

4-Bit Bidirectional Voltage-Level Translator for Open-Drain and Push-Pull Applications

1 FEATURES

- **Qualified for Automotive Applications**
- **AEC-Q100 Qualified with the Grade 1**
- **No Direction-Control**
- **Data Rates**
24Mbps (Push-Pull)
2Mbps (Open-Drain)
- **1.65V to 5.5V on A ports and 2.3V to 5.5V on B Ports ($V_{CCA} \leq V_{CCB}$)**
- **V_{CC} Isolation: If Either V_{CC} is at GND, Both Ports are in the High-Impedance State**
- **No Power-Supply Sequencing Required: Either V_{CCA} or V_{CCB} can be Ramped First**
- **I_{OFF} : Supports Partial-Power-Down Mode Operation**
- **Extended Temperature: -40°C to +125°C**

2 APPLICATIONS

- **Automotive Infotainment**
- **Advance Driver Assistance Systems (ADAS)**
- **Telematics**

3 DESCRIPTIONS

This 4-bit non-inverting translator is a bidirectional voltage-level translator and can be used to establish digital switching compatibility between mixed-voltage systems. It uses two separate configurable power-supply rails, with the A ports supporting operating voltages from 1.65V to 5.5V while it tracks the V_{CCA} supply, and the B ports supporting operating voltages from 2.3V to 5.5V while it tracks the V_{CCB} supply. This allows the support of both lower and higher logic signal levels while providing bidirectional translation capabilities between any of the 1.8V, 2.5V, 3.3V and 5V voltage nodes.

When the output-enable (OE) input is low, all I/Os are placed in the high-impedance state, which significantly reduces the power-supply quiescent current consumption. OE has an internal pull-down current source, as long as V_{CCA} is powered.

To ensure the high-impedance state during power up or power down, OE should be tied to GND through a pull-down resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

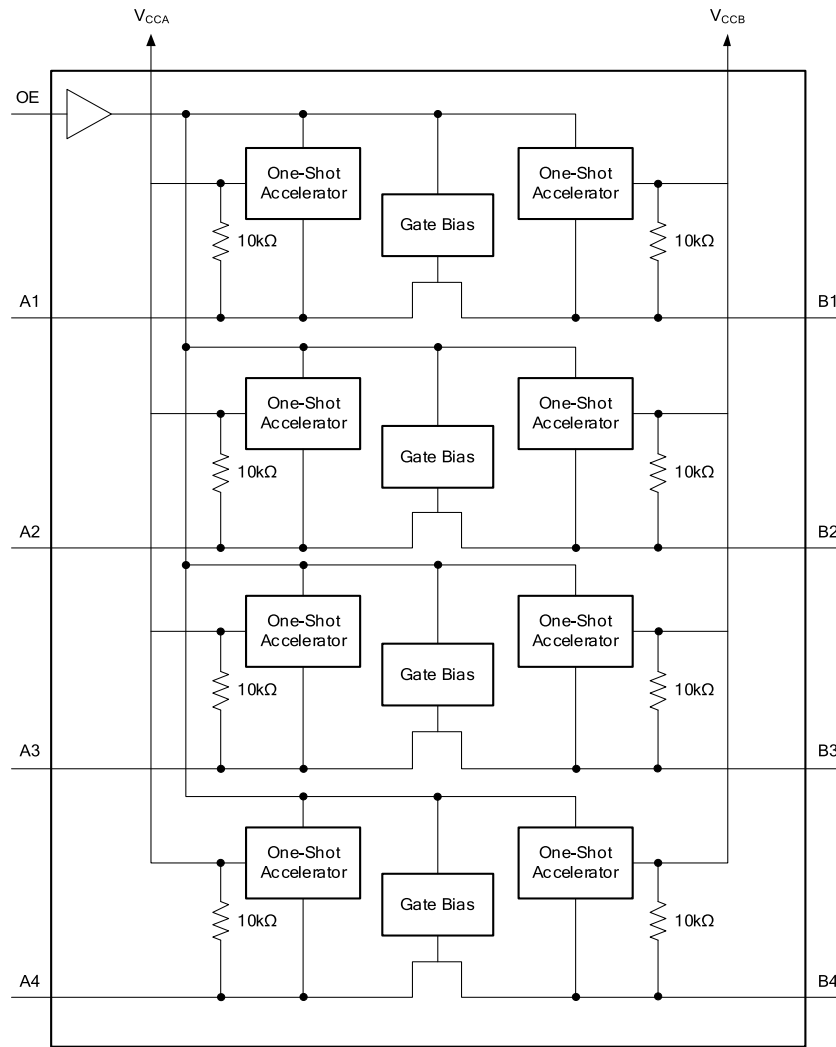
The RS0104-Q1 is available in Green QFN2x1.7-12L and TSSOP-14 packages. It operates over an ambient temperature range of -40°C to +125°C.

Device Information (1)

| PART NUMBER | PACKAGE | BODY SIZE (NOM) |
|-------------|--------------|-----------------|
| RS0104-Q1 | QFN2x1.7-12L | 2.00mmx1.70mm |
| | TSSOP-14 | 5.00mmx4.40mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

4 Functional Block Diagram



Block Diagram

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5 Revision History

Note: Page numbers for previous revisions may differ from page numbers in the current version.

| VERSION | Change Date | Change Item |
|---------|-------------|-------------------------------|
| A.0 | 2022/09/14 | Preliminary version completed |
| A.1 | 2023/06/15 | Initial version completed |

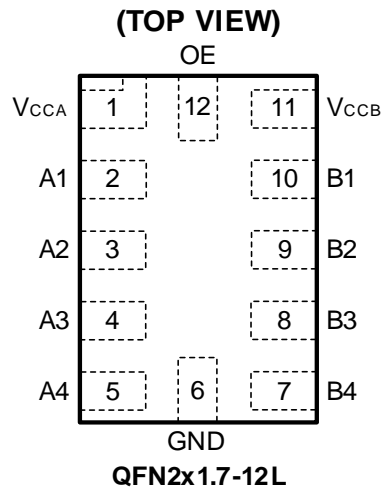
6 PACKAGE/ORDERING INFORMATION (1)

| PRODUCT | ORDERING NUMBER | TEMPERATURE RANGE | PACKAGE LEAD | Lead finish/Ball material (2) | MSL Peak Temp (3) | PACKAGE MARKING (4) | PACKAGE OPTION |
|---------------|----------------------|-------------------|------------------|-------------------------------|-------------------------|---------------------|-----------------------|
| RS0104 -Q1 | RS0104XU TQH12-Q1 | -40°C ~+125°C | QFN2x1.7- 12L | NIPDAUAG | MSL1-260°- Unlimited | 0104 | Tape and Reel,4000 |
| | RS0104XQ -Q1 | -40°C ~+125°C | TSSOP-14 | NIPDAUAG | MSL1-260°- Unlimited | RS0104 | Tape and Reel,4000 |

NOTE:

- (1) This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the right-hand navigation.
- (2) Lead finish/Ball material. Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.
- (3) MSL Peak Temp. The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.
- (4) There may be additional marking, which relates to the lot trace code information (data code and vendor code), the logo or the environmental category on the device.

7 PIN CONFIGURATIONS

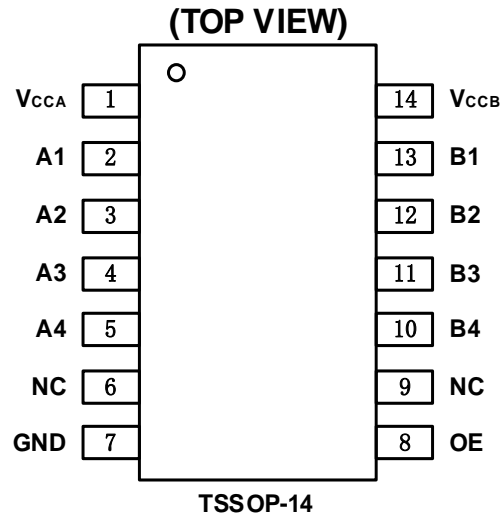


PIN DESCRIPTION

| PIN | NAME | TYPE ⁽¹⁾ | FUNCTION |
|--------------|------------------|---------------------|---|
| QFN2x1.7-12L | | | |
| 1 | V _{CCA} | P | A Port Supply Voltage. $1.65V \leq V_{CCA} \leq 5.5V$ and $V_{CCA} \leq V_{CCB}$. |
| 2 | A1 | I/O | Input/output A1. Reference to V _{CCA} . |
| 3 | A2 | I/O | Input/output A2. Reference to V _{CCA} . |
| 4 | A3 | I/O | Input/output A3. Reference to V _{CCA} . |
| 5 | A4 | I/O | Input/output A4. Reference to V _{CCA} . |
| 6 | GND | – | Ground. |
| 7 | B4 | I/O | Input/output B4. Reference to V _{CCB} . |
| 8 | B3 | I/O | Input/output B3. Reference to V _{CCB} . |
| 9 | B2 | I/O | Input/output B2. Reference to V _{CCB} . |
| 10 | B1 | I/O | Input/output B1. Reference to V _{CCB} . |
| 11 | V _{CCB} | P | B Ports Supply Voltage. $2.3V \leq V_{CCB} \leq 5.5V$. |
| 12 | OE | I | Output Enable (Active High). Pull OE low to place all outputs in 3-state mode. Referenced to V _{CCA} . |

(1) I=input, O=output, I/O=input and output, P=power

PIN CONFIGURATIONS



PIN DESCRIPTION

| PIN | NAME | TYPE ⁽¹⁾ | FUNCTION |
|----------|------------------|---------------------|---|
| TSSOP-14 | | | |
| 1 | V _{CCA} | P | A Port Supply Voltage. $1.65V \leq V_{CCA} \leq 5.5V$ and $V_{CCA} \leq V_{CCB}$ |
| 2 | A1 | I/O | Input/output A1. Reference to V _{CCA} . |
| 3 | A2 | I/O | Input/output A2. Reference to V _{CCA} . |
| 4 | A3 | I/O | Input/output A3. Reference to V _{CCA} . |
| 5 | A4 | I/O | Input/output A4. Reference to V _{CCA} . |
| 6 | NC | - | No internal connection. |
| 7 | GND | — | Ground. |
| 8 | OE | I | Output Enable (Active High). Pull OE low to place all outputs in 3-state mode. Referenced to V _{CCA} . |
| 9 | NC | - | No internal connection. |
| 10 | B4 | I/O | Input/output B4. Reference to V _{CCB} . |
| 11 | B3 | I/O | Input/output B3. Reference to V _{CCB} . |
| 12 | B2 | I/O | Input/output B2. Reference to V _{CCB} . |
| 13 | B1 | I/O | Input/output B1. Reference to V _{CCB} . |
| 14 | V _{CCB} | P | B Ports Supply Voltage. $2.3V \leq V_{CCB} \leq 5.5V$. |

(1) I=input, O=output, I/O=input and output, P=power

8 SPECIFICATIONS

8.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted) ⁽¹⁾

| SYMBOL | PARAMETER | | MIN | MAX | UNIT |
|----------------------------------|--|-------------------|------|-----------------------|------|
| V _{CCA} | Supply Voltage Range | | -0.3 | 6.0 | V |
| V _{CCB} | Supply Voltage Range | | -0.3 | 6.0 | V |
| V _I ⁽²⁾ | Input Voltage Range | A port | -0.3 | 6.0 | V |
| | | B port | -0.3 | 6.0 | |
| | | OE | -0.3 | 6.0 | |
| V _O ⁽²⁾ | Voltage range applied to any output in the high-impedance or power-off state | A port | -0.3 | 6.0 | V |
| | | B port | -0.3 | 6.0 | |
| V _O ⁽²⁾⁽³⁾ | Voltage range applied to any output in the high or low state | A port | -0.3 | V _{CCA} +0.3 | V |
| | | B port | -0.3 | V _{CCB} +0.3 | |
| I _{IK} | Input clamp current | V _I <0 | | -50 | mA |
| I _{OK} | Output clamp current | V _O <0 | | -25 | mA |
| I _O | Continuous output current | | | ±50 | mA |
| | Continuous current through V _{CCA} , V _{CCB} or GND | | | ±100 | mA |
| T _J | Junction Temperature ⁽⁴⁾ | | -40 | 150 | °C |
| T _{stg} | Storage temperature | | -65 | +150 | |

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) The input and output negative-voltage ratings may be exceeded if the input and output current ratings are observed.

(3) The value of V_{CCA} and V_{CCB} are provided in the recommended operating conditions table.

(4) The maximum power dissipation is a function of T_{J(MAX)}, R_{θJA}, and T_A. The maximum allowable power dissipation at any ambient temperature is P_D = (T_{J(MAX)} - T_A) / R_{θJA}. All numbers apply for packages soldered directly onto a PCB.

8.2 ESD Ratings

The following ESD information is provided for handling of ESD-sensitive devices in an ESD protected area only.

| | | | VALUE | UNIT |
|--------------------|-------------------------|---|-------|------|
| V _(ESD) | Electrostatic discharge | Human-Body Model (HBM), per AEC Q100-002 ⁽¹⁾ | ±2000 | V |
| | | Charged-Device Model (CDM), per AEC Q100-011 | ±1000 | |
| | | Latch-Up (LU), per AEC Q100-004 | ±100 | mA |

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.



ESD SENSITIVITY CAUTION

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

8.3 Recommended Operating Conditions

V_{CCI} is the supply voltage associated with the input port. V_{CCO} is the supply voltage associated with the output port.

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|----------------------------------|--|----------------------|-----|-----------------------|------|
| Supply voltage ⁽¹⁾ | V_{CCA} | | 1.65 | | 5.5 | V |
| | V_{CCB} | | 2.3 | | 5.5 | |
| High-level input voltage (V_{IH}) | A-port I/Os | $V_{CCA} = 1.65\text{ V to }1.95\text{ V}$ $V_{CCB} = 2.3\text{ V to }5.5\text{ V}$ | $V_{CCI} - 0.2$ | | V_{CCI} | V |
| | | $V_{CCA} = 2.3\text{ V to }5.5\text{ V}$ $V_{CCB} = 2.3\text{ V to }5.5\text{ V}$ | $V_{CCI} - 0.4$ | | V_{CCI} | V |
| | B-port I/Os | $V_{CCA} = 1.65\text{ V to }5.5\text{ V}$ $V_{CCB} = 2.3\text{ V to }5.5\text{ V}$ | $V_{CCI} - 0.4$ | | V_{CCI} | V |
| | OE input | $V_{CCA} = 1.65\text{ V to }5.5\text{ V}$ $V_{CCB} = 2.3\text{ V to }5.5\text{ V}$ | $V_{CCA} \times 0.8$ | | 5.5 | V |
| Low-level input voltage (V_{IL}) | A-port I/Os | $V_{CCA} = 1.65\text{ V to }5.5\text{ V}$ $V_{CCB} = 2.3\text{ V to }5.5\text{ V}$ | 0 | | 0.15 | V |
| | B-port I/Os | $V_{CCA} = 1.65\text{ V to }5.5\text{ V}$ $V_{CCB} = 2.3\text{ V to }5.5\text{ V}$ | 0 | | 0.15 | V |
| | OE input | $V_{CCA} = 1.65\text{ V to }5.5\text{ V}$ $V_{CCB} = 2.3\text{ V to }5.5\text{ V}$ | 0 | | $V_{CCA} \times 0.25$ | V |
| Input transition rise or fall rate($\Delta t/\Delta v$) | A-port I/Os push-pull driving | | | | 10 | ns/V |
| | B-port I/Os push-pull driving | | | | 10 | ns/V |
| | Control input | | | | 10 | ns/V |
| T_A Operating free-air temperature | | | -40 | | 125 | °C |

(1) V_{CCA} must be less than or equal to V_{CCB} .

(2) The maximum V_{IL} value is provided to ensure that a valid V_{OL} is maintained. The V_{OL} value is V_{IL} plus the voltage drop across the pass gate transistor.

8.4 Electrical Characteristics

over recommended operating free-air temperature range (unless otherwise noted) ⁽¹⁾ ⁽²⁾ ⁽³⁾

| PARAMETER | | CONDITIONS | V _{CCA} | V _{CCB} | TEMP | MIN ⁽⁴⁾ | TYP ⁽⁵⁾ | MAX ⁽⁴⁾ | UNIT |
|-------------------------------------|--------------------------------------|--|---------------------------|------------------|-------|------------------------|--------------------|--------------------|------|
| V _{OHA} | Port A output high voltage | I _{OH} = -20 μA V _{IB} ≥ V _{CCB} - 0.4V | 1.65V to 5.5V | 2.3V to 5.5V | Full | V _{CCA} × 0.7 | | 5.5 | V |
| V _{OLA} | Port A output low voltage | I _{OL} = 1mA V _{IB} ≤ 0.15 V | 1.65V to 5.5V | 2.3V to 5.5V | Full | | | 0.3 | |
| V _{OHB} | Port B output high voltage | I _{OH} = -20 μA V _{IA} ≥ V _{CCA} - 0.2 V | 1.65V to 5.5V | 2.3V to 5.5V | Full | V _{CCB} × 0.7 | | | |
| V _{OLB} | Port B output low voltage | I _{OL} = 1mA V _{IA} ≤ 0.15 V | 1.65V to 5.5V | 2.3V to 5.5V | Full | | | 0.3 | |
| I _I | Input leakage current | OE | 1.65V to 5.5V | 2.3V to 5.5V | +25°C | | | ±1 | μA |
| | | | | | Full | | | ±1.5 | |
| I _{off} | Partial power down current | A Ports | 0V | 0V to 5.5V | +25°C | | | ±0.5 | μA |
| | | | | | Full | | | ±1 | |
| | | B Ports | 0V to 5.5V | 0V | +25°C | | | ±0.5 | μA |
| | | | | | Full | | | ±1 | |
| I _{OZ} ⁽⁶⁾ | High-impedance State output current | A or B port OE=0V | 1.65V to 5.5V | 2.3V to 5.5V | +25°C | | | ±0.5 | μA |
| | | | | | Full | | | ±1 | |
| I _{CCA} | V _{CCA} supply current | V _I = V _O = open I _O = 0 | 1.65V to V _{CCB} | 2.3V to 5.5V | Full | | | 1.0 | μA |
| | | | 5.5V | 0V | Full | | | 1.0 | |
| | | | 0V | 5.5V | Full | | | -1 | |
| I _{CCB} | V _{CCB} supply current | V _I = V _O = open I _O = 0 | 1.65V to V _{CCB} | 2.3V to 5.5V | Full | | | 10 | μA |
| | | | 5.5V | 0V | Full | | | -1 | |
| | | | 0V | 5.5V | Full | | | 1 | |
| I _{CCA} + I _{CCB} | Combined supply current | V _I = V _O = open I _O = 0 | 1.65V to V _{CCB} | 2.3V to 5.5V | Full | | | 15 | μA |
| I _{CCZA} | V _{CCA} supply current | V _I = V _{CC1} or 0V I _O = 0, OE=0V | 1.65V to V _{CCB} | 2.3V to 5.5V | Full | | | 1 | μA |
| I _{CCZB} | V _{CCB} supply current | V _I = V _{CC1} or 0V I _O = 0, OE=0V | 2.3V to 5.5V | 2.3V to 5.5V | Full | | | 1 | μA |
| C _I | Input capacitance | OE | 3.3V | 3.3V | +25°C | | 2.5 | | pF |
| C _{IO} | Input-to-output internal capacitance | A port | 3.3V | 3.3V | +25°C | | 5 | | pF |
| | | B port | 3.3V | 3.3V | +25°C | | 5 | | |

(1) V_{CC1} is the V_{CC} associated with the input port.

(2) V_{CC0} is the V_{CC} associated with the output port

(3) V_{CCA} must be less than or equal to V_{CCB}.

(4) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.

(5) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration.

(6) For I/O ports, the parameter I_{OZ} includes the input leakage current.

8.5 Timing Requirements

8.5.1 $V_{CCA}=1.8V\pm 0.15V$

| | | $V_{CCB}=2.5V \pm 0.2V$ | $V_{CCB}=3.3V \pm 0.2V$ | $V_{CCB}=5V \pm 0.2V$ | UNIT |
|-------------------------|----------------------------------|-------------------------|-------------------------|-----------------------|------|
| | | TYP | TYP | TYP | |
| Data rate | Push-pull driving | 21 | 22 | 24 | Mbps |
| | Open-drain driving | 2 | 2 | 2 | |
| Pulse duration(t_w) | Push-pull driving (data inputs) | 47 | 45 | 41 | ns |
| | Open-drain driving (data inputs) | 500 | 500 | 500 | |

8.5.2 $V_{CCA}=2.5V\pm 0.15V$

| | | $V_{CCB}=2.5V \pm 0.2V$ | $V_{CCB}=3.3V \pm 0.2V$ | $V_{CCB}=5V \pm 0.2V$ | UNIT |
|-------------------------|----------------------------------|-------------------------|-------------------------|-----------------------|------|
| | | TYP | TYP | TYP | |
| Data rate | Push-pull driving | 20 | 22 | 24 | Mbps |
| | Open-drain driving | 2 | 2 | 2 | |
| Pulse duration(t_w) | Push-pull driving (data inputs) | 50 | 45 | 41 | ns |
| | Open-drain driving (data inputs) | 500 | 500 | 500 | |

8.5.3 $V_{CCA}=3.3V\pm 0.15V$

| | | $V_{CCB}=3.3V \pm 0.2V$ | $V_{CCB}=5V \pm 0.2V$ | UNIT |
|-------------------------|----------------------------------|-------------------------|-----------------------|------|
| | | TYP | TYP | |
| Data rate | Push-pull driving | 23 | 24 | Mbps |
| | Open-drain driving | 2 | 2 | |
| Pulse duration(t_w) | Push-pull driving (data inputs) | 43 | 41 | ns |
| | Open-drain driving (data inputs) | 500 | 500 | |

8.5.4 $V_{CCA}=5V\pm 0.15V$

| | | $V_{CCB}=5V \pm 0.2V$ | UNIT |
|-------------------------|----------------------------------|-----------------------|------|
| | | TYP | |
| Data rate | Push-pull driving | 24 | Mbps |
| | Open-drain driving | 2 | |
| Pulse duration(t_w) | Push-pull driving (data inputs) | 41 | ns |
| | Open-drain driving (data inputs) | 500 | |

8.6 Switching Characteristics: $V_{CCA}=1.8V \pm 0.15V$

over recommended operating free-air temperature range (unless otherwise noted)

| PARAMETER | | CONDITIONS | | $V_{CCB}=2.5V\pm 0.2V$ | $V_{CCB}=3.3V\pm 0.2V$ | $V_{CCB}=5V\pm 0.2V$ | UNIT |
|-------------------|---|-------------------------|--------------------|------------------------|------------------------|----------------------|------|
| | | | | TYP | TYP | TYP | |
| t_{PHL} | Propagation delay time high-to-low output | A-to-B | Push-pull driving | 2.5 | 3.1 | 4.5 | ns |
| | | | Open-drain driving | 26.1 | 26.4 | 26.6 | |
| t_{PLH} | Propagation delay time low-to-high output | A-to-B | Push-pull driving | 4.2 | 3.7 | 3.6 | ns |
| | | | Open-drain driving | 221 | 183 | 143 | |
| t_{PHL} | Propagation delay time high-to-low output | B-to-A | Push-pull driving | 2.1 | 2.0 | 2.2 | ns |
| | | | Open-drain driving | 26.1 | 26.1 | 26.2 | |
| t_{PLH} | Propagation delay time low-to-high output | B-to-A | Push-pull driving | 1.8 | 1.6 | 1.5 | ns |
| | | | Open-drain driving | 173 | 89 | 66 | |
| t_{en} | Enable time | OE-to-A or B | | 25 | 21 | 19 | ns |
| t_{dis} | Disable time | OE-to-A or B | | 1250 | 1250 | 1250 | ns |
| t_{rA} | Input rise time | A port rise time | Push-pull driving | 6.9 | 6.1 | 5.6 | ns |
| | | | Open-drain driving | 118 | 39 | 13 | |
| t_{rB} | Input rise time | B port rise time | Push-pull driving | 5.8 | 4.8 | 4.1 | ns |
| | | | Open-drain driving | 166 | 127 | 75 | |
| t_{fA} | Input fall time | A port fall time | Push-pull driving | 3.0 | 2.8 | 2.7 | ns |
| | | | Open-drain driving | 1.9 | 1.7 | 1.6 | |
| t_{fB} | Input fall time | B port fall time | Push-pull driving | 4.8 | 6.2 | 8.4 | ns |
| | | | Open-drain driving | 2.3 | 2.4 | 2.8 | |
| $t_{SK(O)}$ | Skew(time), output | Channel-to-Channel Skew | | 0.5 | 0.5 | 0.5 | ns |
| Maximum data rate | | Push-pull driving | | 21 | 22 | 24 | Mbps |
| | | Open-drain driving | | 2 | 2 | 2 | |

8.7 Switching Characteristics: $V_{CCA}=2.5V \pm 0.15V$

over recommended operating free-air temperature range (unless otherwise noted)

| PARAMETER | | CONDITIONS | | $V_{CCB}=2.5V\pm 0.2V$ | $V_{CCB}=3.3V\pm 0.2V$ | $V_{CCB}=5V\pm 0.2V$ | UNIT |
|-------------------|---|-------------------------|--------------------|------------------------|------------------------|----------------------|------|
| | | | | TYP | TYP | TYP | |
| t_{PHL} | Propagation delay time high-to-low output | A-to-B | Push-pull driving | 2.8 | 3.4 | 5.0 | ns |
| | | | Open-drain driving | 26.3 | 26.5 | 26.6 | |
| t_{PLH} | Propagation delay time low-to-high output | A-to-B | Push-pull driving | 2.7 | 2.5 | 2.4 | ns |
| | | | Open-drain driving | 198 | 169 | 131 | |
| t_{PHL} | Propagation delay time high-to-low output | B-to-A | Push-pull driving | 2.5 | 2.4 | 2.5 | ns |
| | | | Open-drain driving | 26.4 | 26.5 | 26.6 | |
| t_{PLH} | Propagation delay time low-to-high output | B-to-A | Push-pull driving | 2.1 | 2.0 | 1.9 | ns |
| | | | Open-drain driving | 196 | 138 | 63 | |
| t_{en} | Enable time | OE-to-A or B | | 24 | 20 | 17 | ns |
| t_{dis} | Disable time | OE-to-A or B | | 1250 | 1250 | 1250 | ns |
| t_{rA} | Input rise time | A port rise time | Push-pull driving | 3.4 | 2.9 | 2.7 | ns |
| | | | Open-drain driving | 156 | 92 | 13 | |
| t_{rB} | Input rise time | B port rise time | Push-pull driving | 4.7 | 3.5 | 2.7 | ns |
| | | | Open-drain driving | 160 | 124 | 81 | |
| t_{fA} | Input fall time | A port fall time | Push-pull driving | 5.1 | 5.2 | 5.0 | ns |
| | | | Open-drain driving | 2.1 | 2.0 | 1.8 | |
| t_{fB} | Input fall time | B port fall time | Push-pull driving | 5.0 | 6.4 | 8.7 | ns |
| | | | Open-drain driving | 2.0 | 2.2 | 2.8 | |
| $t_{SK(O)}$ | Skew(time), output | Channel-to-channel skew | | 0.5 | 0.5 | 0.5 | ns |
| Maximum data rate | | Push-pull driving | | 20 | 22 | 24 | Mbps |
| | | Open-drain driving | | 2 | 2 | 2 | |

8.8 Switching Characteristics: $V_{CCA}=3.3V \pm 0.3V$

over recommended operating free-air temperature range (unless otherwise noted)

| PARAMETER | | CONDITIONS | | $V_{CCB}=3.3V\pm 0.2V$ | $V_{CCB}=5V\pm 0.2V$ | UNIT |
|-------------------|---|-------------------------|--------------------|------------------------|----------------------|------|
| | | | | TYP | TYP | |
| t_{PHL} | Propagation delay time high-to-low output | A-to-B | Push-pull driving | 3.6 | 5.1 | ns |
| | | | Open-drain driving | 26.4 | 26.6 | |
| t_{PLH} | Propagation delay time low-to-high output | A-to-B | Push-pull driving | 2.3 | 2.1 | ns |
| | | | Open-drain driving | 155 | 109 | |
| t_{PHL} | Propagation delay time high-to-low output | B-to-A | Push-pull driving | 3.1 | 3.3 | ns |
| | | | Open-drain driving | 26.5 | 26.7 | |
| t_{PLH} | Propagation delay time low-to-high output | B-to-A | Push-pull driving | 1.9 | 1.8 | ns |
| | | | Open-drain driving | 158 | 87 | |
| t_{en} | Enable time | OE-to-A or B | | 19 | 15 | ns |
| t_{dis} | Disable time | OE-to-A or B | | 1250 | 1250 | ns |
| t_{rA} | Input rise time | A port rise time | Push-pull driving | 2.3 | 2.1 | ns |
| | | | Open-drain driving | 117 | 48 | |
| t_{rB} | Input rise time | B port rise time | Push-pull driving | 3.0 | 2.4 | ns |
| | | | Open-drain driving | 117 | 75 | |
| t_{fA} | Input fall time | A port fall time | Push-pull driving | 8.0 | 7.6 | ns |
| | | | Open-drain driving | 2.2 | 2.1 | |
| t_{fB} | Input fall time | B port fall time | Push-pull driving | 8.2 | 10.8 | ns |
| | | | Open-drain driving | 2.1 | 2.4 | |
| $t_{sk(O)}$ | Skew(time), output | Channel-to-channel skew | | 0.5 | 0.5 | ns |
| Maximum data rate | | Push-pull driving | | 23 | 24 | Mbps |
| | | Open-drain driving | | 2 | 2 | |

8.9 Switching Characteristics: $V_{CCA}=5.0V \pm 0.35V$

over recommended operating free-air temperature range (unless otherwise noted)

| PARAMETER | | CONDITIONS | | $V_{CCB}=5V \pm 0.2V$ | UNIT |
|-------------------|---|-------------------------|--------------------|-----------------------|------|
| | | | | TYP | |
| t_{PHL} | Propagation delay time high-to-low output | A-to-B | Push-pull driving | 5.6 | ns |
| | | | Open-drain driving | 26.8 | |
| t_{PLH} | Propagation delay time low-to-high output | A-to-B | Push-pull driving | 2.0 | ns |
| | | | Open-drain driving | 155 | |
| t_{PHL} | Propagation delay time high-to-low output | B-to-A | Push-pull driving | 5.8 | ns |
| | | | Open-drain driving | 27.5 | |
| t_{PLH} | Propagation delay time low-to-high output | B-to-A | Push-pull driving | 1.8 | ns |
| | | | Open-drain driving | 160 | |
| t_{en} | Enable time | OE-to-A or B | | 17 | ns |
| t_{dis} | Disable time | OE-to-A or B | | 1250 | ns |
| t_{rA} | Input rise time | A port rise time | Push-pull driving | 1.9 | ns |
| | | | Open-drain driving | 105 | |
| t_{rB} | Input rise time | B port rise time | Push-pull driving | 2.3 | ns |
| | | | Open-drain driving | 95 | |
| t_{fA} | Input fall time | A port fall time | Push-pull driving | 9.0 | ns |
| | | | Open-drain driving | 2.6 | |
| t_{fB} | Input fall time | B port fall time | Push-pull driving | 8.9 | ns |
| | | | Open-drain driving | 2.5 | |
| $t_{sk(O)}$ | Skew(time), output | Channel-to-channel skew | | 0.5 | ns |
| Maximum data rate | | Push-pull driving | | 24 | Mbps |
| | | Open-drain driving | | 2 | |

8.10 Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

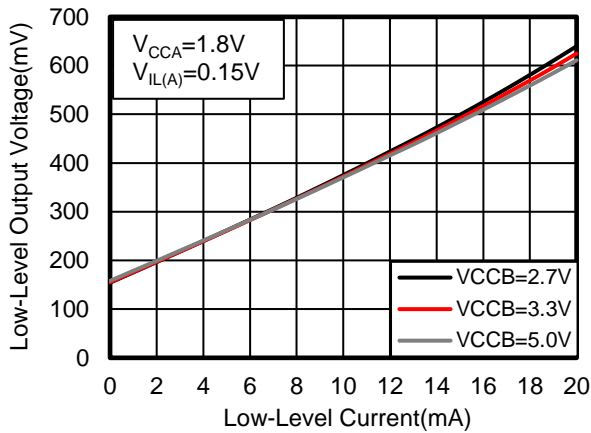


Figure1: Low-Level Output Voltage vs Low-Level Current

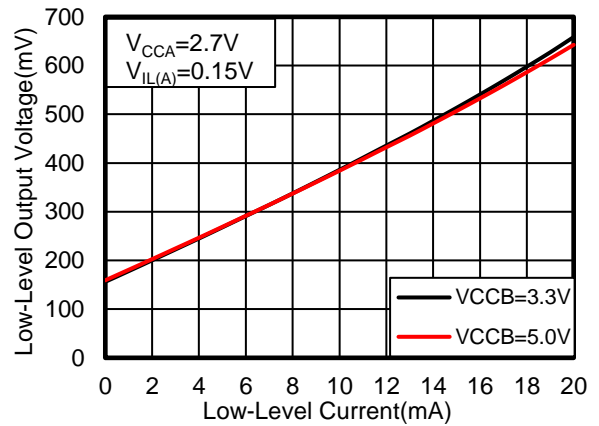


Figure2: Low-Level Output Voltage vs Low-Level Current

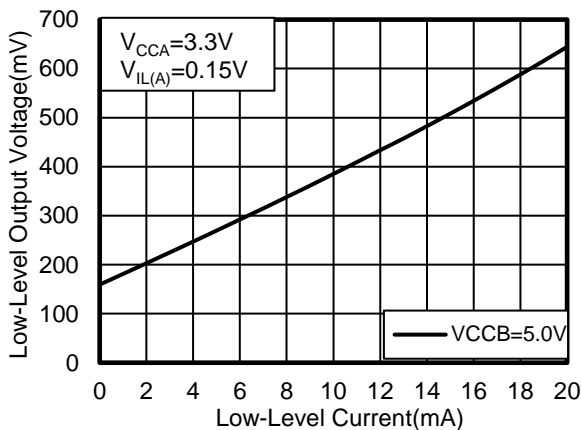


Figure3: Low-Level Output Voltage vs Low-Level Current

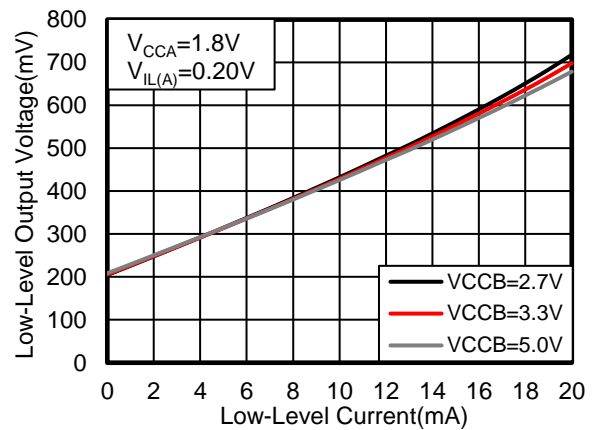


Figure4: Low-Level Output Voltage vs Low-Level Current

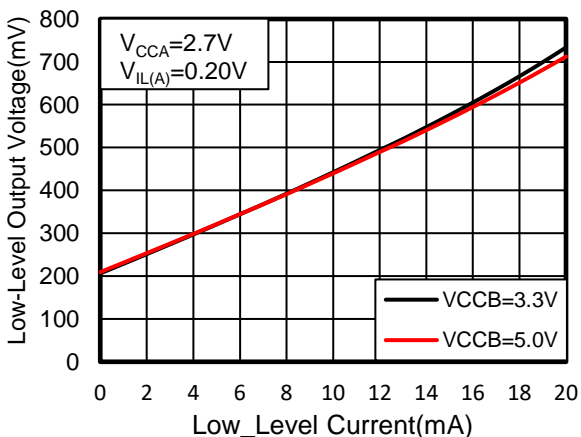


Figure5: Low-Level Output Voltage vs Low-Level Current

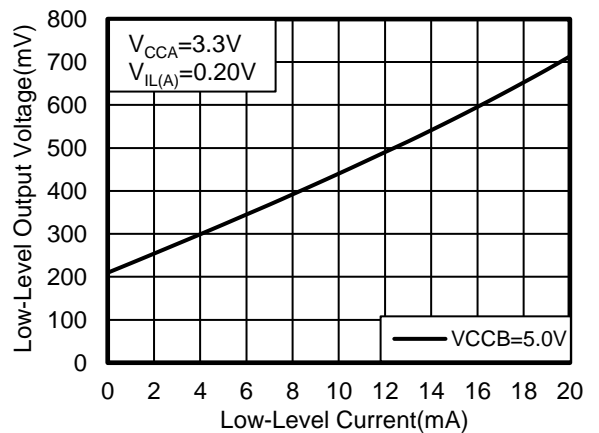


Figure6: Low-Level Output Voltage vs Low-Level Current

Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

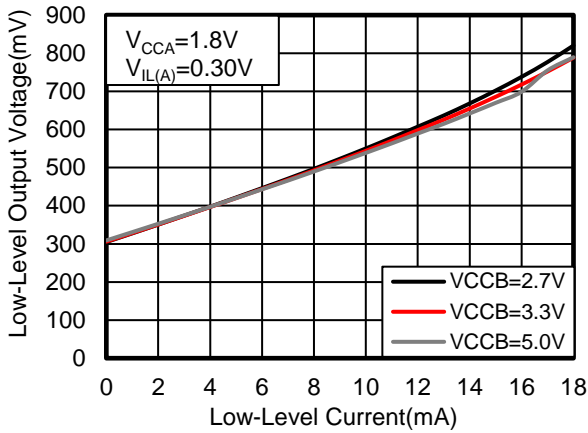


Figure7: Low-Level Output Voltage vs Low-Level Current

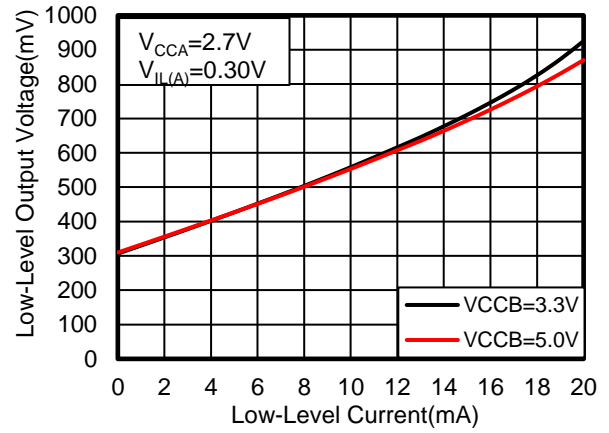


Figure8: Low-Level Output Voltage vs Low-Level Current

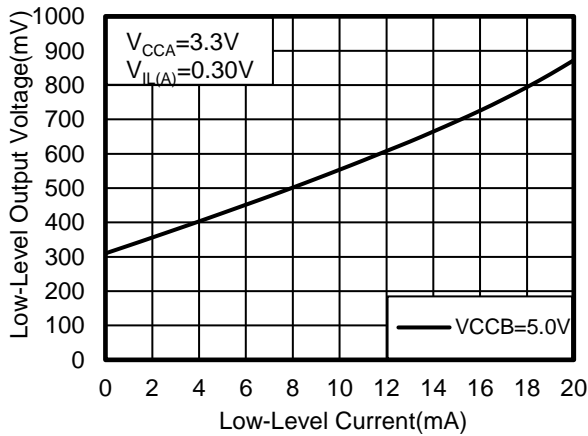


Figure9: Low-Level Output Voltage vs Low-Level Current

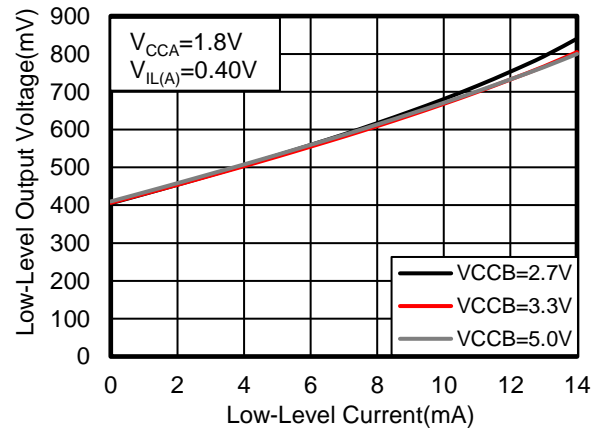


Figure10: Low-Level Output Voltage vs Low-Level Current

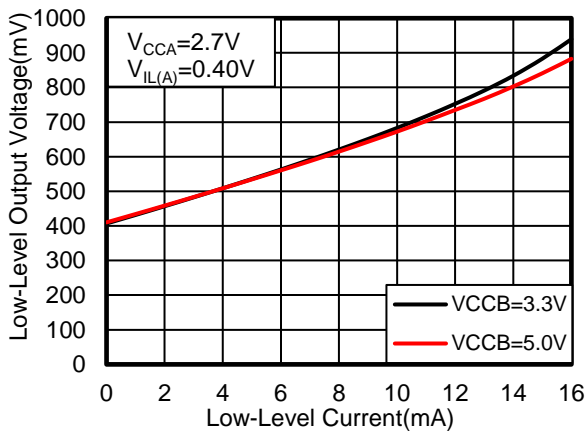


Figure11: Low-Level Output Voltage vs Low-Level Current

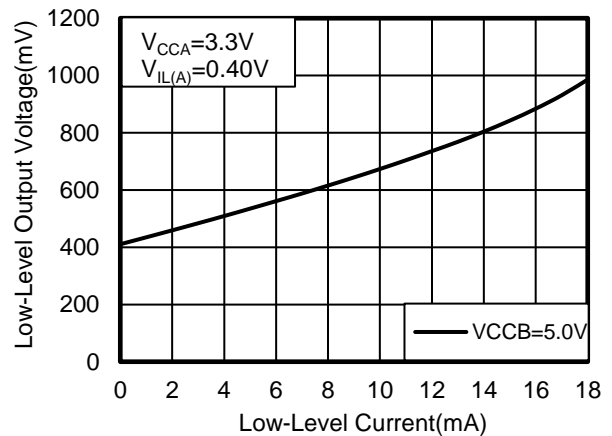


Figure12: Low-Level Output Voltage vs Low-Level Current

Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

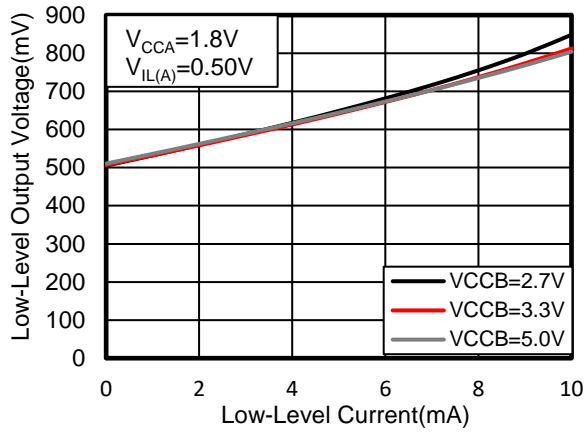


Figure13: Low-Level Output Voltage vs Low-Level Current

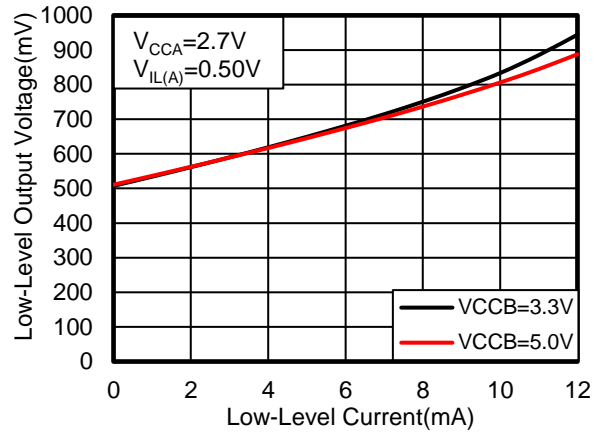


Figure14: Low-Level Output Voltage vs Low-Level Current

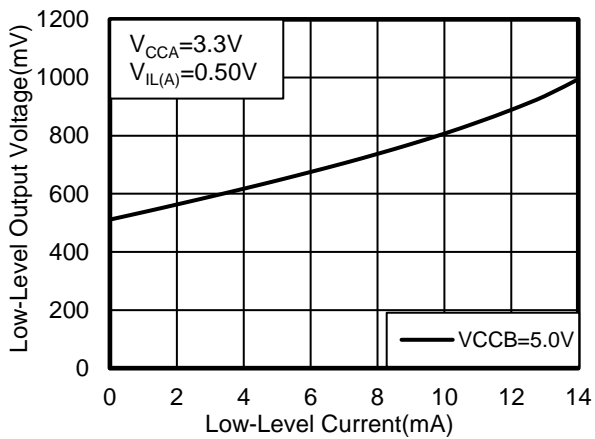


Figure15: Low-level Output Voltage vs Low-Level Current

9 Parameter Measurement Information

Unless otherwise noted, all input pulses are supplied by generators having the following characteristics:

- PRR 10 MHz
- $Z_o = 50 \Omega$
- $dv/dt \geq 1 \text{ V/ns}$

Note: All input pulses are measured one at a time, with one transition per measurement.

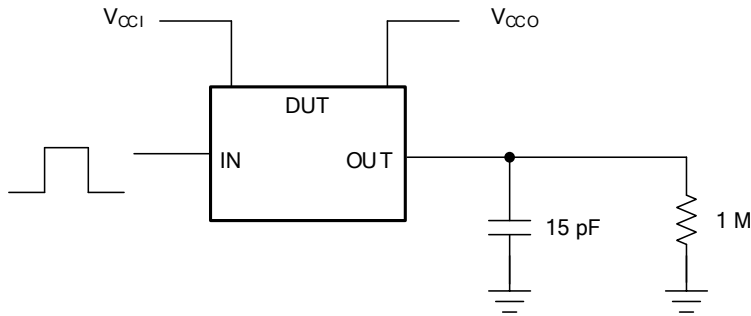


Figure 16. Data Rate, Pulse Duration, Propagation Delay, Output Rise And Fall Time Measurement Using A Push-Pull Driver

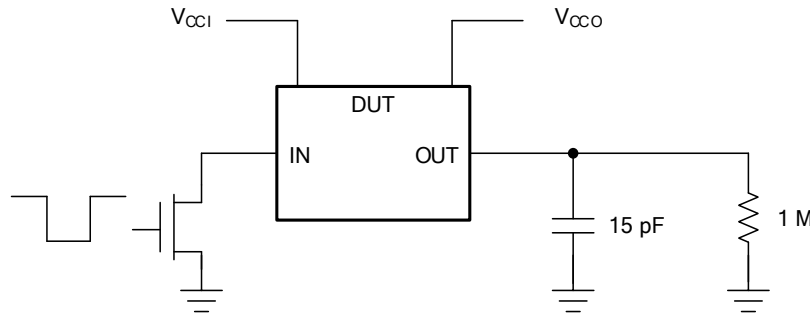


Figure 17. Data Rate, Pulse Duration, Propagation Delay, Output Rise And Fall Time Measurement Using an Open-Drain Driver

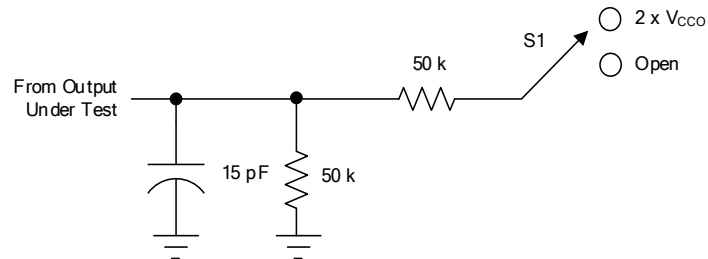
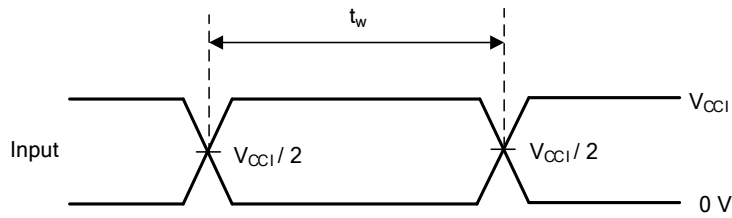


Figure 18. Load Circuit for Enable/Disable Time Measurement

Table 1. Switch Configuration for Enable/Disable Timing

| TEST | S1 |
|------------------------------------|--------------------|
| $t_{PZL}^{(1)}$, $t_{PLZ}^{(2)}$ | $2 \times V_{CC0}$ |
| $t_{PHZL}^{(1)}$, $t_{PZH}^{(2)}$ | Open |

- (1) t_{PZL} and t_{PZH} are the same as t_{en} .
 (2) t_{PLZ} and t_{PHZ} are the same as t_{dis} .



(1) All input pulses are measured one at a time, with one transition per measurement.

Figure 19. Voltage Waveforms Pulse Duration

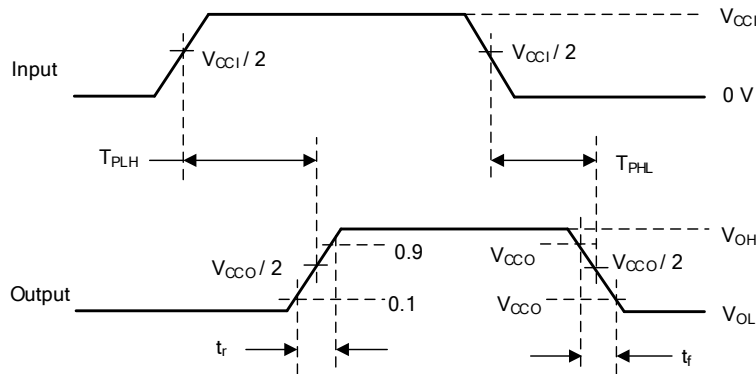


Figure 20. Voltage Waveforms Propagation Delay Times

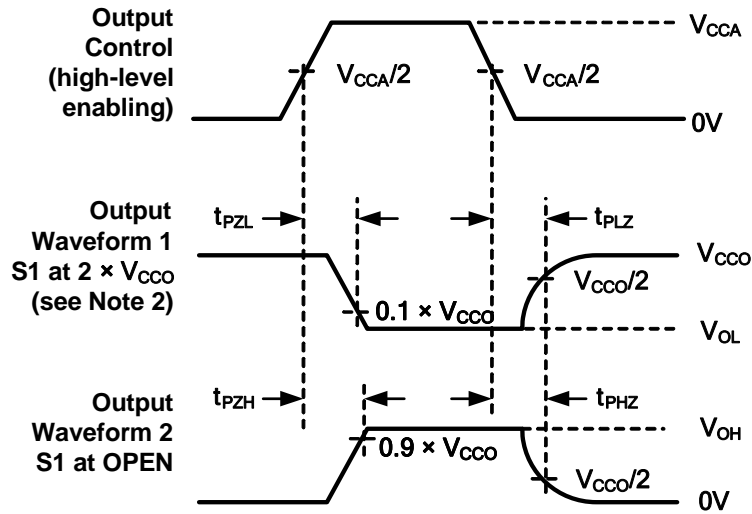


Figure 21. Voltage Waveforms Enable and Disable

10 Feature Description

10.1 Overview

The RS0104-Q1 device is a directionless voltage-level translator specifically designed for translating logic voltage levels. The A port is able to accept I/O voltages ranging from 1.65 V to 5.5 V, while the B port can accept I/O voltages from 2.3 V to 5.5 V. The device is a pass-gate architecture with edge-rate accelerators (one-shots) to improve the overall data rate. 10-k Ω pullup resistors, commonly used in open-drain applications, have been conveniently integrated so that an external resistor is not needed. While this device is designed for open-drain applications, the device can also translate push-pull CMOS logic outputs.

10.2 Architecture

The RS0104-Q1 architecture (see Figure 22) is an auto-direction-sensing based translator that does not require a direction-control signal to control the direction of data flow from A to B or from B to A. These two bidirectional channels independently determine the direction of data flow without a direction-control signal. Each I/O pin can be automatically reconfigured as either an input or an output, which is how this auto-direction feature is realized.

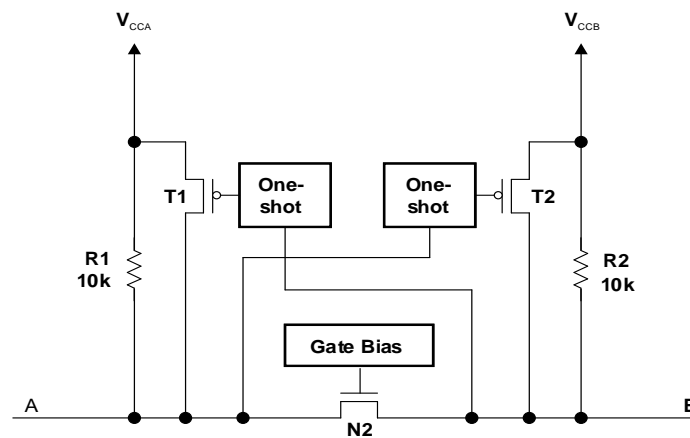


Figure 22. Architecture of a RS0104-Q1 Cell

The RS0104-Q1 employs two key circuits to enable this voltage translation:

- 1) An N-channel pass-gate transistor topology that ties the A-port to the B-port
- 2) Output one-shot (O.S.) edge-rate accelerator circuitry to detect and accelerate rising edges on the A or B Ports.

10.3 Input Driver Requirements

The continuous dc-current "sinking" capability is determined by the external system-level open-drain (or push-pull) drivers that are interfaced to the RS0104-Q1 I/O pins. Since the high bandwidth of these bidirectional I/O circuits is used to facilitate this fast change from an input to an output and an output to an input, they have a modest dc-current "sourcing" capability of hundreds of micro-Amps, as determined by the internal 10-k Ω pullup resistors.

The fall time (t_{fA} , t_{fB}) of a signal depends on the edge-rate and output impedance of the external device driving RS0104-Q1 data I/Os, as well as the capacitive loading on the data lines.

Similarly, the t_{PHL} and max data rates also depend on the output impedance of the external driver. The values for t_{fA} , t_{fB} , t_{PHL} and maximum data rates in the data sheet assume that the output impedance of the external driver is less than 50 Ω .

10.4 Output Load Considerations

We recommend careful PCB layout practices with short PCB trace lengths to avoid excessive capacitive loading and to ensure that proper O.S. triggering takes place. PCB signal trace-lengths should be kept short enough such that the round-trip delay of any reflection is less than the one-shot duration. This improves signal integrity by ensuring that any reflection sees a low impedance at the driver. The O.S. circuits have been designed to stay on for approximately 30 ns. The maximum capacitance of the lumped load that can be driven also depends directly on the one-shot duration. With very heavy capacitive loads, the one-shot can time-out before the signal is driven fully to the positive rail. The O.S. duration has been set to best optimize trade-offs between dynamic ICC, load driving capability, and maximum bit-rate considerations. Both PCB trace length and connectors add to the capacitance that the RS0104-Q1 device output sees, so it is recommended that this lumped-load capacitance be considered to avoid O.S. retriggering, bus contention, output signal oscillations, or other adverse system-level affects.

10.5 Enable and Disable

The RS0104-Q1 device has an OE input that is used to disable the device by setting OE low, which places all I/Os in the Hi-Z state. The disable time (t_{dis}) indicates the delay between the time when OE goes low and when the outputs are disabled (Hi-Z). The enable time (t_{en}) indicates the amount of time the user must allow for the one-shot circuitry to become operational after OE is taken high.

10.6 Pullup or Pulldown Resistors on I/O Lines

Each A-port I/O has an internal 10-k Ω pullup resistor to V_{CCA} , and each B-port I/O has an internal 10-k Ω pullup resistor to V_{CCB} . If a smaller value of pullup resistor is required, an external resistor must be added from the I/O to V_{CCA} or V_{CCB} (in parallel with the internal 10-k Ω resistors). Adding lower value pull-up resistors will affect V_{OL} levels, however. The internal pull-ups of the RS0104-Q1 are disabled when the OE pin is low.

11 Application and Implementation

Information in the following applications sections is not part of the Runic component specification, and Runic does not warrant its accuracy or completeness. Runic's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

11.1 Application Information

The RS0104-Q1 device can be used to bridge the digital-switching compatibility gap between two voltage nodes to successfully interface logic threshold levels found in electronic systems. It should be used in a point-to-point topology for interfacing devices or systems operating at different interface voltages with one another. Its primary target application use is for interfacing with open-drain drivers on the data I/Os such as I²C or 1-wire, where the data is bidirectional and no control signal is available. The device can also be used in applications where a push-pull driver is connected to the data I/Os, but the RS0104-Q1 might be a better option for such push-pull applications.

11.2 Typical Application

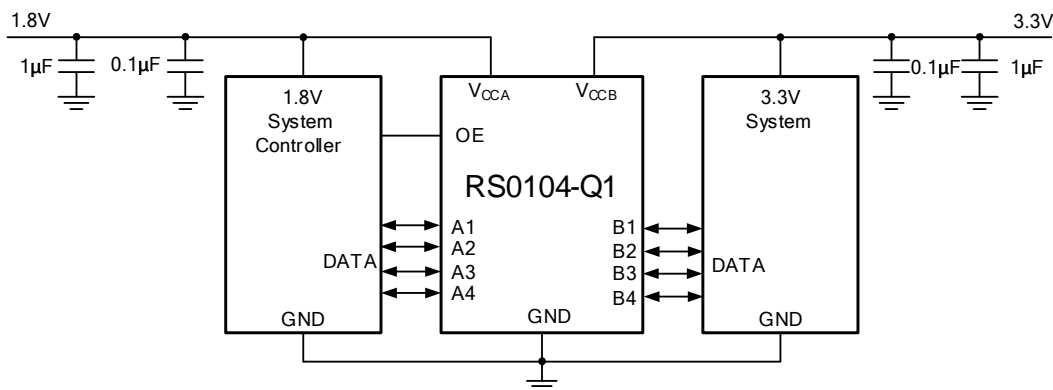
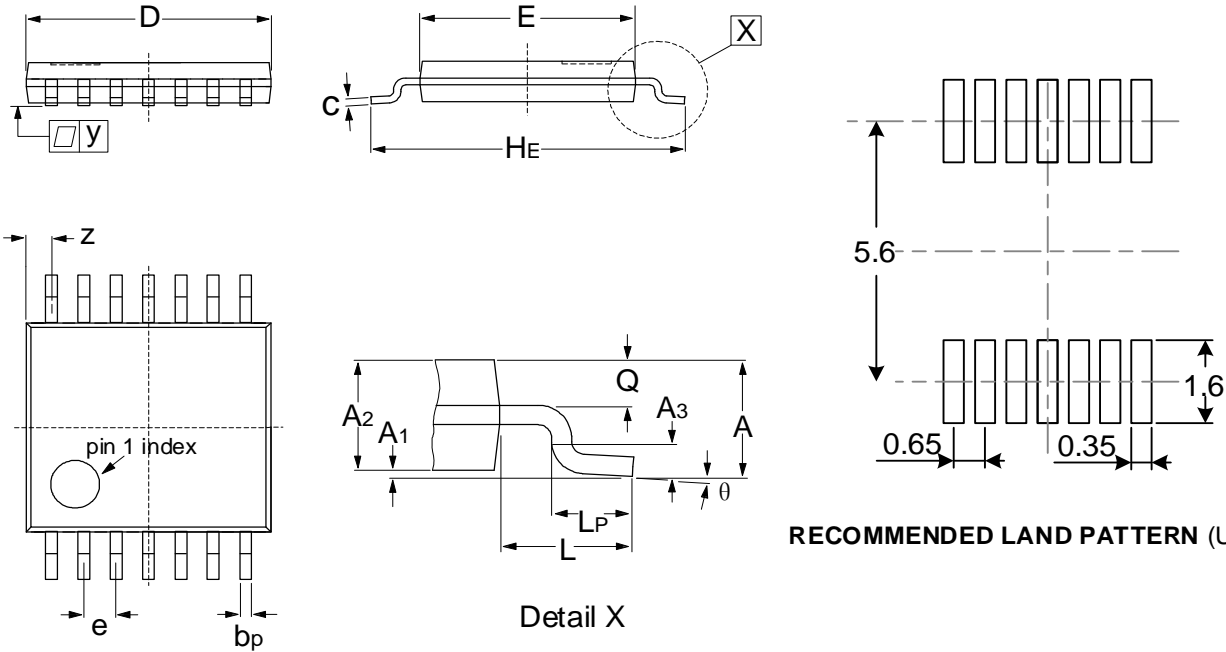
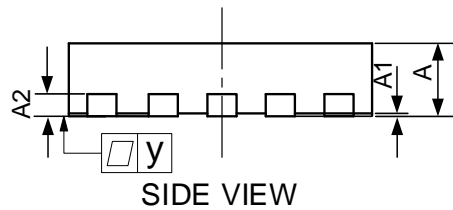
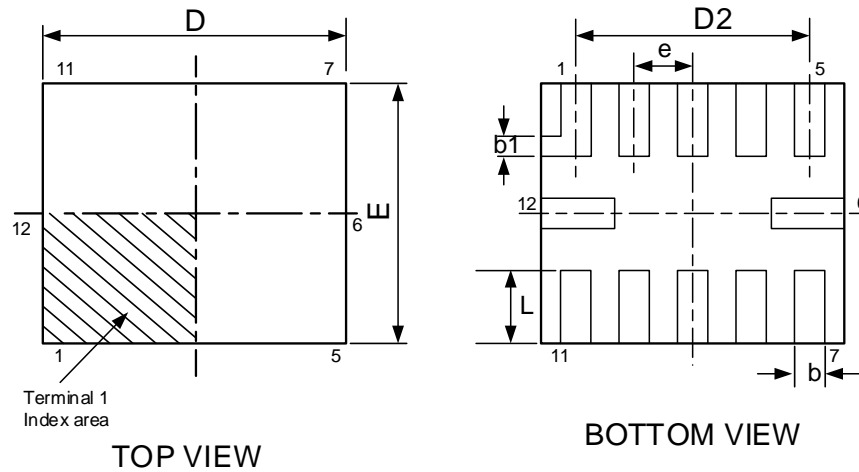


Figure 23. Typical Application Circuit

12 PACKAGE OUTLINE DIMENSIONS TSSOP-14


RECOMMENDED LAND PATTERN (Unit: mm)

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|------------------|---------------------------|-------|----------------------|-------|
| | Min | Max | Min | Max |
| A | | 1.100 | | 0.043 |
| A ₁ | 0.050 | 0.150 | 0.002 | 0.006 |
| A ₂ | 0.800 | 0.950 | 0.031 | 0.037 |
| A ₃ | 0.250 | | 0.010 | |
| b _p | 0.190 | 0.300 | 0.007 | 0.012 |
| c | 0.100 | 0.200 | 0.004 | 0.008 |
| D ^(A) | 4.900 | 5.100 | 0.193 | 0.201 |
| E ^(B) | 4.300 | 4.500 | 0.169 | 0.177 |
| H _E | 6.200 | 6.600 | 0.244 | 0.260 |
| e | 0.650 | | 0.026 | |
| L | 1 | | 0.039 | |
| L _P | 0.500 | 0.750 | 0.020 | 0.030 |
| Q | 0.300 | 0.400 | 0.012 | 0.016 |
| Z ^(A) | 0.380 | 0.720 | 0.015 | 0.028 |
| y | 0.1 | | 0.004 | |
| θ | 0° | 8° | 0° | 8° |

QFN2x1.7-12L


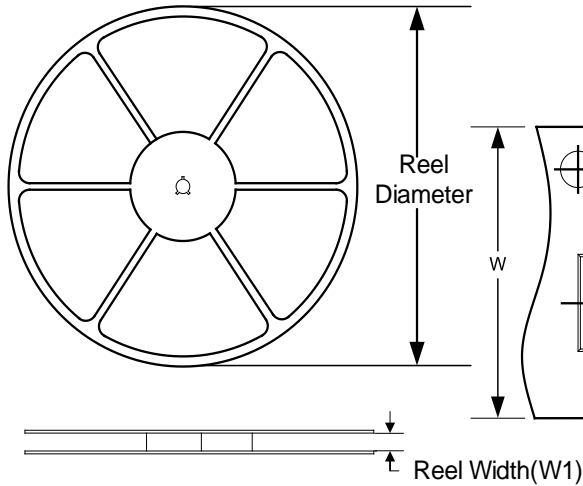
| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|--------|---------------------------|-------|----------------------|-------|
| | Min | Max | Min | Max |
| A | | 0.500 | | 0.020 |
| A1 | 0.000 | 0.050 | 0.000 | 0.002 |
| A2 | 0.127 | | 0.005 | |
| D | 1.900 | 2.100 | 0.075 | 0.083 |
| E | 1.600 | 1.800 | 0.063 | 0.071 |
| D2 | 1.500 | 1.700 | 0.059 | 0.067 |
| b | 0.150 | 0.250 | 0.006 | 0.010 |
| b1 | 0.150 | | 0.006 | |
| e | 0.400 | | 0.016 | |
| y | 0.050 | | 0.002 | |
| L | 0.450 | 0.550 | 0.017 | 0.022 |

NOTE:

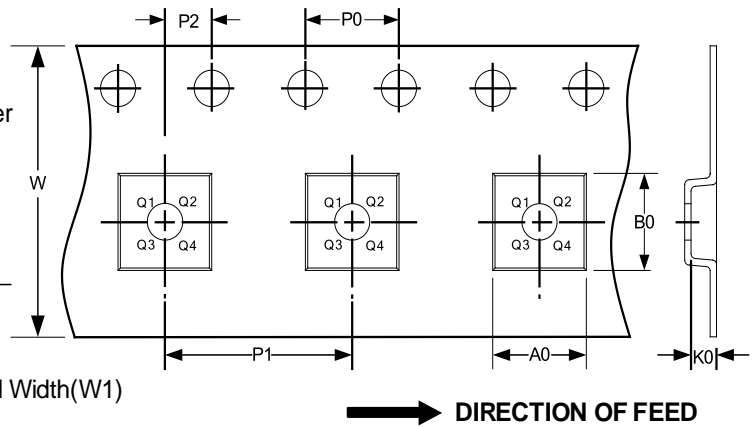
- A. Plastic or metal protrusions of 0.15mm maximum per side are not included.
- B. Plastic interlead protrusions of 0.25mm maximum per side are not included.
- C. All linear dimension is in millimeters.
- D. This drawing is subject to change without notice.
- E. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.

13 TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSION



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

| Package Type | Reel Diameter | Reel Width W1(mm) | A0 (mm) | B0 (mm) | K0 (mm) | P0 (mm) | P1 (mm) | P2 (mm) | W (mm) | Pin1 Quadrant |
|--------------|---------------|-------------------|---------|---------|---------|---------|---------|---------|--------|---------------|
| TSSOP-14 | 13" | 12.4 | 6.95 | 5.60 | 1.20 | 4.0 | 8.0 | 2.0 | 12.0 | Q1 |
| QFN1.7x2-12L | 7" | 9.0 | 1.90 | 2.30 | 0.75 | 4.0 | 4.0 | 2.0 | 8.0 | Q1 |

NOTE:

1. All dimensions are nominal.
2. Plastic or metal protrusions of 0.15mm maximum per side are not included.

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