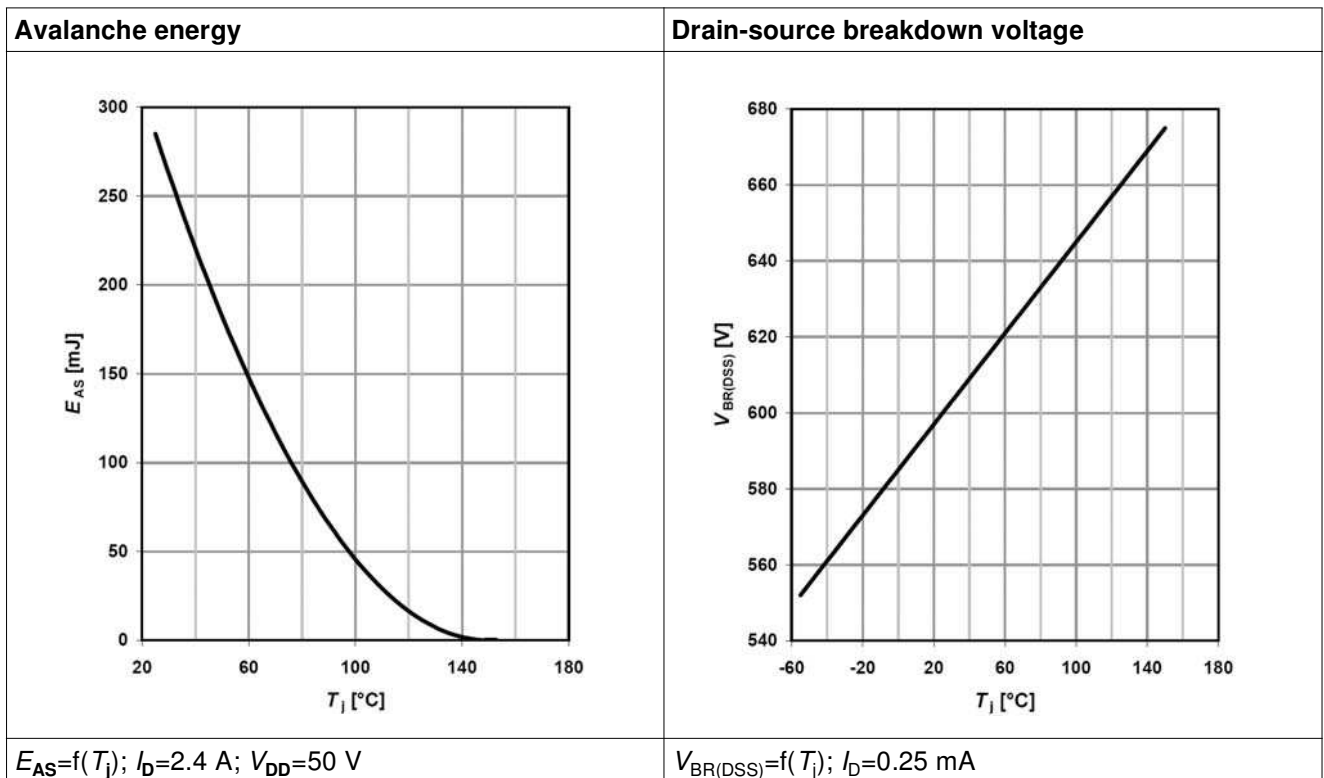


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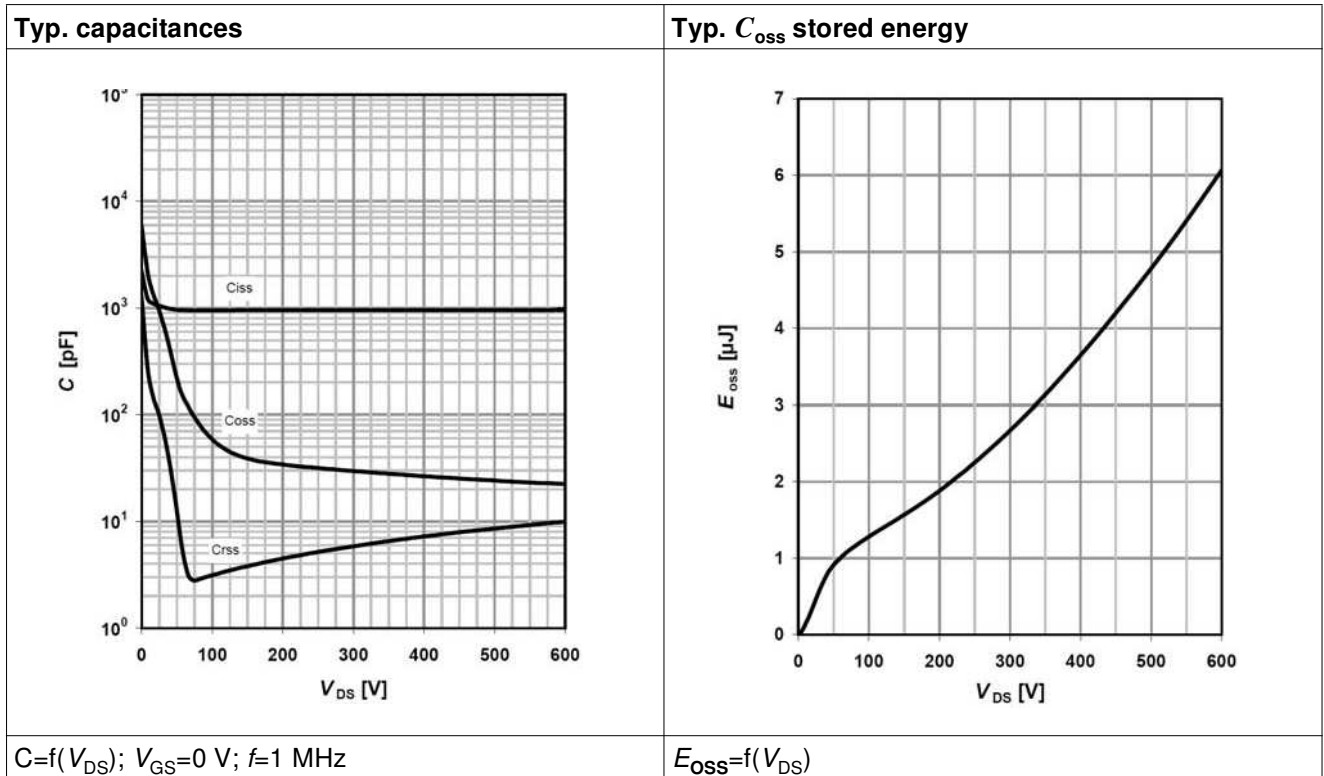
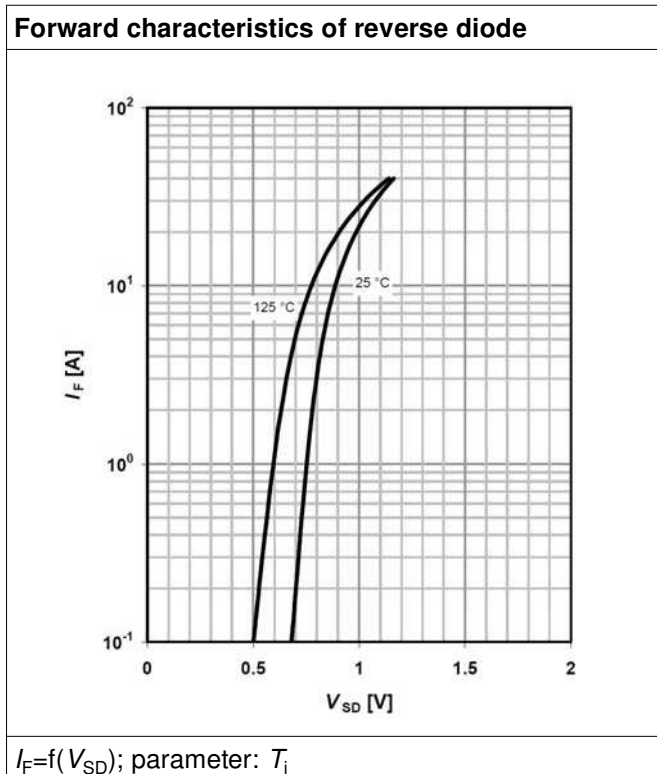


Table 18



## 6 Test circuits

**Table 19** Switching times test circuit and waveform for inductive load

Switching times test circuit for inductive load	Switching time waveform

**Table 20** Unclamped inductive load test circuit and waveform

Unclamped inductive load test circuit	Unclamped inductive waveform

**Table 21** Test circuit and waveform for diode characteristics

Test circuit for diode characteristics	Diode recovery waveform

7 Package outlines

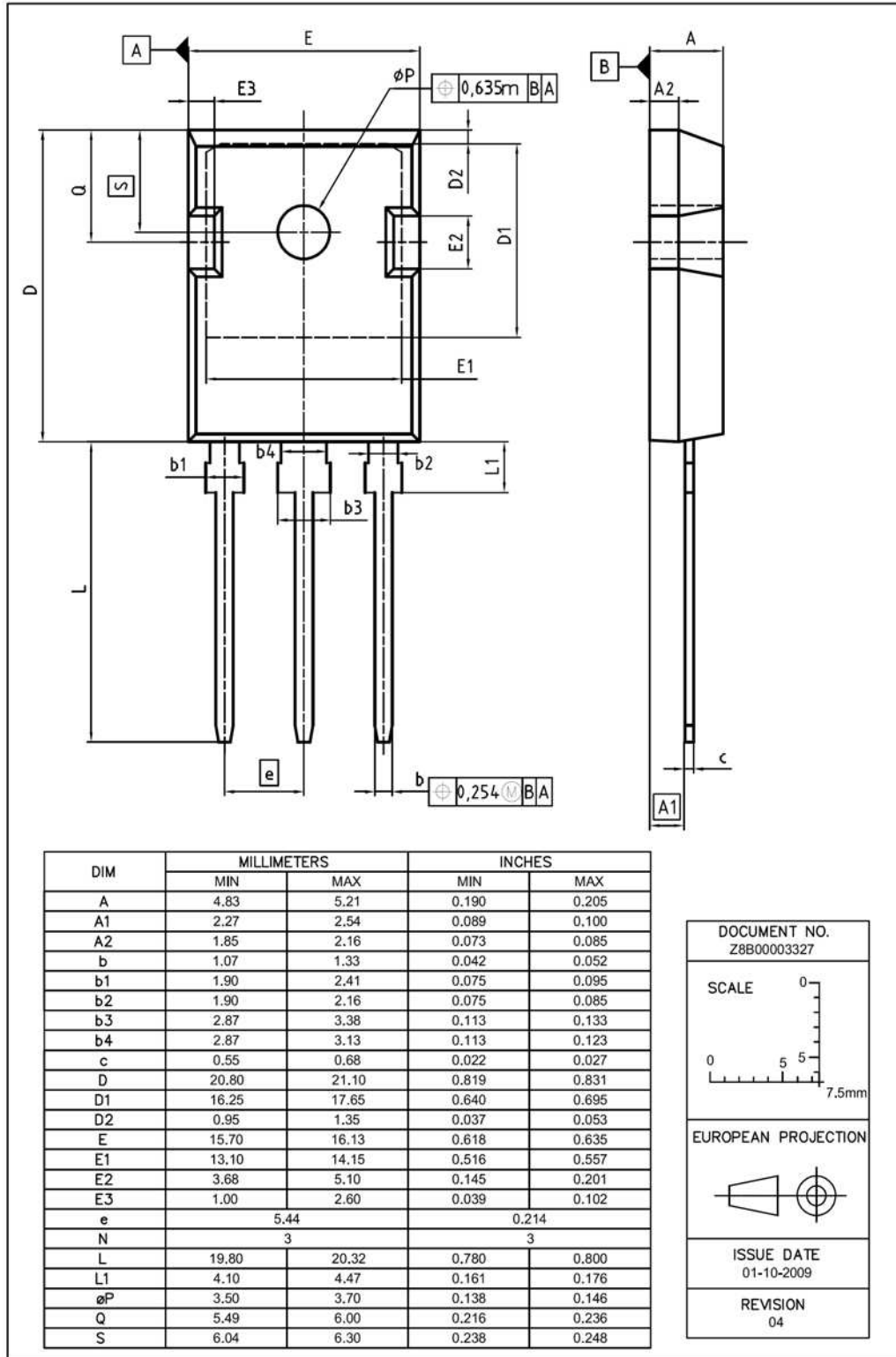
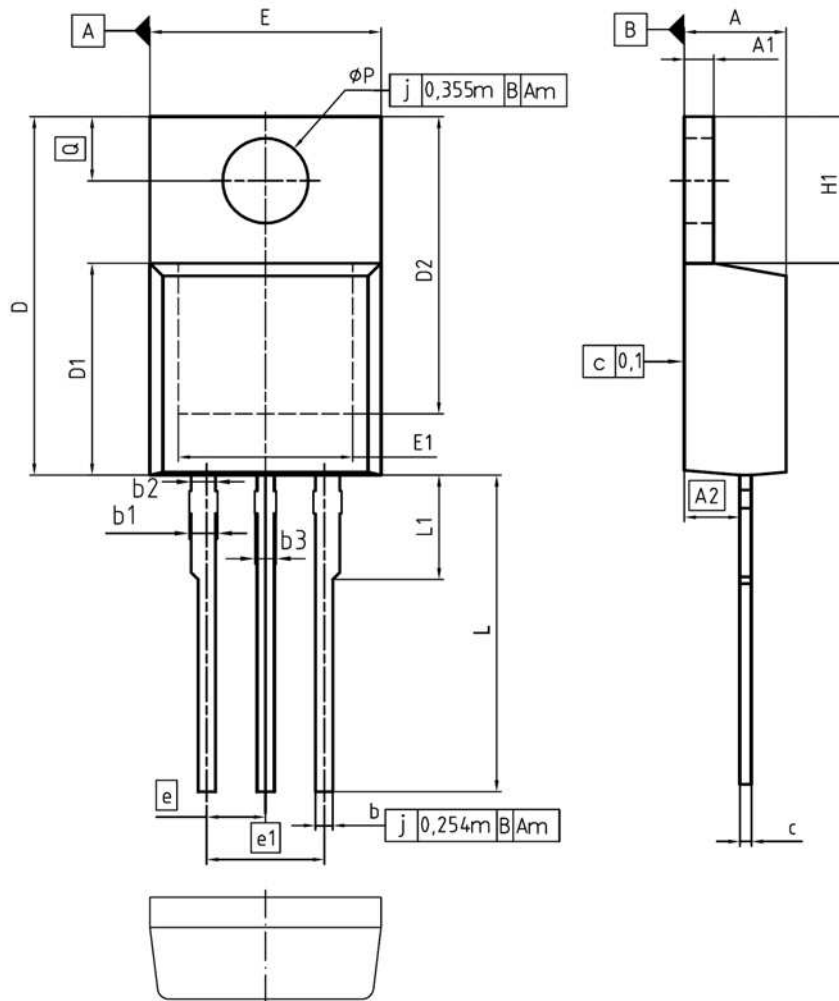


Figure 1 Outlines TO-247, dimensions in mm/inches



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
øP	3.60	3.89	0.142	0.153
Q	2.60	3.00	0.102	0.118

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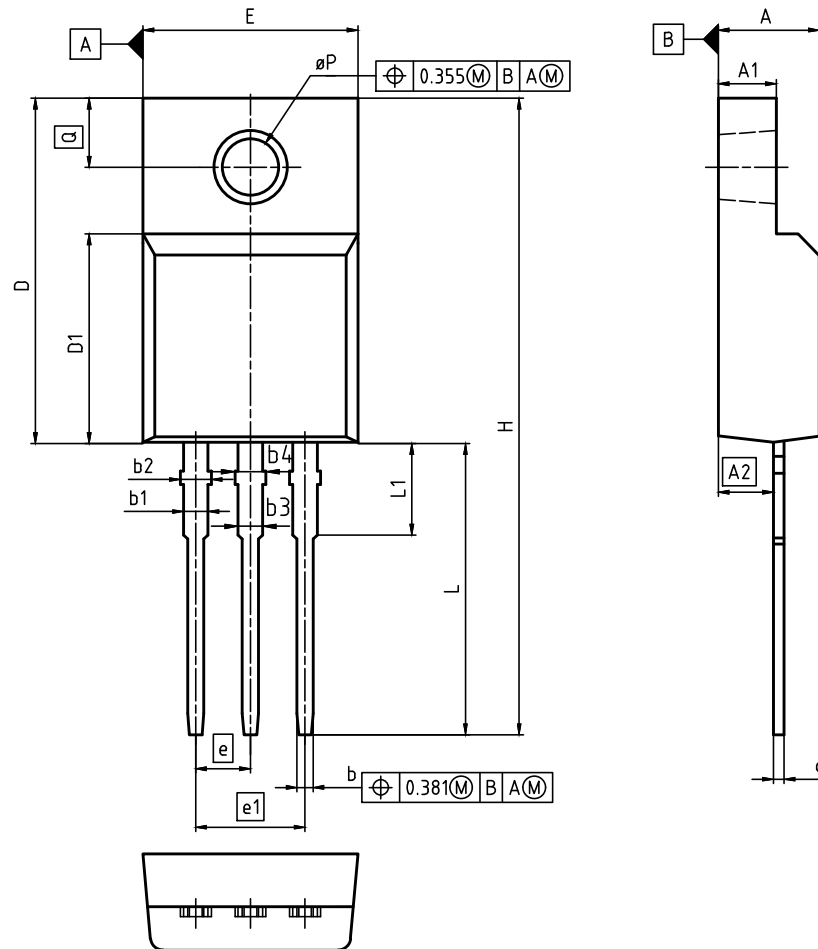
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05

Figure 2 Outlines 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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Figure 3 Outline PG-TO 220 FullPAK, dimensions in mm/inches



## Revision History

IPx60R280E6

**Revision: 2015-02-09, Rev. 2.2**

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.0	2011-06-08	Release final data sheet
2.1	2011-09-14	-
2.2	2015-02-09	PG-TO220 FullPAK package outline update (creation:2014-12-09)

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