

MOSFET

Metal Oxide Semiconductor Field Effect Transistor

CoolMOS™ C6

650V CoolMOS™ C6 Power Transistor
IPL65R650C6S

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™ C6 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.

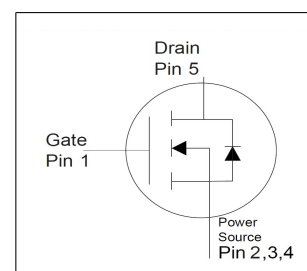
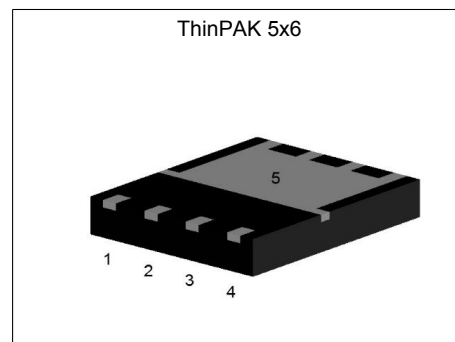


Table 1 Key Performance Parameters

Parameter	Value	Unit
$V_{DS} @ T_{j,max}$	700	V
$R_{DS(on),max}$	0.65	Ω
$Q_{g,typ}$	23	nC
$I_{D,pulse}$	16.6	A
$E_{oss@400V}$	2	μJ
Body diode di/dt	500	A/ μs

Type / Ordering Code	Package	Marking	Related Links
IPL65R650C6S	ThinPAK 5x6 SMD	65C6650	see Appendix A

Table of Contents

Description	2
Maximum ratings	4
Thermal characteristics	4
Electrical characteristics	5
Electrical characteristics diagrams	7
Test Circuits	11
Package Outlines	12
Appendix A	13
Revision History	14
Disclaimer	14

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 ¹⁾	I_D	-	-	6.7 4.2	A	$T_C = 25^\circ\text{C}$ $T_C = 100^\circ\text{C}$
Pulsed drain current ²⁾	$I_{D,pulse}$	-	-	16.6	A	$T_C = 25^\circ\text{C}$
Avalanche energy, single pulse	E_{AS}	-	-	142	mJ	$I_D = 1.3\text{A}$; $V_{DD} = 50\text{V}$
Avalanche energy, repetitive	E_{AR}	-	-	0.21	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	-	-	50	V/ns	$V_{DS} = 0 \dots 520\text{V}$
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 ²⁾	$I_{S,pulse}$	-	-	16.2	A	$T_C = 25^\circ\text{C}$
Reverse diode dv/dt ³⁾	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 ³⁾	di/dt	-	-	500	A/ μs	$V_{DS} = 0 \dots 400\text{V}$, $I_{SD} \leq I_S$, $T_j = 25^\circ\text{C}$

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 ² (one layer 70 μm 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

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

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

³⁾ $V_{DClk} = 400\text{V}$; $V_{DS,peak} < V_{(BR)DSS}$; 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	$V_{(BR)DSS}$	650	-	-	V	$V_{GS}=0V$, $I_D=1mA$
Gate threshold voltage	$V_{(GS)th}$	2.50	3	3.50	V	$V_{DS}=V_{GS}$, $I_D=0.21mA$
Zero gate voltage drain current	I_{DSS}	-	-	1	μA	$V_{DS}=650V$, $V_{GS}=0V$, $T_J=25^\circ C$ $V_{DS}=650V$, $V_{GS}=0V$, $T_J=150^\circ C$
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	Ω	$V_{GS}=10V$, $I_D=2.1A$, $T_J=25^\circ C$ $V_{GS}=10V$, $I_D=2.1A$, $T_J=150^\circ C$
Gate resistance	R_G	-	17.5	-	Ω	$f=1\text{ MHz}$, open drain

Table 5 Dynamic characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	C_{iss}	-	440	-	pF	$V_{GS}=0V$, $V_{DS}=100V$, $f=1MHz$
Output capacitance	C_{oss}	-	30	-	pF	$V_{GS}=0V$, $V_{DS}=100V$, $f=1MHz$
Effective output capacitance, energy related ¹⁾	$C_{o(er)}$	-	21	-	pF	$V_{GS}=0V$, $V_{DS}=0...520V$
Effective output capacitance, time related ²⁾	$C_{o(tr)}$	-	88	-	pF	$I_D=constant$, $V_{GS}=0V$, $V_{DS}=0...520V$
Turn-on delay time	$t_{d(on)}$	-	12	-	ns	$V_{DD}=400V$, $V_{GS}=10V$, $I_D=3.2A$, $R_G=6.8\Omega$
Rise time	t_r	-	9	-	ns	$V_{DD}=400V$, $V_{GS}=10V$, $I_D=3.2A$, $R_G=6.8\Omega$
Turn-off delay time	$t_{d(off)}$	-	80	-	ns	$V_{DD}=400V$, $V_{GS}=10V$, $I_D=3.2A$, $R_G=6.8\Omega$
Fall time	t_f	-	13	-	ns	$V_{DD}=400V$, $V_{GS}=10V$, $I_D=3.2A$, $R_G=6.8\Omega$

Table 6 Gate charge characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate to source charge	Q_{gs}	-	2.5	-	nC	$V_{DD}=520V$, $I_D=3.2A$, $V_{GS}=0$ to 10V
Gate to drain charge	Q_{gd}	-	11	-	nC	$V_{DD}=520V$, $I_D=3.2A$, $V_{GS}=0$ to 10V
Gate charge total	Q_g	-	21	-	nC	$V_{DD}=520V$, $I_D=3.2A$, $V_{GS}=0$ to 10V
Gate plateau voltage	$V_{plateau}$	-	5.5	-	V	$V_{DD}=520V$, $I_D=3.2A$, $V_{GS}=0$ to 10V

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 7 Reverse diode characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Diode forward voltage	V_{SD}	-	0.9	-	V	$V_{GS}=0V$, $I_F=3.2A$, $T_f=25^{\circ}C$
Reverse recovery time	t_{rr}	-	270	-	ns	$V_R=400V$, $I_F=3.2A$, $di_F/dt=100A/\mu s$
Reverse recovery charge	Q_{rr}	-	2	-	μC	$V_R=400V$, $I_F=3.2A$, $di_F/dt=100A/\mu s$
Peak reverse recovery current	I_{rrm}	-	13	-	A	$V_R=400V$, $I_F=3.2A$, $di_F/dt=100A/\mu s$

5 Electrical characteristics diagrams

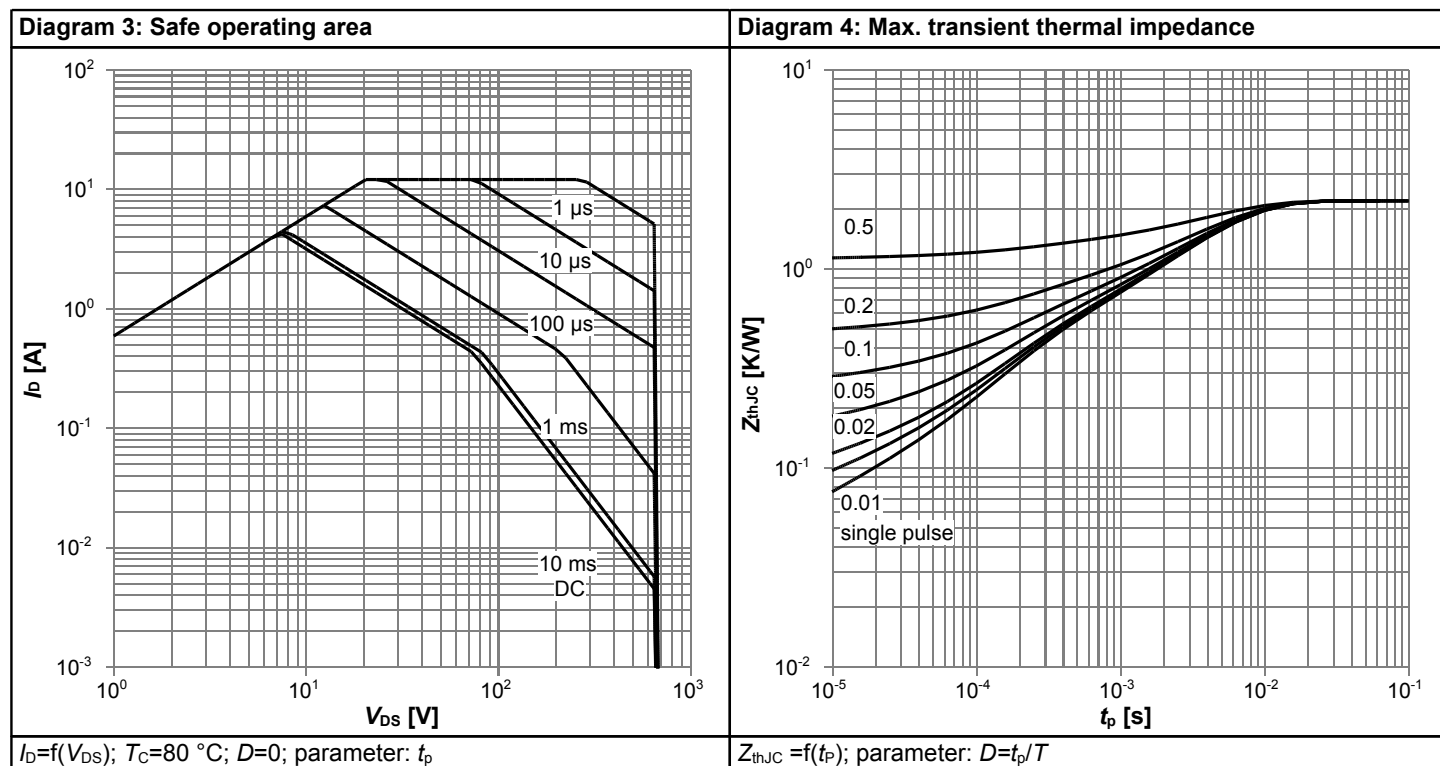
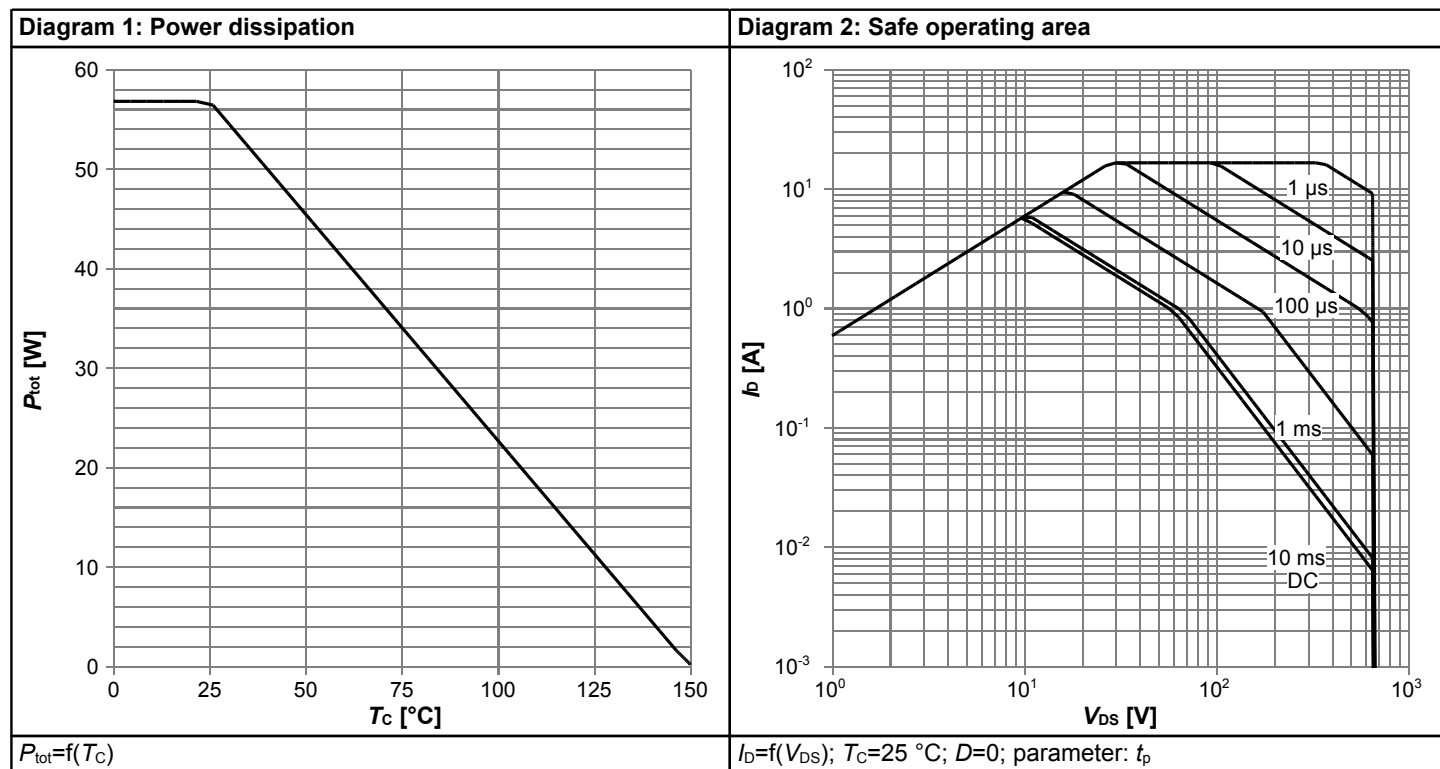


Diagram 5: Typ. output characteristics

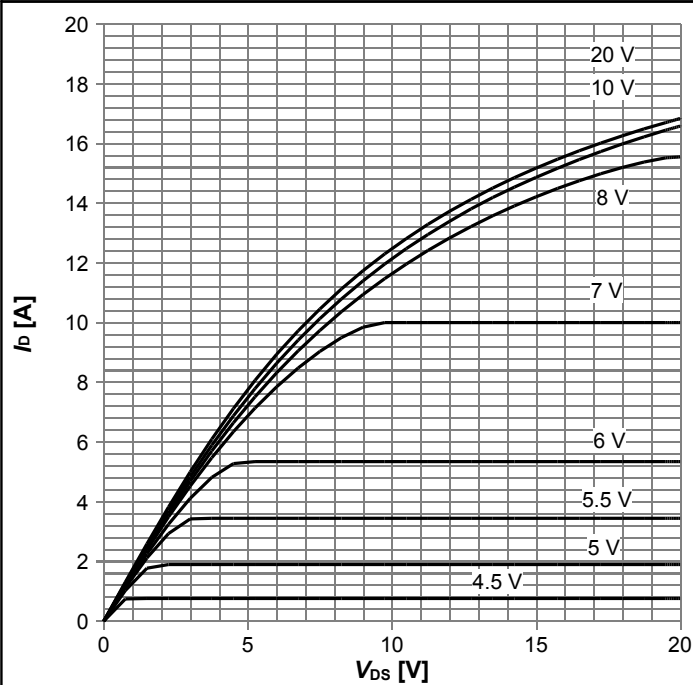

 $I_D = f(V_{DS}); T_J = 25^\circ\text{C}; \text{parameter: } V_{GS}$

Diagram 6: Typ. output characteristics

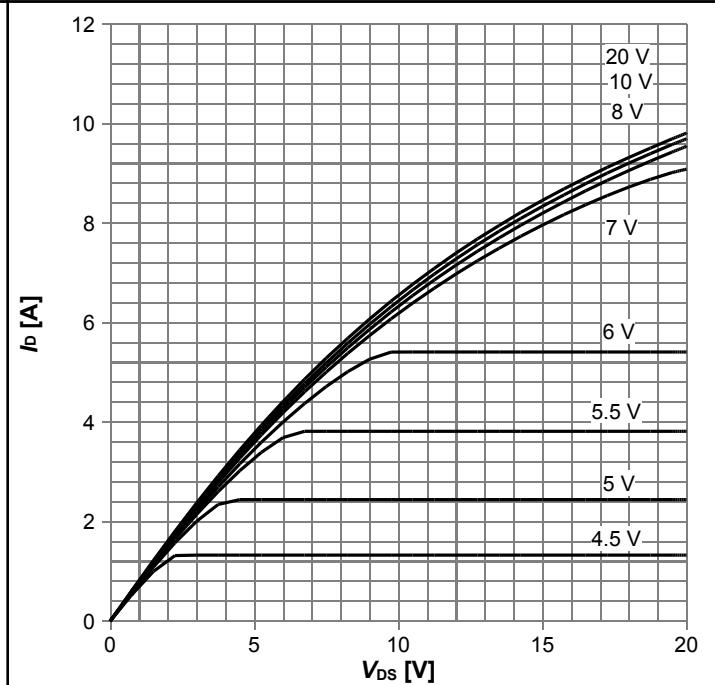

 $I_D = f(V_{DS}); T_J = 125^\circ\text{C}; \text{parameter: } V_{GS}$

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

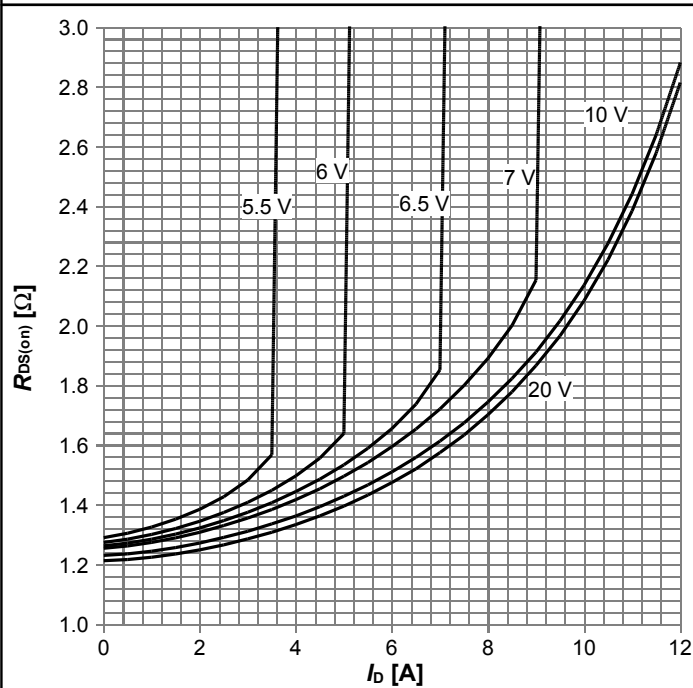

 $R_{DS(on)} = f(I_D); T_J = 125^\circ\text{C}; \text{parameter: } V_{GS}$

Diagram 8: Drain-source on-state resistance

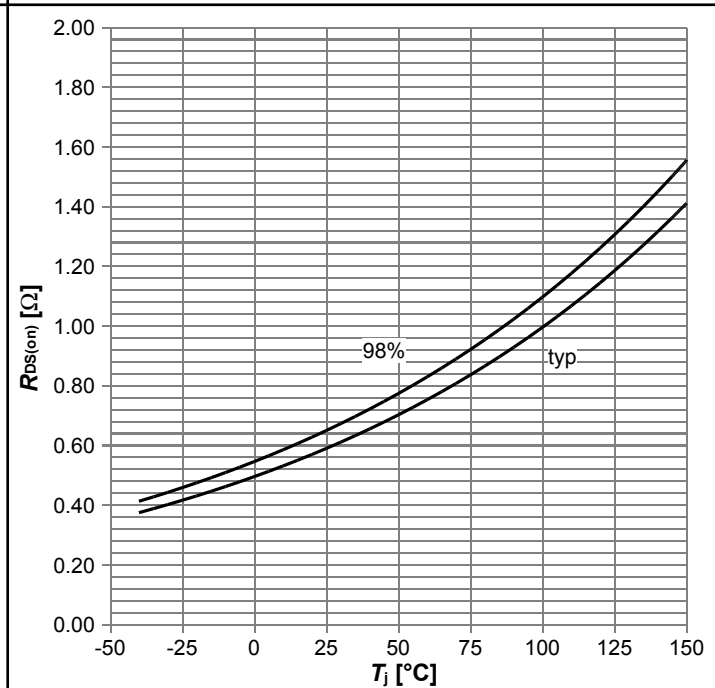

 $R_{DS(on)} = f(T_J); I_D = 2.1\text{ A}; V_{GS} = 10\text{ V}$

Diagram 9: Typ. transfer characteristics

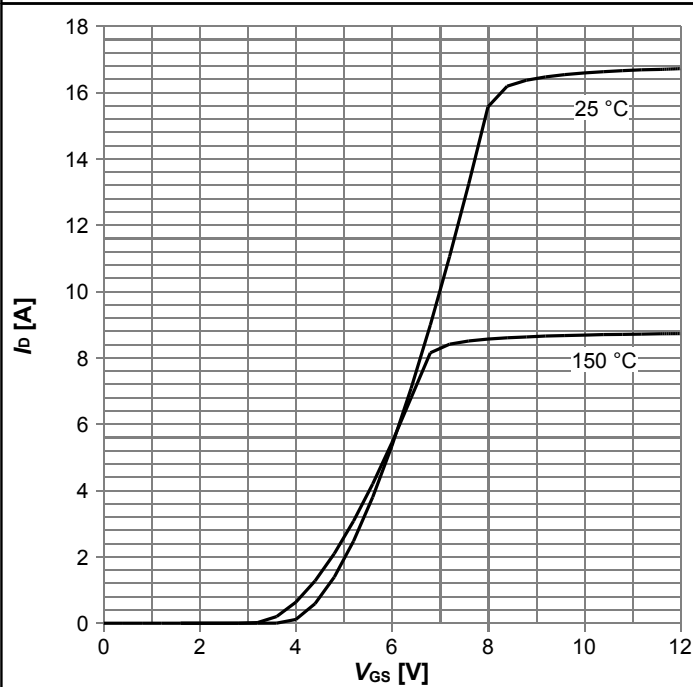

 $I_D = f(V_{GS})$; $V_{DS} = 20V$; parameter: T_j

Diagram 10: Typ. gate charge

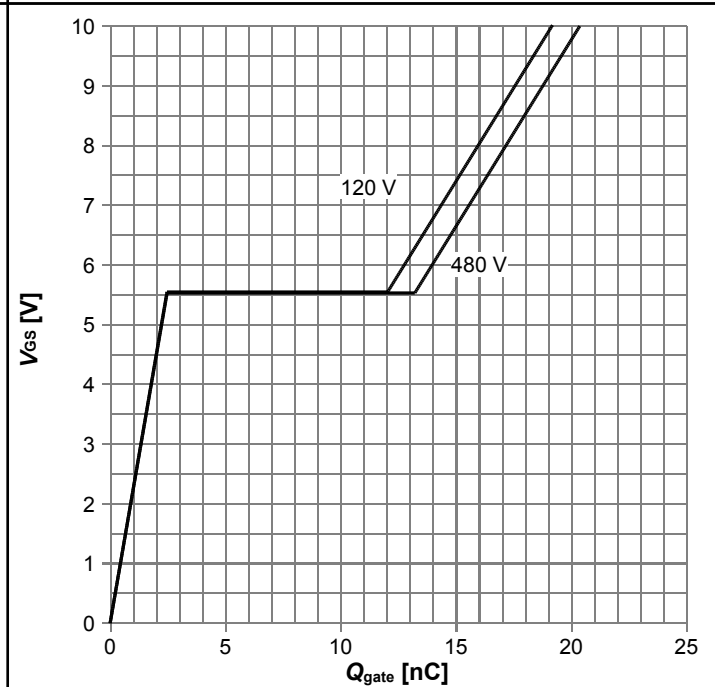

 $V_{GS} = f(Q_{gate})$; $I_D = 3.2$ A pulsed; parameter: V_{DD}

Diagram 11: Forward characteristics of reverse diode

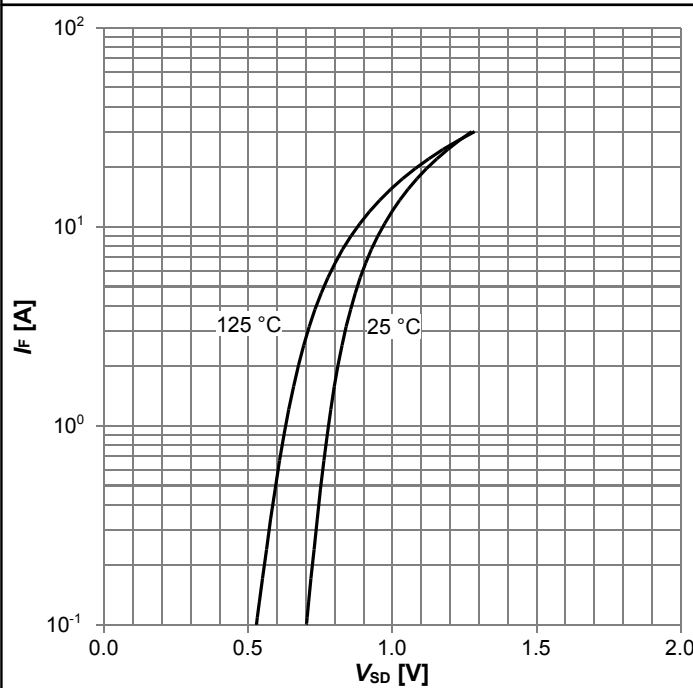

 $I_F = f(V_{SD})$; parameter: T_j

Diagram 12: Avalanche energy

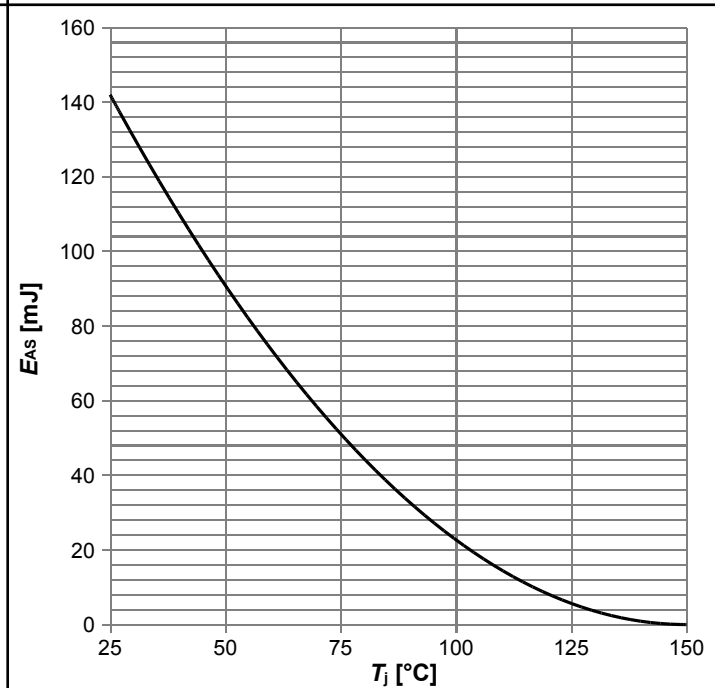
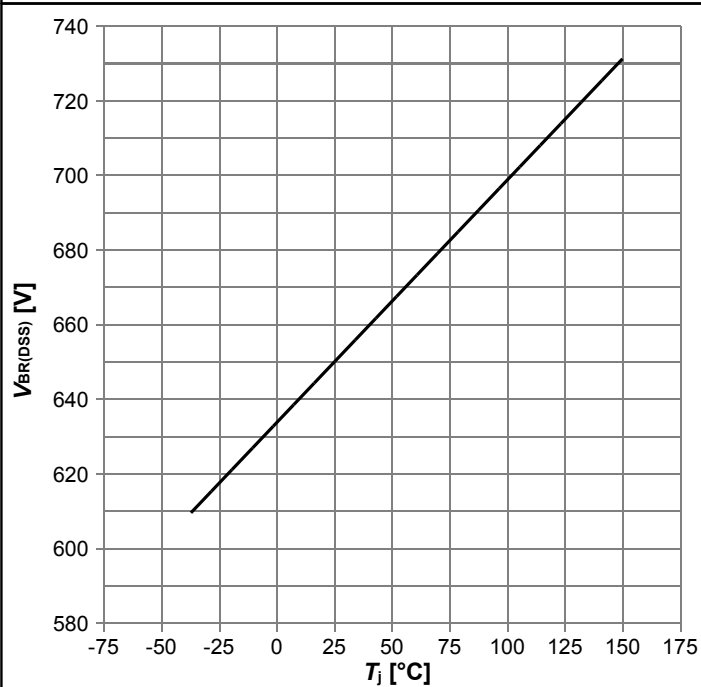
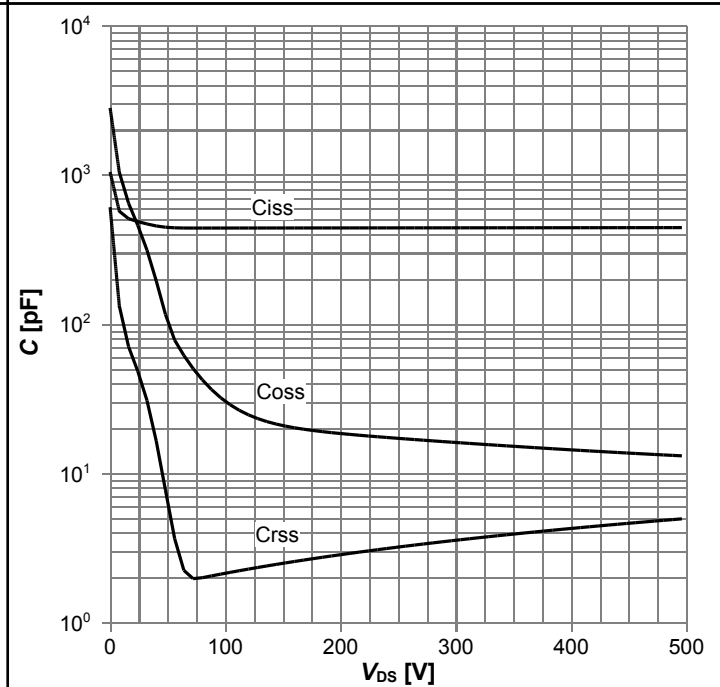

 $E_{AS} = f(T_j)$; $I_D = 1.3$ A; $V_{DD} = 50$ V

Diagram 13: Drain-source breakdown voltage



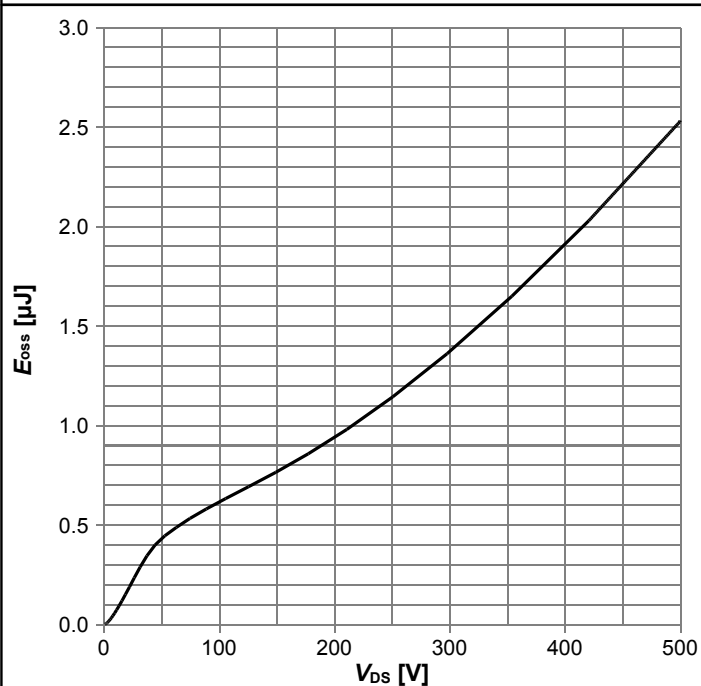
$$V_{BR(DSS)} = f(T_j); I_D = 1 \text{ mA}$$

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

$R_{g1} = R_{g2}$

Diode recovery waveform

$t_{rr} = t_F + t_S$
 $Q_{rr} = Q_F + Q_S$

Table 9 Switching times

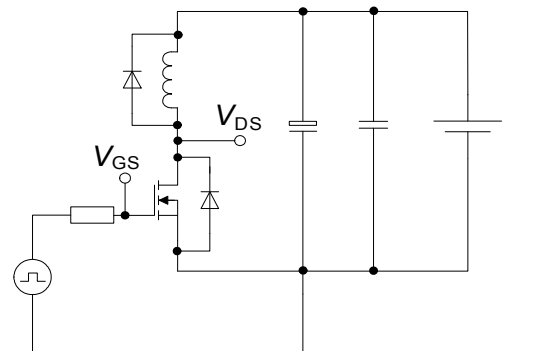
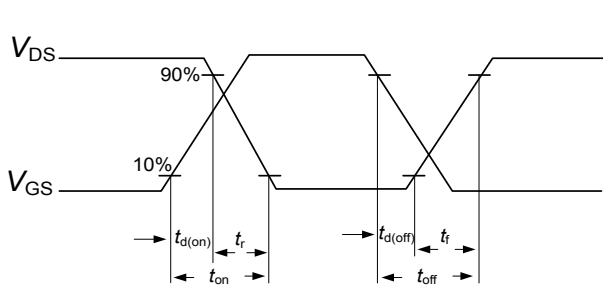
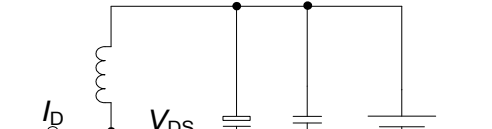
Switching times test circuit for inductive load	Switching times waveform
 The circuit diagram shows a MOSFET switching an inductive load. A pulse generator is connected to the gate of the MOSFET through a resistor. The drain of the MOSFET is connected to an inductor and a diode in parallel, which is then connected to a DC supply. The source of the MOSFET is connected to ground. The drain-source voltage is labeled V_{DS} and the gate-source voltage is labeled V_{GS}. The inductor is represented by a coil symbol, and the diode is shown in parallel with it, with its cathode towards the MOSFET drain.	 The waveform diagram shows the drain-source voltage (V_{DS}) and gate-source voltage (V_{GS}) during switching. The V_{GS} signal is a square wave that transitions between a high level and a low level. The V_{DS} signal shows the voltage across the MOSFET during these transitions. Key time intervals are marked: $t_{d(on)}$ (delay time to turn on), t_r (rise time), $t_{d(off)}$ (delay time to turn off), and t_f (fall time). The 10% and 90% voltage levels are indicated for the transitions.

Table 10 Unclamped inductive load

Unclamped inductive load test circuit	Unclamped inductive waveform
	

7 Package Outlines

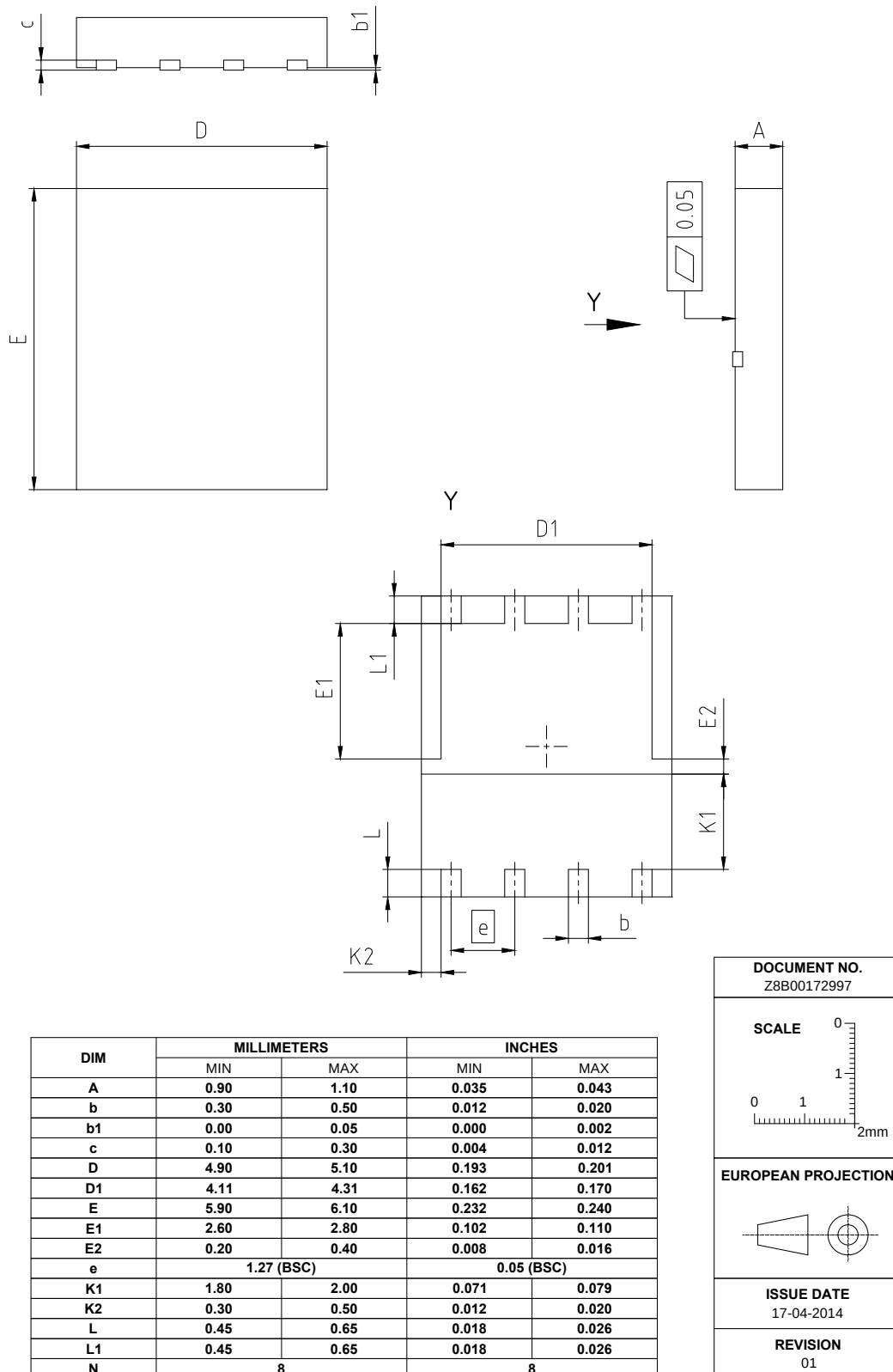


Figure 1 Outline ThinPAK 5x6 SMD, dimensions in mm/inches

8 Appendix A

Table 11 Related Links

- IFX CoolMOS Webpage: www.infineon.com
- IFX Design tools: www.infineon.com

Revision History

IPL65R650C6S

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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