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

1. Feature

- ❒ No Direction-Control
- ❒ Data Rates
  24Mbps (Push-Pull)
  2Mbps (Open-Drain)
- ❒ 1.65V to 5.5V on A ports and 2.3V to 5.5V on B Ports ($V_{CCA} \leq V_{CCB}$)
- ❒ V_{CC} Isolation: If Either V_{CC} is at GND, Both Ports are in the High-Impedance State
- ❒ No Power-Supply Sequencing Required: Either V_{CCA} or V_{CCB} can be Ramped First
- ❒ I_{OFF}: Supports Partial-Power-Down Mode Operation
- ❒ Extended Temperature: -40°C to +85°C
- ❒ Latch-Up Performance Exceeds 100 mA
- ❒ ESD Protection:
  - ■ 4-kV Human-Body Model (HBM)
  - ■ 2-kV Charged-Device Model (CDM)

2. Applications

- ■ Handset
- ■ Smartphone
- ■ Tablet
- ■ Desktop PC

3. General Description

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 outputs are placed in the high-impedance state.

The SC0104 is designed so that the OE input circuit is supplied by V_{CCA}.

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 SC0104 is available in QFN3.5x3.5-14L, and TSSOP-14 packages. It operates over an ambient temperature range of -40°C to +85°C.

4. PACKAGE INFORMATION

PART NUMBER	PACKAGE	BODY SIZE
SC0104S	TSSOP (14)	5.0mm x 4.4mm
SC0104Q	QFN(14)	3.5mm x 3.5mm

Functional Block Diagram

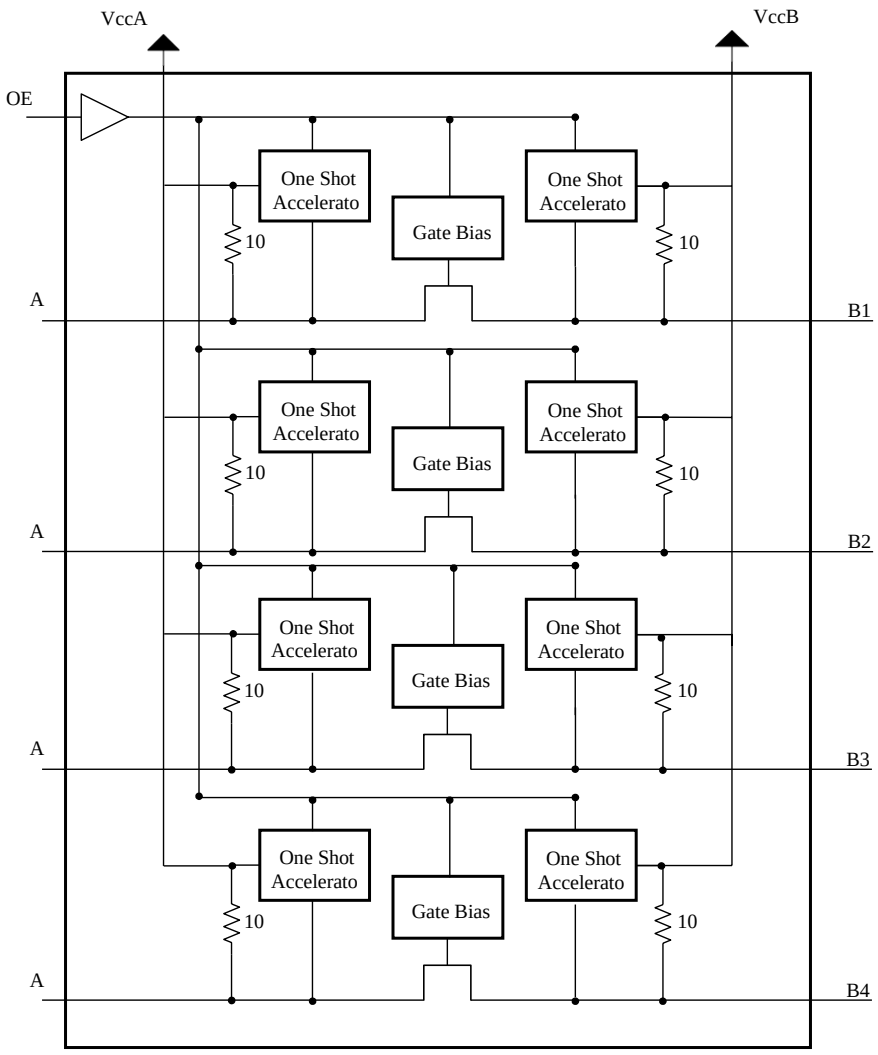
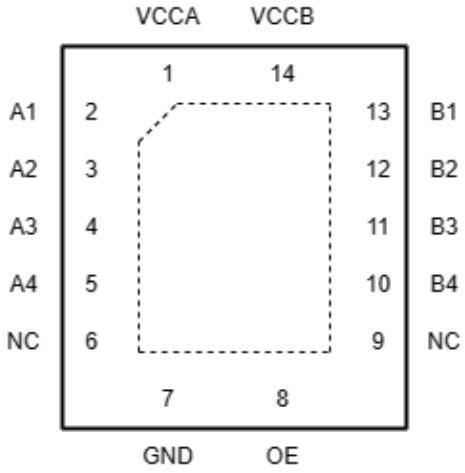


Figure 1.Block Diagram

5. PAD Definition

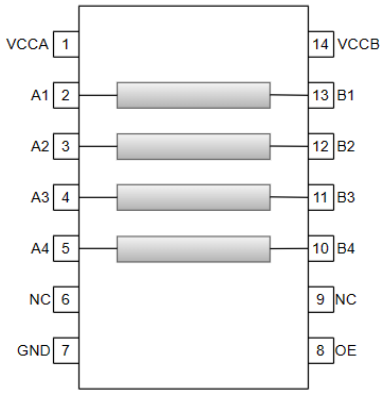


14-Pin QFN Top View
Fig.2 Pad definition of SC0104

Pin Functions:QFN3.5x3.5-14L

Pin	Name	I/O	DESCRIPTION
1	VCCA	POWER	A-port supply voltage. 1.65 V ≤ V_{CCA} ≤ 5.5 V and V_{CCA} ≤ V_{CCB}.
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 internal connection.
7	GND	GROUND	Device ground
8	OE	I	3-state output-mode enable. Pull OE low to place all outputs in 3-state mode. Referenced to V_{CCA}.
9	NC	-	No internal connection.
10	B4	I/O	Input/output B4. Reference to V_{CCB}.
11	B3	I/O	Input/output B3. Reference to V_{CCB}.
12	B2	I/O	Input/output B2. Reference to V_{CCB}.
13	B1	I/O	Input/output B1. Reference to V_{CCB}.
14	VCCB	POWER	B-port supply voltage. 2.3 V ≤ V_{CCB} ≤ 5.5V.
—	Thermal Pad	—	Exposed pad should be soldered to PCB board and connected to GND or left floating.

PAD Definition



14-Pin TSSOP Top View
Pad definition of SC0104

Pin Functions:QFN3.5x3.5-14L

Pin	Name	I/O	DESCRIPTION
1	VCCA	POWER	A-port supply voltage. 1.65 V ≤ V_{CCA} ≤ 5.5 V and V_{CCA} ≤ V_{CCB}.
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 internal connection.
7	GND	GROUND	Device ground
8	OE	I	3-state output-mode enable. Pull OE low to place all outputs in 3-state mode. Referenced to V_{CCA}.
9	NC	-	No internal connection.
10	B4	I/O	Input/output B4. Reference to V_{CCB}.
11	B3	I/O	Input/output B3. Reference to V_{CCB}.
12	B2	I/O	Input/output B2. Reference to V_{CCB}.
13	B1	I/O	Input/output B1. Reference to V_{CCB}.
14	VCCB	POWER	B-port supply voltage. 2.3 V ≤ V_{CCB} ≤ 5.5V.

6. Specifications

6.1 Absolute Maximum Ratings

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

SYMBOL	PARAMETER		MIN	MAX	units
VCCA	Supply Voltage Range		-0.3	6.0	V
VCCB	Supply Voltage Range		-0.3	6.0	V
V_I(2)	Input Voltage Range	A port	-0.3	6.0	V
		B port	-0.3	6.0	
		OE	-0.3	6.0	
V_O(2)	Voltage range applied to any output in the high impedance or power-off state	A port	-0.3	6.0	V
		B port	-0.3	6.0	
V_O(2)(3)	Voltage range applied to any output in the high or low state	A port	-0.3	V_{CCA}+0.3	V
		B port	-0.3	V_{CCB}+0.3	
I_{IK}	Input clamp current	V_I<0		-50	mA
I_{OK}	Output clamp current	V_O<0		-25	mA
I_O	Continuous output current			±50	mA
	Continuous current through VCCA, VCCB or GND			±100	mA
T_J	Junction Temperature			150	℃
T_{stg}	Storage temperature		-60	150	℃

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions is not implied. 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 VCCA and VCCB are provided in the recommended operating conditions table.

6.2 ESD Rating

Symbol	parameter	rating	units
V(ESD) Electrostatic discharge	Human-Body Model (HBM)	±4000	V
	Charged-Device Model（CDM）	±2000	V

6.3 Recommended Operating Conditions

VCCI is the supply voltage associated with the input port. VCCO is the supply voltage associated with the output port.

PARAMETER		VCCA	VCCB	MIN	MAX	UNIT
Supply voltage(1)	VCCA			1.65	5.5	V
	VCCB			2.3	5.5	
High-level input voltage (V_{IH})	A-port I/Os	1.65 V to 1.95 V	2.3 V to 5.5 V	VCCI – 0.2	VCCI	V
		2.3 V to 3.6 V		VCCI – 0.4	VCCI	
	B-port I/Os	1.65 V to 3.6 V	2.3 V to 5.5 V	VCCI – 0.4	VCCI	
	OE input	1.65 V to 3.6 V	2.3 V to 5.5 V	VCCI×0.8	5.5	
Low-level input voltage (V_{IL})	A-port I/Os	1.65 V to 3.6 V	2.3 V to 5.5 V	0	0.15	V
	B-port I/Os	1.65 V to 3.6 V	2.3 V to 5.5 V	0	0.15	
	OE input	1.65 V to 3.6 V	2.3 V to 5.5 V	0	VCCI×0.25	
Input transition rise or fall rate(Δt/Δv)		1.65 V to 3.6 V	2.3 V to 5.5 V		10	ns/V
		1.65 V to 3.6 V	2.3 V to 5.5 V		10	
		1.65 V to 3.6 V	2.3 V to 5.5 V		10	
T_A Operating free-air temperature				-40	85	℃

(1) VCCA must be less than or equal to VCCB.

(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.

6.4 Electrical Characteristics

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

PARAMETER		CONDITIONS	V_{CCA}	V_{CCB}	TEMP	MIN	TYP	MAX	UNITS
V_{OH_A}	Port A output high voltage	I_{OH} = –20 μA $V_{IB} \geq V_{CCB}$ – 0.4V	1.65V to 5.5V	2.3V to 5.5V	Full	$V_{CCA} \times 0.8$			V
V_{OL_A}	Port A output low voltage	I_{OL} = 1mA V_{IB} ≤ 0.15V	1.65V to 5.5V	2.3V to 5.5V	Full			0.4	V
V_{OH_B}	Port B output high voltage	I_{OH} = –20 μA $V_{IA} \geq V_{CCA}$ – 0.4 V	1.65V to 5.5V	2.3V to 5.5V	Full	$V_{CCB} \times 0.8$			V
V_{OL_B}	Port B output low voltage	I_{OL} = 1mA V_{IA} ≤ 0.15 V	1.65V to 5.5V	2.3V to 5.5V	Full			0.4	V
I_I	Input leakage current	OE	1.65V to 5.5V	2.3V to 5.5V	+25°C	-1		1	μA
					Full	-1.5		1.5	
I_{off}	Partial power down current	A Ports	0V	0V to 5.5V	+25°C	-0.5		0.5	μA
					Full	-1		1	
		B Ports	0V to 5.5V	0V	+25°C	-0.5		0.5	μA
					Full	-1		1	
I_{OZ}	High-impedance State output current	A or B port OE=0V	1.65V to V_{CCB}	2.3V to 5.5V	+25°C	-1		1	μA
					Full	-1.5		1.5	
I_{CCA}	V_{CCA} supply current	V_I = V_O = open I_O = 0	1.65V to V_{CCB}	2.3V to 5.5V	+25°C			1.0	μA
			5.5V	0V	Full			1.0	μA
			0V	5.5V	Full			-1	μA
I_{CCB}	V_{CCB} supply current	V_I = V_O = open I_O = 0	1.65V to V_{CCB}	2.3V to 5.5V	+25°C	5		15	μA
			5.5V	0V	Full			-1	μA
			0V	5.5V	Full			1	μA
I_{CCA} + I_{CCB}	Combined supply current	V_I = V_{CCI} = open I_O = 0	1.65V to V_{CCB}	2.3V to 5.5V	+25°C			16	μA
I_{CCZ_A}	V_{CCA} supply current	V_I = V_{CCI} or 0V I_O = 0, OE=0V	1.65V to V_{CCB}	2.3V to 5.5V	Full			1	μA
I_{CCZ_B}	V_{CCB} supply current	V_I = V_{CCI} or 0V I_O = 0, OE=0V	1.65V to V_{CCB}	2.3V to 5.5V	Full			1	μA
C_I	Input capacitance	OE	3.3V	3.3V	+25°C		2.5		pF
C_{IO}	Input-to-output internal capacitance	A port	3.3V	3.3V	+25°C		5		pF
		B port	3.3V	3.3V	+25°C		5		pF

(1) VCCI is the VCC associated with the input port.

(2) VCCO is the VCC associated with the output port.

(3) VCCA must be less than or equal to VCCB.

6.5 Timing Requiremen

V_{CCA}=1.8V±0.15V

		V_{CCB}=2.5V ±0.2V	V_{CCB}=3.3V ±0.3V	V_{CCB}=5V ±0.5V	UNIT
		TYP	TYP	TYP	
Data rate	Push-pull driving	24	24	24	Mbps
	Open-drain driving	2	2	2	
Pulse duration(t_w)	Push-pull driving (data inputs)	41	41	41	ns
	Open-drain driving (data inputs)	500	500	500	

VCCA=2.5V±0.2V

		V_{CCB}=2.5V ±0.2V	V_{CCB}=3.3V ±0.3V	V_{CCB}=5V ±0.5V	UNIT
		TYP	TYP	TYP	
Data rate	Push-pull driving	24	24	24	Mbps
	Open-drain driving	2	2	2	
Pulse duration(t_w)	Push-pull driving (data inputs)	41	41	41	ns
	Open-drain driving (data inputs)	500	500	500	

V_{CCA}=3.3V±0.3V

		V_{CCB}=3.3V ±0.3V	V_{CCB}=5V ±0.5V	UNIT
		TYP	TYP	
Data rate	Push-pull driving	24	24	Mbps
	Open-drain driving	2	2	
Pulse duration(t_w)	Push-pull driving (data inputs)	41	41	ns
	Open-drain driving (data inputs)	500	500	

V_{CCA}=5V±0.5V

		V_{CCB}=5V ±0.5V	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	

6.6 Switching Characteristics：V_{CCA}=1.8V±0.15V

over recommended operating free-air temperature range, V_{CCA} = 1.8 V ± 0.15 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
t_{PHL}	Propagation delay time (high-to-low output)	A-to-B	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		4.6	ns
				V_{CCB} = 3.3 V ± 0.3 V		4.7	
				V_{CCB} = 5 V ± 0.5 V		5.8	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	3.1	9.0	
				V_{CCB} = 3.3 V ± 0.3 V	4.2	11.9	
				V_{CCB} = 5 V ± 0.5 V	6.3	17.6	
t_{PLH}	Propagation delay time (low-to-high output)		Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		6.8	
				V_{CCB} = 3.3 V ± 0.3 V		6.8	
				V_{CCB} = 5 V ± 0.5 V		7	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	45	260	
				V_{CCB} = 3.3 V ± 0.3 V	36	208	
				V_{CCB} = 5 V ± 0.5 V	27	198	
t_{PHL}	Propagation delay time (high-to-low output)	B-to-A	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		4.4	ns
				V_{CCB} = 3.3 V ± 0.3 V		4.5	
				V_{CCB} = 5 V ± 0.5 V		4.7	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	1.9	5.3	
				V_{CCB} = 3.3 V ± 0.3 V	1.5	4.4	
				V_{CCB} = 5 V ± 0.5 V	1.2	4.0	
t_{PLH}	Propagation delay time (low-to-high output)		Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		5.3	
				V_{CCB} = 3.3 V ± 0.3 V		4.5	
				V_{CCB} = 5 V ± 0.5 V		1.8	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	45	175	
				V_{CCB} = 3.3 V ± 0.3 V	36	140	
				V_{CCB} = 5 V ± 0.5 V	27	102	
t_{en}	Enable time	OE-to-A or B		V_{CCB} = 2.5 V ± 0.2 V		36	ns
				V_{CCB} = 3.3 V ± 0.3 V		41	
				V_{CCB} = 5 V ± 0.5 V		43	
t_{dis}	Disable time	OE-to-A or B		V_{CCB} = 2.5 V ± 0.2 V		77	ns
				V_{CCB} = 3.3 V ± 0.3 V		68	
				V_{CCB} = 5 V ± 0.5 V		63	
t_{rA}	Input rise time	A-port rise time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	3.4	9.5	ns
				V_{CCB} = 3.3 V ± 0.3 V	2.7	9.3	
				V_{CCB} = 5 V ± 0.5 V	2.2	8.0	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	38	165	
				V_{CCB} = 3.3 V ± 0.3 V	30	132	
				V_{CCB} = 5 V ± 0.5 V	22	95	
t_{rB}	Input rise time	B-port rise time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	4	10.8	ns
				V_{CCB} = 3.3 V ± 0.3 V	3.2	9.1	
				V_{CCB} = 5 V ± 0.5 V	4.3	7.6	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	34	145	
				V_{CCB} = 3.3 V ± 0.3 V	23	106	
				V_{CCB} = 5 V ± 0.5 V	10	58	

over recommended operating free-air temperature range, VCCA = 1.8 V ± 0.15 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
t_{fA}	Input fall time	A-port fall time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	2	5.9	ns
				V_{CCB} = 3.3 V ± 0.3 V	1.9	6.0	
				V_{CCB} = 5 V ± 0.5 V	1.7	13.3	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	4.4	7.6	
				V_{CCB} = 3.3 V ± 0.3 V	4.3	6.4	
				V_{CCB} = 5 V ± 0.5 V	4.2	6.1	
t_{fB}	Input fall time	B-port fall time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	2.9	7.6	ns
				V_{CCB} = 3.3 V ± 0.3 V	2.8	7.5	
				V_{CCB} = 5 V ± 0.5 V	2.8	8.8	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	6.9	13.8	
				V_{CCB} = 3.3 V ± 0.3 V	7.5	20.0	
				V_{CCB} = 5 V ± 0.5 V	10.2	32.3	
$t_{SK(O)}$	Skew (time), output	Channel-to-channel skew		V_{CCB} = 2.5 V ± 0.2 V		1	ns
				V_{CCB} = 3.3 V ± 0.3 V		1	
				V_{CCB} = 5 V ± 0.5 V		1	
Maximum data rate			Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	24		Mbps
				V_{CCB} = 3.3 V ± 0.3 V	24		
				V_{CCB} = 5 V ± 0.5 V	24		
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	2		
				V_{CCB} = 3.3 V ± 0.3 V	2		
				V_{CCB} = 5 V ± 0.5 V	2		

6.7 Switching Characteristics: V_{CCA}=2.5V±0.2V

over recommended operating free-air temperature range, V_{CCA} = 2.5 V ± 0.2 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
t_{PHL}	Propagation delay time (high-to-low output)	A-to-B	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		3.2	ns
				V_{CCB} = 3.3 V ± 0.3 V		3.3	
				V_{CCB} = 5 V ± 0.5 V		3.4	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	1.7	6.3	
				V_{CCB} = 3.3 V ± 0.3 V	2	6	
				V_{CCB} = 5 V ± 0.5 V	2.1	5.8	
t_{PLH}	Propagation delay time (low-to-high output)	A-to-B	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		3.5	
				V_{CCB} = 3.3 V ± 0.3 V		4.1	
				V_{CCB} = 5 V ± 0.5 V		4.4	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	43	250	
				V_{CCB} = 3.3 V ± 0.3 V	36	206	
				V_{CCB} = 5 V ± 0.5 V	27	190	
t_{PHL}	Propagation delay time (high-to-low output)	B-to-A	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		3	ns
				V_{CCB} = 3.3 V ± 0.3 V		3.6	
				V_{CCB} = 5 V ± 0.5 V		4.3	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	1.8	4.7	
				V_{CCB} = 3.3 V ± 0.3 V	2.6	4.2	
				V_{CCB} = 5 V ± 0.5 V	1.2	4.0	

over recommended operating free-air temperature range, V_{CCA} = 2.5 V ± 0.2 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
t_{PLH}	Propagation delay time (low-to-high output)	B-to-A	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V		2.5	
				V_{CCB} = 3.3 V ± 0.3 V		1.8	
				V_{CCB} = 5 V ± 0.5 V		1.5	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	44	170	
				V_{CCB} = 3.3 V ± 0.3 V	37	140	
				V_{CCB} = 5 V ± 0.5 V	27	103	
t_{en}	Enable time	OE-to-A or B		V_{CCB} = 2.5 V ± 0.2 V		36	ns
				V_{CCB} = 3.3 V ± 0.3 V		41	
				V_{CCB} = 5 V ± 0.5 V		43	
t_{dis}	Disable time	OE-to-A or B		V_{CCB} = 2.5 V ± 0.2 V		77	ns
				V_{CCB} = 3.3 V ± 0.3 V		68	
				V_{CCB} = 5 V ± 0.5 V		63	
t_{rA}	Input rise time	A-port rise time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	2.8	7.4	ns
				V_{CCB} = 3.3 V ± 0.3 V	2.6	6.6	
				V_{CCB} = 5 V ± 0.5 V	1.8	5.6	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	34	149	
				V_{CCB} = 3.3 V ± 0.3 V	31	121	
				V_{CCB} = 5 V ± 0.5 V	24	89	
t_{rB}	Input rise time	B-port rise time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	3.2	8.3	ns
				V_{CCB} = 3.3 V ± 0.3 V	2.9	7.2	
				V_{CCB} = 5 V ± 0.5 V	2.6	6.2	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	35	151	
				V_{CCB} = 3.3 V ± 0.3 V	31	112	
				V_{CCB} = 5 V ± 0.5 V	16.5	64	
t_{fA}	Input fall time	A-port fall time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	1.9	5.7	ns
				V_{CCB} = 3.3 V ± 0.3 V	1.9	5.5	
				V_{CCB} = 5 V ± 0.5 V	1.8	5.3	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	4.4	6.9	
				V_{CCB} = 3.3 V ± 0.3 V	4.3	6.2	
				V_{CCB} = 5 V ± 0.5 V	4.2	5.8	
t_{fB}	Input fall time	B-port fall time	Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	2.2	7.8	ns
				V_{CCB} = 3.3 V ± 0.3 V	2.4	6.7	
				V_{CCB} = 5 V ± 0.5 V	2.6	6.6	
			Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	5.1	8.8	
				V_{CCB} = 3.3 V ± 0.3 V	5.4	9.4	
				V_{CCB} = 5 V ± 0.5 V	5.4	11.2	
$t_{SK(O)}$	Skew (time), output	Channel-to-channel skew		V_{CCB} = 2.5 V ± 0.2 V		1	ns
				V_{CCB} = 3.3 V ± 0.3 V		1	
				V_{CCB} = 5 V ± 0.5 V		1	

over recommended operating free-air temperature range, VCCA = 2.5 V ± 0.2 V (unless otherwise noted)

PARAMETER	TEST CONDITIONS			MIN	MAX	UNIT
Maximum data rate		Push-pull driving	V_{CCB} = 2.5 V ± 0.2 V	24		Mbps
			V_{CCB} = 3.3 V ± 0.3 V	24		
			V_{CCB} = 5 V ± 0.5 V	24		
		Open-drain driving	V_{CCB} = 2.5 V ± 0.2 V	2		
			V_{CCB} = 3.3 V ± 0.3 V	2		
			V_{CCB} = 5 V ± 0.5 V	2		

6.8 Switching Characteristics: V_{CCA}=3.3V±0.3V

over recommended operating free-air temperature range, V_{CCA} = 3.3 V ± 0.3 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
t_{PHL}	Propagation delay time (high-to-low output)	A-to-B	Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V		2.4	ns
				V_{CCB} = 5 V ± 0.5 V		3.1	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	1.3	4.2	
				V_{CCB} = 5 V ± 0.5 V	1.7	4.6	
t_{PLH}	Propagation delay time (low-to-high output)		Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V		4.2	
				V_{CCB} = 5 V ± 0.5 V		4.4	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	40	204	
				V_{CCB} = 5 V ± 0.5 V	34	165	
t_{PHL}	Propagation delay time (high-to-low output)	B-to-A	Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V		2.5	ns
				V_{CCB} = 5 V ± 0.5 V		3.3	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	1	124	
				V_{CCB} = 5 V ± 0.5 V	1	97	
t_{PLH}	Propagation delay time (low-to-high output)		Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V		2.5	
				V_{CCB} = 5 V ± 0.5 V		2.6	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	3	139	
				V_{CCB} = 5 V ± 0.5 V	3	105	
t_{en}	Enable time	OE-to-A or B		V_{CCB} = 3.3 V ± 0.3 V		41	ns
				V_{CCB} = 5 V ± 0.5 V		43	
t_{dis}	Disable time	OE-to-A or B		V_{CCB} = 3.3 V ± 0.3 V		68	ns
				V_{CCB} = 5 V ± 0.5 V		63	
t_{rA}	Input rise time	A-port rise time	Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V	2.3	5.6	ns
				V_{CCB} = 5 V ± 0.5 V	1.9	4.8	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	25	116	
				V_{CCB} = 5 V ± 0.5 V	19	85	
t_{rB}	Input rise time	B-port rise time	Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V	2.5	6.4	ns
				V_{CCB} = 5 V ± 0.5 V	2.1	7.4	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	25	116	
				V_{CCB} = 5 V ± 0.5 V	26	116	
t_{fA}	Input fall time	A-port fall time	Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V	2	5.4	ns
				V_{CCB} = 5 V ± 0.5 V	1.9	5.0	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	4.3	6.1	
				V_{CCB} = 5 V ± 0.5 V	4.2	5.7	

over recommended operating free-air temperature range, V_{CCA} = 3.3 V ± 0.3 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
t_{fB}	Input fall time	B-port fall time	Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V	2.3	7.4	ns
				V_{CCB} = 5 V ± 0.5 V	2.4	7.6	
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	5	7.6	
				V_{CCB} = 5 V ± 0.5 V	4.8	8.3	
$t_{SK(O)}$ Skew (time), output		Channel-to-channel skew		V_{CCB} = 3.3 V ± 0.3 V		1	ns
				V_{CCB} = 5 V ± 0.5 V		1	
Maximum data rate			Push-pull driving	V_{CCB} = 3.3 V ± 0.3 V	24		Mbps
				V_{CCB} = 5 V ± 0.5 V	24		
			Open-drain driving	V_{CCB} = 3.3 V ± 0.3 V	2		
				V_{CCB} = 5 V ± 0.5 V	2		

6.9 Switching Characteristics: VCCA = 5V±0.5 V

over recommended operating free-air temperature range, V_{CCA} = 5 V ± 0.5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
t_{PHL}	Propagation delay time (high-to-low output)		Push-pull driving	V_{CCB} = 5 V ± 0.5 V		5.6	ns
			Open-drain driving	V_{CCB} = 5 V ± 0.5 V	1.6	4.6	
t_{PLH}	Propagation delay time (low-to-high output)		Push-pull driving	V_{CCB} = 5 V ± 0.5 V		2.0	
			Open-drain driving	V_{CCB} = 5 V ± 0.5 V	24	155	
t_{en}	Enable time	OE-to-A or B		V_{CCB} = 5 V ± 0.5 V		43	ns
t_{dis}	Disable time	OE-to-A or B		V_{CCB} = 5 V ± 0.5 V		63	ns
t_r	Input rise time		Push-pull driving	V_{CCB} = 5 V ± 0.5 V	2.7	5.0	ns
			Open-drain driving	V_{CCB} = 5 V ± 0.5 V	19	50	
t_f	Input fall time		Push-pull driving	V_{CCB} = 5 V ± 0.5 V	1.2	3.0	ns
			Open-drain driving	V_{CCB} = 5 V ± 0.5 V	1.8	3.0	
$t_{SK(O)}$ Skew (time), output		Channel-to-channel skew		V_{CCB} = 5 V ± 0.5 V		1	ns
Maximum data rate			Push-pull driving	V_{CCB} = 5 V ± 0.5 V	24		Mbps
			Open-drain driving	V_{CCB} = 5 V ± 0.5 V	2		

7. Parameter Measurement Information

7.1 Load Circuits

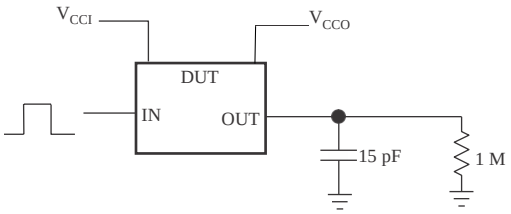


Figure 7-1. Data Rate, Pulse Duration, Propagation Delay, Output Rise-Time and Fall-Time Measurement Using a Push-Pull Driver

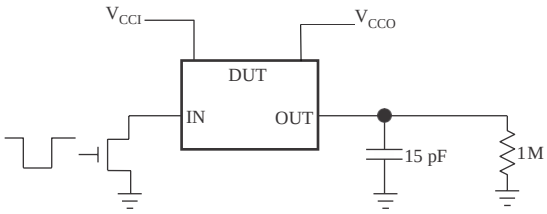
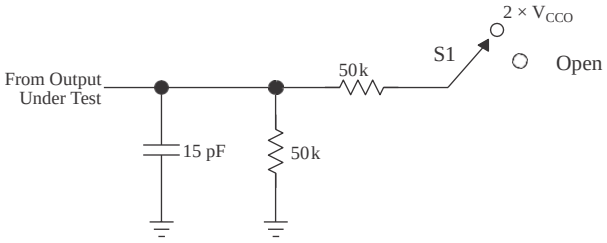


Figure 7-2. Data Rate, Pulse Duration, Propagation Delay, Output Rise-Time and Fall-Time Measurement Using an Open-Drain Driver



TEST	S1
t_{PZL} / t_{PLZ} (t_{dis})	2 × V_{CCO}
t_{PHZ} / t_{PZH} (t_{en})	Open

Figure 7-3. Load Circuit for Enable-Time and Disable-Time Measurement

1. t_{PLZ} and t_{PHZ} are the same as t_{dis}.
2. t_{PZL} and t_{PZH} are the same as t_{en}.
3. V_{CCI} is the V_{CC} associated with the input port.
4. V_{CCO} is the V_{CC} associated with the output port.

7.2 Voltage Waveforms

The outputs are measured one at a time, with one transition per measurement. All input pulses are supplied by generators that have the following characteristics:

- PRR ≤ 10 MHz
- Z_O = 50 Ω
- dv/dt ≥ 1 V/ns

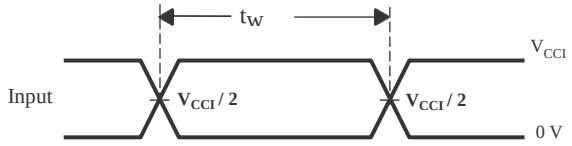


Figure 7-4. Pulse Duration

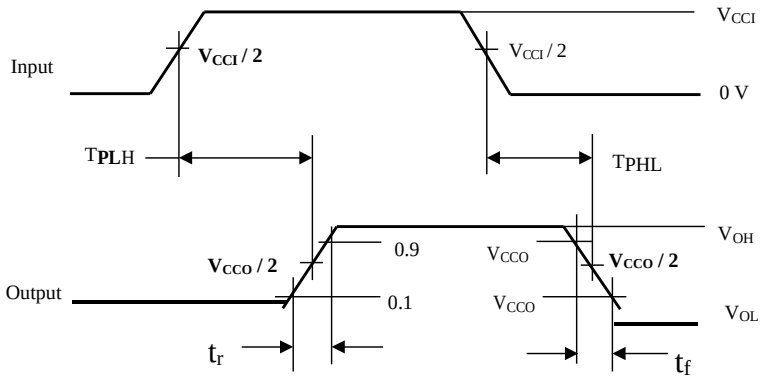
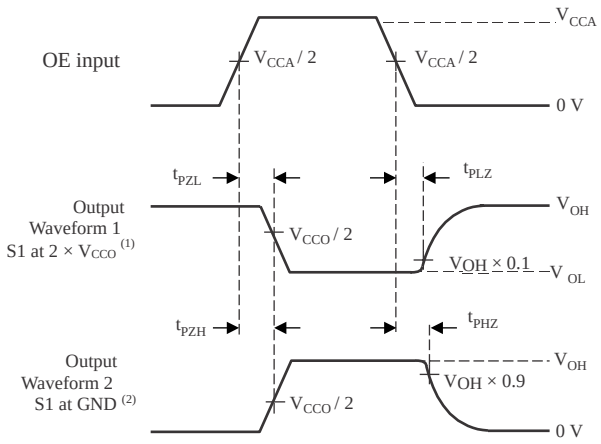


Figure 7-5. Voltage Waveforms Propagation Delay Times

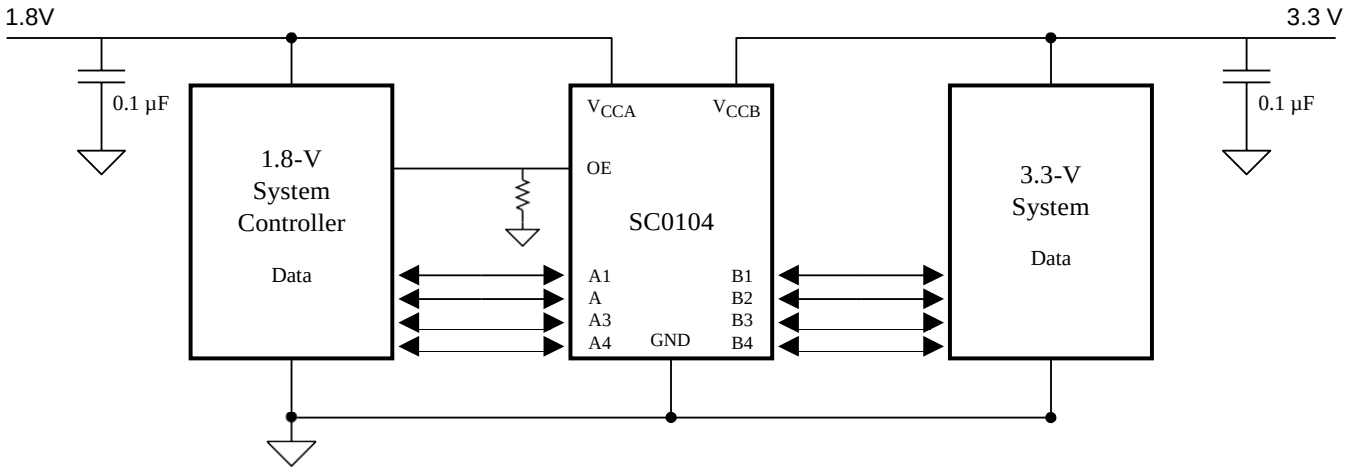


A. Waveform 1 is for an output with internal such that the output is high, except when OE is high (see Figure 7-3).
B. Waveform 2 is for an output with conditions such that the output is low, except when OE is high.

Figure 7-6. Enable and Disable Times

8. Application Information

The SC0104 device can be used to bridge the digital-switching compatibility gap between two voltage nodes to successfully interface logic threshold levels found in electronic systems. It should be used in a point-to-point topology for interfacing devices or systems operating at different interface voltages with one another. Its primary target application use is for interfacing with open-drain drivers on the data I/Os such as I2C , 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.



9. Feature Description

9.1 Architecture

The SC0104 architecture (see Figure 8) 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.

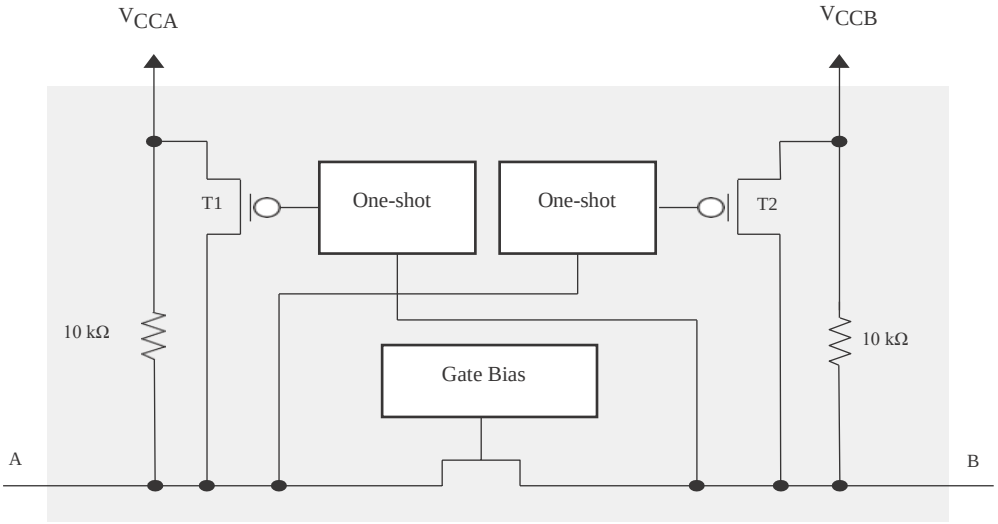


Figure 8-1. Architecture of a SC0104 Cell

9.2 Power Up

During operation, ensure that $V_{CCA} \leq V_{CCB}$ at all times. During power-up sequencing, $V_{CCA} \geq V_{CCB}$ does not damage the device, so any power supply can be ramped up first.

9.3 Enable and Disable

The SC0104 device has an OE input that disables the device by setting OE low, which places all I/Os in the high-impedance state. The disable time (t_{dis}) indicates the delay between the time when the OE pin goes low and when the outputs actually enter the high-impedance state. The enable time (t_{en}) indicates the amount of time the user must allow for the one-shot circuitry to become operational after the OE pin is taken high.

9.4 Pullup and Pulldown Resistors on I/O Lines

Each A-port I/O has an internal 10-kΩ pullup resistor to V_{CCA}, and each B-port I/O has an internal 10-kΩ 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-kΩ resistors).

9.5 Output Load Considerations

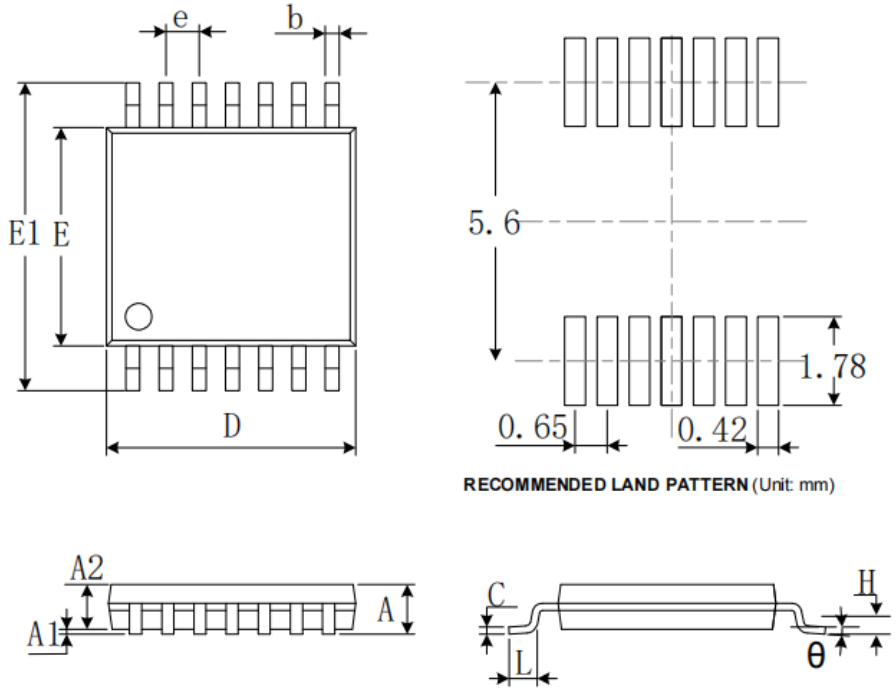
We recommend careful PCB layout practices with short PCB trace lengths to avoid excessive capacitive loading and to ensure that proper O.S. triggering takes place. PCB signal trace-lengths should be kept short enough such that the round-trip delay of any reflection is less than the one-shot duration. 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.

9.6 Input Driver Requirements

The fall time (t_{fA}, t_{fB}) of a signal depends on the output impedance of the external device driving the data I/Os of the SC0104 device. Similarly, the t_{PHL} and maximum data rates also depend on the output impedance of the external driver. The values for t_{fA}, t_{fB}, t_{PHL}, and maximum data rates in the data sheet assume that the output impedance of the external driver is less than 50 Ω.

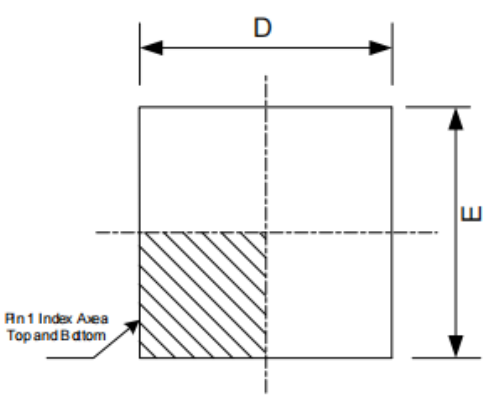
PACKAGE OUTLINE DIMENSIONS

TSSOP-14

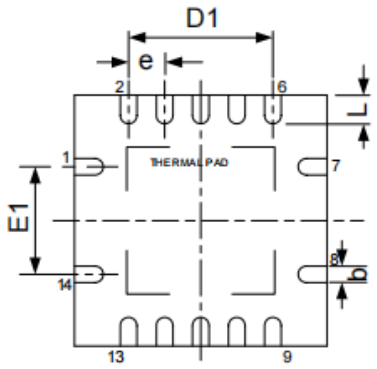


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.860	5.100	0.191	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650(BSC)		0.026(BSC)	
L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

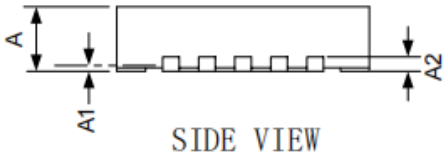
QFN3.5x3.5-14L



TOP VIEW



BOTTOM VIEW



SIDE VIEW

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.000	0.031	0.039
A1	0.000	0.050	0.000	0.002
A2	0.200 REF		0.008 REF	
b	0.180	0.300	0.007	0.012
D	3.350	3.650	0.132	0.144
D1	2.000 TYP		0.079 TYP	
E	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