

## MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## CoolMOS™ P6

600V CoolMOS™ P6 Power Transistor  
IPL60R650P6S

## Data Sheet

Rev. 2.0  
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™ P6 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.

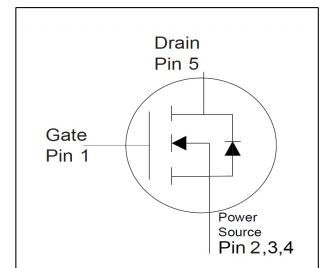
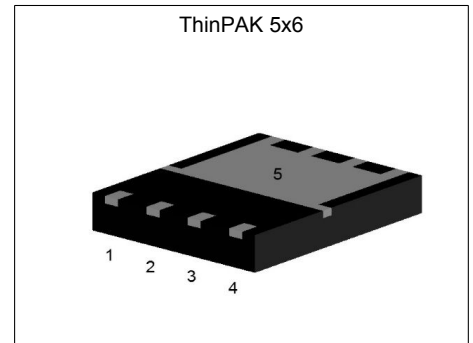
### Features

- 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 mold compound
- 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.

*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
$R_{DS(on),max}$	0.65	$\Omega$
$Q_{g,typ}$	12	nC
$I_{D,pulse}$	16.5	A
$E_{oss@400V}$	1.8	$\mu J$
Body diode $di/dt$	500	A/ $\mu s$

Type / Ordering Code	Package	Marking	Related Links
IPL60R650P6S	ThinPAK 5x6 SMD	60P6650	see Appendix A

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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>	$I_D$	-	-	6.7 4.2	A	$T_C = 25^\circ\text{C}$ $T_C = 100^\circ\text{C}$
Pulsed drain current <sup>2)</sup>	$I_{D,pulse}$	-	-	16.5	A	$T_C=25^\circ\text{C}$
Avalanche energy, single pulse	$E_{AS}$	-	-	133	mJ	$I_D = 1.3\text{A}; V_{DD} = 50\text{V}$
Avalanche energy, repetitive	$E_{AR}$	-	-	0.20	mJ	$I_D = 1.3\text{A}; V_{DD} = 50\text{V}$
Avalanche current, repetitive	$I_{AR}$	-	-	1.3	A	-
MOSFET dv/dt ruggedness	dv/dt	-	-	100	V/ns	$V_{DS} = 0\dots 480\text{V}$
Gate source voltage	$V_{GS}$	-20 -30	-	20 30	V	static; AC ( $f > 1\text{ Hz}$ )
Power dissipation (non FullPAK)	$P_{tot}$	-	-	56.8	W	$T_C=25^\circ\text{C}$
Operating and storage temperature	$T_j, T_{stg}$	-40	-	150	$^\circ\text{C}$	-
Continuous diode forward current	$I_S$	-	-	5.8	A	$T_C=25^\circ\text{C}$
Diode pulse current <sup>2)</sup>	$I_{S,pulse}$	-	-	16.2	A	$T_C = 25^\circ\text{C}$
Reverse diode dv/dt <sup>3)</sup>	dv/dt	-	-	15	V/ns	$V_{DS} = 0\dots 400\text{V}, I_{SD} \leq I_S, T_j=25^\circ\text{C}$
Maximum diode commutation speed <sup>3)</sup>	$di_f/dt$	-	-	500	A/ $\mu\text{s}$	$V_{DS} = 0\dots 400\text{V}, I_{SD} \leq I_S, T_j=25^\circ\text{C}$

## 3 Thermal characteristics

**Table 3 Thermal characteristics (non FullPAK)**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	-	2.2	$^\circ\text{C/W}$	-
Thermal resistance, junction - ambient	$R_{thJA}$	-	35	62	$^\circ\text{C/W}$	Device on 40mm*40mm*1.5 epoxy PCB FR4 with 6cm <sup>2</sup> (one layer 70 $\mu\text{m}$ thick) copper area for drain connection and cooling. PCB is vertical without blown air.
Soldering temperature, wavesoldering only allowed at leads	$T_{sold}$	-	-	260	$^\circ\text{C}$	reflow MSL1

<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>  $V_{DClink}=400\text{V}; V_{DS,peak} < V_{(BR)DSS}$ ; identical low side and high side switch with identical  $R_G$

## 4 Electrical characteristics

**Table 4 Static characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Drain-source breakdown voltage	$V_{(BR)DSS}$	600	-	-	V	$V_{GS}=0V, I_D=1mA$
Gate threshold voltage	$V_{(GS)th}$	3.50	4	4.50	V	$V_{DS}=V_{GS}, I_D=0.2mA$
Zero gate voltage drain current	$I_{DSS}$	-	-	1	$\mu A$	$V_{DS}=600V, V_{GS}=0V, T_j=25^\circ C$ $V_{DS}=600V, V_{GS}=0V, T_j=150^\circ C$
Gate-source leakage current	$I_{GSS}$	-	-	100	nA	$V_{GS}=20V, V_{DS}=0V$
Drain-source on-state resistance	$R_{DS(on)}$	-	0.59	0.65	$\Omega$	$V_{GS}=10V, I_D=2.4A, T_j=25^\circ C$ $V_{GS}=10V, I_D=2.4A, T_j=150^\circ C$
Gate resistance	$R_G$	-	11	-	$\Omega$	$f=1\text{ MHz}, \text{open drain}$

**Table 5 Dynamic characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	$C_{iss}$	-	557	-	pF	$V_{GS}=0V, V_{DS}=100V, f=1MHz$
Output capacitance	$C_{oss}$	-	28	-	pF	$V_{GS}=0V, V_{DS}=100V, f=1MHz$
Effective output capacitance, energy related <sup>1)</sup>	$C_{o(er)}$	-	23	-	pF	$V_{GS}=0V, V_{DS}=0\dots 480V$
Effective output capacitance, time related <sup>2)</sup>	$C_{o(tr)}$	-	88	-	pF	$I_D=\text{constant}, V_{GS}=0V, V_{DS}=0\dots 480V$
Turn-on delay time	$t_{d(on)}$	-	11	-	ns	$V_{DD}=400V, V_{GS}=13V, I_D=3A,$ $R_G=6.8\Omega$
Rise time	$t_r$	-	7	-	ns	$V_{DD}=400V, V_{GS}=13V, I_D=3A,$ $R_G=6.8\Omega$
Turn-off delay time	$t_{d(off)}$	-	33	-	ns	$V_{DD}=400V, V_{GS}=13V, I_D=3A,$ $R_G=6.8\Omega$
Fall time	$t_f$	-	14	-	ns	$V_{DD}=400V, V_{GS}=13V, I_D=3A,$ $R_G=6.8\Omega$

**Table 6 Gate charge characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate to source charge	$Q_{gs}$	-	3	-	nC	$V_{DD}=480V, I_D=3A, V_{GS}=0\text{ to }10V$
Gate to drain charge	$Q_{gd}$	-	5	-	nC	$V_{DD}=480V, I_D=3A, V_{GS}=0\text{ to }10V$
Gate charge total	$Q_g$	-	12	-	nC	$V_{DD}=480V, I_D=3A, V_{GS}=0\text{ to }10V$
Gate plateau voltage	$V_{plateau}$	-	6.1	-	V	$V_{DD}=480V, I_D=3A, V_{GS}=0\text{ to }10V$

<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%  $V_{(BR)DSS}$

<sup>2)</sup>  $C_{o(tr)}$  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 7 Reverse diode characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Diode forward voltage	$V_{SD}$	-	0.9	-	V	$V_{GS}=0V, I_F=3A, T_f=25^\circ C$
Reverse recovery time	$t_{rr}$	-	196	-	ns	$V_R=400V, I_F=3A, di_F/dt=100A/\mu s$
Reverse recovery charge	$Q_{rr}$	-	1.7	-	$\mu C$	$V_R=400V, I_F=3A, di_F/dt=100A/\mu s$
Peak reverse recovery current	$I_{rrm}$	-	17	-	A	$V_R=400V, I_F=3A, di_F/dt=100A/\mu s$

## 5 Electrical characteristics diagrams

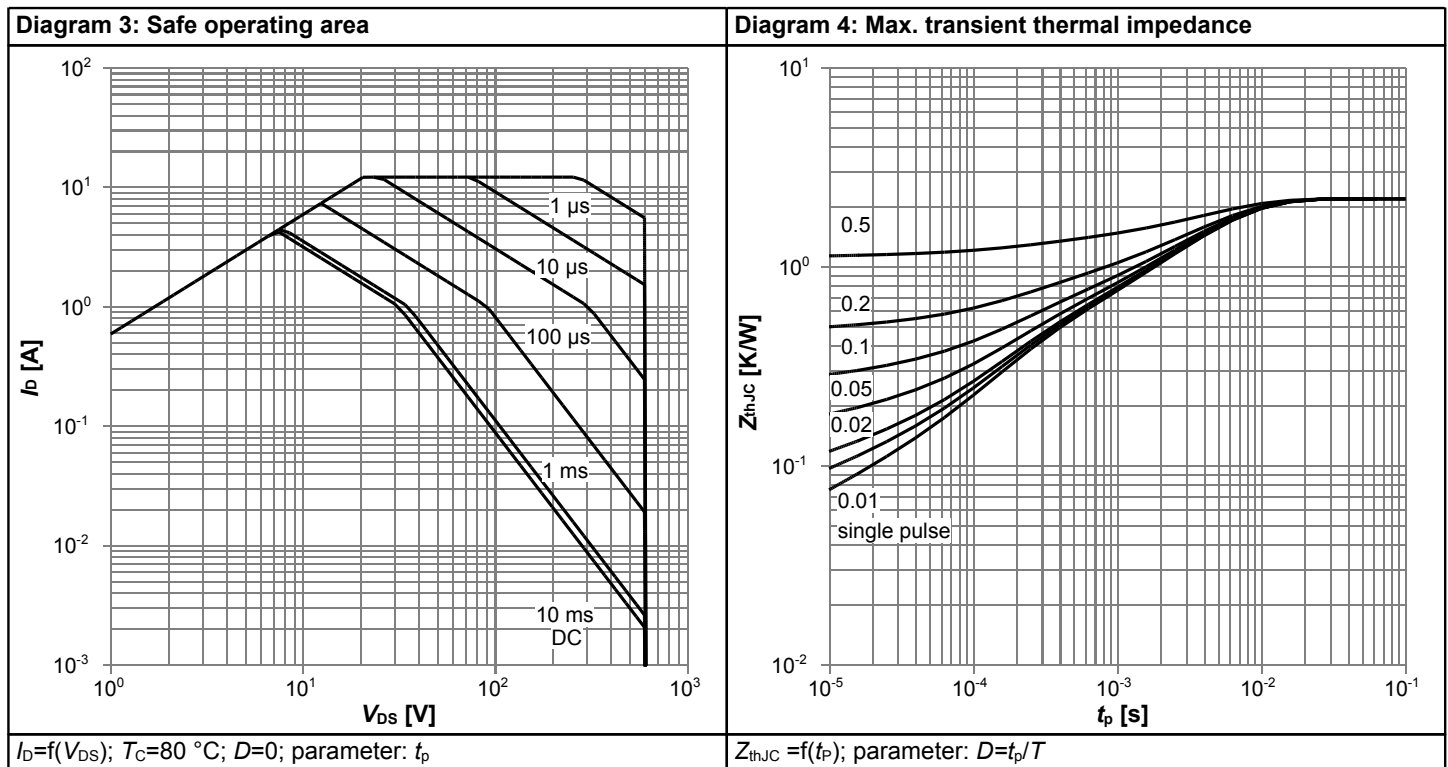
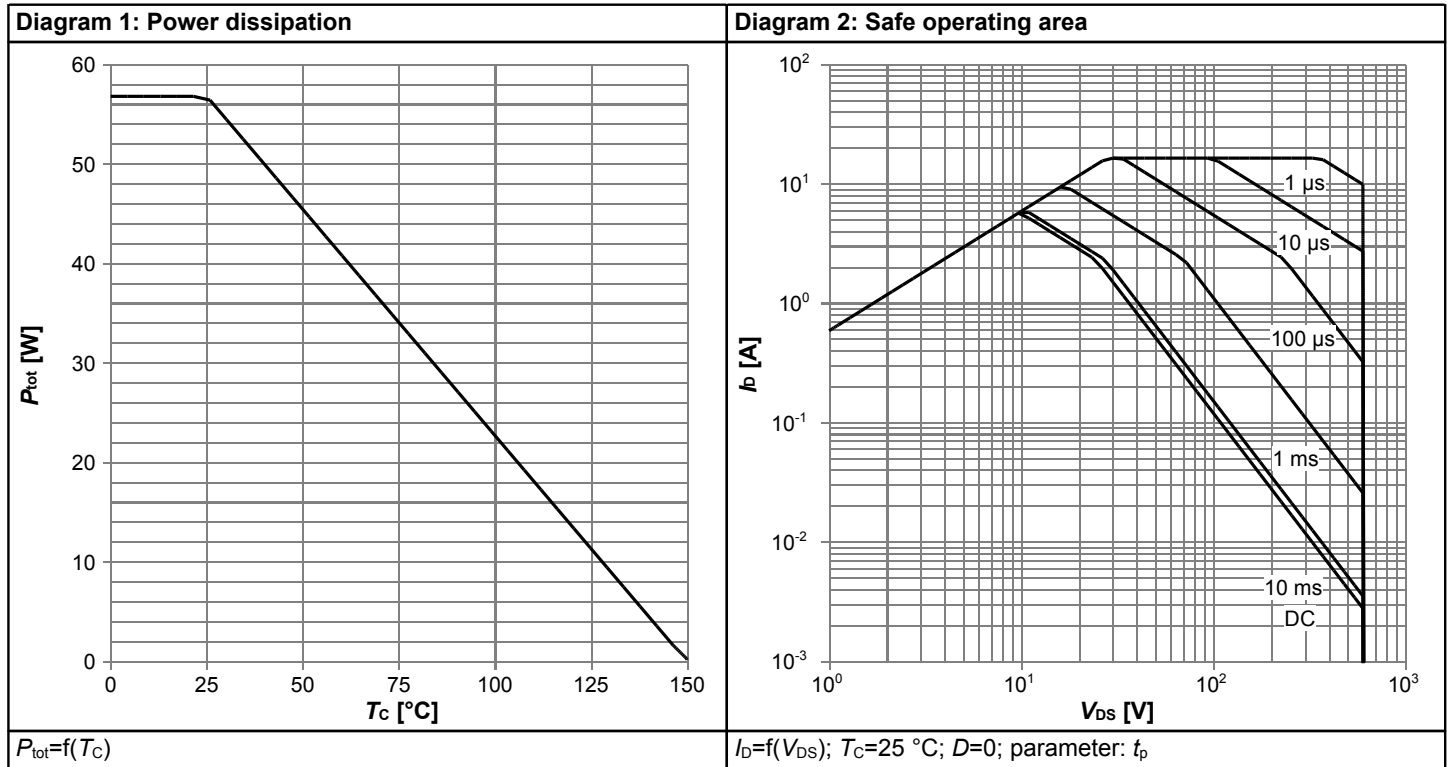
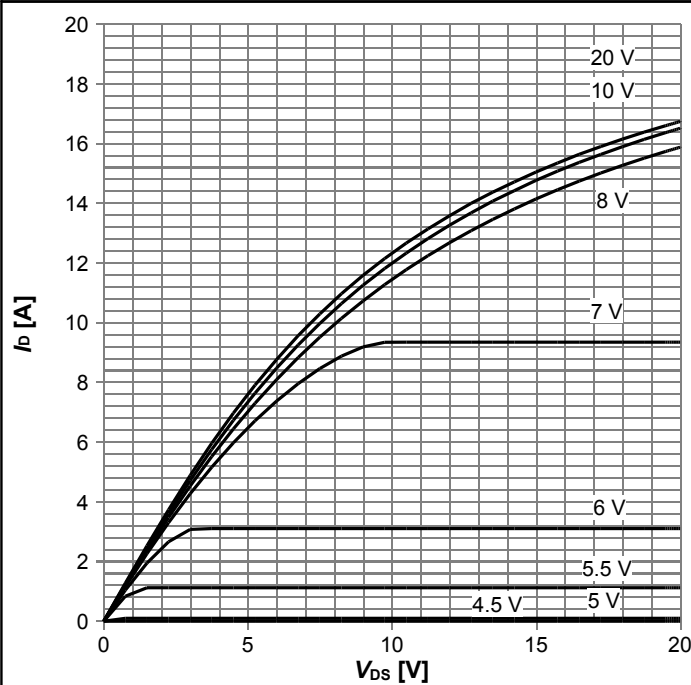
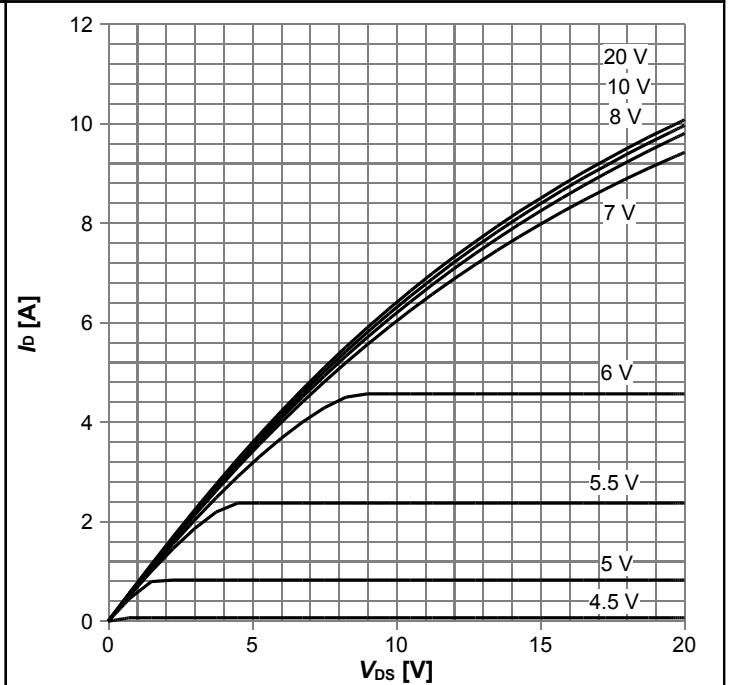


Diagram 5: Typ. output characteristics



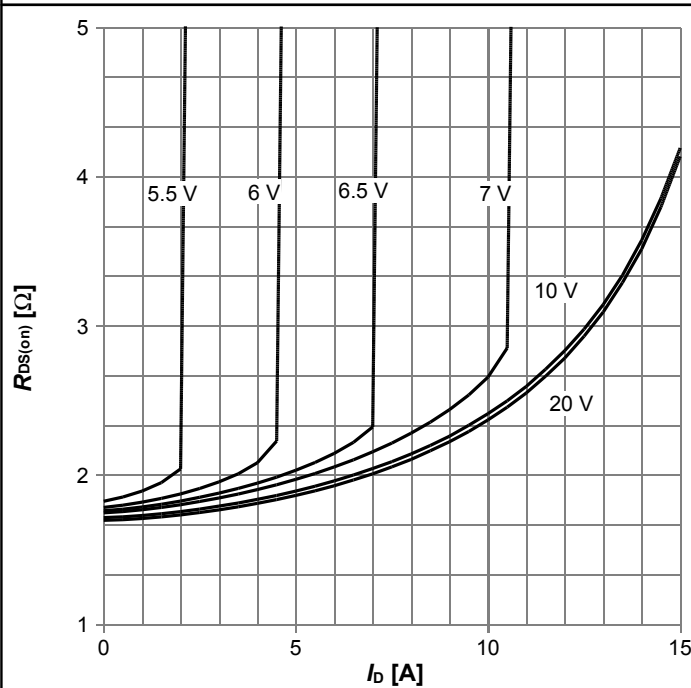
$I_D=f(V_{DS})$ ;  $T_j=25\text{ }^\circ\text{C}$ ; parameter:  $V_{GS}$

Diagram 6: Typ. output characteristics



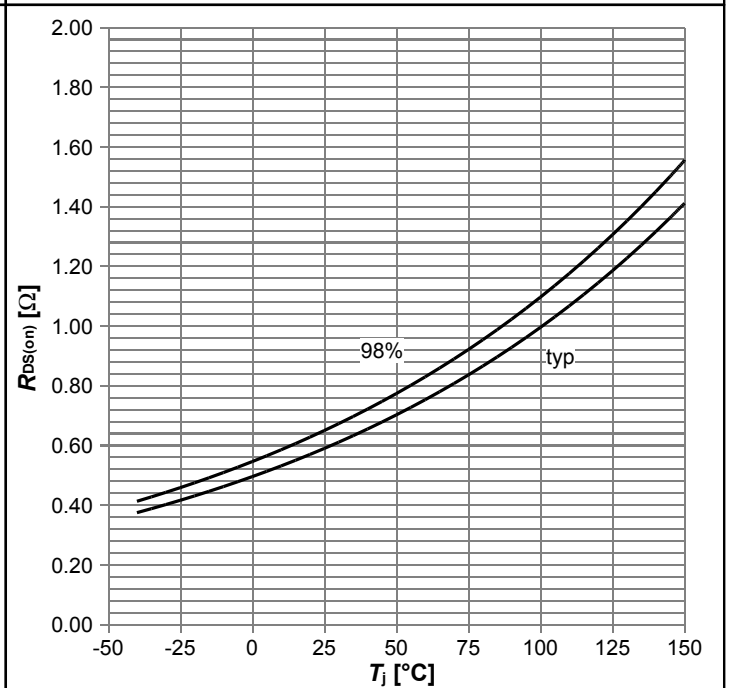
$I_D=f(V_{DS})$ ;  $T_j=125\text{ }^\circ\text{C}$ ; parameter:  $V_{GS}$

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



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

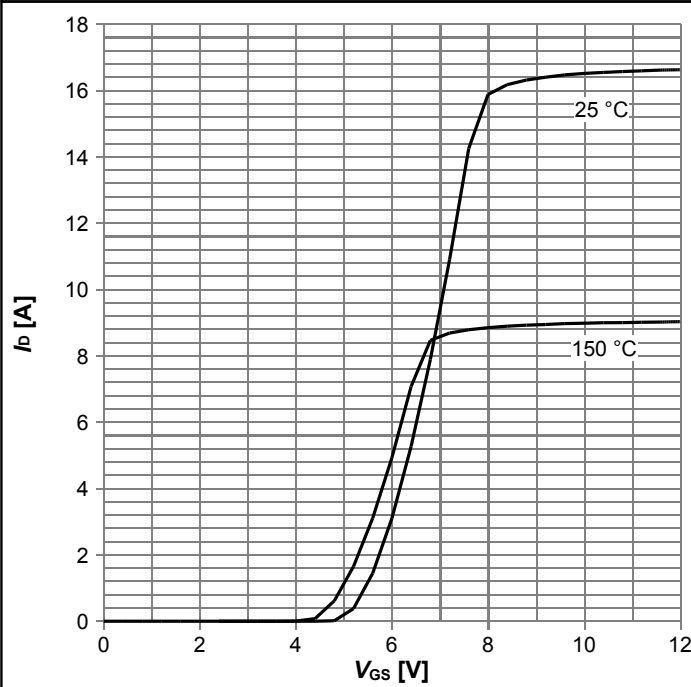
Diagram 8: Drain-source on-state resistance



$R_{DS(on)}=f(T_j)$ ;  $I_D=3\text{ A}$ ;  $V_{GS}=10\text{ V}$

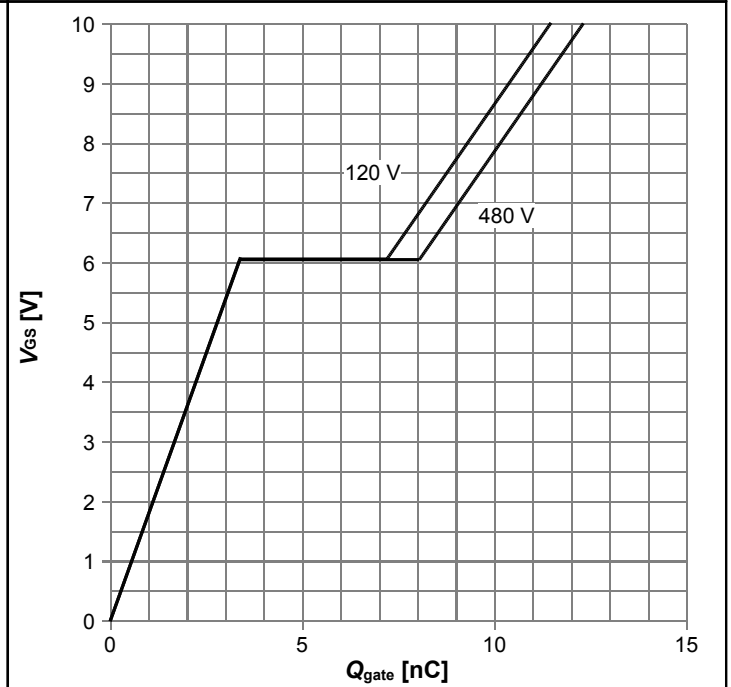


Diagram 9: Typ. transfer characteristics



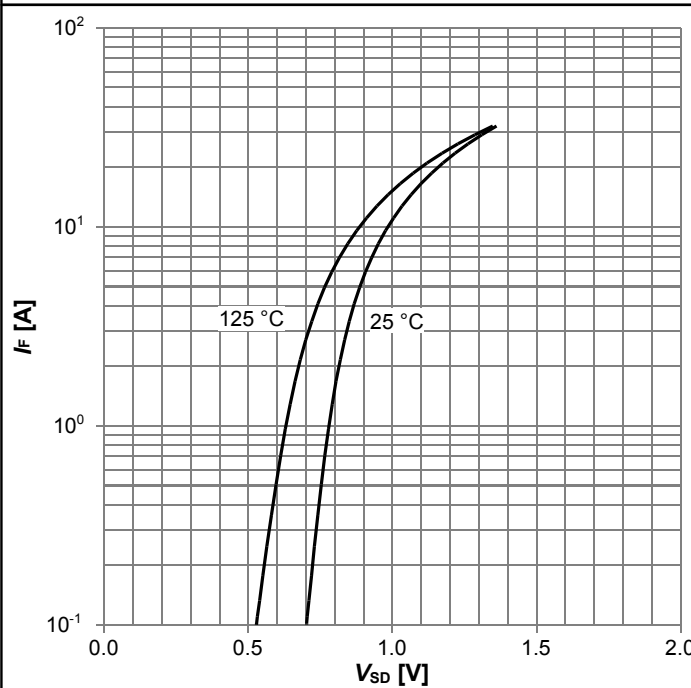
$I_D=f(V_{GS}); V_{DS}=20V$ ; parameter:  $T_j$

Diagram 10: Typ. gate charge



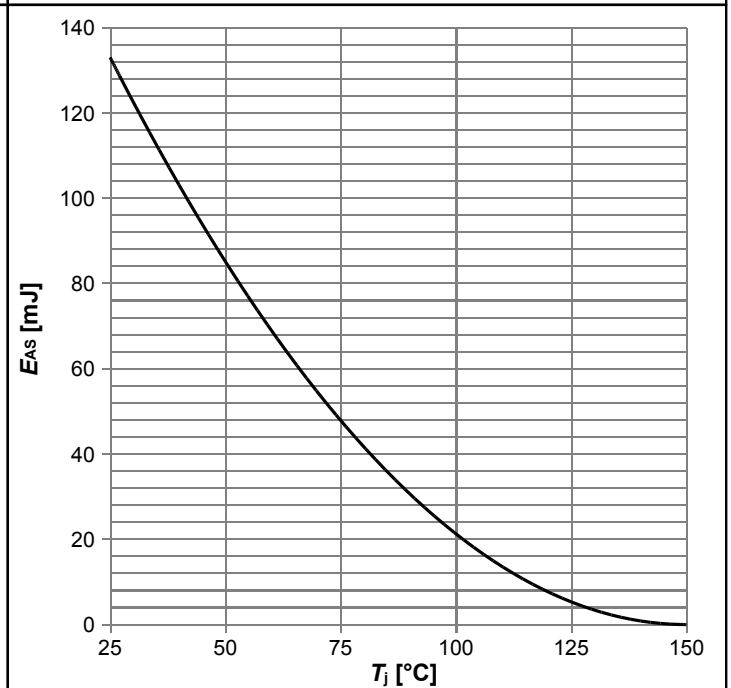
$V_{GS}=f(Q_{gate}); I_D=3\text{ A pulsed}$ ; parameter:  $V_{DD}$

Diagram 11: Forward characteristics of reverse diode



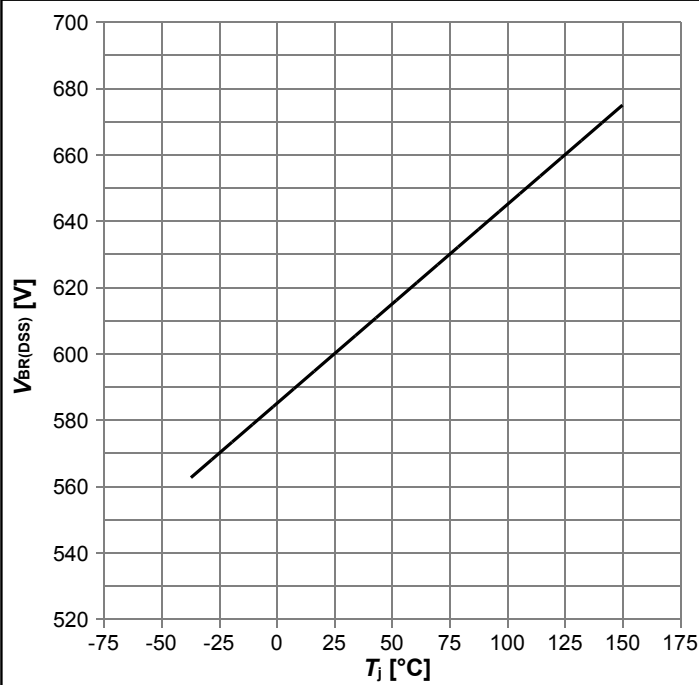
$I_F=f(V_{SD})$ ; parameter:  $T_j$

Diagram 12: Avalanche energy



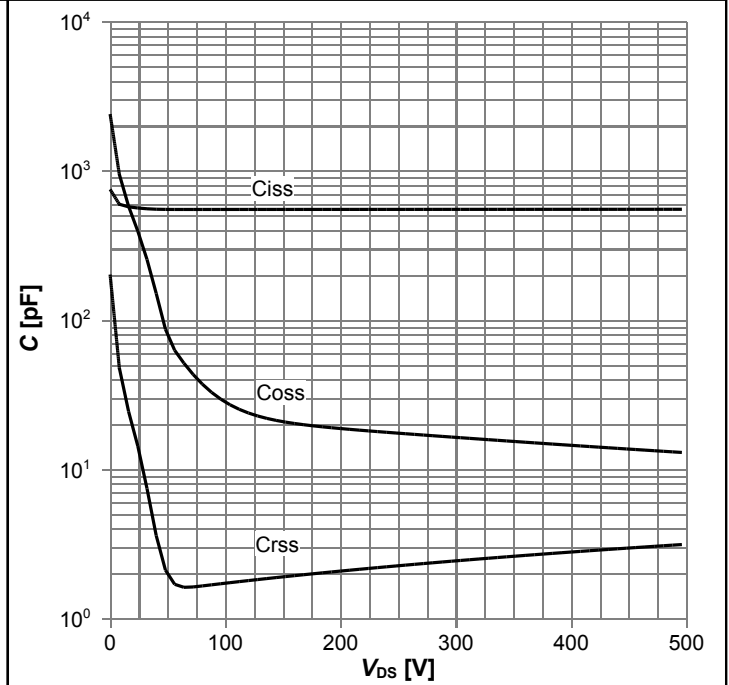
$E_{AS}=f(T_j); I_D=1.3\text{ A}; V_{DD}=50\text{ V}$

Diagram 13: Drain-source breakdown voltage



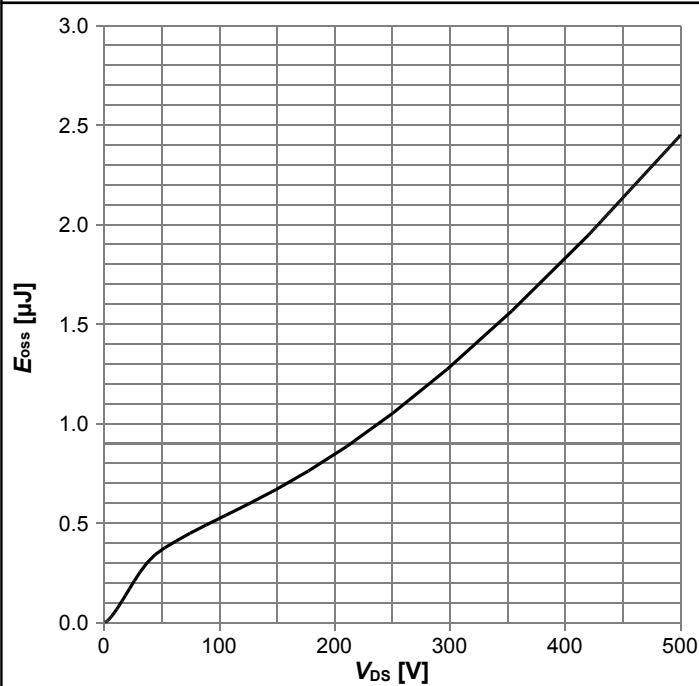
$V_{BR(DSS)}=f(T_j); I_D=1 \text{ mA}$

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 8 Diode characteristics**

Test circuit for diode characteristics	Diode recovery waveform

**Table 9 Switching times**

Switching times test circuit for inductive load	Switching times waveform

**Table 10 Unclamped inductive load**

Unclamped inductive load test circuit	Unclamped inductive waveform

## 7 Package Outlines

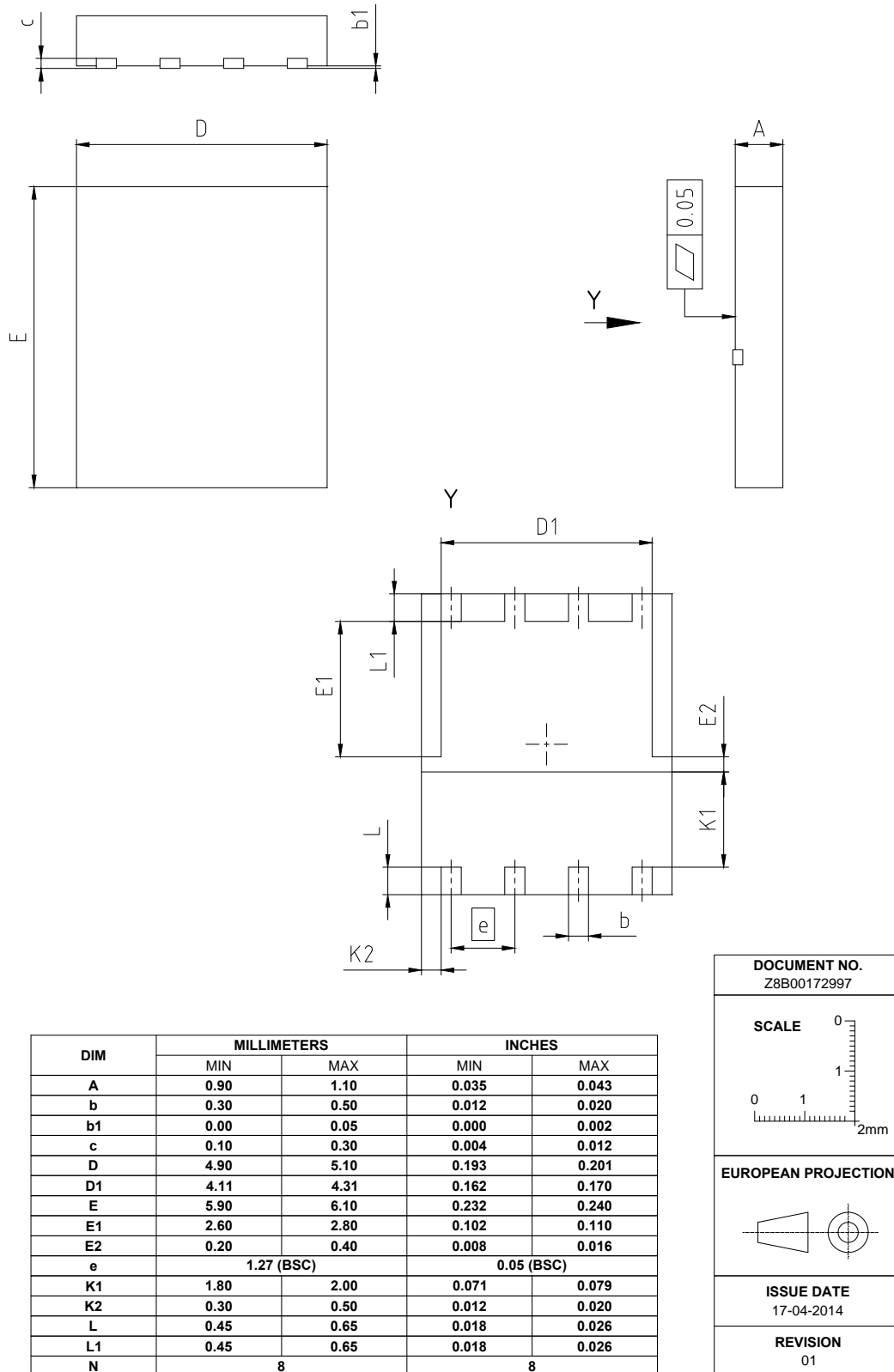


Figure 1 Outline ThinPAK 5x6 SMD, dimensions in mm/inches

## 8 Appendix A

### Table 11 Related Links

- IFX CoolMOS Webpage: [www.infineon.com](http://www.infineon.com)
- IFX Design tools: [www.infineon.com](http://www.infineon.com)

## Revision History

IPL60R650P6S

**Revision: 2014-07-08, Rev. 2.0**

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.0	2014-07-08	Release of final version

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