

# IP4085CX4; IP4385CX4; IP4386CX4; IP4387CX4

Integrated high-performance ESD-protection diodes to  
IEC61000-4-2, level 4

Rev. 01 — 26 March 2009

Product data sheet

## 1. Product profile

---

### 1.1 General description

IP4085CX4, IP4385CX4, IP4386CX4 and IP4387CX4 are designed to protect appliances from destruction by either:

- ElectroStatic Discharges (ESD) of  $\pm 30$  kV, far exceeding IEC 61000-4-2 standard, level 4
- overvoltage
- wrong polarity

Each device has a single high-performance ESD-protection diode with the anode and cathode each connected to two solder balls. The IP4085CX4, IP4385CX4, IP4386CX4 and IP4387CX4 are fabricated using monolithic silicon technology in a Wafer-Level Chip-Scale Package (WLCSP) with a pitch of 0.4 mm (IP438xCX4) or 0.5 mm (IP4085CX4).

### 1.2 Features

- Pb-free, RoHS and Dark Green compliant
- Single integrated high-performance ESD-protection diode
- Surge immunity according to IEC 61000-4-5 (8/20  $\mu$ s) up to 60 A (IP4085CX4)
- ESD protection of >30 kV contact discharge, far exceeding IEC 61000-4-2 standard, level 4
- Small 2  $\times$  2 solder ball WLCSP package with 0.4 mm or 0.5 mm pitch

### 1.3 Applications

- General purpose ESD-protection such as for charger interfaces in:
  - ◆ Cellular and PCS mobile handsets
  - ◆ Cordless telephones
  - ◆ Wireless data (WAN/LAN) systems

## 2. Pinning information

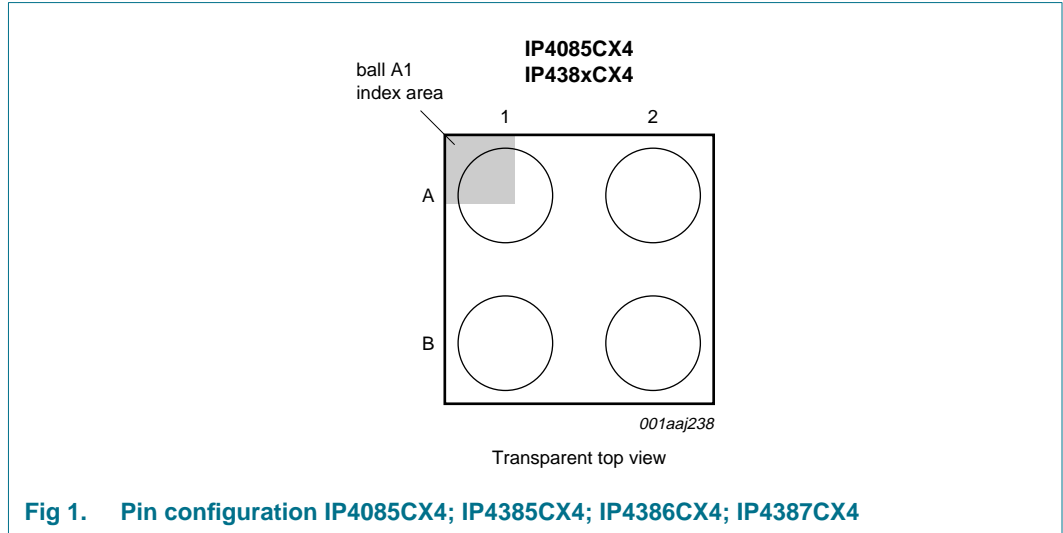


Fig 1. Pin configuration IP4085CX4; IP4385CX4; IP4386CX4; IP4387CX4

Table 1. Pinning

Pin	Description
A1 and A2	diode cathode
B1 and B2	diode anode

## 3. Ordering information

Table 2. Ordering information

Type number	Package		Version
	Name	Description	
IP4085CX4/LF	WLCSP4	wafer level chip-size package: 4 bumps; 0.91 × 0.91 × 0.65 mm	IP4085CX4/LF
IP4385CX4/LF	WLCSP4	wafer level chip-size package: 4 bumps; 0.76 × 0.76 × 0.61 mm	IP438xCX4/LF
IP4386CX4/LF	WLCSP4	wafer level chip-size package: 4 bumps; 0.76 × 0.76 × 0.61 mm	IP438xCX4/LF
IP4387CX4/LF	WLCSP4	wafer level chip-size package: 4 bumps; 0.76 × 0.76 × 0.61 mm	IP438xCX4/LF

## 4. Functional diagram

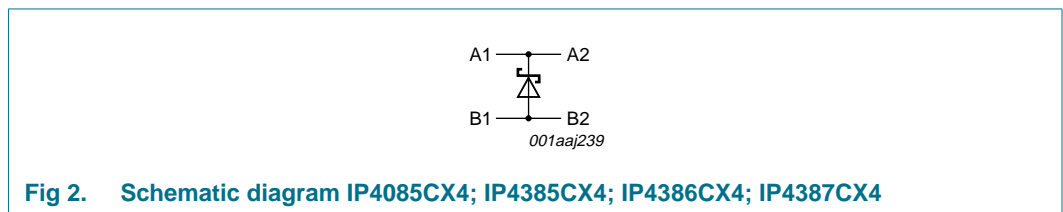


Fig 2. Schematic diagram IP4085CX4; IP4385CX4; IP4386CX4; IP4387CX4

## 5. Limiting values

**Table 3. Limiting values**
*In accordance with the Absolute Maximum Rating System (IEC 60134).*

Symbol	Parameter	Conditions	Min	Max	Unit
V <sub>CC</sub>	supply voltage	IP4085CX4/LF; IP4386CX4/LF	-0.5	+14	V
		IP4385CX4/LF	-0.5	+5.5	V
		IP4387CX4/LF	-0.5	+8.0	V
V <sub>ESD</sub>	electrostatic discharge voltage	all pins to ground			
		contact discharge	[1] -30	+30	kV
		air discharge	[1] -15	+15	kV
		IEC 61000-4-2, level 4; all pins to ground			
		contact discharge	-8	+8	kV
		air discharge	-15	+15	kV
I <sub>PP</sub>	peak pulse current	IEC 61000-4-5; t <sub>p</sub> = 8/20 μs			
		IP4085CX4	60	-	A
		IP4385CX4; IP4387CX4	33	-	A
		IP4386CX4	28	-	A
I <sub>FSM</sub>	non-repetitive peak forward current	10 pulses; 1 pulse per second			
		IP4085CX4; IP4386CX4; t <sub>p</sub> = 2 ms	10	-	A
		IP4085CX4; IP4386CX4; t <sub>p</sub> = 5 ms	8.5	-	A
		IP4085CX4; IP4386CX4; t <sub>p</sub> = 100 ms	3.5	-	A
		IP4385CX4; IP4387CX4; t <sub>p</sub> = 2 ms	11	-	A
		IP4385CX4; IP4387CX4; t <sub>p</sub> = 5 ms	9	-	A
		IP4385CX4; IP4387CX4; t <sub>p</sub> = 100 ms	5	-	A
P <sub>tot</sub>	total power dissipation	forward conducting	[2]		
		IP4085CX4	[3] -	1	W
		IP4385CX4; IP4386CX4; IP4387CX4	[3] -	0.7	W

**Table 3. Limiting values ...continued**

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
T <sub>stg</sub>	storage temperature		-55	+150	°C
T <sub>reflow(peak)</sub>	peak reflow temperature	10 s maximum	-	260	°C
T <sub>amb</sub>	ambient temperature		-30	+85	°C

- [1] Device tested with over 1000 pulses of ±30 kV contact discharges, according to the IEC 61000-4-2 model.
- [2] Severe self-heating demands a heat-dissipation optimized PCB to prevent the device from de-soldering. For ambient temperatures above 50 °C, the guaranteed life time is 48 hours at 0.7 W, assuming R<sub>th</sub> to be 130 K/W as specified in [Table 4](#).
- [3] Permanent operation at maximum power dissipation and above maximum junction temperature will result in a reduced life time.

## 6. Thermal characteristics

**Table 4. Thermal characteristics**

Symbol	Parameter	Conditions	Typ	Unit
R <sub>th(j-a)</sub>	thermal resistance from junction to ambient	on a 2-layer PCB	-	
		IP4085CX4; IP4385CX4; IP4386CX4; IP4387CX4	[1] 130	K/W

- [1] Depends on details of layout.

## 7. Characteristics

**Table 5. Electrical characteristics**

T<sub>amb</sub> = 25 °C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
V <sub>BR</sub>	breakdown voltage	I <sub>R</sub> = 15 mA					
		IP4085CX4; IP4386CX4	16	-	-	V	
		IP4385CX4	7.0	-	-	V	
		IP4387CX4	10	-	-	V	
V <sub>CL(trt)</sub>	transient clamping voltage	I <sub>R</sub> = 1 A; T <sub>amb</sub> ≤ 85 °C at surge peak pulse according to IEC 61000-4-5					
		IP4085CX4	-	-	20.0	V	
		IP4385CX4	-	-	10.0	V	
		IP4386CX4	-	-	20.0	V	
		IP4387CX4	-	-	13.0	V	
I <sub>LR</sub>	reverse leakage current						
		IP4085CX4; IP4385CX4	V <sub>R</sub> = +5.0 V	-	-	200	nA
		IP4386CX4	V <sub>R</sub> = +14.0 V	-	-	200	nA
		IP4387CX4	V <sub>R</sub> = +8.0 V	-	-	800	nA

**Table 5. Electrical characteristics ...continued**

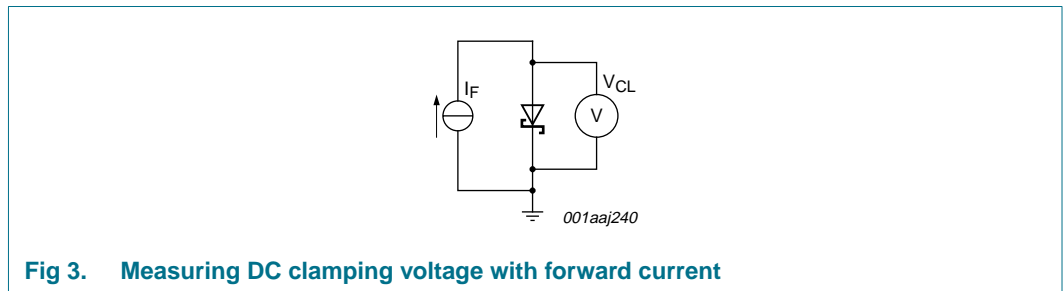
$T_{amb} = 25\text{ }^{\circ}\text{C}$ ; unless otherwise specified.

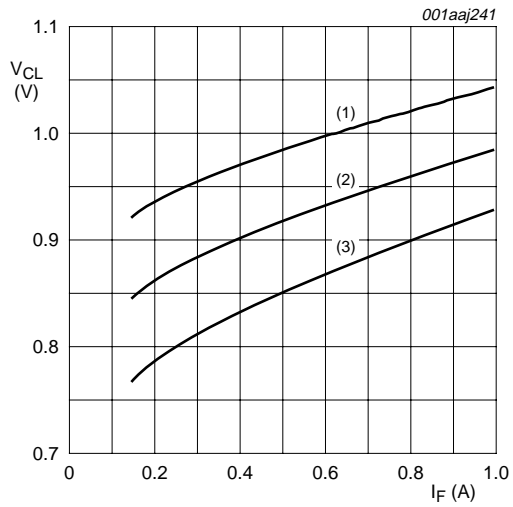
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$C_d$	diode capacitance	DC bias $V_R = 0\text{ V}$ ; $f = 1\text{ MHz}$				
	IP4085CX4		-	180	-	pF
	IP4385CX4		-	450	-	pF
	IP4386CX4		-	160	-	pF
	IP4387CX4		-	290	-	pF
$V_{Fd}$	diode forward voltage	$I_F = 850\text{ mA}$				
	IP4085CX4	$T_{amb} \geq +25\text{ }^{\circ}\text{C}$	-	-	1.15	V
		$-30\text{ }^{\circ}\text{C} \leq T_{amb} \leq +85\text{ }^{\circ}\text{C}$	-	-	1.3	V
	IP4385CX4	$T_{amb} \geq +25\text{ }^{\circ}\text{C}$	-	-	1.0	V
		$-30\text{ }^{\circ}\text{C} \leq T_{amb} \leq +85\text{ }^{\circ}\text{C}$	-	-	1.1	V
	IP4386CX4	$T_{amb} \geq +25\text{ }^{\circ}\text{C}$	-	-	1.15	V
		$-30\text{ }^{\circ}\text{C} \leq T_{amb} \leq +85\text{ }^{\circ}\text{C}$	-	-	1.3	V
	IP4387CX4	$T_{amb} \geq +25\text{ }^{\circ}\text{C}$	-	-	1.10	V
		$-30\text{ }^{\circ}\text{C} \leq T_{amb} \leq +85\text{ }^{\circ}\text{C}$	-	-	1.25	V

## 8. Application information

### 8.1 Forward current DC clamping voltage

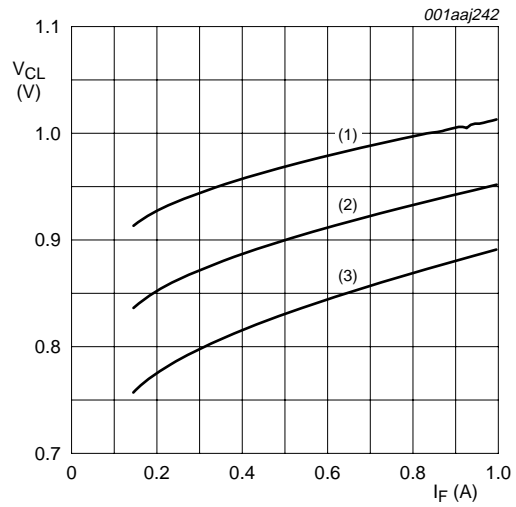
The forward current DC clamping voltage is of interest when protecting circuits from voltage sources with the wrong polarity. [Figure 3](#) shows the basic measurement setup.





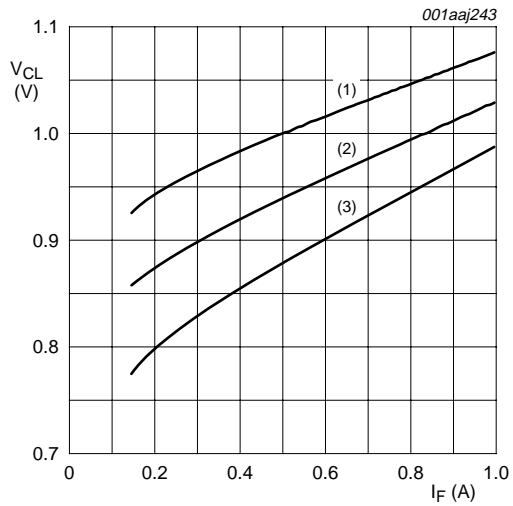
- (1)  $T_{amb} = +25\text{ }^{\circ}\text{C}$ .
- (2)  $T_{amb} = +85\text{ }^{\circ}\text{C}$ .
- (3)  $T_{amb} = -30\text{ }^{\circ}\text{C}$ .

Fig 4. DC clamping voltage as a function of forward current; IP4085CX4



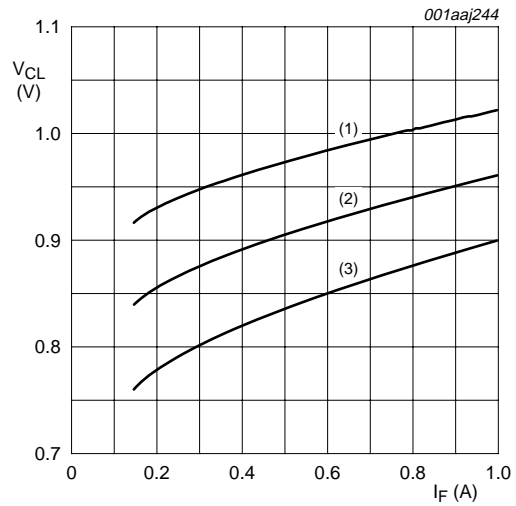
- (1)  $T_{amb} = +25\text{ }^{\circ}\text{C}$ .
- (2)  $T_{amb} = +85\text{ }^{\circ}\text{C}$ .
- (3)  $T_{amb} = -30\text{ }^{\circ}\text{C}$ .

Fig 5. DC clamping voltage as a function of forward current; IP4385CX4



- (1)  $T_{amb} = +25\text{ }^{\circ}\text{C}$ .
- (2)  $T_{amb} = +85\text{ }^{\circ}\text{C}$ .
- (3)  $T_{amb} = -30\text{ }^{\circ}\text{C}$ .

Fig 6. DC clamping voltage as a function of forward current; IP4386CX4



- (1)  $T_{amb} = +25\text{ }^{\circ}\text{C}$ .
- (2)  $T_{amb} = +85\text{ }^{\circ}\text{C}$ .
- (3)  $T_{amb} = -30\text{ }^{\circ}\text{C}$ .

Fig 7. DC clamping voltage as a function of forward current; IP4387CX4

8.2 Peak clamping voltage

The peak clamping voltage for forward and reverse current pulses of 8/20  $\mu\text{s}$  (IEC 61000-4-5) is significant when protecting circuits from power surges due to voltage discharges. The current pulse shape over time is shown in Figure 9. The basic measurement setup for forward current and reverse current pulses respectively are shown in Figure 8 and Figure 14.

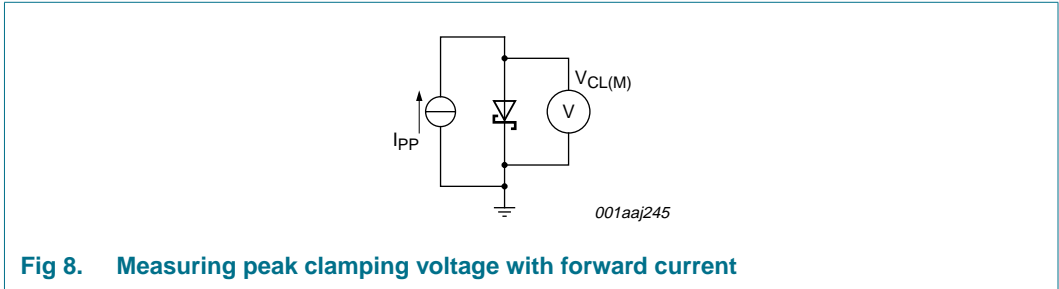


Fig 8. Measuring peak clamping voltage with forward current

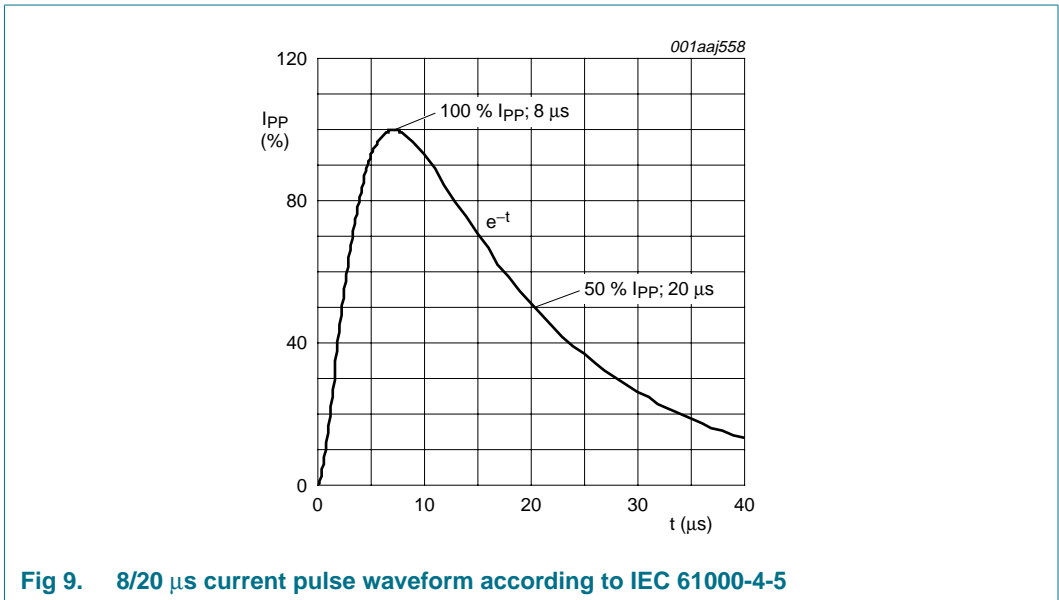
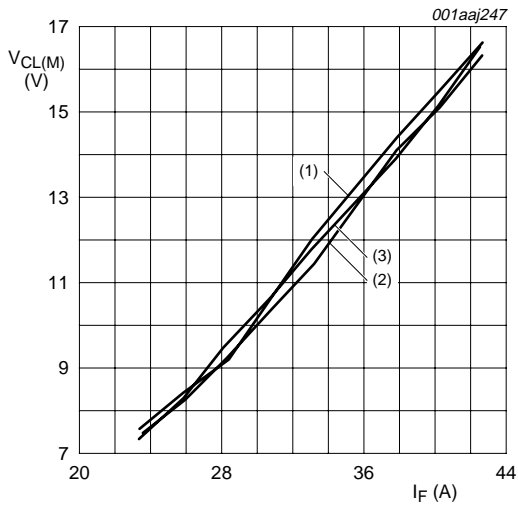
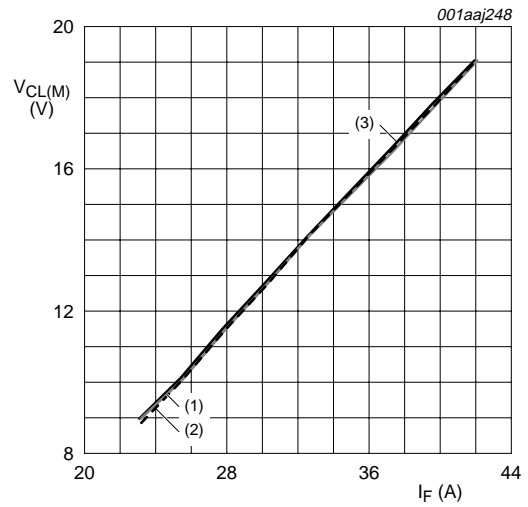


Fig 9. 8/20  $\mu\text{s}$  current pulse waveform according to IEC 61000-4-5



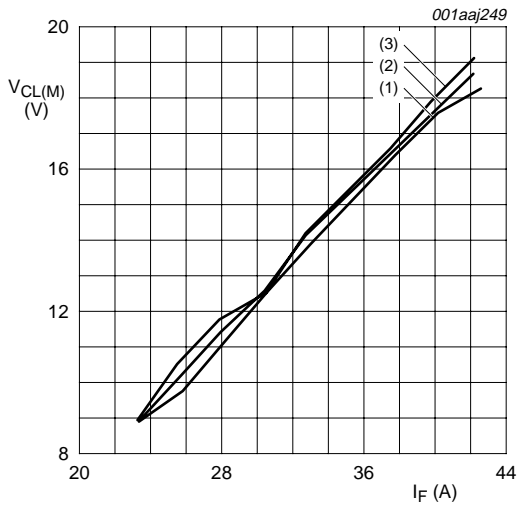
- (1)  $T_{amb} = +25\text{ °C}$ .
- (2)  $T_{amb} = +85\text{ °C}$ .
- (3)  $T_{amb} = -30\text{ °C}$ .

**Fig 10. Peak clamping voltage as a function of forward current; IP4085CX4**



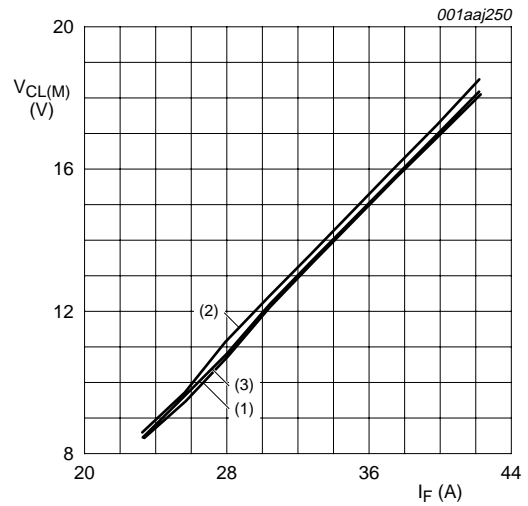
- (1)  $T_{amb} = +25\text{ °C}$ .
- (2)  $T_{amb} = +85\text{ °C}$ .
- (3)  $T_{amb} = -30\text{ °C}$ .

**Fig 11. Peak clamping voltage as a function of forward current; IP4385CX4**



- (1)  $T_{amb} = +25\text{ °C}$ .
- (2)  $T_{amb} = +85\text{ °C}$ .
- (3)  $T_{amb} = -30\text{ °C}$ .

**Fig 12. Peak clamping voltage as a function of forward current; IP4386CX4**



- (1)  $T_{amb} = +25\text{ °C}$ .
- (2)  $T_{amb} = +85\text{ °C}$ .
- (3)  $T_{amb} = -30\text{ °C}$ .

**Fig 13. Peak clamping voltage as a function of forward current; IP4387CX4**



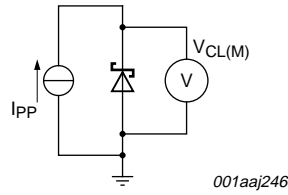
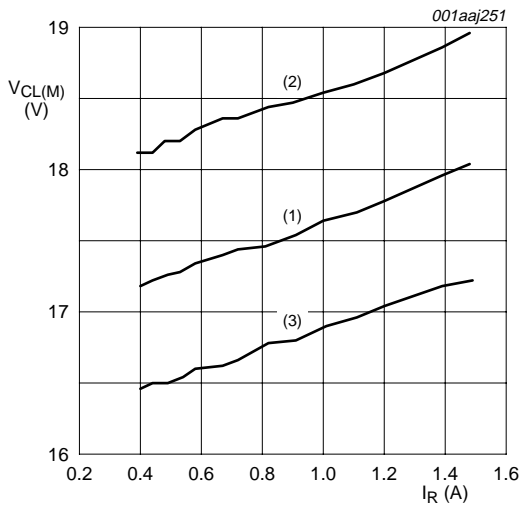
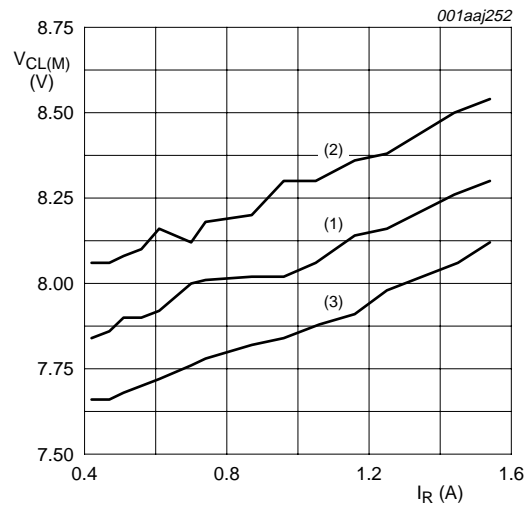


Fig 14. Measuring peak clamping voltage with reverse current



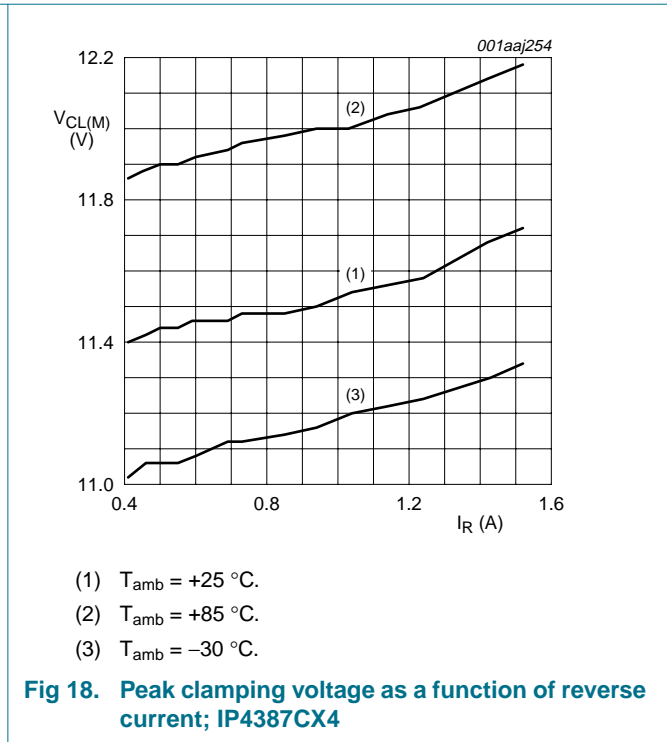
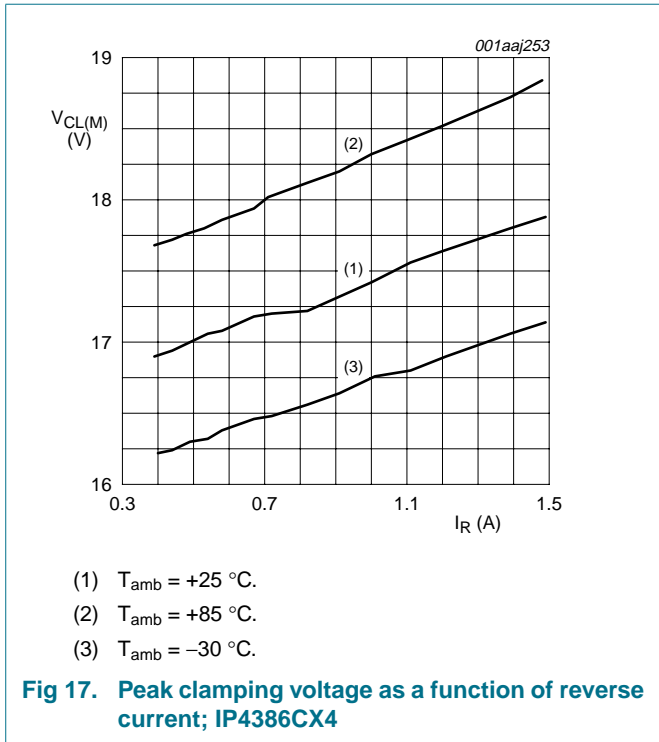
- (1)  $T_{amb} = +25\text{ }^{\circ}\text{C}$ .
- (2)  $T_{amb} = +85\text{ }^{\circ}\text{C}$ .
- (3)  $T_{amb} = -30\text{ }^{\circ}\text{C}$ .

Fig 15. Peak clamping voltage as a function of reverse current; IP4085CX4



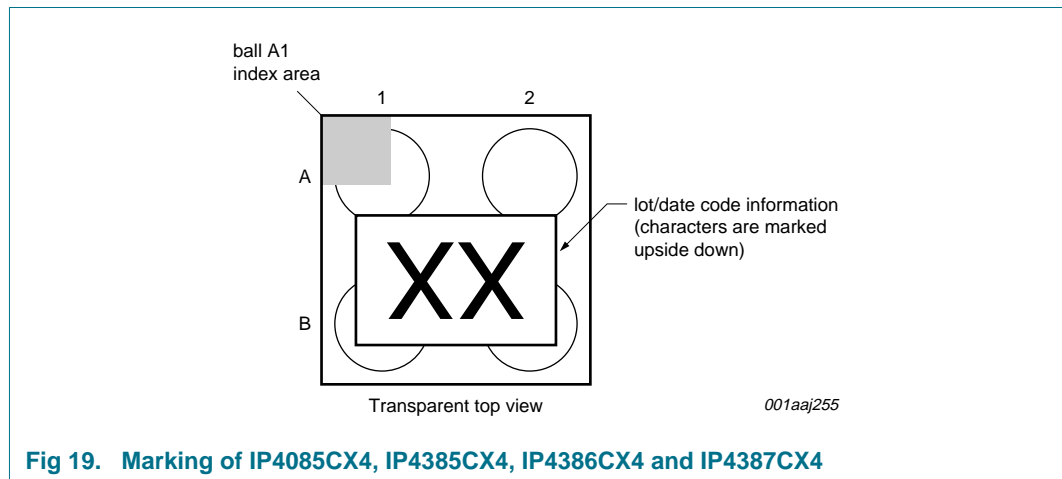
- (1)  $T_{amb} = +25\text{ }^{\circ}\text{C}$ .
- (2)  $T_{amb} = +85\text{ }^{\circ}\text{C}$ .
- (3)  $T_{amb} = -30\text{ }^{\circ}\text{C}$ .

Fig 16. Peak clamping voltage as a function of reverse current; IP4385CX4



**Remark:** Measurements done on a heat-dissipation optimized PCB with massive copper area under the DUT.

## 9. Marking



10. Package outline

WLCSP4: wafer level chip-size package; 4 bumps; 0.91 x 0.91 x 0.65 mm

IP4085CX4/LF

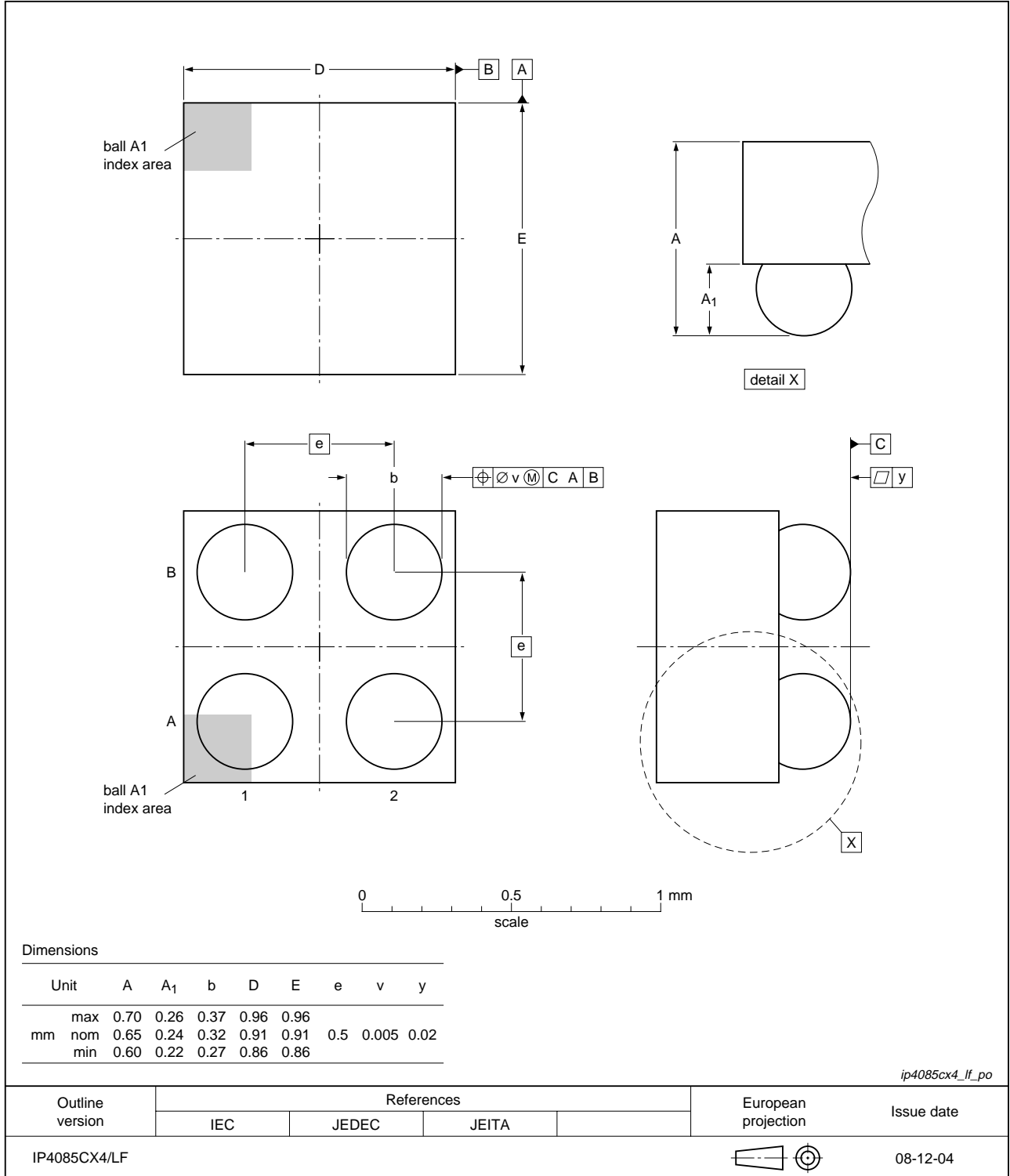


Fig 20. Package outline IP4085CX4/LF (WLCSP4)

WLCSP4: wafer level chip-size package; 4 bumps; 0.76 x 0.76 x 0.61 mm

IP438xCX4/LF

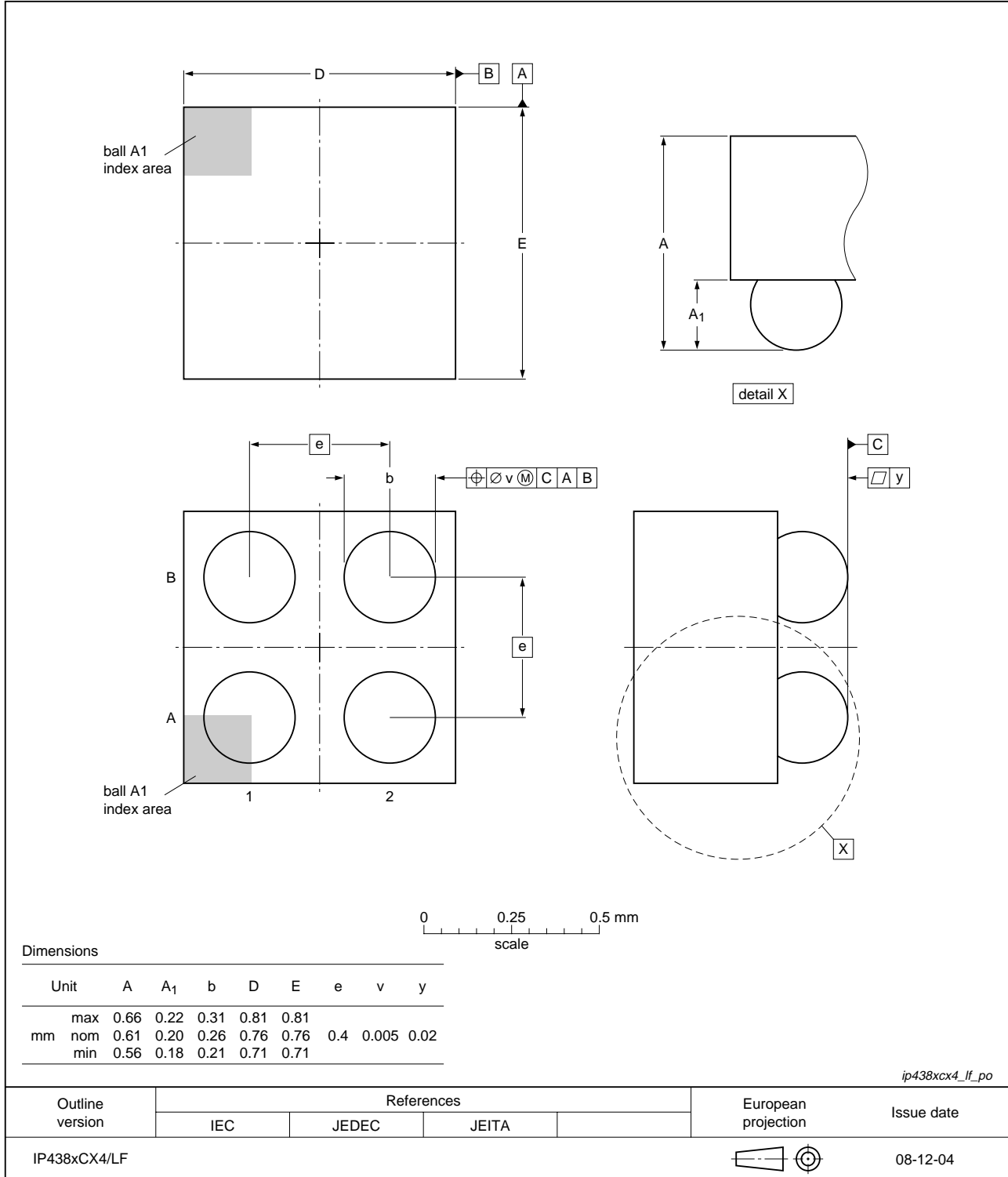


Fig 21. Package outline IP438xCX4/LF (WLCSP4)

## 11. Design and assembly recommendations

### 11.1 PCB design guidelines

For optimum performance it is recommended to use a Non-Solder Mask PCB Design (NSMD), also known as a copper-defined design, incorporating laser-drilled micro-vias connecting the ground pads to a buried ground-plane layer. This results in the lowest possible ground inductance and provides the best high frequency and ESD performance. For this case, refer to [Table 6](#) for the recommended PCB design parameters.

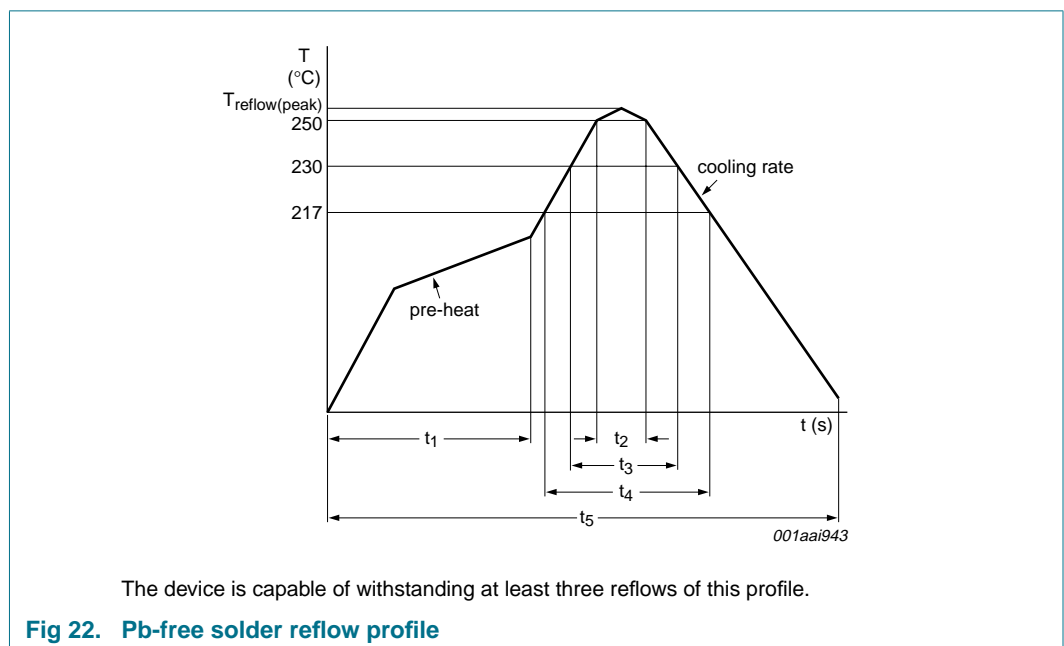
**Table 6. Recommended PCB design parameters**

Parameter	Value or Specification
PCB pad diameter	200 μm
Micro-via diameter	100 μm (0.004 inch)
Solder mask aperture diameter	370 μm
Copper thickness	20 μm to 40 μm
Copper finish	AuNi
PCB material	FR4

### 11.2 PCB assembly guidelines for Pb-free soldering

**Table 7. Assembly recommendations**

Parameter	Value or Specification
Solder screen aperture diameter	330 μm
Solder screen thickness	100 μm (0.004 inch)
Solder paste: Pb-free	SnAg (3 % to 4 %) Cu (0.5 % to 0.9 %)
Solder/flux ratio	50/50
Solder reflow profile	see <a href="#">Figure 22</a>



**Table 8. Reflow soldering process characteristics**

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$T_{\text{reflow(peak)}}$	peak reflow temperature		230	-	260	°C
$t_1$	time 1	soak time	60	-	180	s
$t_2$	time 2	time during $T \geq 250$ °C	-	-	30	s
$t_3$	time 3	time during $T \geq 230$ °C	10	-	50	s
$t_4$	time 4	time during $T > 217$ °C	30	-	150	s
$t_5$	time 5		-	-	540	s
dT/dt	rate of change of temperature	cooling rate	-	-	-6	°C/s
		pre-heat	2.5	-	4.0	°C/s

## 12. Abbreviations

**Table 9. Abbreviations**

Acronym	Description
DUT	Device Under Test
FR4	Flame Retard 4
LAN	Local Area Network
PCB	Printed-Circuit Board
PCS	Personal Communication System
RoHS	Restriction of Hazardous Substances
WAN	Wide Area Network
WLCSP	Wafer-Level Chip-Scale Package

## 13. Revision history

**Table 10. Revision history**

Document ID	Release date	Data sheet status	Change notice	Supersedes
IP4085_4385_4386_4387_CX4_1	20090326	Product data sheet	-	-

## 14. Legal information

### 14.1 Data sheet status

Document status <sup>[1][2]</sup>	Product status <sup>[3]</sup>	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL <http://www.nxp.com>.

### 14.2 Definitions

**Draft** — The document is a draft version only. The content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included herein and shall have no liability for the consequences of use of such information.

**Short data sheet** — A short data sheet is an extract from a full data sheet with the same product type number(s) and title. A short data sheet is intended for quick reference only and should not be relied upon to contain detailed and full information. For detailed and full information see the relevant full data sheet, which is available on request via the local NXP Semiconductors sales office. In case of any inconsistency or conflict with the short data sheet, the full data sheet shall prevail.

### 14.3 Disclaimers

**General** — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information.

**Right to make changes** — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

**Suitability for use** — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in medical, military, aircraft, space or life support equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental

damage. NXP Semiconductors accepts no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

**Applications** — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

**Limiting values** — Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) may cause permanent damage to the device. Limiting values are stress ratings only and operation of the device at these or any other conditions above those given in the Characteristics sections of this document is not implied. Exposure to limiting values for extended periods may affect device reliability.

**Terms and conditions of sale** — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at <http://www.nxp.com/profile/terms>, including those pertaining to warranty, intellectual property rights infringement and limitation of liability, unless explicitly otherwise agreed to in writing by NXP Semiconductors. In case of any inconsistency or conflict between information in this document and such terms and conditions, the latter will prevail.

**No offer to sell or license** — Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

**Export control** — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from national authorities.

### 14.4 Trademarks

Notice: All referenced brands, product names, service names and trademarks are the property of their respective owners.

## 15. Contact information

For more information, please visit: <http://www.nxp.com>

For sales office addresses, please send an email to: [salesaddresses@nxp.com](mailto:salesaddresses@nxp.com)

**16. Contents**

**1 Product profile . . . . . 1**

1.1 General description . . . . . 1

1.2 Features . . . . . 1

1.3 Applications . . . . . 1

**2 Pinning information . . . . . 2**

**3 Ordering information . . . . . 2**

**4 Functional diagram . . . . . 2**

**5 Limiting values . . . . . 3**

**6 Thermal characteristics . . . . . 4**

**7 Characteristics . . . . . 4**

**8 Application information . . . . . 5**

8.1 Forward current DC clamping voltage . . . . . 5

8.2 Peak clamping voltage . . . . . 7

**9 Marking . . . . . 10**

**10 Package outline . . . . . 11**

**11 Design and assembly recommendations . . . 13**

11.1 PCB design guidelines . . . . . 13

11.2 PCB assembly guidelines for Pb-free soldering . . . . . 13

**12 Abbreviations . . . . . 14**

**13 Revision history . . . . . 14**

**14 Legal information . . . . . 15**

14.1 Data sheet status . . . . . 15

14.2 Definitions . . . . . 15

14.3 Disclaimers . . . . . 15

14.4 Trademarks . . . . . 15

**15 Contact information . . . . . 15**

**16 Contents . . . . . 16**

Please be aware that important notices concerning this document and the product(s) described herein, have been included in section 'Legal information'.



© NXP B.V. 2009. **All rights reserved.**

For more information, please visit: <http://www.nxp.com>  
 For sales office addresses, please send an email to: [salesaddresses@nxp.com](mailto:salesaddresses@nxp.com)

Date of release: 26 March 2009

Document identifier: IP4085\_4385\_4386\_4387\_CX4\_1