

MOSFET

Metall Oxide Semiconductor Field Effect Transistor

CoolMOS E6

650V CoolMOS™ E6 Power Transistor
IPx65R380E6

Data Sheet

Rev. 2.2
Final

1 Description

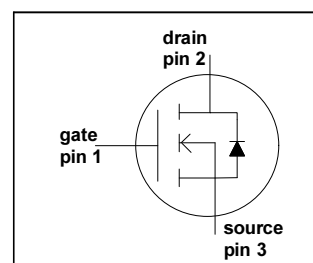
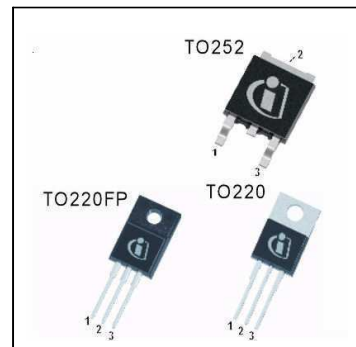
CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. CoolMOS™ E6 series combines the experience of the leading SJ MOSFET supplier with high class innovation. The resulting devices provide 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, 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
$V_{DS} @ T_{j,max}$	700	V
$R_{DS(on),max}$	0.38	Ω
$Q_{g,typ}$	39	nC
$I_{D,pulse}$	29	A
$E_{oss} @ 400V$	2.8	μJ
Body diode di/dt	500	A/ μs

Type / Ordering Code	Package	Marking	Related Links
IPD65R380E6	PG-TO252	65E6380	IFX CoolMOS Webpage IFX Design tools
IPP65R380E6	PG-TO220		
IPA65R380E6	PG-TO220 FullPAK		

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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 ¹⁾	I_D	-	-	10.6	A	$T_C = 25\text{ °C}$
				6.7		$T_C = 100\text{ °C}$
Pulsed drain current ²⁾	$I_{D,pulse}$	-	-	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 ²⁾	$I_{S,pulse}$	-	-	29	A	$T_C = 25\text{ °C}$
Reverse diode dv/dt ³⁾	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 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 TO-220

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

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}	-	-	4.0	°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 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	-		SMD version, device on PCB, 6cm ² cooling area ¹⁾
Soldering temperature, wave- & reflowsoldering 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 $T_j=25\text{ °C}$, 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	μA	$V_{DS}=600\text{ V}$, $V_{GS}=0\text{ V}$, $T_j=25\text{ °C}$
		-	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	Ω	$V_{GS}=10\text{ V}$, $I_D=3.2\text{ A}$, $T_j=25\text{ °C}$
		-	0.89	-		$V_{GS}=10\text{ V}$, $I_D=3.2\text{ A}$, $T_j=150\text{ °C}$
Gate resistance	R_G	-	7.5	-	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}	-	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 ¹⁾	$C_{o(er)}$	-	32	-		$V_{GS}=0\text{ V}$, $V_{DS}=0\dots480\text{ V}$
Effective output capacitance, time related ²⁾	$C_{o(tr)}$	-	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	-	μC	
Peak reverse recovery current	I_{rrm}	-	17	-	A	

5 Electrical characteristics diagrams

Table 10

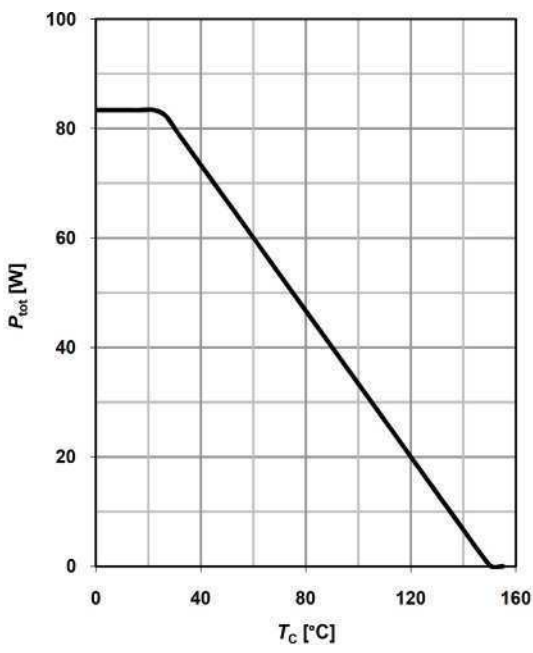
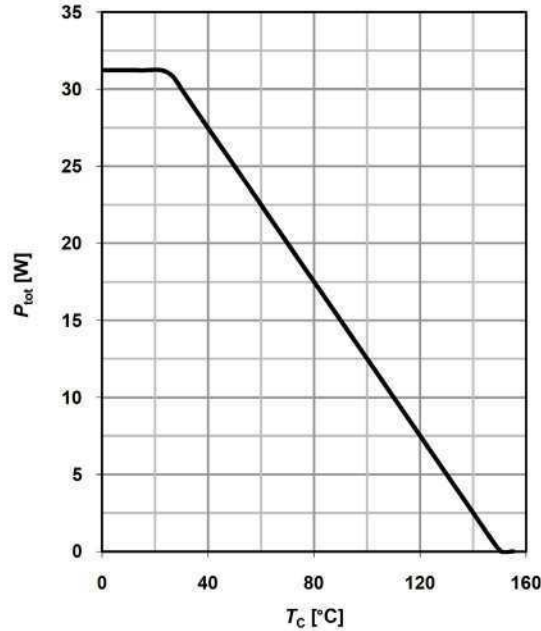
Power dissipation Non FullPAK	Power dissipation FullPAK
	
$P_{tot} = f(T_c)$	$P_{tot} = f(T_c)$

Table 11

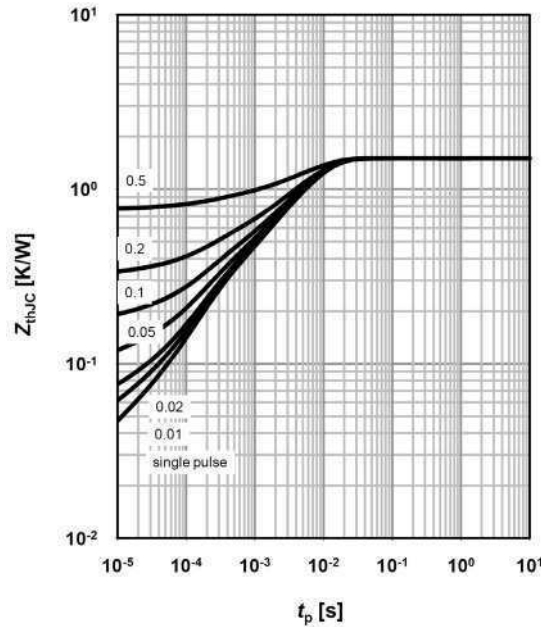
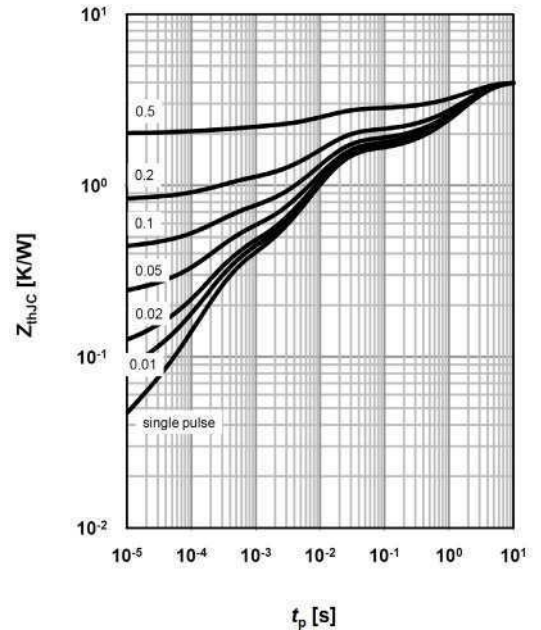
Max. transient thermal impedance Non FullPAK	Max. transient thermal impedance FullPAK
	
$Z_{(thJC)} = f(t_p)$; parameter: $D = t_p/T$	$Z_{(thJC)} = f(t_p)$; parameter: $D = t_p/T$

Table 12

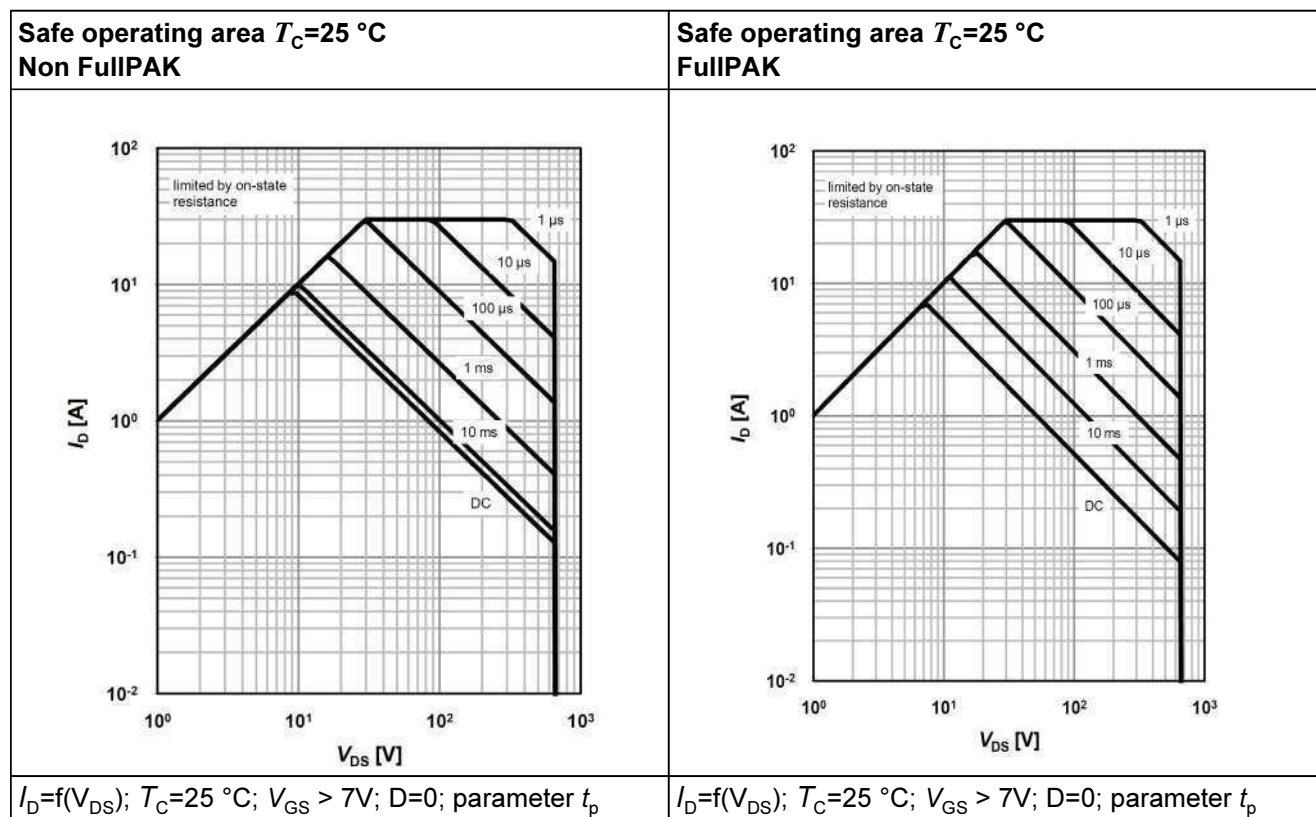


Table 13

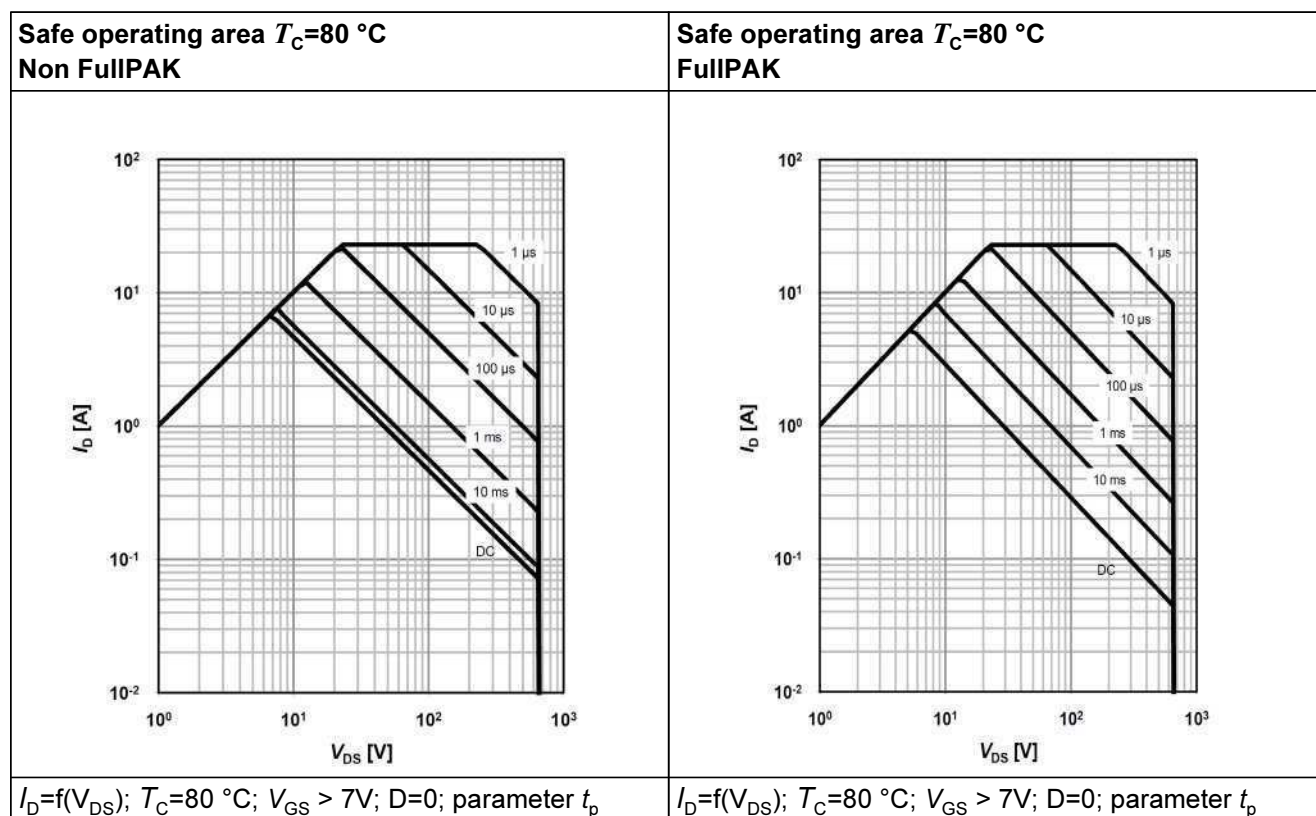


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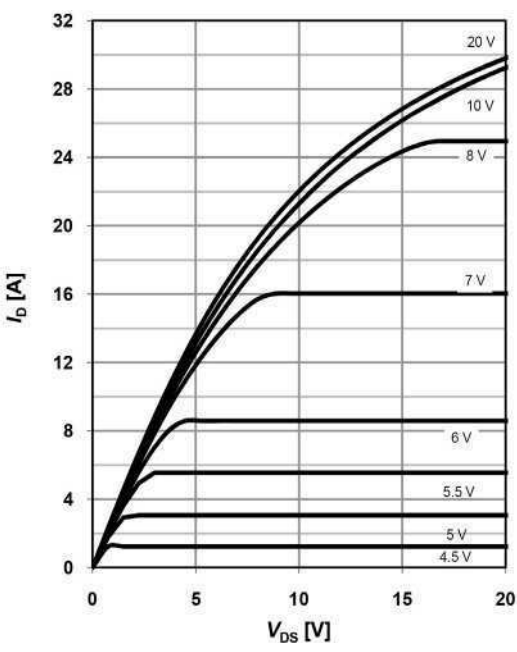
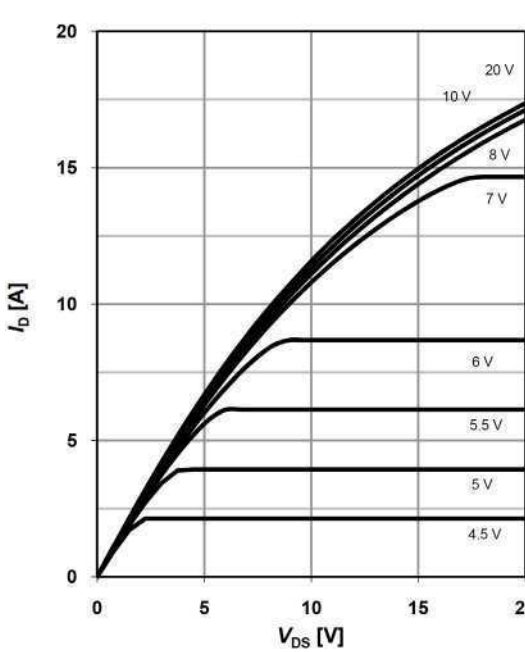
Typ. output characteristics $T_c=25\text{ }^{\circ}\text{C}$	Typ. output characteristics $T_j=125\text{ }^{\circ}\text{C}$
	
$I_D=f(V_{DS}); T_j=25\text{ }^{\circ}\text{C}; \text{parameter: } V_{GS}$	$I_D=f(V_{DS}); T_j=125\text{ }^{\circ}\text{C}; \text{parameter: } V_{GS}$

Table 15

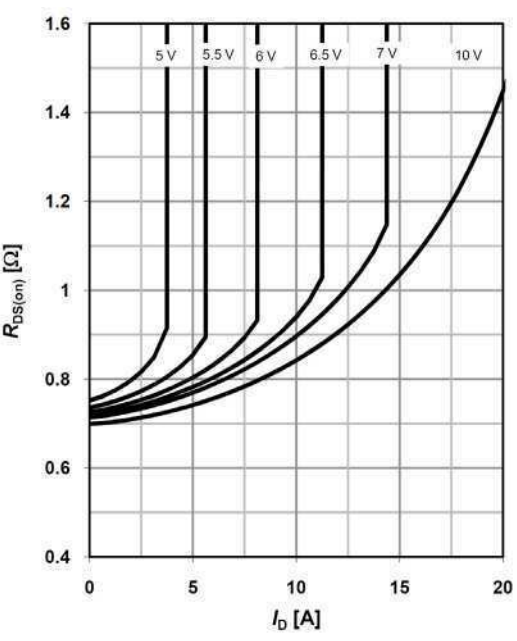
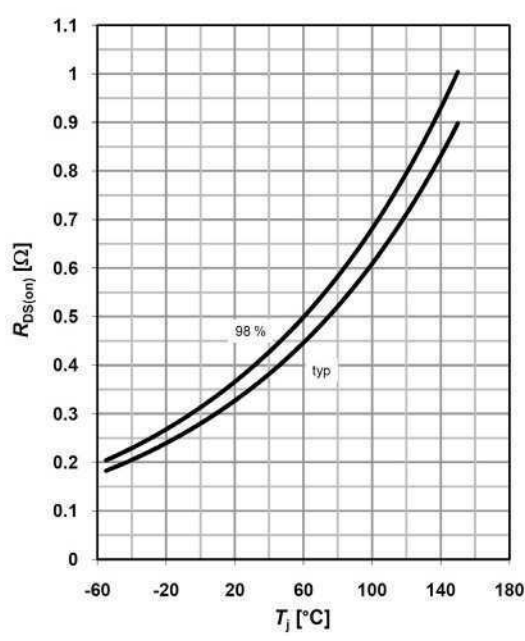
Typ. drain-source on-state resistance	Drain-source on-state resistance
	
$R_{DS(on)}=f(I_D); T_j=125\text{ }^{\circ}\text{C}; \text{parameter: } V_{GS}$	$R_{DS(on)}=f(T_j); I_D=4.9\text{ A}; V_{GS}=10\text{ V}$

Table 16

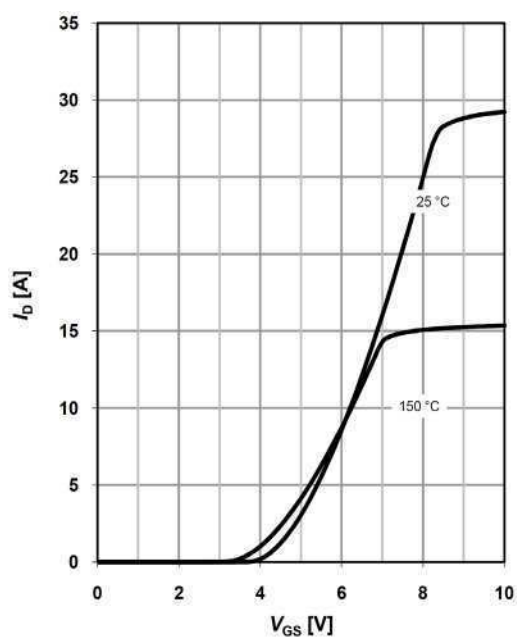
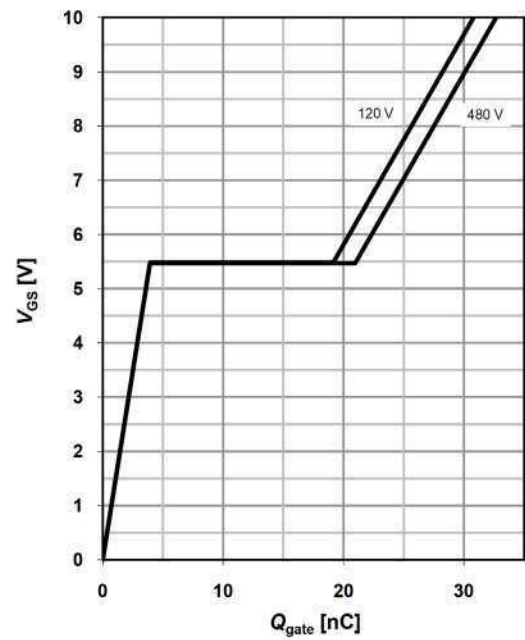
Typ. transfer characteristics	Typ. gate charge
	
$I_D = f(V_{GS}); V_{DS} = 20V$	$V_{GS} = f(Q_{gate}), I_D = 4.9 \text{ A pulsed}$

Table 17

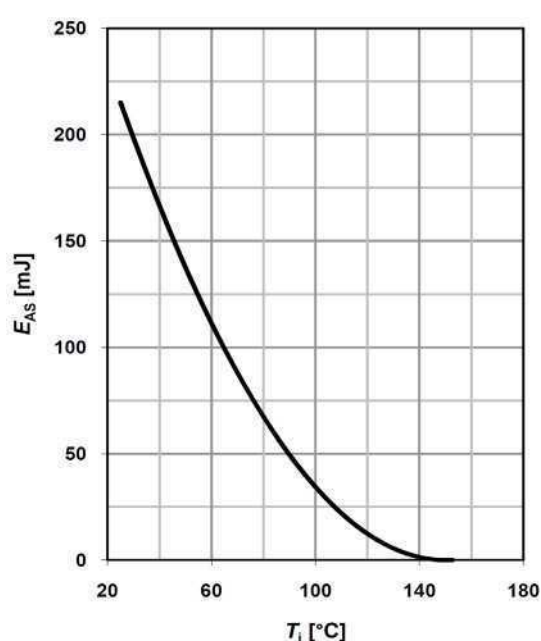
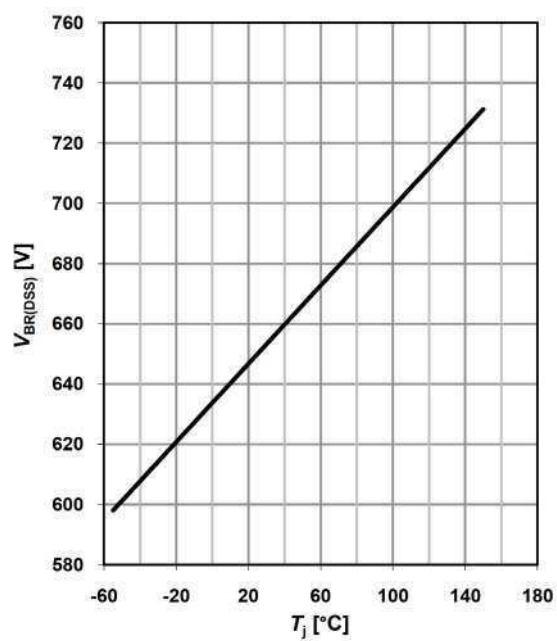
Avalanche energy	Drain-source breakdown voltage
	
$E_{AS} = f(T_j); I_D = 1.8 \text{ A}; V_{DD} = 50 \text{ V}$	$V_{BR(DSS)} = f(T_j); I_D = 1.0 \text{ mA}$

Table 18

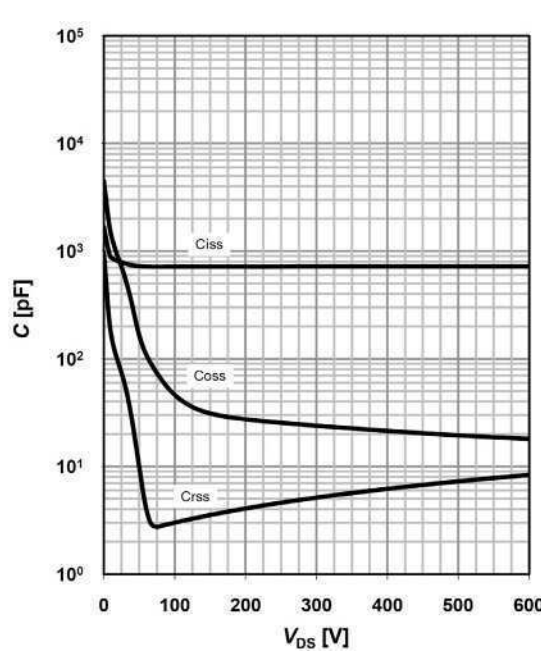
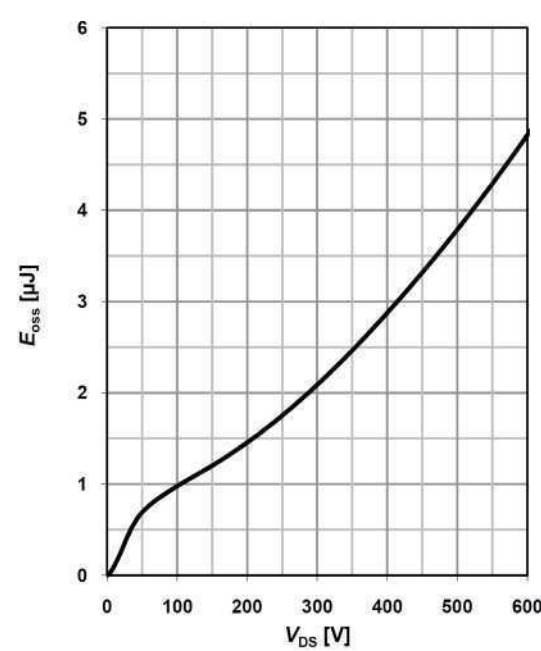
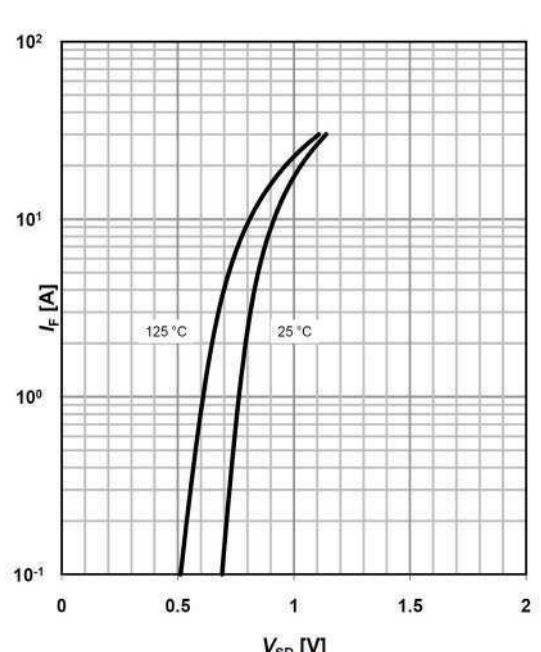
Typ. capacitances	Typ. C_{oss} stored energy
 $C = f(V_{DS}); V_{GS} = 0 \text{ V}; f = 1 \text{ MHz}$	 $E_{oss} = f(V_{DS})$

Table 19

Forward characteristics of reverse diode
 $I_F = f(V_{SD}); \text{parameter: } T_j$

6 Test circuits

Table 20 Switching times test circuit and waveform for inductive load

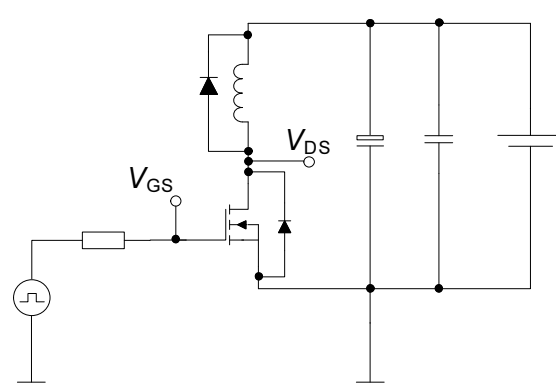
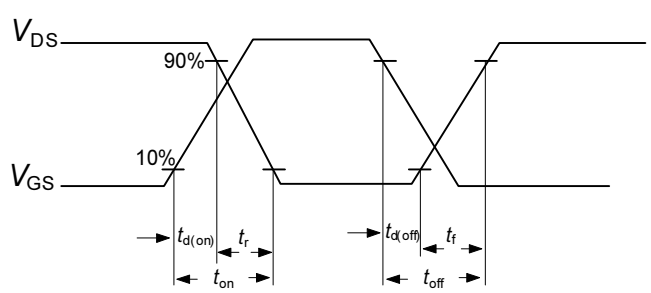
Switching times test circuit for inductive load	Switching time waveform
	

Table 21 Unclamped inductive load test circuit and waveform

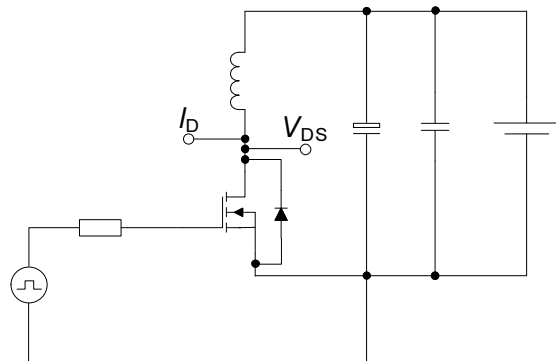
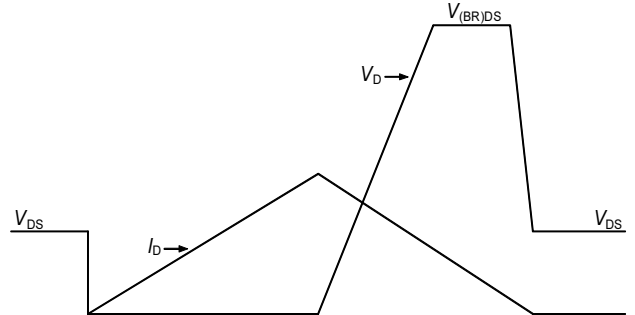
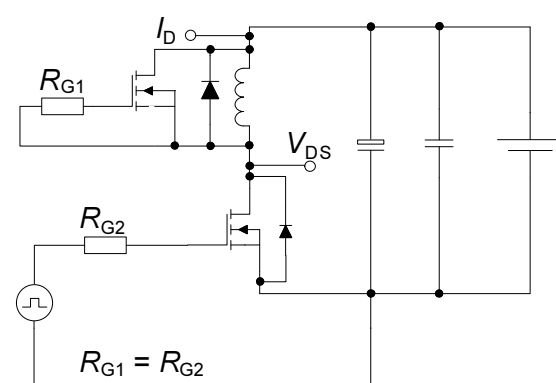
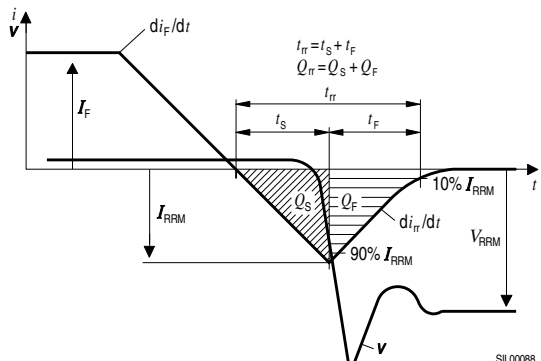
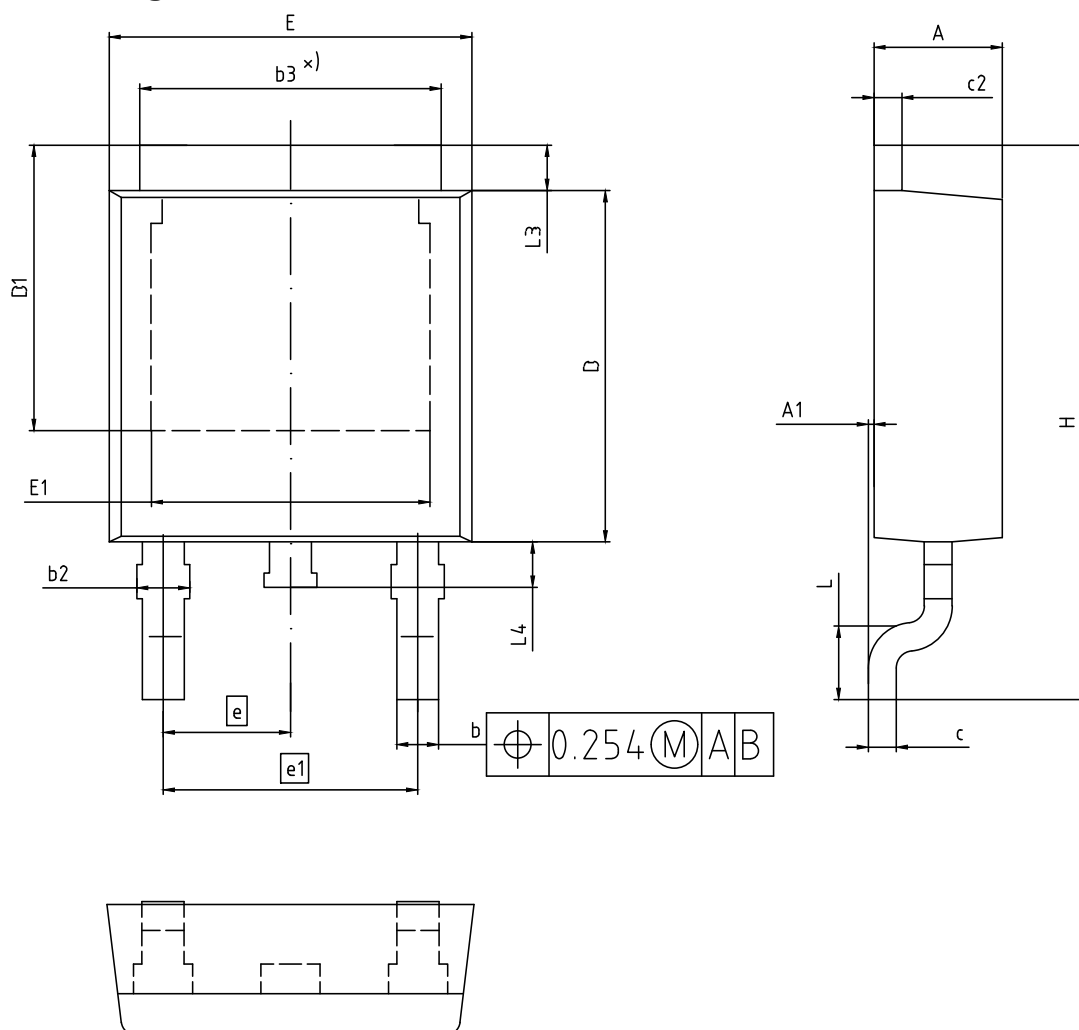
Unclamped inductive load test circuit	Unclamped inductive waveform
	

Table 22 Test circuit and waveform for diode characteristics

Test circuit for diode characteristics	Diode recovery waveform
	

7 Package outlines

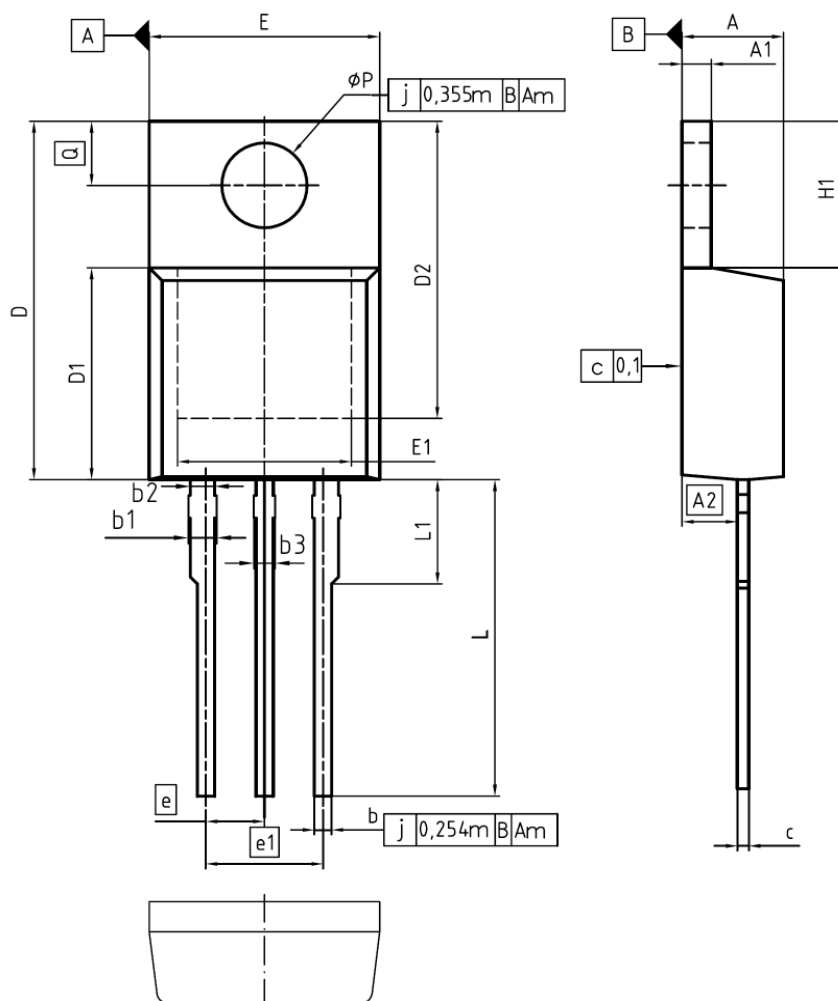


ALL DIMENSIONS REFER TO JEDEC
STANDARD TO-252 AND DO NOT INCLUDE MOLD
FLASH OR PROTRUSIONS.

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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EUROPEAN PROJECTION
ISSUE DATE 01.04.2020

Figure 1 Outlines TO-252, dimensions in mm



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

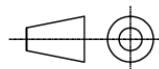
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ISSUE DATE 23-08-2007
REVISION 05

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

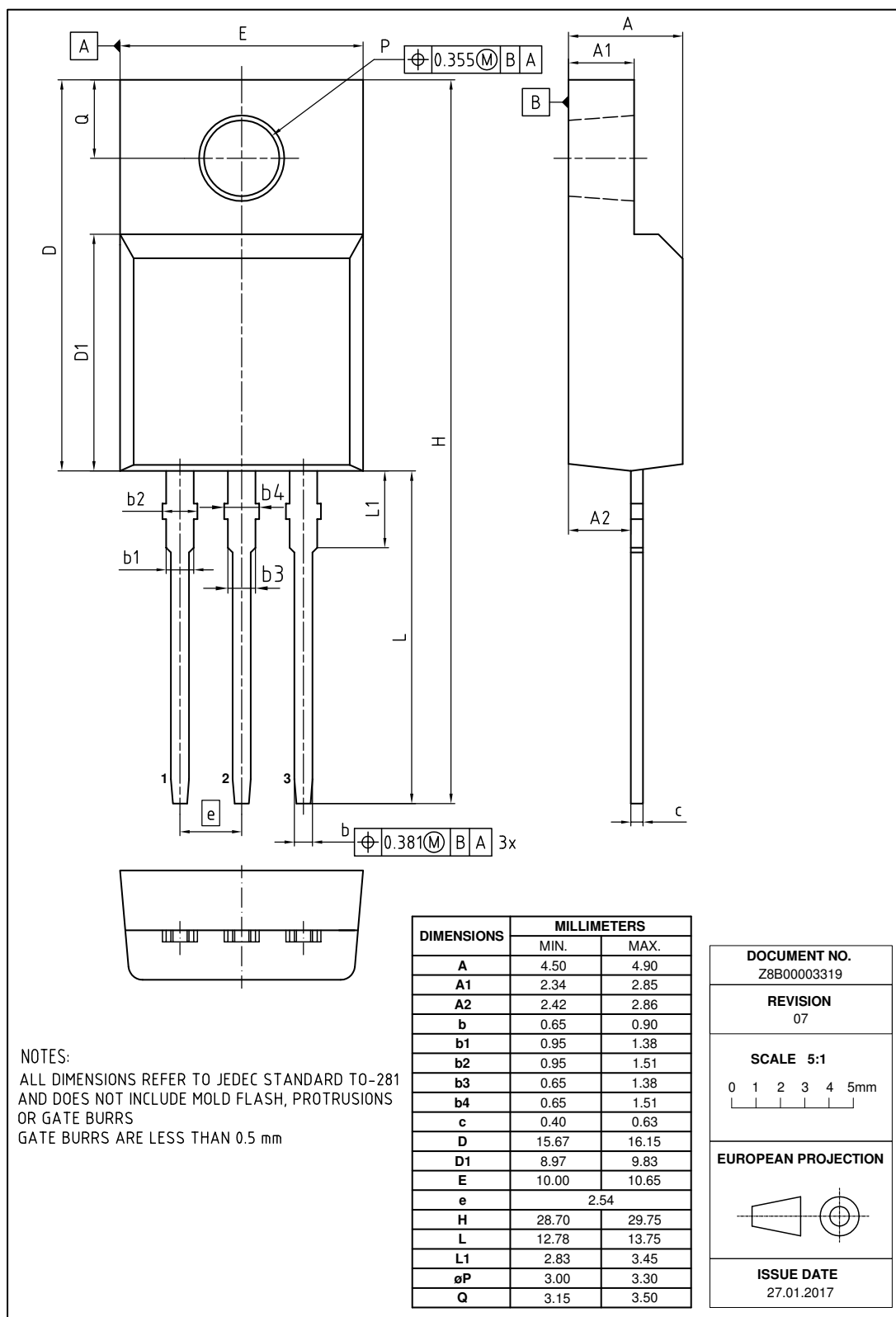


Figure 3 Outlines TO-220 FullPAK, dimensions in mm

Revision History

IPx65R380E6

Revision: 2020-05-20, Rev. 2.2

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.1	2018-03-05	Outline PG-TO-220 FullPAK update
2.2	2020-05-20	Update of the package outlines TO-252

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