

# IP4085CX4; IP4385CX4; IP4386CX4; IP4387CX4

Integrated high-performance ESD protection diodes

Rev. 2 — 14 December 2012

Product data sheet

## 1. Product profile

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### 1.1 General description

Integrated high-performance protection diodes protecting appliances against ElectroStatic Discharge (ESD) of  $\pm 30$  kV, far exceeding IEC 61000-4-2 level 4 standard, overvoltage and wrong polarity.

Each device includes one high-level ESD protection diode in a 4-channel 0.4 mm (IP438xCX4) or 0.5 mm (IP4085CX4) pitch Wafer Level Chip-Size Package (WLCSP). The anode and the cathode of ESD protection diode are each connected to two solder balls.

### 1.2 Features and benefits

- 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, level 4
- Small  $2 \times 2$  solder ball WLCSP package with 0.4 mm or 0.5 mm pitch

### 1.3 Applications

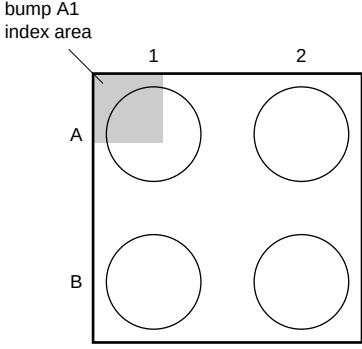
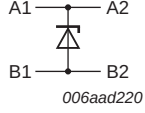
General-purpose ESD protection such as for charger interfaces in:

- Mobile handsets
- Portable devices
- Wireless data systems



## 2. Pinning information

Table 1. Pinning

| Pin       | Description | Simplified outline                                                                                                                                            | Graphic symbol                                                                                       |
|-----------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| A1 and A2 | cathode     |  <p>008aaa236</p> <p>transparent top view,<br/>solder balls facing down</p> |  <p>006aad220</p> |
| B1 and B2 | anode       |                                                                                                                                                               |                                                                                                      |

## 3. Ordering information

Table 2. Ordering information

| Type number    | Package |                                                                    |                |
|----------------|---------|--------------------------------------------------------------------|----------------|
|                | Name    | Description                                                        | Version        |
| IP4085CX4/LF/P | WLCSP4  | wafer level chip-size package: 4 bumps (2 × 2) <a href="#">[1]</a> | IP4085CX4/LF/P |
| IP4385CX4/LF   |         | wafer level chip-size package: 4 bumps (2 × 2) <a href="#">[2]</a> | IP4385CX4/LF   |
| IP4386CX4/P    |         |                                                                    | IP4386CX4/P    |
| IP4387CX4/P    |         |                                                                    | IP4387CX4/P    |

[1] Size: 0.91 × 0.91 × 0.65 mm

[2] Size: 0.76 × 0.76 × 0.61 mm

## 4. Limiting values

**Table 3. Limiting values**

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

| Symbol                    | Parameter                           | Conditions                                       | Min                     | Max  | Unit |
|---------------------------|-------------------------------------|--------------------------------------------------|-------------------------|------|------|
| V <sub>RWM</sub>          | reverse standoff voltage            | IP4085CX4; IP4386CX4                             | −0.5                    | +14  | V    |
|                           |                                     | IP4385CX4                                        | −0.5                    | +5.5 | V    |
|                           |                                     | IP4387CX4                                        | −0.5                    | +8.0 | V    |
| V <sub>ESD</sub>          | electrostatic discharge voltage     | all pins to ground                               |                         |      |      |
|                           |                                     | contact discharge                                | <a href="#">[1]</a> −30 | +30  | kV   |
|                           |                                     | air discharge                                    | <a href="#">[1]</a> −15 | +15  | kV   |
|                           |                                     | IEC 61000-4-2, level 4;<br>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;<br>t <sub>p</sub> = 2 ms   | 10                      | -    | A    |
|                           |                                     | IP4085CX4; IP4386CX4;<br>t <sub>p</sub> = 5 ms   | 8.5                     | -    | A    |
|                           |                                     | IP4085CX4; IP4386CX4;<br>t <sub>p</sub> = 100 ms | 3.5                     | -    | A    |
|                           |                                     | IP4385CX4; IP4387CX4;<br>t <sub>p</sub> = 2 ms   | 11                      | -    | A    |
|                           |                                     | IP4385CX4; IP4387CX4;<br>t <sub>p</sub> = 5 ms   | 9                       | -    | A    |
|                           |                                     | IP4385CX4; IP4387CX4;<br>t <sub>p</sub> = 100 ms | 5                       | -    | A    |
| P <sub>tot</sub>          | total power dissipation             | forward conducting                               | <a href="#">[2]</a>     |      |      |
|                           |                                     | IP4085CX4                                        | <a href="#">[3]</a> -   | 1    | W    |
|                           |                                     | IP4385CX4; IP4386CX4;<br>IP4387CX4               | <a href="#">[3]</a> -   | 0.7  | W    |
| T <sub>stg</sub>          | storage temperature                 |                                                  | −55                     | +150 | °C   |
| T <sub>reflow(peak)</sub> | peak reflow temperature             | t <sub>p</sub> ≤ 10 s                            | -                       | 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 Printed-Circuit Board (PCB) to prevent the device from de-soldering. For ambient temperature 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.

## 5. Thermal characteristics

**Table 4. Thermal characteristics**

| Symbol        | Parameter                                   | Conditions       | Typ     | Unit |
|---------------|---------------------------------------------|------------------|---------|------|
| $R_{th(j-a)}$ | thermal resistance from junction to ambient | on a 2-layer PCB | [1] 130 | K/W  |

[1] Depends on details of PCB layout.

## 6. Characteristics

**Table 5. Electrical characteristics**

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

| Symbol   | Parameter               | Conditions                                                                                       | Min   | Typ | Max  | Unit |
|----------|-------------------------|--------------------------------------------------------------------------------------------------|-------|-----|------|------|
| $V_{BR}$ | breakdown voltage       | $I_R = 15\text{ mA}$                                                                             |       |     |      |      |
|          |                         | IP4085CX4; IP4386CX4                                                                             | 16    | -   | -    | V    |
|          |                         | IP4385CX4                                                                                        | 7.0   | -   | -    | V    |
|          |                         | IP4387CX4                                                                                        | 10    | -   | -    | V    |
| $V_{CL}$ | clamping voltage        | $I_R = 1\text{ A}$ ; $T_{amb} \leq 85\text{ °C}$ at surge peak pulse, according to IEC 61000-4-5 |       |     |      |      |
|          |                         | IP4085CX4                                                                                        | -     | -   | 20   | V    |
|          |                         | IP4385CX4                                                                                        | -     | -   | 10   | V    |
|          |                         | IP4386CX4                                                                                        | -     | -   | 20   | V    |
| $I_{RM}$ | reverse leakage current | IP4387CX4                                                                                        | -     | -   | 13   | V    |
|          |                         | IP4085CX4; IP4385CX4<br>$V_R = +5\text{ V}$                                                      | -     | -   | 200  | nA   |
|          |                         | IP4386CX4; $V_R = +14\text{ V}$                                                                  | -     | -   | 200  | nA   |
|          |                         | IP4387CX4; $V_R = +8\text{ V}$                                                                   | -     | -   | 800  | nA   |
| $C_d$    | diode capacitance       | $V_R = 0\text{ V}$ ; $f = 1\text{ MHz}$                                                          |       |     |      |      |
|          |                         | IP4085CX4                                                                                        | -     | 180 | -    | pF   |
|          |                         | IP4385CX4                                                                                        | -     | 450 | -    | pF   |
|          |                         | IP4386CX4                                                                                        | -     | 160 | -    | pF   |
| $V_F$    | forward voltage         | IP4387CX4                                                                                        | -     | 290 | -    | pF   |
|          |                         | $I_F = 850\text{ mA}$                                                                            |       |     |      |      |
|          |                         | IP4085CX4                                                                                        | [1] - | -   | 1.15 | V    |
|          |                         |                                                                                                  | [2] - | -   | 1.3  | V    |
|          |                         | IP4385CX4                                                                                        | [1] - | -   | 1.0  | V    |
|          |                         |                                                                                                  | [2] - | -   | 1.1  | V    |
|          |                         | IP4386CX4                                                                                        | [1] - | -   | 1.15 | V    |
|          |                         |                                                                                                  | [2] - | -   | 1.3  | V    |
|          |                         | IP4387CX4                                                                                        | [1] - | -   | 1.10 | V    |
|          |                         |                                                                                                  | [2] - | -   | 1.25 | V    |

[1]  $T_{amb} \geq +25\text{ °C}$

[2]  $-30\text{ °C} \leq T_{amb} \leq +85\text{ °C}$

## 7. Application information

### 7.1 Forward current DC clamping voltage

The forward current DC clamping voltage is an indicator of protection level of circuit from voltage sources with the wrong polarity. [Figure 1](#) shows basic measurement setup.

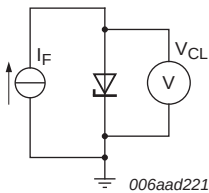
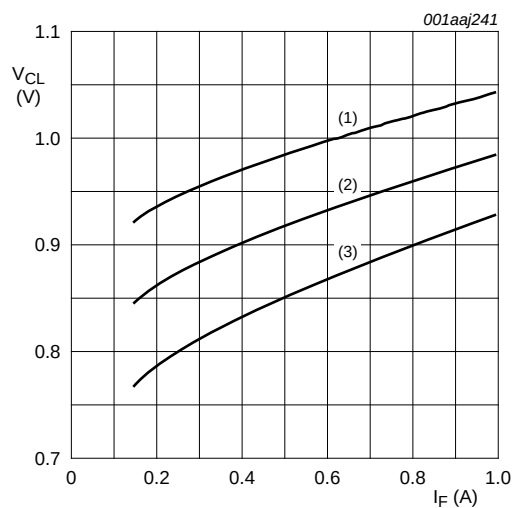
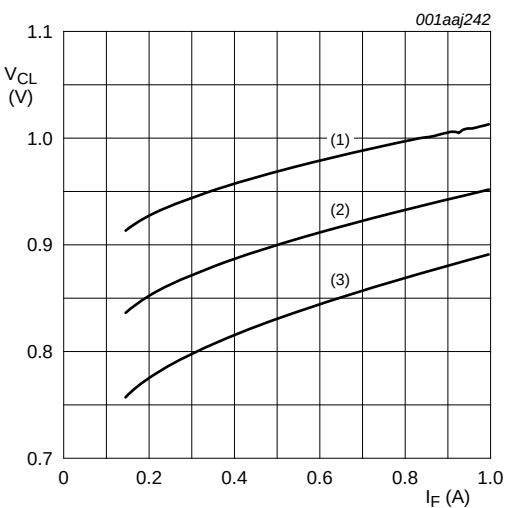


Fig 1. Measuring DC clamping voltage with forward current



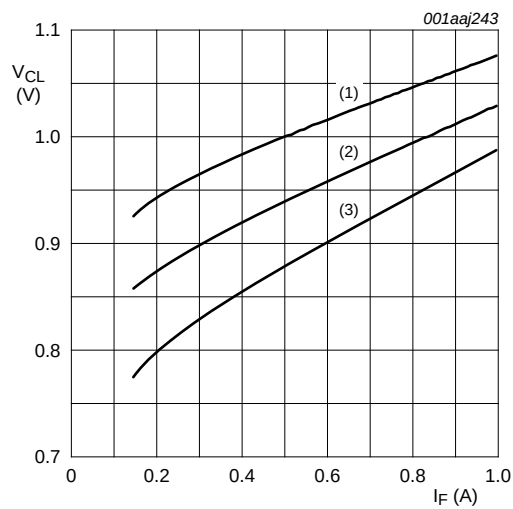
- (1)  $T_{amb} = +25\text{ }^{\circ}\text{C}$
- (2)  $T_{amb} = +85\text{ }^{\circ}\text{C}$
- (3)  $T_{amb} = -30\text{ }^{\circ}\text{C}$

Fig 2. IP4085CX4: DC clamping voltage as a function of forward current



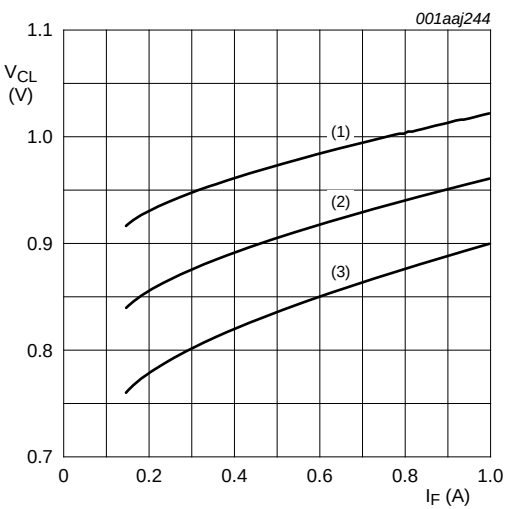
- (1)  $T_{amb} = +25\text{ }^{\circ}\text{C}$
- (2)  $T_{amb} = +85\text{ }^{\circ}\text{C}$
- (3)  $T_{amb} = -30\text{ }^{\circ}\text{C}$

Fig 3. IP4385CX4: DC clamping voltage as a function of forward 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 4. IP4386CX4: DC clamping voltage as a function of forward current

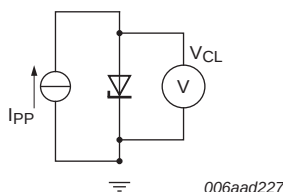


- (1)  $T_{amb} = +25\text{ }^{\circ}\text{C}$
- (2)  $T_{amb} = +85\text{ }^{\circ}\text{C}$
- (3)  $T_{amb} = -30\text{ }^{\circ}\text{C}$

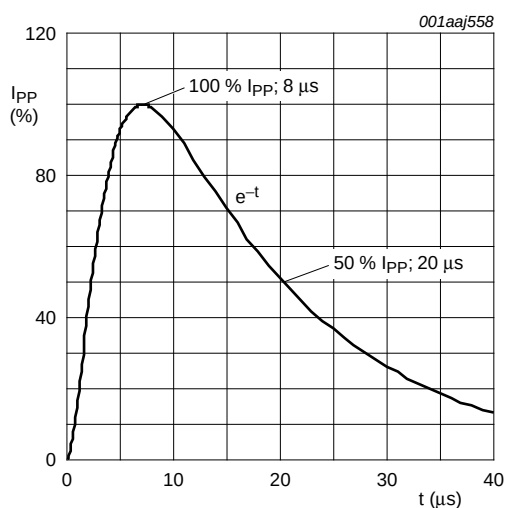
Fig 5. IP4387CX4: DC clamping voltage as a function of forward current

## 7.2 Peak clamping voltage

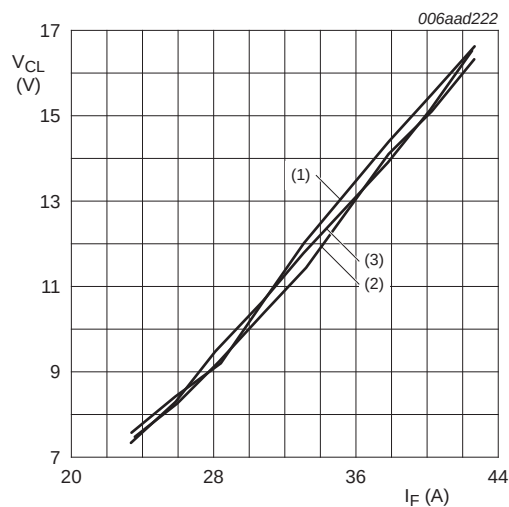
The peak clamping voltage for forward and reverse current pulses of 8/20  $\mu\text{s}$  (IEC 61000-4-5) is an indicator of protection level of circuits from power surges due to voltage discharges. The current pulse shape over time is shown in [Figure 7](#). The basic measurement setup for forward current and reverse current pulses respectively are shown in [Figure 6](#) and [Figure 12](#).



**Fig 6. Measuring peak clamping voltage with forward current**

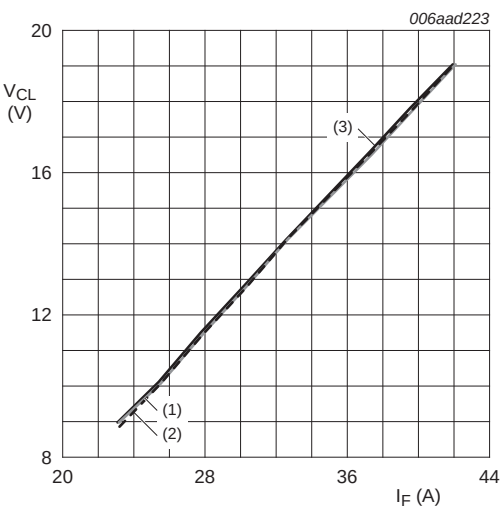


**Fig 7. 8/20  $\mu\text{s}$  current pulse waveform according to IEC 61000-4-5**



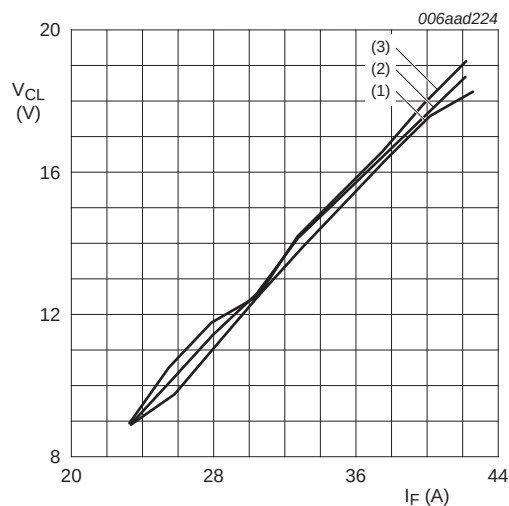
- (1)  $T_{amb} = +25\text{ }^{\circ}\text{C}$
- (2)  $T_{amb} = +85\text{ }^{\circ}\text{C}$
- (3)  $T_{amb} = -30\text{ }^{\circ}\text{C}$

Fig 8. IP4085CX4: peak clamping voltage as a function of forward current



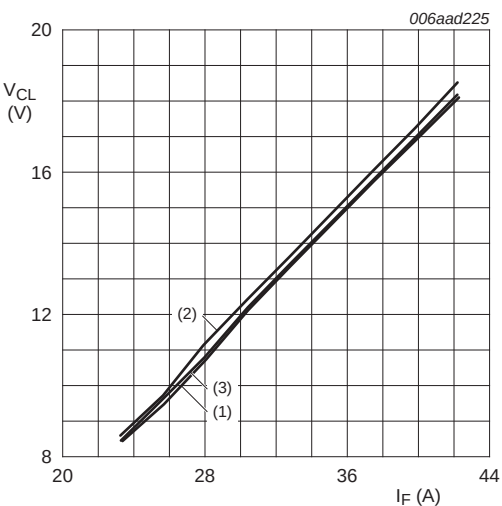
- (1)  $T_{amb} = +25\text{ }^{\circ}\text{C}$
- (2)  $T_{amb} = +85\text{ }^{\circ}\text{C}$
- (3)  $T_{amb} = -30\text{ }^{\circ}\text{C}$

Fig 9. IP4385CX4: peak clamping voltage as a function of forward 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 10. IP4386CX4: peak clamping voltage as a function of forward 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 11. IP4387CX4: peak clamping voltage as a function of forward current



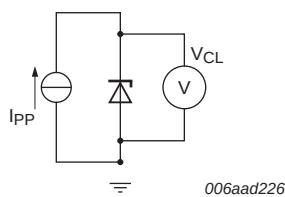
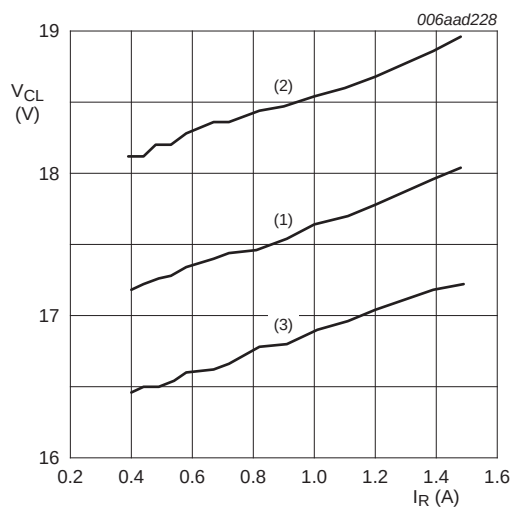
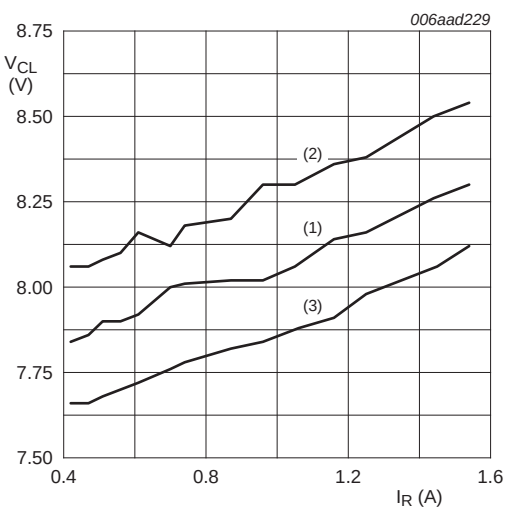


Fig 12. Measuring peak clamping voltage with reverse current



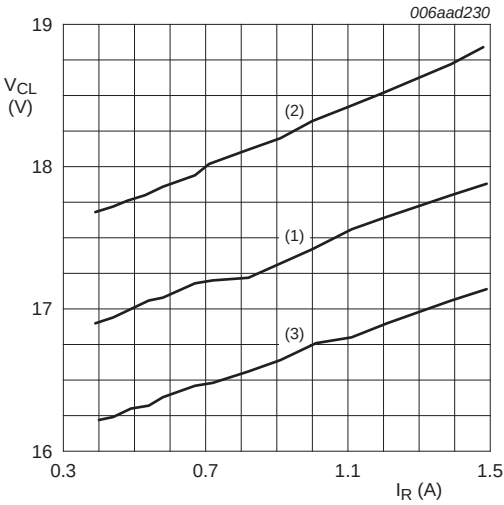
- (1)  $T_{amb} = +25\text{ °C}$
- (2)  $T_{amb} = +85\text{ °C}$
- (3)  $T_{amb} = -30\text{ °C}$

Fig 13. IP4085CX4: peak clamping voltage as a function of reverse current



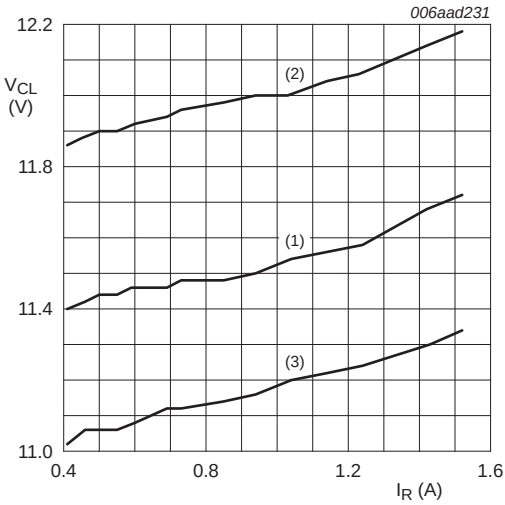
- (1)  $T_{amb} = +25\text{ °C}$
- (2)  $T_{amb} = +85\text{ °C}$
- (3)  $T_{amb} = -30\text{ °C}$

Fig 14. IP4385CX4: peak clamping voltage as a function of 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. IP4386CX4: peak clamping voltage as a function of 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 16. IP4387CX4: peak clamping voltage as a function of reverse current

Measurements are done on a heat-dissipation optimized PCB with massive copper area under the Device Under Test (DUT).



Table 7. Package outline dimensions of IP438xCX4 (WLCSP4)

| Symbol         | Min  | Typ  | Max  | Unit |
|----------------|------|------|------|------|
| A              | 0.56 | 0.61 | 0.66 | mm   |
| A <sub>1</sub> | 0.18 | 0.20 | 0.22 | mm   |
| A <sub>2</sub> | 0.38 | 0.41 | 0.44 | mm   |
| b              | 0.21 | 0.26 | 0.31 | mm   |
| D              | 0.71 | 0.76 | 0.76 | mm   |
| E              | 0.71 | 0.76 | 0.81 | mm   |
| e              | 0.4  | 0.4  | 0.4  | mm   |

## 9. Design and assembly recommendations

### 9.1 PCB design guidelines

For optimum performance, use a Non-Solder Mask Defined (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. Refer to [Table 8](#) for the recommended PCB design parameters.

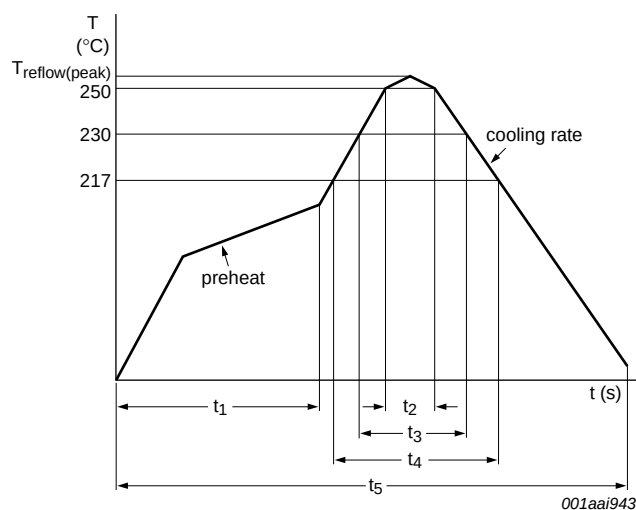
Table 8. Recommended PCB design parameters

| 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                    |

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

Table 9. 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 to flux ratio            | 50 : 50                               |
| Solder reflow profile           | see <a href="#">Figure 18</a>         |



The device is capable of withstanding at least three reflows of this profile.

**Fig 18. Pb-free solder reflow profile**

**Table 10. Reflow soldering process characteristics**

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

## 10. Soldering

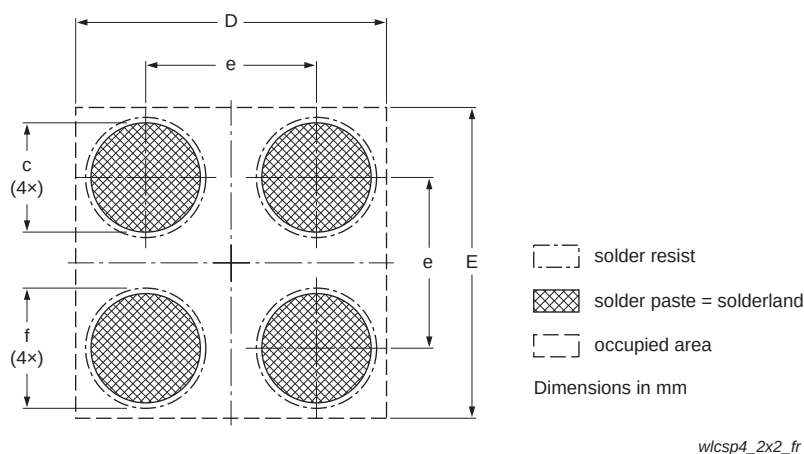


Fig 19. Reflow soldering footprint WLCSP4

Table 11. Soldering dimensions of IP4085CX4 (WLCSP4)

| Symbol | Min  | Typ   | Max  | Unit |
|--------|------|-------|------|------|
| c      | -    | 0.31  | -    | mm   |
| D      | 0.86 | 0.91  | 0.96 | mm   |
| E      | 0.86 | 0.91  | 0.96 | mm   |
| e      | -    | 0.5   | -    | mm   |
| f      | -    | 0.385 | -    | mm   |

Table 12. Soldering dimensions of IP438xCX4 (WLCSP4)

| Symbol | Min  | Typ   | Max  | Unit |
|--------|------|-------|------|------|
| c      | -    | 0.25  | -    | mm   |
| D      | 0.71 | 0.76  | 0.81 | mm   |
| E      | 0.71 | 0.76  | 0.81 | mm   |
| e      | -    | 0.4   | -    | mm   |
| f      | -    | 0.325 | -    | mm   |

## 11. Revision history

**Table 13. Revision history**

| Document ID                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Release date | Data sheet status  | Change notice | Supersedes                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------------|---------------|-------------------------------|
| IP4085_4385_4386_4387_CX4 v.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 20121214     | Product data sheet | -             | IP4085_4385_4386_4387_CX4 v.1 |
| Modifications:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |              |                    |               |                               |
| <ul style="list-style-type: none"><li>• Basic type IP4085CX4/LF removed</li><li>• <a href="#">Section 1 "Product profile"</a>: updated</li><li>• <a href="#">Section 2 "Pinning information"</a>: updated</li><li>• Functional diagram: removed</li><li>• <a href="#">Table 3 "Limiting values"</a>: updated</li><li>• <a href="#">Table 5 "Electrical characteristics"</a>: updated</li><li>• <a href="#">Section 7 "Application information"</a>: updated</li><li>• <a href="#">Figure 1, 6, 8 to 16</a>: updated</li><li>• Marking: removed</li><li>• <a href="#">Section 8 "Package outline"</a>: updated</li><li>• <a href="#">Section 10 "Soldering"</a>: added</li><li>• <a href="#">Section 12 "Legal information"</a>: updated</li></ul> |              |                    |               |                               |
| IP4085_4385_4386_4387_CX4 v.1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 20090326     | Product data sheet | -             | -                             |

## 12. Legal information

### 12.1 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>.

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