

## MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## CoolMOS™ CE

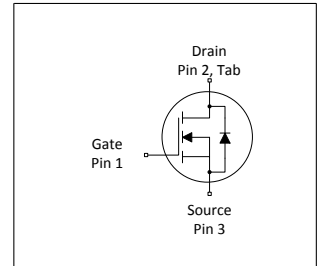
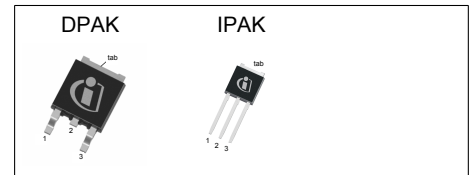
600V CoolMOS™ CE Power Transistor  
IPX60R1K0CE

## Data Sheet

Rev. 2.1  
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™ CE is a price-performance optimized platform enabling to target cost sensitive applications in Consumer and Lighting markets by still meeting highest efficiency standards. The new series provides all benefits of a fast switching Superjunction MOSFET while not sacrificing ease of use and offering the best cost down performance ratio available on the market.



## 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 mold compound
- Qualified for standard grade applications

## Applications

PFC stages, hard switching PWM stages and resonant switching stages for e.g. PC Silverbox, Adapter, LCD & PDP TV and indoor lighting.

*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
$R_{DS(on),max}$	1000	$m\Omega$
$Q_{g,typ}$	13	nC
$I_{D,pulse}$	12	A
$E_{oss@400V}$	1.3	$\mu J$
Body diode $di/dt$	500	$A/\mu s$

Type / Ordering Code	Package	Marking	Related Links
IPD60R1K0CE	PG-TO 252	60S1K0CE	see Appendix A
IPU60R1K0CE	PG-TO 251		

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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>	$I_D$	-	-	4.3 2.7	A	$T_C=25^\circ\text{C}$ $T_C=100^\circ\text{C}$
Pulsed drain current <sup>2)</sup>	$I_{D,pulse}$	-	-	12	A	$T_C=25^\circ\text{C}$
Avalanche energy, single pulse	$E_{AS}$	-	-	46	mJ	$I_D=0.8\text{A}$ ; $V_{DD}=50\text{V}$ ; see table 11
Avalanche energy, repetitive	$E_{AR}$	-	-	0.13	mJ	$I_D=0.8\text{A}$ ; $V_{DD}=50\text{V}$ ; see table 11
Avalanche current, repetitive	$I_{AR}$	-	-	0.8	A	-
MOSFET dv/dt ruggedness	dv/dt	-	-	50	V/ns	$V_{DS}=0\dots480\text{V}$
Gate source voltage (static)	$V_{GS}$	-20	-	20	V	static;
Gate source voltage (dynamic)	$V_{GS}$	-30	-	30	V	AC ( $f > 1\text{ Hz}$ )
Power dissipation TO-252, TO-251	$P_{tot}$	-	-	37	W	$T_C=25^\circ\text{C}$
Storage temperature	$T_{stg}$	-40	-	150	$^\circ\text{C}$	-
Operating junction temperature	$T_j$	-40	-	150	$^\circ\text{C}$	-
Continuous diode forward current	$I_S$	-	-	3.8	A	$T_C=25^\circ\text{C}$
Diode pulse current <sup>2)</sup>	$I_{S,pulse}$	-	-	12	A	$T_C=25^\circ\text{C}$
Reverse diode dv/dt <sup>3)</sup>	dv/dt	-	-	15	V/ns	$V_{DS}=0\dots400\text{V}$ , $I_{SD} \leq I_S$ , $T_j=25^\circ\text{C}$ see table 9
Maximum diode commutation speed	$di_i/dt$	-	-	500	A/ $\mu\text{s}$	$V_{DS}=0\dots400\text{V}$ , $I_{SD} \leq I_S$ , $T_j=25^\circ\text{C}$ see table 9

<sup>1)</sup> Limited by  $T_{j,max}$ . Maximum duty cycle  $D=0.75$

<sup>2)</sup> Pulse width  $t_p$  limited by  $T_{j,max}$

<sup>3)</sup> Identical low side and high side switch with identical  $R_G$

### 3 Thermal characteristics

**Table 3 Thermal characteristics TO-251**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	-	3.41	°C/W	-
Thermal resistance, junction - ambient	$R_{thJA}$	-	-	62	°C/W	leaded
Soldering temperature, wavesoldering only allowed at leads	$T_{sold}$	-	-	260	°C	1.6mm (0.063 in.) from case for 10s

**Table 4 Thermal characteristics TO-252**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	-	3.41	°C/W	-
Thermal resistance, junction - ambient	$R_{thJA}$	-	-	62	°C/W	device on PCB, minimal footprint
Thermal resistance, junction - ambient for SMD version	$R_{thJA}$	-	35	45	°C/W	Device on 40mm*40mm*1.5mm epoxy PCB FR4 with 6cm <sup>2</sup> (one layer, 70µm thickness) copper area for drain connection and cooling. PCB is vertical without air stream cooling.
Soldering temperature, wave & reflow soldering allowed	$T_{sold}$	-	-	260	°C	reflow MSL1

## 4 Electrical characteristics

at  $T_j=25^\circ\text{C}$ , 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	3.0	3.5	V	$V_{DS}=V_{GS}$ , $I_D=0.13\text{mA}$
Zero gate voltage drain current	$I_{DSS}$	-	-	1	$\mu\text{A}$	$V_{DS}=600$ , $V_{GS}=0\text{V}$ , $T_j=25^\circ\text{C}$ $V_{DS}=600$ , $V_{GS}=0\text{V}$ , $T_j=150^\circ\text{C}$
Gate-source leakage current	$I_{GSS}$	-	-	100	nA	$V_{GS}=20\text{V}$ , $V_{DS}=0\text{V}$
Drain-source on-state resistance	$R_{DS(on)}$	-	0.86	1.00	$\Omega$	$V_{GS}=10\text{V}$ , $I_D=1.5\text{A}$ , $T_j=25^\circ\text{C}$ $V_{GS}=10\text{V}$ , $I_D=1.5\text{A}$ , $T_j=150^\circ\text{C}$
Gate resistance	$R_G$	-	16	-	$\Omega$	$f=1\text{MHz}$ , open drain

**Table 6 Dynamic characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	$C_{iss}$	-	280	-	pF	$V_{GS}=0\text{V}$ , $V_{DS}=100\text{V}$ , $f=1\text{MHz}$
Output capacitance	$C_{oss}$	-	21	-	pF	$V_{GS}=0\text{V}$ , $V_{DS}=100\text{V}$ , $f=1\text{MHz}$
Effective output capacitance, energy related <sup>1)</sup>	$C_{o(er)}$	-	14	-	pF	$V_{GS}=0\text{V}$ , $V_{DS}=0\dots480\text{V}$
Effective output capacitance, time related <sup>2)</sup>	$C_{o(tr)}$	-	57	-	pF	$I_D=\text{constant}$ , $V_{GS}=0\text{V}$ , $V_{DS}=0\dots480\text{V}$
Turn-on delay time	$t_{d(on)}$	-	10	-	ns	$V_{DD}=400\text{V}$ , $V_{GS}=10\text{V}$ , $I_D=1.9\text{A}$ , $R_G=12.2\Omega$ ; see table 10
Rise time	$t_r$	-	8	-	ns	$V_{DD}=400\text{V}$ , $V_{GS}=10\text{V}$ , $I_D=1.9\text{A}$ , $R_G=12.2\Omega$ ; see table 10
Turn-off delay time	$t_{d(off)}$	-	60	-	ns	$V_{DD}=400\text{V}$ , $V_{GS}=10\text{V}$ , $I_D=1.9\text{A}$ , $R_G=12.2\Omega$ ; see table 10
Fall time	$t_f$	-	13	-	ns	$V_{DD}=400\text{V}$ , $V_{GS}=10\text{V}$ , $I_D=1.9\text{A}$ , $R_G=12.2\Omega$ ; see table 10

**Table 7 Gate charge characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate to source charge	$Q_{gs}$	-	1.5	-	nC	$V_{DD}=480\text{V}$ , $I_D=1.9\text{A}$ , $V_{GS}=0$ to $10\text{V}$
Gate to drain charge	$Q_{gd}$	-	6.5	-	nC	$V_{DD}=480\text{V}$ , $I_D=1.9\text{A}$ , $V_{GS}=0$ to $10\text{V}$
Gate charge total	$Q_g$	-	13	-	nC	$V_{DD}=480\text{V}$ , $I_D=1.9\text{A}$ , $V_{GS}=0$ to $10\text{V}$
Gate plateau voltage	$V_{\text{plateau}}$	-	5.4	-	V	$V_{DD}=480\text{V}$ , $I_D=1.9\text{A}$ , $V_{GS}=0$ to $10\text{V}$

<sup>1)</sup>  $C_{o(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{o(BR)DSS}$

<sup>2)</sup>  $C_{o(tr)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{o(BR)DSS}$

**Table 8 Reverse diode characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Diode forward voltage	$V_{SD}$	-	0.9	-	V	$V_{GS}=0V$ , $I_F=1.9A$ , $T_j=25^\circ C$
Reverse recovery time	$t_{rr}$	-	220	-	ns	$V_R=400V$ , $I_F=1.9A$ , $di_F/dt=100A/\mu s$ ; see table 9
Reverse recovery charge	$Q_{rr}$	-	1.5	-	$\mu C$	$V_R=400V$ , $I_F=1.9A$ , $di_F/dt=100A/\mu s$ ; see table 9
Peak reverse recovery current	$I_{rrm}$	-	12	-	A	$V_R=400V$ , $I_F=1.9A$ , $di_F/dt=100A/\mu s$ ; see table 9

### 5 Electrical characteristics diagrams

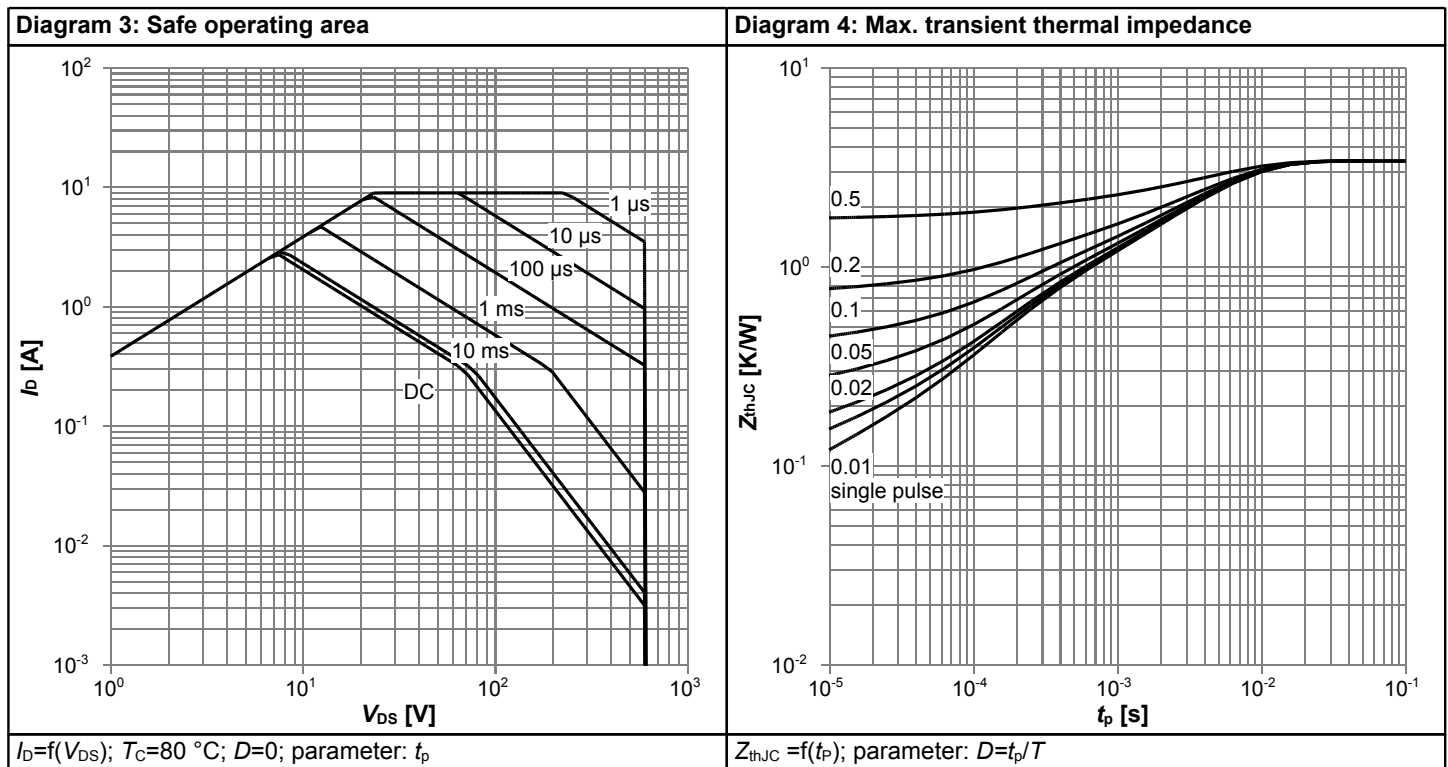
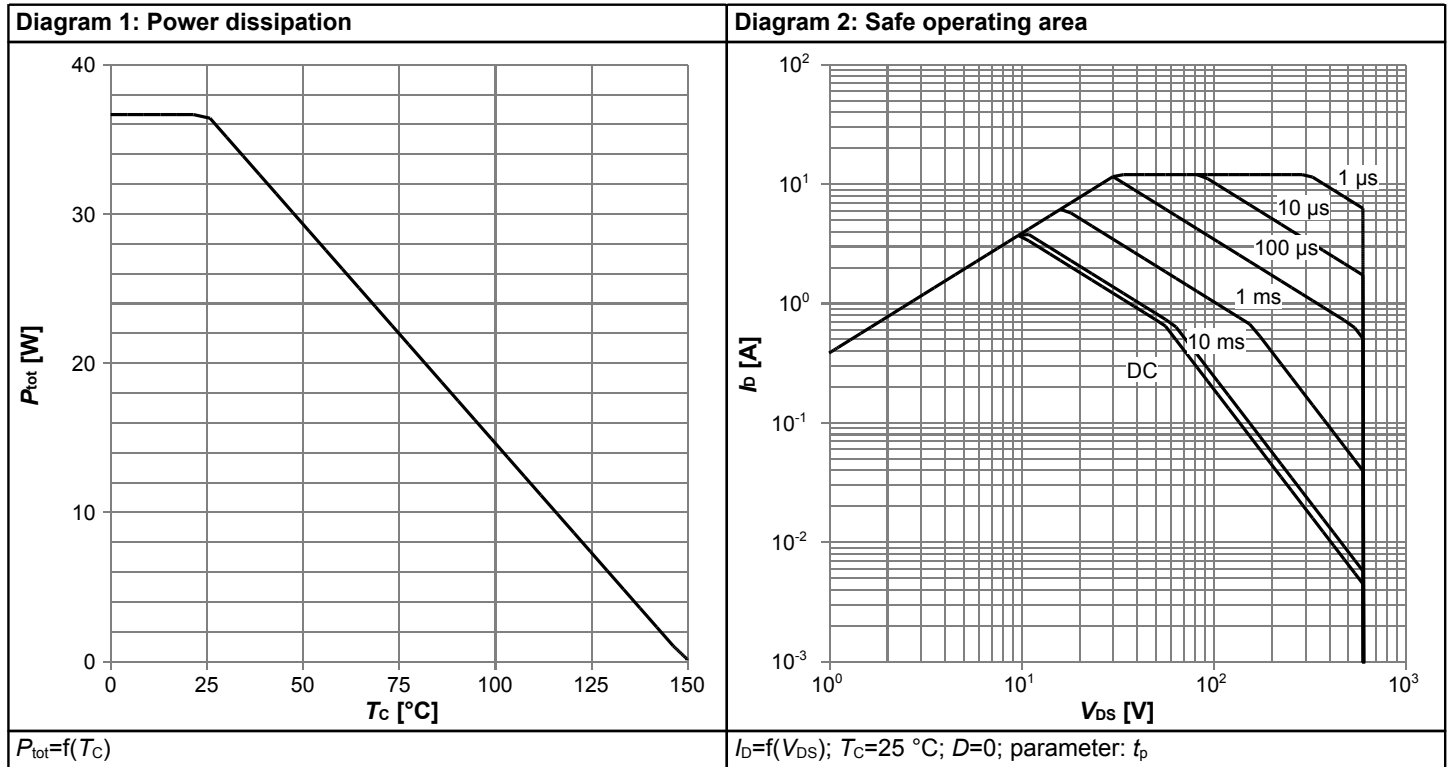
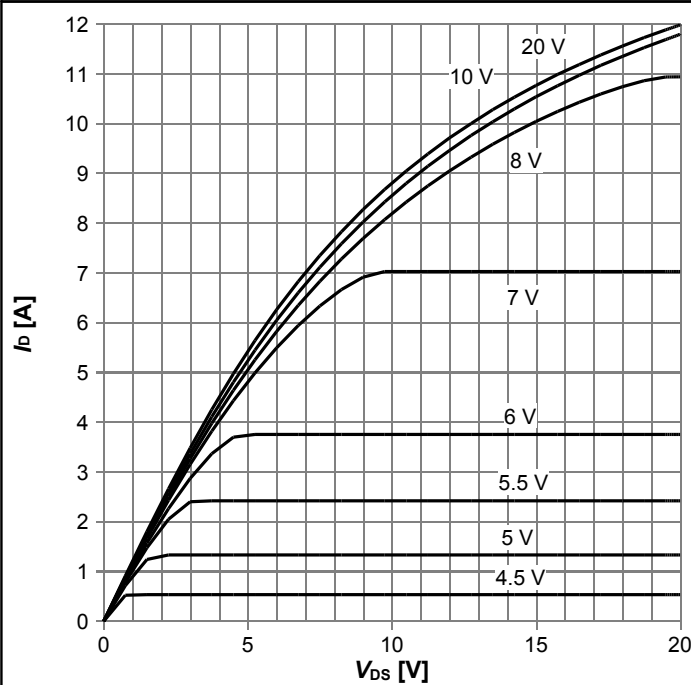


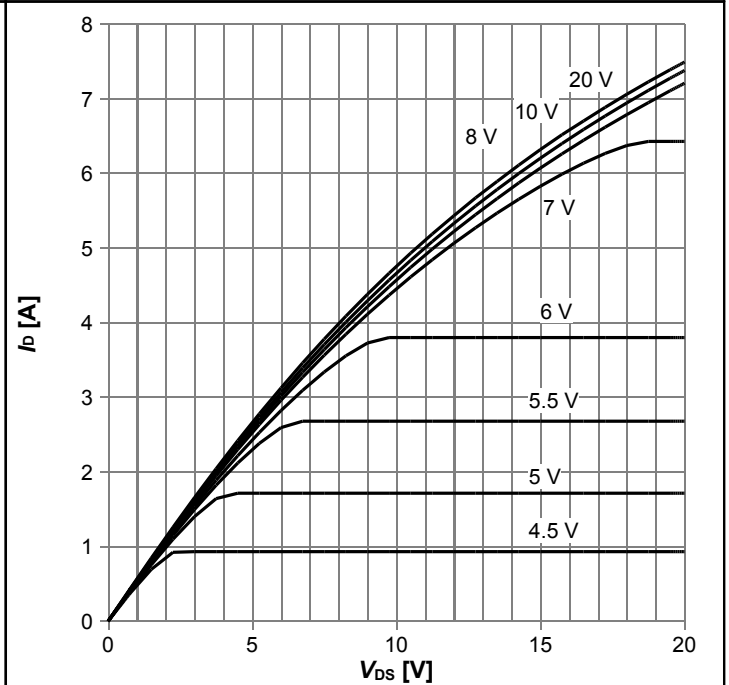


Diagram 5: Typ. output characteristics



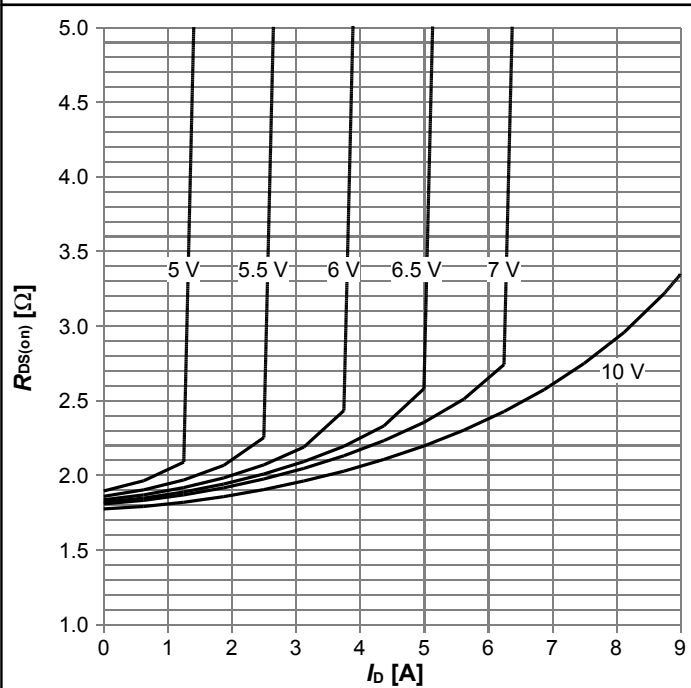
$I_D=f(V_{DS}); T_j=25\text{ }^\circ\text{C};$  parameter:  $V_{GS}$

Diagram 6: Typ. output characteristics



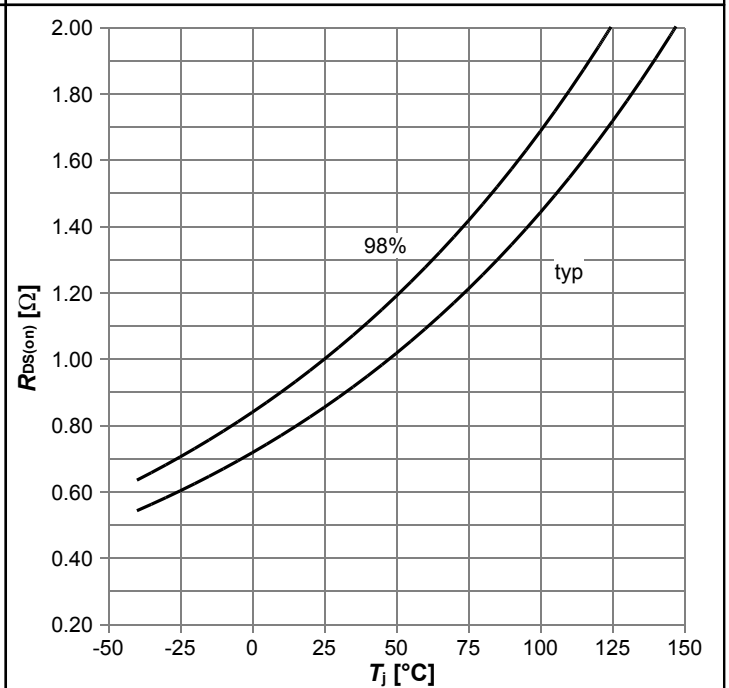
$I_D=f(V_{DS}); T_j=125\text{ }^\circ\text{C};$  parameter:  $V_{GS}$

Diagram 7: Typ. drain-source on-state resistance



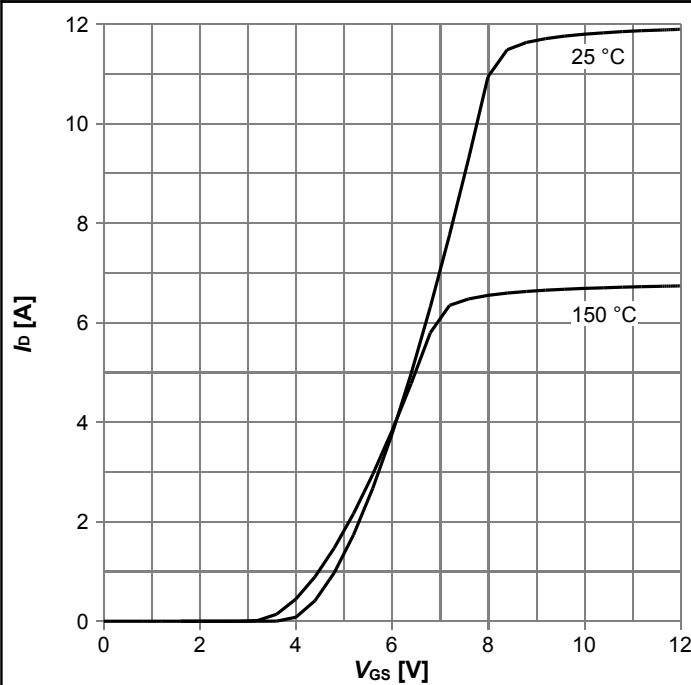
$R_{DS(on)}=f(I_D); T_j=125\text{ }^\circ\text{C};$  parameter:  $V_{GS}$

Diagram 8: Drain-source on-state resistance



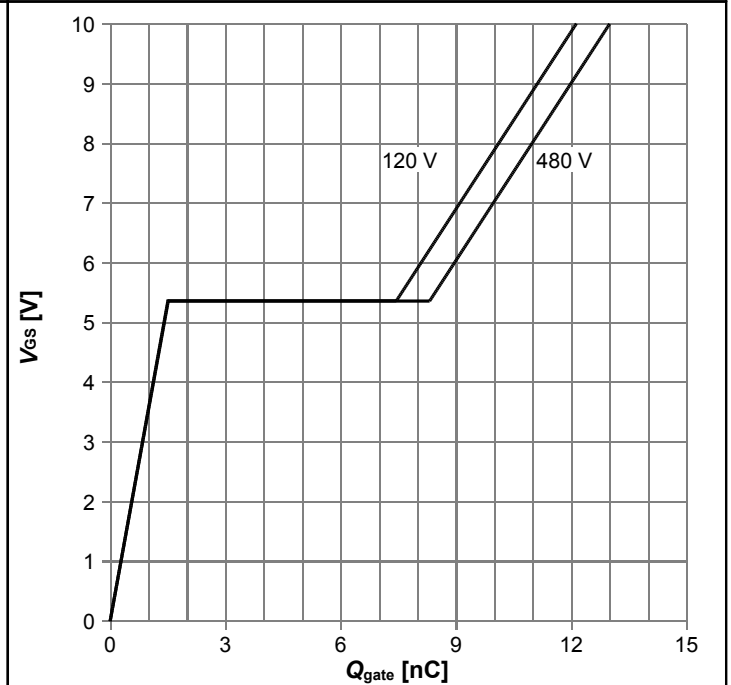
$R_{DS(on)}=f(T_j); I_D=1.5\text{ A}; V_{GS}=10\text{ V}$

Diagram 9: Typ. transfer characteristics



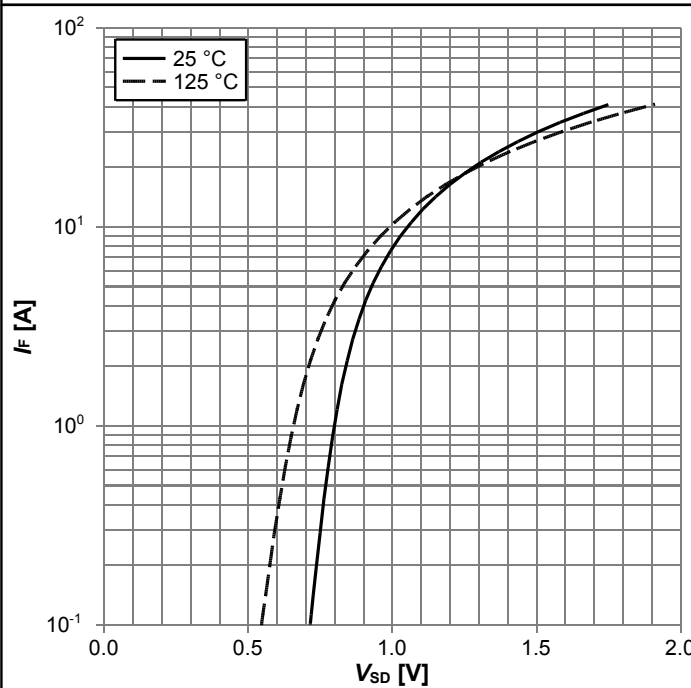
$I_D=f(V_{GS}); V_{DS}=20V; \text{parameter: } T_j$

Diagram 10: Typ. gate charge



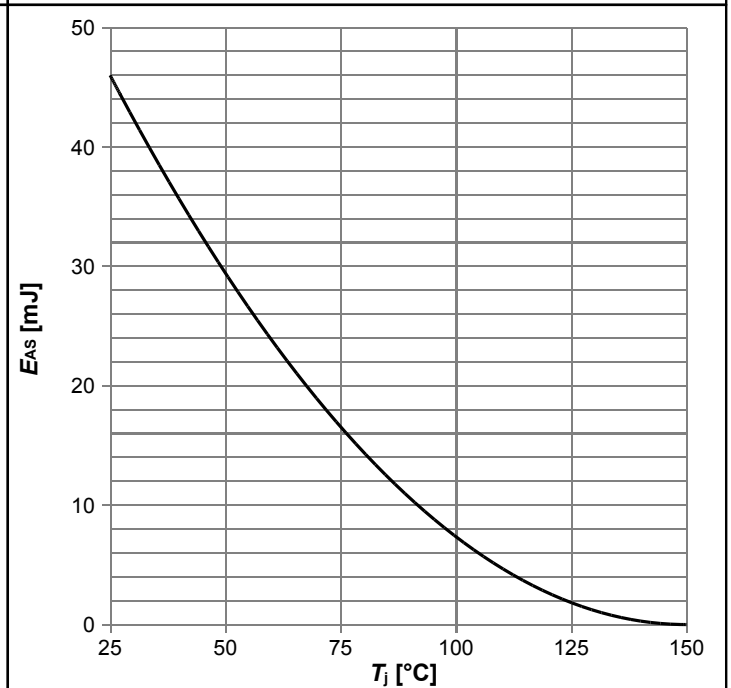
$V_{GS}=f(Q_{gate}); I_D=1.9 \text{ A pulsed}; \text{parameter: } V_{DD}$

Diagram 11: Forward characteristics of reverse diode



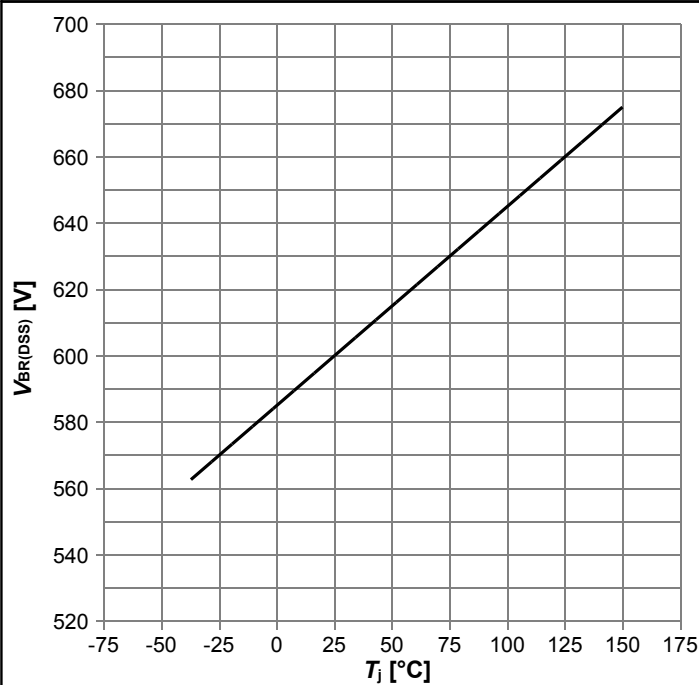
$I_F=f(V_{SD}); \text{parameter: } T_j$

Diagram 12: Avalanche energy



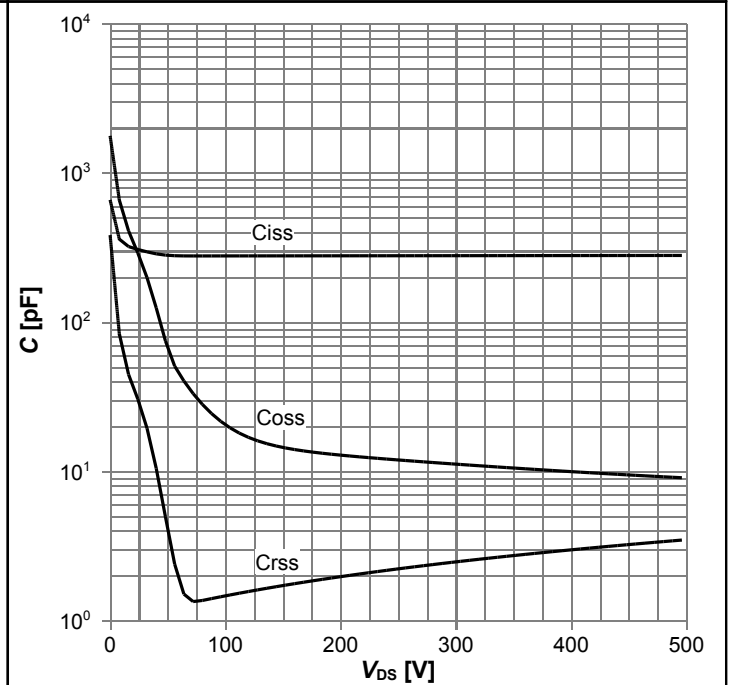
$E_{AS}=f(T_j); I_D=0.8 \text{ A}; V_{DD}=50 \text{ V}$

Diagram 13: Drain-source breakdown voltage



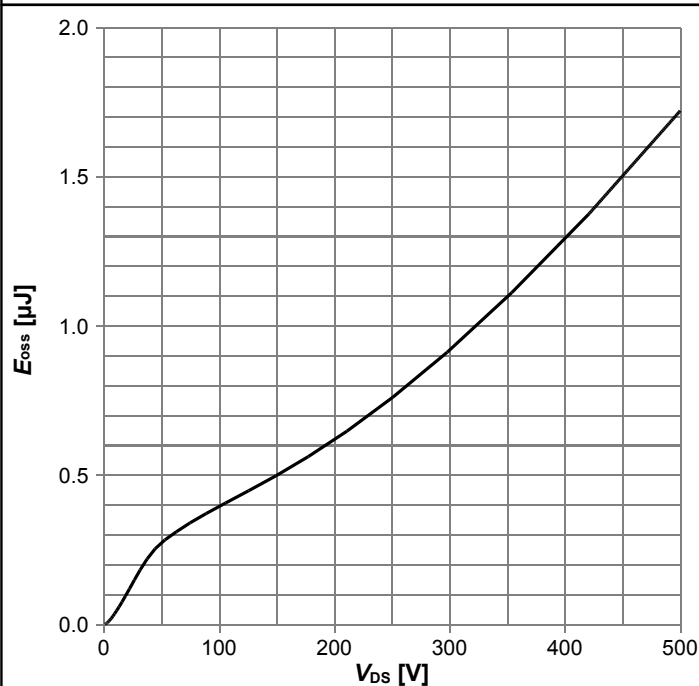
$V_{BR(DSS)}=f(T_j); I_D=0.25 \text{ mA}$

Diagram 14: Typ. capacitances



$C=f(V_{DS}); V_{GS}=0 \text{ V}; f=1 \text{ MHz}$

Diagram 15: Typ. Coss stored energy



$E_{oss}=f(V_{DS})$

## 6 Test Circuits

**Table 9 Diode characteristics**

Test circuit for diode characteristics	Diode recovery waveform
<p><math>R_{g1} = R_{g2}</math></p>	<p><math>t_{rr} = t_F + t_S</math>  <math>Q_r = Q_F + Q_S</math></p>

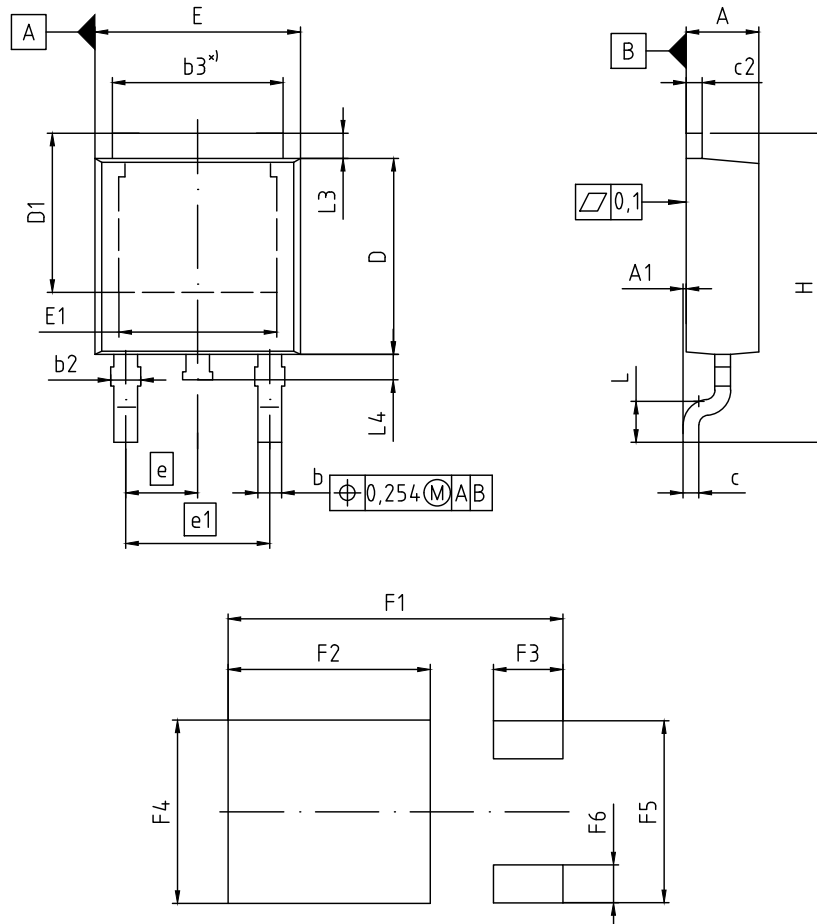
**Table 10 Switching times**

Switching times test circuit for inductive load	Switching times waveform

**Table 11 Unclamped inductive load**

Unclamped inductive load test circuit	Unclamped inductive waveform

## 7 Package Outlines



\*) 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	5.60	0.185	0.220
e	2.29 (BSC)		0.090 (BSC)	
e1	4.57 (BSC)		0.180 (BSC)	
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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Figure 1 Outline PG-TO 252, dimensions in mm/inches

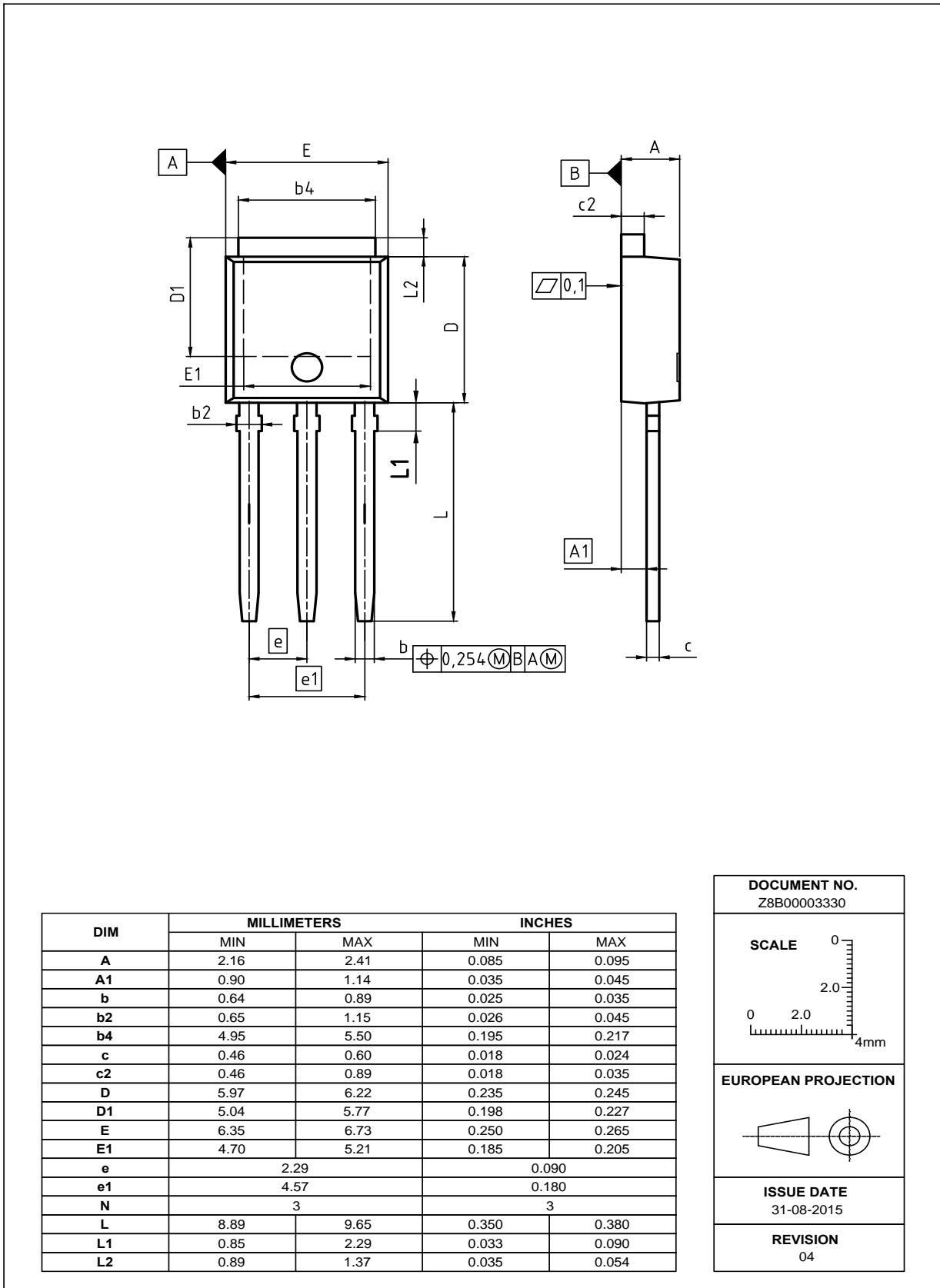


Figure 2 Outline PG-TO 251, dimensions in mm/inches

## 8 Appendix A

### Table 12 Related Links

- IFX CoolMOS™ CE Webpage: [www.infineon.com](http://www.infineon.com)
- IFX CoolMOS™ CE application note: [www.infineon.com](http://www.infineon.com)
- IFX CoolMOS™ CE simulation model: [www.infineon.com](http://www.infineon.com)
- IFX Design tools: [www.infineon.com](http://www.infineon.com)

## Revision History

IPD60R1K0CE, IPU60R1K0CE

**Revision: 2015-11-17, Rev. 2.1**

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.0	2014-09-25	Release of final version
2.1	2015-11-17	Updated to qualified for standard grade & updated package drawing

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