

# CBTU02044

## High-speed two-differential channels 1-to-2 switch

Rev. 1.2 — 21 April 2022

Product data sheet

## 1 General description

CBTU02044 is a high-speed differential 1-to-2 switching chip optimized to interface with PCIe4.0 for server and client applications. This high performance switch chip could be used for other high-speed interfaces such as PCIe-Gen4, MIPI, DP1.4, and DDR. CBTU02044 also functions as a 2-to-1 MUX by selecting 1 (Port A) as output out of one of the two differential ports (either Port B or C).

Pinouts are optimized for minimum number of layout layers and for achievement of very low crosstalk to meet stringent crosstalk requirements at higher data rate. CBTU02044 is a small package with optimized footprint for smaller real estate occupancy.

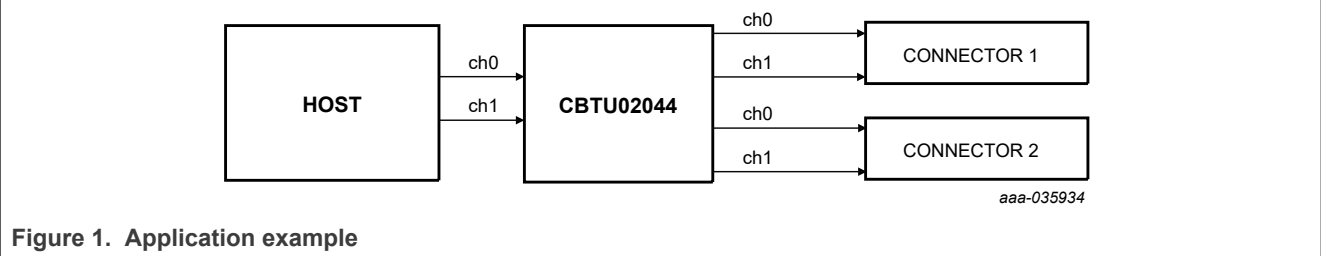
CBTU02044 is available in 1.6 mm x 2.4 mm x 0.5 mm HUQFN16 package with 0.4 mm pitch.

## 2 Features and benefits

- Optimized high-speed signal integrity
- Minimize crosstalk to meet stringent PCIe4.0 requirement
- Two-differential channels 1-to-2 switch/2-to-1 mux
  - Low insertion loss (typ): 0.56 dB at 100 MHz; 1.1 dB at 5 GHz; 1.5 dB at 8 GHz
  - Low off-state isolation: -70 dB at 100 MHz, -23 dB at 5 GHz, -18 dB at 8 GHz
  - Low return loss (typ): 21 dB at 2.5 GHz; 18 dB at 5 GHz; 15 dB at 8 GHz
  - Low ON-state resistance: 10  $\Omega$  (typ)
  - 3 dB bandwidth (typ): 17 GHz (typ)
  - DDNEXT < -50 dB @ 8 GHz
  - DDFEXT < -48 dB @ 8 GHz
  - VIC common mode input voltage VIC: 0 V to 2 V
  - Differential input voltage VID < 1.6 V
  - Intra-pair skew < 4 ps
- VDD power supply voltage range: 1.62 V to 3.63 V
- Low current consumption:
  - For active mode = 200  $\mu$ A (typ)
  - For power-saving = 3  $\mu$ A (typ)
- CMOS SEL and XSD pins
- Back current protection on all I/O pins of these switches
- Patent pending high performance analog pass-gate technology
- All channels support rail-to-rail input voltage (up to 2.4 V)
- HUQFN16 1.6 mm x 2.4 mm x 0.5 mm package with 0.4 mm pitch
- ESD: 2000 V HBM; 1000 V CDM
- Operating temperature range: -40 °C to +85 °C



3 Application example



4 Ordering information

Table 1. Ordering information

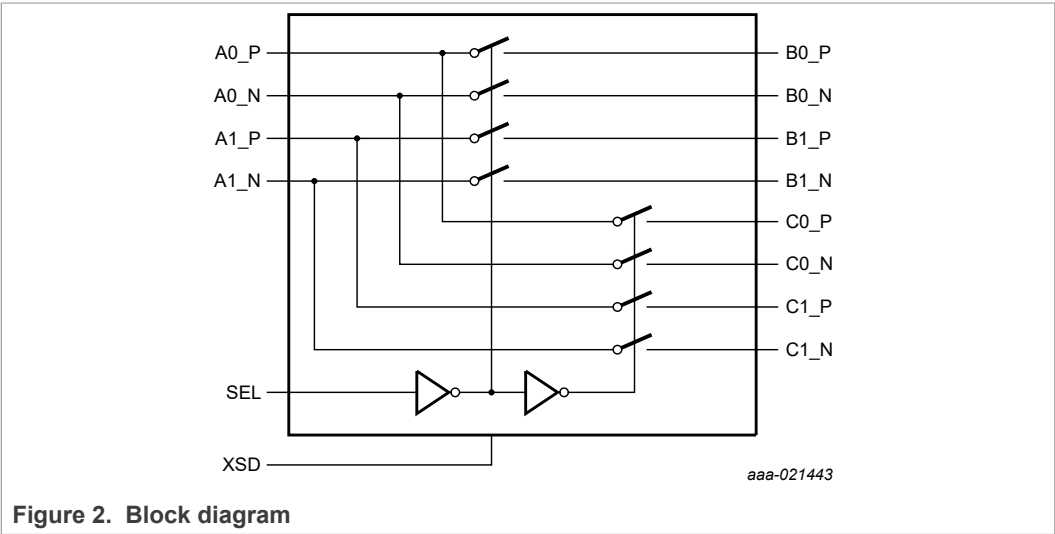
| Type number | Topside marking | Package |                                                                                                            |           |
|-------------|-----------------|---------|------------------------------------------------------------------------------------------------------------|-----------|
|             |                 | Name    | Description                                                                                                | Version   |
| CBTU02044HE | 44              | HUQFN16 | Plastic, super thin quad flat package; no leads; 16 terminals; body 1.6 mm x 2.4 mm x 0.5 mm; 0.4 mm pitch | SOT1832-1 |

4.1 Ordering options

Table 2. Ordering options

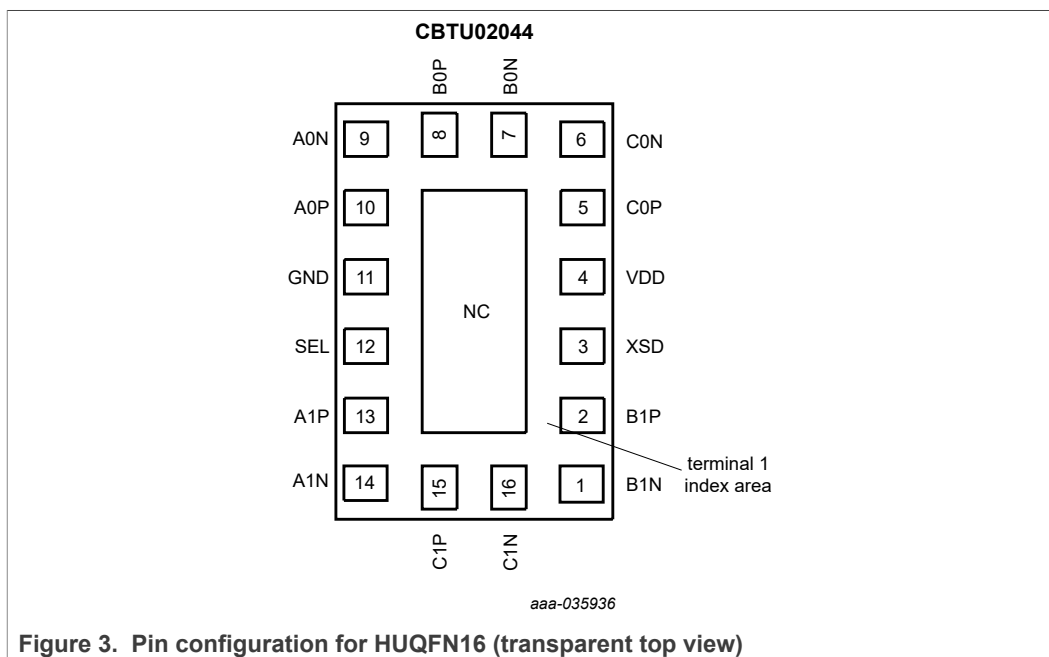
| Type number | Orderable part number | Package | Packing method                       | Minimum order quantity | Temperature                         |
|-------------|-----------------------|---------|--------------------------------------|------------------------|-------------------------------------|
| CBTU02044   | CBTU02044HEJ          | HUQFN16 | REEL 13" Q1/T1<br>*STANDARD MARK SMD | 10000                  | T <sub>amb</sub> = -40 °C to +85 °C |

5 Block diagram



## 6 Pinning information

### 6.1 Pinning



Refer to [Section 11](#) for package related information.

### 6.2 Pin description

Table 3. Pin description

| Symbol            | Pin | Type | Description |
|-------------------|-----|------|-------------|
| Data path signals |     |      |             |
| A0N               | 9   | I/O  | Ch0 input   |
| A0P               | 10  | I/O  |             |
| B0P               | 8   | I/O  | B0 output   |
| B0N               | 7   | I/O  |             |
| C0N               | 6   | I/O  | C0 output   |
| C0P               | 5   | I/O  |             |
| A1P               | 13  | I/O  | Ch1 input   |
| A1N               | 14  | I/O  |             |
| B1P               | 2   | I/O  | B1 output   |
| B1N               | 1   | I/O  |             |
| C1N               | 16  | I/O  | C1 output   |
| C1P               | 15  | I/O  |             |
| Control signal    |     |      |             |

Table 3. Pin description...continued

| Symbol                   | Pin        | Type          | Description                                                                                                                                                         |
|--------------------------|------------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SEL                      | 12         | GPIO input    | Input signal driven by GPIO<br>When SEL = LOW, Port A and Port B are mutually connected<br>When SEL = HIGH, port A and port C are mutually connected                |
| XSD                      | 3          | CMOS input    | Shutdown pin; should be driven LOW for normal operation. When HIGH, all paths are switched off (high impedance state). And supply current consumption is minimized. |
| <b>Power supply</b>      |            |               |                                                                                                                                                                     |
| VDD                      | 4          | power         | Power supply range between 1.62 V and 3.63 V                                                                                                                        |
| <b>Ground connection</b> |            |               |                                                                                                                                                                     |
| GND                      | 11         | ground        | 0 V; must connect to PCB ground                                                                                                                                     |
| NC                       | center pad | not connected | Center pad is not connected to the device ground pin inside the package. Recommend to connect center pad to PCB ground                                              |

## 7 Functional description

Refer to [Figure 2](#) of CBTU02044.

The CBTU02044 provides a shutdown function to minimize power consumption when the switch is not active, while the power to CBTU02044 is provided. The XSD pin (power down = HIGH) places all channels in high-impedance state while reducing current consumption to near-zero. When XSD pin is LOW, the device operates normally.

Table 4. ON/OFF control table

| XSD  | SEL  | Function                    |
|------|------|-----------------------------|
| HIGH | X    | A, B and C ports are high-Z |
| LOW  | LOW  | A to B ports and vice versa |
| LOW  | HIGH | A to C ports and vice versa |

## 8 Limiting values

Table 5. Limiting values <sup>[1]</sup>

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

| Symbol           | Parameter                       | Conditions |     | Min  | Max  | Unit |
|------------------|---------------------------------|------------|-----|------|------|------|
| V <sub>DD</sub>  | supply voltage                  |            | [2] | -0.3 | +4.4 | V    |
| V <sub>I</sub>   | input voltage of control pins   |            | [2] | -0.3 | +4.4 | V    |
| V <sub>IO</sub>  | voltage of I/O pins of switches |            | [2] | -0.3 | +2.6 | V    |
| T <sub>stg</sub> | storage temperature             |            |     | -65  | +150 | °C   |
| V <sub>ESD</sub> | electrostatic discharge voltage | HBM        | [3] | -    | 2000 | V    |
|                  |                                 | CDM        | [4] | -    | 1000 | V    |

[1] Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

[2] All voltage values, except differential voltages, are with respect to network ground terminal.

[3] Human Body Model: ANSI/EOS/ESD-S5.1-1994, standard for ESD sensitivity testing, Human Body Model - Component level; Electrostatic Discharge Association, Rome, NY, USA.

[4] Charged Device Model: ANSI/EOS/ESD-S5.3-1-1999, standard for ESD sensitivity testing, Charged Device Model - Component level; Electrostatic Discharge Association, Rome, NY, USA.

## 9 Recommended operating conditions

**Table 6. Operating conditions***Over operating free-air temperature range (unless otherwise noted)*

| Symbol           | Parameter                     | Conditions            | Min  | Typ | Max  | Unit |
|------------------|-------------------------------|-----------------------|------|-----|------|------|
| VDD              | supply voltage                | 3.3 V supply option   | 1.62 | -   | 3.63 | V    |
| V <sub>I</sub>   | input voltage                 | CMOS inputs           | -0.3 | -   | VDD  | V    |
|                  |                               | switch I/O pins       | -0.3 | -   | +2.4 | V    |
| T <sub>amb</sub> | ambient operating temperature | operating in free air | -40  | -   | +85  | °C   |

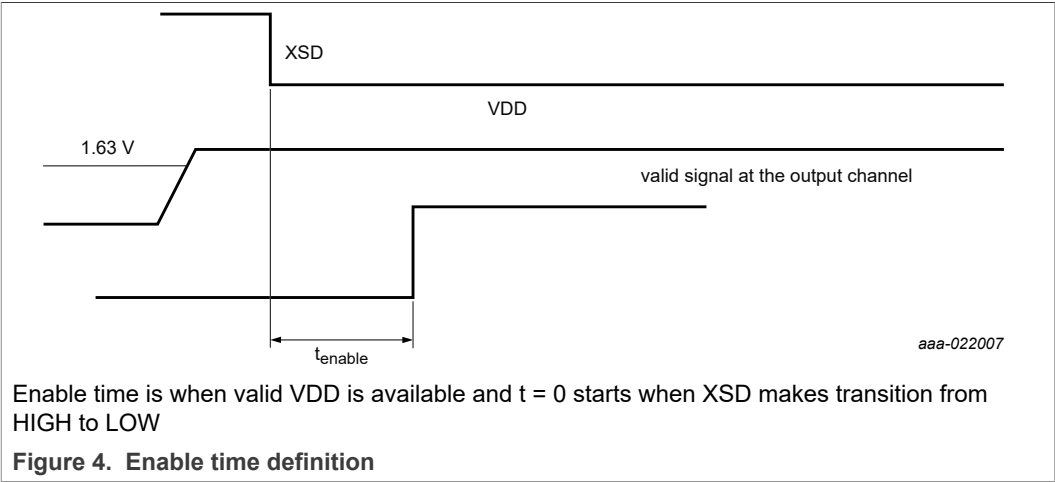
10 Characteristics

10.1 Device general characteristics

Table 7. General characteristics

| Symbol               | Parameter            | Conditions                                                                                       | Min | Typ <sup>[1]</sup> | Max | Unit |
|----------------------|----------------------|--------------------------------------------------------------------------------------------------|-----|--------------------|-----|------|
| I <sub>DD</sub>      | supply current       | XSD = HIGH (disable)                                                                             | -   | 3                  | 10  | μA   |
|                      |                      | XSD = LOW (enable)                                                                               | -   | 250                | 450 | μA   |
| t <sub>startup</sub> | start-up time        | supply voltage ramping up to valid with XSD = LOW to channel specified operating characteristics | -   | -                  | 30  | μs   |
| t <sub>en</sub>      | enable time          | XSD going LOW to channel specified operating characteristics                                     | -   | 90                 | 220 | μs   |
| t <sub>rcfg</sub>    | reconfiguration time | SEL state changes <sup>[2]</sup>                                                                 | -   | 18                 | 30  | ns   |

[1] Typical values are at VDD = 1.8 V; T<sub>amb</sub> = 25 °C, and maximum loading  
[2] Smooth transition without glitch



## 10.2 Switch channel characteristics

Table 8. Dynamic and static characteristics

| Symbol             | Parameter                                  | Conditions                                                                     | Min  | Typ                 | Max               | Unit |
|--------------------|--------------------------------------------|--------------------------------------------------------------------------------|------|---------------------|-------------------|------|
| DDIL               | differential insertion loss                | Channel is OFF                                                                 |      |                     |                   |      |
|                    |                                            | f = 5 GHz                                                                      | -    | 20                  | -                 | dB   |
|                    |                                            | f = 100 MHz                                                                    | -    | 40                  | -                 | dB   |
|                    |                                            | Channel is ON                                                                  |      |                     |                   |      |
|                    |                                            | f = 8 GHz                                                                      | -    | 1.5                 | -                 | dB   |
|                    |                                            | f = 5 GHz                                                                      | -    | 1.1                 | -                 | dB   |
|                    |                                            | f = 2.5 GHz                                                                    | -    | 0.8                 | -                 | dB   |
|                    |                                            | f = 100 MHz                                                                    | -    | 0.56                | -                 | dB   |
| B <sub>3dB</sub>   | bandwidth                                  |                                                                                | -    | 17                  | -                 | GHz  |
| DDRL               | differential return loss                   | f = 8 GHz                                                                      | -    | 15                  | -                 | dB   |
|                    |                                            | f = 5 GHz                                                                      | -    | 18                  | -                 |      |
|                    |                                            | f = 2.5 GHz                                                                    | -    | 21                  | -                 | dB   |
| DDNEXT             | High-Speed Differential near-end crosstalk | A0 to A1 or B0 to B1 or C0 to C1 ports                                         |      |                     |                   |      |
|                    |                                            | f = 8 GHz                                                                      | -    | -                   | -48               | dB   |
| DDFEXT             | High-Speed far-end crosstalk               | A to B or A to C ports (or vice versa)                                         |      |                     |                   |      |
|                    |                                            | f = 8 GHz                                                                      | -    | -                   | -46               | dB   |
| V <sub>I</sub>     | input voltage                              | Switch I/O pins                                                                | -0.3 | -                   | 2.4               | V    |
| V <sub>IC</sub>    | Common-mode input voltage                  | for all switch ports                                                           | 0    | -                   | 2.0               | V    |
| V <sub>ID_PP</sub> | Differential input voltage                 |                                                                                | -    | 1.2                 | 1.6               | V    |
| I <sub>IH</sub>    | HIGH-level input leakage current           | High-speed switch I/O;<br>A, B and C ports; XSD = HIGH; V <sub>I</sub> = 2.0 V | -    | -                   | 1.5               | μA   |
| I <sub>IL</sub>    | LOW-level input leakage current            | High-speed switch I/O;<br>A, B and C ports; XSD = HIGH; V <sub>I</sub> = GND   | -    | -                   | 1.5               | μA   |
| V <sub>IK</sub>    | Input negative clamping voltage            | Voltage on high-speed channel pins; I <sub>I</sub> = -18 mA                    | -    | -                   | -1.2              | V    |
| t <sub>PD</sub>    | propagation delay at 8 GHz                 | From A port to B or C port or vice versa                                       | -    | 32                  | 35 <sup>[1]</sup> | ps   |
| t <sub>sk</sub>    | Intra-pair skew                            | Skew between P and N for all the ports                                         | -    | 3                   | -                 | ps   |
| R <sub>onse</sub>  | single-end ON-state resistance             | Switch ON resistance with source current is 18 mA                              | -    | 10                  | 14                | Ω    |
| Z <sub>input</sub> | DC CM input impedance                      | XSD = HIGH and V <sub>I</sub> > 0 V                                            | -    | 3000 <sup>[1]</sup> | -                 | KΩ   |
| C <sub>in</sub>    | input capacitance at 2.5 GHz               | VDD = 1.8 V; V <sub>I</sub> = 1.4 V or floating                                | -    | 622 <sup>[1]</sup>  | -                 | fF   |

[1] Guaranteed by design

### 10.3 Control signals characteristics

Table 9. SEL input buffer characteristics

| Symbol   | Parameter                        | Conditions                            | Min  | Typ | Max | Unit    |
|----------|----------------------------------|---------------------------------------|------|-----|-----|---------|
| $V_{IH}$ | HIGH-level input voltage         |                                       | 1.4  | -   | -   | V       |
| $V_{IL}$ | LOW-level input voltage          |                                       | -0.3 | -   | 0.4 | V       |
| $I_{IH}$ | HIGH-level input leakage current | Measured with input at $V_I = V_{DD}$ | -    | -   | 1.5 | $\mu A$ |
| $I_{IL}$ | LOW-level input leakage current  | Measured with input at $V_I = 0 V$    | -    | -   | 1.5 | $\mu A$ |

Table 10. XSD input buffer characteristics

| Symbol   | Parameter                        | Conditions                            | Min        | Typ | Max        | Unit    |
|----------|----------------------------------|---------------------------------------|------------|-----|------------|---------|
| $V_{IH}$ | HIGH-level input voltage         |                                       | 0.75 % VDD | -   | -          | V       |
| $V_{IL}$ | LOW-level input voltage          |                                       | -0.3       | -   | 0.25 % VDD | V       |
| $I_{IH}$ | HIGH-level input leakage current | Measured with input at $V_I = V_{DD}$ | -          | -   | 1.5        | $\mu A$ |
| $I_{IL}$ | LOW-level input leakage current  | Measured with input at $V_I = 0 V$    | -          | -   | 1.5        | $\mu A$ |



12 Packing information

12.1 SOT1832-1 (HUQFN16); Reel pack, SMD, 13" Q1/T1 standard product orientation; Orderable part number ending ,118 or J; Ordering code (12NC) ending 118

12.1.1 Packing method

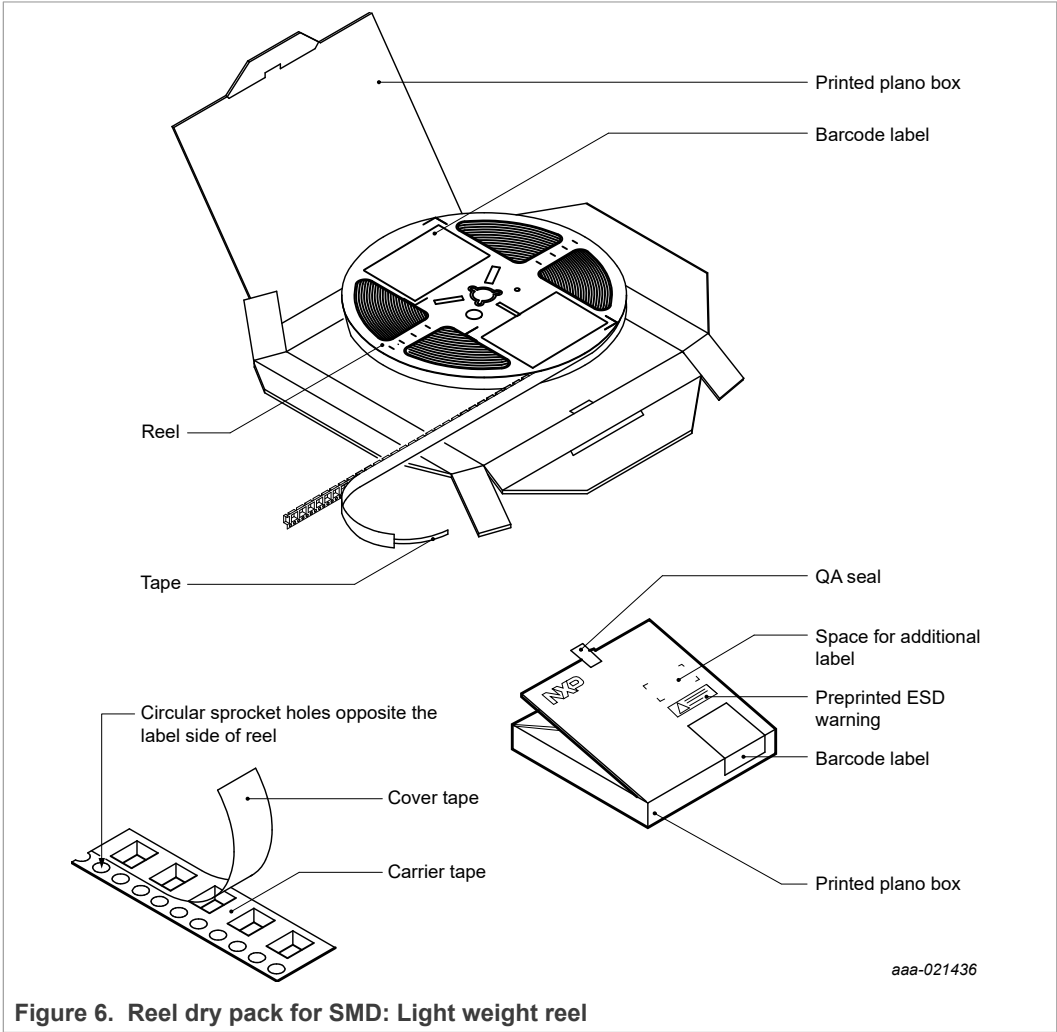


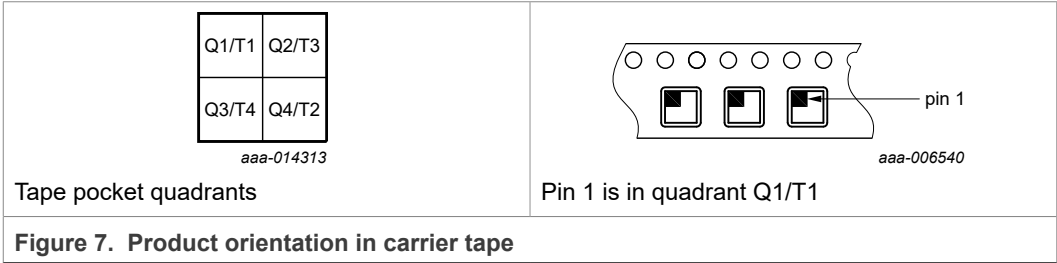
Table 11. Dimensions and quantities

| Reel dimensions<br>d × w (mm) <sup>[1]</sup> | SPQ/PQ<br>(pcs) <sup>[2]</sup> | Reels<br>per box | Outer box dimensions<br>l × w × h (mm) |
|----------------------------------------------|--------------------------------|------------------|----------------------------------------|
| 330 × 8                                      | 10000                          | 1                | 342 × 338 × 27                         |

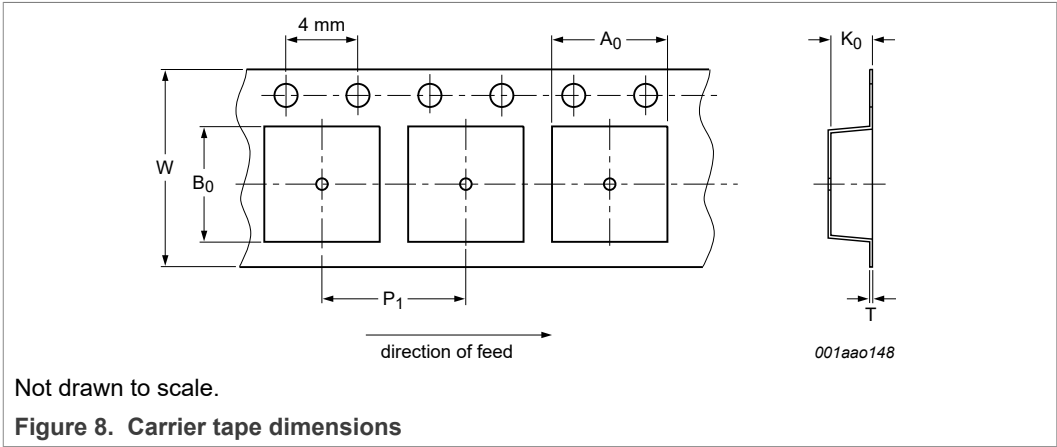
[1] d = reel diameter; w = tape width.  
[2] Packing quantity dependent on specific product type.

View ordering and availability details at [NXP order portal](#), or contact your local NXP representative.

12.1.2 Product orientation



12.1.3 Carrier tape dimensions



12.1.4 Reel dimensions

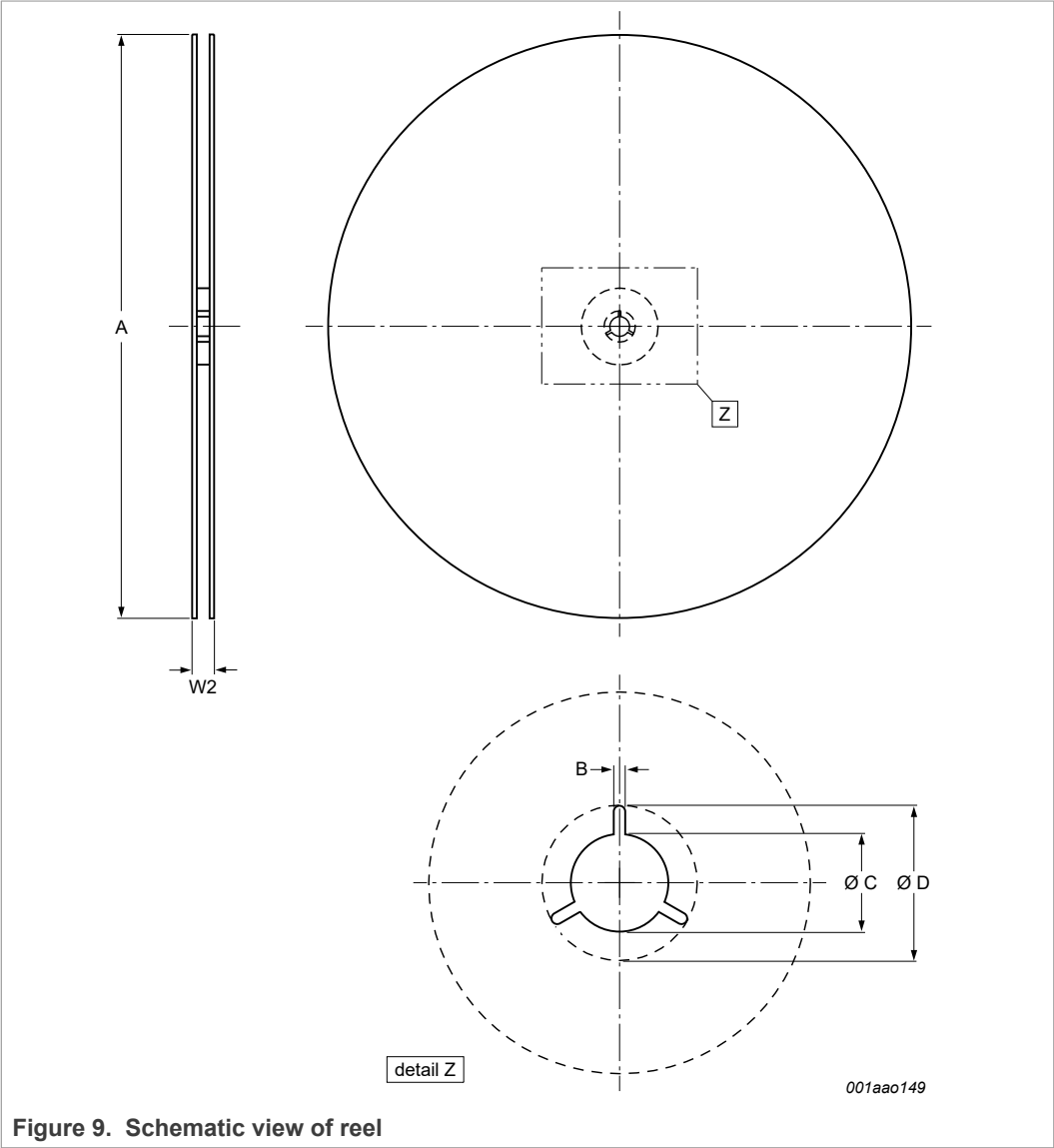


Table 13. Reel dimensions  
In accordance with IEC 60286-3.

| A [nom]<br>(mm) | W2 [max]<br>(mm) | B [min]<br>(mm) | C [min]<br>(mm) | D [min]<br>(mm) |
|-----------------|------------------|-----------------|-----------------|-----------------|
| 330             | 14.4             | 1.5             | 12.8            | 20.2            |

12.1.5 Barcode label

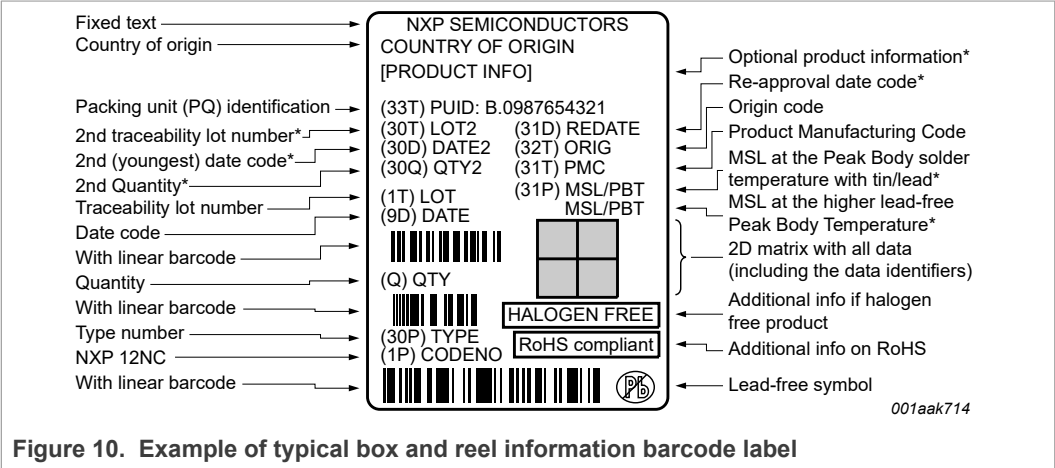


Table 14. Barcode label dimensions

| Box barcode label<br>l × w (mm) | Reel barcode label<br>l × w (mm) |
|---------------------------------|----------------------------------|
| 100 × 75                        | 36 × 75                          |

## 13 Soldering of SMD packages

This text provides a very brief insight into a complex technology. A more in-depth account of soldering ICs can be found in Application Note AN10365 “*Surface mount reflow soldering description*”.

### 13.1 Introduction to soldering

Soldering is one of the most common methods through which packages are attached to Printed Circuit Boards (PCBs), to form electrical circuits. The soldered joint provides both the mechanical and the electrical connection. There is no single soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and Surface Mount Devices (SMDs) are mixed on one printed wiring board; however, it is not suitable for fine pitch SMDs. Reflow soldering is ideal for the small pitches and high densities that come with increased miniaturization.

### 13.2 Wave and reflow soldering

Wave soldering is a joining technology in which the joints are made by solder coming from a standing wave of liquid solder. The wave soldering process is suitable for the following:

- Through-hole components
- Leaded or leadless SMDs, which are glued to the surface of the printed circuit board

Not all SMDs can be wave soldered. Packages with solder balls, and some leadless packages which have solder lands underneath the body, cannot be wave soldered. Also, leaded SMDs with leads having a pitch smaller than ~0.6 mm cannot be wave soldered, due to an increased probability of bridging.

The reflow soldering process involves applying solder paste to a board, followed by component placement and exposure to a temperature profile. Leaded packages, packages with solder balls, and leadless packages are all reflow solderable.

Key characteristics in both wave and reflow soldering are:

- Board specifications, including the board finish, solder masks and vias
- Package footprints, including solder thieves and orientation
- The moisture sensitivity level of the packages
- Package placement
- Inspection and repair
- Lead-free soldering versus SnPb soldering

### 13.3 Wave soldering

Key characteristics in wave soldering are:

- Process issues, such as application of adhesive and flux, clinching of leads, board transport, the solder wave parameters, and the time during which components are exposed to the wave
- Solder bath specifications, including temperature and impurities

### 13.4 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see [Figure 11](#)) than a SnPb process, thus reducing the process window
- Solder paste printing issues including smearing, release, and adjusting the process window for a mix of large and small components on one board
- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature) and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic). In addition, the peak temperature must be low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with [Table 15](#) and [Table 16](#)

Table 15. SnPb eutectic process (from J-STD-020D)

| Package thickness (mm) | Package reflow temperature (°C) |       |
|------------------------|---------------------------------|-------|
|                        | Volume (mm <sup>3</sup> )       |       |
|                        | < 350                           | ≥ 350 |
| < 2.5                  | 235                             | 220   |
| ≥ 2.5                  | 220                             | 220   |

Table 16. Lead-free process (from J-STD-020D)

| Package thickness (mm) | Package reflow temperature (°C) |             |        |
|------------------------|---------------------------------|-------------|--------|
|                        | Volume (mm <sup>3</sup> )       |             |        |
|                        | < 350                           | 350 to 2000 | > 2000 |
| < 1.6                  | 260                             | 260         | 260    |
| 1.6 to 2.5             | 260                             | 250         | 245    |
| > 2.5                  | 250                             | 245         | 245    |

Moisture sensitivity precautions, as indicated on the packing, must be respected at all times.

Studies have shown that small packages reach higher temperatures during reflow soldering, see [Figure 11](#).

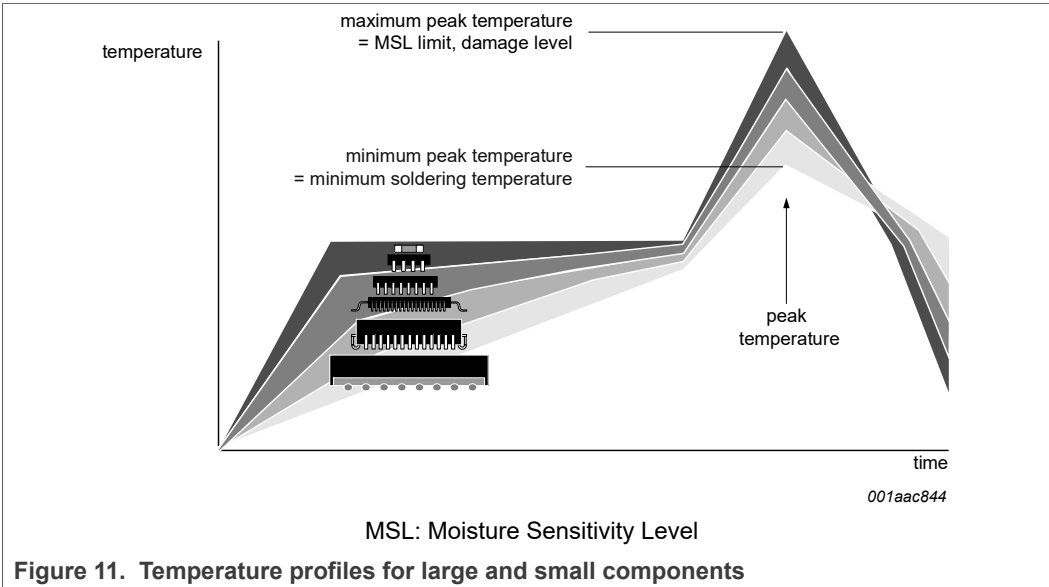


Figure 11. Temperature profiles for large and small components

For further information on temperature profiles, refer to Application Note AN10365 “Surface mount reflow soldering description”.



## 15 Abbreviations

Table 17. Abbreviations

| Acronym | Description                         |
|---------|-------------------------------------|
| CDM     | Charged Device Model                |
| HBM     | Human Body Model                    |
| MIPI    | Mobile Industry Processor Interface |

## 16 Revision history

Table 18. Revision history

| Document ID     | Release date                                                                                    | Data sheet status  | Change notice | Supersedes      |
|-----------------|-------------------------------------------------------------------------------------------------|--------------------|---------------|-----------------|
| CBTU02044 v.1.2 | 20220421                                                                                        | Product data sheet | -             | CBTU02044 v.1.1 |
| Modifications:  | • <a href="#">Section 10.2</a> : Removed duplicate Table 8 (Dynamic and static characteristics) |                    |               |                 |
| CBTU02044 v.1.1 | 20210928                                                                                        | Product data sheet | 2021090241    | -               |
| CBTU02044 v.1.0 | 20200427                                                                                        | Product data sheet | -             | -               |

## 17 Legal information

### 17.1 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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