

# MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## CoolMOS™ E6 600V

600V CoolMOS™ E6 Power Transistor  
IPx60R600E6

## Data Sheet

Rev. 2.4  
Final

## 600V CoolMOS™ E6 Power Transistor

IPD60R600E6, IPP60R600E6  
IPA60R600E6

### 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.

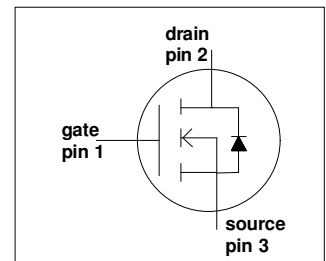
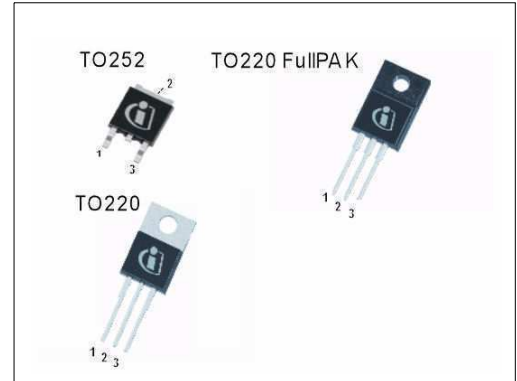
#### Features

- 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, Pb-free plating, halogen free
- Fully qualified according to JEDEC for Industrial Applications

#### 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
$R_{DS(on),max}$	0.6	$\Omega$
$Q_{g,typ}$	20.5	nC
$I_{D,pulse}$	19	A
$E_{oss} @ 400V$	1.9	$\mu J$
Body diode $di/dt$	500	A/ $\mu s$

Type / Ordering Code	Package	Marking	Related Links
IPD60R600E6	PG-TO252	6R600E6	<a href="#">IFX CoolMOS Webpage</a>
IPP60R600E6	PG-TO220		<a href="#">IFX Design tools</a>
IPA60R600E6	PG-TO220 FullIPAK		

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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>	$I_D$	-	-	7.3	A	$T_C = 25\text{ °C}$
				4.6		$T_C = 100\text{ °C}$
Pulsed drain current <sup>2)</sup>	$I_{D,pulse}$	-	-	19	A	$T_C = 25\text{ °C}$
Avalanche energy, single pulse	$E_{AS}$	-	-	133	mJ	$I_D = 1.3\text{ A}, V_{DD} = 50\text{ V}$ (see table 21)
Avalanche energy, repetitive	$E_{AR}$	-	-	0.2		$I_D = 1.3\text{ A}, V_{DD} = 50\text{ V}$
Avalanche current, repetitive	$I_{AR}$	-	-	1.3	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-252	$P_{tot}$	-	-	63	W	$T_C = 25\text{ °C}$
Power dissipation for TO-220 FullPAK	$P_{tot}$	-	-	28	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	$I_S$	-	-	6.3	A	$T_C = 25\text{ °C}$
Diode pulse current <sup>2)</sup>	$I_{S,pulse}$	-	-	19	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 <sub>r</sub> /dt			500	A/μs	(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 (IPP60R600E6)**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	-	2.0	°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 (IPA60R600E6)**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	-	4.5	°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 (IPD60R600E6)**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	-	2.0	°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 6cm<sup>2</sup> 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	$V_{(BR)DSS}$	600	-	-	V	$V_{GS}=0\text{ V}, I_D=0.25\text{ mA}$
Gate threshold voltage	$V_{GS(th)}$	2.5	3	3.5		$V_{DS}=V_{GS}, I_D=0.20\text{ mA}$
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	$R_{DS(on)}$	-	0.54	0.60	$\Omega$	$V_{GS}=10\text{ V}, I_D=2.4\text{ A}, T_J=25\text{ °C}$
		-	1.40	-		$V_{GS}=10\text{ V}, I_D=2.4\text{ A}, T_J=150\text{ °C}$
Gate resistance	$R_G$	-	10	-	$\Omega$	$f=1\text{ MHz}$ , open drain

**Table 7 Dynamic characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	$C_{iss}$	-	440	-	pF	$V_{GS}=0\text{ V}, V_{DS}=100\text{ V}, f=1\text{ MHz}$
Output capacitance	$C_{oss}$	-	30	-		
Effective output capacitance, energy related <sup>1)</sup>	$C_{o(er)}$	-	21	-		
Effective output capacitance, time related <sup>2)</sup>	$C_{o(tr)}$	-	88	-	ns	$I_D=\text{constant}, V_{GS}=0\text{ V}, V_{DS}=0\dots480\text{ V}$
Turn-on delay time	$t_{d(on)}$	-	10	-		
Rise time	$t_r$	-	8	-		
Turn-off delay time	$t_{d(off)}$	-	58	-		
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	$Q_{gs}$	-	2.5	-	nC	$V_{DD}=480\text{ V}$ , $I_D=3.0\text{ A}$ , $V_{GS}=0\text{ to }10\text{ V}$
Gate to drain charge	$Q_{gd}$	-	10.5	-		
Gate charge total	$Q_g$	-	20.5	-		
Gate plateau voltage	$V_{\text{plateau}}$	-	5.4	-	V	

**Table 9 Reverse diode characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Diode forward voltage	$V_{SD}$	-	0.9	-	V	$V_{GS}=0\text{ V}$ , $I_F=3.0\text{ A}$ , $T_j=25\text{ °C}$
Reverse recovery time	$t_{rr}$	-	250	-	ns	$V_R=400\text{ V}$ , $I_F=3.0\text{ A}$ , $di_F/dt=100\text{ A}/\mu\text{s}$ (see table 22)
Reverse recovery charge	$Q_{rr}$	-	2.1	-	$\mu\text{C}$	
Peak reverse recovery current	$I_{rrm}$	-	16	-	A	

5 Electrical characteristics diagrams

Table 10

Power dissipation TO-220, TO-252	Power dissipation TO-220 FullPAK
$P_{tot} = f(T_C)$	$P_{tot} = f(T_C)$

Table 11

Max. transient thermal impedance TO-220, TO-252	Max. transient thermal impedance TO-220 FullPAK
$Z_{(thJC)} = f(t_p)$ ; parameter: $D = t_p/T$	$Z_{(thJC)} = f(t_p)$ ; parameter: $D = t_p/T$



Table 12

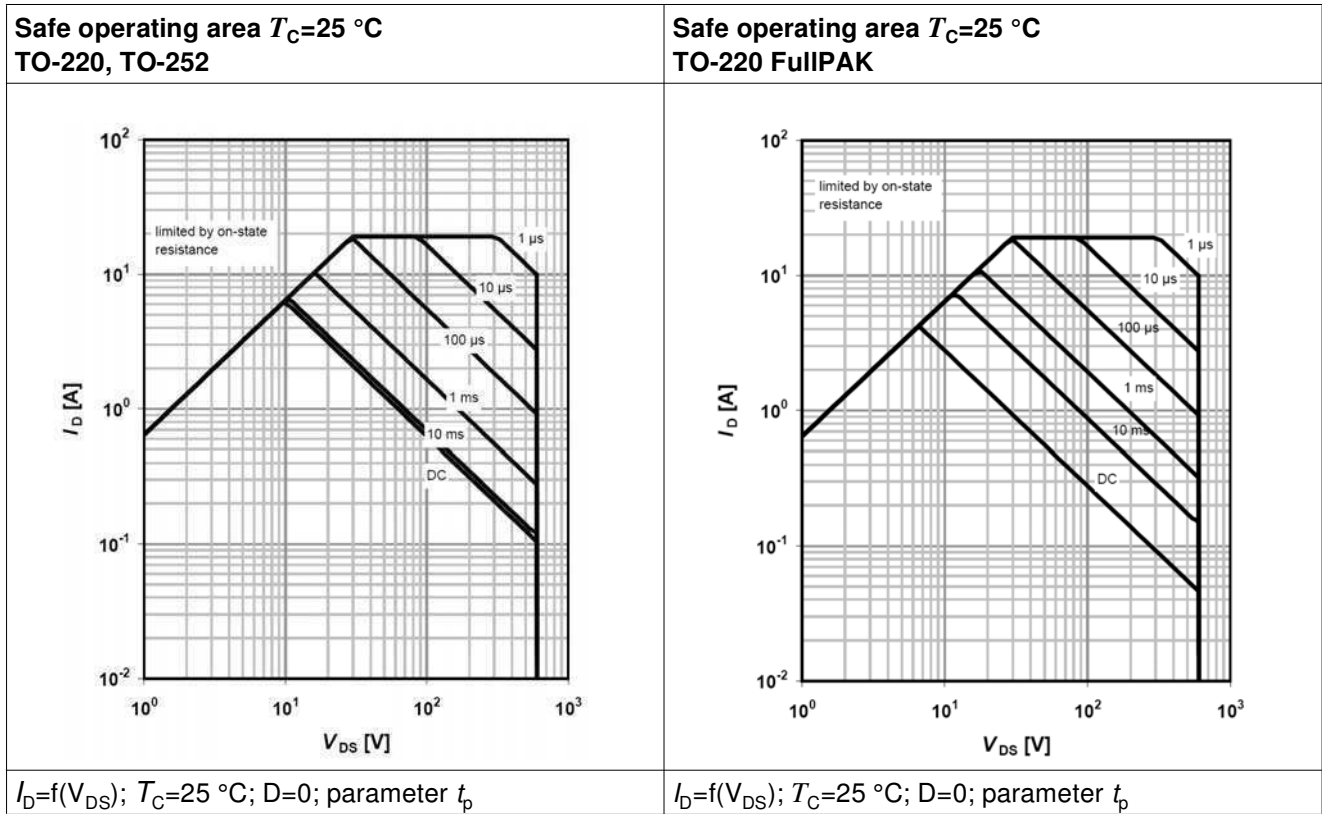


Table 13

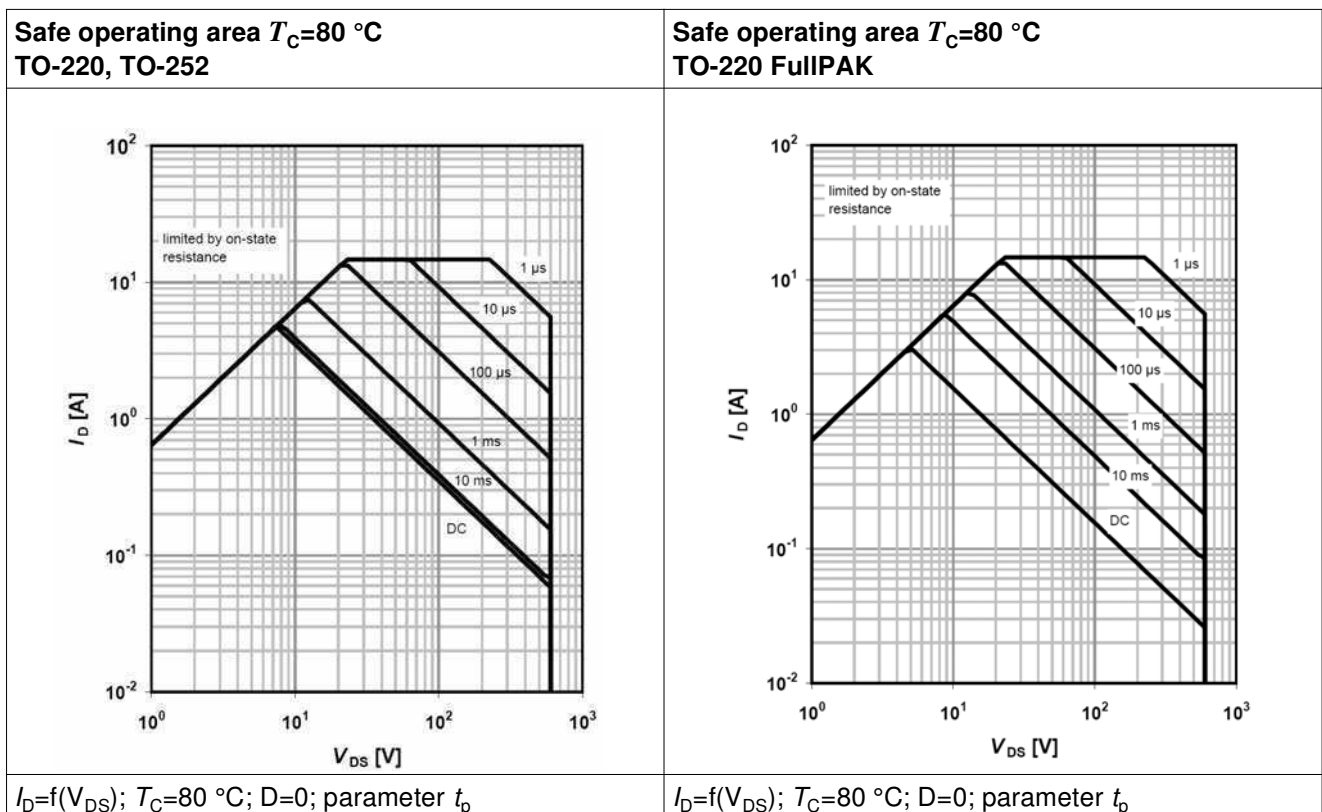


Table 14

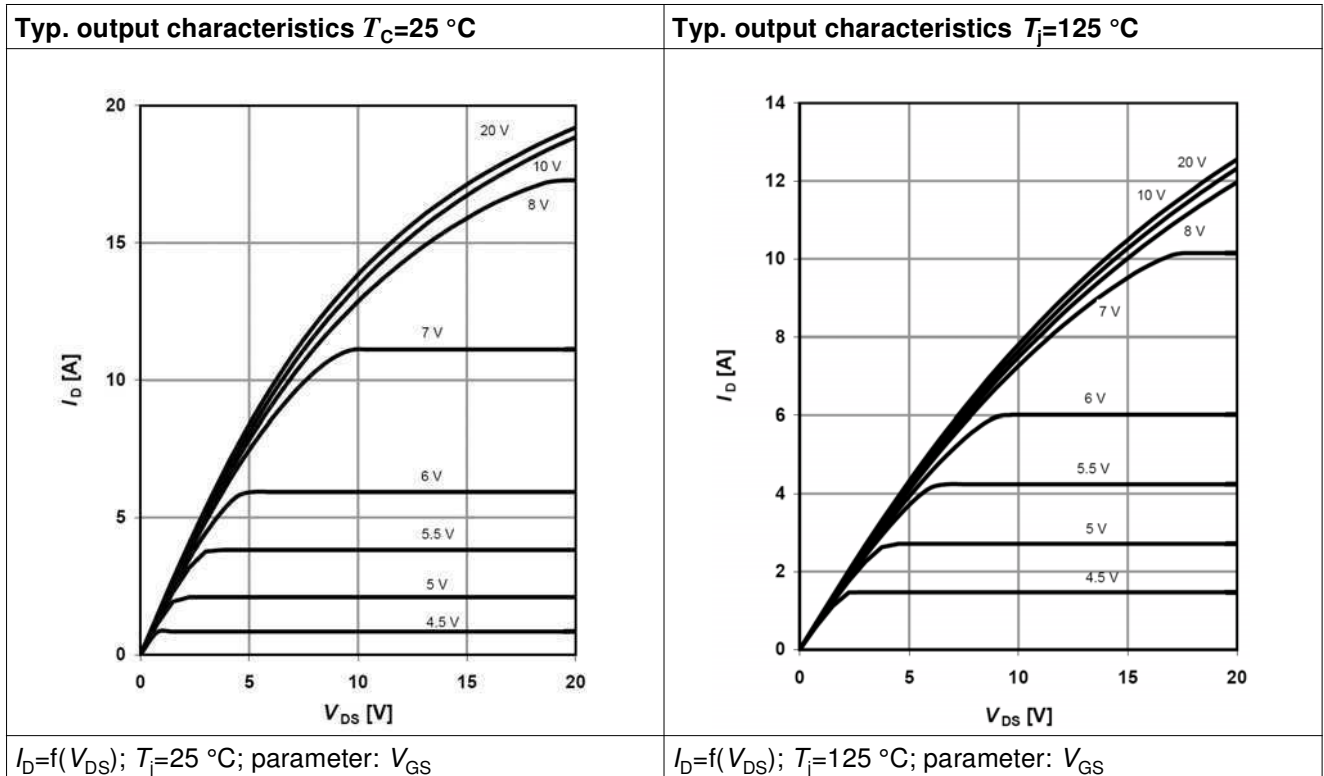


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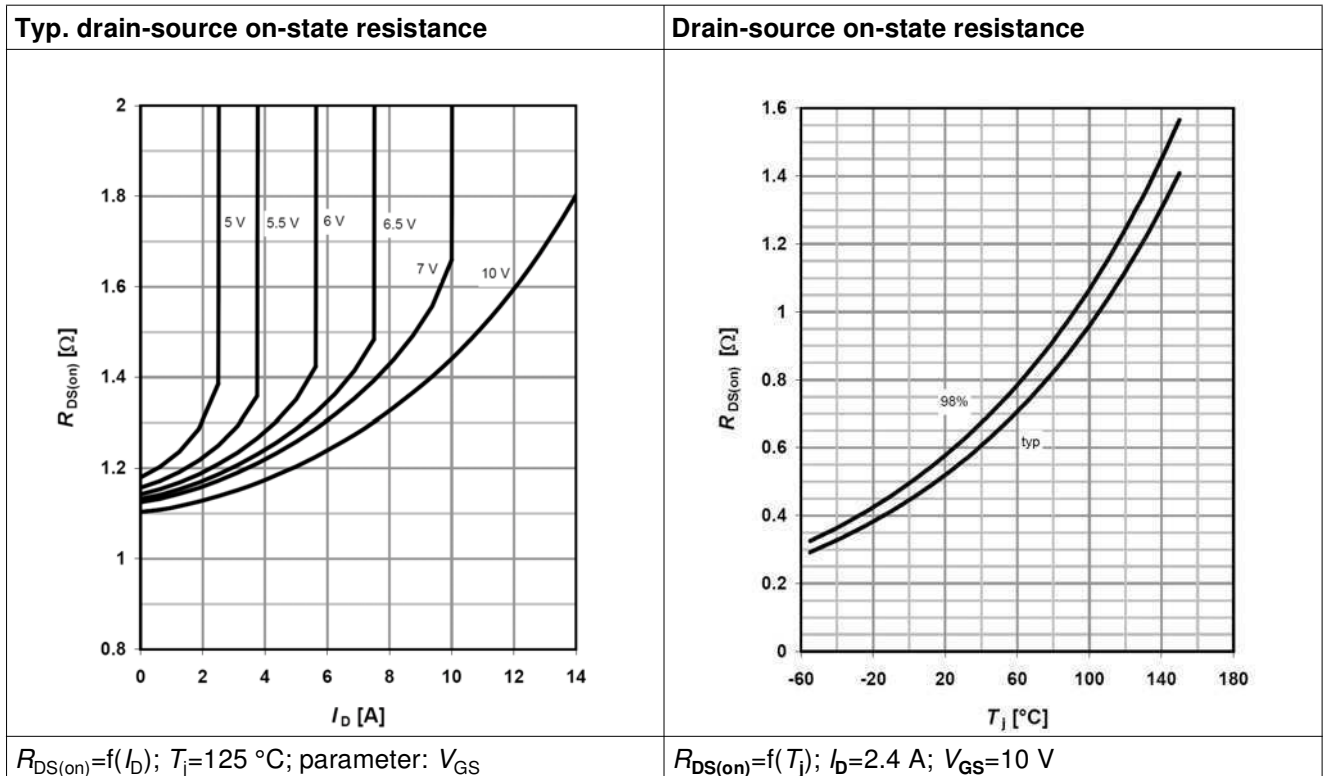


Table 16

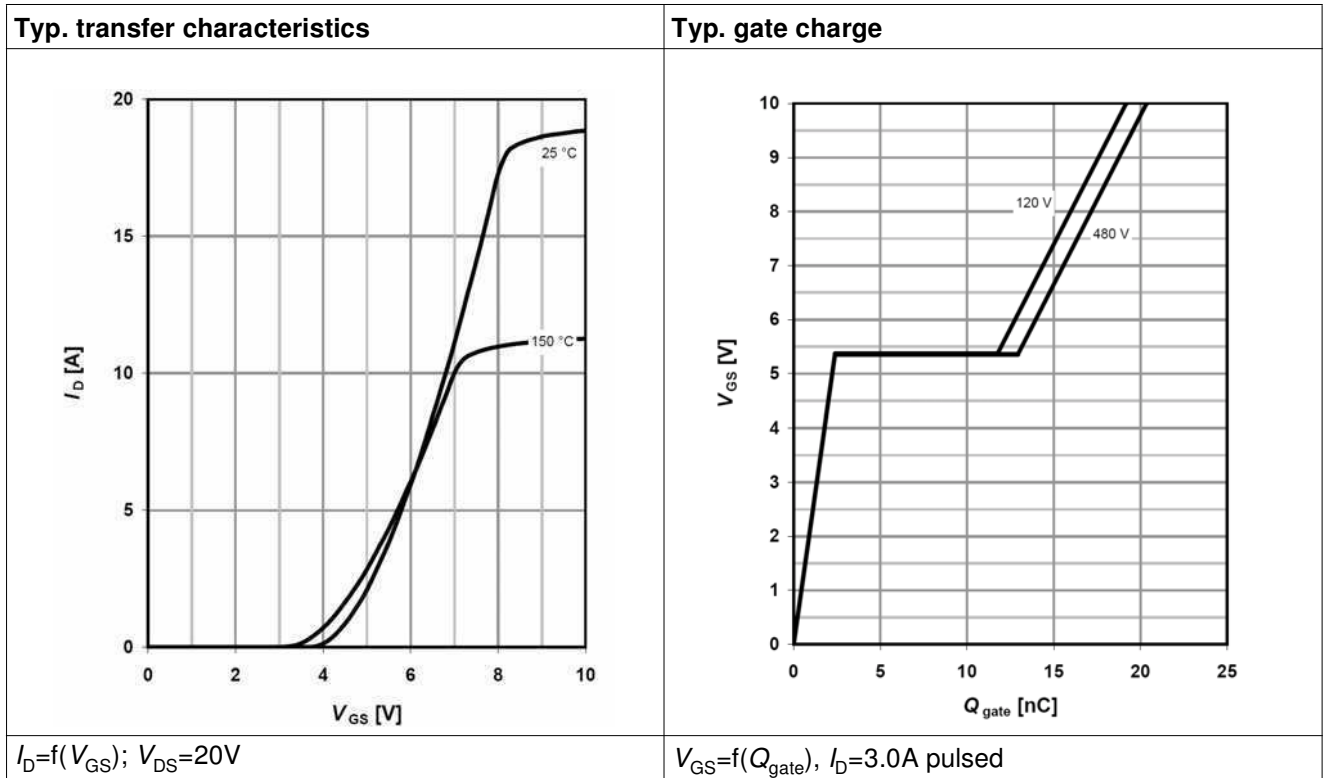


Table 17

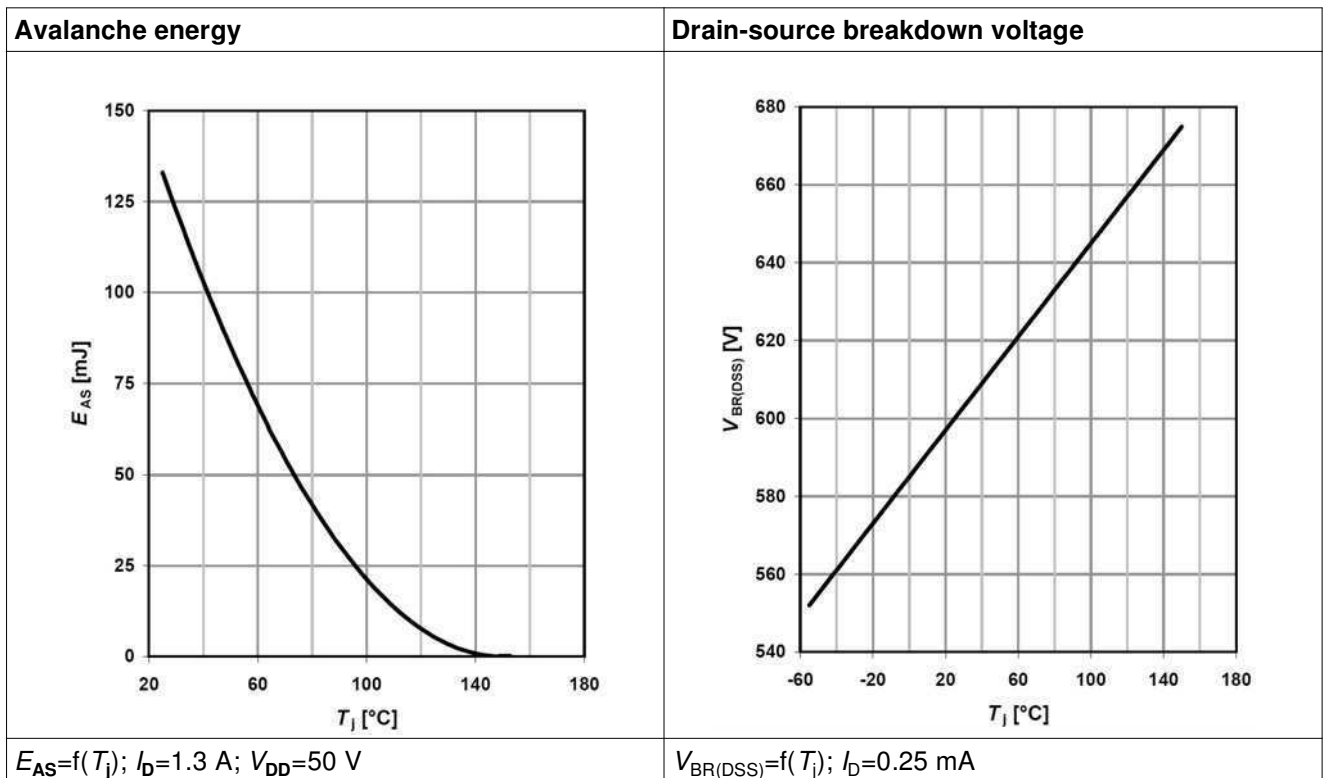


Table 18

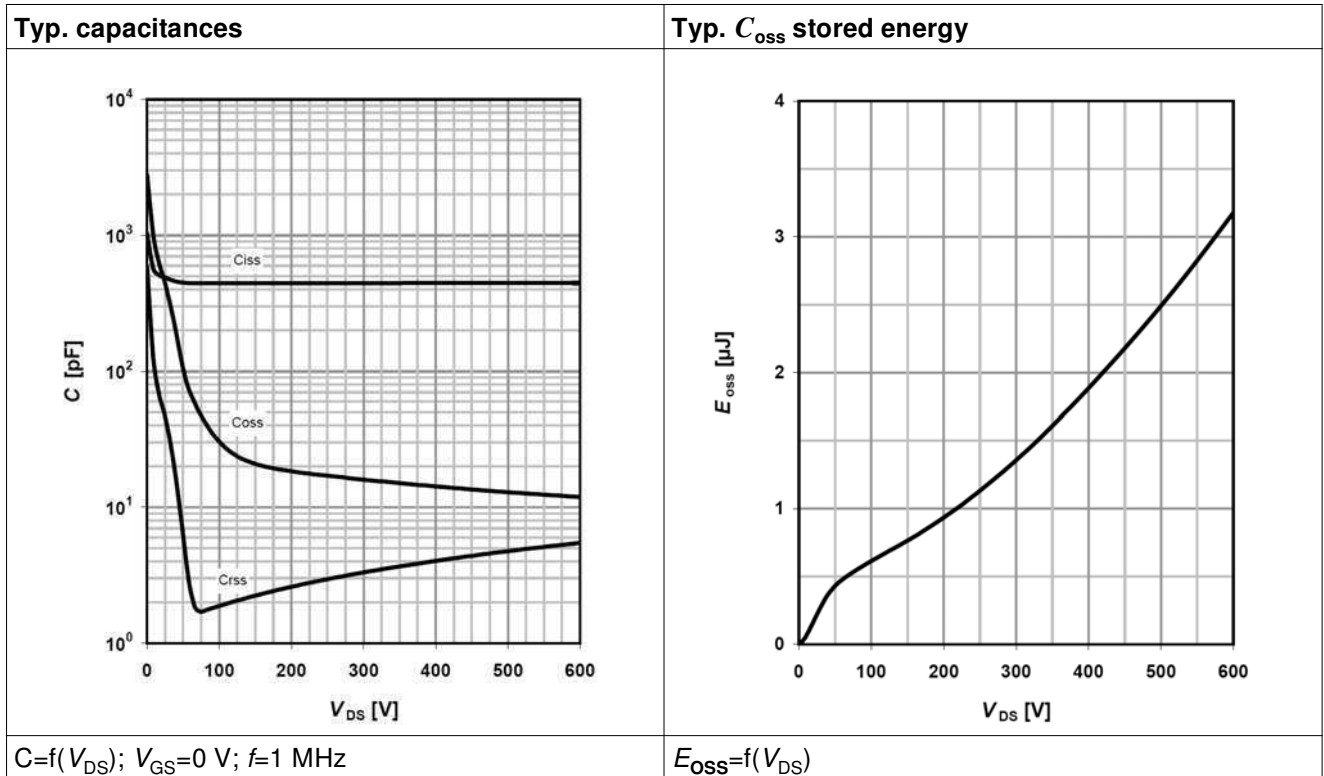
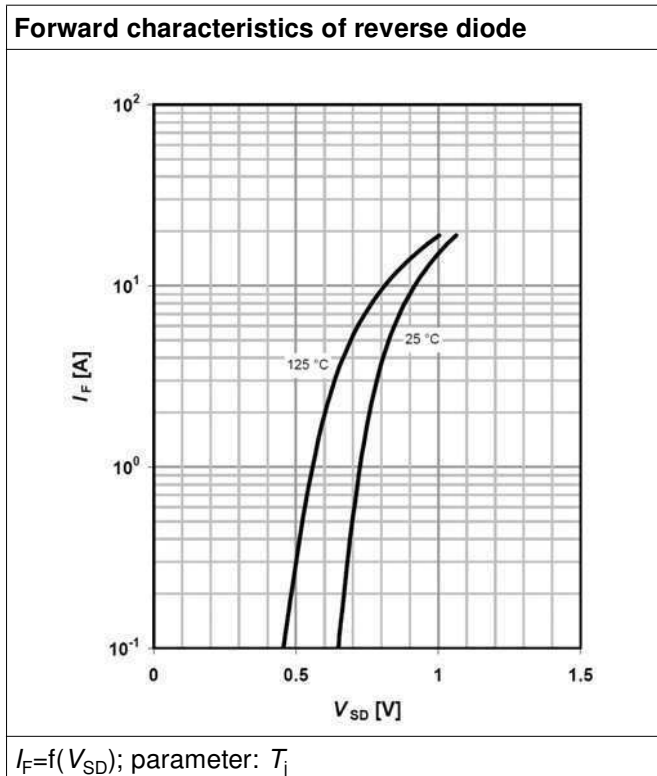


Table 19



## 6 Test circuits

Table 20 Switching times test circuit and waveform for inductive load

Switching times test circuit for inductive load	Switching time waveform

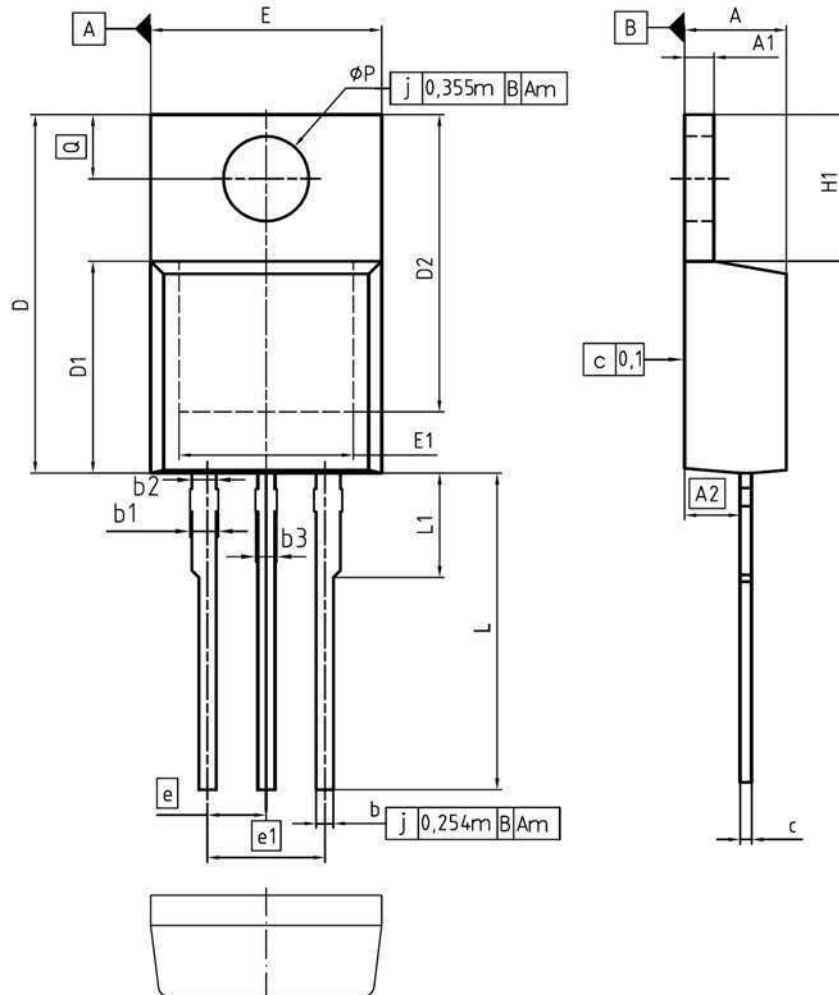
Table 21 Unclamped inductive load test circuit and waveform

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



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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05

Figure 1 Outlines TO-220, dimensions in mm/inches

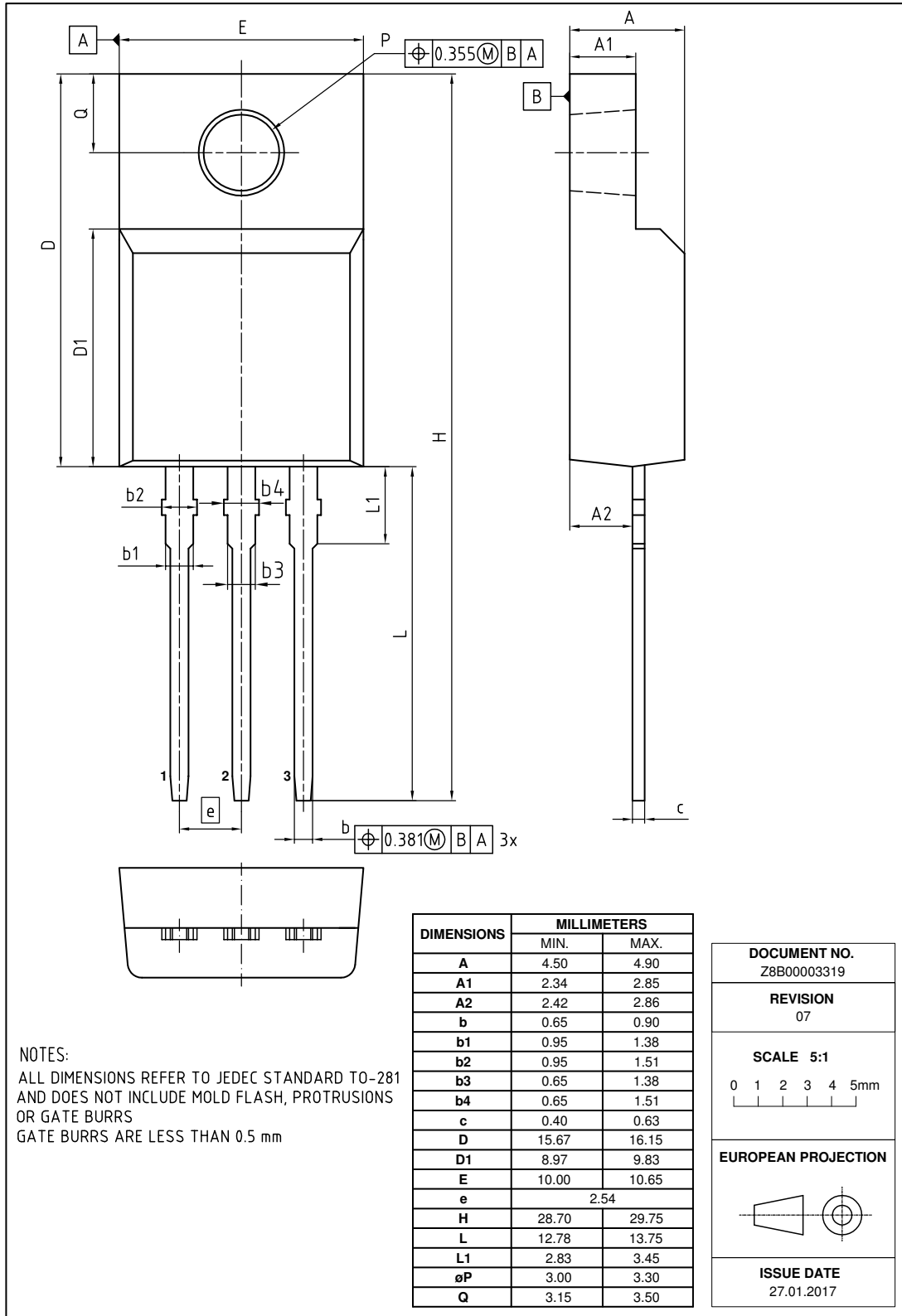
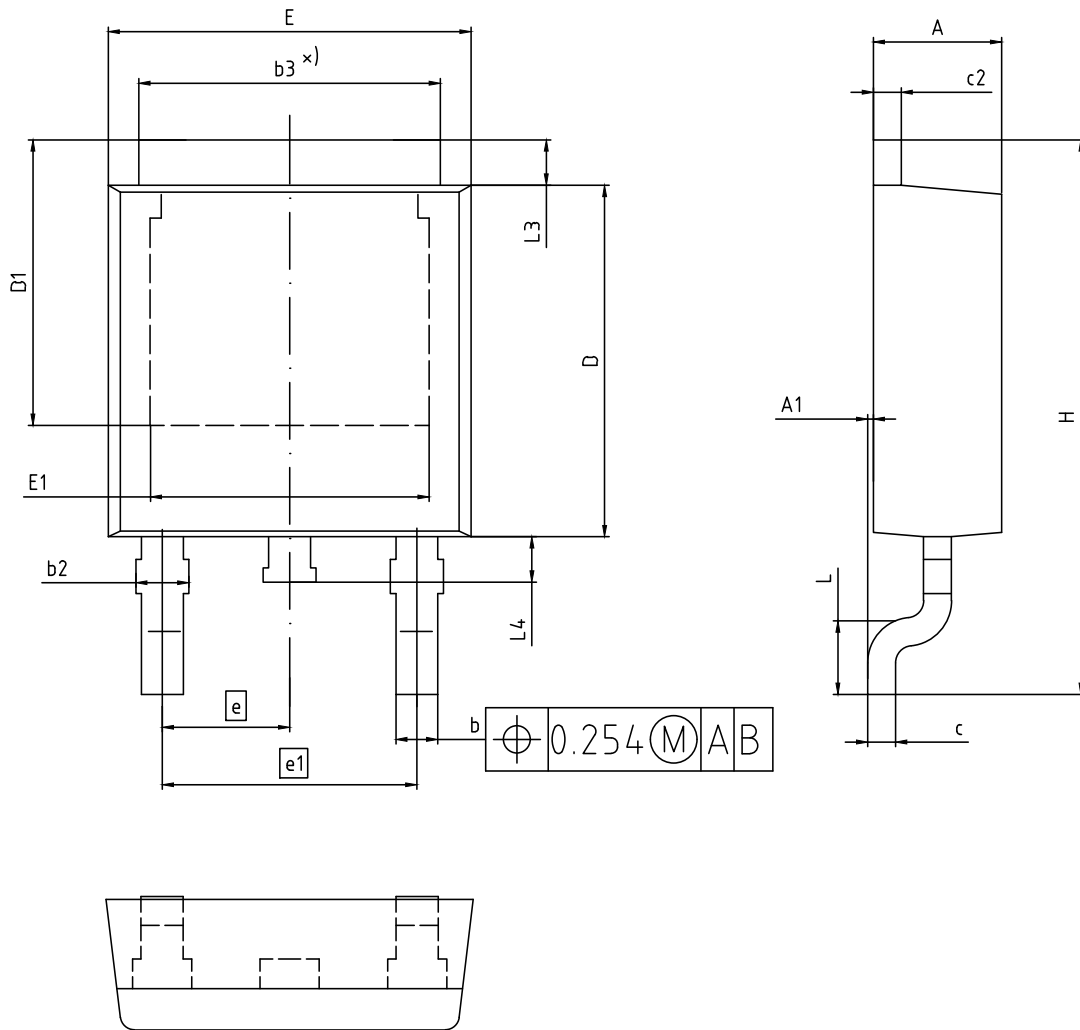


Figure 2 Outline PG-TO 220 FullPAK, dimensions in mm



ALL DIMENSIONS REFER TO JEDEC STANDARD TO-252 AND DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.

DIMENSION	MILLIMETERS	
	MIN.	MAX.
A	2.16	2.41
A1	0.00	0.15
b	0.64	0.89
b2	0.65	1.15
b3	4.95	5.50
c	0.46	0.61
c2	0.40	0.98
D	5.97	6.22
D1	5.02	5.84
E	6.35	6.73
E1	4.32	5.50
e	2.29	
e1	4.57	
N	3	
H	9.40	10.48
L	1.18	1.78
L3	0.89	1.27
L4	0.51	1.02

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Figure 3 Outlines TO-252, dimensions in mm



## Revision History

IPx60R600E6

**Revision: 2020-05-20, Rev. 2.4**

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	2015-02-11	PG-TO220 FullPAK package outline update (creation:2014-12-10)
2.3	2018-03-04	Outline PG-TO-220 FullPAK update
2.4	2020-05-20	Update of the package outlines TO-252

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