

CBTL02GP023

5 Gbps rail-to-rail low insertion loss switch

Rev. 2 — 14 August 2017

Product data sheet

1. General description

The CBTL02GP023 is a one port high performance 5 Gbps rail-to-rail low insertion loss 4x SPST switch chip optimized to interface USB3.0 signals with high voltage (e.g. USB2 signals) off isolation. It supports 5 Gbps USB3.0 signals and large swing USB2 or UART signals in dongle or plug applications. It also can be used as a general purpose 5 Gbps rail-to-rail low insertion loss switch chip in other applications.

The common mode voltage of all the input or output pins have wide common mode range from 0 V to VDD.

CBTL02GP023 is available in 1.5 mm × 2.1 mm × 0.32 mm DHX2QFN14 package with 0.4 mm pitch.

2. Features and benefits

- One port (two differential channels) 5 Gbps rail-to-rail low insertion loss switch
- Differential channels:
 - ◆ Low insertion loss: -1.5 dB at 2.5 GHz; -1 dB at 100 MHz
 - Low return loss: < -15 dB at 2.5 GHz
 - ◆ Low ON-state resistance: 11 Ω (typ)
 - ◆ Bandwidth: 7 GHz (typ)
 - Low off-state isolation: -16 dB at 2.5 GHz; -40 dB at 100 MHz
 - Low DDNEXT crosstalk: < -35 dB at 2.5 GHz and 500 MHz
 - ◆ VIC common mode input voltage: 0 to VDD
 - ◆ Differential input voltage VID: 1.2 V (Max)
 - ◆ Intra-pair skew: 6 ps (typ)
- VDD Power Supply voltage range in the dongle or plug:
 - ◆ 2.7 V (min) to 3.5 V (max)
- Low active current consumption: 500 μ A (max)
 - ◆ Minimum disable current (ENH = LOW): 12 μ A (max)
- Back current protection on all I/O pins
- Patent pending high performance analog pass-gate technology
- All channels support rail-to-rail input voltage
- Small DHX2QFN14 1.5mm × 2.1 mm × 0.32 mm package with 0.4 mm pitch
- ESD protection exceeds 2000V HBM per JDS-001-2012 and 750 V CDM per JESD22-C101
- Latch-up testing is done to JEDEC Standard JESD78 which exceeds 100 mA
- Operating temperature range: -20 °C to +85 °C



3. Ordering information

Table 1. Ordering information

| Type number | Topside marking | Package | | |
|-------------|-----------------|-----------|---|-----------|
| | | Name | Description | Version |
| CBTL02GP023 | 23 | DHX2QFN14 | Plastic, super thin quad flat package; no leads; 14 terminals; body 1.5 mm x 2.1 mm x 0.32 mm; 0.4 mm pitch | SOT1458-1 |

3.1 Ordering options

Table 2. Ordering options

| Type number | Orderable part number | Package | Packing method | Minimum order quantity | Temperature |
|-------------|-----------------------|-----------|---|------------------------|-------------------------------------|
| CBTL02GP023 | CBTL02GP023HOZ | DHX2QFN14 | REEL 13" Q1/T1 *STANDARD MARK SBB | 20000 | T _{amb} = -20 °C to +85 °C |

4. Block diagram

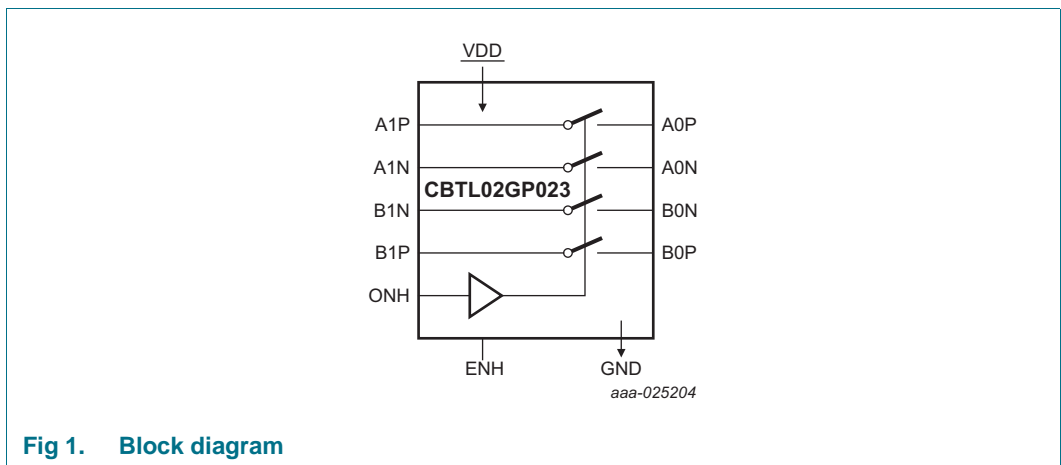


Fig 1. Block diagram

5. Pinning information

5.1 Pinning

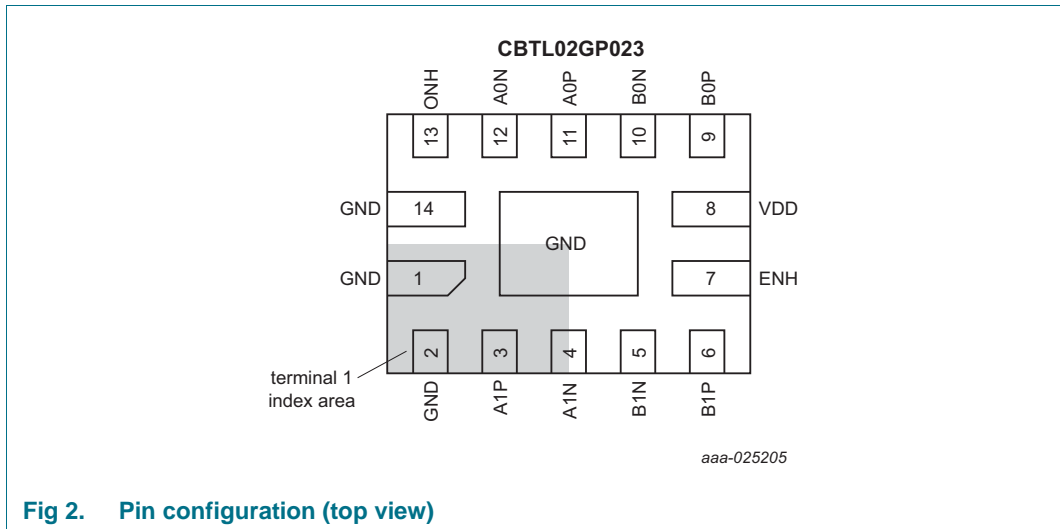


Fig 2. Pin configuration (top view)

Refer to [Section 10 “Package outline”](#) for package related information.

5.2 Pin description

Table 3. Pin description

| Symbol | Pin | Type | Description |
|--------------------------|----------------------|------------------|--|
| Data path signals | | | |
| A1P | 3 | differential I/O | USB3.0 differential signals for A port |
| A1N | 4 | differential I/O | |
| A0N | 12 | differential I/O | USB3.0 differential signals for A port (P and N is crossed for A port) |
| A0P | 11 | differential I/O | |
| B1N | 5 | differential I/O | USB3.0 differential signals for B port |
| B1P | 6 | differential I/O | |
| B0N | 10 | differential I/O | USB3.0 differential signals for B port (P and N is a flow through differential path for B port) |
| B0P | 9 | differential I/O | |
| Control signal | | | |
| ENH | 7 | control input | When HIGH, enables switches. When LOW, whole chip is powered down |
| ONH | 13 | control input | When HIGH, all switches are turned on. When LOW, all switches are OFF, but the control circuit is still working to improve isolation performance |
| Power supply | | | |
| VDD | 8 | power | Power supply range between 2.7 V and 3.5 V |
| Ground connection | | | |
| GND | 1, 2, 14, center pad | ground | 0 V |

6. Functional description

Refer to [Figure 1 “Block diagram”](#) of CBTL02GP023.

ENH pin is used to power down the switches. When ENH is low, the switches are in high impedance sleep mode. ONH can also be used to control the switch with better OFF isolation performance.

Table 4. Enable control table

| ENH | Switch state | Max current consumption |
|-----|--------------|-------------------------|
| 0 | OFF | 12 μ A |
| 1 | ON | 500 μ A |

Table 5. ONH and ENH control table

| ONH | ENH | Switch state | Max current | OFF isolation at 2.5 GHz |
|-----|-----|--------------|-------------|--------------------------|
| 0 | 0 | OFF | 12 μ A | -11 dB |
| 0 | 1 | OFF | 500 μ A | -16 dB |
| 1 | 0 | OFF | 12 μ A | -11 dB |
| 1 | 1 | ON | 500 μ A | NA |

7. Limiting values

Table 6. Limiting values [\[1\]](#)

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

| Symbol | Parameter | Conditions | Min | Max | Unit |
|------------------|---------------------------------|-------------------------|------|------|------|
| V _{DD} | supply voltage | [2] | -0.3 | +4.6 | V |
| V _I | input voltage of control pins | [2] | -0.3 | +5.5 | V |
| V _{IO} | voltage of I/O pins of switches | [2] | -0.3 | +4.6 | V |
| T _{stg} | storage temperature | | -65 | +150 | °C |
| V _{ESD} | electrostatic discharge voltage | HBM [3] | - | 2000 | V |
| | | CDM [4] | - | 750 | 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.

8. Recommended operating conditions

Table 7. Operating conditions

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|------------------|-------------------------------|-----------------------|------|-----|------|------|
| V _{DD} | supply voltage | 3.3 V supply option | 2.7 | - | 3.5 | V |
| V _I | input voltage | CMOS inputs | -0.3 | - | +5.5 | V |
| | | MUX I/O pins | -0.3 | - | +3.5 | V |
| T _{amb} | ambient operating temperature | operating in free air | -20 | - | +85 | °C |

9. Characteristics

9.1 Device general characteristics

Table 8. General characteristics

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---------------|---|---|-----|-----|------|---------|
| I_{DD} | supply current | VDD = 3.5 V | - | - | 0.5 | mA |
| P_{cons} | power consumption | VDD = 3.5 V | - | - | 1.75 | mW |
| P_{sleep} | sleep mode power consumption | ENH = 0 | - | - | 42 | μ W |
| $T_{Startup}$ | start-up time | supply voltage valid and ENH goes HIGH to channel specified operating characteristics | - | 220 | 500 | μ s |
| T_{switch} | 5 Gbps rail-to-rail low insertion loss switching time | ONH goes from LOW to HIGH | - | 2 | 10 | μ s |
| | | ONH goes from HIGH to LOW | - | 200 | 1000 | μ s |

9.2 Switch channel characteristics

Table 9. Dynamic and static characteristics

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------|-----------------------------|--|-----|------|-----|------|
| DDIL | differential insertion loss | Channel is off with ENH = HIGH and ONH = LOW | | | | |
| | | f = 2.5 GHz | - | -16 | - | dB |
| | | f = 100 MHz | - | -40 | - | dB |
| | | Channel is off with whole chip disabled ENH = LOW and ONH = X (don't care) | | | | |
| | | f = 2.5 GHz | - | -11 | - | dB |
| | | f = 100 MHz | - | -30 | - | dB |
| | | Channel is on with ONH = HIGH and ENH = HIGH | | | | |
| | | f = 2.5 GHz | - | -1.5 | - | dB |
| | | f = 100 MHz | - | -1 | - | dB |
| DDRL | Differential Return Loss | f = 2.5 GHz | - | -15 | - | dB |

Table 9. Dynamic and static characteristics ...continued

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-----------------------|---|---|-----|-----|-----|------|
| DDNEXT | High Speed Tx to Rx. Differential near-end crosstalk | A1P/N to B1P/N or A0P/N to B0P/N | | | | |
| | | f=-2.5GHz | - | -20 | - | dB |
| DDFEXT | High Speed Tx to Rx. Differential far-end crosstalk | A1P/N to B0P/N or A0P/N to B1P/N | | | | |
| | | | - | -20 | - | dB |
| R _{on} | ON-state resistance | V _{DD} = 2.7 V; V _I = 2.2 V; I _I = 10 mA | - | 11 | 15 | Ω |
| C _{in} | Input capacitance | V _{DD} = 2.8 V; V _I = 1.4 V; at 10 MHz | - | 3 | - | pF |
| B _{-3dB} | Bandwidth | V _{IC} = 0 V | - | 7 | - | GHz |
| T _{pd} | Propagation delay | From input to output pairs | - | 70 | - | ps |
| T _{sk(diff)} | Differential skew time | Intra-pair | - | 6 | - | ps |
| V _I | Input voltage | for all switch ports | 0 | - | 3.5 | V |
| V _{IC} | Common-mode input voltage | for all switch ports | 0 | - | VDD | V |
| I _{LH} | High level input leakage current | V _{DD} =MAX; V _I =V _{DD} | - | - | ±1 | μA |
| I _{LIL} | Low level input leakage current | V _{DD} =MAX; V _I =GND | - | - | ±1 | μA |

9.3 Control signals characteristics

Table 10. ENH input buffer characteristics

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-----------------|-----------------------------|--|----------|-----|----------|------|
| V _{IH} | HIGH-level input voltage | CMOS inputs | 0.7* VDD | - | - | V |
| V _{IL} | LOW-level input voltage | CMOS inputs | - | - | 0.3* VDD | V |
| I _{LI} | Input leakage current | Measured with input at V _I =VDD and V _I =0V | | | 1 | μA |

Table 11. ONH input buffer characteristics

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|------------|--------------------------|---|------|-----|------|---------|
| V_{IH} | HIGH-level input voltage | CMOS input | 2.15 | - | - | V |
| V_{IL} | LOW-level input voltage | after glitch filter to debounce noise | - | - | 0.5 | V |
| I_{LI} | Input leakage current | Measured with input at $V_{IH} = V_{DD}$ and $V_{IL} = 0$ V | - | - | 0.1 | μ A |
| t_{degl} | deglitch time | time from ONH signal going LOW and staying LOW below V_{IL} level | - | 200 | 1000 | μ s |

[1] The I_{LI} value is guaranteed by design and bench test

10. Package outline

DHX2QFN14: plastic dual in-line compatible thermal exchanged super thin quad flat package; no leads; 14 terminals; body 1.5 x 2.1 x 0.32 mm

SOT1458-1

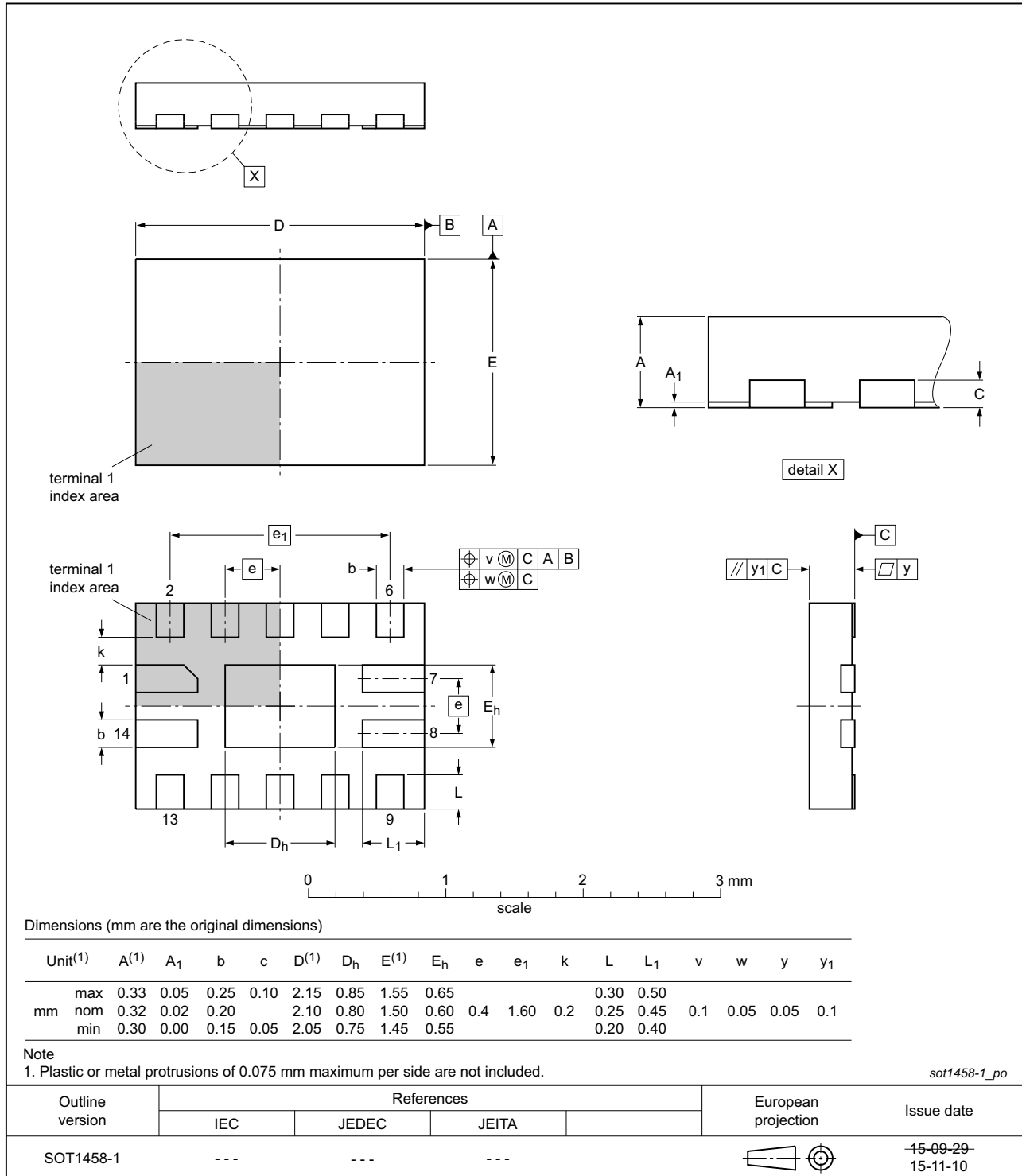


Fig 3. Package outline SOT1458-1 (DHX2QFN14)

11. Packing information

11.1 DHX2QFN14; Reel pack, SMD, 13"; Q1/T1 standard product orientation; Orderable part number ending ,431 or Z; Ordering code (12NC) ending 431

11.1.1 Packing method

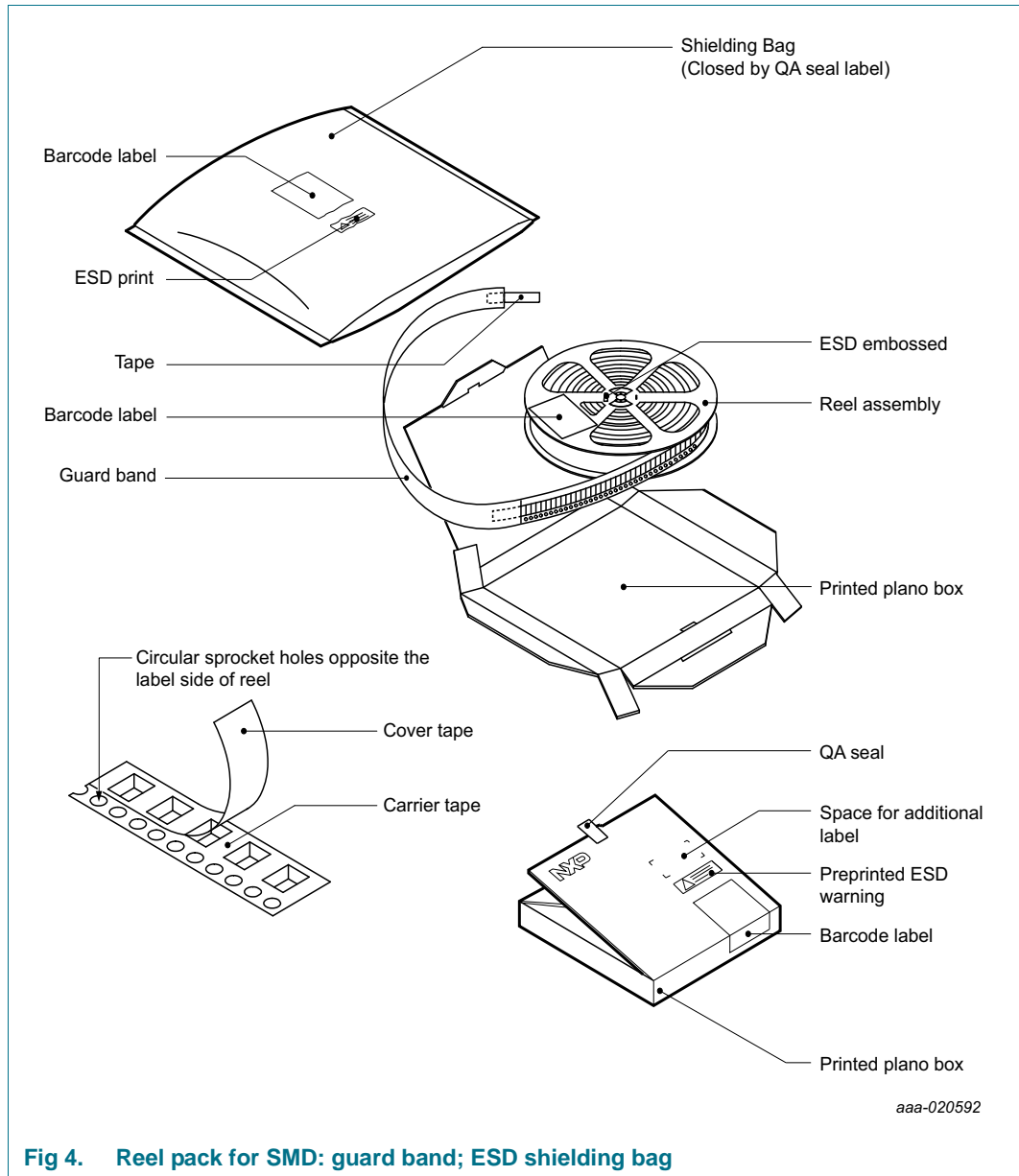


Fig 4. Reel pack for SMD: guard band; ESD shielding bag

Table 12. Dimensions and quantities

| Reel dimensions d × w (mm) [1] | SPQ/PQ (pcs) [2] | Reels per box | Outer box dimensions l × w × h (mm) |
|-----------------------------------|---------------------|------------------|--|
| 330 × 8 | 20000 | 1 | 342 × 338 × 25 |

[1] d = reel diameter; w = tape width.

[2] Packing quantity dependent on specific product type.

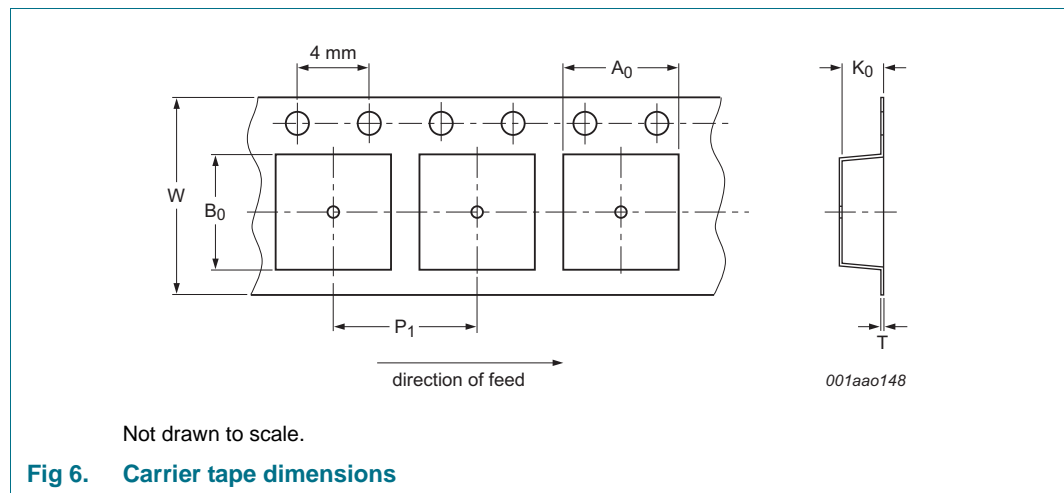
View ordering and availability details at [NXP order portal](#), or contact your local NXP representative.

11.1.2 Product orientation



Fig 5. Product orientation in carrier tape

11.1.3 Carrier tape dimensions



Not drawn to scale.

Fig 6. Carrier tape dimensions

Table 13. Carrier tape dimensions

In accordance with IEC 60286-3.

| A ₀ (mm) | B ₀ (mm) | K ₀ (mm) | T (mm) | P ₁ (mm) | W (mm) |
|---------------------|---------------------|---------------------|-------------|---------------------|-----------|
| 1.80 ± 0.05 | 2.40 ± 0.05 | 0.45 ± 0.05 | 0.25 ± 0.03 | 4.0 ± 0.10 | 8.0 ± 0.1 |

11.1.4 Reel dimensions

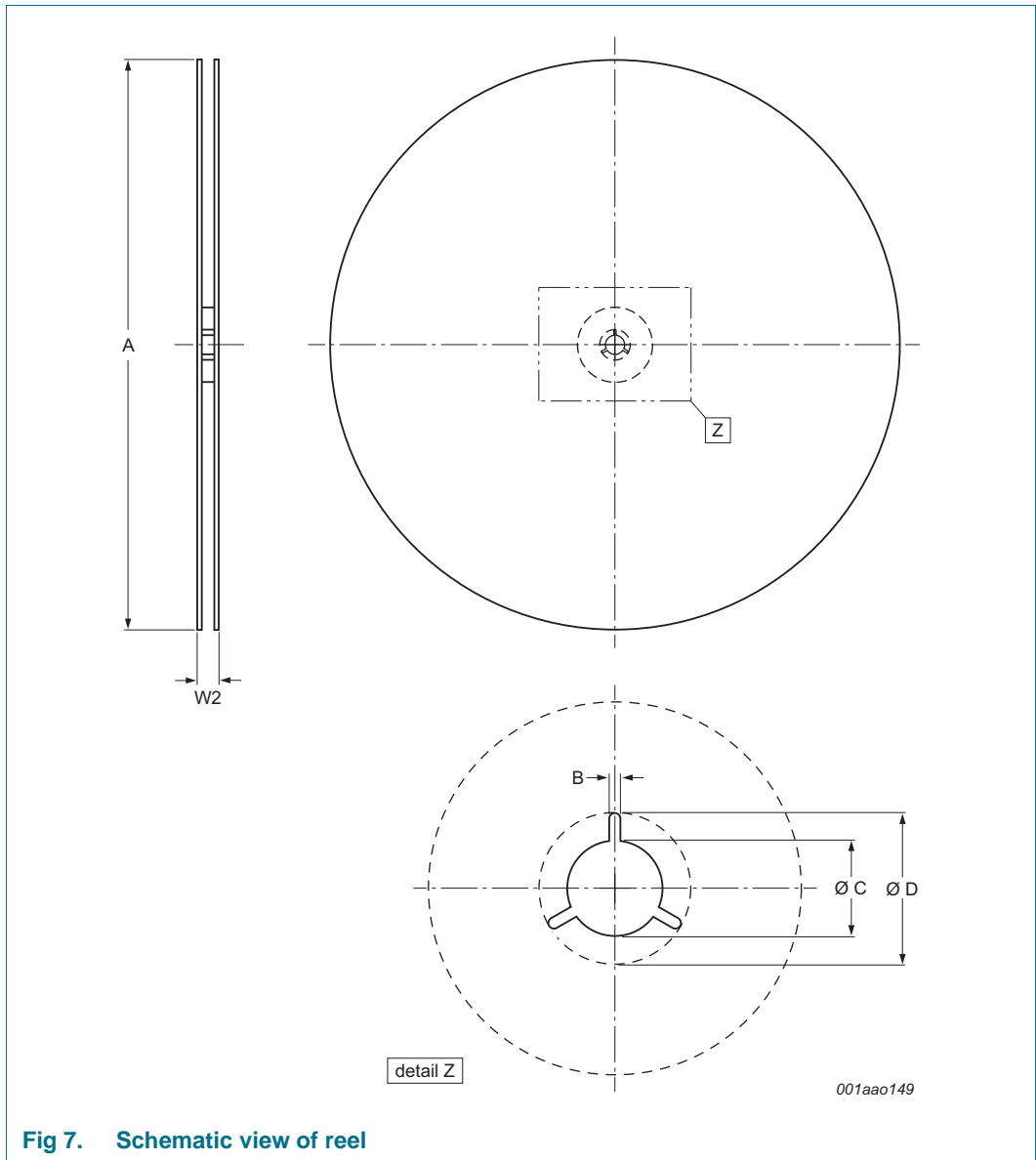


Fig 7. Schematic view of reel

Table 14. Reel dimensions
In accordance with IEC 60286-3.

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

11.1.5 Barcode label

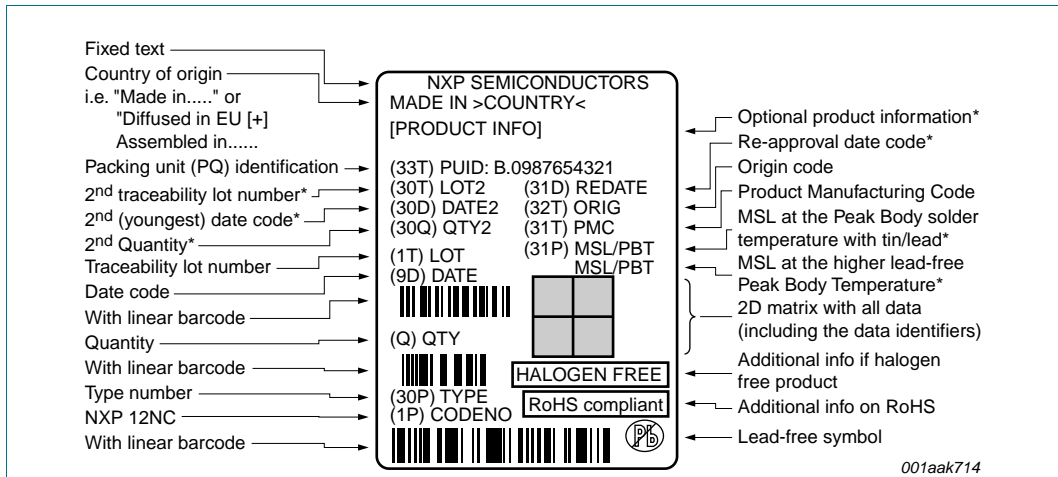


Fig 8. Example of typical box and reel information barcode label

Table 15. Barcode label dimensions

| Box barcode label l × w (mm) | Reel barcode label l × w (mm) |
|---------------------------------|----------------------------------|
| 100 × 75 | 100 × 75 |

12. 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”.

12.1 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.

12.2 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

12.3 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

12.4 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 9](#)) 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 16](#) and [17](#)

Table 16. SnPb eutectic process (from J-STD-020D)

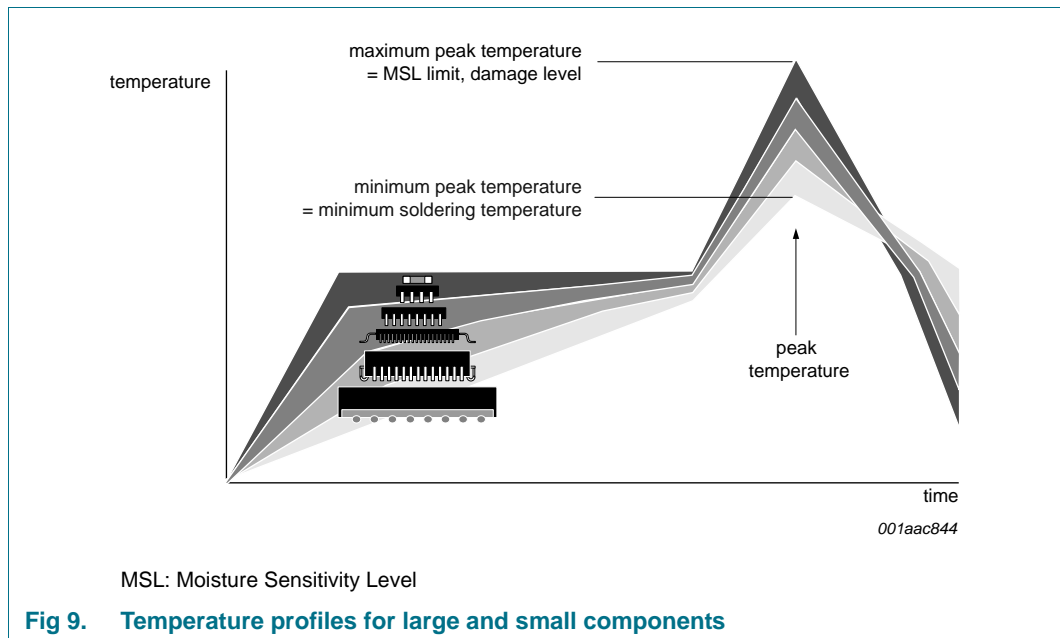
| Package thickness (mm) | Package reflow temperature (°C) | |
|------------------------|---------------------------------|-------|
| | Volume (mm ³) | |
| | < 350 | ≥ 350 |
| < 2.5 | 235 | 220 |
| ≥ 2.5 | 220 | 220 |

Table 17. Lead-free process (from J-STD-020D)

| Package thickness (mm) | Package reflow temperature (°C) | | |
|------------------------|---------------------------------|-------------|--------|
| | Volume (mm ³) | | |
| | < 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 9](#).



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

13. Abbreviations

Table 18. Abbreviations

| Acronym | Description |
|---------|----------------------|
| CDM | Charged Device Model |
| Gbps | Gigabits per second |
| HBM | Human Body Model |

14. Revision history

Table 19. Revision history

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|-----------------|--|--------------------|---------------|-----------------|
| CBTL02GP023 v.2 | 20170814 | Product data sheet | - | CBTL02GP023 v.1 |
| Modifications: | Changed description of switch from "ON/OFF switch" to "5 Gbps rail-to-rail low insertion loss switch" throughout | | | |
| CBTL02GP023 v.1 | 20170601 | Product data sheet | - | - |

15. Legal information

15.1 Data sheet status

| Document status ^{[1][2]} | Product status ^[3] | Definition |
|-----------------------------------|-------------------------------|---|
| Objective [short] data sheet | Development | This document contains data from the objective specification for product development. |
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17. Contents

| | | |
|-----------|--|-----------|
| 1 | General description | 1 |
| 2 | Features and benefits | 1 |
| 3 | Ordering information | 2 |
| 3.1 | Ordering options | 2 |
| 4 | Block diagram | 2 |
| 5 | Pinning information | 3 |
| 5.1 | Pinning | 3 |
| 5.2 | Pin description | 3 |
| 6 | Functional description | 4 |
| 7 | Limiting values | 5 |
| 8 | Recommended operating conditions | 5 |
| 9 | Characteristics | 6 |
| 9.1 | Device general characteristics | 6 |
| 9.2 | Switch channel characteristics | 6 |
| 9.3 | Control signals characteristics | 7 |
| 10 | Package outline | 9 |
| 11 | Packing information | 10 |
| 11.1 | DHX2QFN14; Reel pack, SMD, 13"; Q1/T1 standard product orientation; Orderable part number ending ,431 or Z; Ordering code (12NC) ending 431 | 10 |
| 11.1.1 | Packing method | 10 |
| 11.1.2 | Product orientation | 11 |
| 11.1.3 | Carrier tape dimensions | 11 |
| 11.1.4 | Reel dimensions | 12 |
| 11.1.5 | Barcode label | 13 |
| 12 | Soldering of SMD packages | 13 |
| 12.1 | Introduction to soldering | 13 |
| 12.2 | Wave and reflow soldering | 13 |
| 12.3 | Wave soldering | 14 |
| 12.4 | Reflow soldering | 14 |
| 13 | Abbreviations | 15 |
| 14 | Revision history | 16 |
| 15 | Legal information | 17 |
| 15.1 | Data sheet status | 17 |
| 15.2 | Definitions | 17 |
| 15.3 | Disclaimers | 17 |
| 15.4 | Trademarks | 18 |
| 16 | Contact information | 18 |
| 17 | Contents | 19 |

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