

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

## 1 FEATURES

- **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**
- **ESD Protection Exceeds JESD 22**
  - **5000-V Human-Body Model (A114)**
  - **400-V Machine Model (A115)**
  - **1000-V Charged-Device Model (JS-002)**
- **Extended Temperature: -40°C to +85°C**

## 2 APPLICATIONS

- **Handset**
- **Smartphone**
- **Tablet**
- **Desktop PC**

## 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.

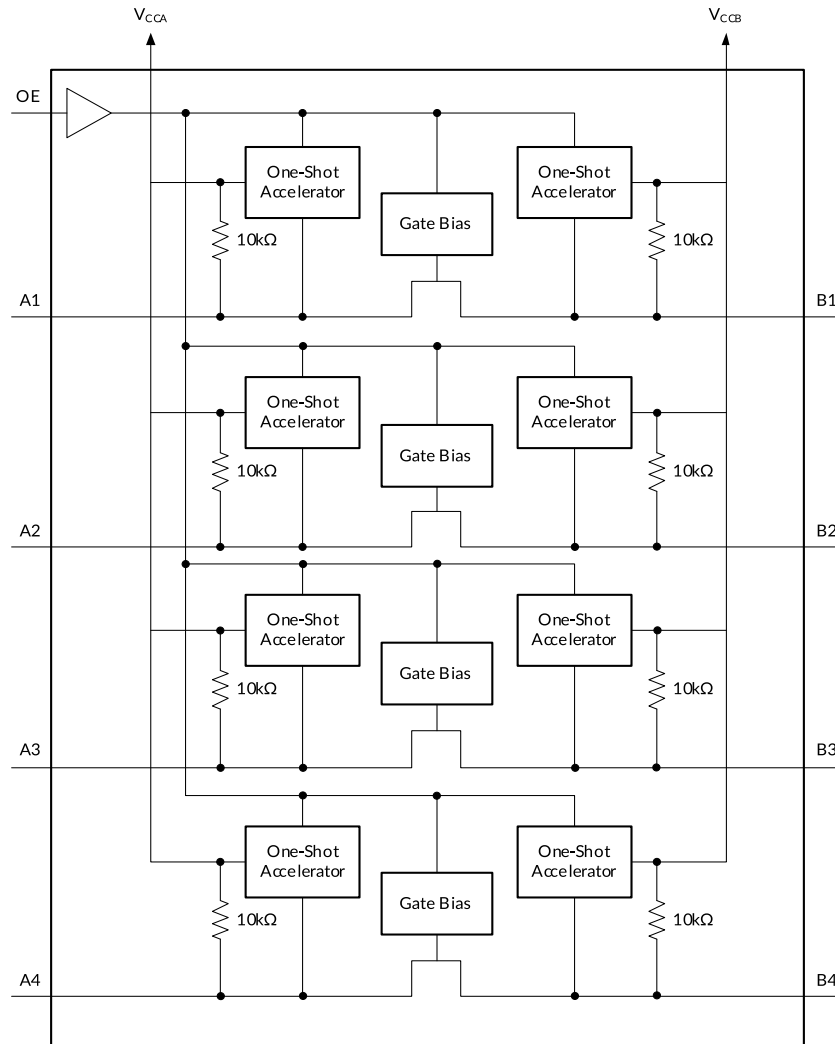
The RS0104 is available in Green QFN3.5X3.5-14, UQFN2X2-12, UQFN1.7X2-12 and TSSOP14 packages. It operates over an ambient temperature range of -40°C to +85°C.

**Device Information <sup>(1)</sup>**

PART NUMBER	PACKAGE	BODY SIZE (NOM)
RS0104	QFN3.5X3.5-14	3.50mm×3.50mm
	UQFN2X2-12	2.00mm×2.00mm
	UQFN1.7X2-12	2.00mm×1.70mm
	TSSOP14	5.00mm×4.40mm

(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.1	2020/11/03	Initial version completed
A.2	2021/01/09	Add Moisture Sensitivity Level information
A.3	2021/04/02	Add QFN2X1.7-12L package
A.4	2021/10/12	1.Change QFN3.5X3.5-14L PACKAGE OPTION 2.Add TAPE AND REEL INFORMATION
A.5	2021/11/01	1. Change Recommended Operating Conditions in Page 9 @A.4 Version. 2. Add Typical Characteristics
A.6	2022/03/29	Change QFN3.5X3.5-14L PACKAGE thickness spec
B.1	2022/09/01	Version updated
B.2	2023/07/06	1. Update PACKAGE OUTLINE DIMENSIONS NOTE in Page 29 @B.1 Version 2. Change the Voltage Waveforms Enable and Disable diagram in Page 22@ B.1 Version 3. Update RS0104YTQE12 PACKAGE OUTLINE DIMENSIONS A Symbol in Page 28@ B.1 Version
B.3	2024/01/29	1. Update FEATURES on Page 1@RevB.2 2. Update ESD Ratings on Page 10@RevB.2 3. Added Package thermal impedance on Page 10@RevB.2
B.3.1	2024/02/23	Modify packaging naming

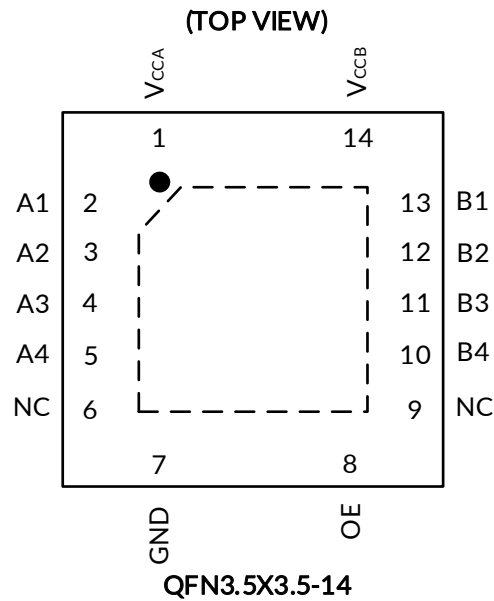
**6 PACKAGE/ORDERING INFORMATION <sup>(1)</sup>**

PRODUCT	ORDERING NUMBER	TEMPERATURE RANGE	PACKAGE LEAD	PACKAGE MARKING <sup>(2)</sup>	MSL <sup>(3)</sup>	PACKAGE OPTION
RS0104	RS0104YTQF14	-40°C ~+85°C	QFN3.5X3.5-14	RS0104	MSL3	Tape and Reel,5000
	RS0104YTQE12	-40°C ~+85°C	UQFN2X2-12	0104	MSL3	Tape and Reel,3000
	RS0104YUTQH12	-40°C ~+85°C	UQFN1.7X2-12	0104	MSL3	Tape and Reel,4000
	RS0104YQ	-40°C ~+85°C	TSSOP14	RS0104	MSL3	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) 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.
- (3) MSL, The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications.

## 7 PIN CONFIGURATIONS

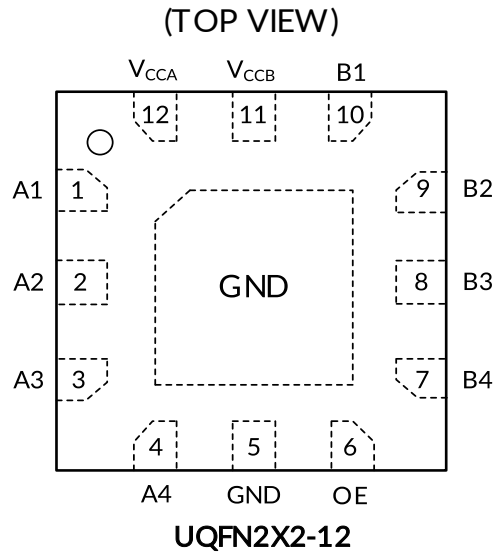


### PIN DESCRIPTION

PIN	NAME	TYPE <sup>(1)</sup>	FUNCTION
QFN3.5X3.5-14			
1	V <sub>CCA</sub>	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 <sub>CCA</sub> .
3	A2	I/O	Input/output A2. Reference to V <sub>CCA</sub> .
4	A3	I/O	Input/output A3. Reference to V <sub>CCA</sub> .
5	A4	I/O	Input/output A4. Reference to V <sub>CCA</sub> .
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 <sub>CCA</sub> .
9	NC	-	No internal connection.
10	B4	I/O	Input/output B4. Reference to V <sub>CCB</sub> .
11	B3	I/O	Input/output B3. Reference to V <sub>CCB</sub> .
12	B2	I/O	Input/output B2. Reference to V <sub>CCB</sub> .
13	B1	I/O	Input/output B1. Reference to V <sub>CCB</sub> .
14	V <sub>CCB</sub>	P	B Ports Supply Voltage. $2.3V \leq V_{CCB} \leq 5.5V$ .
-	Thermal Pad	-	Exposed pad should be soldered to PCB board and connected to GND or left floating.

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

## PIN CONFIGURATIONS

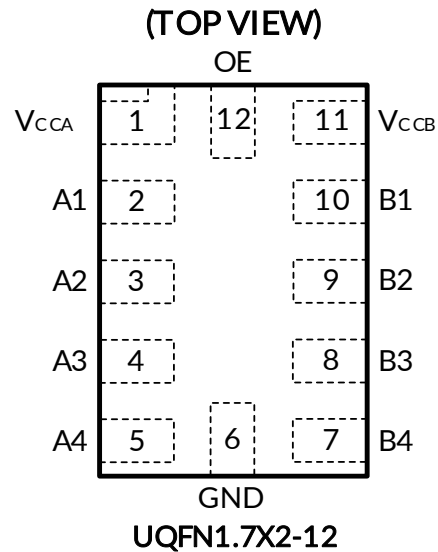


### PIN DESCRIPTION

PIN	NAME	TYPE <sup>(1)</sup>	FUNCTION
<b>UQFN2X2-12</b>			
1	A1	I/O	Input/output A1. Reference to $V_{CCA}$ .
2	A2	I/O	Input/output A2. Reference to $V_{CCA}$ .
3	A3	I/O	Input/output A3. Reference to $V_{CCA}$ .
4	A4	I/O	Input/output A4. Reference to $V_{CCA}$ .
5	GND	-	Ground.
6	OE	I	Output Enable (Active High). Pull OE low to place all outputs in 3-state mode. Referenced to $V_{CCA}$ .
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	$V_{CCA}$	P	A Port Supply Voltage. $1.65V \leq V_{CCA} \leq 5.5V$ and $V_{CCA} \leq V_{CCB}$ .
Exposed Pad	GND	-	Exposed pad should be soldered to PCB board and connected to GND or left floating.

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

## PIN CONFIGURATIONS



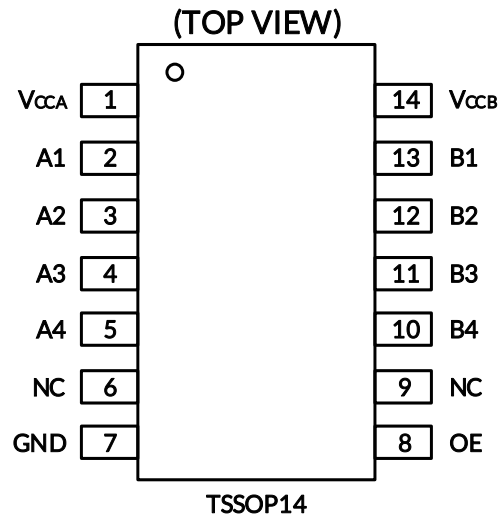
## PIN DESCRIPTION

PIN	NAME	TYPE <sup>(1)</sup>	FUNCTION
UQFN1.7X2-12			
1	V <sub>CCA</sub>	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 <sub>CCA</sub> .
3	A2	I/O	Input/output A2. Reference to V <sub>CCA</sub> .
4	A3	I/O	Input/output A3. Reference to V <sub>CCA</sub> .
5	A4	I/O	Input/output A4. Reference to V <sub>CCA</sub> .
6	GND	-	Ground.
7	B4	I/O	Input/output B4. Reference to V <sub>CCB</sub> .
8	B3	I/O	Input/output B3. Reference to V <sub>CCB</sub> .
9	B2	I/O	Input/output B2. Reference to V <sub>CCB</sub> .
10	B1	I/O	Input/output B1. Reference to V <sub>CCB</sub> .
11	V <sub>CCB</sub>	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 <sub>CCA</sub> .

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



## PIN CONFIGURATIONS



## PIN DESCRIPTION

PIN	NAME	TYPE <sup>(1)</sup>	FUNCTION
TSSOP14			
1	V <sub>CCA</sub>	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 <sub>CCA</sub> .
3	A2	I/O	Input/output A2. Reference to V <sub>CCA</sub> .
4	A3	I/O	Input/output A3. Reference to V <sub>CCA</sub> .
5	A4	I/O	Input/output A4. Reference to V <sub>CCA</sub> .
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 <sub>CCA</sub> .
9	NC	-	No internal connection.
10	B4	I/O	Input/output B4. Reference to V <sub>CCB</sub> .
11	B3	I/O	Input/output B3. Reference to V <sub>CCB</sub> .
12	B2	I/O	Input/output B2. Reference to V <sub>CCB</sub> .
13	B1	I/O	Input/output B1. Reference to V <sub>CCB</sub> .
14	V <sub>CCB</sub>	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) <sup>(1)</sup>

SYMBOL	PARAMETER		MIN	MAX	UNIT
V <sub>CCA</sub>	Supply Voltage Range		-0.3	6.0	V
V <sub>CCB</sub>	Supply Voltage Range		-0.3	6.0	V
V <sub>I</sub> <sup>(2)</sup>	Input Voltage Range	A port	-0.3	6.0	V
		B port	-0.3	6.0	
		OE	-0.3	6.0	
V <sub>O</sub> <sup>(2)</sup>	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 <sub>O</sub> <sup>(2)(3)</sup>	Voltage range applied to any output in the high or low state	A port	-0.3	V <sub>CCA</sub> +0.3	V
		B port	-0.3	V <sub>CCB</sub> +0.3	
I <sub>IK</sub>	Input clamp current	V <sub>I</sub> <0		-50	mA
I <sub>OK</sub>	Output clamp current	V <sub>O</sub> <0		-25	mA
I <sub>O</sub>	Continuous output current			±50	mA
	Continuous current through V <sub>CCA</sub> , V <sub>CCB</sub> or GND			±100	mA
θ <sub>JA</sub>	Package thermal impedance <sup>(4)</sup>	QFN3.5X3.5-14		53	°C/W
		UQFN1.7X2-12		120	
		TSSOP14		121	
		UQFN2X2-12		TBD	
T <sub>J</sub>	Junction Temperature <sup>(5)</sup>		-40	150	°C
T <sub>stg</sub>	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<sub>CCA</sub> and V<sub>CCB</sub> are provided in the recommended operating conditions table.

(4) The package thermal impedance is calculated in accordance with JESD-51.

(5) The maximum power dissipation is a function of T<sub>J(MAX)</sub>, R<sub>θJA</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any ambient temperature is P<sub>D</sub> = (T<sub>J(MAX)</sub> - T<sub>A</sub>) / R<sub>θJA</sub>. 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 <sub>(ESD)</sub>	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±5000	V
		Charged-device model (CDM)	±1000	
		Machine model (MM)	±400	

(1) JEDEC document JEP155 states that 500 V HBM allows safe manufacturing with a standard ESD control process.



#### 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 <sup>(1)</sup>	$V_{CCA}$		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		85	°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) <sup>(1)</sup> <sup>(2)</sup> <sup>(3)</sup>

PARAMETER		CONDITIONS	V <sub>CCA</sub>	V <sub>CCB</sub>	TEMP	MIN <sup>(4)</sup>	TYP <sup>(5)</sup>	MAX <sup>(4)</sup>	UNITS
V <sub>OHA</sub>	Port A output high voltage	I <sub>OH</sub> = -20 μA V <sub>IB</sub> ≥ V <sub>CCB</sub> - 0.4V	1.65V to 5.5V	2.3V to 5.5V	Full	V <sub>CCA</sub> × 0.7		5.5	V
V <sub>OLA</sub>	Port A output low voltage	I <sub>OL</sub> = 1mA V <sub>IB</sub> ≤ 0.15 V	1.65V to 5.5V	2.3V to 5.5V	Full			0.3	
V <sub>OHB</sub>	Port B output high voltage	I <sub>OH</sub> = -20 μA V <sub>IA</sub> ≥ V <sub>CCA</sub> - 0.2 V	1.65V to 5.5V	2.3V to 5.5V	Full	V <sub>CCB</sub> × 0.7			
V <sub>OLB</sub>	Port B output low voltage	I <sub>OL</sub> = 1mA V <sub>IA</sub> ≤ 0.15 V	1.65V to 5.5V	2.3V to 5.5V	Full			0.3	
I <sub>I</sub>	Input leakage current	OE	1.65V to 5.5V	2.3V to 5.5V	+25°C			±1	μA
					Full			±1.5	
I <sub>off</sub>	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 <sub>oz</sub> <sup>(6)</sup>	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 <sub>CCA</sub>	V <sub>CCA</sub> supply current	V <sub>I</sub> = V <sub>O</sub> = open I <sub>O</sub> = 0	1.65V to V <sub>CCB</sub>	2.3V to 5.5V	Full			1.0	μA
			5.5V	0V	Full			1.0	
			0V	5.5V	Full			-1	
I <sub>CCB</sub>	V <sub>CCB</sub> supply current	V <sub>I</sub> = V <sub>O</sub> = open I <sub>O</sub> = 0	1.65V to V <sub>CCB</sub>	2.3V to 5.5V	Full			10	μA
			5.5V	0V	Full			-1	
			0V	5.5V	Full			1	
I <sub>CCA</sub> + I <sub>CCB</sub>	Combined supply current	V <sub>I</sub> = V <sub>O</sub> = open I <sub>O</sub> = 0	1.65V to V <sub>CCB</sub>	2.3V to 5.5V	Full			15	μA
I <sub>CCA</sub>	V <sub>CCA</sub> supply current	V <sub>I</sub> = V <sub>CCI</sub> or 0V I <sub>O</sub> = 0, OE=0V	1.65V to V <sub>CCB</sub>	2.3V to 5.5V	Full			1	μA
I <sub>CCB</sub>	V <sub>CCB</sub> supply current	V <sub>I</sub> = V <sub>CCI</sub> or 0V I <sub>O</sub> = 0, OE=0V	2.3V to 5.5V	2.3V to 5.5V	Full			1	μA
C <sub>I</sub>	Input capacitance	OE	3.3V	3.3V	+25°C		2.5		pF
C <sub>IO</sub>	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<sub>CCI</sub> is the V<sub>CC</sub> associated with the input port.

(2) V<sub>CCO</sub> is the V<sub>CC</sub> associated with the output port

(3) V<sub>CCA</sub> must be less than or equal to V<sub>CCB</sub>.

(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<sub>oz</sub> 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		$V_{CCB}=2.5V\pm 0.2V$	$V_{CCB}=3.3V\pm 0.2V$	$V_{CCB}=5V\pm 0.2V$	UNITS
				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		$V_{CCB}=2.5V\pm0.2V$	$V_{CCB}=3.3V\pm0.2V$	$V_{CCB}=5V\pm0.2V$	UNITS
				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		$V_{CCB}=3.3V \pm 0.2V$	$V_{CCB}=5V \pm 0.2V$	UNITS
				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	



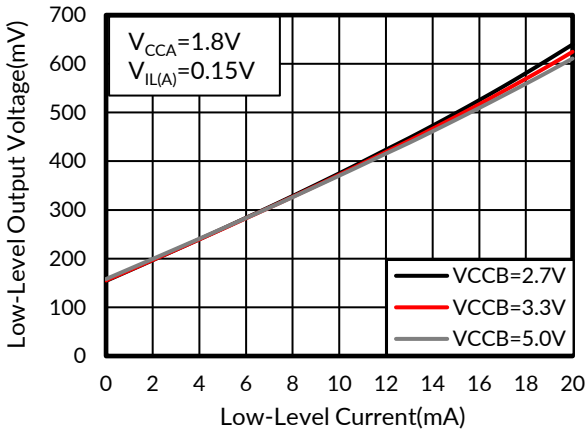
## 8.9 Switching Characteristics: $V_{CCA}=5.0V \pm 0.35V$

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

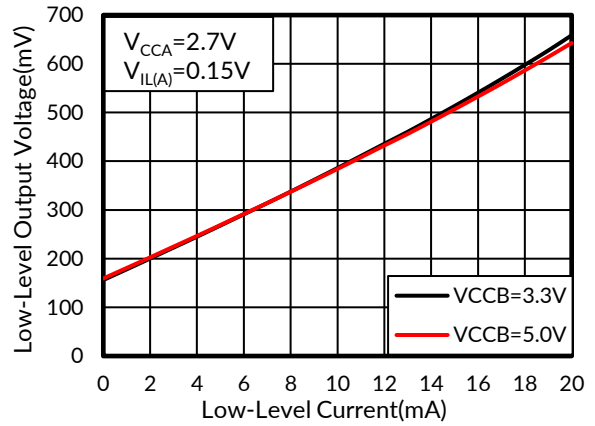
PARAMETER		CONDITIONS		$V_{CCB}=5V \pm 0.2V$	UNITS
				TYP	
$t_{PHL}$	Propagation delay time high-to-low output	A-to-B	Push-pull driving	5.6	ns
			Open-drain driving	26.8	
$t_{PLH}$	Propagation delay time low-to-high output	A-to-B	Push-pull driving	2.0	ns
			Open-drain driving	155	
$t_{PHL}$	Propagation 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

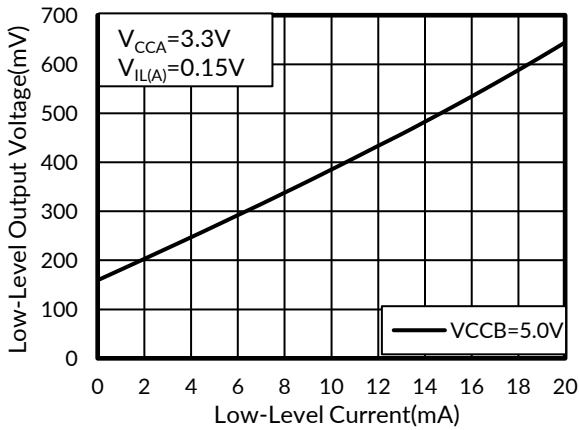
NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.



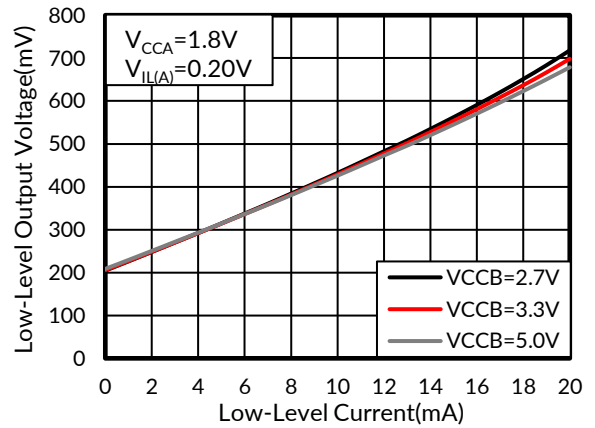
**Figure1: Low-Level Output Voltage vs Low-Level Current**



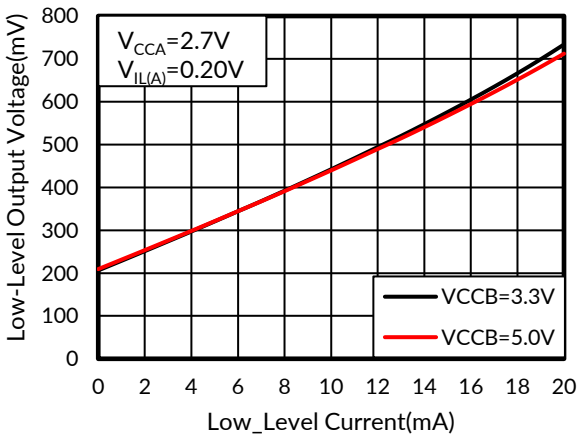
**Figure2: Low-Level Output Voltage vs Low-Level Current**



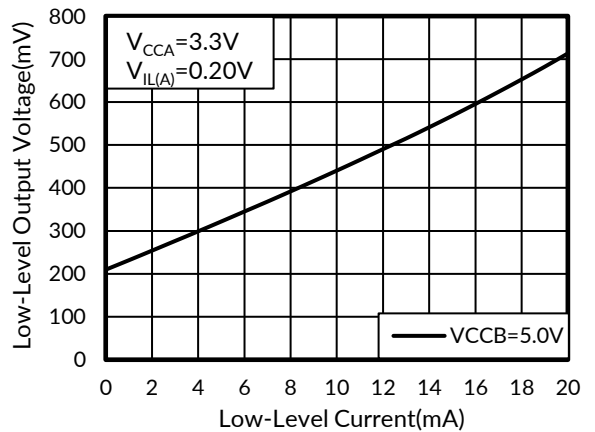
**Figure3: Low-Level Output Voltage vs Low-Level Current**



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



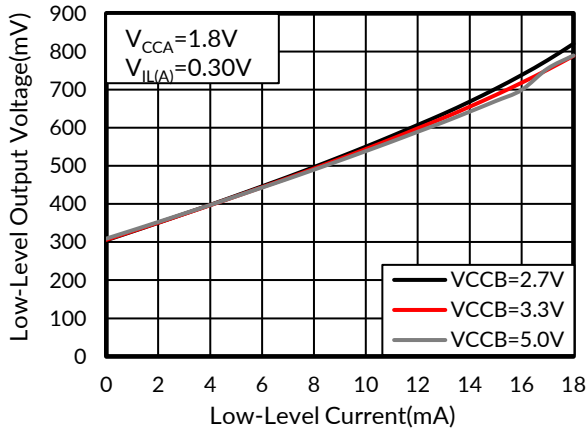
**Figure5: Low-Level Output Voltage vs Low-Level Current**



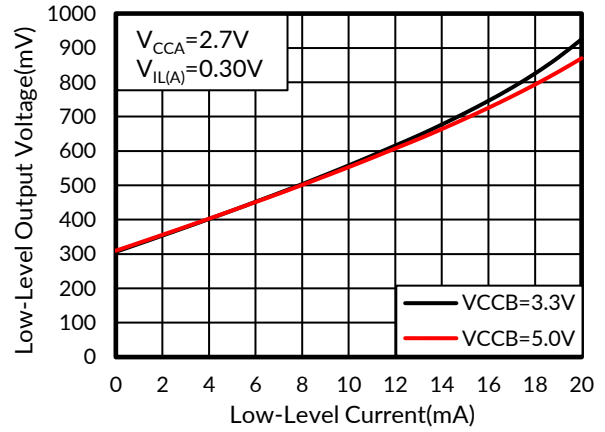
**Figure6: Low-Level Output Voltage vs Low-Level Current**

### Typical Characteristics

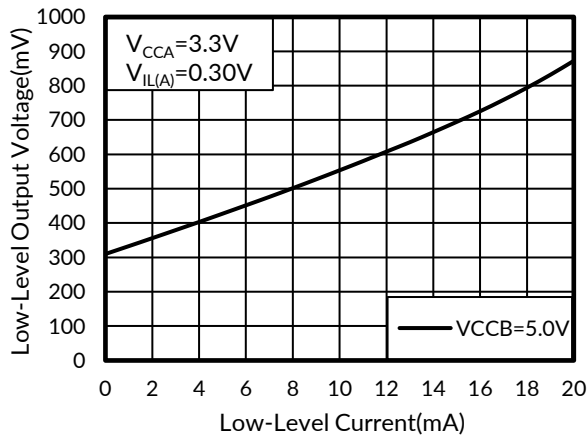
NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.



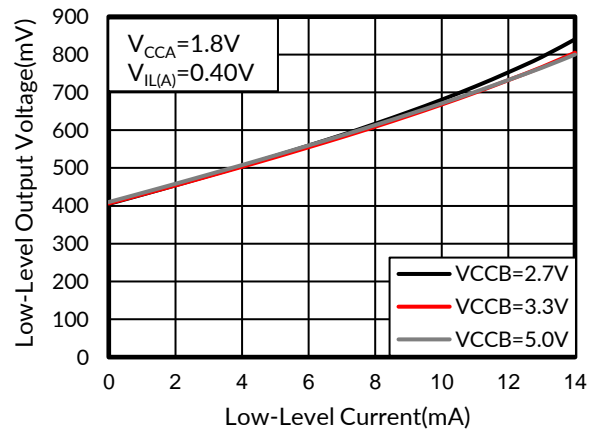
**Figure7: Low-Level Output Voltage vs Low-Level Current**



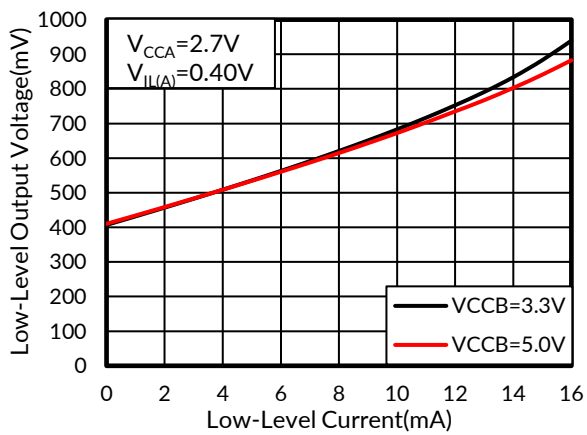
**Figure8: Low-Level Output Voltage vs Low-Level Current**



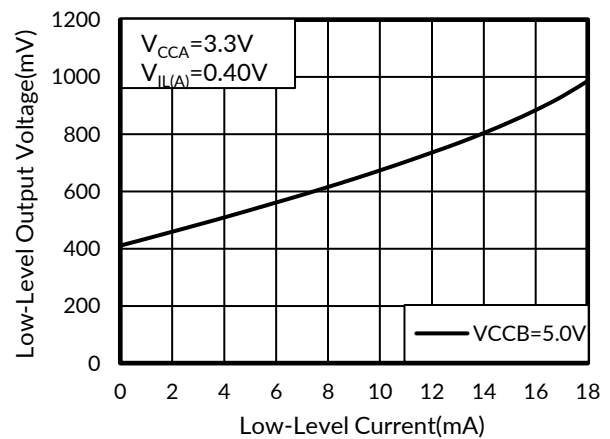
**Figure9: Low-Level Output Voltage vs Low-Level Current**



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



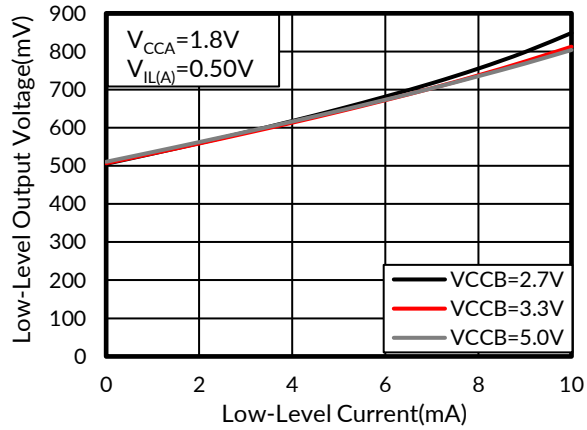
**Figure11: Low-Level Output Voltage vs Low-Level Current**



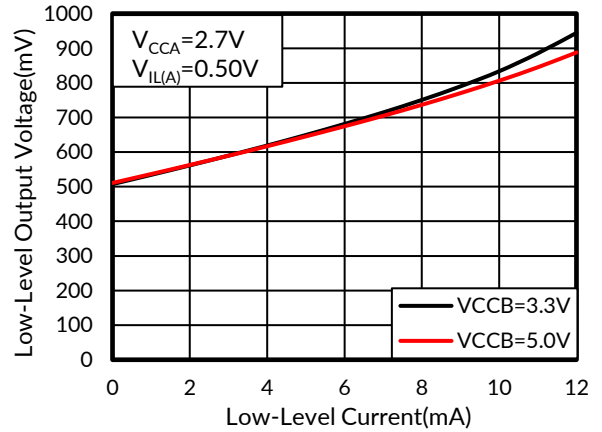
**Figure12: Low-Level Output Voltage vs Low-Level Current**

### Typical Characteristics

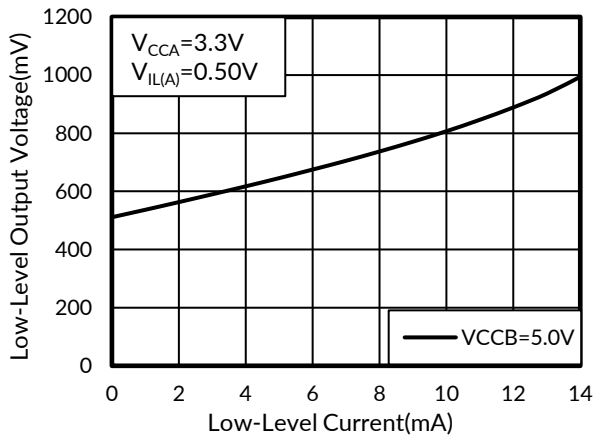
NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.



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



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



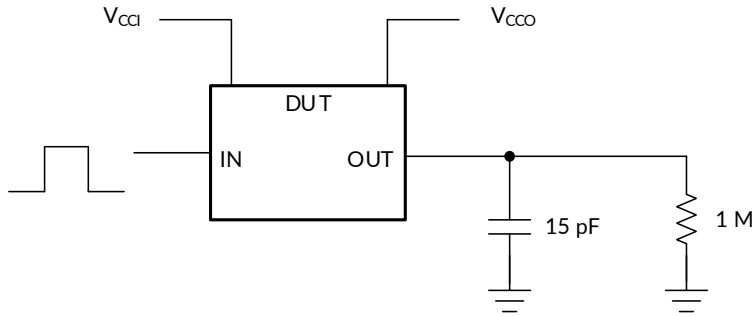
**Figure15: Low-level Output Voltage vs Low-Level Current**

## 9 Parameter Measurement Information

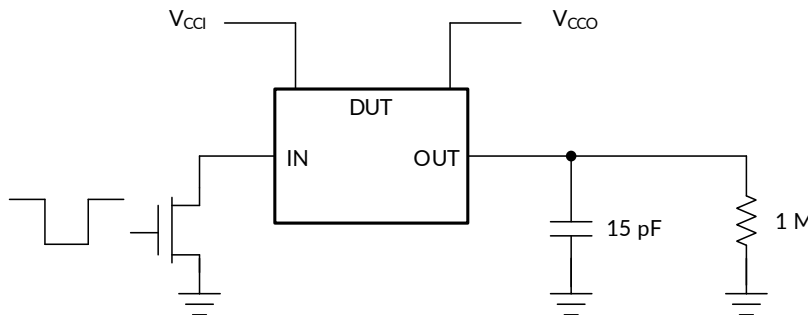
Unless otherwise noted, all input pulses are supplied by generators having the following characteristics:

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

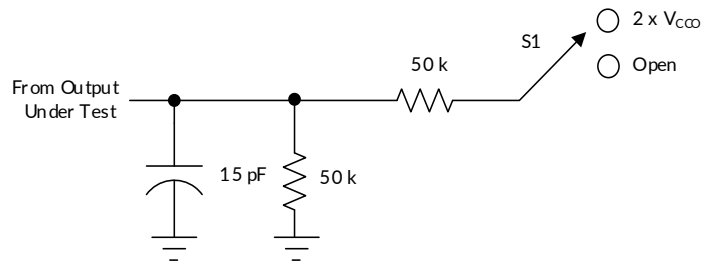
Note: All input pulses are measured one at a time, with one transition per measurement.



**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**



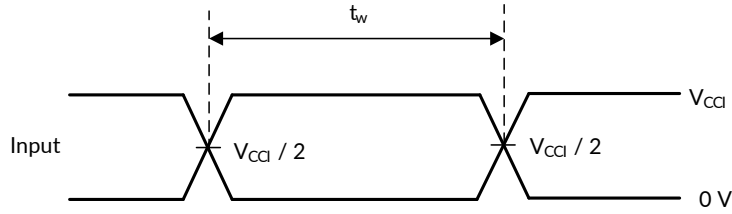
**Figure 18. Load Circuit for Enable/Disable Time Measurement**

**Table 1. Switch Configuration for Enable/Disable Timing**

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

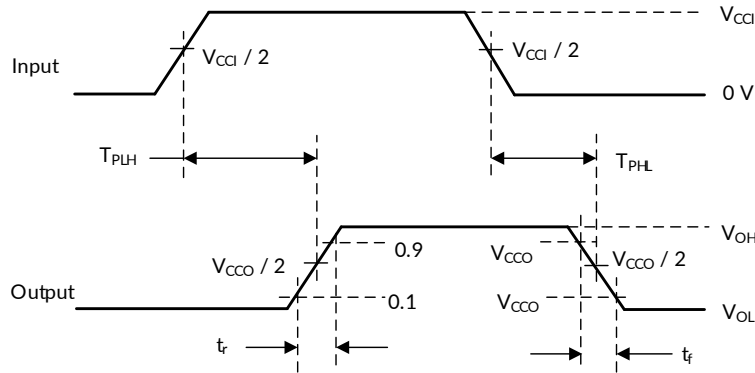
(1)  $t_{PZL}$  and  $t_{PHZ}$  are the same as  $t_{en}$ .

(2)  $t_{PLZ}$  and  $t_{PHZ}$  are the same as  $t_{dis}$ .

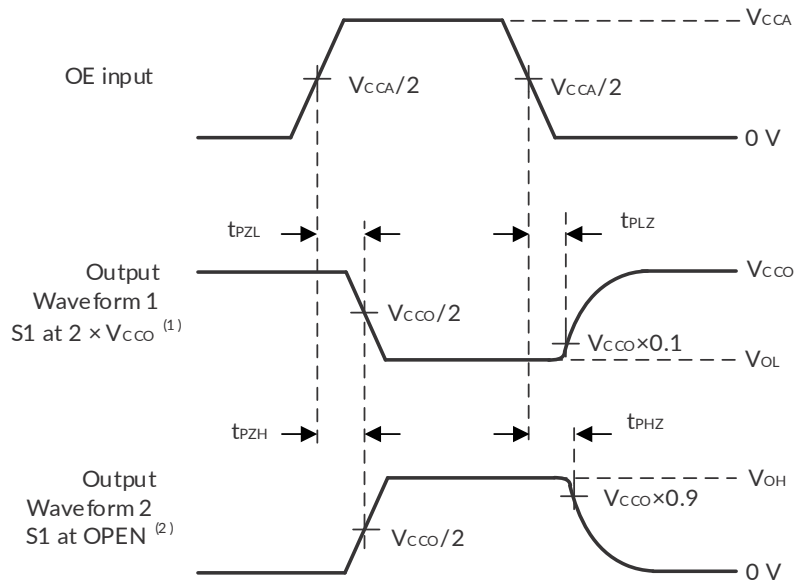


(1) All input pulses are measured one at a time, with one transition per measurement.

**Figure 19. Voltage Waveforms Pulse Duration**



**Figure 20. Voltage Waveforms Propagation Delay Times**



A. Waveform 1 is for an output with internal such that the output is high, except when OE is high.  
 B. Waveform 2 is for an output with conditions such that the output is low, except when OE is high.

**Figure 21. Voltage Waveforms Enable and Disable**

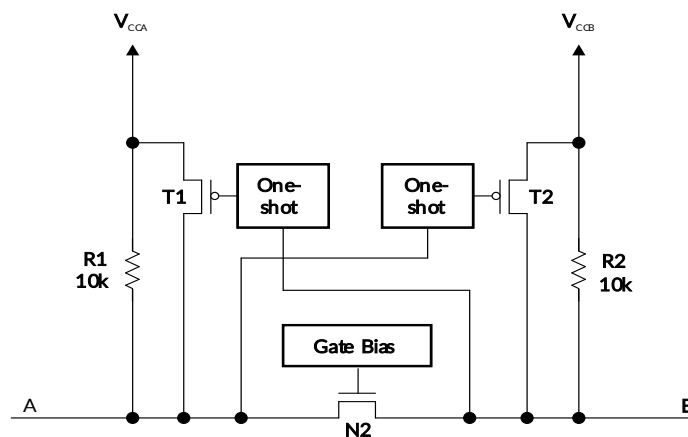
## 10 Feature Description

### 10.1 Overview

The RS0104 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 $\Omega$  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 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 Cell**

The RS0104 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 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 $\Omega$  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 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  $\Omega$ .

## Feature Description

### 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 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 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 $\Omega$  pullup resistor to  $V_{CCA}$ , and each B-port I/O has an internal 10-k $\Omega$  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 $\Omega$  resistors). Adding lower value pull-up resistors will affect  $V_{OL}$  levels, however. The internal pull-ups of the RS0104 are disabled when the OE pin is low.



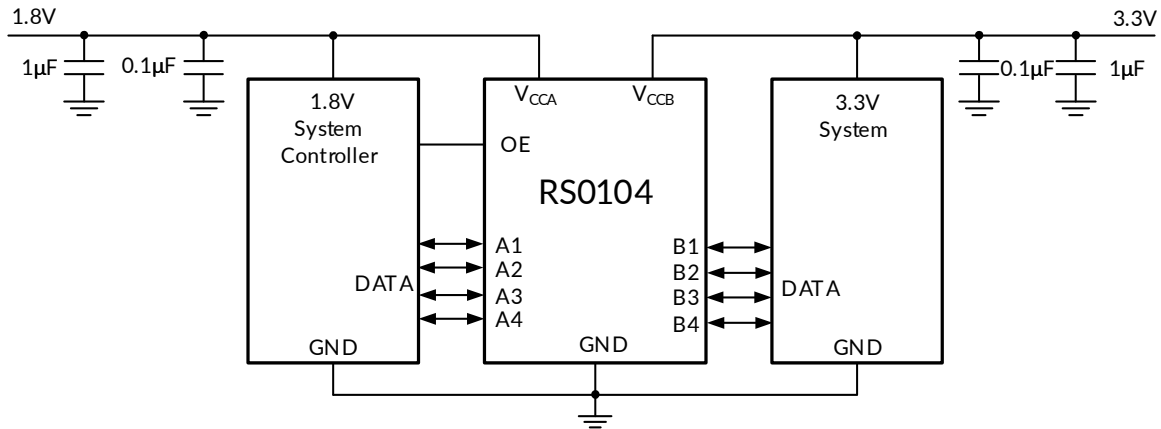
## 11 Application and Implementation

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 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 I<sup>2</sup>C 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 might be a better option for such push-pull applications.

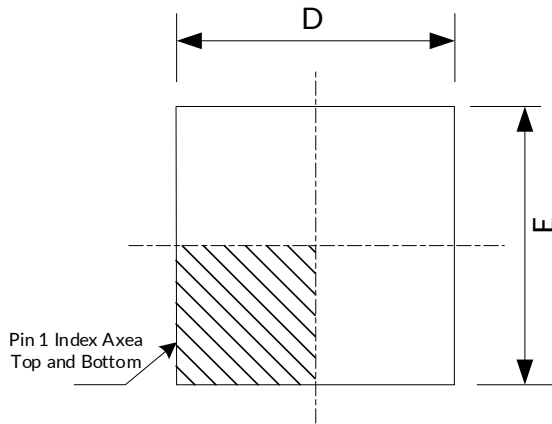
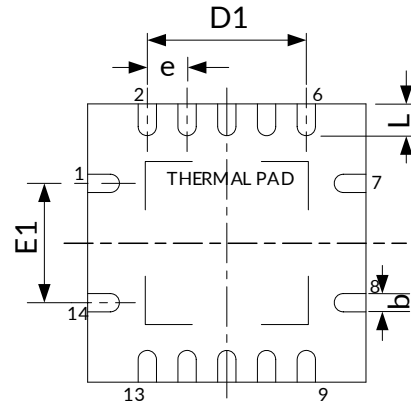
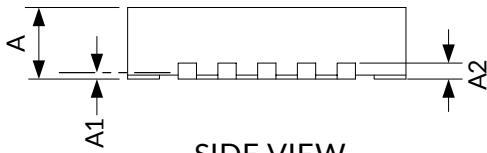
### 11.2 Typical Application



**Figure 23. Typical Application Circuit**

# 12 PACKAGE OUTLINE DIMENSIONS

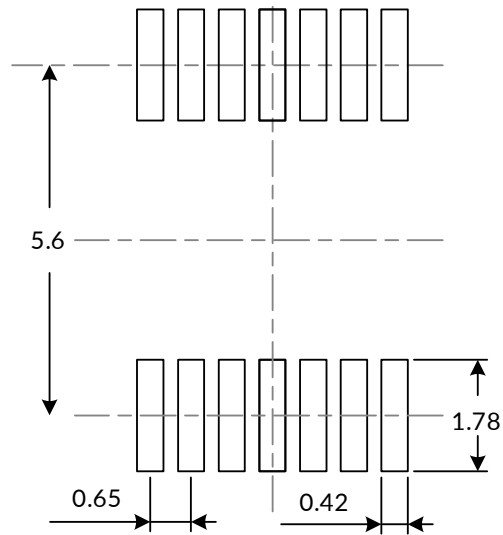
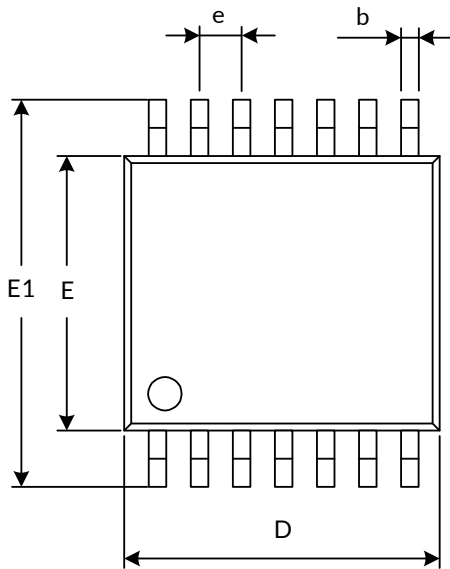
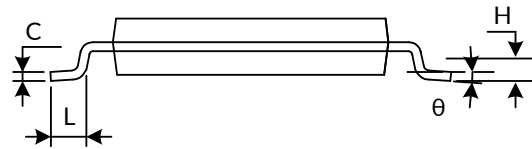
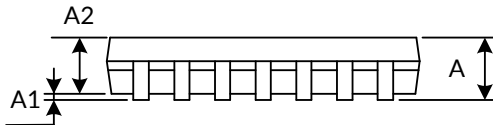
## QFN3.5X3.5-14<sup>(3)</sup>


**TOP VIEW**

**BOTTOM VIEW**

**SIDE VIEW**

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A <sup>(1)</sup>	0.700	0.900	0.028	0.035
A1	0.000	0.050	0.000	0.002
A2	0.200 REF <sup>(2)</sup>		0.008 REF <sup>(2)</sup>	
b	0.180	0.300	0.007	0.012
D <sup>(1)</sup>	3.350	3.650	0.132	0.144
D1	2.000 TYP		0.079 TYP	
E <sup>(1)</sup>	3.350	3.650	0.007	0.012
E1	1.500 TYP		0.059 TYP	
e	0.500 TYP		0.020 TYP	
L	0.300	0.500	0.012	0.020

**NOTE:**

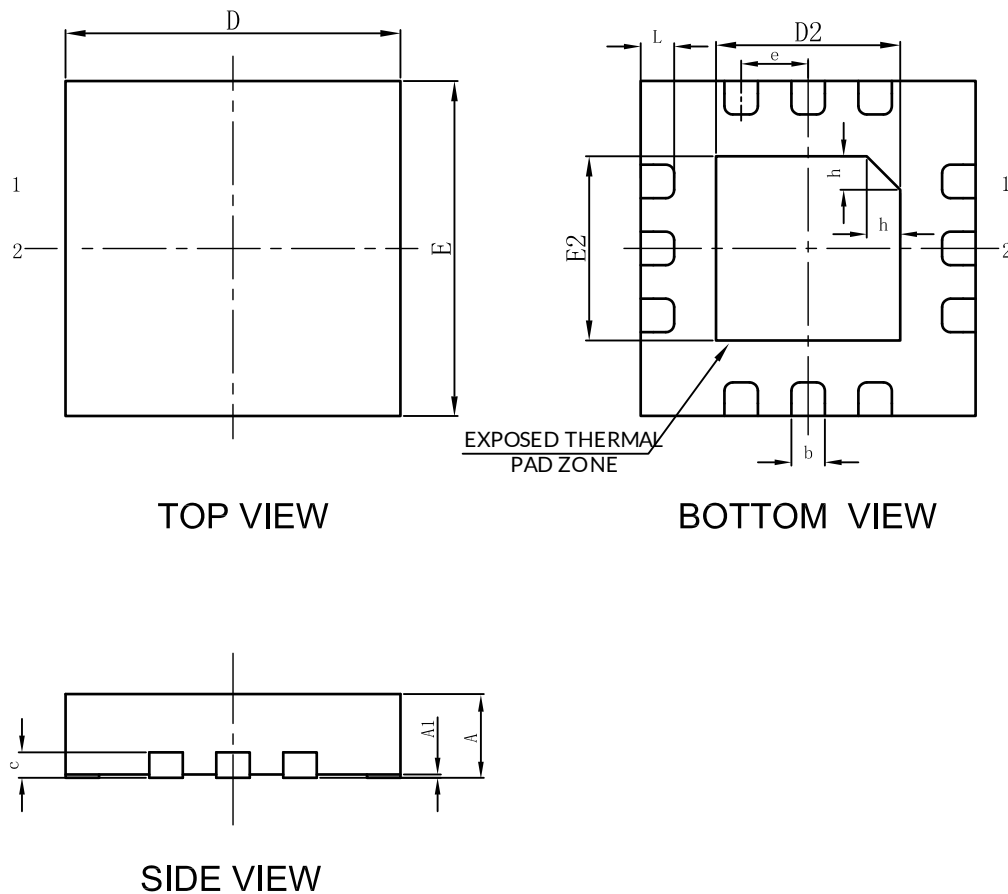
1. Plastic or metal protrusions of 0.075mm maximum per side are not included.
2. REF is the abbreviation for Reference.
3. This drawing is subject to change without notice.

**TSSOP14 (3)**

**RECOMMENDED LAND PATTERN (Unit: mm)**


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A <sup>(1)</sup>		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D <sup>(1)</sup>	4.860	5.100	0.191	0.201
E <sup>(1)</sup>	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650(BSC) <sup>(2)</sup>		0.026(BSC) <sup>(2)</sup>	
L	0.500	0.700	0.020	0.028
H	0.250(TYP)		0.010(TYP)	
$\theta$	1°	7°	1°	7°

**NOTE:**

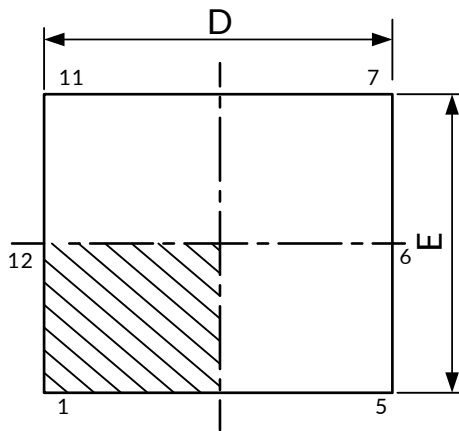
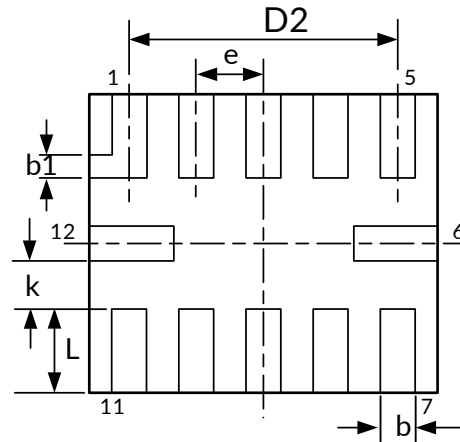
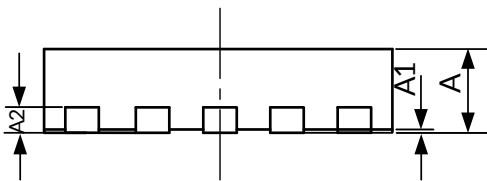
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

**UQFN2X2-12<sup>(3)</sup>**


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A <sup>(1)</sup>	0.500	0.600	0.020	0.024
A1	0.000	0.050	0.000	0.002
c	0.100	0.200	0.004	0.008
b	0.150	0.250	0.006	0.010
D <sup>(1)</sup>	1.900	2.100	0.075	0.083
E <sup>(1)</sup>	1.900	2.100	0.075	0.083
D2	1.000	1.200	0.039	0.057
E2	1.000	1.200	0.039	0.057
e	0.400 BSC <sup>(2)</sup>		0.016 BSC <sup>(2)</sup>	
h	0.150	0.250	0.006	0.010
L	0.150	0.250	0.006	0.010

**NOTE:**

1. Plastic or metal protrusions of 0.075mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

**UQFN1.7X2-12<sup>(4)</sup>**

**TOP VIEW**

**BOTTOM VIEW**

**SIDE VIEW**

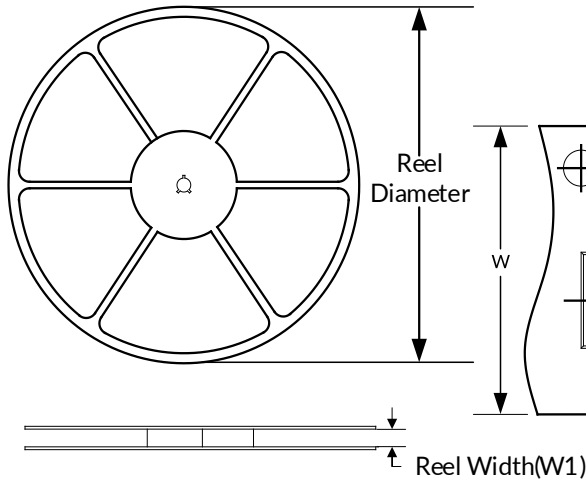
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A <sup>(1)</sup>	0.450	0.550	0.018	0.022
A1	0.000	0.050	0.000	0.002
A2	0.152 REF <sup>(2)</sup>		0.006 REF <sup>(2)</sup>	
D <sup>(1)</sup>	1.900	2.100	0.075	0.083
E <sup>(1)</sup>	1.600	1.800	0.063	0.071
D2	1.500	1.700	0.059	0.067
b	0.150	0.250	0.006	0.010
b1	0.150 REF <sup>(2)</sup>		0.006 REF <sup>(2)</sup>	
k	0.250 REF <sup>(2)</sup>		0.010 REF <sup>(2)</sup>	
e	0.400 BSC <sup>(3)</sup>		0.016 BSC <sup>(3)</sup>	
L	0.400	0.600	0.016	0.024

**NOTE:**

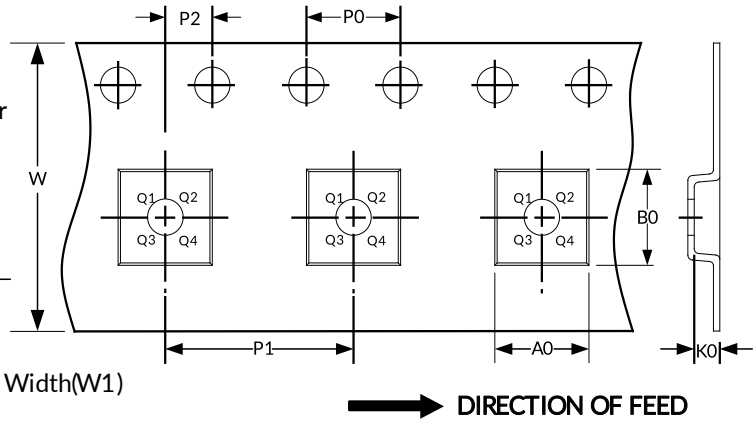
1. Plastic or metal protrusions of 0.075mm maximum per side are not included.
2. REF is the abbreviation for Reference.
3. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
4. This drawing is subject to change without notice.

### 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
QFN3.5X3.5-14	13"	12.4	3.80	3.80	1.10	4.0	8.0	2.0	12.0	Q1
TSSOP14	13"	12.4	6.95	5.60	1.20	4.0	8.0	2.0	12.0	Q1
UQFN1.7X2-12	7"	9.0	1.90	2.30	0.75	4.0	4.0	2.0	8.0	Q1
UQFN2X2-12	7"	9.0	2.13	2.13	0.88	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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