MOSFET

Metal Oxide Semiconductor Field Effect Transistor

CoolMOS™ E6 600V

600V CoolMOS™ E6 Power Transistor
IPx60R380E6

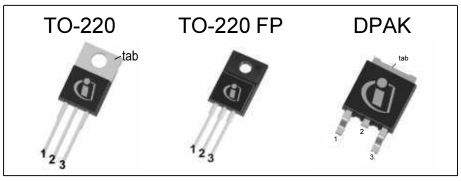
Data Sheet

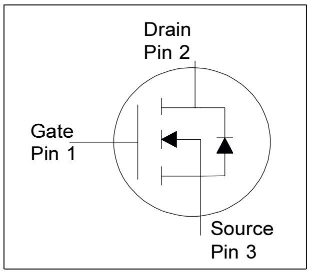
Rev. 2.6
Final

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™ 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 Rdson*Qg and Eoss
- Very high commutation ruggedness
- Easy to use/drive
- Pb-free plating, Halogen free mold compound (except PG-TO252)
- Qualified for industrial grade applications according to JEDEC (J-STD20 and JESD22)

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.

Table 1 Key Performance Parameters

Parameter	Value	Unit
V_{DS} @ $T_{j\,max}$	650	V
RDS(on),max	0.38	Ω
Qg,typ	32	nC
ID,pulse	30	A
Eoss @ 400V	2.8	µJ
Body diode di/dt	500	A/µs

Type / Ordering Code	Package	Marking	Related Links
IPP60R380E6	PG-TO 220	6R380E6	see Appendix A
IPA60R380E6	PG-TO 220 FullPAK		
IPD60R380E6	PG-TO 252		

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			10.6	A	T_C = 25°C
				6.7		T_C = 100°C
Pulsed drain current [2]	$I_{D,pulse}$			30	A	T_C = 25°C
Avalanche energy, single pulse	E_{AS}			210	mJ	I_D = 1.8A, V_{DD} = 50V (see table 22)
Avalanche energy, repetitive	E_{AR}			0.32	mJ	I_D = 1.8A, V_{DD} = 50V
Avalanche current, repetitive	I_{AR}			1.8	A	
MOSFET dv/dt ruggedness	dv/dt			50	V/ns	V_{DS} = 0 ... 480V
Gate source voltage	V_{GS}	-20		20	V	static
		-30		30		AC (f > 1 Hz)
Power dissipation (non FullPAK) TO-220	P_{tot}			83	W	T_C = 25°C
Power dissipation (FullPAK) TO-220 FP	P_{tot}			31	W	T_C = 25°C
Operating and storage temperature	T_j, T_{stg}	-55		150	°C	
Mounting torque (non FullPAK) TO-220				60	Ncm	M3 and M3.5 screws
Mounting torque (FullPAK) TO-220 FP				50	Ncm	M2.5 screws
Continuous diode forward current	I_S			9.2	A	T_C = 25°C
Diode pulse current	$I_{S,pulse}$			30	A	T_C = 25°C
Reverse diode dv/dt [3]	dv/dt			15	V/ns	V_{DS} = 0 ... 480V, $I_{SD} \leq I_D$, T_j = 25°C (see table 20)
Maximum diode commutation speed	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

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}			1.5	°C/W	
Thermal resistance, junction - ambient	R_{thJA}			62	°C/W	leaded
Soldering temperature, wavesoldering only allowed at leads	T_{sold}			260	°C	1.6 mm (0.063 in.) from case for 10s

Table 4 Thermal characteristics TO-220 FP

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}			4.0	°C/W	
Thermal resistance, junction - ambient	R_{thJA}			80	°C/W	leaded
Soldering temperature, wavesoldering only allowed at leads	T_{sold}			260	°C	1.6 mm (0.063 in.) from case for 10s

Table 5 Thermal characteristics DPAK

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}			1.5	°C/W	
Thermal resistance, junction - ambient [1)]	R_{thJA}			62	°C/W	SMD version, device on PCB, minimal footprint
			35			SMD version, device on PCB, 6cm² cooling area
Soldering temperature, wave- & reflowsoldering allowed	T_{sold}			260	°C	reflow MSL

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

4 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	$V_{(BR)DSS}$	600			V	V_{GS} = 0V, I_D = 0.25mA
Gate threshold voltage	$V_{GS(th)}$	2.5	3	3.5	V	V_{DS} = V_{GS}, I_D = 0.3mA
Zero gate voltage drain current	I_{DSS}			1	µA	V_{DS} = 600V, V_{GS} = 0V, T_j = 25°C
			10			V_{DS} = 600V, 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	$R_{DS(on)}$		0.340	0.38	Ω	V_{GS} = 10V, I_D = 3.8A, T_j = 25°C
			0.890			V_{GS} = 10V, I_D = 3.8A, T_j = 150°C
Gate resistance	R_G		7.5		Ω	f = 1MHz, open drain

Table 7 Dynamic characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	C_{iss}		700		pF	V_{GS} = 0V, V_{DS} = 100V, f = 1MHz
Output capacitance	C_{oss}		46		pF	
Effective output capacitance, energy related [1]	$C_{o(er)}$		30		pF	V_{GS} = 0V, V_{DS} = 0 ... 480V
Effective output capacitance, time related [2]	$C_{o(tr)}$		136		pF	I_D = constant, V_{GS} = 0V, V_{DS} = 0 ... 480V
Turn-on delay time	$t_{d(on)}$		11		ns	V_{DD} = 400V, V_{GS} = 13V, I_D = 4.8A, R_G = 3.4Ω (see table 22)
Rise time	t_r		9		ns	
Turn-off delay time	$t_{d(off)}$		56		ns	
Fall time	t_f		8		ns	

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} = 480V, I_D = 4.8A, V_{GS} = 0 to 10V
Gate to drain charge	Q_{gd}		16		nC	
Gate charge total	Q_g		32		nC	
Gate plateau voltage	$V_{plateau}$		5.4		V	

[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 9 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 = 4.8A, T_j = 25°C
Reverse recovery time	t_{rr}		290		ns	V_R = 400V, I_F = 4.8A, di_F/dt = 100A/µs (see table 20)
Reverse recovery charge	Q_{rr}		3.3		µC	
Peak reverse recovery current	I_{rrm}		21		A	

5 Electrical characteristics diagrams

Table 10

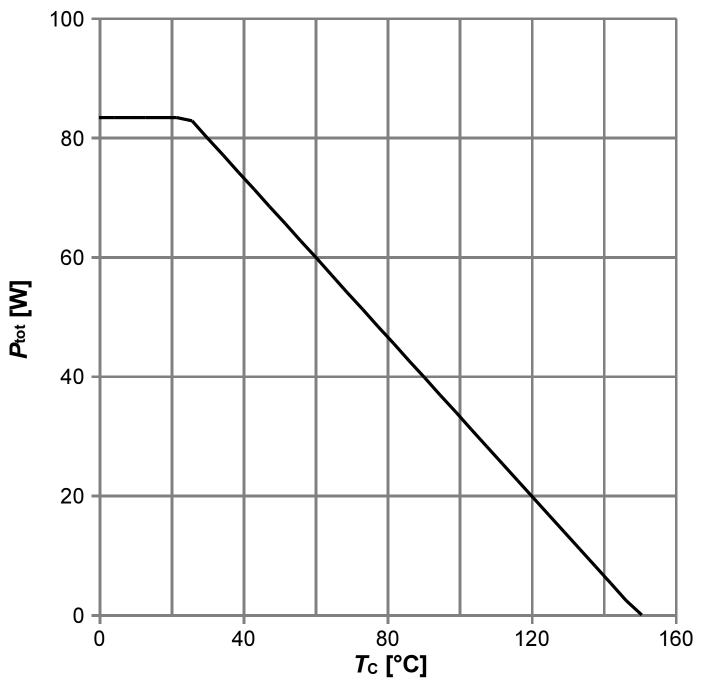
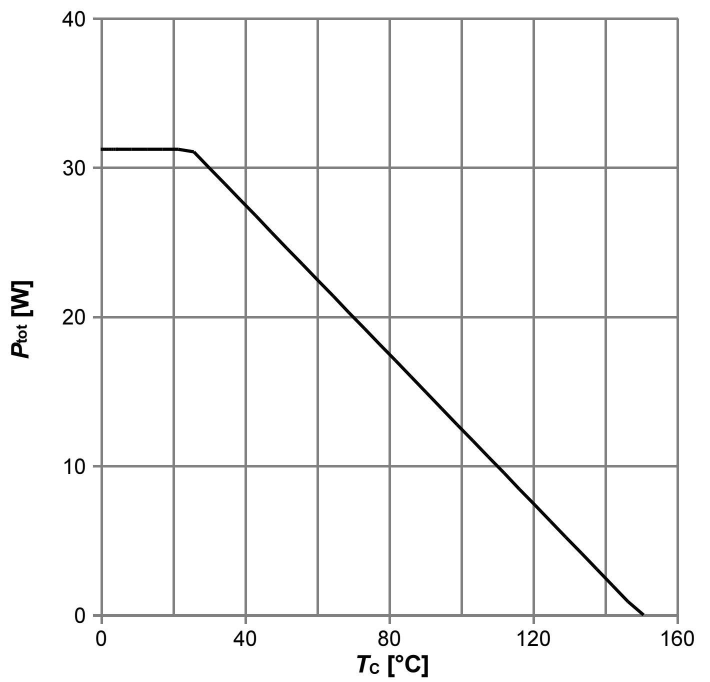
Power dissipation (Non FullPAK)	Power dissipation (FullPAK)
	
P_{tot}=f(T_C)	P_{tot}=f(T_C)

Table 11

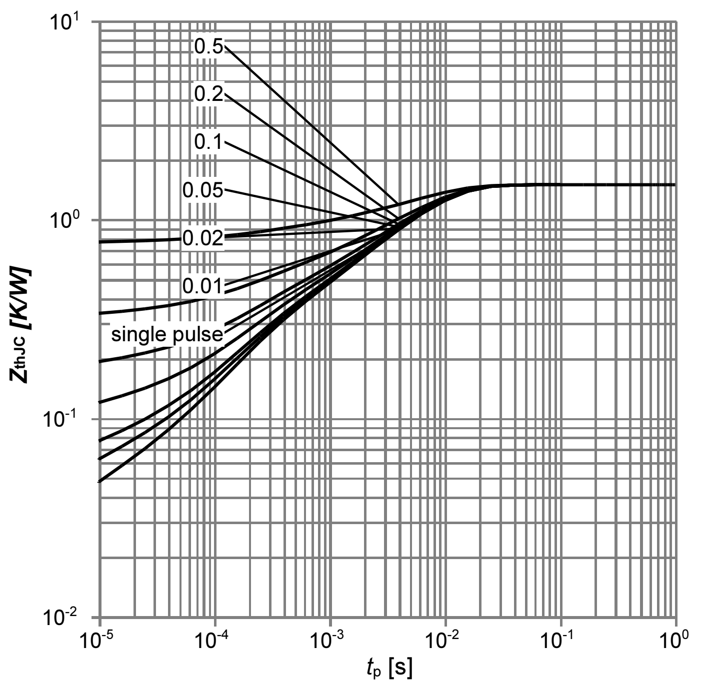
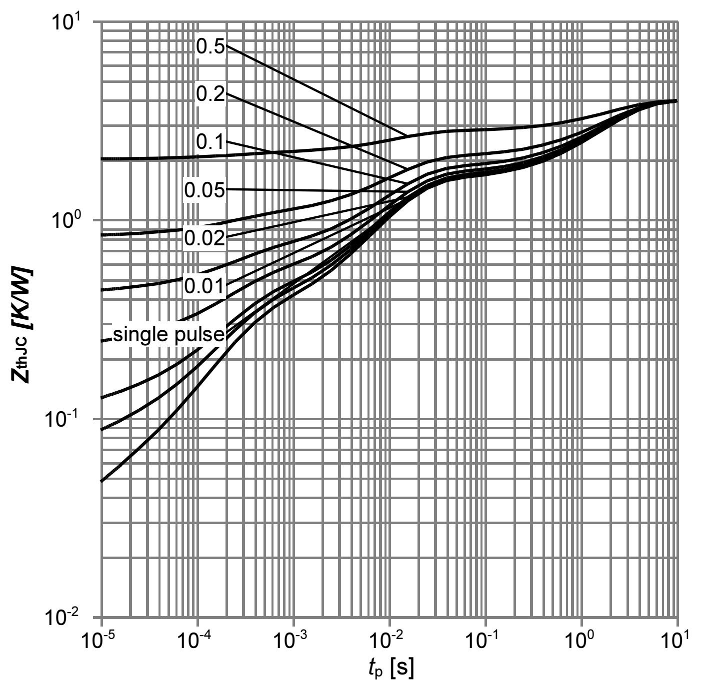
Max. transient thermal impedance (Non FullPAK)	Max. transient thermal impedance (FullPAK)
	
Z_{thJC} =f(t_P); parameter: $D=t_p/T$	Z_{thJC} =f(t_P); parameter: $D=t_p/T$

Table 12

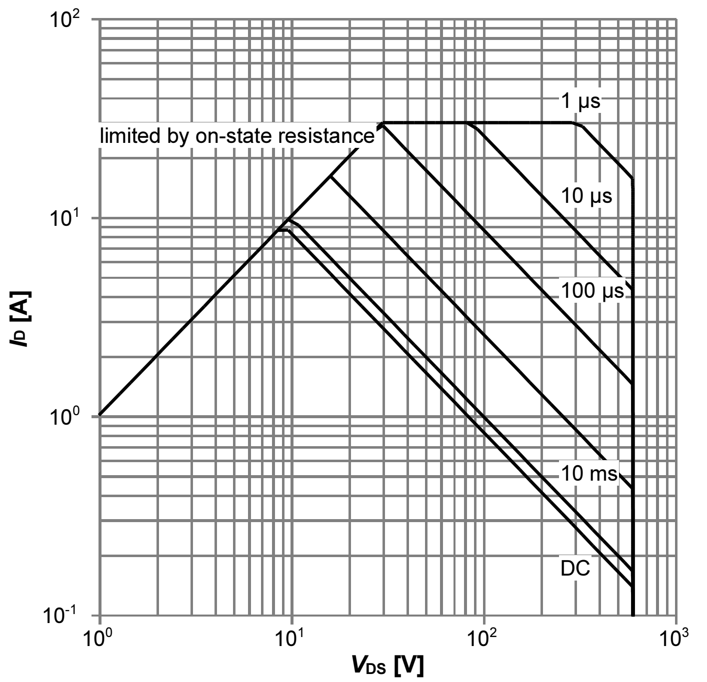
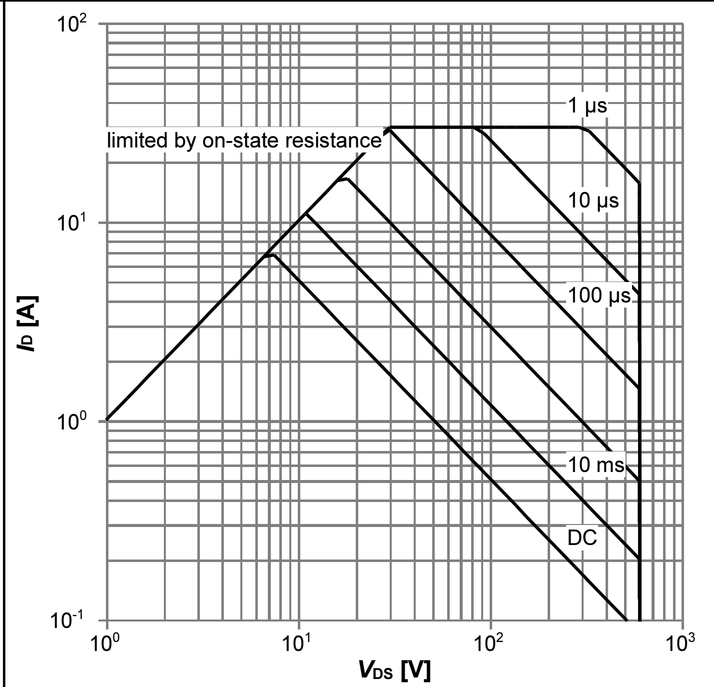
Safe operating area T_C=25°C (Non FullPAK)	Safe operating area T_C=25°C (FullPAK)
	
I_D=f(V_{DS}); V_{GS}>7V; T_C=25 °C; D=0; parameter: t_p	I_D=f(V_{DS}); V_{GS}>7V; T_C=25 °C; D=0; parameter: t_p

Table 13

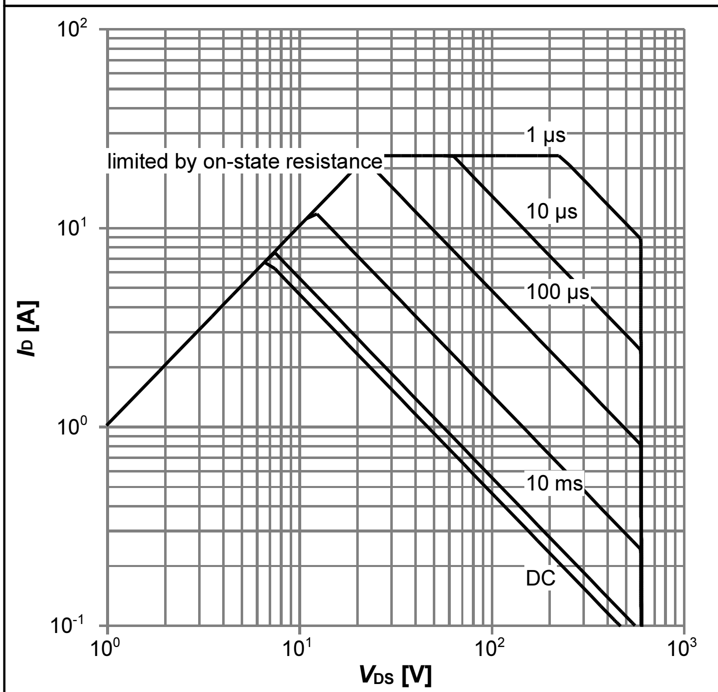
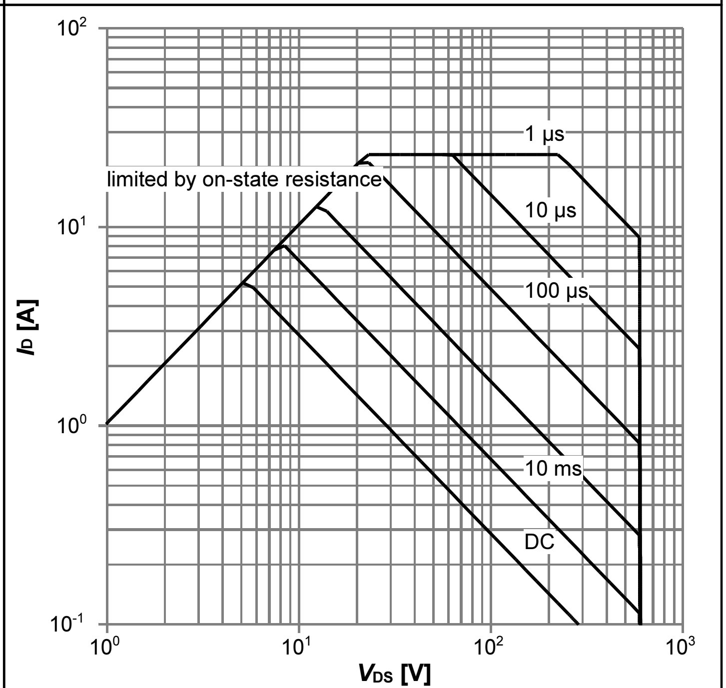
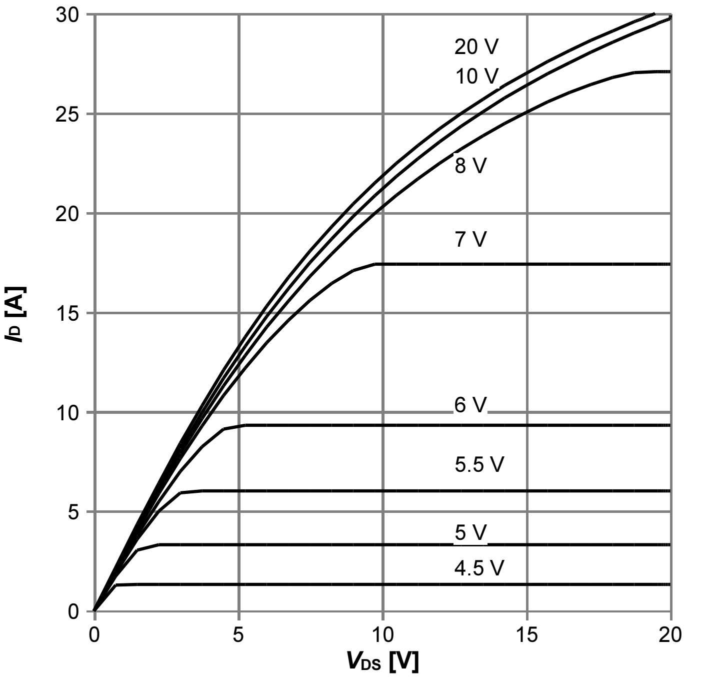
Safe operating area T_C=80°C (Non FullPAK)	Safe operating area T_C=80°C (FullPAK)
	
I_D=f(V_{DS}); V_{GS}>7V; T_C=80 °C; D=0; parameter: t_p	I_D=f(V_{DS}); V_{GS}>7V; T_C=80 °C; D=0; parameter: t_p

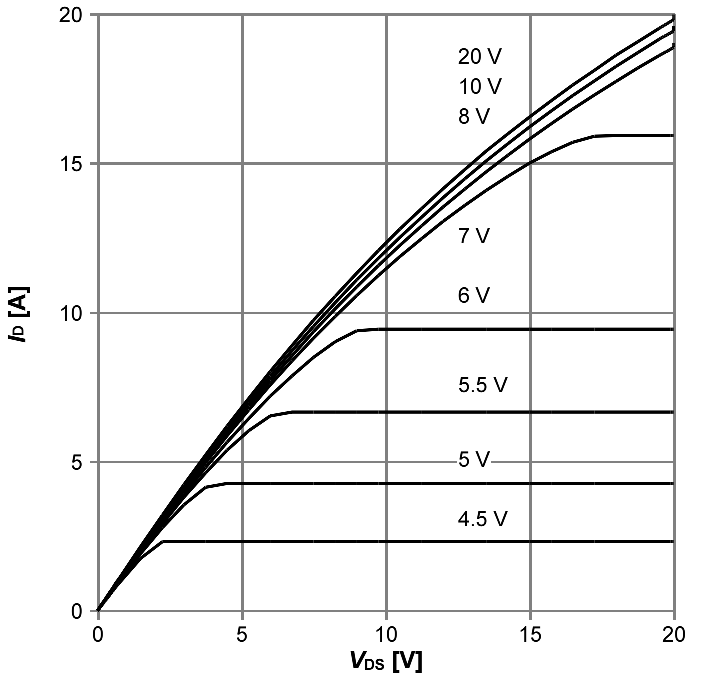
Table 14

Typ. output characteristics T_C=25°C



I_D=f(V_{DS}); T_j=25 °C; parameter: V_{GS}

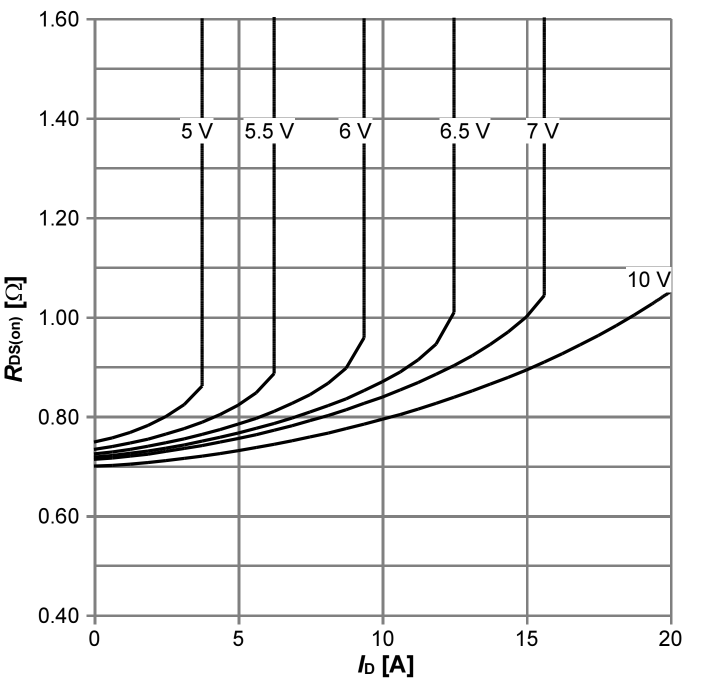
Typ. output characteristics T_C=125°C



I_D=f(V_{DS}); T_j=125 °C; parameter: V_{GS}

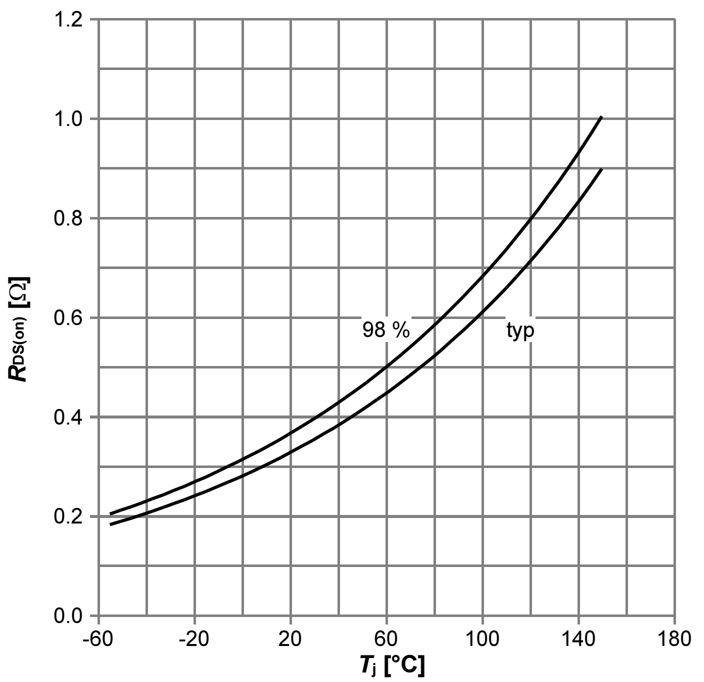
Table 15

Typ. drain-source on-state resistance



$R_{DS(on)}$=f(I_D); T_j=125 °C; parameter: V_{GS}

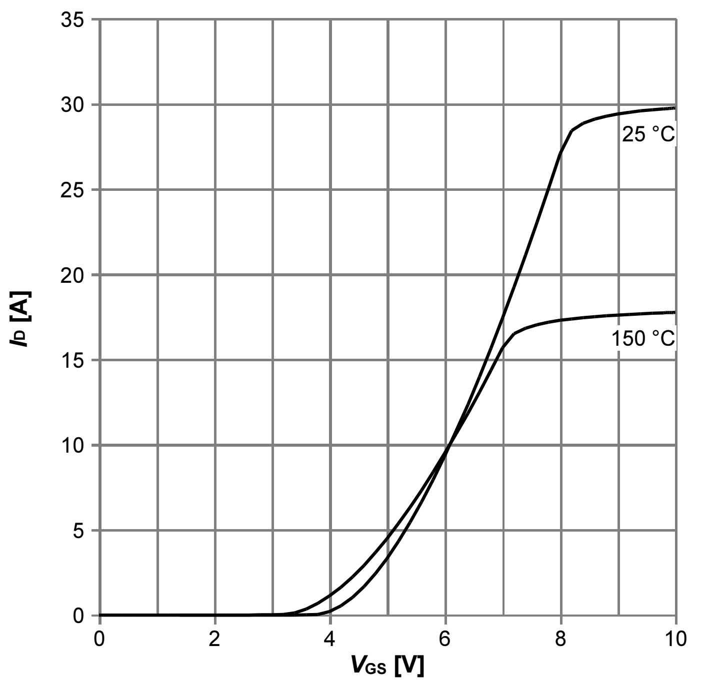
Drain-source on-state resistance



$R_{DS(on)}$=f(T_j); I_D=3.8 A; V_{GS}=10 V

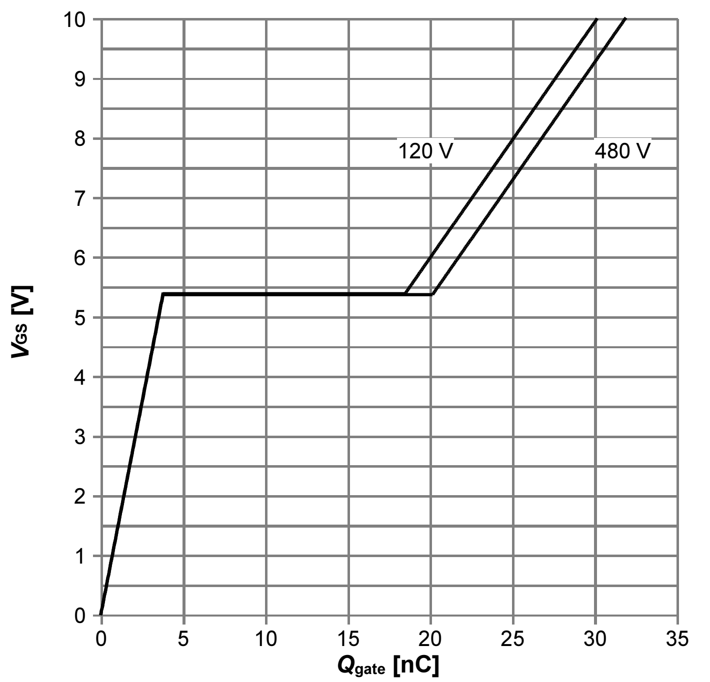
Table 16

Typ. transfer characteristics



I_D=f(V_{GS}); V_{DS}= 20V; parameter: T_j

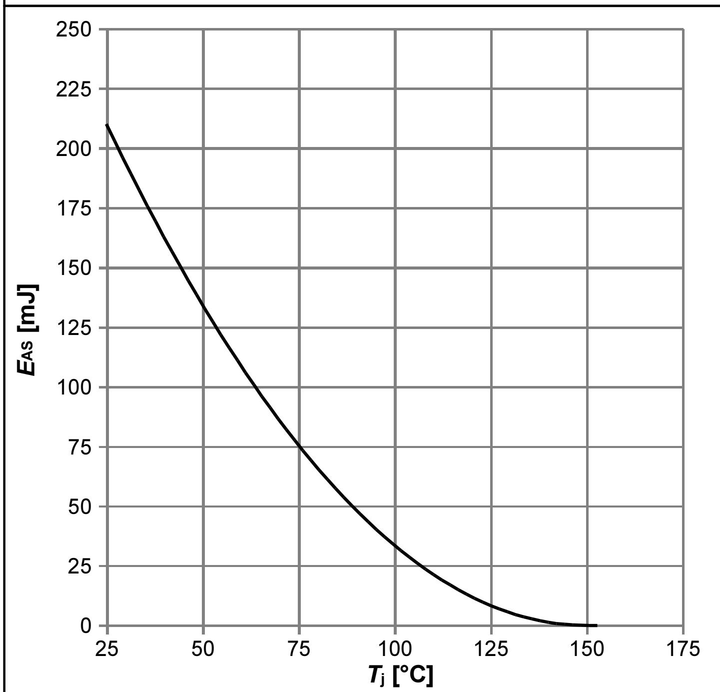
Typ. gate charge



V_{GS}=f(Q_{gate}); I_D=4.8 A pulsed; parameter: V_{DD}

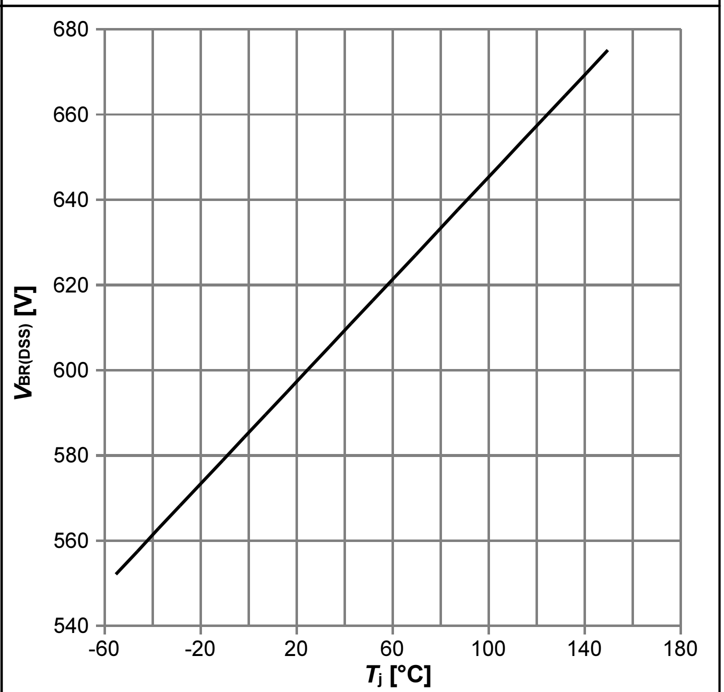
Table 17

Avalanche energy



E_{AS}=f(T_j); I_D=1.8 A; V_{DD}=50 V

Drain-source breakdown voltage



$V_{BR(DSS)}$=f(T_j); I_D=0.25 mA

Table 18

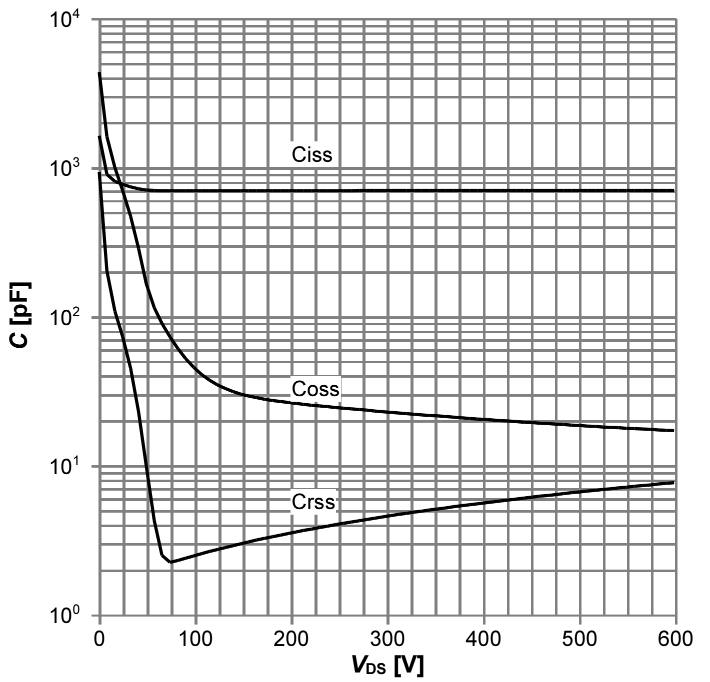
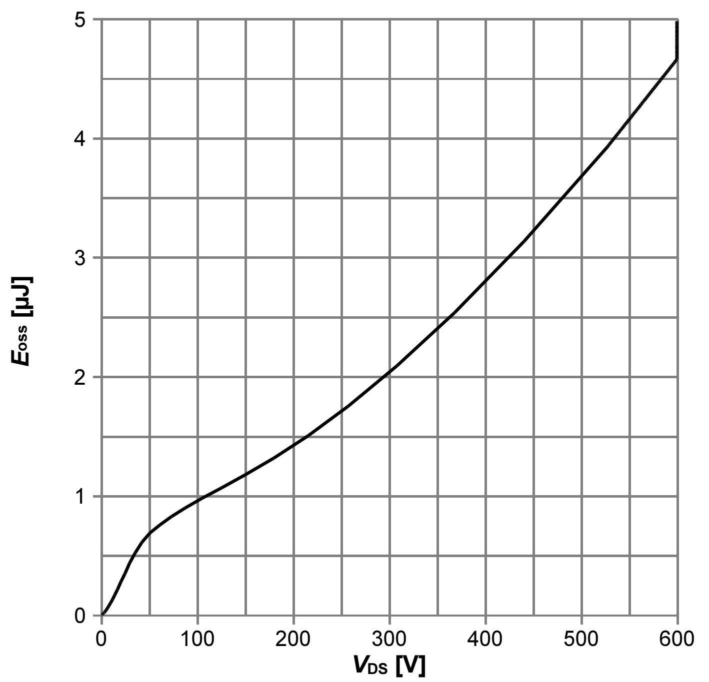
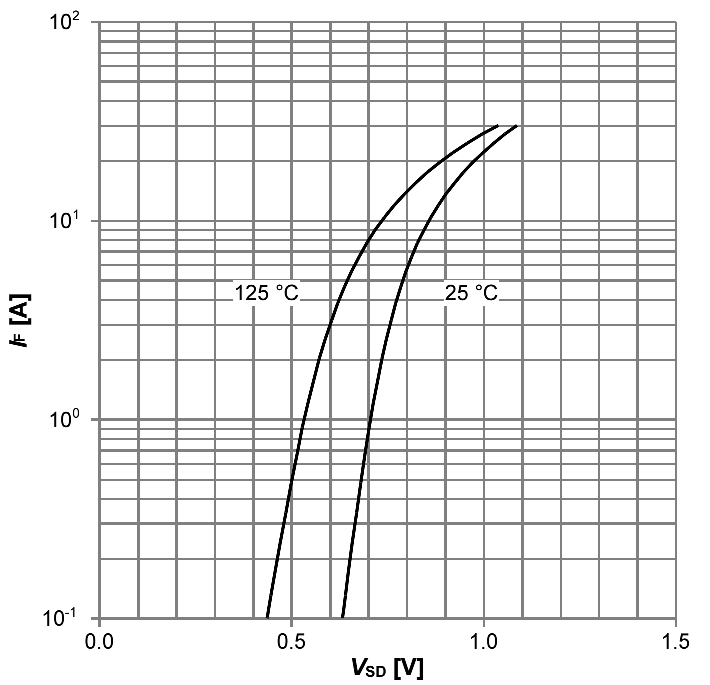
Typ. capacitances	Typ. C_{oss} stored energy
	
C=f(V_{DS}); V_{GS}=0 V; f=1 MHz	E_{oss}=f(V_{DS})

Table 19

Forward characteristics of reverse diode

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

6 Test Circuits

Table 20 Diode characteristics

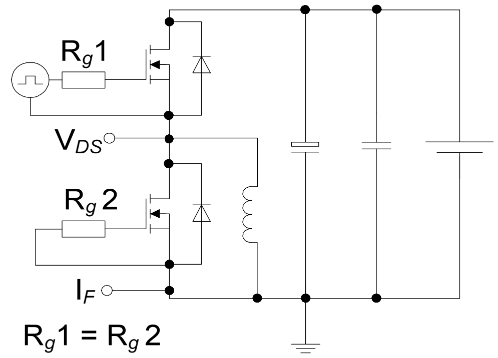
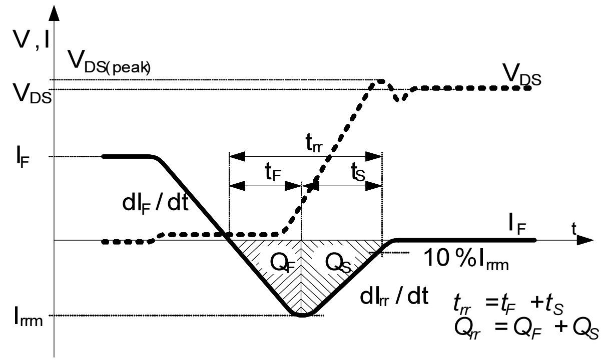
Test circuit for diode characteristics	Diode recovery waveform
	

Table 21 Switching times

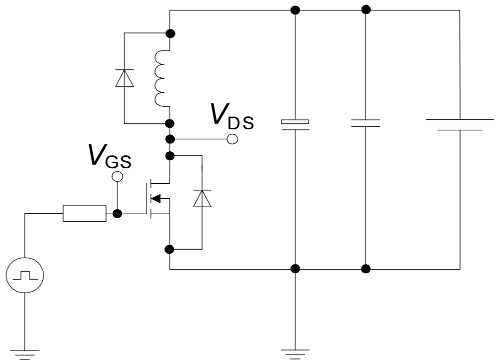
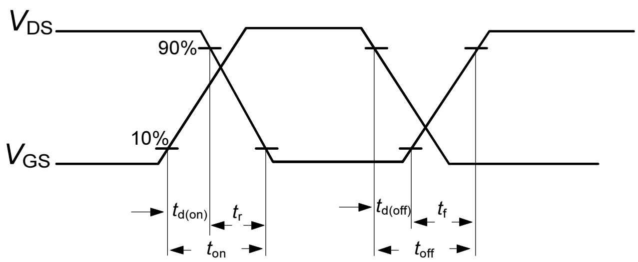
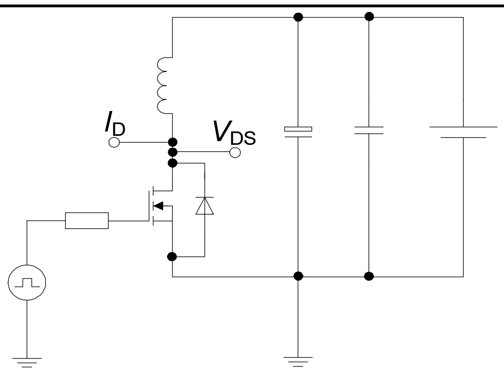
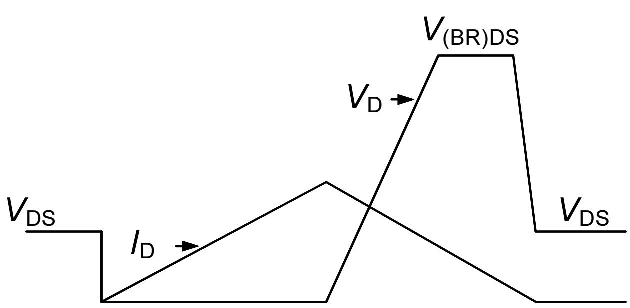
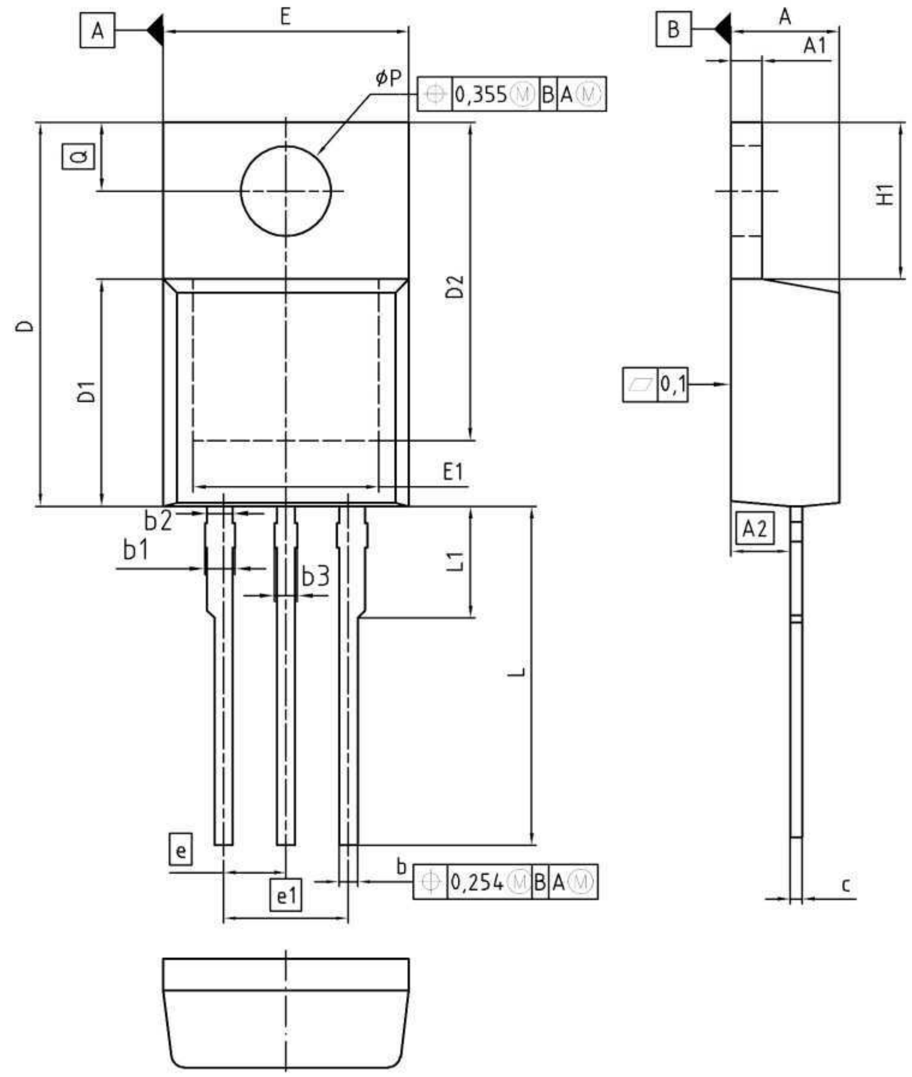
Switching times test circuit for inductive load	Switching times waveform
	

Table 22 Unclamped inductive load

Unclamped inductive load test circuit	Unclamped inductive 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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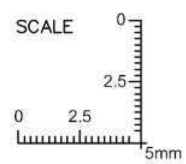

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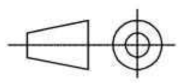

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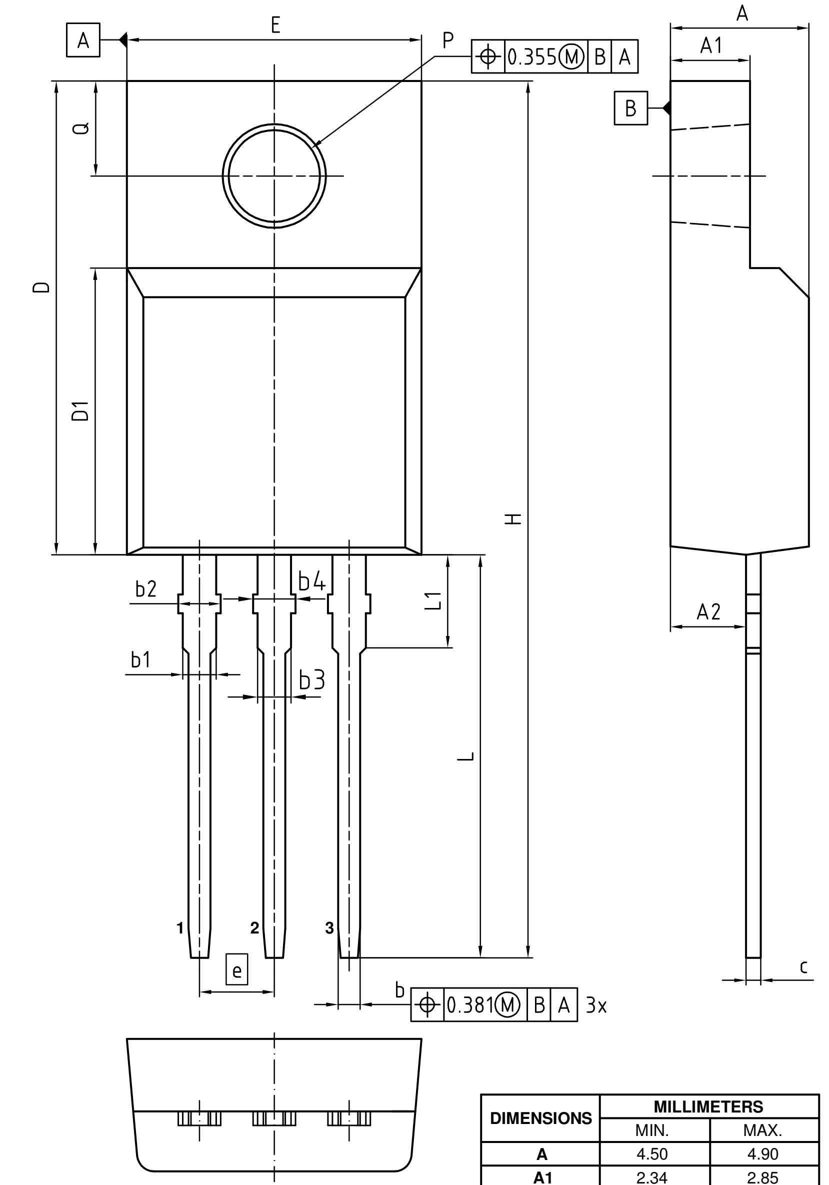
REVISION
06

Figure 1 Outline PG-TO 220, 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

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Z8B00003319

REVISION
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SCALE 5:1
0 1 2 3 4 5mm

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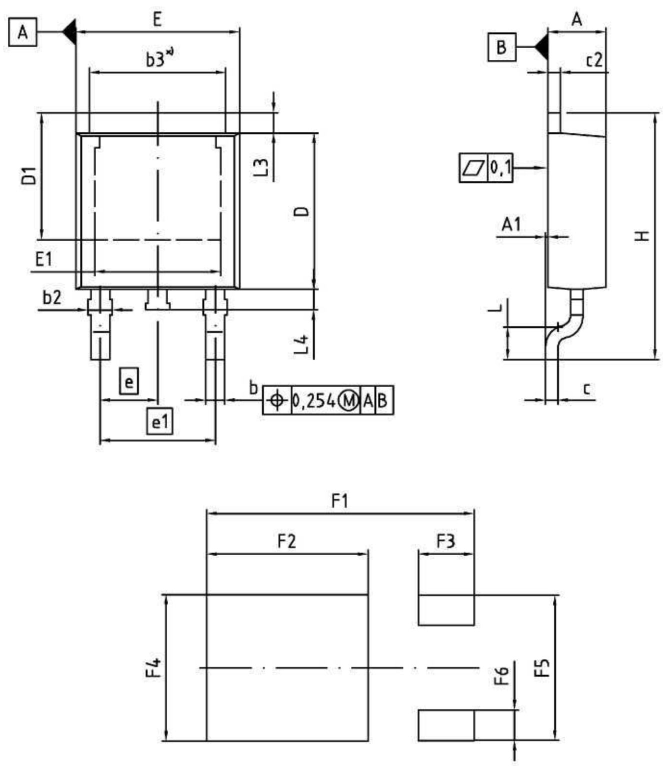
27.01.2017

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

TO252-3 (DPAK)



*) mold flash not included

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 (BSC)		0.090 (BSC)	
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	10.60		0.417	
F2	6.40		0.252	
F3	2.20		0.087	
F4	5.80		0.228	
F5	5.76		0.227	
F6	1.20		0.047	

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Z8B00003328

SCALE
0 2.0 4mm

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16-02-2011

REVISION
04

Figure 3 Outline PG-TO 252, dimensions in mm/inches

8 Appendix A

Table 23 Related Links

- **IFX CoolMOS Webpage:** www.infineon.com
- **IFX Design Tools:** www.infineon.com

Revision History

IPx60R380E6

Revision: 2018-03-04, Rev. 2.6

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.4	2013-05-15	PG-TO252 Package Added
2.5	2015-02-09	PG-TO220 FullPAK package outline update (creation:2014-12-09)
2.6	2018-03-04	Outline PG-TO-220 FullPAK update

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