

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Features

- 4-bit Bidirectional Level Shifter
- Open-Drain and Push-Pull Output
- Max Data Rate ($V_{CCA} = 3.3\text{ V}$, $V_{CCB} = 5\text{ V}$):
 - 100 Mbps (Push-Pull), 1.2 Mbps (Open-drain)
- Voltage-Level Translation Between:
 - V_{CCA} Range: 1.65 V to 3.6 V
 - V_{CCB} Range: 1.65 V to 5.5 V
- 5 V Tolerant OE Enable Pin
- High-Impedance A1~4 and B1~4 Pins for OE = LOW
- VCC Isolation Feature: Either VCC Input = GND, All Outputs in High-Impedance State
- I_{OFF} Supports Partial Power-down Mode
- No Power-up Sequency Required for V_{CCA} , V_{CCB}
- ESD Protection:
 - A Port $\pm 4000\text{-V}$ Human-Body Model
 - B Port $\pm 8000\text{-V}$ Human-Body Model
 - B Port $\pm 4000\text{-V}$ IEC 61000-4-2 Contact Discharge
 - 1500-V Charged-Device Model

Description

The TPT20104 device is a 4-bit level shifter with an enable (OE) input and can work from 1.65 V to 3.6 V V_{CCA} and 1.65 V to 5.5 V V_{CCB} . V_{CCA} must be less than or equal to V_{CCB} . The TPT20104 supports bidirectional voltage translation among 1.8 V, 2.5 V, 3.3 V, and 5 V.

The A1~4 I/Os are connected to the B1~4 I/Os, which allows bidirectional data flow between ports. If OE is low, the translator switch is off, and a high-impedance state exists between A ports and B ports to isolate both sides. OE input circuit is internally connected to V_{CCA} .

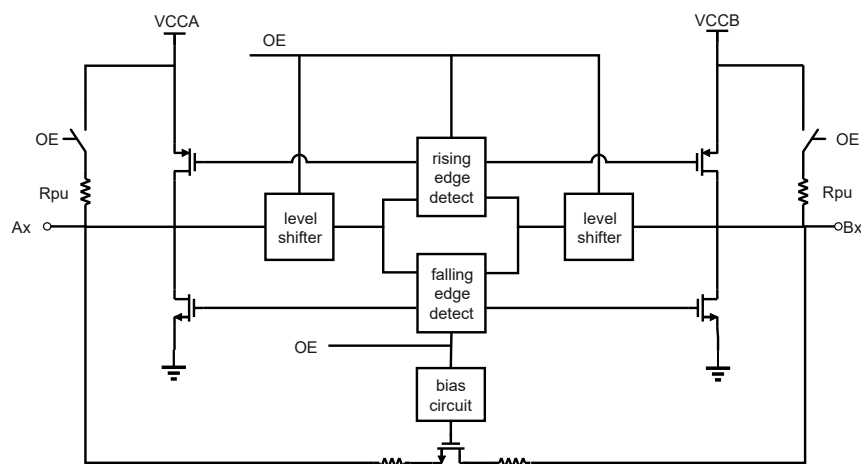
The 4-bit bidirectional buffer isolates capacitance and allows 15 pF on either side of the device to support 100 Mbps speeds in Push-Pull mode in 3.3 V V_{CCA} and 5 V V_{CCB} supply, and support 1.2 Mbps speeds in Open-Drain mode.

TPT20104 is available in TSSOP14, QFN1.7x2.0-12, and QFN3.5x3.5-14 package and is characterized from -40°C to $+125^{\circ}\text{C}$.

Applications

- Servers/Storages
- Routers (Telecom Switching Equipment)
- Personal Computers/ Consumer handsets
- Industrial Automation

Functional Block Diagram



4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

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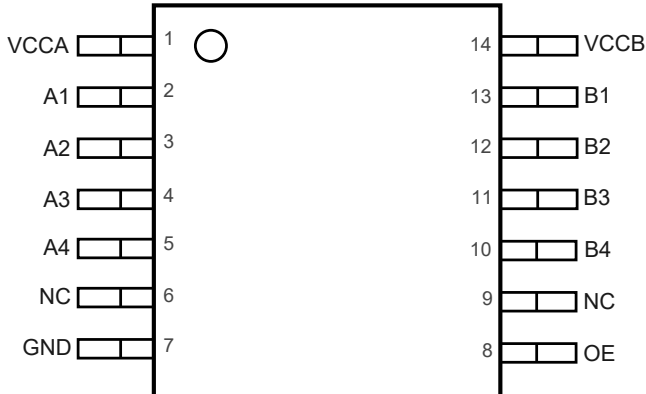
4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull**Revision History**

Date	Revision	Notes
2024-07-19	Rev.Pre.0	Initial version
2024-08-28	Rev.A.0	Released version
2025-04-08	Rev.A.1	Updated the POD

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Pin Configuration and Functions

TPT20104-TS2R
TSSOP14 Package
Top View



TPT20104-QFMR
QFN3.5x3.5-14 Package
Top View

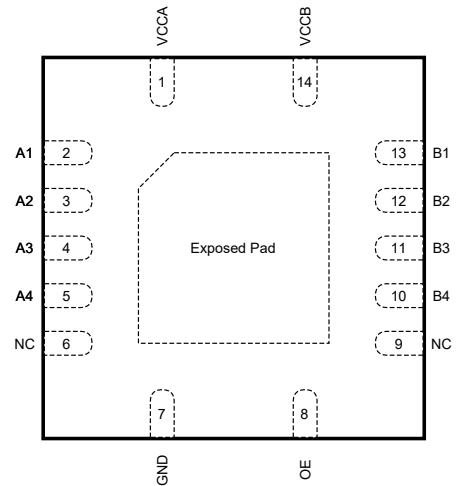


Table 1. Pin Functions: TPT20104

Pin		I/O	Description
No.	Name		
1	VCCA	I	Side-A supply voltage
2	A1	I/O	Input/output A1. Referenced to V _{CCA}
3	A2	I/O	Input/output A2. Referenced to V _{CCA}
4	A3	I/O	Input/output A3. Referenced to V _{CCA}
5	A4	I/O	Input/output A4. Referenced to V _{CCA}
6	NC	--	No Connection
7	GND	I	Supply ground
8	OE	I	Active-high enable input. Referenced to V _{CCA} . Not allowed to be floating
9	NC	--	No Connection
10	B4	I/O	Input/output B4. Referenced to V _{CCB}
11	B3	I/O	Input/output B3. Referenced to V _{CCB}
12	B2	I/O	Input/output B2. Referenced to V _{CCB}
13	B1	I/O	Input/output B1. Referenced to V _{CCB}
14	VCCB	I	Side-B supply voltage
15	Epad	--	For QFN package, the exposed thermal pad must be connected to ground.

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

TPT20104-QN5R
QFN1.7x2-12 Package
Top View

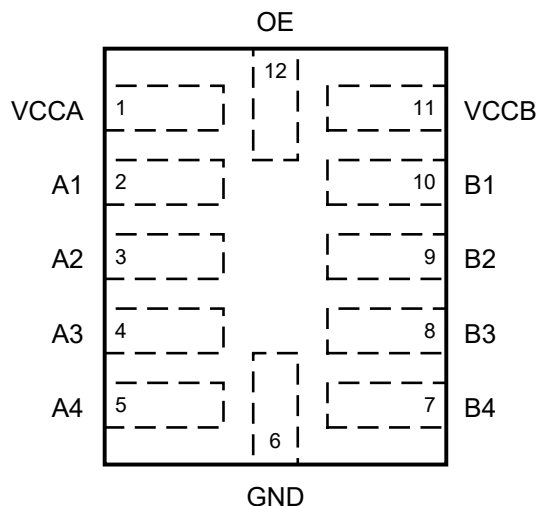


Table 2. Pin Functions: TPT20104

Pin		I/O	Description
No.	Name		
1	VCCA	I	Side-A supply voltage
2	A1	I/O	Input/output A1. Referenced to V _{CCA}
3	A2	I/O	Input/output A2. Referenced to V _{CCA}
4	A3	I/O	Input/output A3. Referenced to V _{CCA}
5	A4	I/O	Input/output A4. Referenced to V _{CCA}
6	GND	I	Supply ground
7	B4	I/O	Input/output B4. Referenced to V _{CCB}
8	B3	I/O	Input/output B3. Referenced to V _{CCB}
9	B2	I/O	Input/output B2. Referenced to V _{CCB}
10	B1	I/O	Input/output B1. Referenced to V _{CCB}
11	VCCB	I	Side-B supply voltage
12	OE	i	Active-high enable input. Referenced to V _{CCA} . Not allowed to be floating

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Specifications

Absolute Maximum Ratings ⁽¹⁾

Parameter		Min	Max	Unit
V _{CCA}	DC Reference Voltage Range (side-A)	-0.5	4.6	V
V _{CCB}	DC Reference Bias Voltage Range (side-B)	-0.5	6.5	V
V _I	Input Voltage Range, side-A	-0.5	4.6	V
	Input Voltage Range, side-B	-0.5	6.5	V
V _O	Voltage Range Applied to Any Output in the High-impedance or Power-off State, V _O , side-A	-0.5	4.6	V
	Voltage Range Applied to Any Output in the High-impedance or Power-off State, V _O , side-B	-0.5	6.5	V
	Voltage Range Applied to Any Output in the High or Low State, V _O , side-A	-0.5	V _{CCA} + 0.5	V
	Voltage Range Applied to any Output in the High or Low State, V _O , side-B	-0.5	V _{CCB} + 0.5	V
I _{IK}	Input Clamp Current, V _I < 0		-50	mA
I _{OK}	Output Clamp Current, V _{I/O} < 0		-50	mA
I _O	Continuous Output Current	-50	50	mA
I _C	Continuous Current through Each V _{CCA} , V _{CCB} , or GND	-100	100	mA
T _J	Maximum Junction Temperature		150	°C
T _{STG}	Storage Temperature Range	-65	150	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

(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.

ESD, Electrostatic Discharge Protection

Parameter		Condition	Value	Unit
HBM	Human Body Model ESD, side-A ports	ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±4	kV
	Human Body Model ESD, side-B ports	ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±8	kV
IEC ESD	IEC Contact Discharge	IEC-61000-4-2, Bus Pin: B ports	±4	kV
	IEC Air-Gap Discharge	IEC-61000-4-2, Bus Pin: B ports	±8	kV
CDM	Charged Device Model ESD, side-A and side-B ports	ANSI/ESDA/JEDEC JS-002 ⁽²⁾	±1.5	kV
LU	Latch up	LU, per JESD78, All Pins	±500	mA

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

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

Recommended Operating Conditions

Parameter		V _{CCA}	V _{CCB}	Min	Max	Unit
V _{CCA}	Reference Voltage, side-A			1.65	3.6	V
V _{CCB}	Reference Voltage, side-B			1.65	5.5	V
V _{IH}	Side-A Ports High-level Input Voltage	1.65 V to 1.95 V	1.65 V to 5.5 V	V _{CCI} - 0.2	V _{CCI}	V
	Side-A Ports High-level Input Voltage	2.3 V to 3.6 V	1.65 V to 5.5 V	V _{CCI} - 0.4	V _{CCI}	V
	Side-B Ports High-level Input Voltage	1.65 V to 3.6 V	1.65 V to 5.5 V	V _{CCI} - 0.4	V _{CCI}	V
	OE Inputs High-level Input Voltage	1.65 V to 3.6 V	1.65 V to 5.5 V	V _{CCA} × 0.65	5.5	V
V _{IL}	Side-A Ports Low-level Input Voltage	1.65 V to 3.6 V	1.65 V to 5.5 V	0	0.15	V
	Side-B Ports Low-level Input Voltage	1.65 V to 3.6 V	1.65 V to 5.5 V	0	0.15	V
	OE Inputs Low-level Input Voltage	1.65 V to 3.6 V	1.65 V to 5.5 V	0	V _{CCA} × 0.35	V
Δt/Δv	Side-A Ports Input Transition Rise or Fall Rate	1.65 V to 3.6 V	1.65 V to 5.5 V		10	ns/V
	Side-B Ports Input Transition Rise or Fall Rate	1.65 V to 3.6 V	1.65 V to 5.5 V		10	
	OE Input Transition Rise or Fall Rate	1.65 V to 3.6 V	1.65 V to 5.5 V		10	
T _A	Operating Ambient Temperature			-40	125	°C

(1) V_{CCI} is the supply voltage of the input side-A or side-B port.

(2) V_{CCA} should be less than or equal to V_{CCB}, and V_{CCA} must not be higher than 3.6 V.

Thermal Information

Package Type	θ _{JA}	θ _{Jc}	Unit
TSSOP14	113	49	°C/W
QFN3.5x3.5-14	53	65	°C/W
QFN1.7x2-12	115	41	°C/W

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Electrical Characteristics

All test conditions: $V_{CCA} = 1.65\text{ V to }3.6\text{ V}$, $V_{CCB} = 1.65\text{ V to }5.5\text{ V}$, $T_A = -40^\circ\text{C to }+125^\circ\text{C}$, unless otherwise noted.

Parameter	Conditions	V_{CCA}	V_{CCB}	Min	Typ	Max	Unit
Supply Voltage and Current							
V_{OHA}	Port A High-level Output voltage	$I_{OH} = -20\text{ }\mu\text{A}$, $V_{IB} \geq V_{CCB} - 0.4\text{ V}$	1.65 V to 3.6 V	1.65 V to 5.5 V	$V_{CCA} \times 0.67$		V
V_{OLA}	Port A Low-level Output Voltage	$I_{OL} = 220\text{ }\mu\text{A}$, $V_{IB} \leq 0.15\text{ V}$	1.65 V	1.65 V to 5.5 V		0.4	V
		$I_{OL} = 300\text{ }\mu\text{A}$, $V_{IB} \leq 0.15\text{ V}$	2.3 V	1.65 V to 5.5 V		0.4	
		$I_{OL} = 400\text{ }\mu\text{A}$, $V_{IB} \leq 0.15\text{ V}$	3.0 V	3.0 V to 5.5 V		0.55	
		$I_{OL} = 1000\text{ }\mu\text{A}$, $V_{IB} \leq 0.15\text{ V}$	1.65 V to 3.6 V	3.0 V to 5.5 V		0.6	
V_{OHB}	Port B High-level Output voltage	$I_{OH} = -20\text{ }\mu\text{A}$, $V_{IA} \geq V_{CCA} - 0.2\text{ V}$	1.65 V to 3.6 V	1.65 V to 5.5 V	$V_{CCB} \times 0.67$		V
V_{OLB}	Port B Low-level Output voltage	$I_{OL} = 220\text{ }\mu\text{A}$, $V_{IA} \leq 0.15\text{ V}$	1.65 V to 3.6 V	1.65 V		0.4	V
		$I_{OL} = 300\text{ }\mu\text{A}$, $V_{IA} \leq 0.15\text{ V}$	1.65 V to 3.6 V	2.3 V		0.4	
		$I_{OL} = 400\text{ }\mu\text{A}$, $V_{IA} \leq 0.15\text{ V}$	1.65 V to 3.6 V	3.0 V		0.55	
		$I_{OL} = 620\text{ }\mu\text{A}$, $V_{IA} \leq 0.15\text{ V}$	1.65 V to 3.6 V	4.5 V		0.55	
		$I_{OL} = 1000\text{ }\mu\text{A}$, $V_{IA} \leq 0.15\text{ V}$	1.65 V to 3.6 V	4.5 V		0.6	
I_I	Input Leakage Current	OE: $V_I = V_{CCI}$ or GND	1.65 V	1.65 V to 5.5 V	-2	2	μA
I_{OZ}	High-impedance State Output Current	Port A or B, OE = GND	1.65 V	1.65 V to 5.5 V	-2	2	μA
I_{CCA}	Quiescent Supply Current for V_{CCA}	$V_I = V_O = \text{Open}$, $I_O = 0$, OE = V_{CCA}	1.65 V to 3.6 V	1.65 V to 5.5 V		5	μA
			3.6 V	0		5	
			0	5.5 V	-1	1	
I_{CCB}	Quiescent Supply Current for V_{CCB}	$V_I = V_O = \text{Open}$, $I_O = 0$, OE = V_{CCA}	1.65 V to 3.6 V	1.65 V to 5.5 V		15	μA
			3.6 V	0	-1	1	
			0	5.5 V		10	

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Parameter		Conditions	V _{CCA}	V _{CCB}	Min	Typ	Max	Unit
I _{CCA} + I _{CCB}	Combined Supply Current	V _I = V _{CCI} , I _O = 0, OE = V _{CCA}	1.65 V to 3.6 V	1.65 V to 5.5 V			15	μA
I _{OFF}	OFF Current	A port: V _I or V _O = 0 to 3.6	0	0 V to 5.5 V	-5		5	μA
		B port: V _I or V _O = 0 to 3.6	0 V to 3.6 V	0	-5		5	μA
I _{CCZA}	High Impedance State V _{CCA} Supply Current	V _I = V _O = Open, I _O = 0, OE = GND	1.65 V to 3.6 V	1.65 V to 5.5 V			5	μA
I _{CCZB}	High Impedance State V _{CCB} Supply Current	V _I = V _O = Open, I _O = 0, OE = GND	1.65 V to 3.6 V	1.65 V to 5.5 V			15	μA
C _I	Input Capacitance ⁽¹⁾	OE	3.3 V	3.3 V		5	10	pF
C _{IO}	Input/output Capacitance ⁽¹⁾	Port A	3.3 V	3.3 V		7	10	pF
		Port B	3.3 V	3.3 V		10	15	pF

(1) Test data based on bench tests and design simulation.

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

AC Timing Requirements -- VCCA = 1.8 V

All test conditions: VCCA = 1.65 V to 1.95 V, TA = -40°C to +125°C, unless otherwise noted. The data is based on bench test and design simulation.

Parameter	Condition	VCCB	Min	Typ	Max	Unit
fD	Push-pull mode	1.65 V to 1.95 V			40	Mbps
		2.3 V to 2.7 V			45	Mbps
		3.0 V to 3.6 V			40	Mbps
		4.5 V to 5.5 V			40	Mbps
	Open-drain mode	1.65 V to 1.95 V			0.8	Mbps
		2.3 V to 2.7 V			0.8	Mbps
		3.0 V to 3.6 V			0.8	Mbps
		4.5 V to 5.5 V			1	Mbps
tw	Push-pull mode	1.65 V to 1.95 V	25			ns
		2.3 V to 2.7 V	22.22			ns
		3.0 V to 3.6 V	25			ns
		4.5 V to 5.5 V	25			ns
	Open-drain mode	1.65 V to 1.95 V	1250			ns
		2.3 V to 2.7 V	1250			ns
		3.0 V to 3.6 V	1250			ns
		4.5 V to 5.5 V	1000			ns
tPHL	A-to-B, push-pull driving	1.65 V to 1.95 V			20	ns
		2.3 V to 2.7 V			20	ns
		3.0 V to 3.6 V			15	ns
		4.5 V to 5.5 V			15	ns
	A-to-B, open-drain driving	1.65 V to 1.95 V	1.7		20	ns
		2.3 V to 2.7 V	1.7		20	ns
		3.0 V to 3.6 V	1.6		15	ns
		4.5 V to 5.5 V	1.5		15	ns
tPLH	A-to-B, push-pull driving	1.65 V to 1.95 V			20	ns
		2.3 V to 2.7 V			20	ns
		3.0 V to 3.6 V			15	ns

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Parameter		Condition	V _{CCB}	Min	Typ	Max	Unit
			4.5 V to 5.5 V			15	ns
		A-to-B, open-drain driving	1.65 V to 1.95 V			800	ns
			2.3 V to 2.7 V			700	ns
			3.0 V to 3.6 V			600	ns
			4.5 V to 5.5 V			500	ns
t _{PHL}	Propagation Delay (High-to-Low)	B-to-A, push-pull driving	1.65 V to 1.95 V			20	ns
			2.3 V to 2.7 V			17	ns
			3.0 V to 3.6 V			15	ns
			4.5 V to 5.5 V			15	ns
		B-to-A, open-drain driving	1.65 V to 1.95 V			20	ns
			2.3 V to 2.7 V	2		20	ns
			3.0 V to 3.6 V	1.9		15	ns
			4.5 V to 5.5 V	1.8		15	ns
t _{PLH}	Propagation Delay (Low-to-High)	B-to-A, push-pull driving	1.65 V to 1.95 V			20	ns
			2.3 V to 2.7 V			15	ns
			3.0 V to 3.6 V			15	ns
			4.5 V to 5.5 V			15	ns
		B-to-A, open-drain driving	1.65 V to 1.95 V			900	ns
			2.3 V to 2.7 V			700	ns
			3.0 V to 3.6 V			600	ns
			4.5 V to 5.5 V			500	ns
t _{en}	Enable time	OE-to-A or B, push-pull driving	1.65 V to 5.5 V			100	ns
t _{dis}	Disable time	OE-to-A or B, push-pull driving	1.65 V to 5.5 V			410	ns
tr _A	Input rise time	A-port rise time, push-pull driving	1.65 V to 1.95 V			20	ns
			2.3 V to 2.7 V	1.6		20	ns
			3.0 V to 3.6 V	1.4		15	ns
			4.5 V to 5.5 V	1.4		15	ns
		A-port rise time, open-drain driving	1.65 V to 1.95 V	1.7		1200	ns
			2.3 V to 2.7 V	1.7		800	ns
			3.0 V to 3.6 V	1.4		600	ns

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Parameter		Condition	V _{CCB}	Min	Typ	Max	Unit
			4.5 V to 5.5 V	1.2		500	ns
t _{riB}	Input rise time	B-port rise time, push-pull driving	1.65 V to 1.95 V	1.3		22	ns
			2.3 V to 2.7 V	1.3		20	ns
			3.0 V to 3.6 V	0.9		15	ns
			4.5 V to 5.5 V	0.7		15	ns
		B-port rise time, open-drain driving	1.65 V to 1.95 V	1		1200	ns
			2.3 V to 2.7 V	1		800	ns
			3.0 V to 3.6 V	1		700	ns
			4.5 V to 5.5 V	0.6		500	ns
t _{fiA}	Input fall time	A-port fall time, push-pull driving	1.65 V to 1.95 V	1		20	ns
			2.3 V to 2.7 V	1.6		20	ns
			3.0 V to 3.6 V	1.4		15	ns
			4.5 V to 5.5 V	1.4		15	ns
		A-port fall time, open-drain driving	1.65 V to 1.95 V	1.7		20	ns
			2.3 V to 2.7 V	1.7		15	ns
			3.0 V to 3.6 V	1.4		15	ns
			4.5 V to 5.5 V	1.2		15	ns
t _{fiB}	Input fall time	B-port fall time, push-pull driving	1.65 V to 1.95 V	1.3		20	ns
			2.3 V to 2.7 V	1.3		15	ns
			3.0 V to 3.6 V	0.9		10	ns
			4.5 V to 5.5 V	0.7		10	ns
		B-port fall time, open-drain driving	1.65 V to 1.95 V	1		20	ns
			2.3 V to 2.7 V	1		20	ns
			3.0 V to 3.6 V	1		15	ns
			4.5 V to 5.5 V	0.7		15	ns
t _{sk(O)}	Skew (time), output	Channel-to-channel skew, push-pull driving	1.65 V to 5.5 V			1	ns

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

AC Timing Requirements -- VCCA = 2.5 V

All test conditions: V_{CCA} = 2.3 V to 2.7 V, T_A = -40°C to +125°C, unless otherwise noted. The data is based on bench test and design simulation.

Parameter		Condition	VCCB	Min	Typ	Max	Unit
f _D	Data rate	Push-pull mode	2.3 V to 2.7 V			60	Mbps
			3.0 V to 3.6 V			75	Mbps
			4.5 V to 5.5 V			75	Mbps
		Open-drain mode	2.3 V to 2.7 V			0.8	Mbps
			3.0 V to 3.6 V			0.8	Mbps
			4.5 V to 5.5 V			1	Mbps
t _w	Pulse duration	Push-pull mode	2.3 V to 2.7 V	16.66			ns
			3.0 V to 3.6 V	13.33			ns
			4.5 V to 5.5 V	13.33			ns
		Open-drain mode	2.3 V to 2.7 V	1250			ns
			3.0 V to 3.6 V	1250			ns
			4.5 V to 5.5 V	1000			ns
t _{PHL}	Propagation Delay (High-to-Low)	A-to-B, push-pull driving	2.3 V to 2.7 V			15	ns
			3.0 V to 3.6 V			15	ns
			4.5 V to 5.5 V			15	ns
		A-to-B, open-drain driving	2.3 V to 2.7 V			15	ns
			3.0 V to 3.6 V			15	ns
			4.5 V to 5.5 V			15	ns
t _{PLH}	Propagation Delay (Low-to-High)	A-to-B, push-pull driving	2.3 V to 2.7 V			15	ns
			3.0 V to 3.6 V			15	ns
			4.5 V to 5.5 V			15	ns
		A-to-B, open-drain driving	2.3 V to 2.7 V			15	ns
			3.0 V to 3.6 V			30	ns
			4.5 V to 5.5 V			20	ns
t _{PHL}	Propagation Delay (High-to-Low)	B-to-A, push-pull driving	2.3 V to 2.7 V			15	ns
			3.0 V to 3.6 V			15	ns
			4.5 V to 5.5 V			15	ns
		B-to-A, open-drain driving	2.3 V to 2.7 V			15	ns
			3.0 V to 3.6 V			15	ns
			4.5 V to 5.5 V			15	ns
t _{PLH}	Propagation Delay (Low-to-High)	B-to-A, push-pull driving	2.3 V to 2.7 V			15	ns
			3.0 V to 3.6 V			15	ns
			4.5 V to 5.5 V			15	ns

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Parameter		Condition	VCCB	Min	Typ	Max	Unit
		B-to-A, open-drain driving	2.3 V to 2.7 V			15	ns
			3.0 V to 3.6 V			10	ns
			4.5 V to 5.5 V			10	ns
t _{en}	Enable time	OE-to-A or B, push-pull driving	2.3 V to 5.5 V			100	ns
t _{dis}	Disable time	OE-to-A or B, push-pull driving	2.3 V to 5.5 V			400	ns
tr _A	Input rise time	A-port rise time, push-pull driving	2.3 V to 2.7 V	1.89		15	ns
			3.0 V to 3.6 V	1.6		15	ns
			4.5 V to 5.5 V	1.5		15	ns
		A-port rise time, open-drain driving	2.3 V to 2.7 V	110		800	ns
			3.0 V to 3.6 V	157		700	ns
			4.5 V to 5.5 V	116		500	ns
tr _B	Input rise time	B-port rise time, push-pull driving	2.3 V to 2.7 V	1.7		15	ns
			3.0 V to 3.6 V	1.3		10	ns
			4.5 V to 5.5 V	0.9		10	ns
		B-port rise time, open-drain driving	2.3 V to 2.7 V	107		800	ns
			3.0 V to 3.6 V	140		600	ns
			4.5 V to 5.5 V	77		500	ns
tf _A	Input fall time	A-port fall time, push-pull driving	2.3 V to 2.7 V	1.5		10	ns
			3.0 V to 3.6 V	1.2		10	ns
			4.5 V to 5.5 V	1.3		10	ns
		A-port fall time, open-drain driving	2.3 V to 2.7 V	1.5		10	ns
			3.0 V to 3.6 V	1.2		10	ns
			4.5 V to 5.5 V	1.1		10	ns
tf _B	Input fall time	B-port fall time, push-pull driving	2.3 V to 2.7 V	1.4		10	ns
			3.0 V to 3.6 V	0.9		10	ns
			4.5 V to 5.5 V	0.7		10	ns
		B-port fall time, open-drain driving	2.3 V to 2.7 V	0.4		20	ns
			3.0 V to 3.6 V	0.5		10	ns
			4.5 V to 5.5 V	0.4		10	ns
t _{sk(O)}	Skew (time), output	Channel-to channel skew, push-pull driving	2.3 V to 5.5 V			1	ns

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

AC Timing Requirements -- VCCA = 3.3 V

All test conditions: V_{CCA} = 3.0 V to 3.6 V, T_A = -40°C to +125°C, unless otherwise noted. The data is based on bench test and design simulation.

Parameter		Condition	V _{CCB}	Min	Typ	Max	Unit
f _D	Data rate	Push-pull mode	3.0 V to 3.6 V			80	Mbps
		Push-pull mode	4.5 V to 5.5 V			100	Mbps
		Open-drain mode	3.0 V to 3.6 V			0.8	Mbps
		Open-drain mode	4.5 V to 5.5 V			1.2	Mbps
t _w	Pulse duration	Push-pull mode	3.0 V to 3.6 V	12.5			ns
		Push-pull mode	4.5 V to 5.5 V	10			ns
		Open-drain mode	3.0 V to 3.6 V	1250			ns
		Open-drain mode	4.5 V to 5.5 V	833			ns
t _{PHL}	Propagation Delay (High-to-Low)	A-to-B, push-pull driving	3.0 V to 3.6 V			15	ns
			4.5 V to 5.5 V			10	ns
		A-to-B, open-drain driving	3.0 V to 3.6 V	2.1		20	ns
			4.5 V to 5.5 V	1.5		15	ns
t _{PLH}	Propagation Delay (Low-to-High)	A-to-B, push-pull driving	3.0 V to 3.6 V			15	ns
			4.5 V to 5.5 V			15	ns
		A-to-B, open-drain driving	3.0 V to 3.6 V	0.15		900	ns
			4.5 V to 5.5 V	0.3		500	ns
t _{PHL}	Propagation Delay (High-to-Low)	B-to-A, push-pull driving	3.0 V to 3.6 V			15	ns
			4.5 V to 5.5 V			15	ns
		B-to-A, open-drain driving	3.0 V to 3.6 V	3.19		20	ns
			4.5 V to 5.5 V	1.8		15	ns
t _{PLH}	Propagation Delay (Low-to-High)	B-to-A, push-pull driving	3.0 V to 3.6 V			20	ns
			4.5 V to 5.5 V			10	ns
		B-to-A, open-drain driving	3.0 V to 3.6 V			900	ns
			4.5 V to 5.5 V			500	ns
t _{en}	Enable time	OE-to-A or B, push-pull driving	3.0 V to 5.5 V			100	ns
t _{dis}	Disable time	OE-to-A or B, push-pull driving	3.0 V to 3.6 V			410	ns
t _{rA}	Input rise time	A-port rise time, push-pull driving	3.0 V to 3.6 V	2.1		15	ns
			4.5 V to 5.5 V	1.4		15	ns
		A-port rise time, open-drain driving	3.0 V to 3.6 V	2.2		446	ns
			4.5 V to 5.5 V	1.2		337	ns
t _{rB}	Input rise time	B-port rise time, push-pull driving	3.0 V to 3.6 V	2		15	ns
			4.5 V to 5.5 V	0.7		10	ns

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Parameter		Condition	V _{CCB}	Min	Typ	Max	Unit
		B-port rise time, open-drain driving	3.0 V to 3.6 V	2		427	ns
			4.5 V to 5.5 V	0.6		290	ns
t _{fA}	Input fall time	A-port fall time, push-pull driving	3.0 V to 3.6 V	1.4		10	ns
			4.5 V to 5.5 V	1.2		10	ns
		A-port fall time, open-drain driving	3.0 V to 3.6 V	1.4		10	ns
			4.5 V to 5.5 V	1.2		10	ns
t _{fB}	Input fall time	B-port fall time, push-pull driving	3.0 V to 3.6 V	1.3		10	ns
			4.5 V to 5.5 V	1.1		10	ns
		B-port fall time, open-drain driving	3.0 V to 3.6 V	1.3		10	ns
			4.5 V to 5.5 V	1.1		10	ns
t _{SK(O)}	Skew (time), output	Channel-to-channel skew, push-pull driving	3.0 V to 5.5 V			1	ns

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Typical Performance Characteristics

All test conditions: $V_{CCA} = 1.65\text{ V}$ to 3.6 V , $V_{CCB} = 1.65\text{ V}$ to 5.5 V , unless otherwise noted.

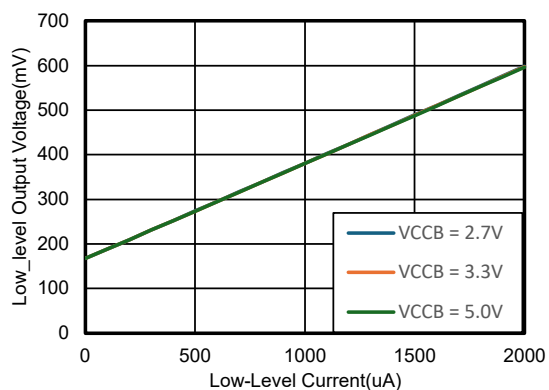


Figure 1. $V_{OL(Bx)}$ vs $I_{OL(Bx)}$, $V_{CCA} = 1.8\text{ V}$, $V_{IL(A)} = 0.15\text{ V}$

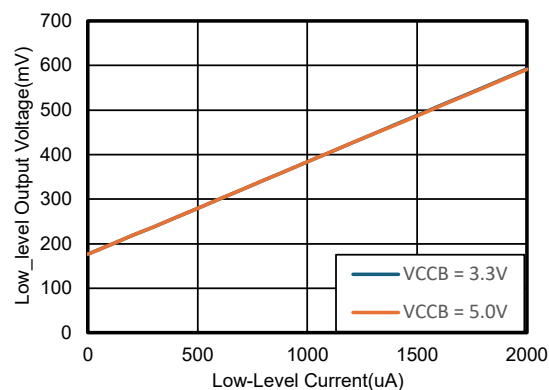


Figure 2. $V_{OL(Bx)}$ vs $I_{OL(Bx)}$, $V_{CCA} = 2.5\text{ V}$, $V_{IL(A)} = 0.15\text{ V}$

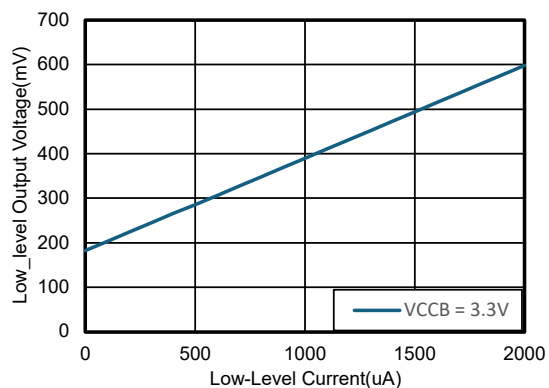


Figure 3. $V_{OL(Bx)}$ vs $I_{OL(Bx)}$, $V_{CCA} = 3.3\text{ V}$, $V_{IL(A)} = 0.15\text{ V}$

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Parameter Measurement Waveforms

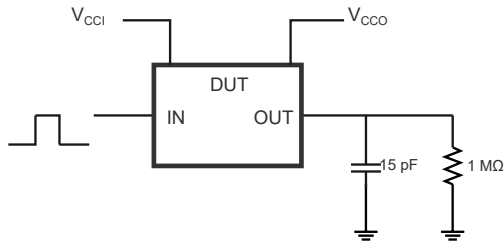


Figure 4. Timing Measurement Load Circuit of Push-Pull Driver

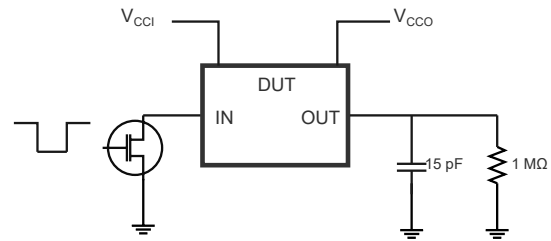


Figure 5. Timing Measurement Load Circuit of Push-Pull Driver

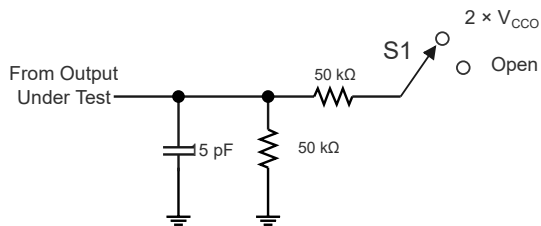


Figure 6. Load Circuit for Enable and Disable Time Measurement

Test	S1
t_{PZL}/t_{PLZ}	$2 \times V_{CCO}$
t_{PHZ}/t_{PZH}	Open

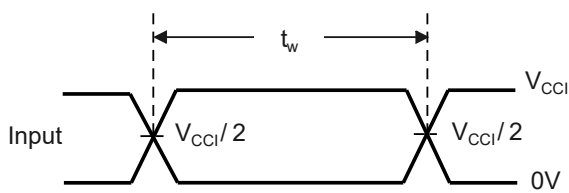


Figure 7. Pulse Duration

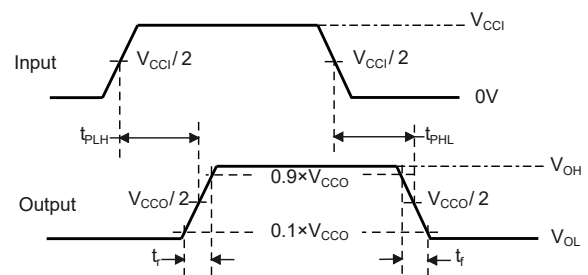


Figure 8. Propagation Delay Times

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

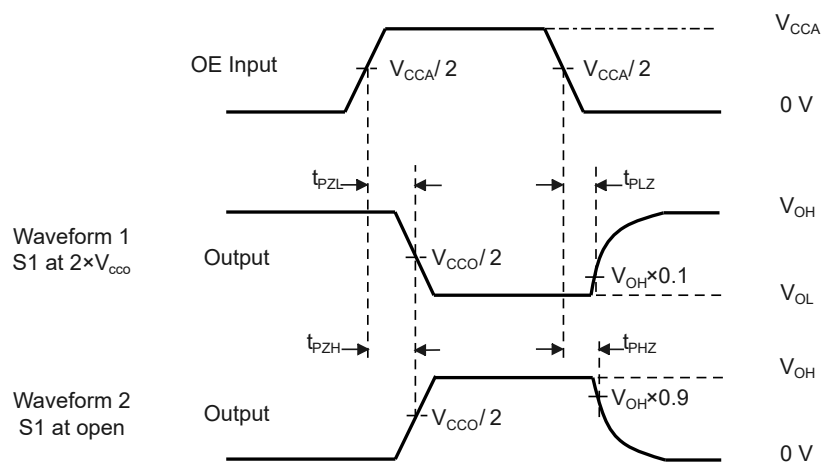


Figure 9. Enable and Disable Times

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Detailed Description

Overview

The TPT20104 device is a 4-bit level shifter with an enable (OE) input, and can work from 1.65 V to 3.6 V V_{CCA} and 1.65 V to 5.5 V V_{CCB} . V_{CCA} must be less than or equal to V_{CCB} . The TPT20104 supports bidirectional voltage translation between 1.8 V, 2.5 V, 3.3 V, and 5 V. The A1~4 I/Os are connected to the B1~4 I/O, which allows bidirectional data flow between ports. If OE is low, the translator switch is off, and a high-impedance state exists between ports to isolate both sides. 4-bit bidirectional buffer isolates capacitance and allows 15 pF on either side of the device to support 100 Mbps speeds in Push-Pull mode in 3.3 V V_{CCA} and 5 V V_{CCB} , and support 1.2 Mbps speed in Open-Drain mode.

Functional Block Diagram

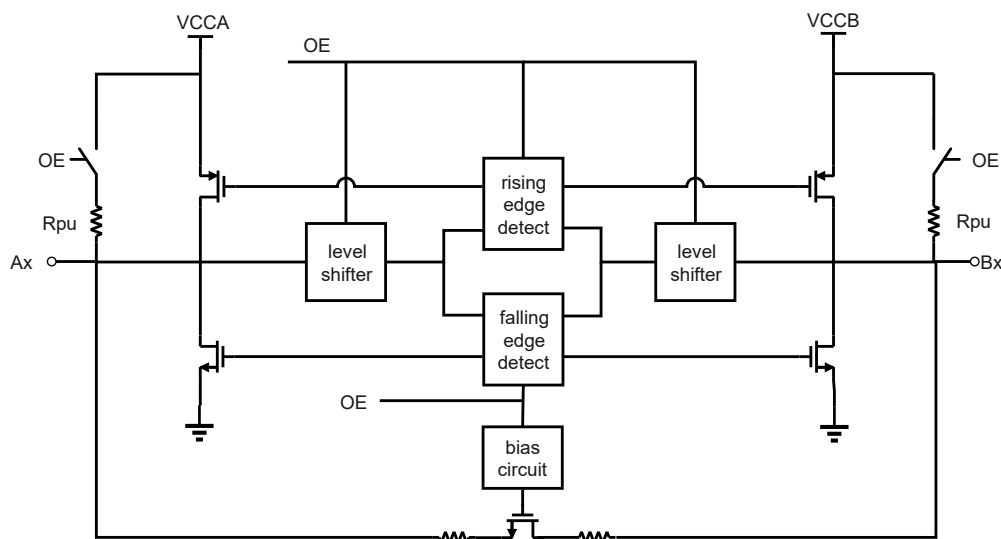


Figure 10. Functional Block Diagram

Feature Description

Power Up

During operation, make sure that $V_{CCA} \leq V_{CCB}$ at all times. During power-up period, even if $V_{CCA} \geq V_{CCB}$, it does not damage the device, so there is no power-on sequence requirement; any power supply can be ramped up first.

Enable (OE)

The OE pin is active-HIGH, with switching thresholds referenced to V_{CCA} . When driven LOW, OE disables the TPT20104 and places all I/Os in a high-impedance state. The t_{dis} parameter indicates the delay time between the OE pin going low and I/Os outputs entering the high-impedance state. Then Enable time t_{en} indicates the period of time that the user operates the one-shot circuit after the OE pin goes high.

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

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Table 3. Device Function table

Input OE	Translator Function
H	$A_x = B_x$
L	A_x is disconnected to B_x , high-impedance

(1) The OE pin should be pulled up to V_{CCA} or pulled down to GND, Not allowed to be floating.

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Application and Implementation

Note

Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

Application Information

The TPT20104 device is a 4-bit level shifter, with an enable (OE) input, and can work from 1.65-V to 3.6-V V_{CCA} and 1.65-V to 5.5-V V_{CCB} . V_{CCA} must be less than or equal to V_{CCB} . TPT20104 supports bidirectional voltage translation between 1.8 V, 2.5 V, 3.3 V, and 5 V. The A1~4 I/Os are connected to the B1~4 I/O, which allows bidirectional data flow between ports. If OE is low, the translator switch is off, and a high-impedance state exists between ports to isolate both sides.

- Servers/ Storages
- Routers (Telecom Switching Equipment)
- Personal Computers/ Consumer handsets
- Industrial Automation

Typical Application

A typical application is shown in [Figure 11](#). The TPT20104 device can be used in level-translation applications for interfacing devices or systems operating at different interface voltages with one another. The TPT20104 device is ideal for use in applications where an open-drain driver is connected to the data I/Os, and also can be used in applications where a push-pull driver is connected to the data I/Os.

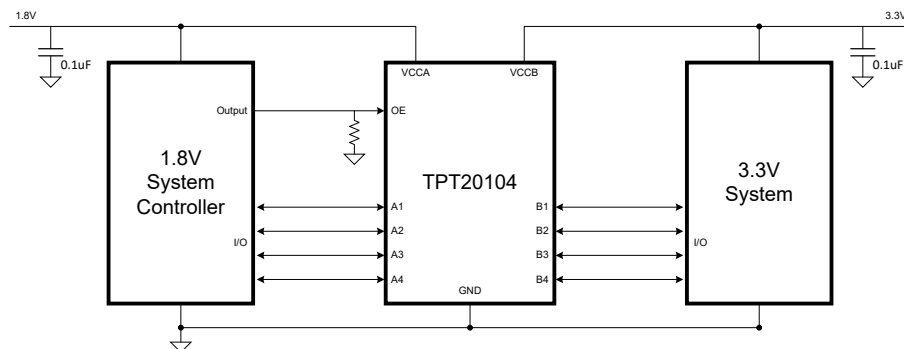


Figure 11. Typical Application Circuit

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Layout

Layout Example

Reflections and matching are closely related to loop antenna theory, but different enough to warrant their own discussion. When a PCB trace turns a corner at a 90° angle, a reflection can occur. This is primarily due to the change in width of the trace. At the apex of the turn, the trace width is increased to 1.414 times its width. This change in width upsets the transmission line characteristics, especially the distributed capacitance and self-inductance of the trace, thus resulting in the reflection. Not all PCB traces can be straight, so they have to turn corners. The following shows progressively better techniques of rounding corners. Only the last example (BEST) maintains constant trace width and minimizes reflections.

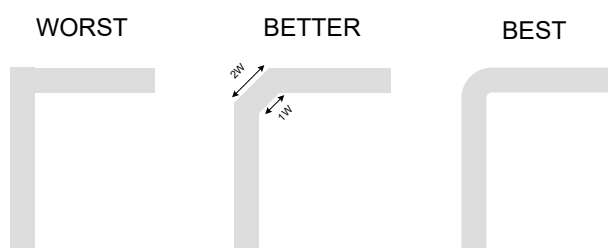


Figure 12. Trace Example

Route high-speed signals using a minimum of vias and corners which reduces signal reflections and impedance changes. When a via must be used, increase the clearance size around it to minimize its capacitance. Each via introduces discontinuities in the signal's transmission line and increases the chance of picking up interference from the other layers of the board. Be careful when designing test points, through-hole pins are not recommended at high frequencies.

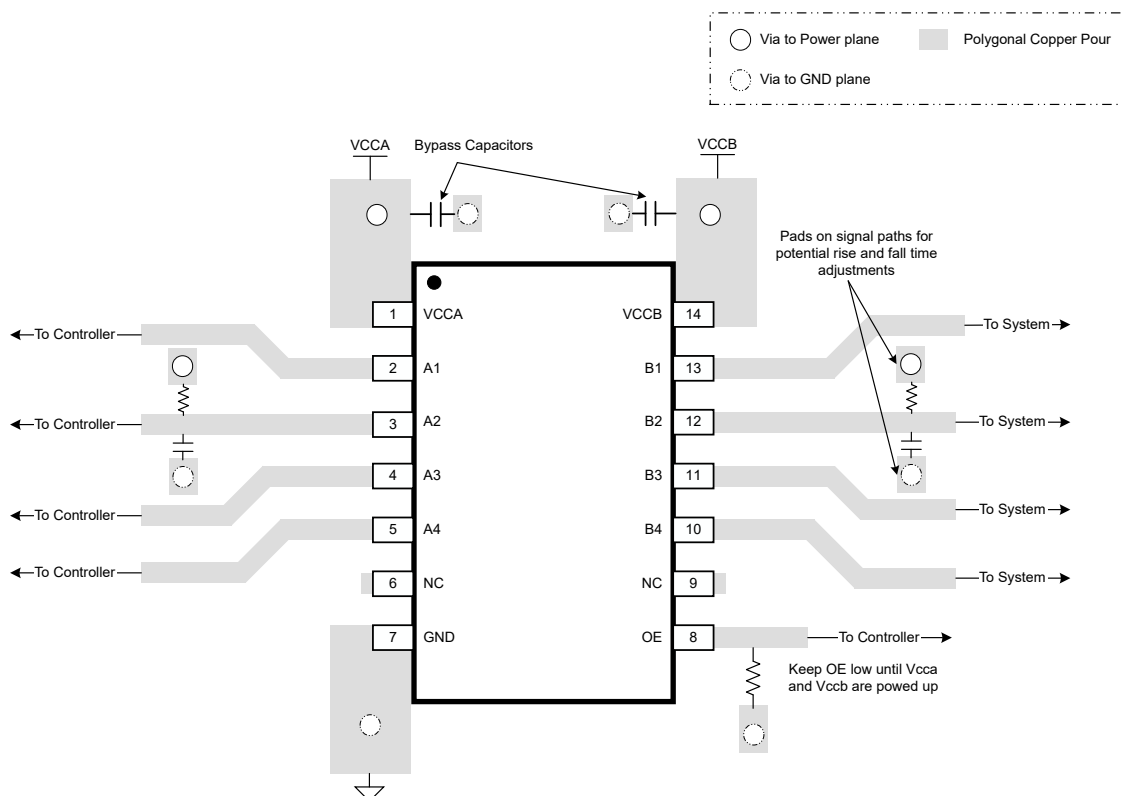
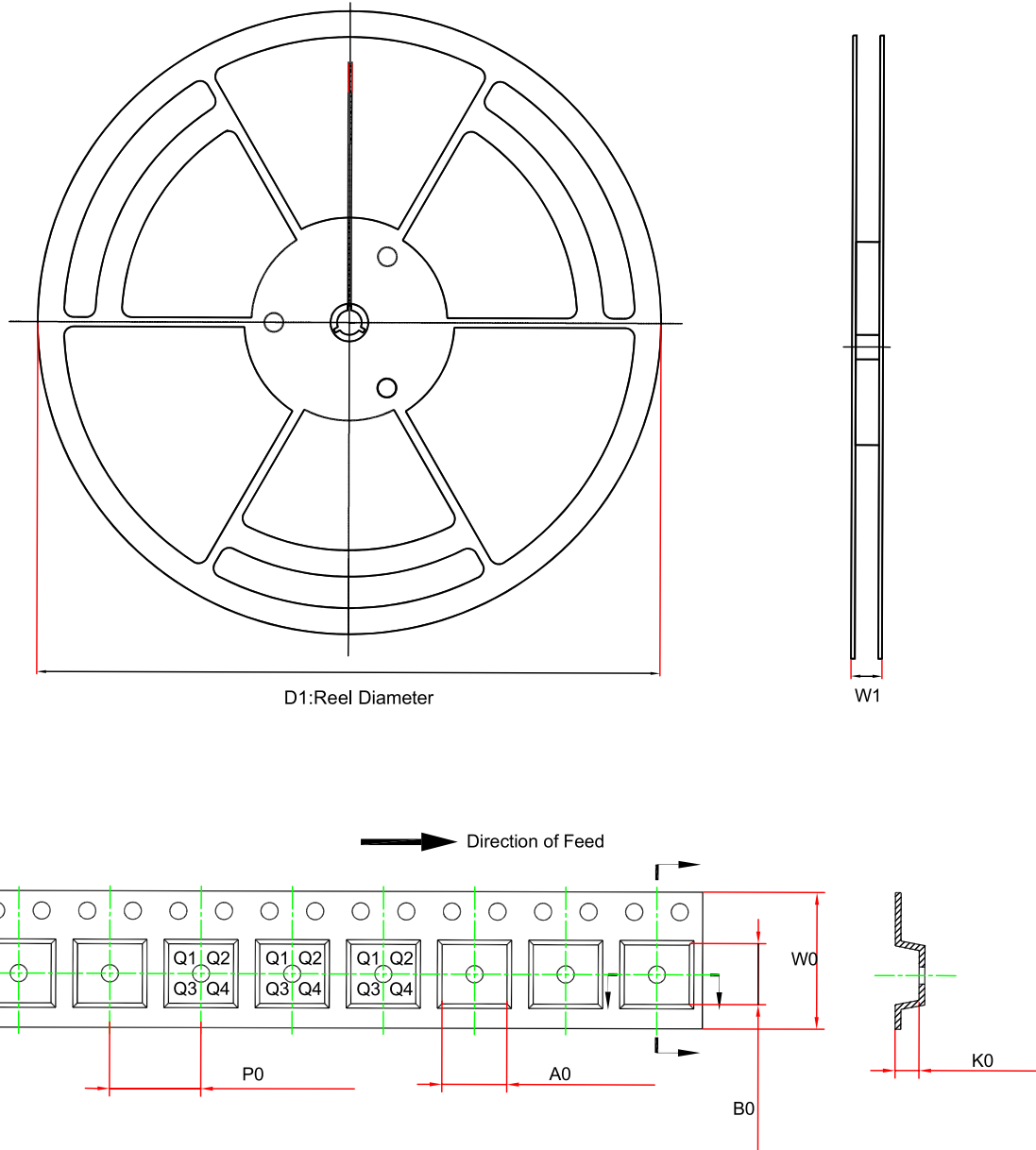


Figure 13. Layout Example

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Tape and Reel Information

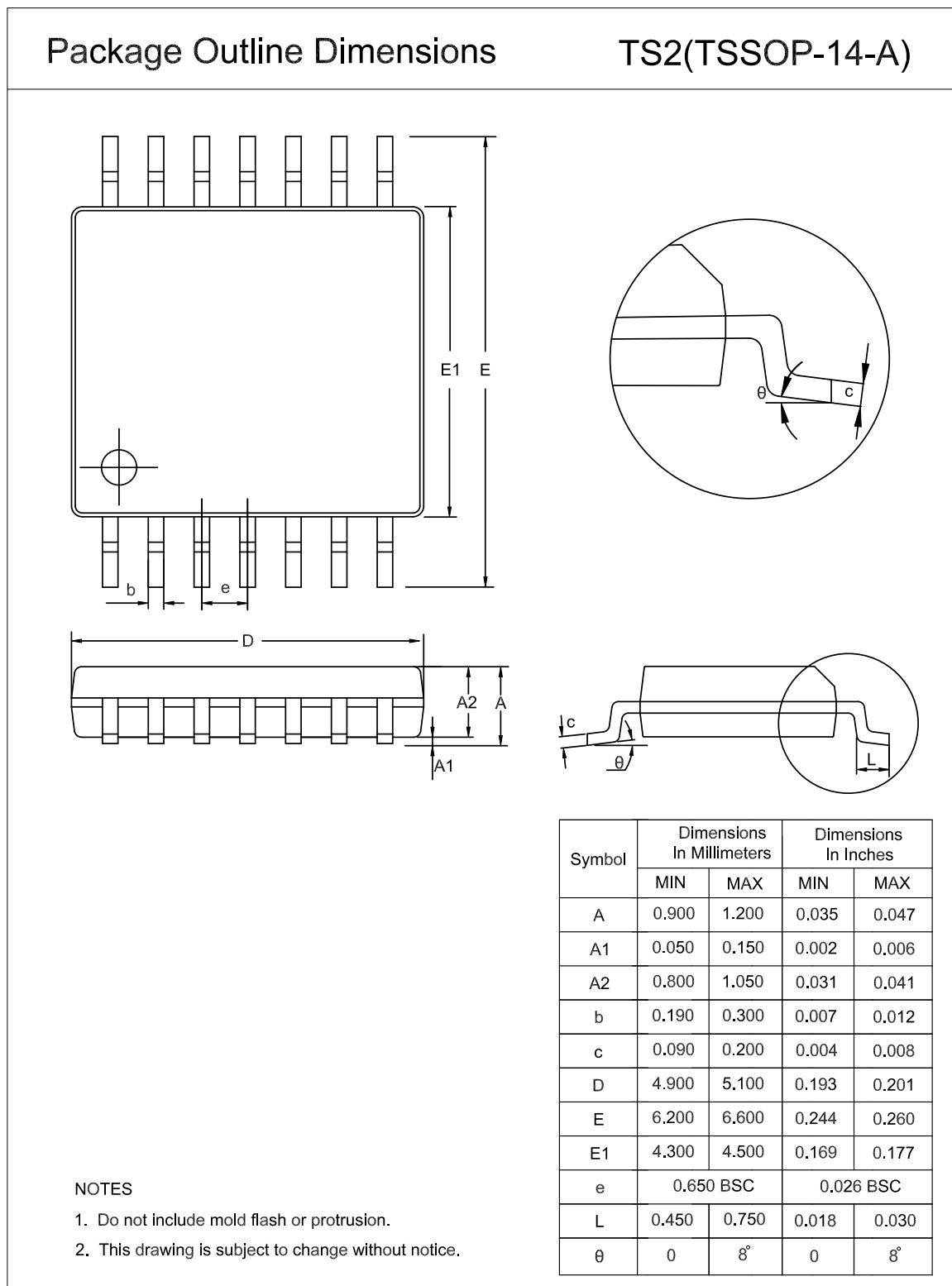


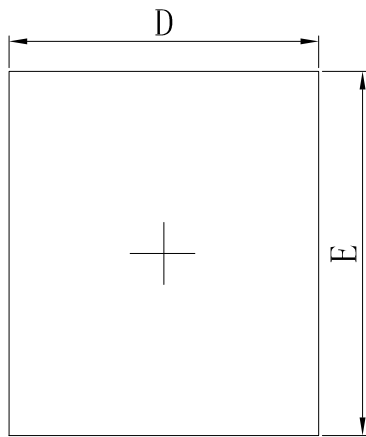
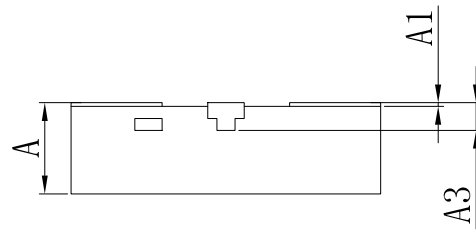
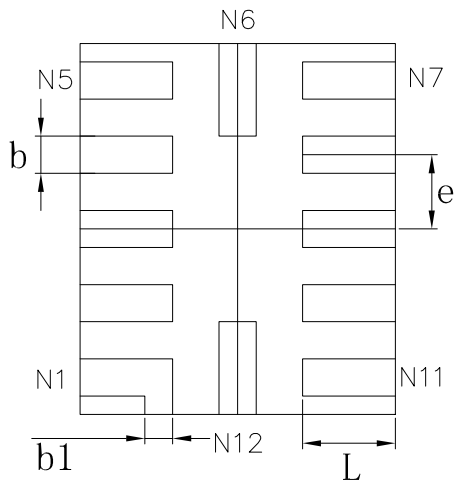
Order Number	Package	D1 (mm)	A0 (mm)	K0 (mm)	W0 (mm)	W1 (mm)	B0 (mm)	P0 (mm)	Pin1 Quadrant
TPT20104-TS2R	TSSOP14	330.0	6.8	1.5	12.0	17.6	5.5	8.0	Q1
TPT20104-QFMR	QFN3.5X3.5-14	330.0	3.8	1.1	12.0	17.6	3.8	8.0	Q1
TPT20104-QN5R	QFN1.7X2-12	180.0	1.9	0.75	8.0	13.1	2.3	4.0	Q1

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

Package Outline Dimensions

TSSOP14



4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull
QFN1.7X2-12
Package Outline Dimensions
QN5(QFN1.7X2-12-A)

TOP VIEW

SIDE VIEW

BOTTOM VIEW
NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

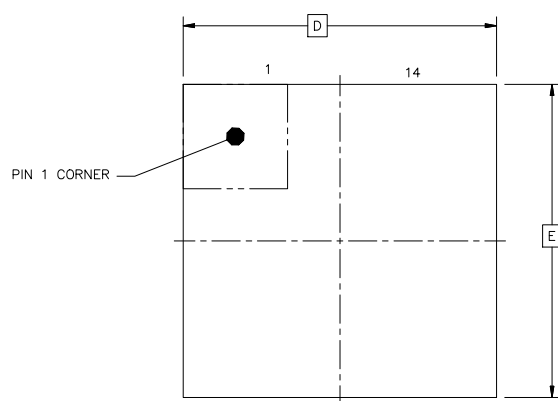
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.450	0.550	0.018	0.022
A1	0.000	0.050	0.000	0.002
A3	0.152 REF		0.006 REF	
b	0.150	0.250	0.006	0.010
b1	0.150 REF		0.006 REF	
D	1.600	1.800	0.063	0.071
E	1.900	2.100	0.075	0.083
e	0.400 BSC		0.016 BSC	
L	0.400	0.600	0.016	0.024

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

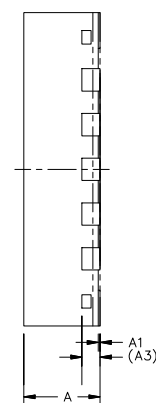
QFN3.5X3.5-14

Package Outline Dimensions

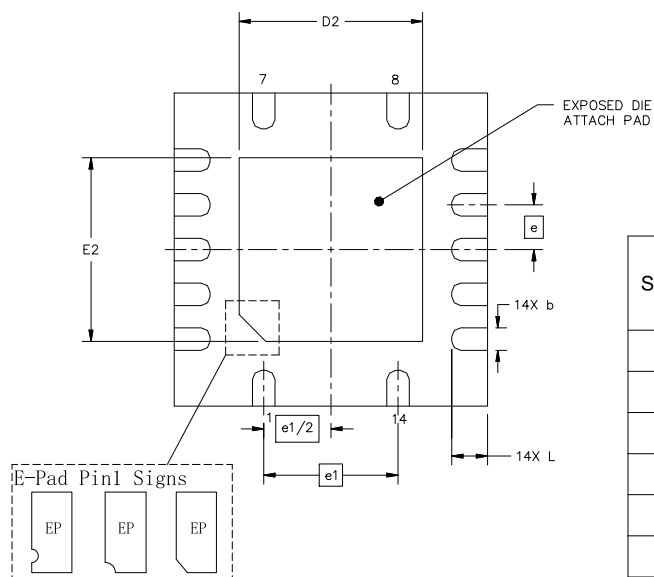
QFM(QFN3.5X3.5-14-B)



TOP VIEW



SIDE VIEW



BOTTOM VIEW

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.
3. The many types of E-pad Pin1 signs may appear in the product.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
b	0.200	0.300	0.008	0.012
D	3.400	3.600	0.134	0.142
D2	1.950	2.150	0.077	0.085
E	3.400	3.600	0.134	0.142
E2	1.950	2.150	0.077	0.085
e	0.500 BSC		0.020 BSC	
e1	1.500 BSC		0.059 BSC	
L	0.350	0.450	0.014	0.018

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull**Order Information**

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPT20104-TS2R	-40 to 125°C	TSSOP-14	20104	MSL3	Tape and Reel,3000	Green
TPT20104-QFMR	-40 to 125°C	QFN3.5X3.5-14	20104	MSL3	Tape and Reel,4000	Green
TPT20104-QN5R	-40 to 125°C	QFN1.7X2-12	T14	MSL1	Tape and Reel,4000	Green

Green: 3PEAK defines "Green" to mean RoHS compatible and free of halogen substances.

4-bit Bidirectional Level Shifter for Open-Drain and Push-Pull

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