Automotive 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 V, V_{CCB} = 5 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 Sequence Required for V_{CCA} and V_{CCB}
- ESD Protection:
  - A Port ±4000-V Human-Body Model
  - B Port ±8000-V Human-Body Model
  - B Port ±4000-V IEC 61000-4-2 Contact Discharge
  - 1500-V Charged-Device Model
- AEC-Q100 Qualified for Automotive Applications
  - Device Temperature Grade 1: −40 °C to 125 °C

Applications

- Automotive and Transportation
  - Body Electronics / Lighting
  - Power Train / Chassis
  - Infotainment / Cluster
  - ADAS / Safety
- GPIO, UART, I2C, MDIO, PMBus, SMBus, SDIO, and other Interfaces

Description

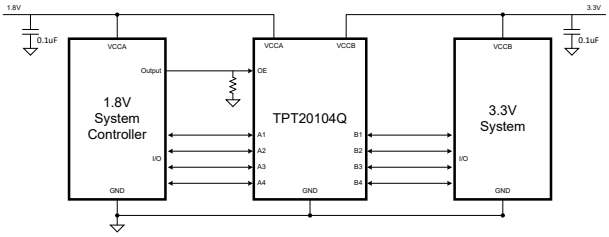
The TPT20104Q device is an automotive 4-bit level shifter, with an enable (OE) input and can work from 1.65 V to 3.6 V V_{CCA} and 1.65 V to 5.5 V V_{CCB}, V_{CCA} must be less than or equal to V_{CCB}. The TPT20104Q supports bidirectional voltage translation among 1.8 V, 2.5 V, 3.3 V, and 5 V.

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 the A port and the B port to isolate both sides. And 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 speed in the push-pull mode in 3.3-V V_{CCA} and 5-V V_{CCB} supply, and supports 1.2-Mbps speed in the open-drain mode.

The TPT20104Q is available in TSSOP14, QFN3.5X3.5-14 and QFN1.7X2-12 packages and is characterized from −40°C to +125°C.

Typical Application Circuit



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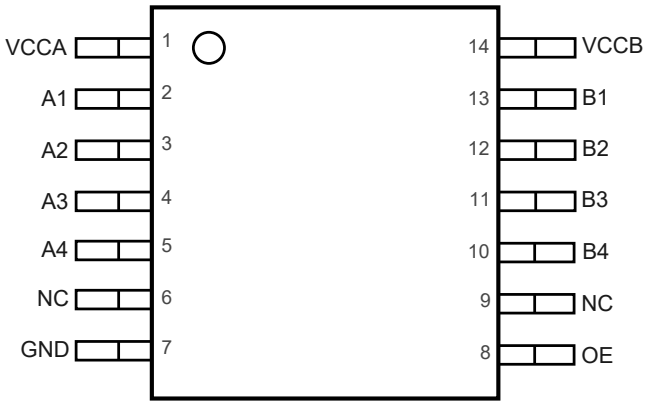
Revision History

Date	Revision	Notes
2024-09-04	Rev.Pre.0	Initial version
2025-06-27	Rev.A.0	Released version

Pin Configuration and Functions

TPT20104Q-TS2R
TSSOP14 Package
Top View



TPT20104Q-QFMR
QFN3.5x3.5-14 Package
Top View

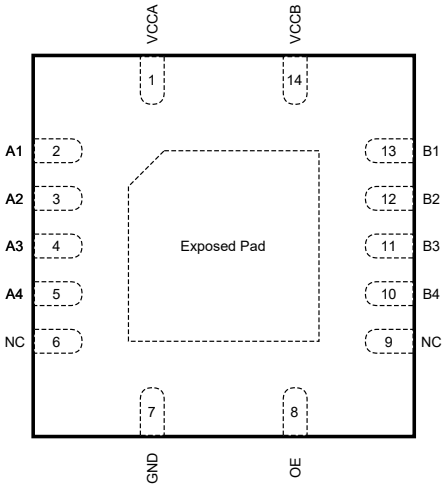


Table 1. Pin Functions: TPT20104Q

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 the QFN package, the exposed thermal pad must be connected to ground.

TPT20104Q-QN5R
QFN1.7x2-12 Package
Top View

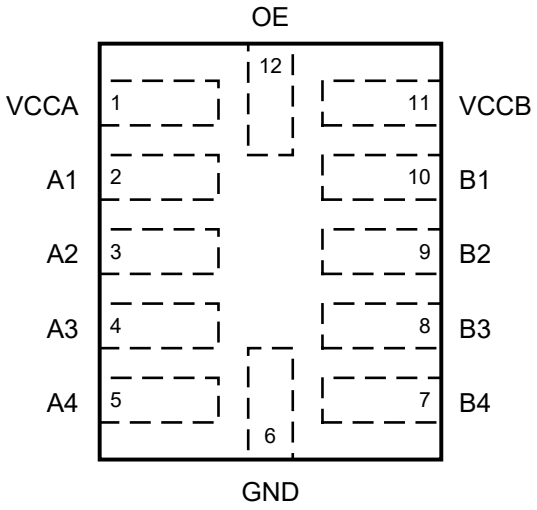


Table 2. Pin Functions: TPT20104Q

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

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-A	−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	AEC Q100-002(1)	±4	kV
	Human Body Model ESD, Side-B Ports	AEC Q100-002(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	AEC Q100-011	±1.5	kV
LU	Latch up	LU, per JESD78, All Pin	±500	mA

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

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} x 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} x 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

Electrical Characteristics

All test conditions: V_{CCA} = 1.65 V to 3.6 V, V_{CCB} = 1.65 V to 5.5 V, T_A = −40°C to +125°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 μA, V_{IB} ≥ V_{CCB} – 0.4 V	1.65 V to 3.6 V	1.65 V to 5.5 V	V_{CCA} x 0.67			V
V_{OLA}	Port A Low-level Output Voltage	I_{OL} = 220 μA, V_{IB} ≤ 0.15 V	1.65 V	1.65 V to 5.5 V			0.4	V
		I_{OL} = 300 μA, V_{IB} ≤ 0.15 V	2.3 V	1.65 V to 5.5 V			0.4	
		I_{OL} = 400 μA, V_{IB} ≤ 0.15 V	3.0 V	3.0 V to 5.5 V			0.55	
		I_{OL} = 1000 μA, V_{IB} ≤ 0.15 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 μA, V_{IA}≥ V_{CCA} – 0.2 V	1.65 V to 3.6 V	1.65 V to 5.5 V	V_{CCB} x 0.67			V
V_{OLB}	Port B Low-level Output Voltage	I_{OL} = 220 μA, V_{IA} ≤ 0.15 V	1.65 V to 3.6 V	1.65 V			0.4	V
		I_{OL} = 300 μA, V_{IA} ≤ 0.15 V	1.65 V to 3.6 V	2.3 V			0.4	
		I_{OL} = 400 μA, V_{IA} ≤ 0.15 V	1.65 V to 3.6 V	3.0 V			0.55	
		I_{OL} = 620 μA, V_{IA} ≤ 0.15 V	1.65 V to 3.6 V	4.5 V			0.55	
		I_{OL} = 1000 μA, V_{IA} ≤ 0.15 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 = 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 = 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	

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: VI or Vo = 0 to 3.6	0	0 V to 5.5 V	−5		5	μA
		B port: VI or Vo = 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.

AC Timing Requirements -- VCCA = 1.8 V

All test conditions: V_{CCA} = 1.65 V to 1.95 V, T_A = −40 °C to +125 °C. The data is based on bench tests and design simulations, unless otherwise noted.

Parameter		Condition	V_{CCB}	Min	Typ	Max	Unit
f_D	Data Rate	Push-pull mode	1.65 V to 1.95 V			40	Mbps
			2.3 V to 2.7 V			40	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
t_W	Pulse Duration	Push-pull mode	1.65 V to 1.95 V	25			ns
			2.3 V to 2.7 V	25			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
t_{PHL}	Propagation Delay (High-to-Low)	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
t_{PLH}	Propagation Delay (Low-to-High)	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

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

Parameter		Condition	V_{CCB}	Min	Typ	Max	Unit
			4.5 V to 5.5 V	1.2		500	ns
tr_B	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
tf_A	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
tf_B	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
T_{Looplh} (1)	Loop Time (High to Low)	Port A1- A4, push-pull driving	3.0 V to 3.6 V			60	ns
		Port A4- A1, push-pull driving	3.0 V to 3.6 V			60	ns
T_{Loophl} (1)	Loop Time (Low to High)	Port A1~A4, push-pull driving	3.0 V to 3.6 V			60	ns
		Port A4~A1, push-pull driving	3.0 V to 3.6 V			60	ns

(1) The data is based on production test.

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. The data is based on bench tests and design simulations, unless otherwise noted.

Parameter		Condition	V_{CCB}	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

Parameter		Condition	V_{CCB}	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

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. The data is based on bench tests and design simulations, unless otherwise noted.

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
tr_A	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
tr_B	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

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
tf_A	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
tf_B	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

Typical Performance Characteristics

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

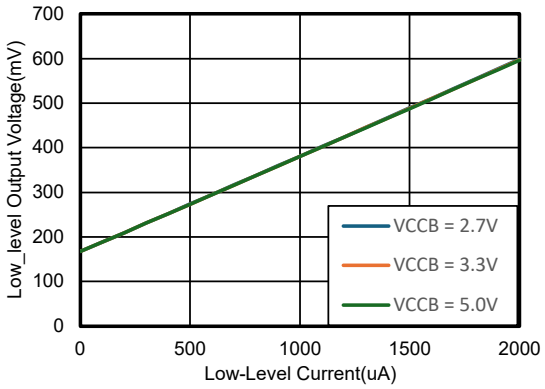


Figure 1. $V_{OL(Bx)}$ vs. $I_{OL(Bx)}$, V_{CCA} = 1.8 V, $I_{OL(A)}$ = 0.15 V

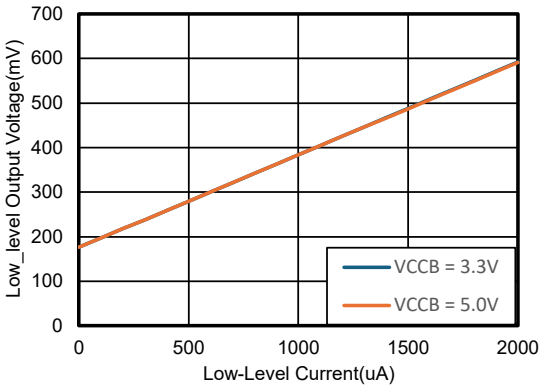


Figure 2. $V_{OL(Bx)}$ vs. $I_{OL(Bx)}$, V_{CCA} = 2.5 V, $I_{OL(A)}$ = 0.15 V

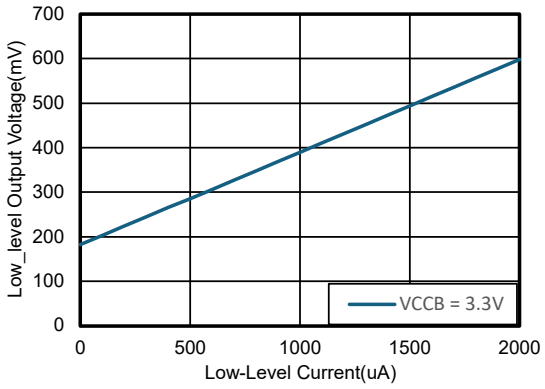


Figure 3. $V_{OL(Bx)}$ vs. $I_{OL(Bx)}$, V_{CCA} = 3.3 V, $I_{OL(A)}$ = 0.15 V

Parameter Measurement Waveforms

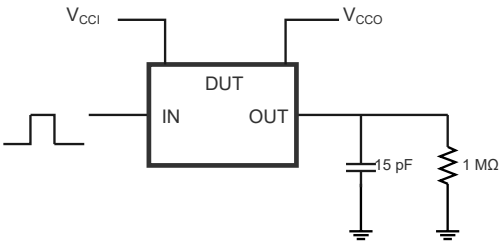


Figure 4. Timing Measurement Load Circuit of Push-Pull Driver

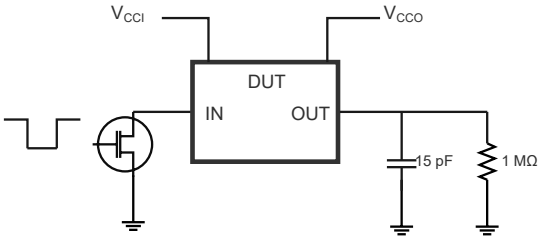


Figure 5. Timing Measurement Load Circuit of Push-Pull Driver

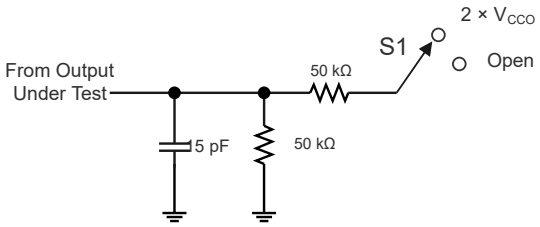


Figure 6. Load Circuit for Enable and Disable Time Measurement

Test	S1
t_{PZL}/t_{PLZ}	2 x V_{CCO}
t_{PHZ}/t_{PZH}	Open

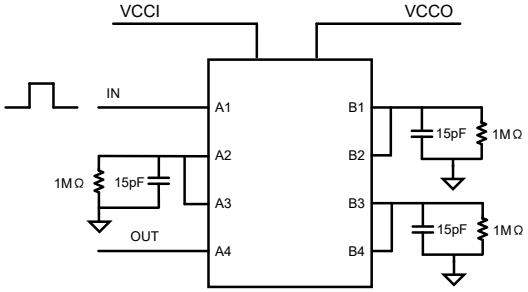


Figure 7. Timing Measurement Load Circuit of T_{loop}

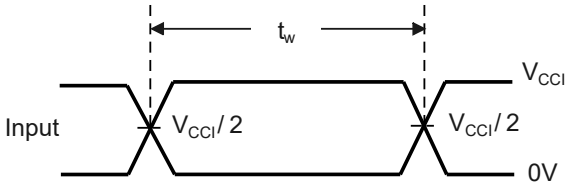


Figure 8. Pulse Duration

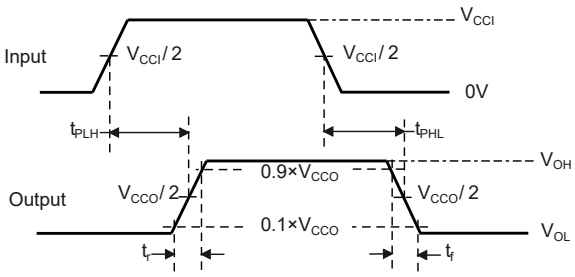


Figure 9. Propagation Delay Times

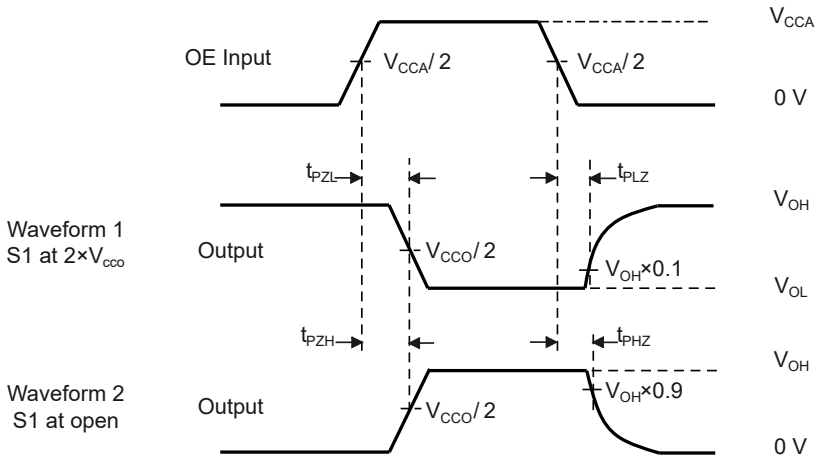


Figure 10. Enable and Disable Times

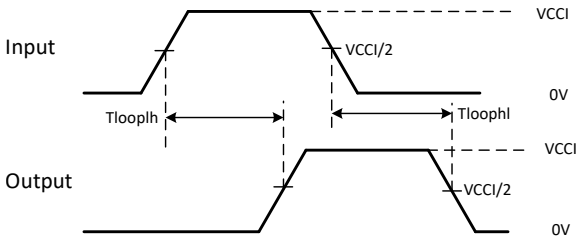


Figure 11. T_{loop} Times

Detailed Description

Overview

The TPT20104Q device is an automotive 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 TPT20104Q supports bidirectional voltage translation among 1.8 V, 2.5 V, 3.3 V, and 5 V. The A1~4 I/O 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 the A port and the B port to isolate both sides. The 4-bit bidirectional buffer isolates capacitance and allows 15 pF on either side of the device to support 100-Mbps speed in push-pull mode in 3.3 V V_{CCA} and 5 V V_{CCB}, and supports 1.2-Mbps speed in open-drain mode.

Functional Block Diagram

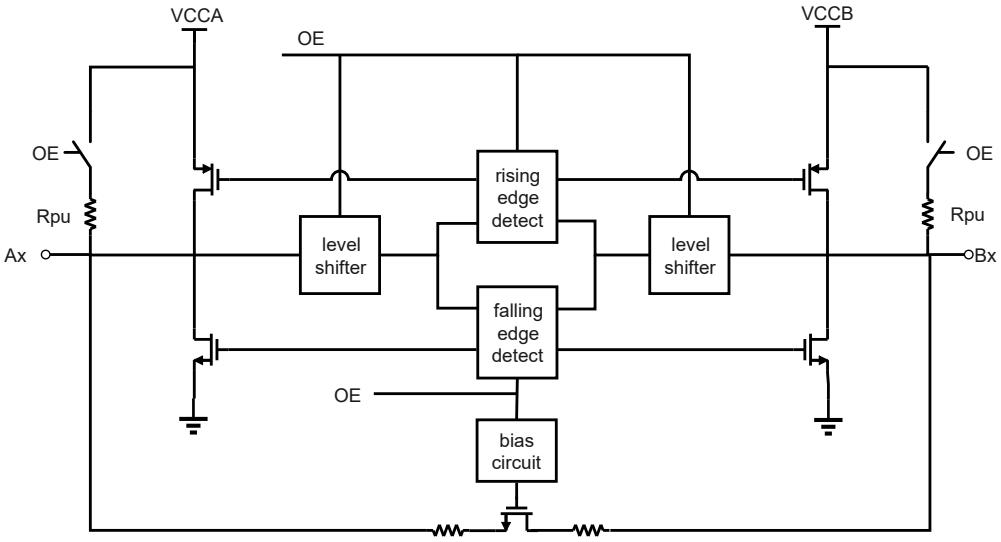


Figure 12. Functional Block Diagram

Feature Description

Power Up

During operation, make sure that $V_{CCA} \leq V_{CCB}$ at all times. During the 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 TPT20104Q and places all I/Os in a high-impedance state. The t_{dis} parameter indicates the delay time between OE pin going low and I/Os outputs entering the high-impedance state. Then Enable time t_{en} indicates the period time that the user operates the one-shot circuit after the OE pin is going 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 current-sourcing capability of the driver.

Table 3. Device Function Table

Input OE (1)	Translator Function
H	Ax = Bx
L	Ax is disconnected to Bx, high-impedance

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

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 TPT20104Q device is an automotive 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 TPT20104Q supports bidirectional voltage translation among 1.8 V, 2.5 V, 3.3 V, and 5 V. The A1~4 I/O 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 the A port and the B port to isolate both sides.

- Automotive and Transportation
  - Body Electronics / Lighting
  - Power Train / Chassis
  - Infotainment / Cluster
  - ADAS / Safety
- GPIO, UART, I2C, MDIO, PMBus, SMBus, SDIO, and other Interfaces

Typical Application

A typical application is shown in Figure 13. The TPT20104Q device can be used in level-translation applications for interfacing devices or systems operating at different interface voltages with one another. The TPT20104Q 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.

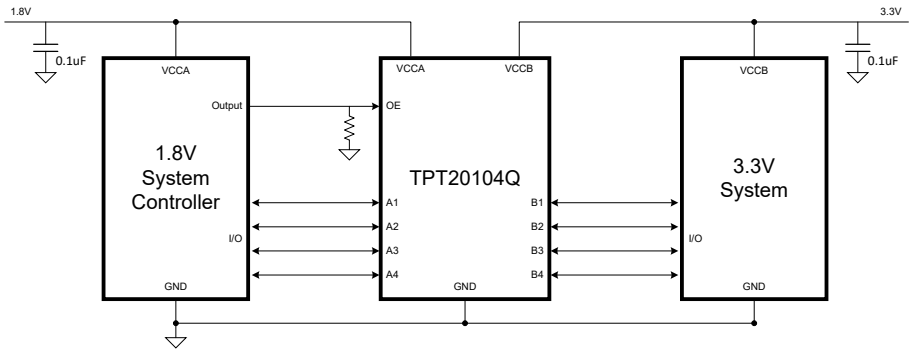


Figure 13. Typical Application Circuit

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. Below shows progressively better techniques of rounding corners. Only the last example (BEST) maintains constant trace width and minimizes reflections.

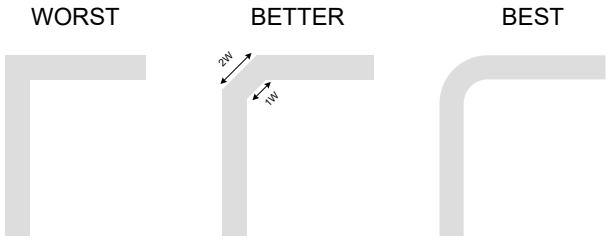


Figure 14. Trace Example

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 transmission line of the signal 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 frequency.

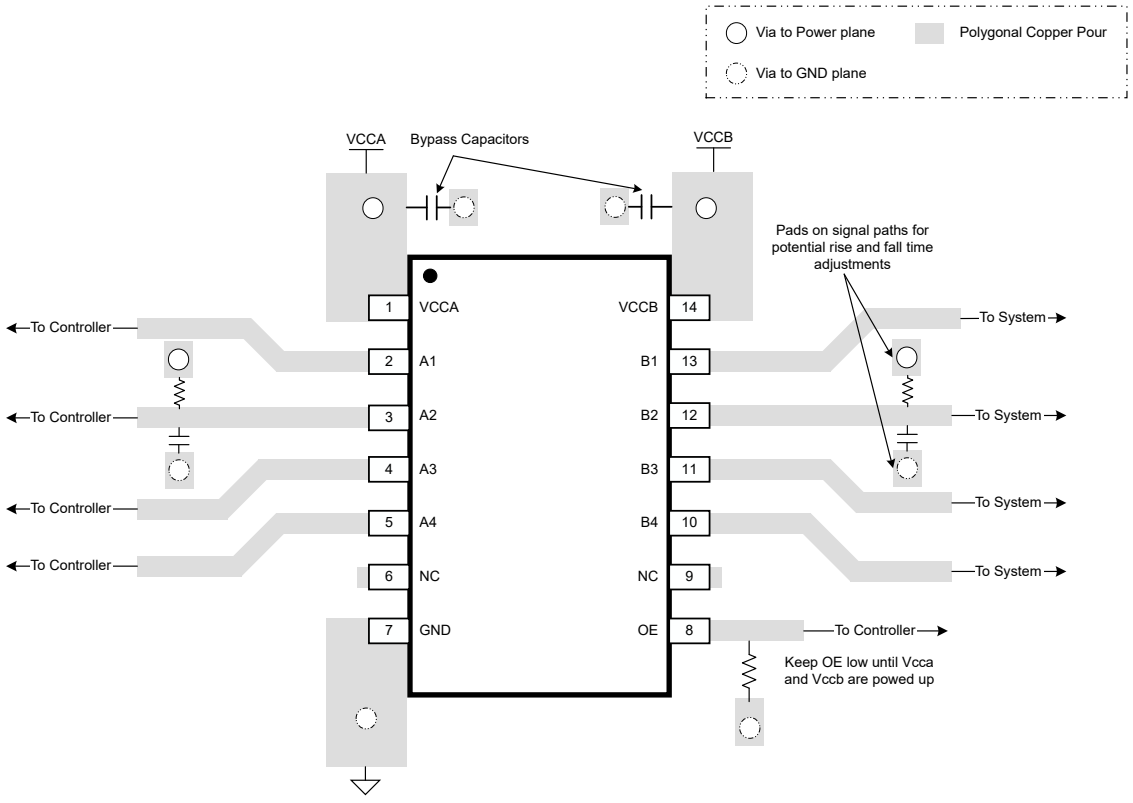
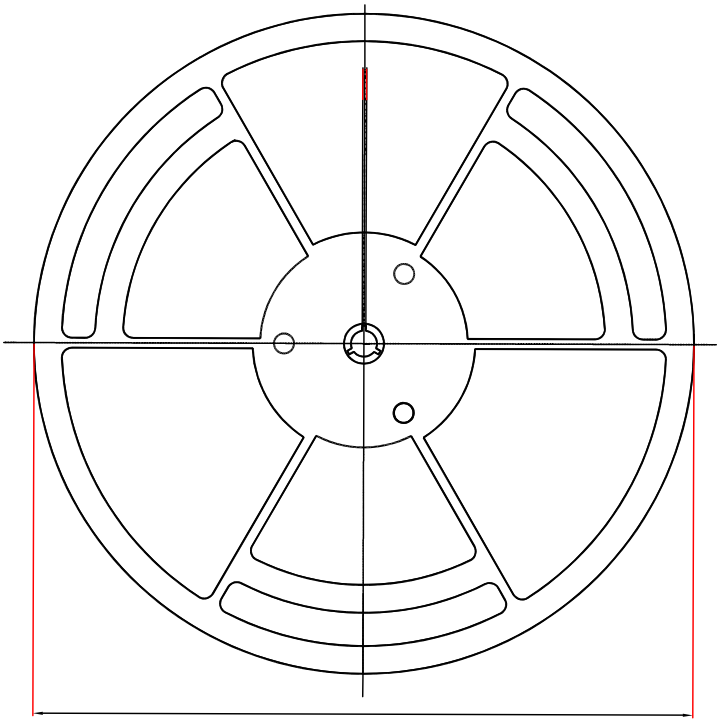
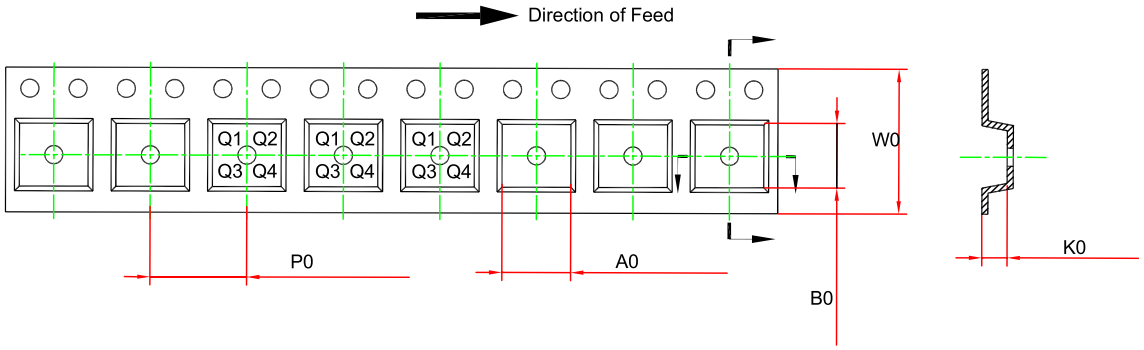


Figure 15. Layout Example

Tape and Reel Information



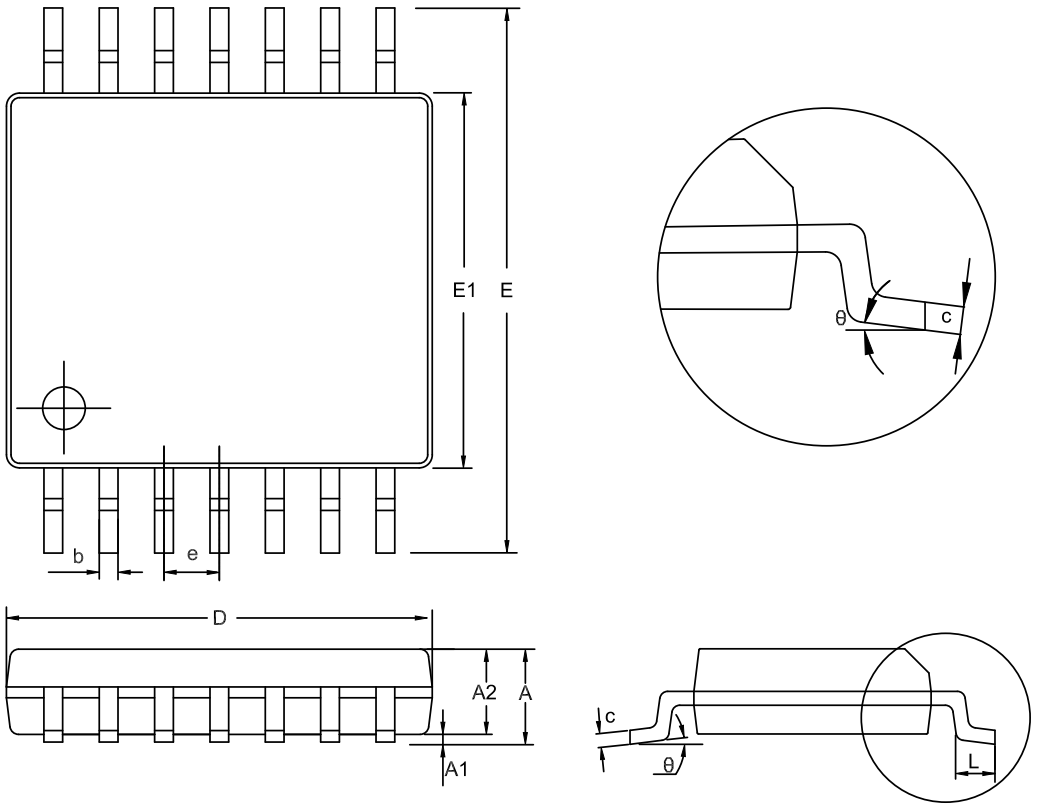


Order Number	Package	D1 (mm)	A0 (mm)	K0 (mm)	W0 (mm)	W1 (mm)	B0 (mm)	P0 (mm)	Pin1 Quadrant
TPT20104Q-TS2R-S	TSSOP14	330.0	6.8	1.5	12.0	17.6	5.5	8.0	Q1
TPT20104Q-QFMR-S	QFN3.5X3.5-14	330.0	3.75	1.0	12.0	17.6	3.75	8.0	Q1
TPT20104Q-QN5R-S	QFN1.7X2-12	178.0	1.9	0.75	8.0	12.1	2.3	4.0	Q1

Package Outline Dimensions

TSSOP14

Package Outline Dimensions TS2(TSSOP-14-A)



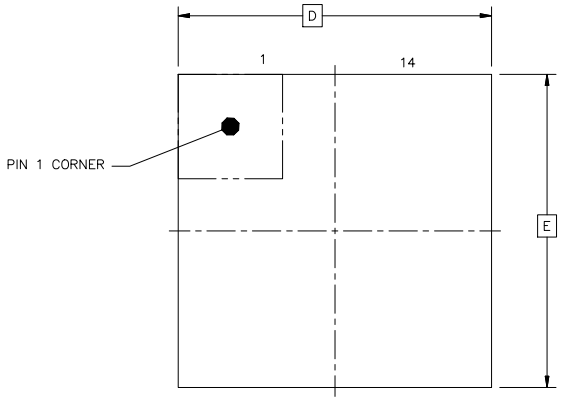
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.200	0.035	0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.900	5.100	0.193	0.201
E	6.200	6.600	0.244	0.260
E1	4.300	4.500	0.169	0.177
e	0.650 BSC		0.026 BSC	
L	0.450	0.750	0.018	0.030
θ	0	8°	0	8°

NOTES

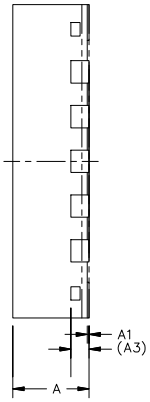
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

QFN3.5X3.5-14

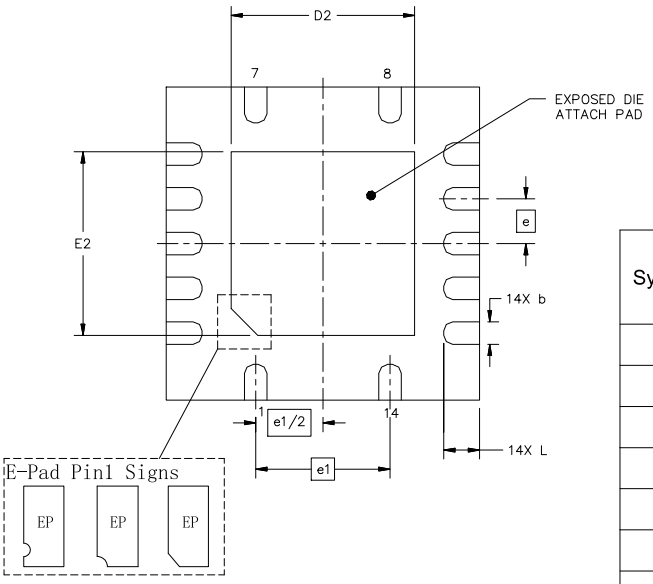
Package Outline Dimensions QFM(QFN3.5X3.5-14-B)



TOP VIEW



SIDE VIEW



BOTTOM VIEW

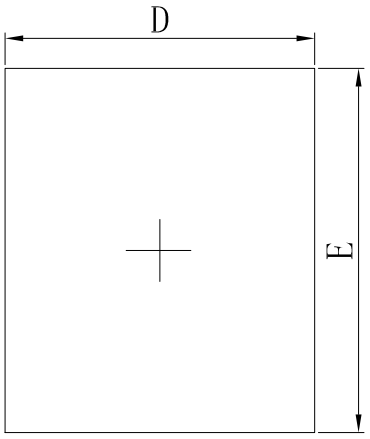
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
b	0.200	0.300	0.008	0.012
D	3.400	3.600	0.134	0.142
D2	1.950	2.150	0.077	0.085
E	3.400	3.600	0.134	0.142
E2	1.950	2.150	0.077	0.085
e	0.500 BSC		0.020 BSC	
e1	1.500 BSC		0.059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

NOTES

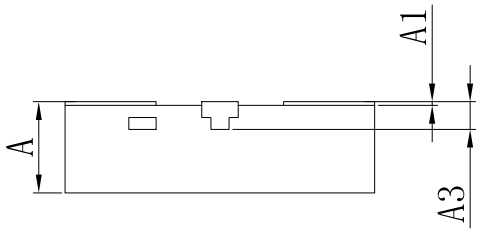
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.
3. The many types of E-pad Pin1 signs may appear in the product.

QFN1.7X2-12

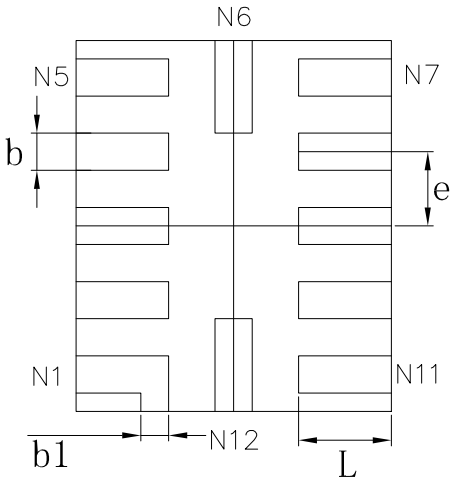
Package Outline Dimensions QN5(QFN1.7X2-12-A)



TOP VIEW



SIDE VIEW



BOTTOM VIEW

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

NOTES

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

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPT20104Q-TS2R-S	−40 to 125°C	TSSOP14	0104Q	MSL3	Tape and Reel,3000	Green
TPT20104Q-QFMR-S	−40 to 125°C	QFN3.5X3.5-14	0104Q	MSL3	Tape and Reel,4000	Green
TPT20104Q-QN5R-S	−40 to 125°C	QFN1.7X2-12	14Q	MSL3	Tape and Reel,4000	Green

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

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