

## CCE4503

### IO-Link Device Transceiver

The CCE4503 is an easy-to-use device side IO-Link compliant transceiver. It combines IO-Link compliant communication capability with advanced protection circuitry and additional features while keeping the application small and simple. Controlled by an UART interface (TXD, RXD, TXEN), the output drivers can be configured as PNP, NPN or Push-Pull. Three LDO options and an automatic wake-up detection simplify the overall system requirements and reduce the need for additional external circuitry. The integrated protection features such as reverse-polarity protection, overcurrent protection, undervoltage detection and thermal protection ensure a robust functionality and communication. With the small 3mm x 3mm DFN10 package size, it is especially suitable for space limited sensor and actuator applications.

### Features

- IO-Link Compliant Transceiver
- One IO-Link channel with up to 250 mA permanent driving current
- 350 mA peak (typ.)
- Configurable PNP-, NPN- and Push-Pull mode
- Configurable current limit
- Configurable slew rate limitation for optimized EMC
- Wake-up detection
- Small DFN 10-pin package
- 3 LDO Options with up to 20 mA
- 3.3V LDO output
- 5V LDO output
- External LDO
- Reverse-polarity protection
- Overcurrent detection
- Undervoltage detection
- Overtemperature detection

### Applications

- IO-Link Sensors
- IO-Link Actuators
- High voltage level shifter
- Industrial automation

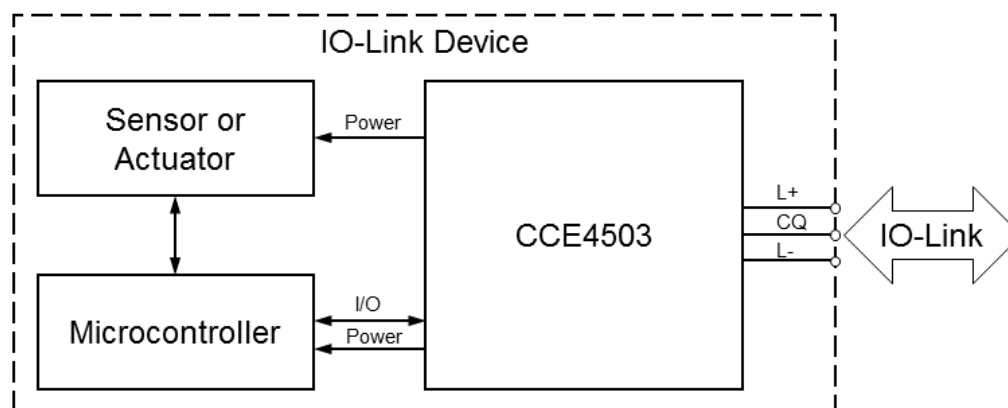


Figure 1. Application Diagram

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## 1. Overview

### 1.1 Block Diagram

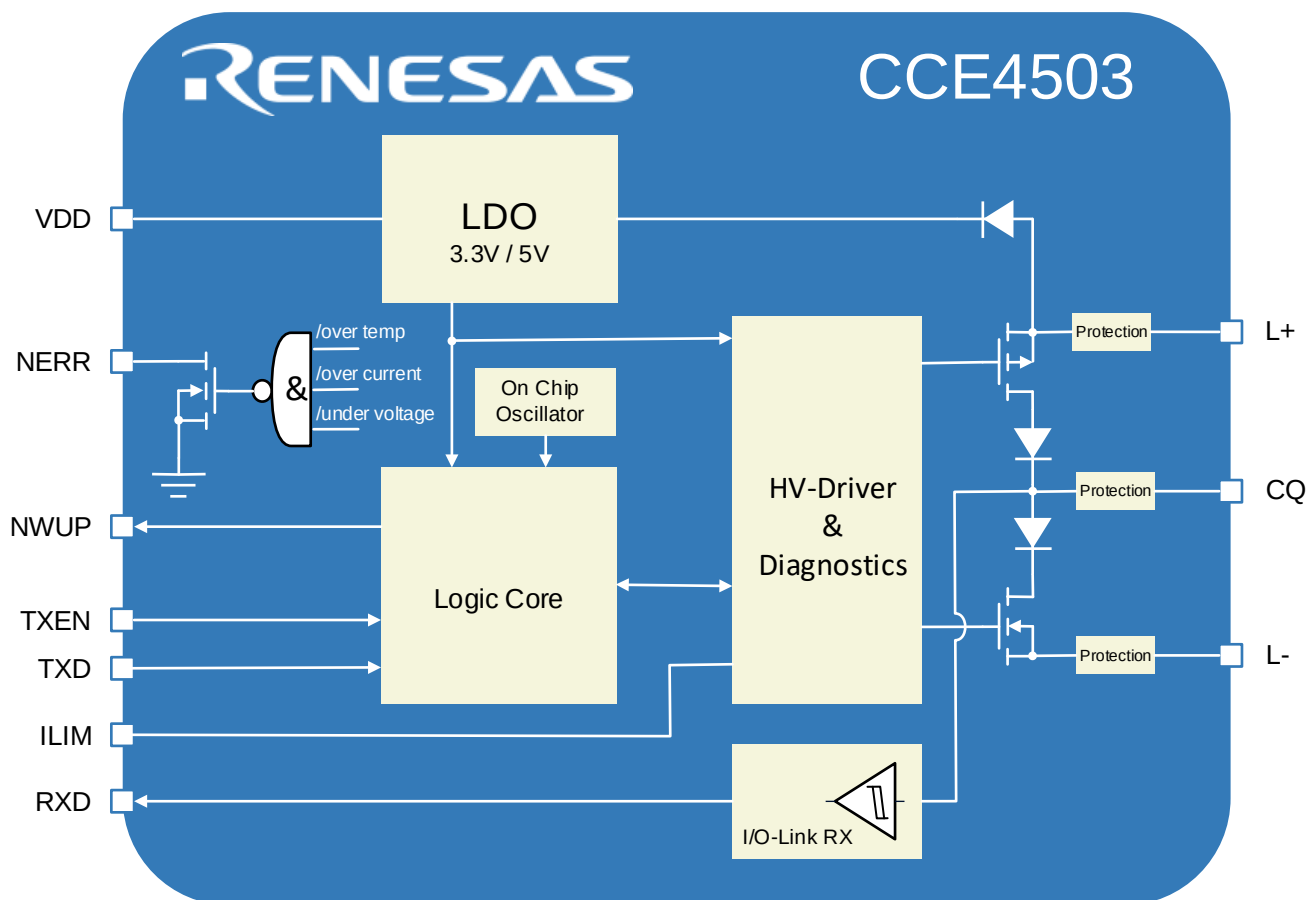


Figure 2: Block Diagram

## 2. Pin Information

### 2.1 Pin Assignment

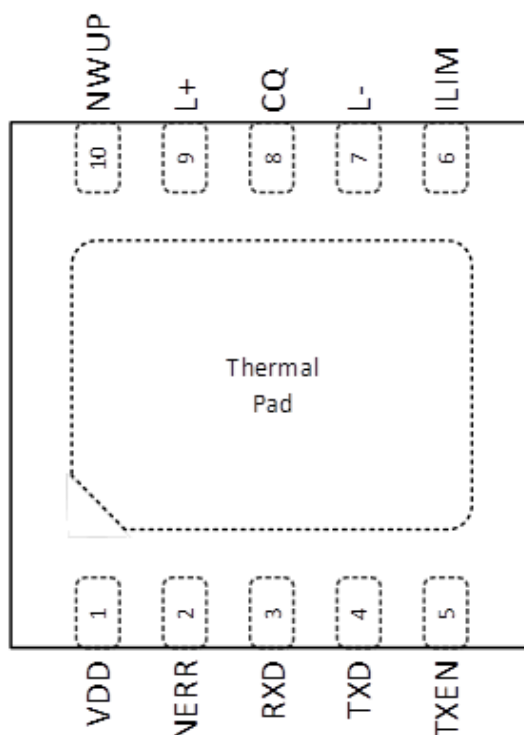


Figure 3: DFN10 Pinout Diagram (Top View)

### 2.2 Pin Descriptions

| Pin Number | Pin Name    | Type   | Rest State | Description                                                                             |
|------------|-------------|--------|------------|-----------------------------------------------------------------------------------------|
| 1          | VDD         | PWR    |            | 3.3V - 5V Supply Voltage Input / Output                                                 |
| 2          | NERR        | OD     | High-Z     | Error Output (Overcurrent detection, Undervoltage detection, Overtemperature detection) |
| 3          | RXD         | DO     |            | Channel signal output                                                                   |
| 4          | TXD         | DI, PU |            | Channel signal input                                                                    |
| 5          | TXEN        | DI, PD |            | Channel driver enable                                                                   |
| 6          | ILIM        | AI     |            | Current Limit configuration                                                             |
| 7          | L-          | PWR    |            | Ground supply (IO-Link)                                                                 |
| 8          | CQ          | DIO    |            | IO-Link data                                                                            |
| 9          | L+          | PWR    |            | Positive supply (IO-Link)                                                               |
| 10         | NWUP        | OD     | High-Z     | Wake-up detection (Channel short detection)                                             |
| PAD        | Thermal Pad | GND    |            | Thermal Pad, connect to VSS or leave open                                               |

## 2.3 Pin Type Definition

| Pin Type | Description                   |
|----------|-------------------------------|
| DI       | Digital input                 |
| DO       | Digital output                |
| DIO      | Digital input/output          |
| OD       | Digital Output open drain     |
| PU       | Pull-up resistor (fixed)      |
| PD       | Pull-down resistor (fixed)    |
| PWR      | Power                         |
| AI       | Analog input                  |
| AO       | Analog output                 |
| AIO      | Analog input/output           |
| BP       | Back drive protection         |
| SPU      | Switchable pull-up resistor   |
| SPD      | Switchable pull-down resistor |
| GND      | Ground                        |

### 3. Characteristics

#### 3.1 Absolute Maximum Ratings

**CAUTION:** Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions can adversely impact product reliability and result in failures not covered by warranty.

| Parameter                  | Conditions                                 | Name                     | Min           | Max            | Unit |
|----------------------------|--------------------------------------------|--------------------------|---------------|----------------|------|
| Supply Voltage             | Static, referenced to $V_{L-}$             | $V_{L+} - V_{L-}$        | -40           | 40             | V    |
| Supply Voltage             | Dynamic ( $t \leq 100 \mu s$ )             | $V_{L+} - V_{L-\_pulse}$ | -42           | 42             | V    |
| Storage Temperature        |                                            | $T_{storage}$            | -55           | +175           | °C   |
| Voltage at pin CQ          | Referenced to $V_{L-}$ : $V_{CQ} - V_{L-}$ | $V_{CQ,max}$             | $V_{L-} - 1V$ | $V_{L+} + 1V$  | V    |
| Voltage at all other pins  | Referenced to $V_{L-}$                     | $V_{IO,max}$             | -0.7          | $V_{DD} + 0.7$ | V    |
| Logic Level Supply Voltage |                                            | $V_{DD,max}$             |               | 6              | V    |
| Output current             | At pin RXD, NWUP, NERR                     | $I_{OutMax}$             | -5            | 5              | mA   |

#### 3.2 ESD Ratings

| ESD Model/Test                                                                        | Rating                | Unit |
|---------------------------------------------------------------------------------------|-----------------------|------|
| Human Body Model (Tested per JS-001-2012 HBM)                                         | 4 (8 <sup>1</sup> )   | kV   |
| ESD Contact Discharge (Tested per IEC61000-4-2) <sup>2</sup>                          | 16                    | kV   |
| Electrical Fast Transient (Burst) (Tested per IEC61000-4-4) <sup>3</sup>              | TBD                   | kV   |
| Surge (Tested per IEC61000-4-5, adapted to 500 $\Omega$ 1.2/50 $\mu s$ ) <sup>4</sup> | 0.8 (5 <sup>5</sup> ) | kV   |
| Latch-Up (Tested per JESD78E; Class 1 & 2)                                            | 100                   | mA   |

<sup>1</sup> Higher Rating for L+, L- and CQ

<sup>2</sup> Valid for L+, L- and CQ

<sup>3</sup> Valid for L+, L- and CQ

<sup>4</sup> Valid for L+, L- and CQ; 100 nF between L+ and L-, 1  $\mu F$  between VDD and GND

<sup>5</sup> Up to 5 kV with TVS Diodes (e.g. SMAJ33A) connected between L+, L- and CQ (higher Voltages have not been tested)

### 3.3 Recommended Operating Conditions

| Parameter                  | Conditions                                                    | Pin  | Name                | Min             | Typ | Max             | Unit |
|----------------------------|---------------------------------------------------------------|------|---------------------|-----------------|-----|-----------------|------|
| Main Supply Voltage        |                                                               | 7, 9 | V <sub>L+</sub>     | 7               |     | 36              | V    |
| Supply Voltage Ripple      | F <sub>ripple</sub> = DC ... 100kHz<br>V <sub>L+</sub> > 12 V | 9    | ΔV <sub>L+</sub>    |                 |     | 1               | V    |
| Voltage CQ                 | Receiver mode                                                 | 8    | V <sub>CQ_MAX</sub> | V <sub>L-</sub> |     | V <sub>L+</sub> | V    |
| Logic Level Supply Voltage | External Supply                                               | 1    | VDD                 | 3               |     | 5.5             | V    |
| Operating Temperature      | Ambient temperature                                           |      | T <sub>amb</sub>    | -40             |     | +125            | °C   |
| Junction Temperature       |                                                               |      | T <sub>j</sub>      | -40             |     | +150            | °C   |
| LDO Output Current         | 3.3V LDO or 5V LDO                                            | 1    | I <sub>VDD</sub>    |                 |     | 20              | mA   |
| ILIM External Resistor     | To L-                                                         | 6    | R <sub>ILIM</sub>   | 0               |     | 100             | kΩ   |
| LDO External Capacitor     | To L-                                                         | 1    | C <sub>LDO</sub>    | 0.8             | 1   | 1.2             | μF   |

### 3.4 Electrical Characteristics

The electrical parameters are valid for the entire range of operating conditions as specified under 3.3 “Recommended Operating conditions” unless noted otherwise.

#### 3.4.1. Input / Output CQ

| Parameter                          | Conditions                                                     | Pin | Name                | Min                   | Typ         | Max             | Unit |
|------------------------------------|----------------------------------------------------------------|-----|---------------------|-----------------------|-------------|-----------------|------|
| Output voltage low level           | active pull down,<br>I <sub>OL</sub> = -200mA                  | 8   | V <sub>OL</sub>     | 0                     |             | 1.5             | V    |
| Output voltage high level          | active pull up,<br>I <sub>OH</sub> = +200mA                    | 8   | V <sub>OH</sub>     | V <sub>L+</sub> - 1.5 |             | V <sub>L+</sub> | V    |
| Leakage current                    | input enabled<br>0 ≤ V <sub>CQ</sub> ≤ V <sub>L+</sub> - 0.1 V | 8   | I <sub>leak</sub>   | -2                    |             | 2               | μA   |
| Maximum Permanent Output Current   | Current of CQ channel                                          | 8   | I <sub>CQmax</sub>  | -250                  |             | 250             | mA   |
| Output source current limit        | R <sub>ILIM</sub> = 0 or hZ<br>R <sub>ILIM</sub> = 100 kΩ      | 8   | I <sub>limP</sub>   | 300<br>35             | 350<br>50   | 400<br>70       | mA   |
| Output sink current limit          | R <sub>ILIM</sub> = 0 or hZ<br>R <sub>ILIM</sub> = 100 kΩ      | 8   | I <sub>limN</sub>   | -400<br>-70           | -350<br>-50 | -300<br>-35     | mA   |
| Load capacitance                   |                                                                | 8   | C <sub>L</sub>      |                       |             | 5               | nF   |
| Output rise/fall time (20% to 80%) | Open load, R <sub>ILIM</sub> = 0 or hZ                         | 8   | t <sub>r,f</sub>    |                       |             | 869             | ns   |
| Switch On Time                     |                                                                | 8   | t <sub>DLY_LH</sub> |                       |             | 4               | μs   |

|                                                  |            |   |                        |      |       |      |    |
|--------------------------------------------------|------------|---|------------------------|------|-------|------|----|
| Switch Off Time                                  |            | 8 | t <sub>DLY_HL</sub>    |      |       | 4    | μs |
| Short circuit detection time                     |            | 8 | T <sub>SHORT</sub>     |      |       | 300  | μs |
| Short circuit disable time                       | RILIM ≠ hZ | 8 | T <sub>SHORT_DIS</sub> |      | 15    |      | ms |
| Wake-up detection time start                     |            | 8 | T <sub>WAKE_S</sub>    | 38   | 56    | 70   | μs |
| Wake-up detection time end                       |            | 8 | T <sub>WAKE_E</sub>    | 89   | 112   | 150  | μs |
| Wake-up detection time delay                     |            | 8 | T <sub>WAKE_D</sub>    |      |       | 150  | μs |
| Input threshold high level                       |            | 8 | V <sub>IH</sub>        | 10.5 | 11.75 | 13   | V  |
| Input threshold low level                        |            | 8 | V <sub>IL</sub>        | 8    | 9.75  | 11.5 | V  |
| Hysteresis between input thresholds high and low |            | 8 | V <sub>Hyst</sub>      |      | 2     |      | V  |

### 3.4.2. Digital I/O

| Parameter               | Conditions                   | Pin      | Name               | Min       | Typ | Max       | Unit |
|-------------------------|------------------------------|----------|--------------------|-----------|-----|-----------|------|
| <b>Input</b>            |                              |          |                    |           |     |           |      |
| Input Voltage LOW       |                              | 4, 5     | V <sub>IN_L</sub>  |           |     | 0.3 * VDD | V    |
| Input Voltage HIGH      |                              | 4, 5     | V <sub>IN_H</sub>  | 0.7 * VDD |     |           | V    |
| Input Pull-Up current   | V <sub>pin</sub> =0V         | 4, 5     | I <sub>PU</sub>    | 4         | 30  | 110       | μA   |
| Input Pull-Down current | V <sub>pin</sub> = VDD       | 4, 5     | I <sub>PD</sub>    | -110      | -30 | -4        | μA   |
| <b>Output</b>           |                              |          |                    |           |     |           |      |
| Output Voltage LOW      | I <sub>OUT_LOW</sub> = 2 mA  | 2, 3, 10 | V <sub>OUT_L</sub> |           |     | 0.4       | V    |
| Output Voltage HIGH     | I <sub>OUT_HIGH</sub> = 2 mA | 3        | V <sub>OUT_H</sub> | 0.8 * VDD |     |           | V    |



### 3.4.3. 3.3V / 5V Voltage Regulator

| Parameter                                       | Conditions                                          | Pin | Name                | Min | Typ | Max | Unit |
|-------------------------------------------------|-----------------------------------------------------|-----|---------------------|-----|-----|-----|------|
| Output Voltage VDD                              | 3.3V Regulator                                      | 1   | VDD <sub>3V3</sub>  | 3.0 | 3.3 | 3.6 | V    |
|                                                 | 5V Regulator                                        | 1   | VDD <sub>5V</sub>   | 4.5 | 5   | 5.5 | V    |
| Voltage Drop                                    | Load Current = 20 mA                                | 1   | V <sub>DO</sub>     |     |     | 2   | V    |
| Output Current VDD                              |                                                     | 1   | I <sub>VDD</sub>    |     |     | 20  | mA   |
| Line regulation                                 | I <sub>OUT</sub> = 1 mA<br>V <sub>L+</sub> = 24 V   | 1   | REG                 |     |     | 2   | mV/V |
| Load regulation                                 | DC current up to 20 mA<br>V <sub>L+</sub> = 24 V    | 1   |                     |     |     | 1   | %    |
| Power Supply rejection ratio                    | 100 kHz, I <sub>OUT</sub> = 20 mA                   | 1   | PSRR                | 40  |     |     | dB   |
| Power-On Threshold                              | Only applies to the driver without LDO (CCE4503-0V) | 1   | V <sub>RST</sub>    | 2.7 |     | 3.0 | V    |
| Undervoltage lockout voltage (V <sub>L+</sub> ) |                                                     | 1   | V <sub>L+,min</sub> |     | 6   |     | V    |
| Undervoltage lockout voltage (V <sub>DD</sub> ) |                                                     | 1   | V <sub>DD,min</sub> |     |     | 3   | V    |
| Start-up time                                   |                                                     | 1   |                     |     |     | 5   | μs   |

## 3.5 Thermal Characteristics

| Parameter            | Description                              | Conditions | Min | Typ | Max | Unit |
|----------------------|------------------------------------------|------------|-----|-----|-----|------|
| T <sub>ALARM_H</sub> | Alarm temperature (higher threshold)     |            | 150 | 165 | 180 | °C   |
| T <sub>ALARM_L</sub> | Alarm temperature (lower threshold)      |            | 140 | 155 | 170 | °C   |
| T <sub>WARNING</sub> | Warning temperature (higher threshold)   |            | 125 | 140 | 155 | °C   |
| R <sub>θja</sub>     | Thermal resistance (junction to ambient) |            |     |     | 30  | K/W  |

## 4. Electrical Specifications

CCE4503 is a fully reverse polarity protected IO-Link device transceiver with one IO-Link channel. The system consists of a high voltage output stage with integrated overcurrent protection, a high voltage input stage with a spike-tolerant filter, a logic core with UART interface, an internal oscillator and an optional LDO. The LDO output voltage is factory programmed and needs to be specified with the order. To simplify the IO-Link protocol handling, a wake-up detection and automatic recovery function are implemented. Additional advanced protection features such as overtemperature detection and undervoltage detection ensure robust functionality in industrial applications. All pins are ESD-protected.

## 4.1 Output Stage

The output stage switches the output transistors in regard to TXD and TXEN. In IO-Link mode or Push-Pull mode TXEN is used to enable or disable the output stage. If TXEN is set high, the output stage is enabled and the output of CQ can be controlled by TXD (inverted). If TXEN is set low, the output stage is disabled and put into an inactive low-power state. RXD always reflects the current inverted state of CQ.

TXEN and TXD can also be used to configure the device in NPN, PNP and Push-Pull mode. See Table 1. NPN mode can be configured by setting TXD high and using TXEN as control pin. PNP mode can be configured by setting TXD low and using TXEN as control pin.

**Table 1. Output stage truth table**

| Mode                                          | TXEN | TXD | CQ     |
|-----------------------------------------------|------|-----|--------|
| IO-Link<br>(regular operation)<br>/ Push-Pull | 0    | 0   | High-Z |
|                                               | 0    | 1   | High-Z |
|                                               | 1    | 0   | 1      |
|                                               | 1    | 1   | 0      |
| NPN                                           | 0    | 1   | High-Z |
|                                               | 1    | 1   | 0      |
| PNP                                           | 0    | 0   | High-Z |
|                                               | 1    | 0   | 1      |

## 4.2 Current limit and slew rate configuration

The driver slew rate as well as the current limit is configured by a resistor  $R_{ILIM}$  connected to ILIM. The value of the resistor intended for configuration is specified between  $0\Omega$  and  $100\text{ k}\Omega$ , where a lower resistor value leads to faster switching and higher maximum currents. The automatic recovery function is only available for  $R_{ILIM} < 1\text{ M}\Omega$ .

**Table 2: Current limit and slew rate configuration**

| Resistor                               | Current limit  | Slew rate   | Automatic recovery |
|----------------------------------------|----------------|-------------|--------------------|
| $0\Omega - 100\text{ k}\Omega$         | 350 mA - 50 mA | Fast - slow | Yes                |
| Open ( $R_{ILIM} > 4\text{ M}\Omega$ ) | 350 mA         | Fast        | No                 |

Note: If ILIM is left open ( $R_{ILIM} > 4\text{ M}\Omega$ ) the output driver operates as if connected to VSS ( $R_{ILIM} = 0\Omega$ ), but with automatic recovery disabled.

### 4.3 Automatic Recovery

If a short is detected, the output stage is automatically disabled after the time  $t_{\text{SHORT}}$ . The automatic recovery function enables the output again after  $t_{\text{SHORT\_DIS}}$  and checks if the overcurrent is still present (see Figure 4).

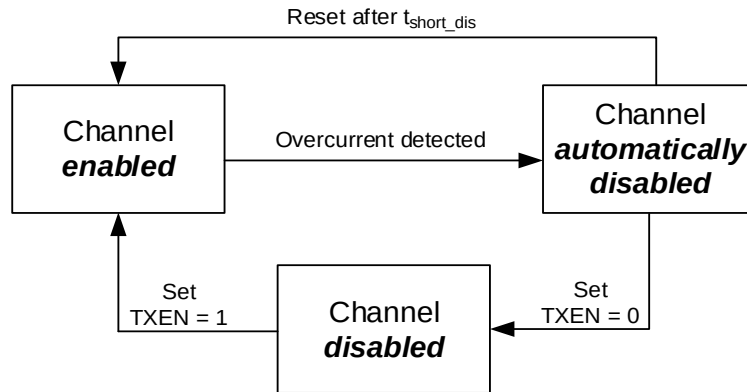


Figure 4: Automatic recovery

### 4.4 Wake-up detection

An overcurrent pulse of  $t_{\text{WAKE}}$  will be detected as wake-up pulse. When a wake-up pulse is detected, the output of NWUP will switch from high impedance to low until TXEN is toggled by the microcontroller.

An overcurrent pulse  $> t_{\text{WAKE}}$  will be detected as overcurrent fault condition.

An overcurrent pulse  $< t_{\text{WAKE}}$  will not be detected.

### 4.5 Error output handling

The error output NERR combines the indication of three error sources and will be tied low if any fault condition is detected. The following error sources are indicated by NERR:

- Overtemperature
- Undervoltage
- Overcurrent

The overtemperature and undervoltage detections are combinational outputs and keep the NERR signal low as long as the error is present. The overcurrent detection is latched and will be reset when the CCE4503 leaves the transmit mode (TXEN = 0).

### 4.6 Overtemperature detection

The overtemperature detection detects 3 thresholds:

- At  $T_{\text{WARNING}}$  the output of NERR will be tied low. This is a combinational signal and cannot be reset by the MCU. It will be reset once the temperature drops below  $T_{\text{WARNING}}$ .
- At  $T_{\text{ALARM\_H}}$ , the chip will switch off the outputs. This cannot be reset by the MCU.
- When the temperature drops again below  $T_{\text{ALARM\_L}}$ , the output is released and can be controlled by TXEN and TXD.

## 4.7 Allowed Reverse polarity connections

The CCE4503 is designed to handle all possible permutations of reverse polarity.

## 5. Package Information

### 5.1 Package Outlines

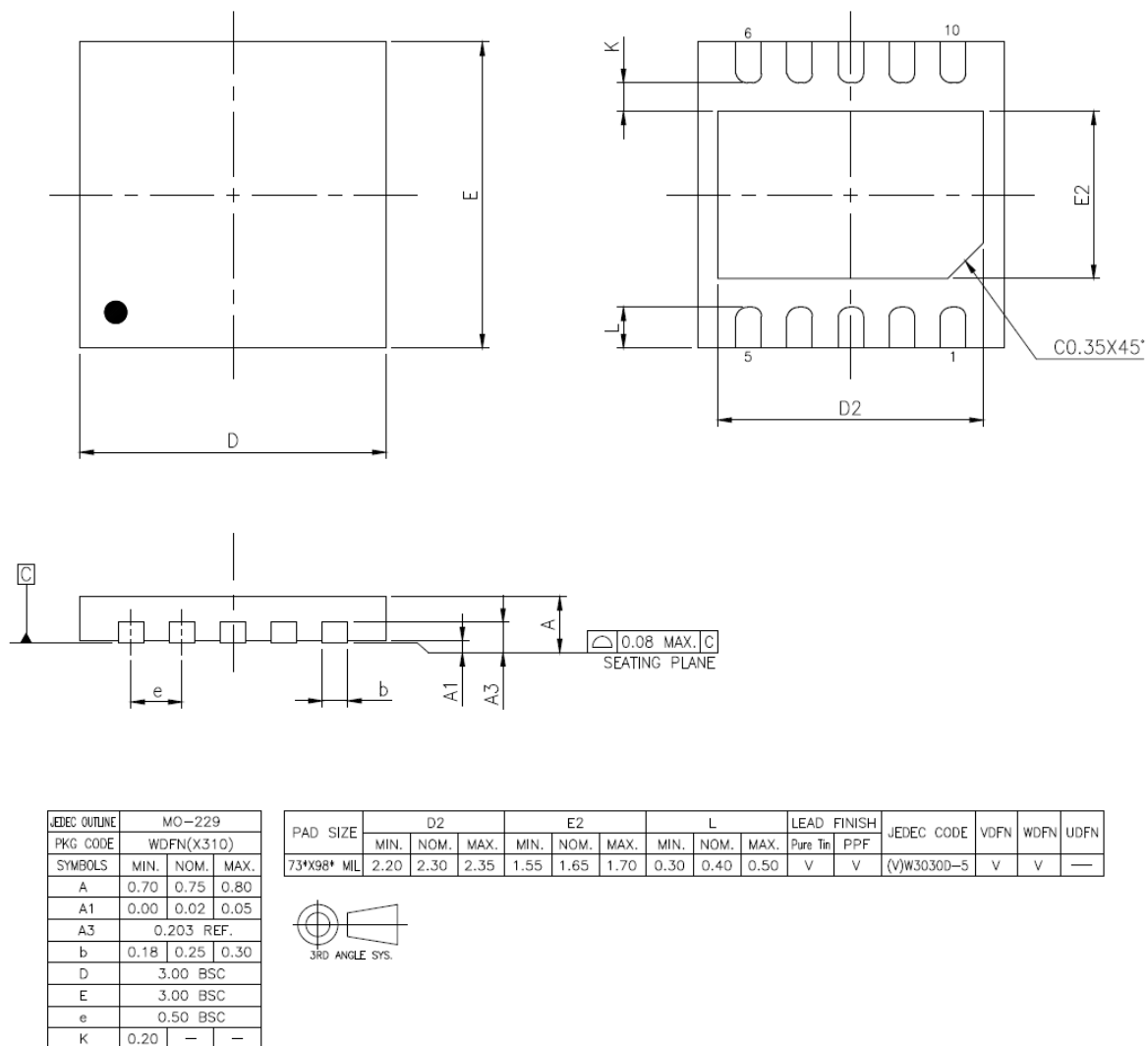


Figure 5: DFN10 Package Outline Drawing

## 5.2 Tape and Reel Information

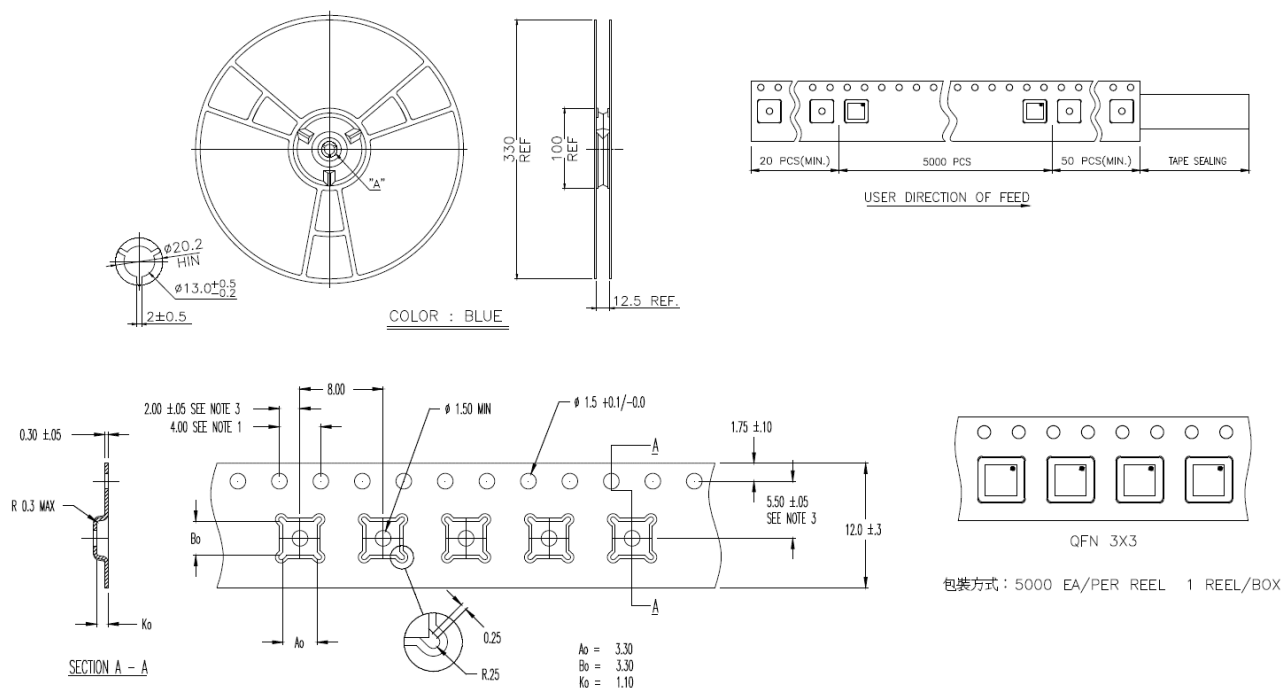


Figure 6: Tape and Reel Information

## 5.3 Soldering Information

Refer to the IPC/JEDEC standard J-STD-020 for relevant soldering information. This document can be downloaded from <http://www.jedec.org>.

## 6. Ordering Information

The ordering number consists of the part number followed by a suffix (shown as "xx") indicating the LDO option. For details and availability, please consult your Renesas Electronics [local sales representative](#).

Table 3: Ordering Information

| Part Number    | Package | Size (mm) | Shipment Form | Pack Quantity |
|----------------|---------|-----------|---------------|---------------|
| CCE4503 xx LDO | DFN10   | 3 x 3     | T&R           | 4000          |

### Part Number Legend:

**CCE4503** **3V** **LDO**

→ VDD output Voltage  
 0V – external LDO  
 3V – 3.3V LDO  
 5V – 5V LDO

## 7. Application Information

The CCE4503 may need to be connected to some external components depending on the desired operating environment:

- If an LDO is selected (5V or 3.3V), a 1  $\mu$ F capacitor from VDD to L- must be provided by the customer
- Outputs NERR and NWUP are open-drain outputs. Usually, the internal pull-up resistors of the MCU can be used. If no pull-up resistors can be configured, the customer needs to connect external resistors.
- A resistor RLIM may be used to set the overcurrent limit and slew rate. For maximum slew rate and overcurrent limit, the pin can be connected to VSS or left open.

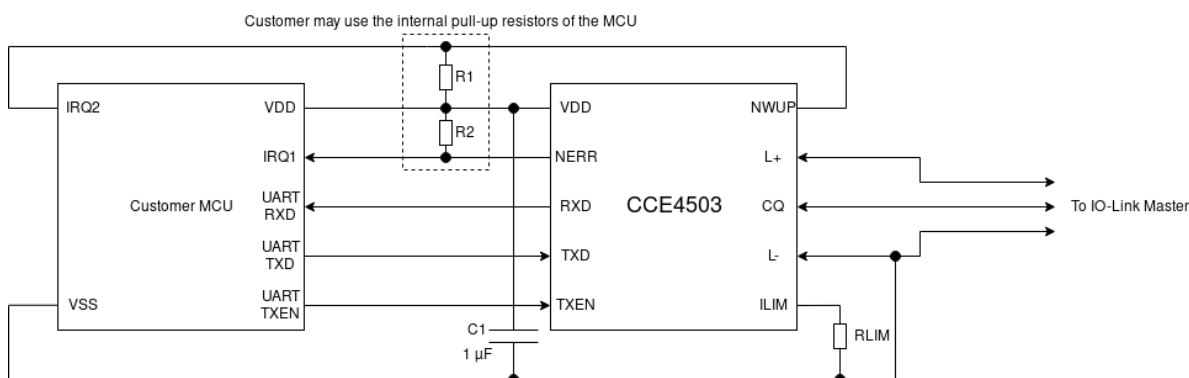


Figure 7: CCE4503 application

## 8. Revision History

| Revision | Date        | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|----------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2.8      | 04-Jan-2024 | Moved Operating Temperature from Absolute Maximum Ratings to Recommended Operating Conditions<br>Moved Junction Temperature from Absolute Maximum Ratings to Recommended Operating Conditions                                                                                                                                                                                                                                                                                                                         |
| 2.7      | 15-Dez-2023 | Added information about RXD in Output Stage<br>Updated Voltage at pin CQ in Recommended Operating Conditions<br>Updated Wake-up detection time $T_{WAKE}$ in Input / Output CQ<br>Changed specification for $V_{OUT\_L}$ , $V_{OUT\_H}$ , $V_{IN\_L}$ , $V_{IN\_H}$ , $I_{PU}$ in Digital I/O<br>Removed inductive load from Input / Output CQ<br>Removed voltage limitation from condition of LDO output current in Recommended Operating Conditions<br>Changed Tape and Reel Information (change of pin 1 location) |
| 2.6      | 09-May-2023 | Corrected part naming<br>Updated Absolut Maximum Ratings<br>Updated ESD Ratings                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 2.5      | 25-Jan-2023 | Corrected formatting of document<br>Added Chapter ESD Ratings                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 2.4      | 06-Dec-2022 | Updated to Renesas<br>Added Tape and Reel Information                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 2.3      | 23-Jul-2020 | Changed Ordering Information                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 2.2      | 27-May-2020 | Corrected Electrical Characteristics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 2.1      | 26-May-2020 | Corrected Electrical Characteristics<br>Added Errata sheet note                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 2.0      | 20-Feb-2020 | Initial version. Preliminary                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |



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