

# X3G-OH047; X3T-OH047; X3G-OH048; X3T-OH048

## Magnetic field sensor

Rev. 1 — 4 April 2011

Product specification

## 1. Product profile

### 1.1 General description

The X3G-OH047, X3G-OH048, X3T-OH047 and X3T-OH048 are sensitive magnetic field sensors, employing the magneto-resistive effect of thin film permalloy. The sensors contain two parallel supplied Wheatstone bridges at a relative angle of 45° to each other.

A rotating magnetic field in the surface parallel to the chip (x-y plane) will deliver two independent sinusoidal output signals, one following a  $\cos(2\alpha)$  and the other following a  $\sin(2\alpha)$  function,  $\alpha$  being the angle between sensor and field direction (see [Figure 5](#) and [Figure 6](#)).

The X3G-OH047, X3G-OH048, X3T-OH047 and X3T-OH048 are suited for high precision angle measurement applications under low field conditions (saturation field strength 25 kA/m).

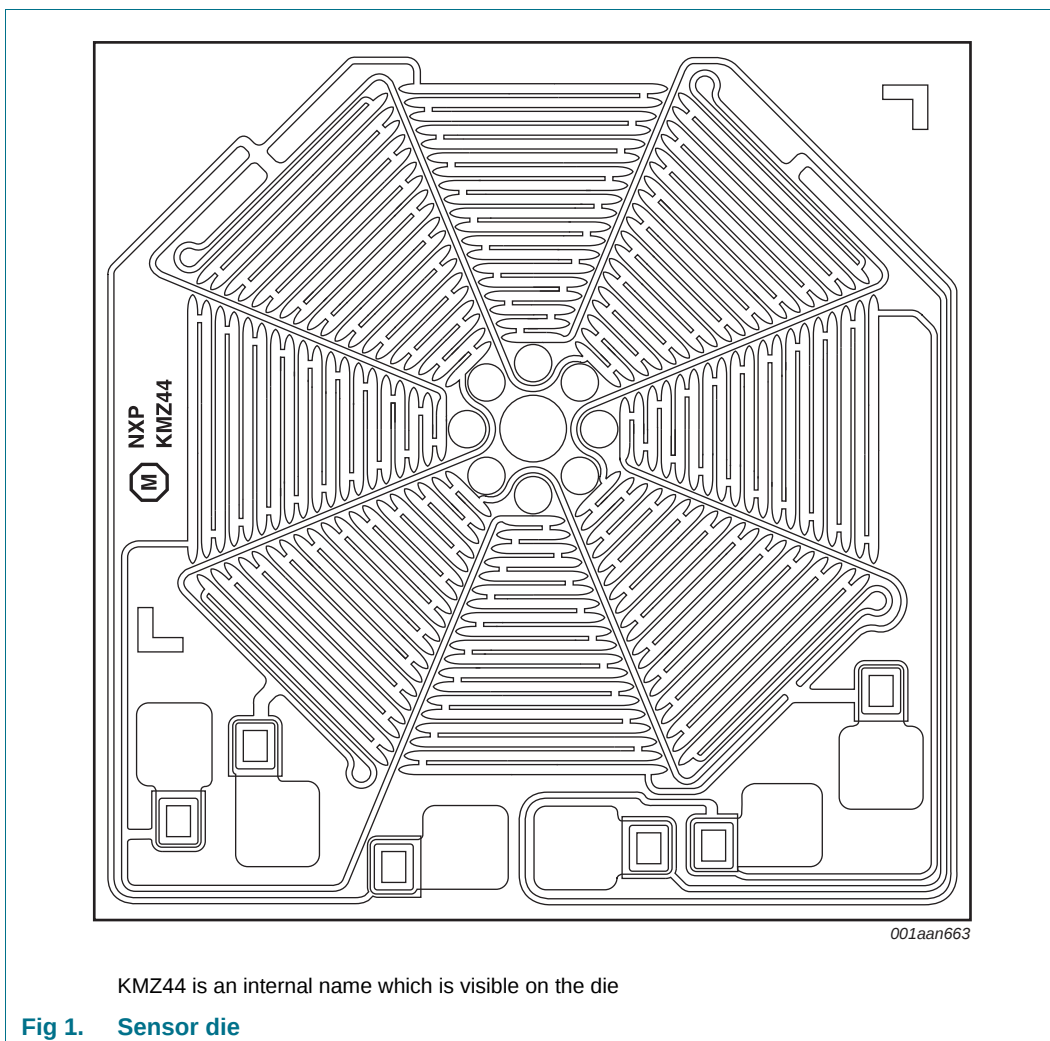
The sensors can be operated at any frequency between DC and 1 MHz.

All type numbers shown in this data sheet are valid for a single-die (single sensor). The double-die has two magnetic field sensors with electrical and magnetic parameters which fulfill the specified single-die values and do not correlate to each other.

**Table 1. Product overview**

| Type number | Sensor     | Packing             |
|-------------|------------|---------------------|
| X3G-OH047   | double-die | sawn wafer; on foil |
| X3G-OH048   | single-die | sawn wafer; on foil |
| X3T-OH047   | double-die | taped on reel       |
| X3T-OH048   | single-die | taped on reel       |





## 1.2 Features and benefits

- Accurate and reliable angle measurement
- Mechanical robustness, contactless principle
- Wear-free operation
- Accuracy independent of mechanical tolerances
- Extended temperature range

## 1.3 Applications

- |                              |                      |
|------------------------------|----------------------|
| ■ Steering angle and torsion | ■ Window wipers      |
| ■ Headlight adjustment       | ■ Fuel level         |
| ■ Motor positioning          | ■ Mirror positioning |

## 1.4 Quick reference data

**Table 2. Quick reference data**

$T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $H_{ext} = 25\text{ kA/m}$ ;  $V_{CC} = 5\text{ V}$ ; unless otherwise specified.

| Symbol           | Parameter                                    | Conditions                                                                                                                         | Min                                         | Typ | Max | Unit                  |
|------------------|----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|-----|-----|-----------------------|
| $V_{CC}$         | supply voltage                               |                                                                                                                                    | -                                           | 5   | 9   | V                     |
| $V_M$            | peak voltage                                 | see <a href="#">Figure 3</a>                                                                                                       | <a href="#">[1]</a> <a href="#">[2]</a> 60  | 67  | 75  | mV                    |
| $V_{offset}$     | offset voltage                               | per supply voltage;<br>see <a href="#">Figure 3</a>                                                                                | <a href="#">[1]</a> -2                      | -   | +2  | mV/V                  |
| $TC_{V(offset)}$ | offset voltage<br>temperature<br>coefficient | per supply voltage;<br>$T_{amb} = -40\text{ }^{\circ}\text{C}$ to $+150\text{ }^{\circ}\text{C}$ ;<br>see <a href="#">Figure 3</a> | <a href="#">[1]</a> <a href="#">[3]</a> -2  | -   | +2  | ( $\mu\text{V/V/K}$ ) |
| $R_{bridge}$     | bridge resistance                            |                                                                                                                                    | <a href="#">[1]</a> <a href="#">[4]</a> 2.7 | 3.2 | 3.7 | k $\Omega$            |

[1] Applicable for bridge 1 and bridge 2.

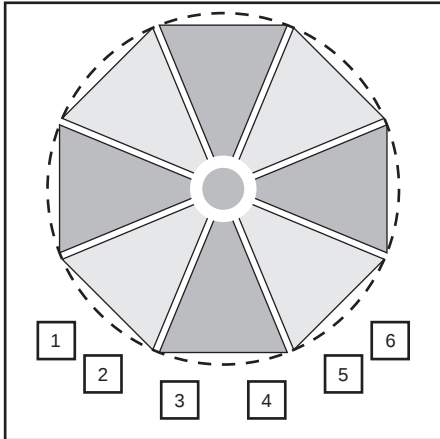
[2]  $V_M = |V_{O(max)} - V_{offset}|$ . Periodicity of  $V_M$ :  $\sin(2\alpha)$  and  $\cos(2\alpha)$ , respectively.

[3]  $TC_{V(offset)} = \frac{V_{offset}(at\ 150\text{ }^{\circ}\text{C}) - V_{offset}(at\ -40\text{ }^{\circ}\text{C})}{150\text{ }^{\circ}\text{C} - (-40\text{ }^{\circ}\text{C})}$

[4] Bridge resistance between pad 5 to pad 1 and pad 4 to pad 2.

## 2. Pinning information

**Table 3. Pinning**

| Pad | Symbol   | Description                  | Simplified outline                                                                   |
|-----|----------|------------------------------|--------------------------------------------------------------------------------------|
| 1   | ON1      | output voltage bridge 1      |  |
| 2   | ON2      | output voltage bridge 2      |                                                                                      |
| 3   | GND      | common ground                |                                                                                      |
| 4   | OP2      | output voltage bridge 2      |                                                                                      |
| 5   | OP1      | output voltage bridge 1      |                                                                                      |
| 6   | $V_{CC}$ | common bridge supply voltage |                                                                                      |

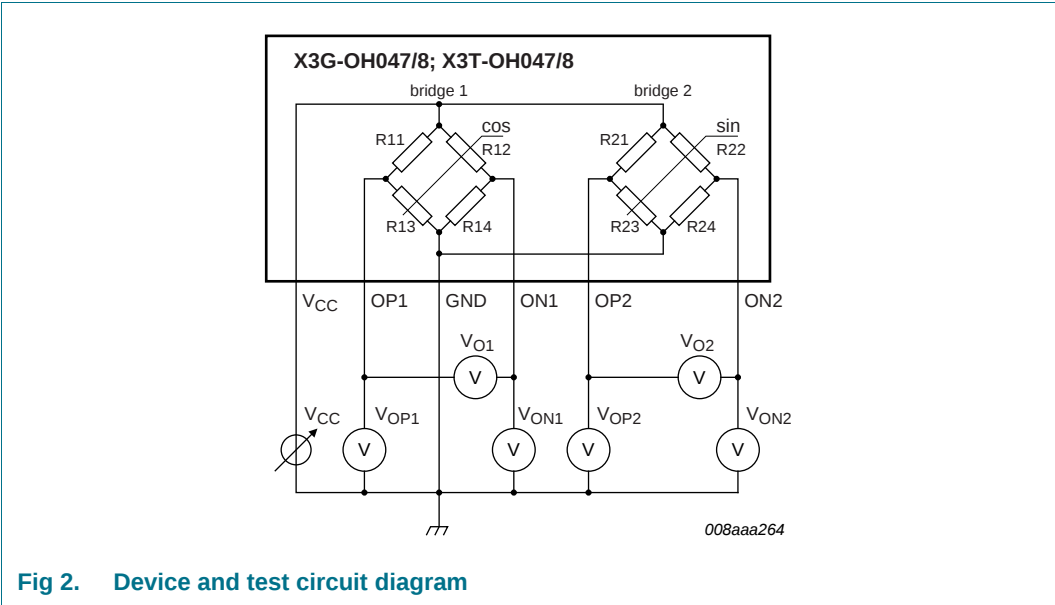
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3. Ordering information

Table 4. Ordering information

| Type number | Package  |                                 |              |
|-------------|----------|---------------------------------|--------------|
|             | Name     | Description                     | Version      |
| X3G-OH047   | bare die | double-die; sawn wafer; on foil | OL-X3G-OH047 |
| X3G-OH048   | bare die | single-die; sawn wafer; on foil | OL-X3G-OH048 |
| X3T-OH047   | bare die | double-die; taped on reel       | OL-X3T-OH047 |
| X3T-OH048   | bare die | single-die; taped on reel       | OL-X3T-OH048 |

4. Circuit diagram



5. Limiting values

Table 5. Limiting values

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

| Symbol           | Parameter                        | Conditions | Min | Max  | Unit |
|------------------|----------------------------------|------------|-----|------|------|
| V <sub>CC</sub>  | supply voltage                   |            | -   | 9    | V    |
| H <sub>ext</sub> | external magnetic field strength | [1]        | 25  | -    | kA/m |
| T <sub>amb</sub> | ambient temperature              |            | -40 | +150 | °C   |

[1] Minimum stimulating magnetic field parallel to the chip surface (x-y plane) to achieve specified angular accuracy.

## 6. Characteristics

**Table 6. Characteristics**

$T_{amb} = 25\text{ °C}$ ;  $H_{ext} = 25\text{ kA/m}$ <sup>[1]</sup>;  $V_{CC} = 5\text{ V}$ ; unless otherwise specified.

| Symbol           | Parameter                                     | Conditions                                                                                     | Min                          | Typ   | Max   | Unit     |
|------------------|-----------------------------------------------|------------------------------------------------------------------------------------------------|------------------------------|-------|-------|----------|
| $V_{CC}$         | supply voltage                                |                                                                                                | -                            | 5     | 9     | V        |
| $V_M$            | peak voltage                                  | see <a href="#">Figure 3</a>                                                                   | <a href="#">[2][3]</a> 60    | 67    | 75    | mV       |
| $TC_{VM}$        | peak voltage temperature coefficient          | $T_{amb} = -40\text{ °C to }+150\text{ °C}$                                                    | <a href="#">[2][4]</a> -0.30 | -0.36 | -0.42 | %/K      |
| $R_{bridge}$     | bridge resistance                             |                                                                                                | <a href="#">[2][5]</a> 2.7   | 3.2   | 3.7   | kΩ       |
| $TC_{R(bridge)}$ | bridge resistance temperature coefficient     | $T_{amb} = -40\text{ °C to }+150\text{ °C}$                                                    | <a href="#">[2][6]</a> 0.24  | 0.27  | 0.29  | %/K      |
| $V_{offset}$     | offset voltage                                | per supply voltage; see <a href="#">Figure 3</a>                                               | <a href="#">[2]</a> -2       | -     | +2    | mV/V     |
| $TC_{V(offset)}$ | offset voltage temperature coefficient        | per supply voltage; $T_{amb} = -40\text{ °C to }+150\text{ °C}$ ; see <a href="#">Figure 3</a> | <a href="#">[2][7]</a> -2    | -     | +2    | (μV/V)/K |
| $V_{o(hys)}$     | hysteresis output voltage                     | see <a href="#">Figure 4</a>                                                                   | <a href="#">[2][8]</a> 0     | 0.05  | 0.18  | %FS      |
| $\omega$         | angular velocity                              |                                                                                                | 0                            | -     | 1     | MHz      |
| $k$              | amplitude synchronism                         |                                                                                                | <a href="#">[9]</a> 98.9     | 100   | 101.1 | %        |
| $TC_k$           | amplitude synchronism temperature coefficient | $T_{amb} = -40\text{ °C to }+150\text{ °C}$                                                    | <a href="#">[10]</a> -0.01   | 0     | +0.01 | %/K      |
| $\Delta\alpha$   | angular inaccuracy                            |                                                                                                | <a href="#">[11]</a> 0       | 0.05  | 0.1   | deg      |

[1] Minimum stimulating magnetic field parallel to the chip surface (x-y plane) to achieve angular inaccuracy.

[2] Applicable for bridge 1 and bridge 2.

[3]  $V_M = |V_{O(max)} - V_{offset}|$ . Periodicity of  $V_M$ :  $\sin(2\alpha)$  and  $\cos(2\alpha)$ , respectively.

$$[4] \quad TC_{VM} = \frac{V_M(at\ 150\text{ °C}) - V_M(at\ -40\text{ °C})}{V_M(at\ 25\text{ °C}) \times (150\text{ °C} - (-40\text{ °C}))}$$

[5] Bridge resistance between pad 5 to pad 1 and pad 4 to pad 2.

$$[6] \quad TC_{R(bridge)} = \frac{R_{bridge}(at\ 150\text{ °C}) - R_{bridge}(at\ -40\text{ °C})}{R_{bridge}(at\ 25\text{ °C}) \times (150\text{ °C} - (-40\text{ °C}))}$$

$$[7] \quad TC_{V(offset)} = \frac{V_{offset}(at\ 150\text{ °C}) - V_{offset}(at\ -40\text{ °C})}{150\text{ °C} - (-40\text{ °C})}$$

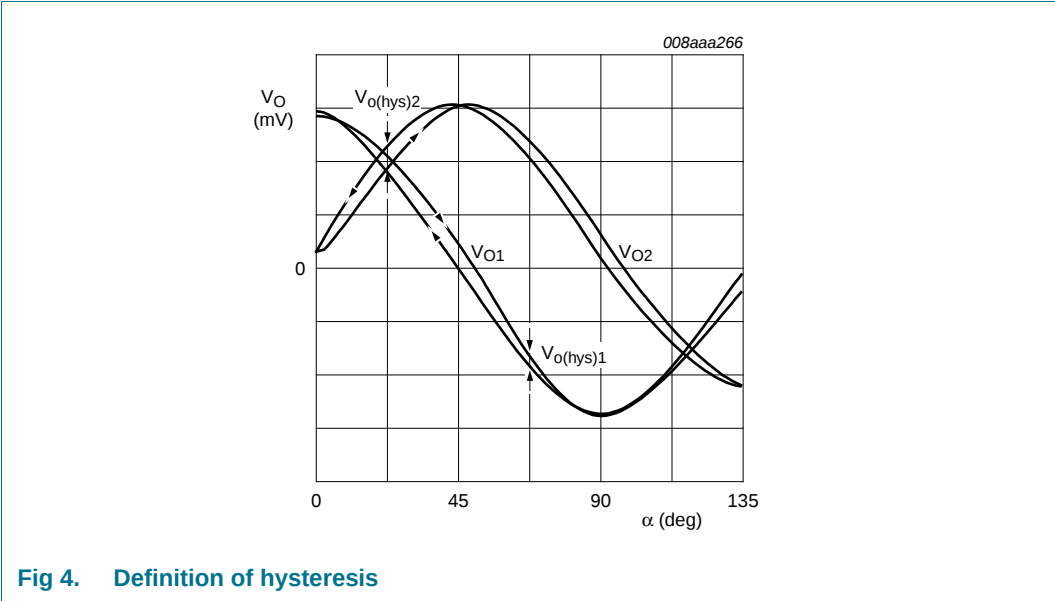
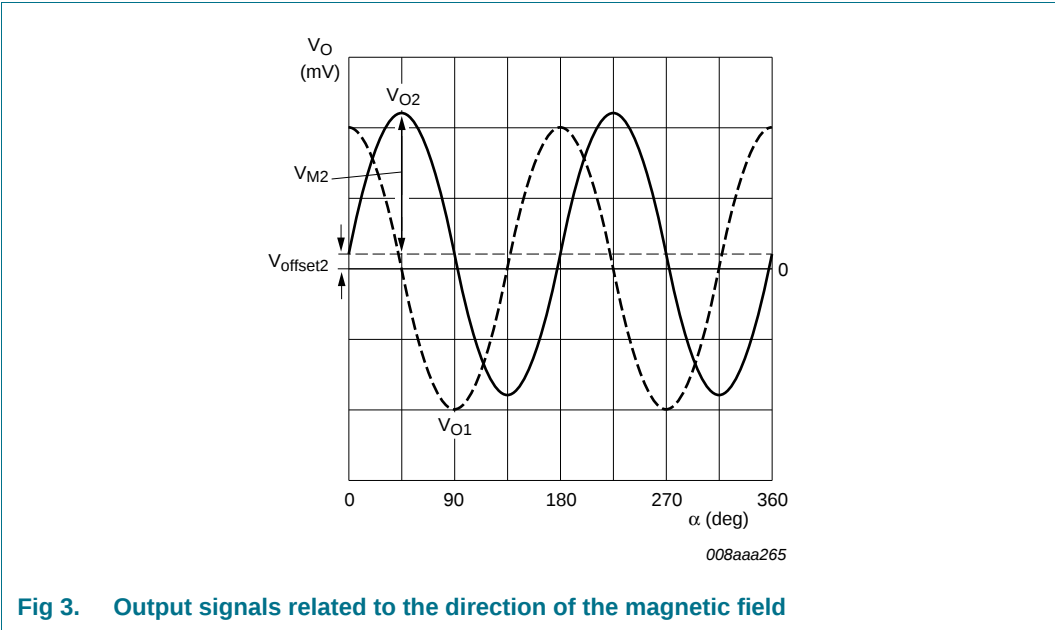
$$[8] \quad V_{o(hys)1} = \left| \frac{V_{O1}(67.5^\circ)135^\circ \rightarrow 45^\circ - V_{O1}(67.5^\circ)45^\circ \rightarrow 135^\circ}{2 \times V_{M1}} \right|$$

$$V_{o(hys)2} = \left| \frac{V_{O2}(22.5^\circ)90^\circ \rightarrow 0^\circ - V_{O2}(22.5^\circ)0^\circ \rightarrow 90^\circ}{2 \times V_{M2}} \right|$$

$$[9] \quad k = \frac{V_{M1}}{V_{M2}}$$

$$[10] \quad TC_k = \frac{k(at\ 150\text{ °C}) - k(at\ -40\text{ °C})}{k(at\ 25\text{ °C}) \times (150\text{ °C} - (-40\text{ °C}))}$$

[11]  $\Delta\alpha = |\alpha_{real} - \alpha_{meas}|$ ;  $V_{offset} = 0\text{ V}$ ; inaccuracy of angular measurement due to deviations from ideal sinusoidal characteristics, calculated from the third and fifth harmonics of the spectrum  $V_O$ .



## 7. Bare die outline

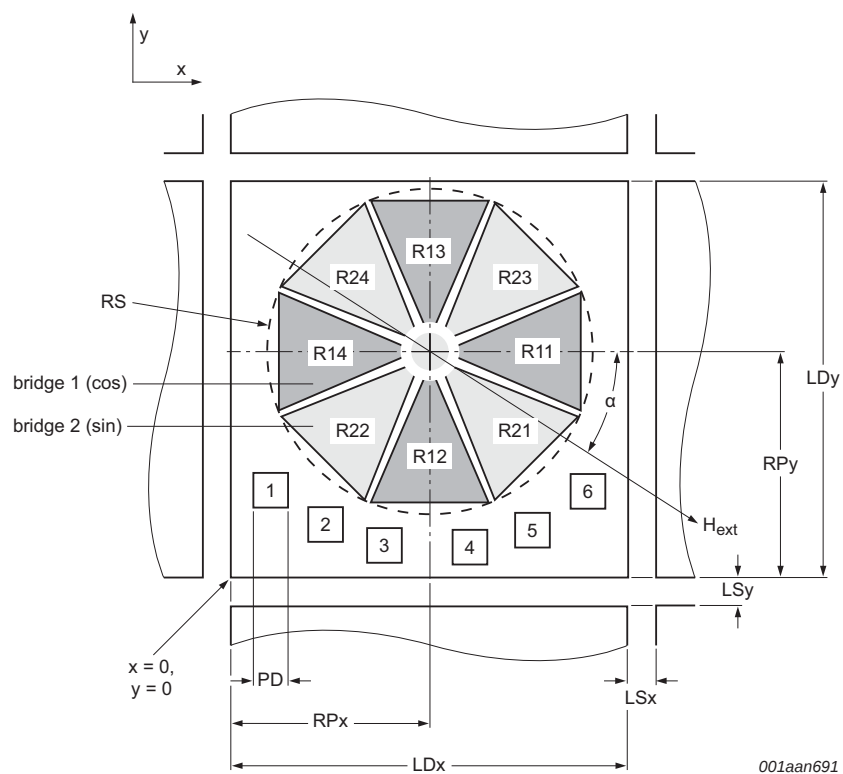


Fig 5. Bare die outline (single die)

Table 7. Mechanical dimensions for [Figure 5](#)

| Symbol | Parameter              | x    | y    | Radius/diameter | Unit          |
|--------|------------------------|------|------|-----------------|---------------|
| LD     | die size               | 1150 | 1150 | -               | $\mu\text{m}$ |
| LS     | sawing lane width      | 60   | 60   | -               | $\mu\text{m}$ |
| RP     | reading point position | 575  | 642  | -               | $\mu\text{m}$ |
| RS     | sensitive area radius  | -    | -    | 480             | $\mu\text{m}$ |
| PD     | pad diameter           | -    | -    | 110             | $\mu\text{m}$ |
| 1      | position pad 1         | 108  | 230  | -               | $\mu\text{m}$ |
| 2      | position pad 2         | 243  | 125  | -               | $\mu\text{m}$ |
| 3      | position pad 3         | 489  | 95   | -               | $\mu\text{m}$ |
| 4      | position pad 4         | 632  | 95   | -               | $\mu\text{m}$ |
| 5      | position pad 5         | 900  | 125  | -               | $\mu\text{m}$ |
| 6      | position pad 6         | 1032 | 200  | -               | $\mu\text{m}$ |

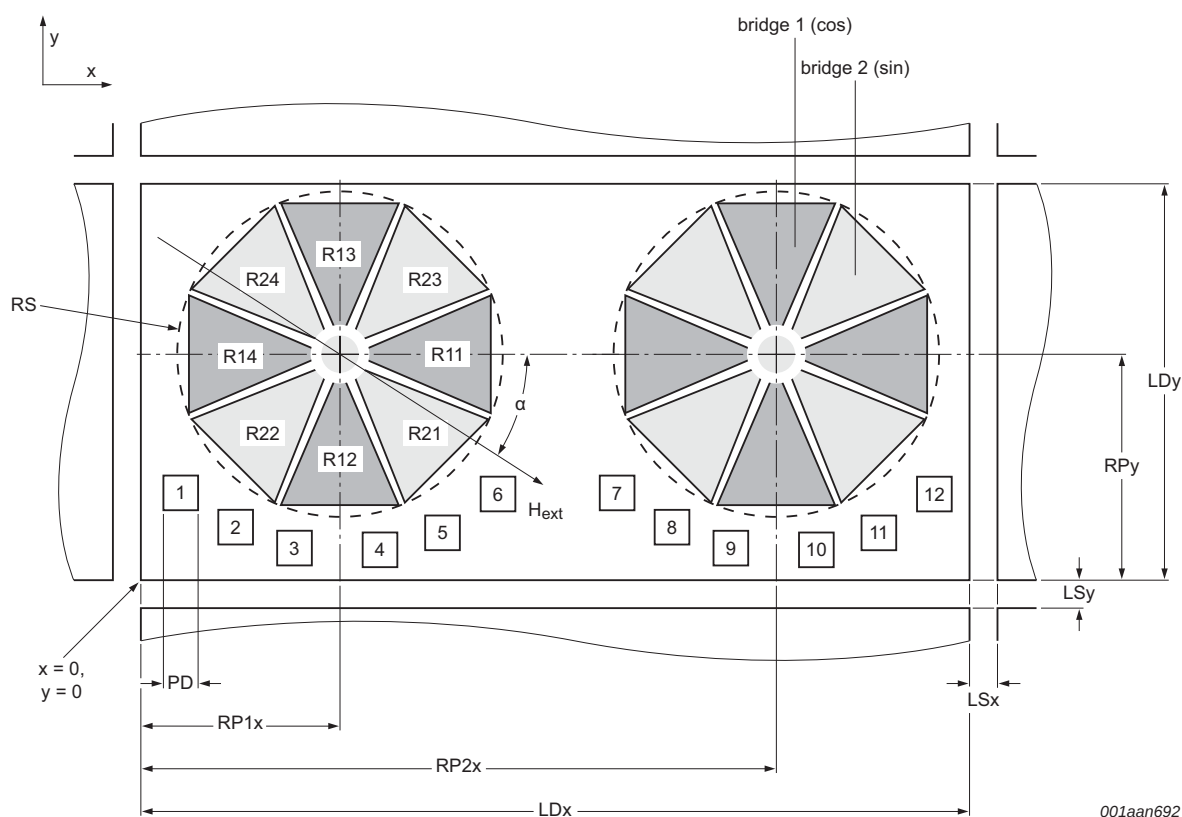


Fig 6. Bare die outline (double die)

Table 8. Mechanical dimensions for Figure 6

| Symbol | Parameter                | x    | y    | Radius/diameter | Unit          |
|--------|--------------------------|------|------|-----------------|---------------|
| LD     | die size                 | 2360 | 1150 |                 | $\mu\text{m}$ |
| LS     | sawing lane width        | 60   | 60   |                 | $\mu\text{m}$ |
| RP1    | reading point position 1 | 575  | 642  |                 | $\mu\text{m}$ |
| RP2    | reading point position 2 | 1785 | 642  |                 | $\mu\text{m}$ |
| RS     | sensitive area radius    | -    | -    | 480             | $\mu\text{m}$ |
| PD     | pad diameter             | -    | -    | 110             | $\mu\text{m}$ |
| 1      | position pad 1           | 108  | 230  |                 | $\mu\text{m}$ |
| 2      | position pad 2           | 243  | 125  |                 | $\mu\text{m}$ |
| 3      | position pad 3           | 489  | 95   |                 | $\mu\text{m}$ |
| 4      | position pad 4           | 632  | 95   |                 | $\mu\text{m}$ |
| 5      | position pad 5           | 900  | 125  |                 | $\mu\text{m}$ |
| 6      | position pad 6           | 1032 | 200  |                 | $\mu\text{m}$ |
| 7      | position pad 7           | 1318 | 230  |                 | $\mu\text{m}$ |
| 8      | position pad 8           | 1453 | 125  |                 | $\mu\text{m}$ |
| 9      | position pad 9           | 1699 | 95   |                 | $\mu\text{m}$ |

Table 8. Mechanical dimensions for Figure 6 ...continued

| Symbol | Parameter       | x    | y   | Radius/diameter | Unit |
|--------|-----------------|------|-----|-----------------|------|
| 10     | position pad 10 | 1842 | 95  |                 | μm   |
| 11     | position pad 11 | 2110 | 125 |                 | μm   |
| 12     | position pad 12 | 2242 | 200 |                 | μm   |

Table 9. Wafer dimensions

| Symbol | Parameter       | Value    | Unit |
|--------|-----------------|----------|------|
| WD     | wafer diameter  | 150      | mm   |
| WT     | wafer thickness | 380 ± 15 | μm   |

## 8. Packing information

### 8.1 Tape construction for X3G-OH047 and X3G-OH048

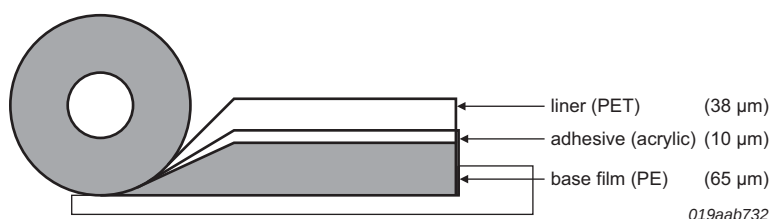
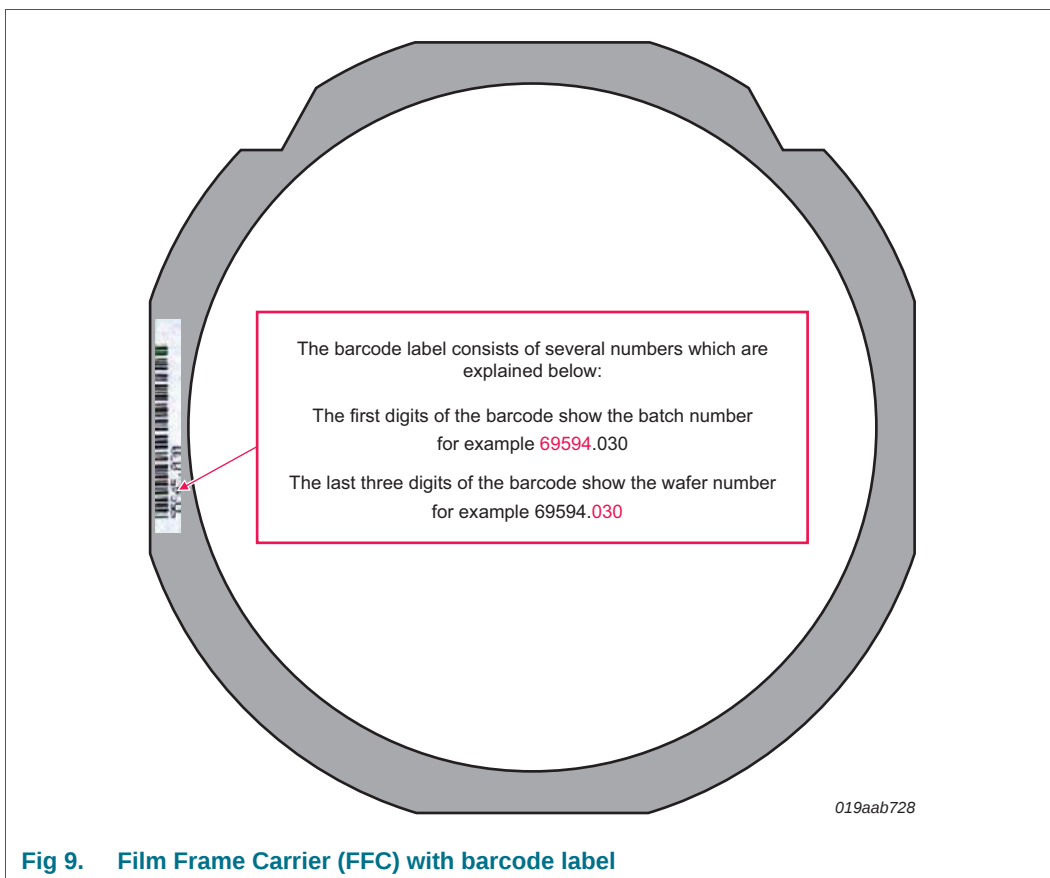


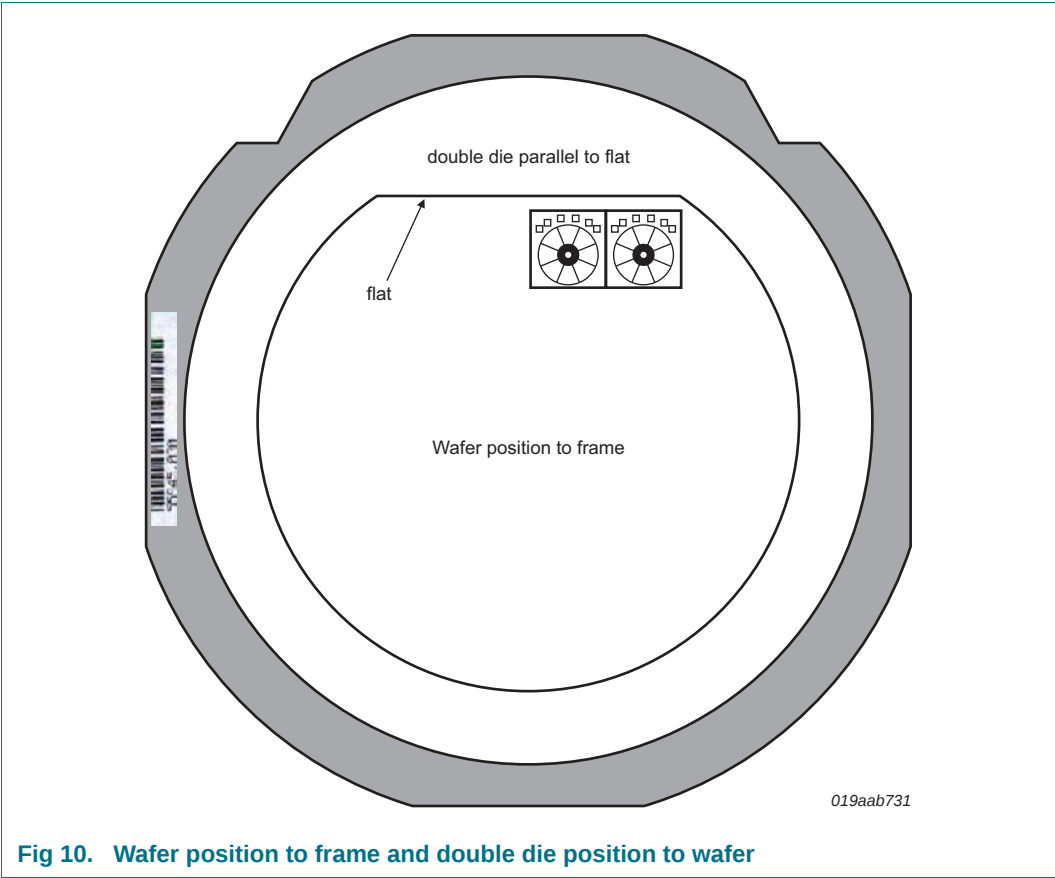
Fig 7. Tape construction

Table 10. Material composition

| Parameter       | Content         | Typical value | Unit  |
|-----------------|-----------------|---------------|-------|
| Total thickness | -               | 75            | μm    |
| Adhesion        | -               | 55 / 20       | g/mm  |
| Ionic impurity  | Na <sup>+</sup> | 0.027         | μg/ml |
|                 | K <sup>+</sup>  | < 0.004       | μg/ml |
|                 | Cl              | 0.045         | μg/ml |







## 8.2 Carrier tape for X3T-OH047 and X3T-OH048

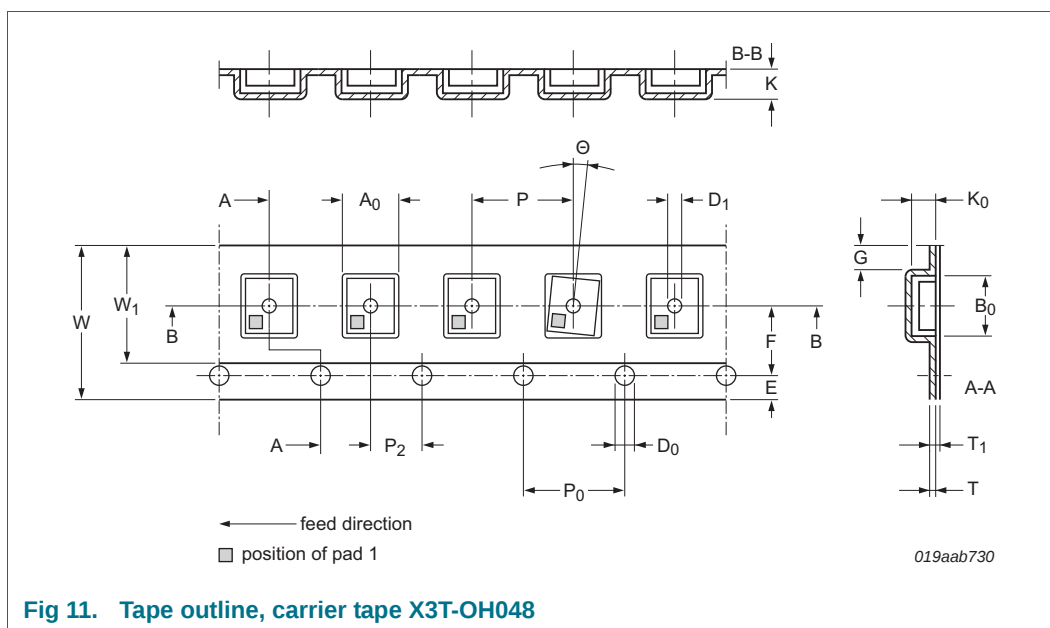


Fig 11. Tape outline, carrier tape X3T-OH048

Table 11. Dimensions for [Figure 11 “Tape outline, carrier tape X3T-OH048”](#)

| Item                          | Symbol         | Specification  |           |
|-------------------------------|----------------|----------------|-----------|
|                               |                | Dimension [mm] | Tolerance |
| Overall dimensions            |                |                |           |
| Tape width                    | W              | 8              | ±0.1      |
| Thickness                     | K              | ≤ 1.2          | -         |
| Distance                      | G              | ≥ 0.75         | -         |
| Sprocket holes                |                |                |           |
| Diameter                      | D <sub>0</sub> | 1.5            | ±0.1      |
| Distance                      | E              | 1.75           | ±0.1      |
| Pitch <sup>[1]</sup>          | P <sub>0</sub> | 4              | ±0.1      |
| Distance between center lines |                |                |           |
| Length direction              | P <sub>2</sub> | 2              | ±0.05     |
| Width direction               | F              | 3.5            | ±0.05     |
| Compartments                  |                |                |           |
| Length                        | A <sub>0</sub> | 1.4            | ±0.05     |
| Width                         | B <sub>0</sub> | 1.4            | ±0.05     |
| Depth                         | K <sub>0</sub> | 0.8            | ±0.05     |
| Hole diameter                 | D <sub>1</sub> | 0.5            | ±0.1      |
| Pitch                         | P              | 4              | ±0.1      |
| Device                        |                |                |           |
| Outline                       | X3T-OH048      |                |           |
| Rotation                      | Θ              | ≤ 20°          | -         |
| Carrier tape antistatic       |                |                |           |
| Film thickness <sup>[2]</sup> | T              | 0.25           | ±0.07     |

Table 11. Dimensions for [Figure 11 “Tape outline, carrier tape X3T-OH048”](#) ...continued

| Item                 | Symbol         | Specification  |           |
|----------------------|----------------|----------------|-----------|
|                      |                | Dimension [mm] | Tolerance |
| Cover tape           |                |                |           |
| Width                | W <sub>1</sub> | ≤ 5.75         | -         |
| Film thickness       | T <sub>1</sub> | ≤ 0.1          | -         |
| Bending radius       |                |                |           |
| In winding direction | R              | ≥ 30           | -         |

- [1] Cumulate pitch error  $\pm 0.2$  over 10 pitch.  
 [2] Carbon loaded polystyrene 100 % recyclable.

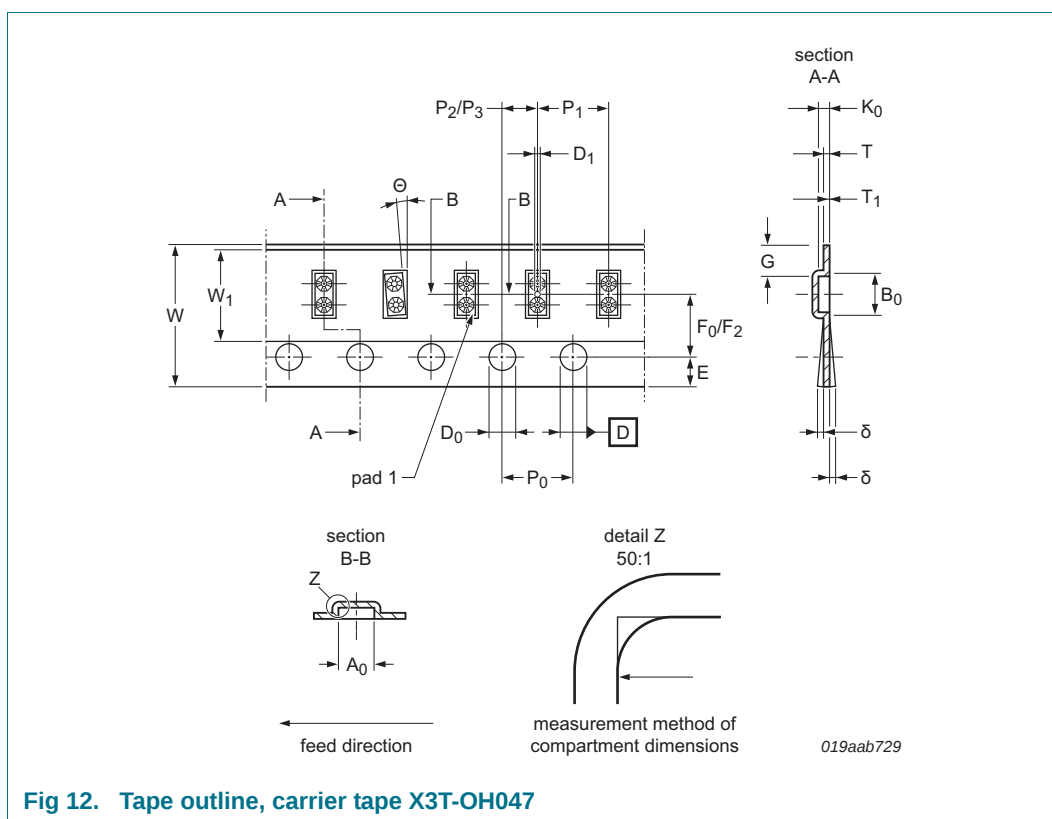


Fig 12. Tape outline, carrier tape X3T-OH047

Table 12. Dimensions for [Figure 12 “Tape outline, carrier tape X3T-OH047”](#)

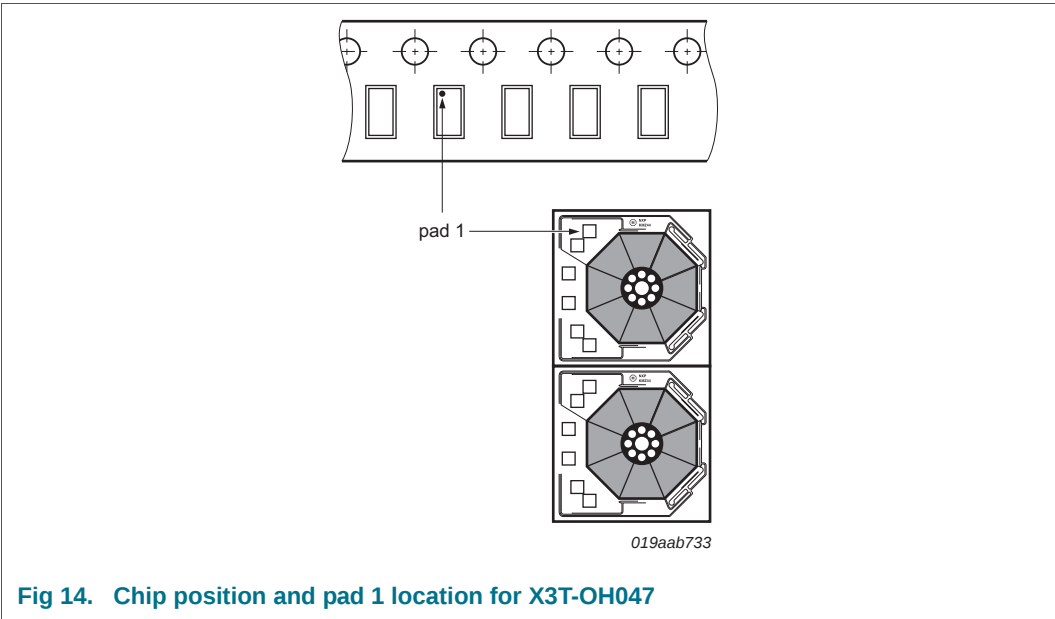
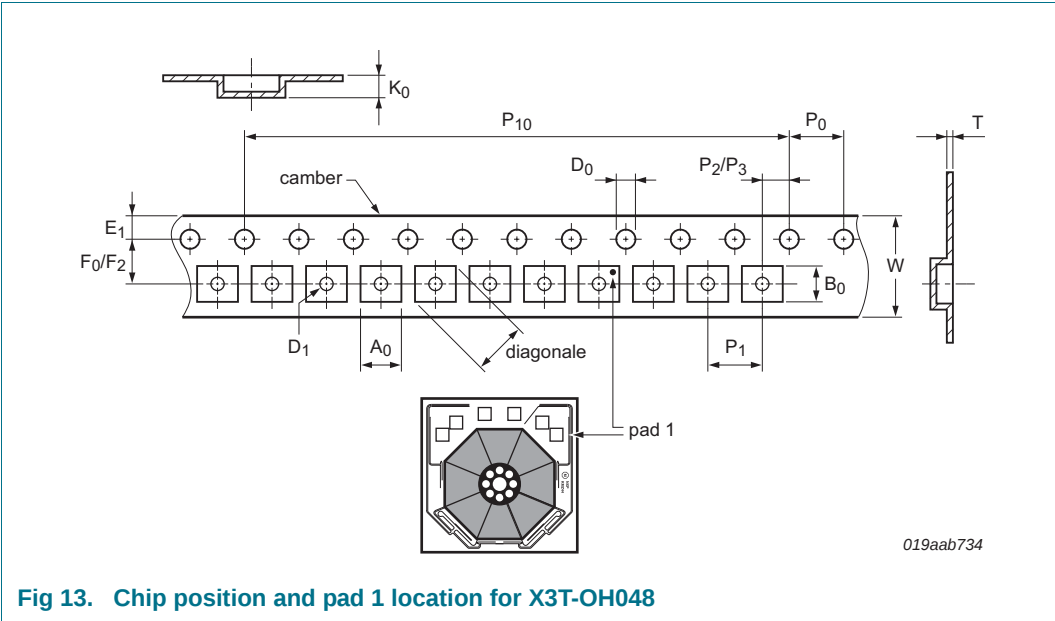
| Item                 | Symbol         | Specification  |           |
|----------------------|----------------|----------------|-----------|
|                      |                | Dimension [mm] | Tolerance |
| Overall dimensions   |                |                |           |
| Tape width           | W              | 8              | ±0.1      |
| Distance             | G              | ≥ 0.75         | -         |
| Sprocket holes       |                |                |           |
| Diameter             | D <sub>0</sub> | 1.5            | ±0.1      |
| Distance             | E              | 1.75           | ±0.1      |
| Pitch <sup>[1]</sup> | P <sub>0</sub> | 4              | ±0.1      |

Table 12. Dimensions for [Figure 12 “Tape outline, carrier tape X3T-OH047”](#) ...continued

| Item                          | Symbol         | Specification  |           |
|-------------------------------|----------------|----------------|-----------|
|                               |                | Dimension [mm] | Tolerance |
| Distance between center lines |                |                |           |
| Sprocket hole / cavity center | P <sub>2</sub> | 2              | ±0.05     |
| Sprocket hole / cavity hole   | P <sub>3</sub> | 2              | ±0.05     |
| Sprocket hole / cavity center | F <sub>0</sub> | 3.5            | ±0.05     |
| Sprocket hole / cavity hole   | F <sub>2</sub> | 3.5            | ±0.05     |
| Compartments                  |                |                |           |
| Length                        | A <sub>0</sub> | 1.4            | ±0.05     |
| Width overall                 | B <sub>0</sub> | 2.7            | ±0.05     |
| Depth                         | K <sub>0</sub> | 0.5            | ±0.05     |
| Hole diameter                 | D <sub>1</sub> | 0.5            | ±0.1      |
| Pitch                         | P <sub>1</sub> | 4              | ±0.1      |
| Device                        |                |                |           |
| Outline                       | X3T-OH047      |                |           |
| Rotation                      | Θ              | ≤ 15°          | -         |
| Carrier tape antistatic       |                |                |           |
| Film thickness <sup>[2]</sup> | T              | 0.25           | ±0.07     |
| Bend                          | δ              | ≤ 0.3          | -         |
| Cover tape                    |                |                |           |
| Width                         | W <sub>1</sub> | 5.3            | ±0.1      |
| Film thickness                | T <sub>1</sub> | 0.05           | ±0.01     |
| Bending radius                |                |                |           |
| In winding direction          | R              | ≥ 30           | -         |

[1] Cumulate pitch error ±0.2 over 10 pitch.

[2] Carbon loaded polystyrene 100 % recyclable.



9. Revision history

Table 13. Revision history

| Document ID         | Release date | Data sheet status     | Change notice | Supersedes |
|---------------------|--------------|-----------------------|---------------|------------|
| X3G_T_OH047_048 v.1 | 20110404     | Product specification | -             | -          |

## 10. Legal information

### 10.1 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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Date of release: 4 April 2011

Document identifier: X3G\_T\_OH047\_048