

# MOSFET

Metall Oxide Semiconductor Field Effect Transistor

## CoolMOS E6

650V CoolMOS™ E6 Power Transistor  
IPx65R600E6

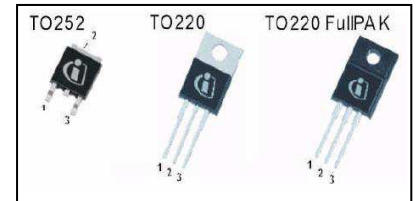
## Data Sheet

Rev. 2.3, 2018-02-28

Power Management & Multimarket

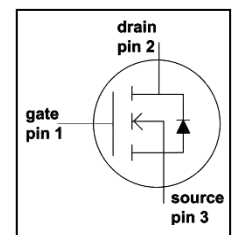
## 1 Description

CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. CoolMOS™ DE 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  $F O M R_{dson} * Q_g$  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 e.g. PC Silverbox, Adapter, LCD & PDP TV, Lightning, 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
$R_{DS(on), max}$	0.6	$\Omega$
$Q_G, typ$	23	nC
$I_D, pulse$	18	A
$E_{oss} @ 400V$	2	$\mu J$
Body diode di/dt	500	A/ $\mu s$

Type / Ordering Code	Package	Marking	Related links
IPD65R600E6	PG-TO252	65E6600	<a href="#">IFX CoolMOS Webpage</a> <a href="#">IFX Design tools</a>
IPP65R600E6	PG-TO220		
IPA65R600E6	PG-TO220 FullIPAK		

1) J-STD20 and JESD22

2) For PG-TO252: non-Halogen free (OPN: IPD65R600E6BT); Halogen free (OPN: IPD65R600E6AT)

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## 2 Maximum ratings

At  $T_j = 25^\circ\text{C}$ , 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	$T_C = 25^\circ\text{C}$
		–	–	4.6		$T_C = 100^\circ\text{C}$
Pulsed drain current <sup>2)</sup>	$I_{D, \text{pulse}}$	–	–	18		$T_C = 25^\circ\text{C}$
Averlance energy, single pulse	$E_{AS}$	–	–	142	mJ	$I_D = 1.3\text{A}; V_{DD} = 50\text{V};$ $T_C = 25^\circ\text{C}$ (see Table 11)
Averlance energy, repetitive	$E_{AR}$	–	–	0.21		$I_D = 1.3\text{A}, V_{DD} = 50\text{V}$
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 Non FullPAK	$P_{tot}$	–	–	63	W	$T_C = 25^\circ\text{C}$
Power dissipation for FullPAK	$P_{tot}$	–	–	28	W	$T_C = 25^\circ\text{C}$
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	$T_C = 25^\circ\text{C}$
Diode pulse current <sup>2)</sup>	$I_{S, \text{pulsed}}$	–	–	18	A	$T_C = 25^\circ\text{C}$
Reverse diode dv/dt <sup>3)</sup>	$dv/dt$	–	–	15	V/ns	$V_{DS} = 0 \dots 480\text{V}, I_{SD} \leq I_D,$
Maximum diode commutation speed <sup>3)</sup>	$di/dt$			500	A/ $\mu\text{s}$	$T_C = 125^\circ\text{C}$ (see table 22)

1) Limited by  $T_{j, \text{max}}$ . Maximum duty cycle  $D=0.75$

2) Pulse width  $t_p$  limited by  $T_{j, \text{max}}$

3) Identical low side and high side switch with identical  $R_\theta$

### 3 Thermal characteristics

**Table 3 Thermal characteristics TO-220 (IPP65R600E6)**

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	1.6mm (0.063 in.) from case for 10 s

**Table 4 Thermal characteristics TO-220 FullPAK (IPA65R600E6)**

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	1.6mm (0.063 in.) from case for 10 s

**Table 5 Thermal characteristics TO-252 (IPD65R600E6)**

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- & reflowsoldering only 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  $T_j=25^\circ\text{C}$ , 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	$V_{GS}=0V, I_D=1.0mA$
Gate threshold voltage	$V_{GS(th)}$	2.5	3	3.5		$V_{DS}=V_{GS}, I_D=0.21mA$
Zero gate Voltage drain current	$I_{DSS}$	–	–	1	$\mu\text{A}$	$V_{DS}=600V, V_{GS}=0V,$ $T_f=25^\circ\text{C}$
		–	10	–		$V_{DS}=600V, V_{GS}=0V,$ $T_f=150^\circ\text{C}$
Gate- source leakage current	$I_{GSS}$	–	–	100	nA	$V_{GS}=20V, V_{DS}=0V$
Drain- source on- state resistance	$R_{DS(on)}$	–	0.54	0.6	$\Omega$	$V_{GS}=10V, I_D=2.1A,$ $T_f=25^\circ\text{C}$
		–	1.40	–		$V_{GS}=10V, I_D=2.1A,$ $T_f=150^\circ\text{C}$
Gate resistance	$R_G$	–	10.5	–	$\Omega$	$f=1\text{MHz}, \text{open drain}$

**Table7 Dynamic characteristics**

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Input capacitance	$C_{iss}$	–	440	–	pF	$V_{GS}=0V, V_{DS}=100V,$ $f=1\text{MHz}$
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	–		
Turn- on delay time	$t_{d(on)}$	–	10	–	ns	$V_{DD}=400V$ $V_{GS}=13V, I_D=3.2A,$ $R_G=6.8\Omega$ (see table 20)
Rise time	$t_r$	–	8	–		
Turn- off delay time	$t_{d(off)}$	–	64	–		
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	$Q_{GS}$	–	2.75	–	nC	$V_{DD}=480V, I_D=3.2A,$ $V_{GS}=0$ to 10 V
Gate to drain charge	$Q_{GD}$	–	12	–		
Gate charge, total	$Q_G$	–	23	–		
Gate plateau voltage	$V_{plateau}$	–	5.5	–	V	

**Table 8 Reverse diode characteristics**

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Diode forward voltage	$V_{SD}$	–	0.9	–	V	$V_{GS}=0V, I_F=3.2A,$ $T_J=25^\circ C$
Reverse recovery time	$t_{rr}$	–	270	–	ns	$V_R=400V, I_F=3.2A,$ $diF/dt=100A/\mu s$ (see table 22)
Reverse recovery charge	$Q_{rr}$	–	2.0	–	nC	
Peak reverse recovery current	$I_{rrm}$	–	13	–	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 Non FullPAK
$Z_{(thJC)} = f(t_p)$ ; parameter: $D = t_p/T$	$Z_{(thJC)} = f(t_p)$ ; parameter: $D = t_p/T$



Table 12

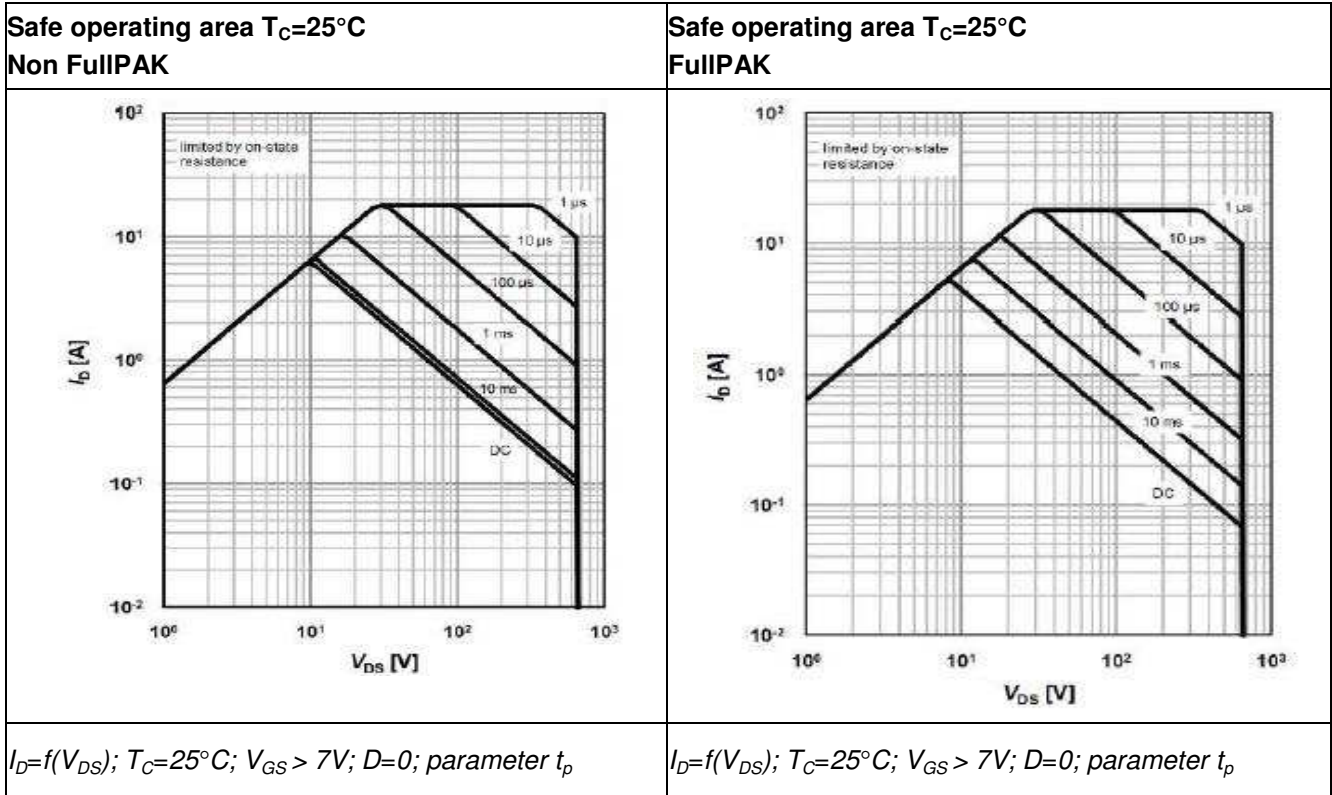


Table 13

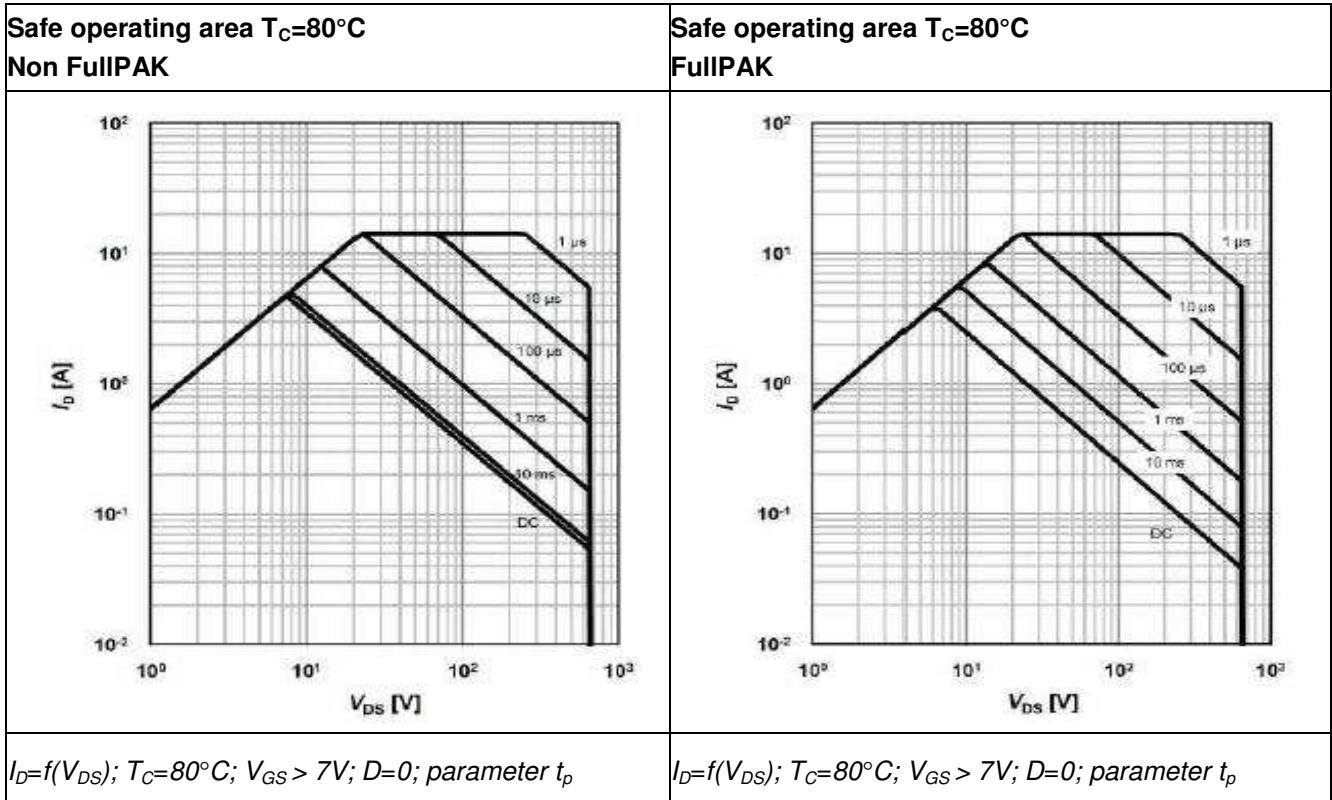


Table 14

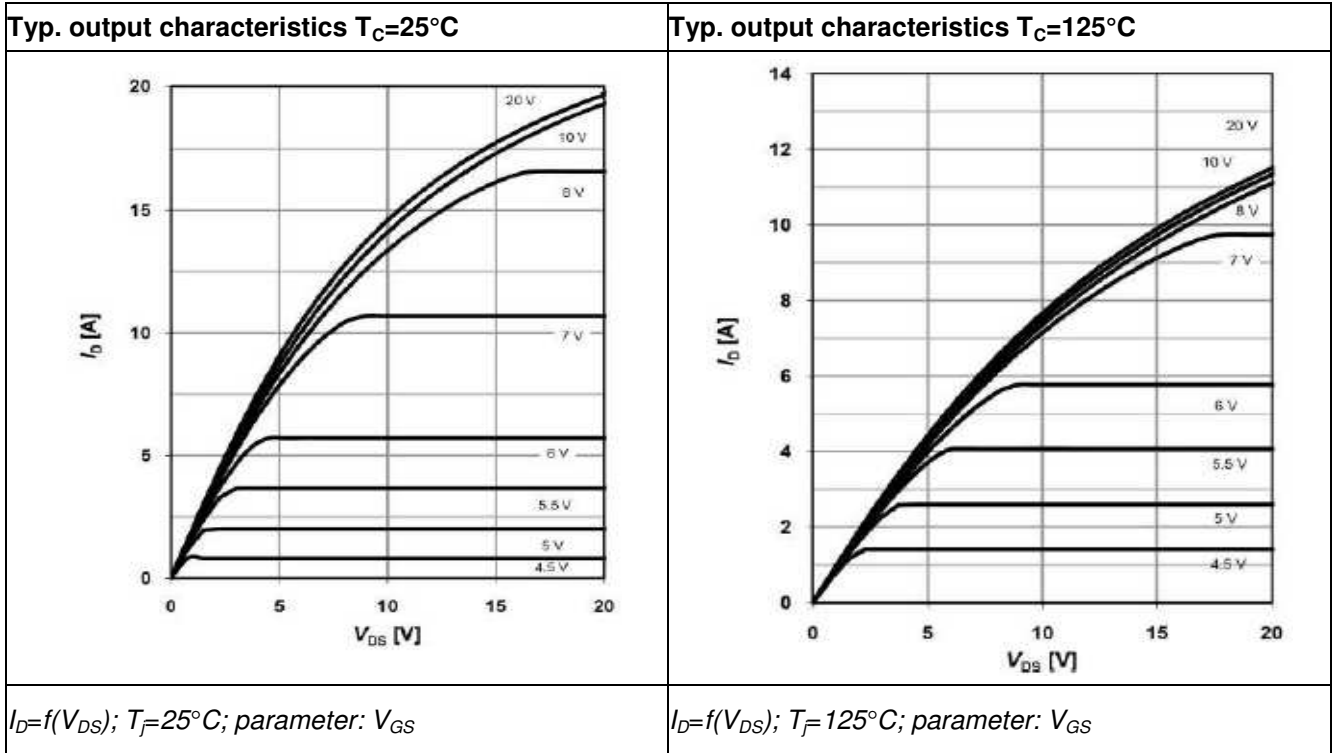


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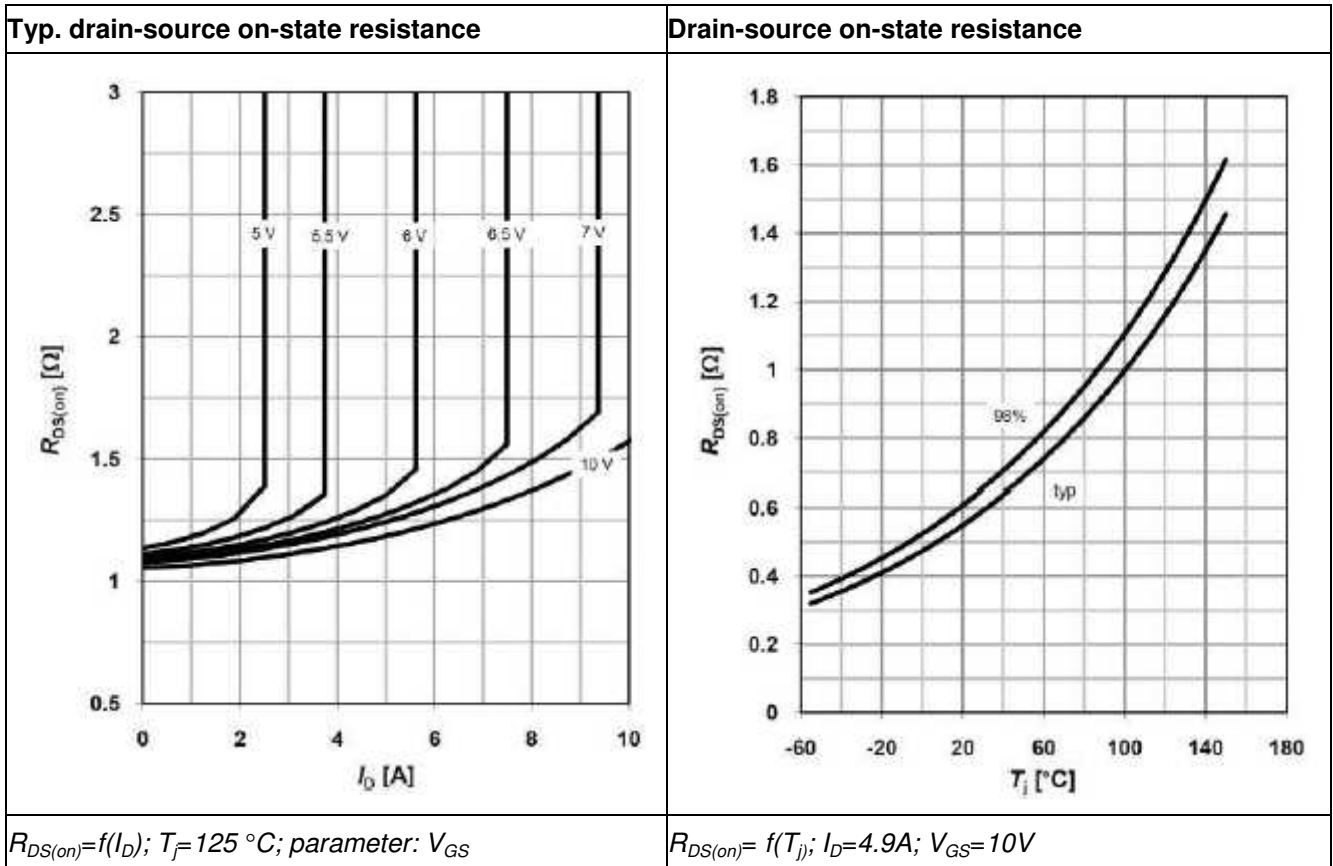


Table 16

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

Table 17

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

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
$I_r=f(V_{SD}); \text{parameter: } T_j$

## 6 Test circuits

Table 20 Switching times test circuit and waveform for inductive load

Switching times test circuit for inductive load	Switching time waveform

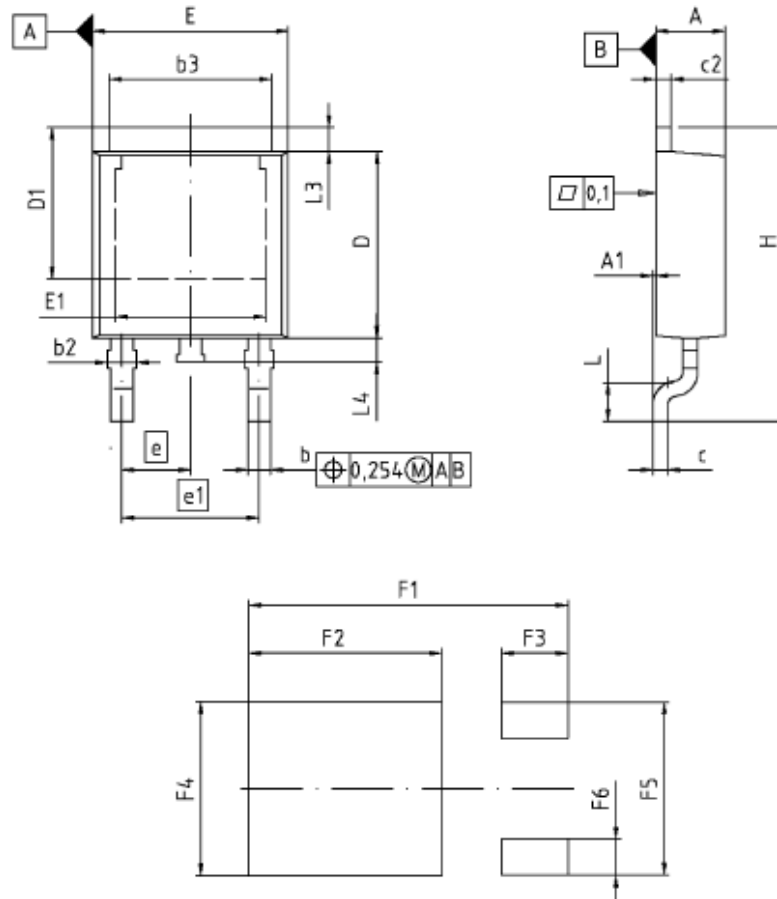
Table 11

Unclamped inductive load test circuit	Unclamped inductive waveform

Table 22

Test circuit for diode characteristics	Diode recovery waveform

7 Package outlines



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.16	2.41	0.085	0.095
A1	0.00	0.15	0.000	0.008
b	0.84	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	0.80	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		0.090	
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	10.50	10.70	0.413	0.421
F2	6.30	6.50	0.248	0.256
F3	2.10	2.30	0.083	0.091
F4	5.70	5.90	0.224	0.232
F5	5.66	5.66	0.223	0.231
F6	1.10	1.30	0.043	0.051

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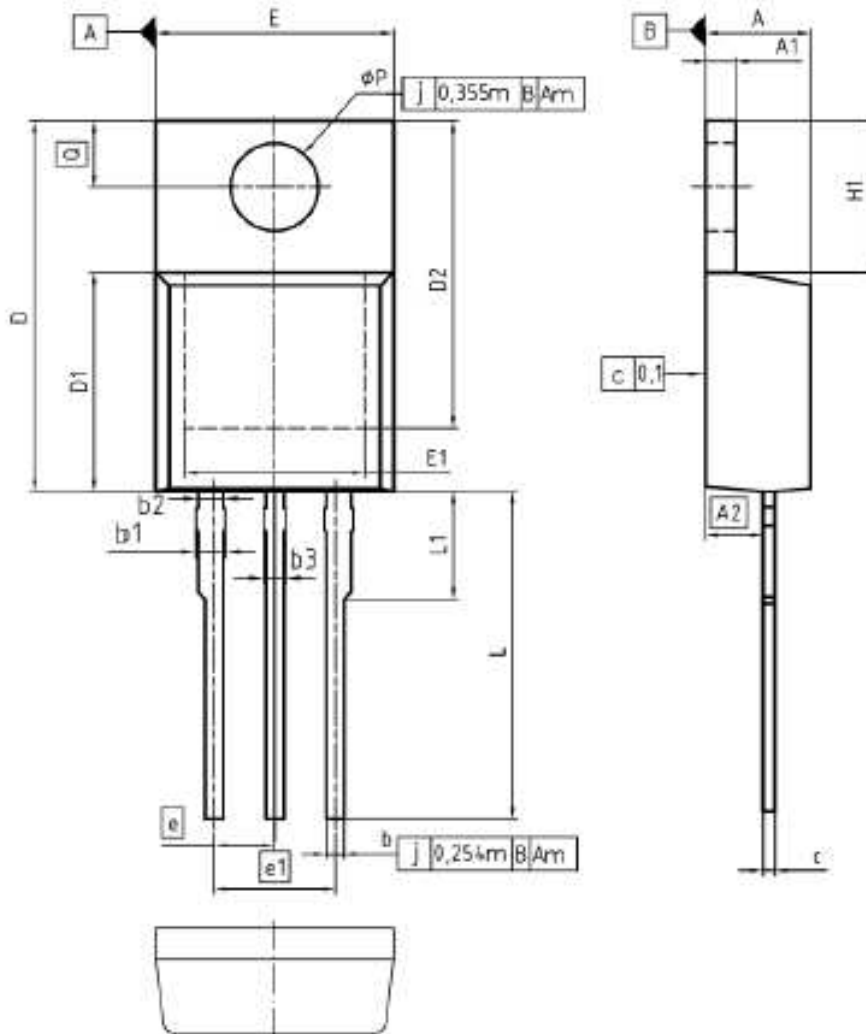
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ISSUE DATE  
19-10-2007

REVISION  
03

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	8.00	0.256	0.339
e	2.54		0.100	
e1	5.08		0.200	
N	3		3	
H1	6.90	6.90	0.232	0.272
L	13.00	14.00	0.512	0.551
L1	-	4.00	-	0.159
φP	3.60	3.60	0.142	0.153
Q	2.60	3.00	0.102	0.118

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ISSUE DATE  
23-06-2007

REVISION  
05

Figure 2 Outlines TO220, dimensions in mm/inches

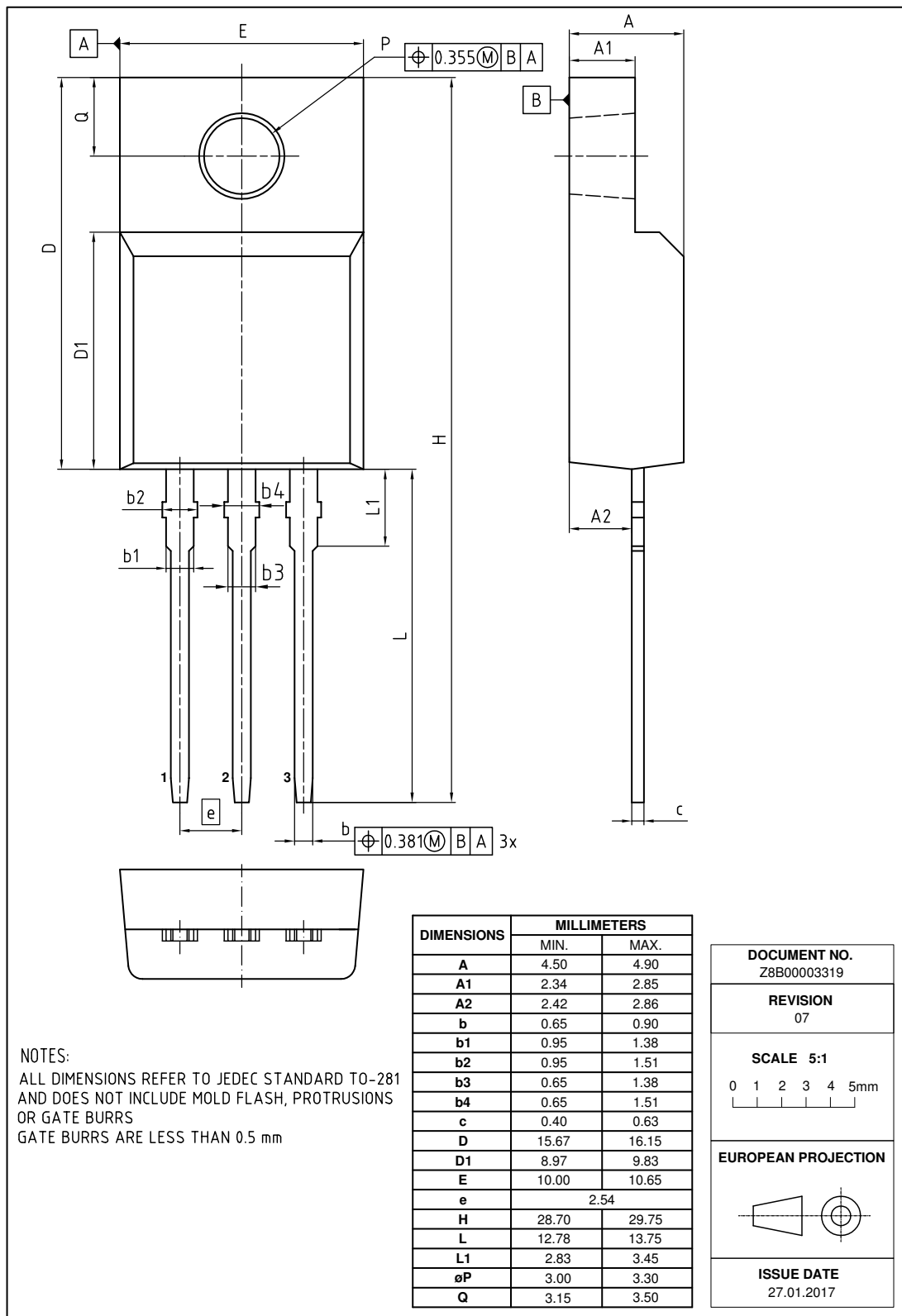


Figure 3 Outlines TO220 FullPAK, dimensions in mm



# 650V CoolMOS™ E6 Power Transistor

## IPx65R600E6

### Revision History

IPx65R600E6

**Revision: 2018-03-04, Rev. 2.3**

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.2	2016-08-04	Revised TO220 Full PAK package drawing on page 16
2.3	2018-03-04	Outline PG-TO-220 FullPAK update

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**Infineon Technologies AG**  
**81726 München, Germany**  
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