



# BCT0104H

## 4-Bit Bidirectional Voltage-Level Translator

### BCT0104H

#### 4-Bit Bidirectional Voltage-Level Translator

#### GENERAL DESCRIPTION

This four-bit non-inverting translator is a bidirectional voltage-level translator and can be used to establish digital switching compatibility between mixed-voltage systems. It uses two separate configurable power-supply rails, with the A ports supporting operating voltages from 1.1V to 3.6V while it tracks the VCCA supply, and the B ports supporting operating voltages from 1.65V to 5.5V while it tracks the VCCB supply. This allows the support of both lower and higher logic signal levels while providing bidirectional translation capabilities between any of the 1.2V, 1.8V, 2.5V, 3.3V, and 5V voltage nodes.

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

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

#### FEATURES

- No Direction-Control Signal Needed
- Data Rates  
24Mbps (Push-Pull)  
2Mbps (Open-Drain)
- 1.1V to 3.6V on A Ports and 1.65V to 5.5V on B Ports ( $V_{CCA} \leq V_{CCB}$ )
- VCC Isolation: If Either VCC is at GND, Both Ports are in the High-Impedance State
- No Power-Supply Sequencing Required, Either VCCA or VCCB can be Ramped First
- I<sub>OFF</sub>: Supports Partial-Power-Down Mode Operation
- Available in FO-12L package.

#### APPLICATIONS

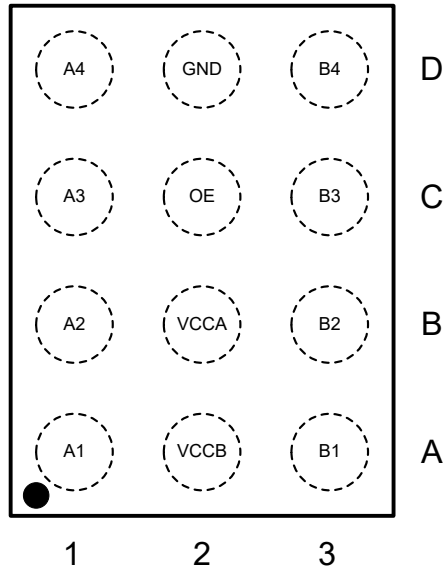
- I2C BUS
- Portable POS Systems
- Smart Card Readers
- Cell-Phones
- GPS
- Portable Communication Devices

#### ORDERING INFORMATION

Order Number	Package Type	Temperature Range	Marking	QTY/Reel
BCT0104HEFC-TR	FO-12L	-40°C to +85°C	ZQZK XXX	3000

Note 1: "XXX" in Marking will be appeared as the batch code.

### PIN CONFIGURATION (Top View)



FO-12L

### PIN DESCRIPTION

PIN	NAME	FUNCTION
A1	A1	Input/Output A. Referenced to $V_{CCA}$ .
B1	A2	Input/Output A. Referenced to $V_{CCA}$ .
C1	A3	Input/Output A. Referenced to $V_{CCA}$ .
D1	A4	Input/Output A. Referenced to $V_{CCA}$ .
A2	$V_{CCB}$	B-Port Supply Voltage. $1.65V \leq V_{CCB} \leq 5.5V$ .
B2	$V_{CCA}$	A-Port Supply Voltage. $1.1V \leq V_{CCA} \leq 3.6V$ and $V_{CCA} \leq V_{CCB}$ .
C2	OE	Output Enable (Active High). Pull OE low to place all outputs in 3-state mode. Referenced to $V_{CCA}$ .
D2	GND	Ground.
A3	B1	Input/Output B. Referenced to $V_{CCB}$ .
B3	B2	Input/Output B. Referenced to $V_{CCB}$ .
C3	B3	Input/Output B. Referenced to $V_{CCB}$ .
D3	B4	Input/Output B. Referenced to $V_{CCB}$ .



# BCT0104H

## 4-Bit Bidirectional Voltage-Level Translator

### ABSOLUTE MAXIMUM RATINGS

$V_{CCA}$ , Supply Voltage Range.....	-0.3V to 5V
$V_{CCB}$ , Supply Voltage Range.....	-0.3V to 6V
$V_I$ , A Port, B Port, OE Input Voltage Range (2).....	-0.3V to 6V
$V_O$ , Voltage Range Applied to Any Output in the High- Impedance or Power-Off State (2)	
A Port.....	-0.3V to 5V
B Port.....	-0.3V to 6V
$V_O$ , Voltage Range Applied to Any Output in the High or Low State (2) (3)	
A Port.....	-0.3V to $V_{CCA} + 0.3V$
B Port.....	-0.3V to $V_{CCB} + 0.3V$
$I_{IK}$ , Input Clamp Current ( $V_I < 0$ ) .....	-50mA
$I_{OK}$ , Output Clamp Current ( $V_O < 0$ ) .....	-50mA
$I_O$ , Continuous Output Current.....	$\pm 50mA$
Continuous Current through $V_{CCA}$ , $V_{CCB}$ , or GND.....	$\pm 100mA$
Operating Temperature Range.....	-40°C to +85°C
Junction Temperature.....	150°C
Storage Temperature Range.....	-65°C to +150°C
Lead Temperature (Soldering, 10sec).....	260°C
ESD	
HBM B Port.....	8KV
HBM Other Pin.....	4KV

NOTE:

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 in the operational sections of the specifications is not implied. Exposure to absolute Maximum rating conditions for extended periods may affect device reliability.
2. The input and output negative-voltage ratings may be exceeded if the input and output current ratings are observed.
3. The value of  $V_{CCA}$  and  $V_{CCB}$  are provided in the recommended operating conditions table.



# BCT0104H

## 4-Bit Bidirectional Voltage-Level Translator

### ELECTRICAL CHARACTERISTICS

( $V_{CCA} = 1.1V$  to  $3.6V$ ,  $V_{CCB} = 1.65V$  to  $5.5V$ , typical values are at  $T_A = +25^\circ C$ , unless otherwise noted)

PARAMETER		CONDITIONS	MIN	TYP	MAX	UNITS
<b>RECOMMENDED OPERATING CONDITIONS</b> <sup>(1) (2)</sup>						
Supply Voltage <sup>(3)</sup>	$V_{CCA}$		1.1		3.6	V
	$V_{CCB}$		1.65		5.5	
High-Level Input Voltage ( $V_{IH}$ )	A Port I/Os	$V_{CCA} = 1.1V$ to $1.95V$ , $V_{CCB} = 1.65V$ to $5.5V$	$V_{CCI} - 0.2$		$V_{CCI}$	V
		$V_{CCA} = 2.3V$ to $3.6V$ , $V_{CCB} = 1.65V$ to $5.5V$	$V_{CCI} - 0.4$		$V_{CCI}$	
	B Port I/Os		$V_{CCI} - 0.4$		$V_{CCI}$	
	OE Input		$V_{CCA} \times 0.8$		5.5	
Low-Level Input Voltage ( $V_{IL}$ )	A Port I/Os		0		0.15	V
	B Port I/Os		0		0.15	
	OE Input		0		$V_{CCA} \times 0.25$	
Input Transition Rise or Fall Rate ( $\Delta t/\Delta V$ )	A Port I/Os Push-Pull Driving				10	ns/V
	B Port I/Os Push-Pull Driving				10	
	Control Input				10	
<b>ELECTRICAL CHARACTERISTICS</b>						
A Port High Level Output Voltage ( $V_{OHA}$ )	$I_{OH} = -20\mu A$ , $V_{IB} \geq V_{CCB} - 0.4V$		$V_{CCA} \times 0.7$			V
A Port Low Level Output Voltage ( $V_{OLA}$ )	$I_{OL} = 1mA$ , $V_{IB} \leq 0.15V$				0.4	
B Port High Level Output Voltage ( $V_{OHB}$ )	$I_{OH} = -20\mu A$ , $V_{IA} \geq V_{CCA} - 0.4V$		$V_{CCB} \times 0.7$			
B Port Low Level Output Voltage ( $V_{OLB}$ )	$I_{OL} = 1mA$ , $V_{IA} \leq 0.15V$				0.4	
Input Leakage Current ( $I_I$ )	OE			1.0		$\mu A$
Power Off Leakage Current ( $I_{OFF}$ )	A Port	$V_{CCA} = 0V$ , $V_{CCB} = 0V$ to $5.5V$		0.1		
	B Port	$V_{CCA} = 0V$ to $5.5V$ , $V_{CCB} = 0V$		0.1		
3-State Output Leakage ( $I_{OZ}$ )	A or B Port	OE = 0V		0.1		
Quiescent Supply Current ( $I_{CCA}$ )	$V_I = V_O = OPEN$ , $I_O = 0$	$V_{CCA} = 1.1V$ to $V_{CCB}$ , $V_{CCB} = 2.3V$ to $3.6V$		0.1		$\mu A$
		$V_{CCA} = 5.5V$ , $V_{CCB} = 0V$		0.1		
		$V_{CCA} = 0V$ , $V_{CCB} = 5.5V$		0.1		
Quiescent Supply Current ( $I_{CCB}$ )	$V_I = V_O = OPEN$ , $I_O = 0$	$V_{CCA} = 1.1V$ to $3.6V$ , $V_{CCB} = 1.65V$ to $5.5V$		14		$\mu A$
		$V_{CCA} = 3.6V$ , $V_{CCB} = 0V$		0.1		
		$V_{CCA} = 0V$ , $V_{CCB} = 5.5V$		0.1		
Quiescent Supply Current ( $I_{CCA} + I_{CCB}$ )	$V_I = V_O = OPEN$ , $I_O = 0$	$V_{CCA} = 1.1V$ to $3.6V$ , $V_{CCB} = 1.65V$ to $5.5V$		14		$\mu A$



# BCT0104H

## 4-Bit Bidirectional Voltage-Level Translator

### ELECTRICAL CHARACTERISTICS

( $V_{CCA} = 1.1V$  to  $3.6V$ ,  $V_{CCB} = 1.65V$  to  $5.5V$ , typical values are at  $T_A = +25^\circ C$ , unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
Quiescent Supply Current ( $I_{CCZA}$ )	$V_I = V_{CCI}$ , $I_O = 0$ , OE = GND	$V_{CCA} = 1.1V$ to $3.6V$ , $V_{CCB} = 1.65V$ to $5.5V$		0.1		$\mu A$
		$V_{CCA} = 3.6V$ , $V_{CCB} = 0V$		0.1		
		$V_{CCA} = 0V$ , $V_{CCB} = 5.5V$		0.1		
Quiescent Supply Current ( $I_{CCZB}$ )	$V_I = V_{CCI}$ , $I_O = 0$ , OE = GND	$V_{CCA} = 1.1V$ to $3.6V$ , $V_{CCB} = 1.65V$ to $5.5V$		0.1		$\mu A$
		$V_{CCA} = 3.6V$ , $V_{CCB} = 0V$		0.1		
		$V_{CCA} = 0V$ , $V_{CCB} = 5.5V$		0.1		
OE Input Capacitance ( $C_I$ )	$V_{CCA} = 3.3V$ , $V_{CCB} = 3.3V$		5.0		pF	
Input/Output Capacitance A Port ( $C_{IO}$ )	$V_{CCA} = 3.3V$ , $V_{CCB} = 3.3V$		7.0		pF	
Input/Output Capacitance B Port ( $C_{IO}$ )			9.0			

**NOTES:**

1.  $V_{CCI}$  is the  $V_{CC}$  associated with the input port.
2.  $V_{CCO}$  is the  $V_{CC}$  associated with the output port.
3.  $V_{CCA}$  must be less than or equal to  $V_{CCB}$ , and  $V_{CCA}$  must not exceed 5.5V.



# BCT0104H

## 4-Bit Bidirectional Voltage-Level Translator

### TIMING REQUIREMENTS

(typical values are at  $T_A = +25^\circ\text{C}$ , unless otherwise noted)

		$V_{CCB} = 1.8\text{V}$	$V_{CCB} = 3.3\text{V}$	$V_{CCB} = 5\text{V}$	UNITS	
		TYP	TYP	TYP		
<b>(<math>T_A = +25^\circ\text{C}</math>, <math>V_{CCA} = 1.2\text{V}</math>, unless otherwise noted.)</b>						
Data Rate	Push-Pull Driving		24	22	19	Mbps
	Open-Drain Driving		2	2	2	
Pulse Duration ( $t_w$ )	Push-Pull Driving	Data Inputs	41	45	53	ns
	Open-Drain Driving		500	500	500	
<b>(<math>T_A = +25^\circ\text{C}</math>, <math>V_{CCA} = 1.8\text{V}</math>, unless otherwise noted.)</b>						
Data Rate	Push-Pull Driving		24	24	20	Mbps
	Open-Drain Driving		2	2	2	
Pulse Duration ( $t_w$ )	Push-Pull Driving	Data Inputs	41	41	50	ns
	Open-Drain Driving		500	500	500	
<b>(<math>T_A = +25^\circ\text{C}</math>, <math>V_{CCA} = 3.3\text{V}</math>, unless otherwise noted.)</b>						
Data Rate	Push-Pull Driving			23	19	Mbps
	Open-Drain Driving			2	2	
Pulse Duration ( $t_w$ )	Push-Pull Driving	Data Inputs		43	53	ns
	Open-Drain Driving			500	500	



# BCT0104H

## 4-Bit Bidirectional Voltage-Level Translator

### SWITCHING CHARACTERISTICS

( $V_{CCA} = 1.2V$ , typical values are at  $T_A = +25^\circ C$ , unless otherwise noted)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	TEST CONDITIONS	$V_{CCB} = 1.8V$	$V_{CCB} = 3.3V$	$V_{CCB} = 5V$	UNITS
$t_{PHL}$	A	B	Push-Pull Driving	4.0	6.0	7.7	ns
			Open-Drain Driving	8	10	18	
$t_{PLH}$			Push-Pull Driving	10.7	10.1	10.0	
			Open-Drain Driving	32	24	22	
$t_{PHL}$	B	A	Push-Pull Driving	3.1	2.7	2.6	ns
			Open-Drain Driving	5	3	2	
$t_{PLH}$			Push-Pull Driving	6.0	5.3	4.3	
			Open-Drain Driving	9	9	9	
$t_{EN} (t_{PZH} \& t_{PZL})$	OE	A or B		17	15	14	ns
$t_{DIS} (t_{PHZ} \& t_{PLZ})$	OE	A or B		614	616	626	
$t_{rA}$	A Port Rise Time		Push-Pull Driving	9.5	9.0	8.8	ns
			Open-Drain Driving	10	9.8	9.3	
$t_{rB}$	B Port Rise Time		Push-Pull Driving	12	11	10	ns
			Open-Drain Driving	36	25	21	
$t_{fA}$	A Port Fall Time		Push-Pull Driving	6.7	7.0	7.1	ns
			Open-Drain Driving	6.6	6.7	6.9	
$t_{fB}$	B Port Fall Time		Push-Pull Driving	7.2	9.3	12.3	ns
			Open-Drain Driving	7.1	9.2	12.2	
$t_{sk(0)}$	Channel-to-Channel Skew			0.5	0.5	0.5	ns

### SWITCHING CHARACTERISTICS

( $V_{CCA} = 1.8V$ , typical values are at  $T_A = +25^\circ C$ , unless otherwise noted)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	TEST CONDITIONS	$V_{CCB} = 1.8V$	$V_{CCB} = 3.3V$	$V_{CCB} = 5V$	UNITS
$t_{PHL}$	A	B	Push-Pull Driving	4.7	6.7	8.6	ns
			Open-Drain Driving	7	9	13	
$t_{PLH}$			Push-Pull Driving	6.7	5.4	5.2	
			Open-Drain Driving	35	23	19	
$t_{PHL}$	B	A	Push-Pull Driving	4.1	3.1	2.7	ns
			Open-Drain Driving	8	7	6	
$t_{PLH}$			Push-Pull Driving	3.6	2.9	2.4	
			Open-Drain Driving	7	6	6	
$t_{EN} (t_{PZH} \& t_{PZL})$	OE	A or B		14	13	12	ns
$t_{DIS} (t_{PHZ} \& t_{PLZ})$	OE	A or B		630	635	640	
$t_{rA}$	A Port Rise Time		Push-Pull Driving	5.7	5.4	5.2	ns
			Open-Drain Driving	8	7	6	
$t_{rB}$	B Port Rise Time		Push-Pull Driving	8.8	6.9	6.0	ns
			Open-Drain Driving	35	22	19	
$t_{fA}$	A Port Fall Time		Push-Pull Driving	7.3	7.3	7.3	ns
			Open-Drain Driving	6.8	6.8	6.8	
$t_{fB}$	B Port Fall Time		Push-Pull Driving	7.6	9.6	12.7	ns
			Open-Drain Driving	7.1	9.5	12.2	
$t_{sk(0)}$	Channel-to-Channel Skew			0.5	0.5	0.5	ns

### SWITCHING CHARACTERISTICS

( $V_{CCA} = 3.3V$ , typical values are at  $T_A = +25^\circ C$ , unless otherwise noted)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	TEST CONDITIONS	$V_{CCB} = 3.3V$	$V_{CCB} = 5V$	UNITS
$t_{PHL}$	A	B	Push-Pull Driving	8.0	10	ns
			Open-Drain Driving	12	15	
$t_{PLH}$			Push-Pull Driving	3.3	3.0	
			Open-Drain Driving	13	11	
$t_{PHL}$	B	A	Push-Pull Driving	4.5	3.6	ns
			Open-Drain Driving	11	10	
$t_{PLH}$			Push-Pull Driving	1.8	1.3	
			Open-Drain Driving	5	5	
$t_{EN}$ ( $t_{PZH}$ & $t_{PZL}$ )	OE	A or B		12	11	ns
$t_{DIS}$ ( $t_{PHZ}$ & $t_{PLZ}$ )	OE	A or B		630	635	
$t_{rA}$	A Port Rise Time		Push-Pull Driving	3.2	3.0	ns
			Open-Drain Driving	7	6	
$t_{rB}$	B Port Rise Time		Push-Pull Driving	5.0	3.5	ns
			Open-Drain Driving	16	10	
$t_{fA}$	A Port Fall Time		Push-Pull Driving	9.6	9.8	ns
			Open-Drain Driving	9.2	9.3	
$t_{fB}$	B Port Fall Time		Push-Pull Driving	10.2	13.8	ns
			Open-Drain Driving	9.5	12.3	
$t_{sk(0)}$	Channel-to-Channel Skew			0.5	0.5	ns

### APPLICATION INFORMATION

The BCT0104H can be used to bridge the digital-switching compatibility gap between two voltage nodes to successfully interface logic threshold levels found in electronic systems. It should be used in a point-to-point topology for interfacing devices or systems operating at different interface voltages with one another. Its primary target application use is for interfacing with open-drain drivers on the data I/Os such as I2C or 1-wire, where the data is bidirectional and no control signal is available. The BCT0104H can also be used in applications where a push-pull driver is connected to the data I/Os

### Block Diagram

The BCT0104H architecture (see Figure 1) 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 four 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.

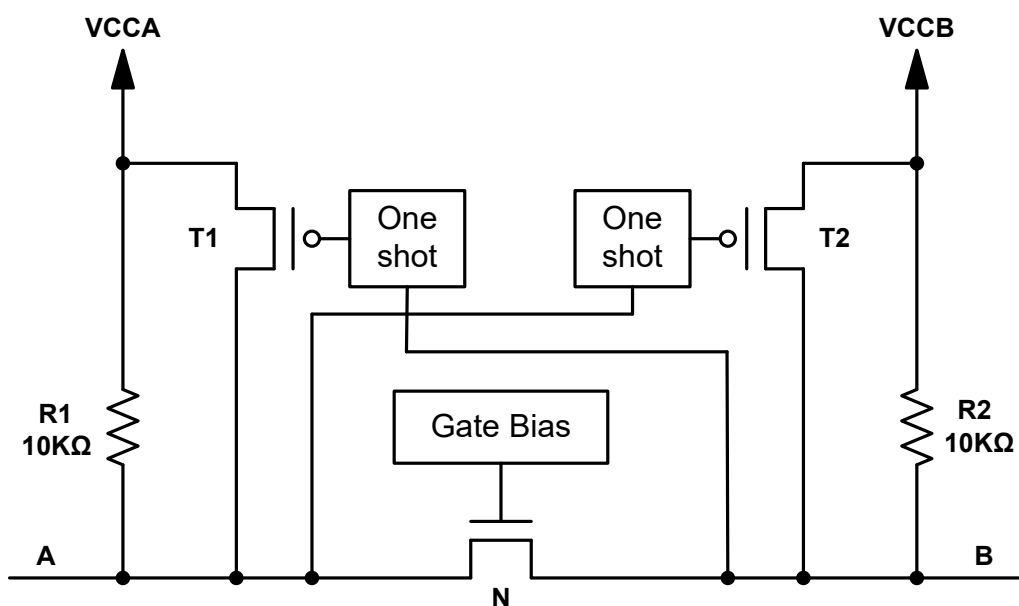


Figure 1 Block Diagram of BCT0104H I/O Cell



# BCT0104H

## 4-Bit Bidirectional Voltage-Level Translator

---

The BCT0104H employs two key circuits to enable this voltage translation: An N-channel pass-gate transistor topology that ties the A port to the B port. Output one-shot (O.S.) edge-rate accelerator circuitry to detect and accelerate rising edges on the A or B ports.

### 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 BCT0104H. Similarly, the  $t_{PHL}$  and data rates also depend on the output impedance of the external driver. The values for  $t_{fA}$ ,  $t_{fB}$ ,  $t_{PHL}$ , and data rates in the datasheet assume that the output impedance of the external driver is less than 50Ω.

### Power Up

During operation, ensure that  $V_{CCA} \leq V_{CCB}$  at all times. The sequencing of each power supply will not damage the device during the power up operation, so either power supply can be ramped up first.

### 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 30ns. 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  $I_{CC}$ , load driving capability, and maximum bit-rate considerations. Both PCB trace length and connectors add to the capacitance that the BCT0104H 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.

### Enable and Disable

The BCT0104H has an OE input that is used to disable the device by setting OE low, which places all I/Os in the Hi-Z state. OE has an internal pull-down current source, as long as  $V_{CCA}$  is powered. The disable time ( $t_{DIS}$ ) indicates the delay between the time when OE goes low and when the outputs are disabled (Hi-Z). The enable time ( $t_{EN}$ ) indicates the amount of time the user must allow for the one-shot circuitry to become operational after OE is taken high.

### Pull-up or Pull-down Resistors on I/O Lines

Each A port I/O has an internal  $10k\Omega$  pull-up resistor to  $V_{CCA}$ , and each B port I/O has an internal  $10k\Omega$  pull-up resistor to  $V_{CCB}$ . If a smaller value of pull-up resistor is required, an external resistor must be added from the I/O to  $V_{CCA}$  or  $V_{CCB}$  (in parallel with the internal  $10k\Omega$  resistors). Adding lower value pull-up resistors will effect  $V_{OL}$  levels, however. The internal pull-ups of the BCT0104H are disabled when the OE pin is low.

### Typical Application Circuit

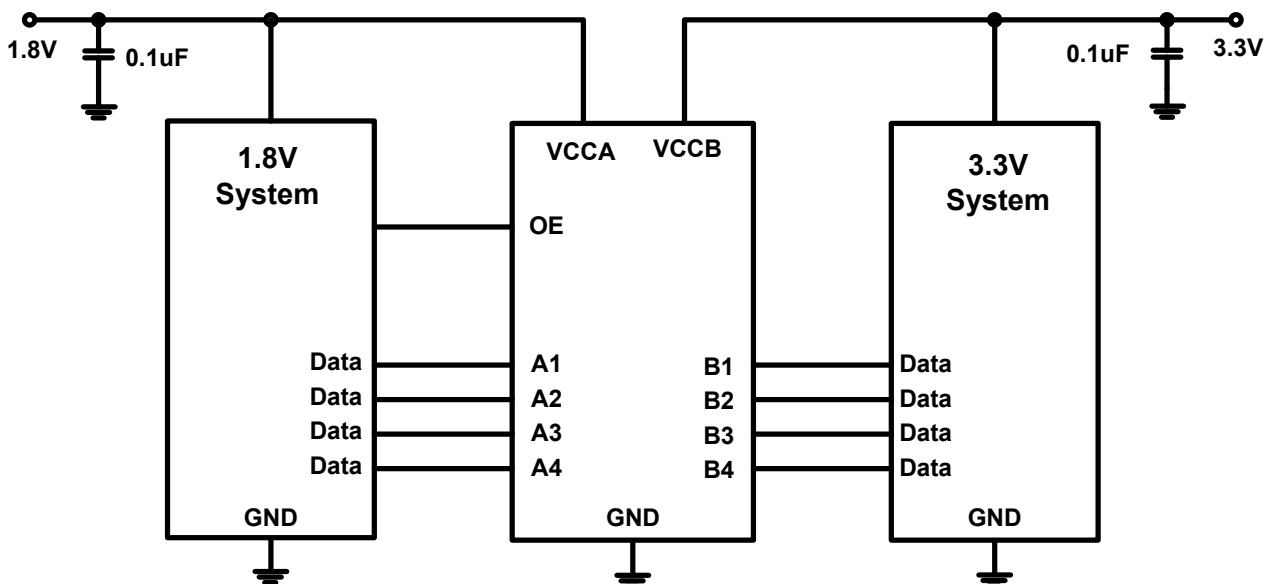
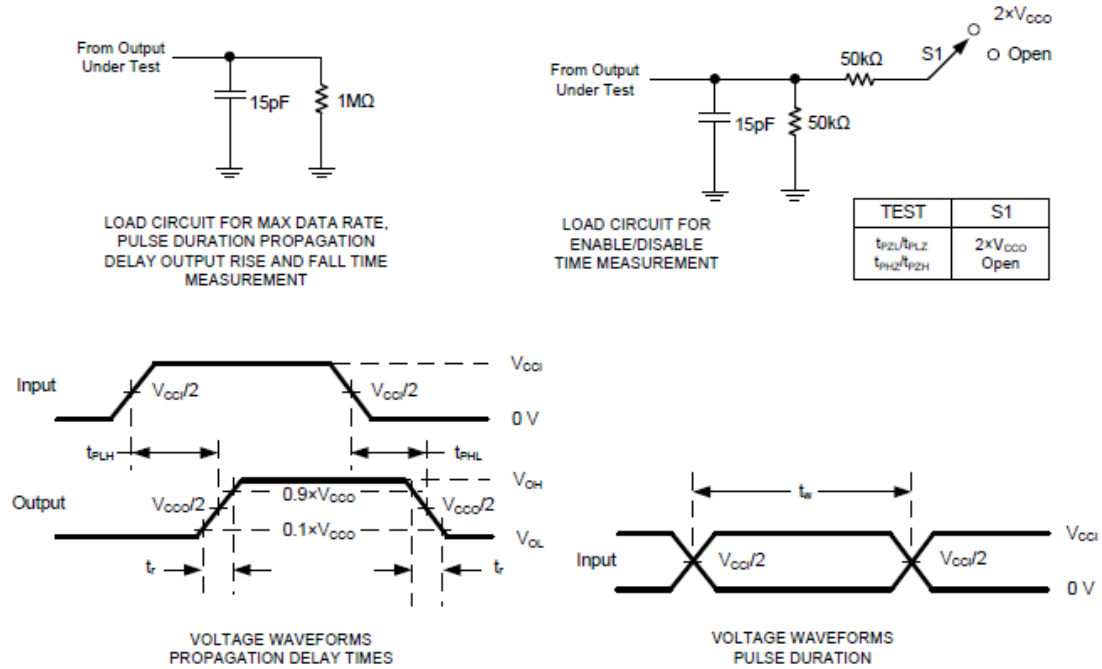


Figure 2 Typical Application Circuit

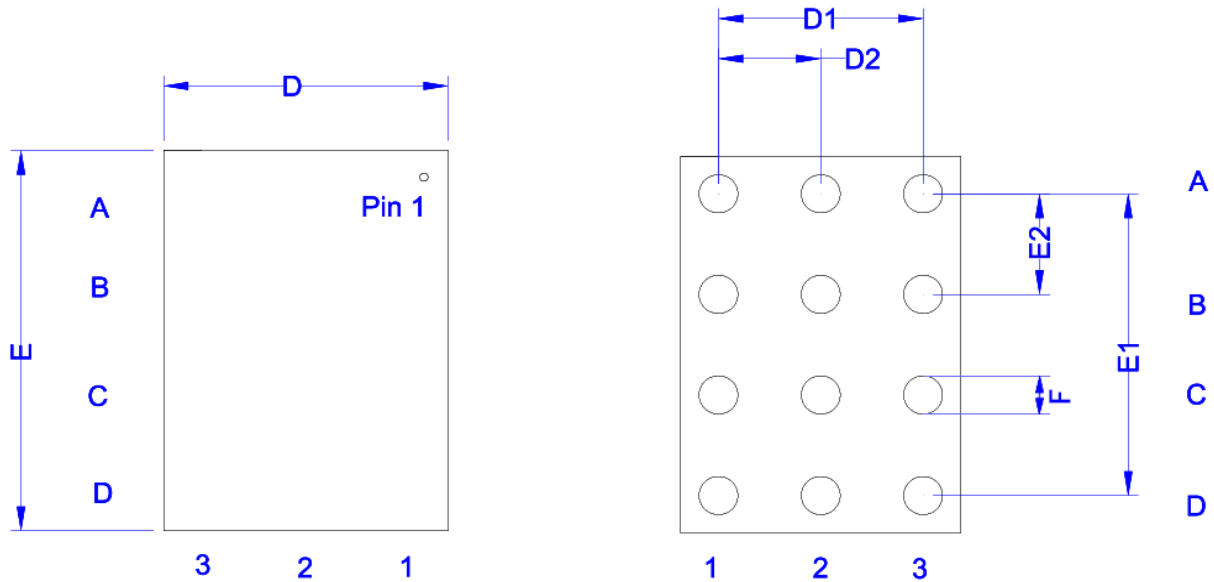
### Test Circuits



- A. C<sub>L</sub> includes probe and jig capacitance.
- B. All input pulses are supplied by generators having the following characteristics: PRR≤10MHz, Z<sub>o</sub>=50Ω, dv/dt≥1V/ns.
- C. The outputs are measured one at a time, with one transition per measurement.
- D. t<sub>rLH</sub> and t<sub>rHL</sub> are the same as t<sub>pd</sub>.
- E. V<sub>ccI</sub> is the V<sub>CC</sub> associated with the input port.
- F. V<sub>ccO</sub> is the V<sub>CC</sub> associated with the output port.
- G. All parameters and waveforms are not applicable to all devices.

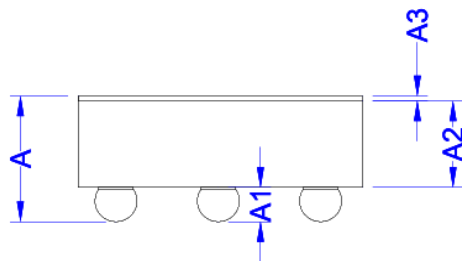
Figure 3 Load Circuits and Voltage Waveforms

### PACKAGE OUTLINE DIMENSIONS FO-12L



TOP VIEW

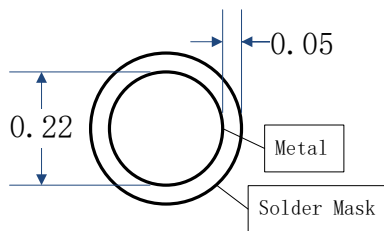
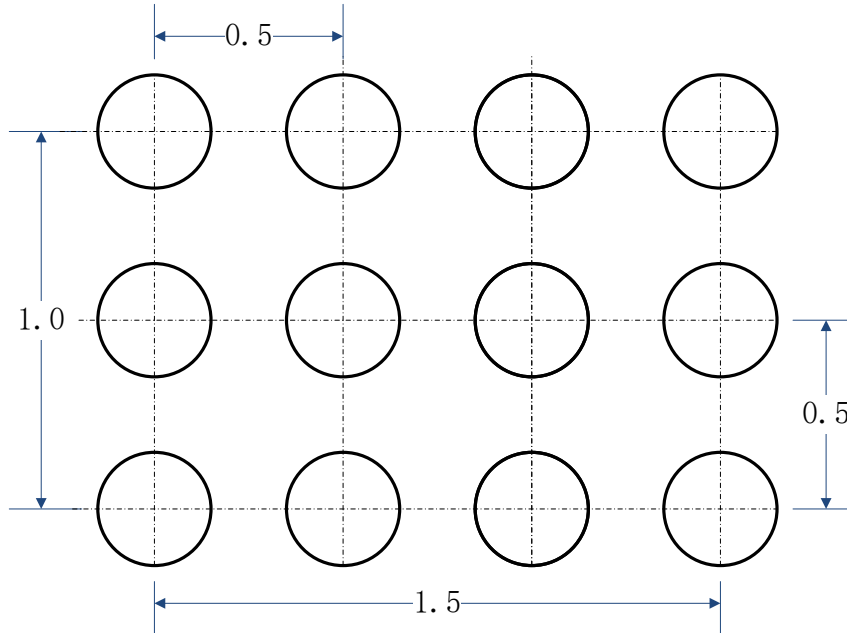
BOTTOM VIEW



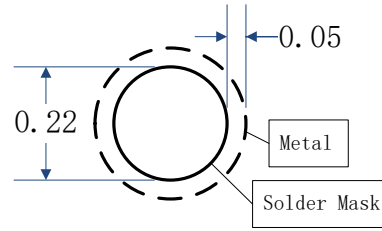
SIDE VIEW

Symbol	Min(mm)	Typ(mm)	Max(mm)
A	0.582	0.625	0.668
A1	0.145	0.170	0.195
A2	0.417	0.430	0.443
A3	0.020	0.025	0.030
D	1.345	1.370	1.395
E	1.845	1.870	1.895
F	0.202	0.222	0.242
D1		1	
D2		0.5	
E1		1.5	
E2		0.5	

**RECOMMENDED PCB LAYOUT PATTERN:**



**NSMD PAD**



**SMD PAD**

**FO-12L**