

MOSFET

Metal Oxide Semiconductor Field Effect Transistor

CoolMOS™ ThinkPAK 8x8

650V CoolMOS™ E6 Power Transistor
IPL65R660E6

Data Sheet

Rev. 2.1
Final

Industrial & Multimarket

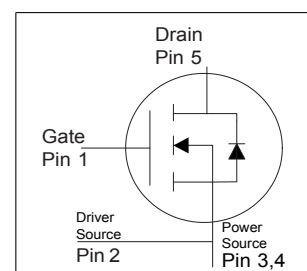
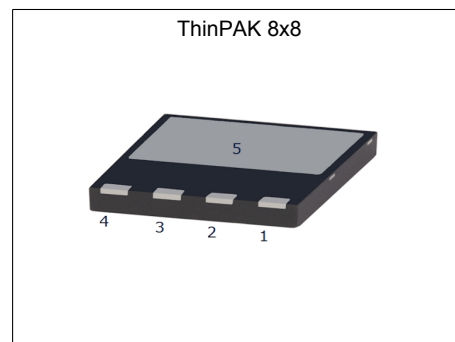
1 Description

CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. 650V 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 offering an extremely fast and robust body diode. This combination of extremely low switching, commutation and conduction losses together with highest robustness make especially resonant switching applications more reliable, more efficient, lighter and cooler.

ThinPAK

ThinPAK is a new leadless SMD package for HV MOSFETs. The new package has a very small footprint of only 64mm² (vs. 150mm² for the D²PAK) and a very low profile with only 1mm height (vs. 4.4mm for the D²PAK). The significantly smaller package size, combined with benchmark low parasitic inductances, provides designers with a new and effective way to decrease system solution size in power-density driven designs.



Features

- Reduced board space consumption
- Increased power density
- Short commutation loop
- Smooth switching waveform
- easy to use products
- Extremely low losses due to very low FOM $R_{ds(on)} \cdot Q_g$ and E_{oss}
- Pb-free plating, Halogen free
- Qualified for industrial grade applications according to JEDEC (J-STD20 and JESD22)



Applications

PFC stages, hard switching PWM stages and resonant switching stages for e.g. PC Silverbox, Adapter, LCD TV, Lighting, Server, Telecom.

Table 1 Key Performance Parameters

Parameter	Value	Unit
$V_{DS} @ T_{j,max}$	700	V
$R_{DS(on),max}$	0.66	Ω
Q_g,typ	23	nC
$I_D,pulse$	16	A
$E_{oss} @ 400V$	1.9	μJ
Body diode di/dt	500	A/ μs

Type / Ordering Code	Package	Marking	Related Links
IPL65R660E6	PG-VSON-4	65E6660	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 ¹⁾	I_D			7.0	A	$T_C = 25^\circ\text{C}$
				4.4		$T_C = 100^\circ\text{C}$
Pulsed drain current ²⁾	$I_{D,pulse}$			16	A	$T_C = 25^\circ\text{C}$
Avalanche energy, single pulse	E_{AS}			142	mJ	$I_D = 1.3\text{A}$, $V_{DD} = 50\text{V}$ (see table 10)
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	$V_{DS} = 0 \dots 480\text{V}$
Gate source voltage	V_{GS}	-20		20	V	static
		-30		30		AC ($f > 1\text{ Hz}$)
Operating and storage temperature	T_j, T_{stg}	-40		150	$^\circ\text{C}$	
Continuous diode forward current	I_S			6.0	A	$T_C = 25^\circ\text{C}$
Diode pulse current	$I_{S,pulse}$			16	A	$T_C = 25^\circ\text{C}$
Reverse diode dv/dt ³⁾	dv/dt			15	V/ns	$V_{DS} = 0 \dots 400\text{V}$, $I_{SD} \leq I_D$,
Maximum diode commutation speed	di/dt			500	A/ μs	$T_j = 25^\circ\text{C}$ (see table 8)
Power dissipation	P_{tot}			63	W	$T_C = 25^\circ\text{C}$

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 ThinPAK 8x8

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}			2	°C/W	
Thermal resistance, junction - ambient ¹⁾	R_{thJA}			65	°C/W	SMD version, device on PCB, minimal footprint
				45		SMD version, device on PCB, 6cm ² cooling area
Soldering temperature, wave- & reflowsoldering allowed	T_{sold}			260	°C	reflow MSL 3

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 $T_j = 25^\circ\text{C}$, unless otherwise specified

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	$V_{GS(th)}$	2.5	3	3.5	V	$V_{DS} = V_{GS}, I_D = 0.2mA$
Zero gate voltage drain current	I_{DSS}			1	μA	$V_{DS} = 650V, V_{GS} = 0V, T_j = 25^\circ C$
			10			$V_{DS} = 650V, V_{GS} = 0V, T_j = 150^\circ C$
Gate-source leakage current	I_{GSS}			100	nA	$V_{GS} = 20V, V_{DS} = 0V$
Drain-source on-state resistance	$R_{DS(on)}$		0.594	0.66	Ω	$V_{GS} = 10V, I_D = 2.1A, T_j = 25^\circ C$
			1.544			$V_{GS} = 10V, I_D = 2.1A, T_j = 150^\circ C$
Gate resistance	R_G		5		Ω	$f = 1MHz$, 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	
Effective output capacitance, energy related ¹⁾	$C_{o(er)}$		21		pF	$V_{GS} = 0V, V_{DS} = 0 \dots 480V$
Effective output capacitance, time related ²⁾	$C_{o(tr)}$		88		pF	$I_D = \text{constant}, V_{GS} = 0V, V_{DS} = 0 \dots 480V$
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 9)
Rise time	t_r		8		ns	
Turn-off delay time	$t_{d(off)}$		64		ns	
Fall time	t_f		11		ns	

Table 6 Gate charge characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate to source charge	Q_{gs}		2.75		nC	$V_{DD} = 480V, I_D = 3.2A, V_{GS} = 0 \text{ to } 10V$
Gate to drain charge	Q_{gd}		12		nC	
Gate charge total	Q_g		23		nC	
Gate plateau voltage	$V_{plateau}$		5.5		V	

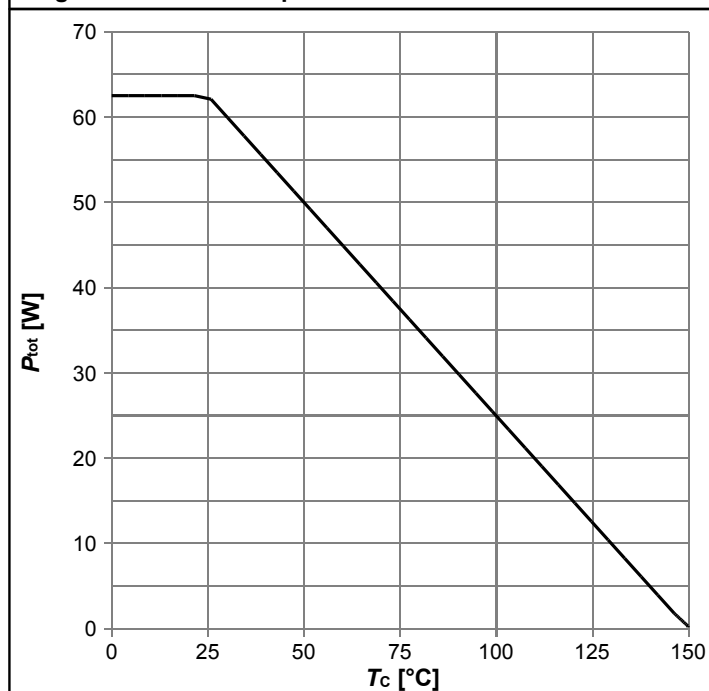
¹⁾ $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% $V_{(BR)DSS}$

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% $V_{(BR)DSS}$

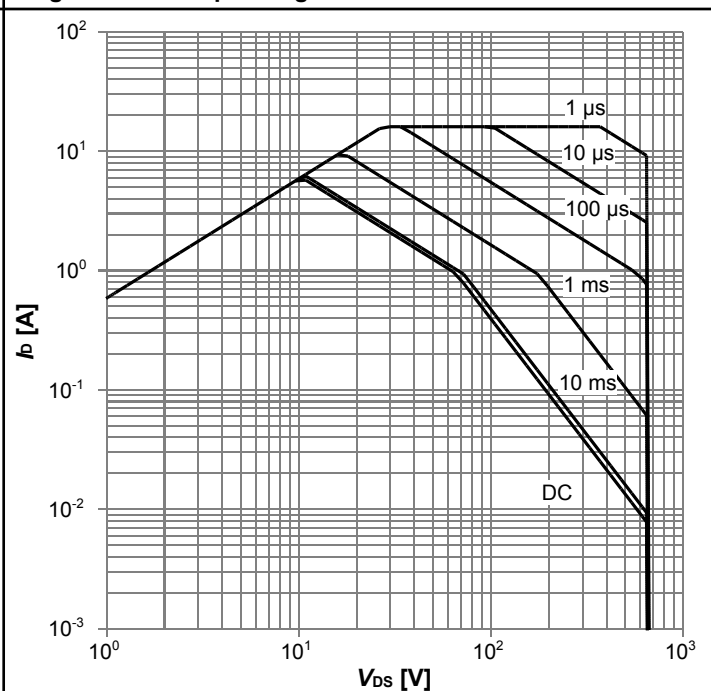
Table 7 Reverse diode characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Diode forward voltage	V_{SD}		0.9		V	$V_{GS} = 0V, I_F = 3.2A, T_J = 25^{\circ}C$
Reverse recovery time	t_{rr}		270		ns	$V_R = 400V, I_F = 3.2A,$ $di_F/dt = 100A/\mu s$ (see table 8)
Reverse recovery charge	Q_{rr}		2		μC	
Peak reverse recovery current	I_{rrm}		13		A	

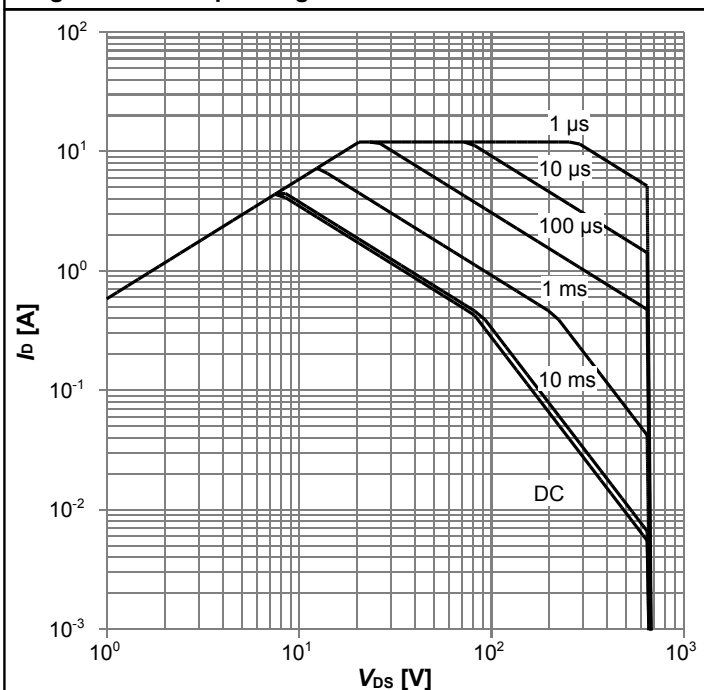
5 Electrical characteristics diagrams

Diagram 1: Power dissipation


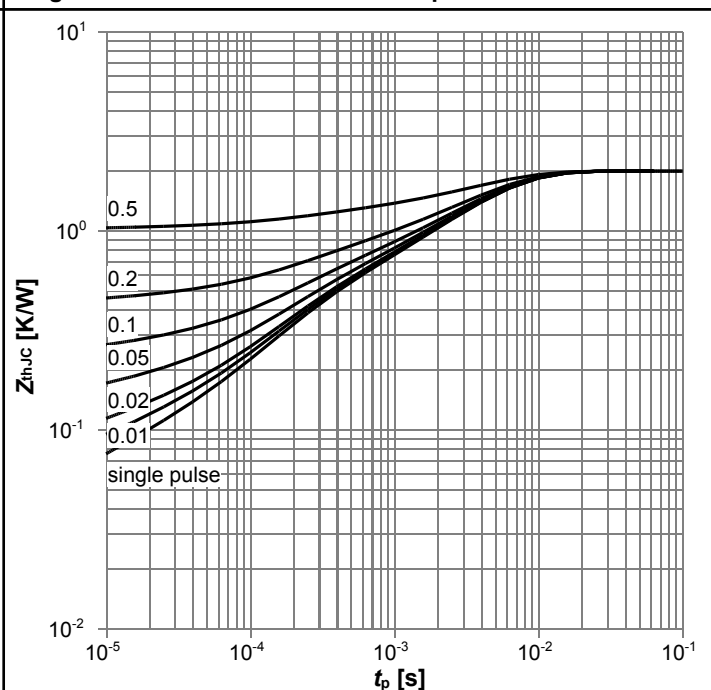
$$P_{tot}=f(T_c)$$

Diagram 2: Safe operating area


$$I_D=f(V_{DS}); T_c=25\text{ °C}; D=0; \text{parameter: } t_p$$

Diagram 3: Safe operating area


$$I_D=f(V_{DS}); T_c=80\text{ °C}; D=0; \text{parameter: } t_p$$

Diagram 4: Max. transient thermal impedance


$$Z_{thJC}=f(t_p); \text{parameter: } D=t_p/T$$

Diagram 5: Typ. output characteristics

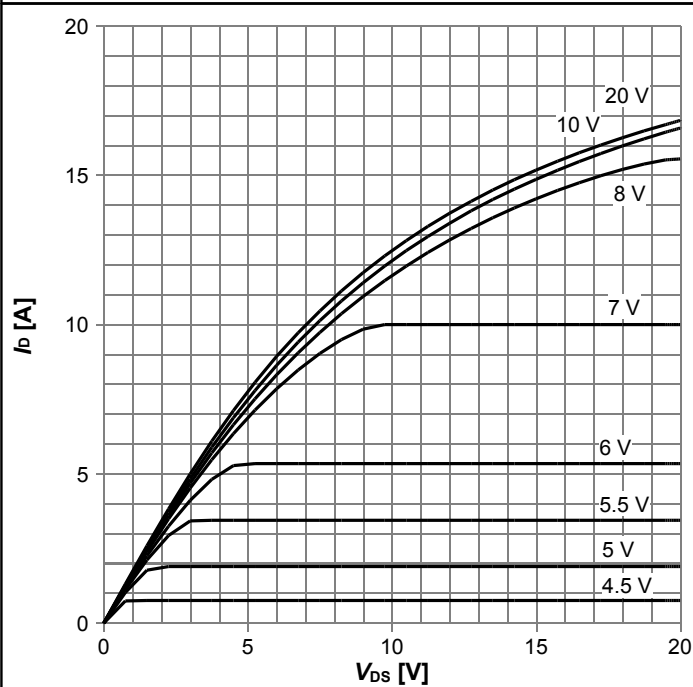

 $I_D = f(V_{DS}); T_J = 25^\circ\text{C}; \text{parameter: } V_{GS}$

Diagram 6: Typ. output characteristics

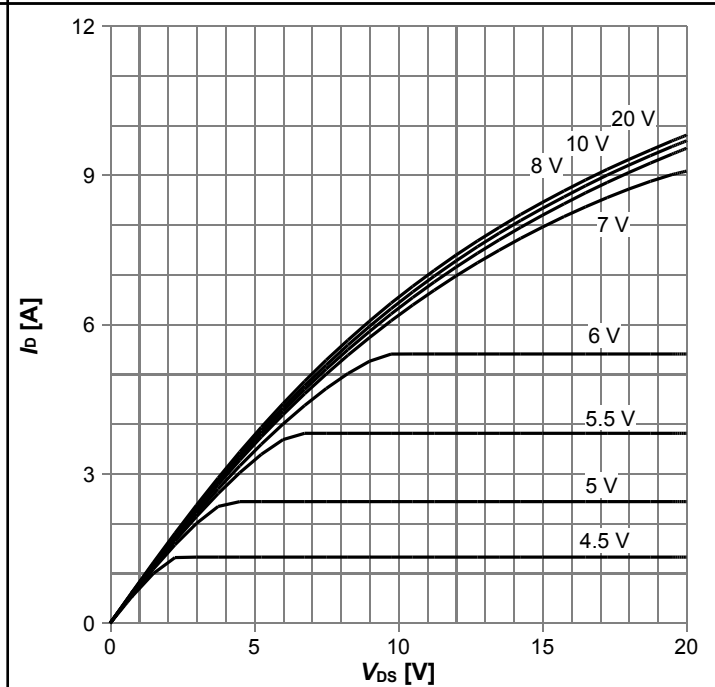

 $I_D = f(V_{DS}); T_J = 125^\circ\text{C}; \text{parameter: } V_{GS}$

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

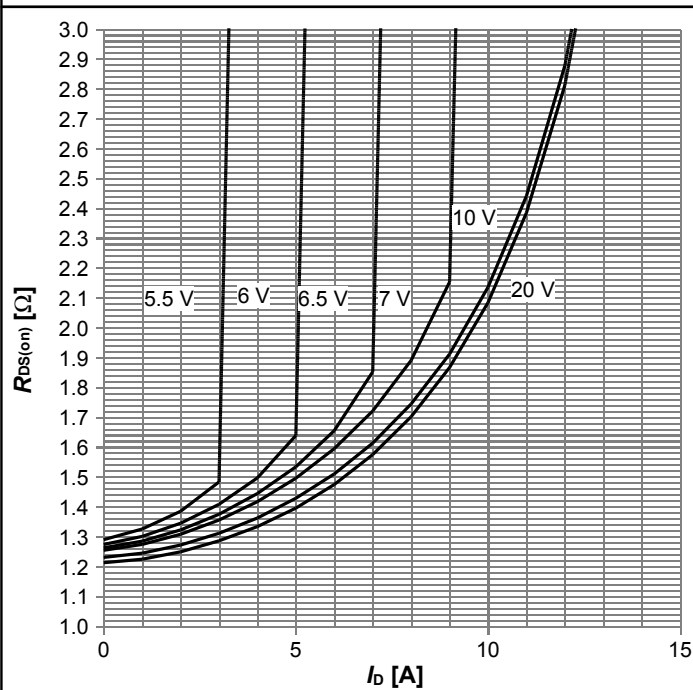

 $R_{DS(on)} = f(I_D); T_J = 125^\circ\text{C}; \text{parameter: } V_{GS}$

Diagram 8: Drain-source on-state resistance

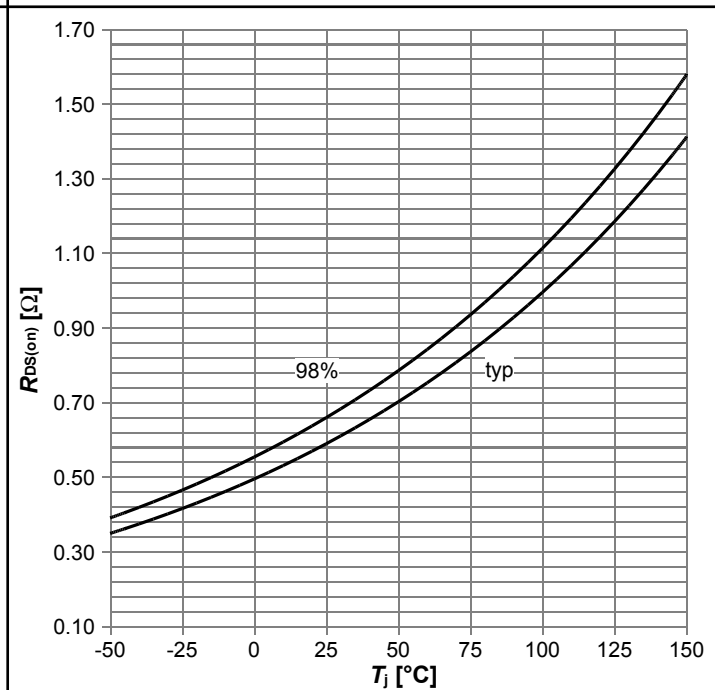

 $R_{DS(on)} = f(T_J); I_D = 2.1\text{ A}; V_{GS} = 10\text{ V}$

Diagram 9: Typ. transfer characteristics

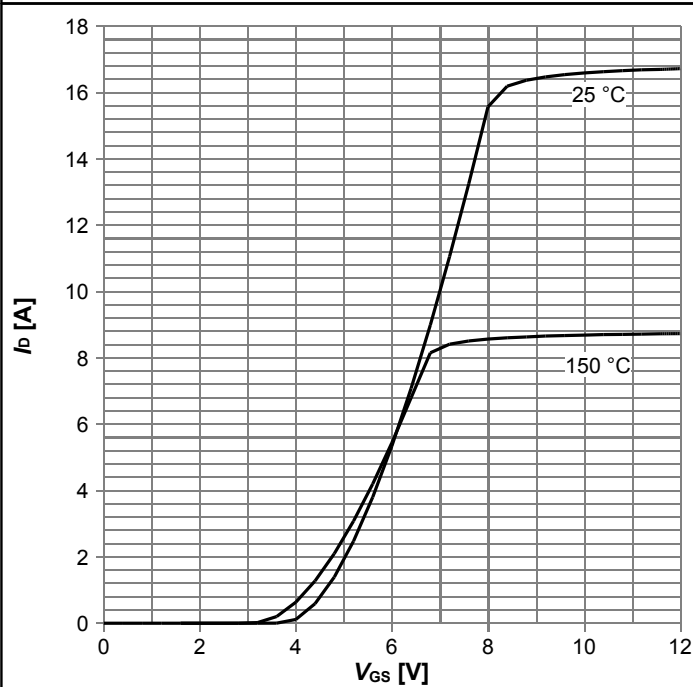

 $I_D = f(V_{GS}); V_{DS} = 20V; \text{parameter: } T_j$

Diagram 10: Typ. gate charge

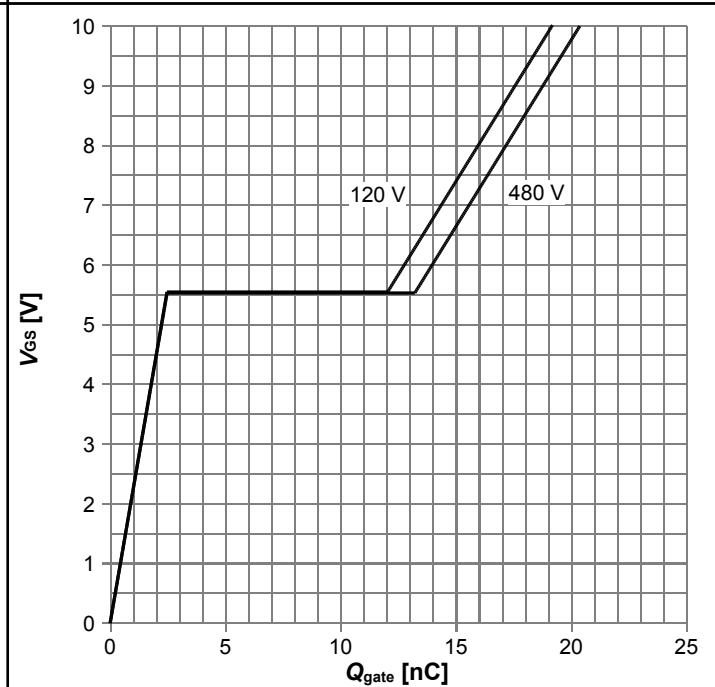

 $V_{GS} = f(Q_{gate}); I_D = 3.2 \text{ A pulsed}; \text{parameter: } V_{DD}$

Diagram 11: Forward characteristics of reverse diode

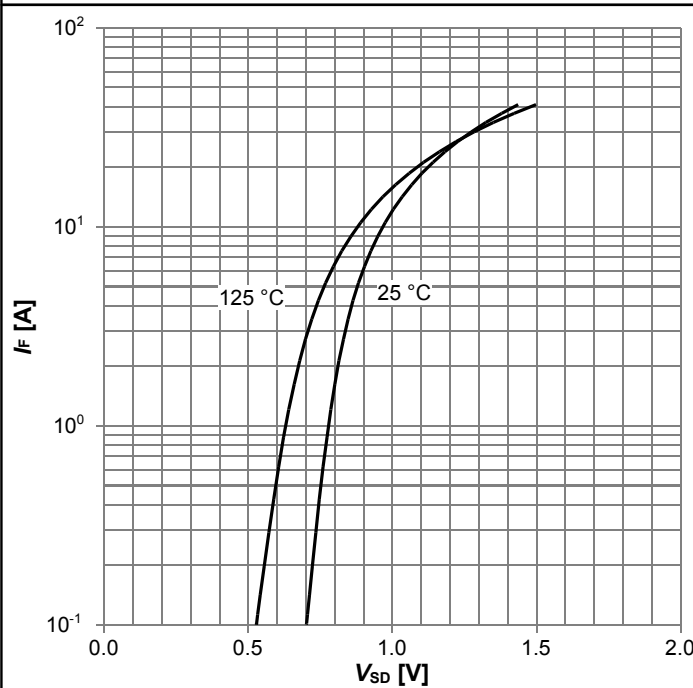

 $I_F = f(V_{SD}); \text{parameter: } T_j$

Diagram 12: Avalanche energy

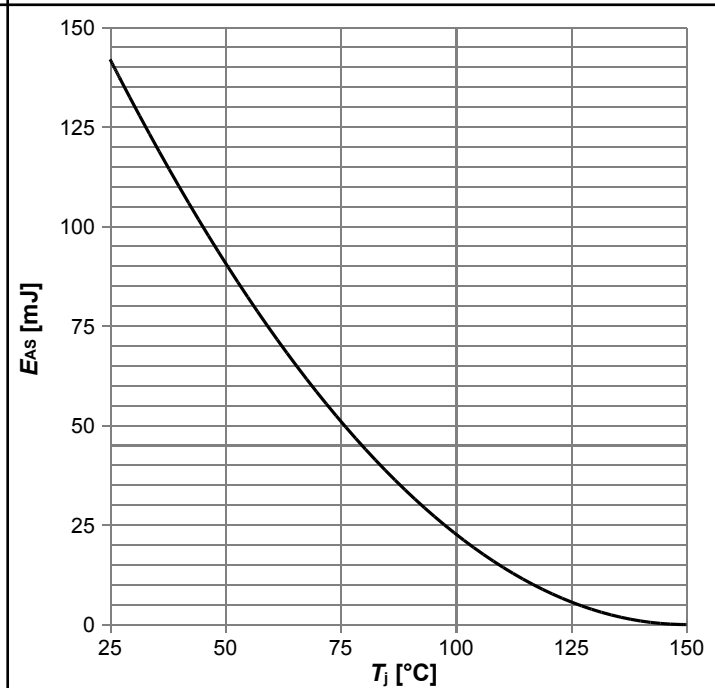
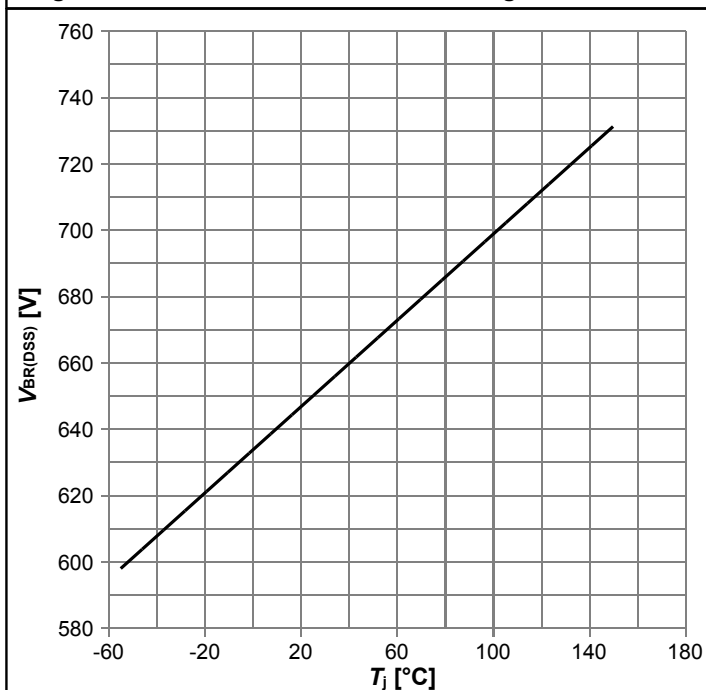
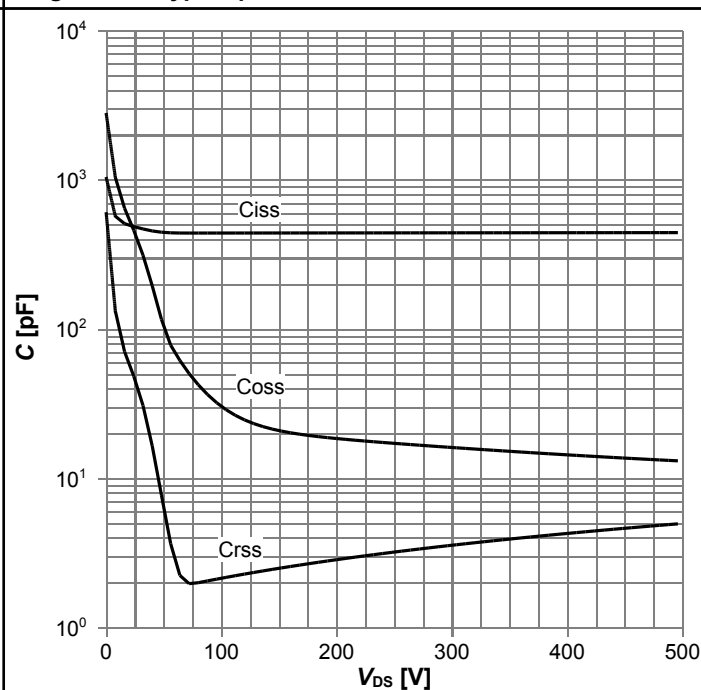

 $E_{AS} = f(T_j); I_D = 1.2 \text{ A}; V_{DD} = 50 \text{ V}$

Diagram 13: Drain-source breakdown voltage



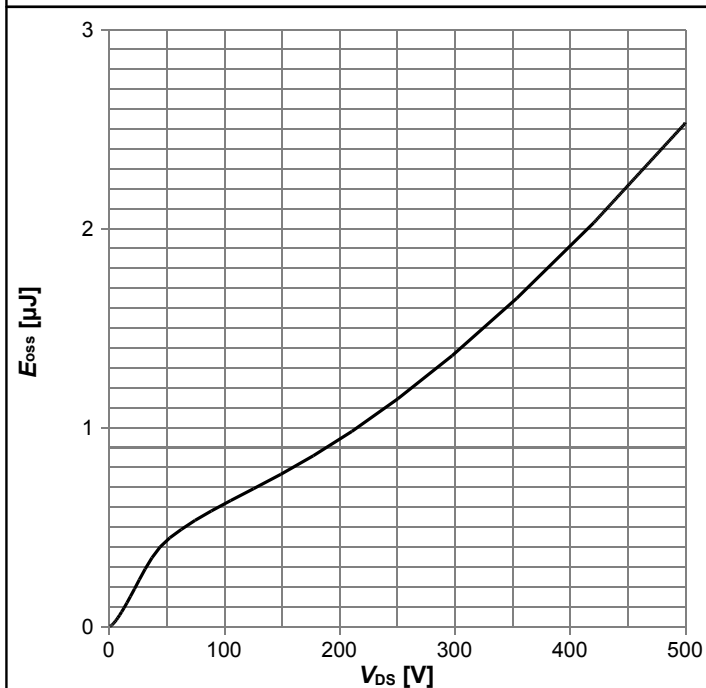
$$V_{BR(DSS)} = f(T_j); I_D = 1 \text{ mA}$$

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

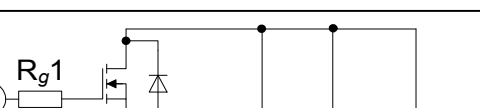
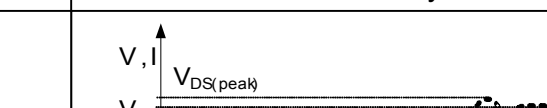
Test circuit for diode characteristics  $R_{g1} = R_{g2}$	Diode recovery waveform  $t_{rr} = t_F + t_S$ $Q_{rr} = Q_F + Q_S$
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Table 9 Switching times

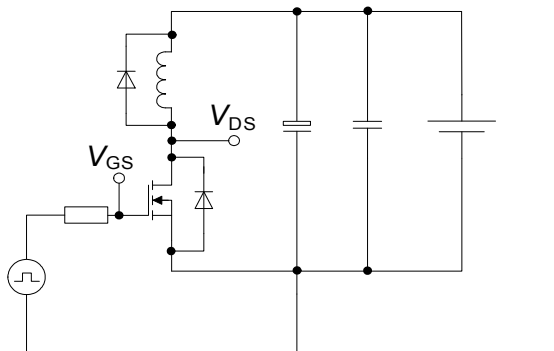
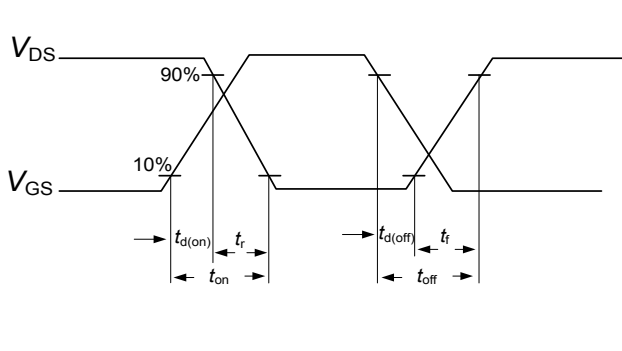
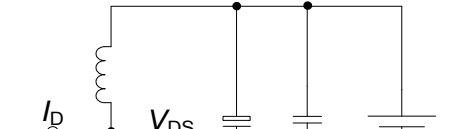
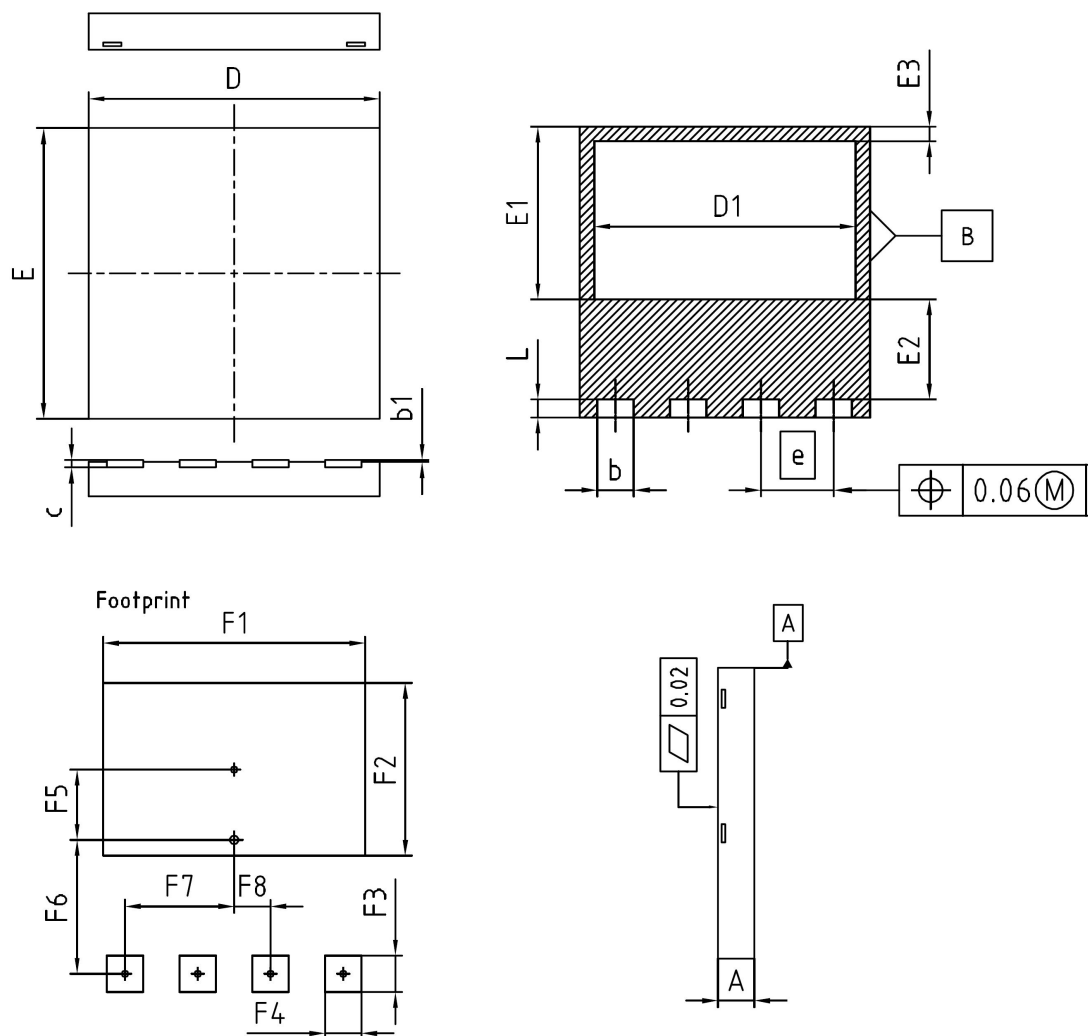
Switching times test circuit for inductive load	Switching times waveform
 The circuit diagram illustrates a switching test setup for an inductive load. A MOSFET is driven by a gate driver circuit consisting of a resistor and a pulse source. The MOSFET's drain is connected to an inductive load (represented by an inductor and a diode in parallel) which is connected to a DC voltage source. The drain-source voltage V_{DS} is measured across the load. The gate-source voltage V_{GS} is also indicated.	 The waveform diagram shows the switching transitions of the MOSFET. The top trace represents the drain-source voltage V_{DS} and the bottom trace represents the gate-source voltage V_{GS}. The transitions are characterized by the following time intervals: $t_{d(on)}$: Delay time from gate voltage rise to 10% of V_{DS} falling. t_r: Rise time of V_{DS} from 90% to 100%. t_{on}: Total turn-on time from 10% to 100% of V_{DS}. $t_{d(off)}$: Delay time from gate voltage fall to 90% of V_{DS} rising. t_f: Fall time of V_{DS} from 90% to 10%. t_{off}: Total turn-off time from 90% to 10% of V_{DS}.

Table 10 Unclamped inductive load

Unclamped inductive load test circuit	Unclamped inductive waveform
	

7 Package Outlines



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	0.90	1.10	0.035	0.043
b	0.90	1.10	0.035	0.043
b1	0.00	0.05	0.000	0.002
c	0.10	0.30	0.004	0.012
D	7.90	8.10	0.311	0.319
D1	7.10	7.30	0.280	0.287
E	7.90	8.10	0.311	0.319
E1	4.65	4.85	0.183	0.191
E2	2.65	2.85	0.104	0.112
E3	0.30	0.50	0.012	0.020
e	2.00 (BSC)		0.079 (BSC)	
L	0.40	0.60	0.016	0.024
N	4		4	
F1	7.20		0.283	
F2	4.75		0.187	
F3	1.00		0.039	
F4	1.00		0.039	
F5	1.43		0.056	
F6	4.20		0.165	
F7	3.00		0.118	
F8	1.00		0.039	

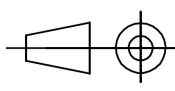
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ISSUE DATE 05-04-2010
REVISION 01

Figure 1 Outline PG-VSON-4, 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

IPL65R660E6

Revision: 2014-03-07, Rev. 2.1

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.0	2013-08-26	Release of final version
2.1	2014-03-07	Added in Features list: Qualified for industrial grade application

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Any information within this document that you feel is wrong, unclear or missing at all? Your feedback will help us to continuously improve the quality of this document. Please send your proposal (including a reference to this document) to:

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