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

General Description

The ETS0104 is a 4-bit bidirectional level translator in which the input and output ports are switched automatically without direction control. Each channel can be mixed and matched with different output types (open-drain or push-pull) and mixed data flows (transmit or receive) without intervention from the host. All of the I/O ports are designed to track two different power supply rails, V_{VCCA} and V_{VCCB} respectively. The VCCB pin accepts any supply voltage from 1.65V to 5.5V while the VCCA pin accepts any supply voltage from 1.08V to 3.6V such that V_{VCCA} is less than or equal to V_{VCCB}. This tracking allows for low-voltage bidirectional translation between any of the 1.2V, 1.8V, 2.5V, 3.3V, and 5V voltage nodes.

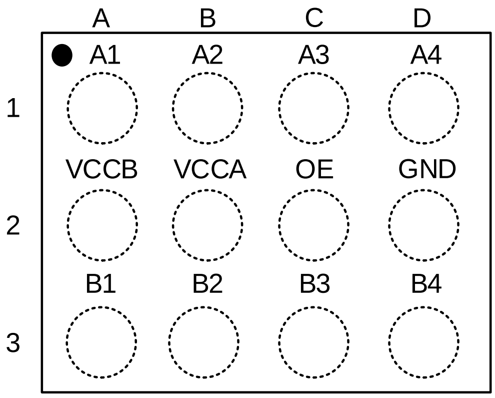
The ETS0104 has enable pin (OE), which can be used to disable both I/O ports by putting them in high-impedance state. The OE signal is referenced to the V_{VCCA} supply.

Features

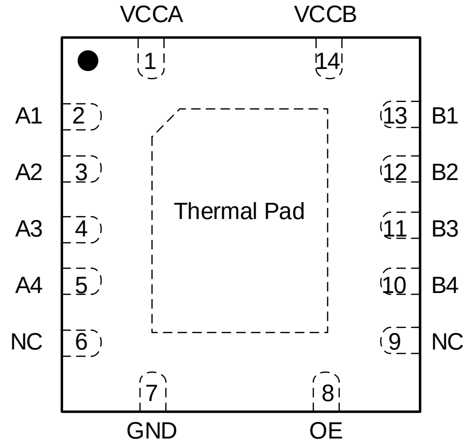
- No Direction-control Signal Required
- Maximum Data Rates:
  -- 60Mbps (Push Pull)
  -- 2Mbps (Open Drain)
- 1.08V to 3.6V on A Port and 1.65V to 5.5V on B Port ($V_{VCCA} \le V_{VCCB}$)
- No Power-supply Sequencing Required, V_{VCCA} or V_{VCCB} can be Ramped First
- I^3C compatible (12.5MHz Supported)
- Latch-up Performance Exceeds 100mA Per JEDEC JESD78F
- A Port ESD Protection:
  -- 2000V Human-Body Model (JEDEC JS-001)
  -- 1000V Charged-Device Model (JEDEC JS-002)
- B Port ESD Protection:
  -- 5000V Human-Body Model (JEDEC JS-001)
  -- 1000V Charged-Device Model (JEDEC JS-002)
- Part No. and Package Information

Part No.	Package	Packing Option	MSL
ETS0104	FOWLP12 (1.91mm × 1.41mm)	Tape and Reel, 3K/Reel	1
ETS0104Y	QFN14 (3.5mm × 3.5mm)	Tape and Reel, 3K/Reel	3
ETS0104Y2	QFN12 (2.0mm × 2.0mm)	Tape and Reel, 3K/Reel	1
ETS0104Y3	QFN12 (1.8mm × 1.8mm)	Tape and Reel, 3K/Reel	1
ETS0104V	TSSOP14 (5.0mm × 4.4mm)	Tape and Reel, 4K/Reel	3

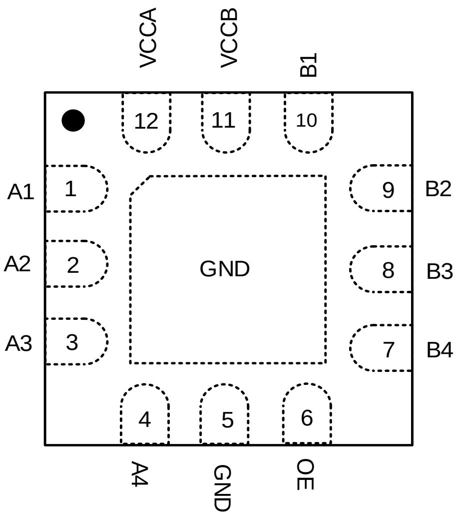
Pin Configuration



ETS0104



ETS0104Y



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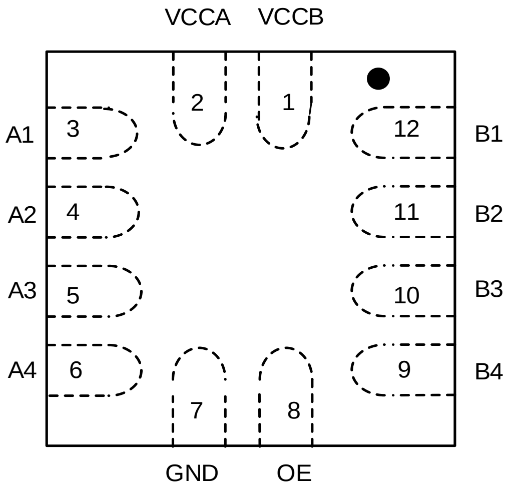

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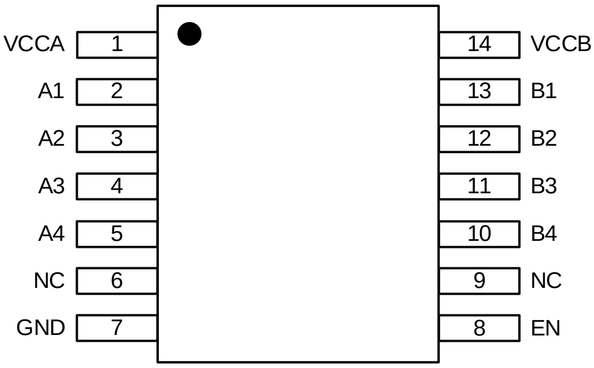


ETS0104V

TOP VIEW

Figure1. Pin Configuration

Pin Function

Pin No.				Pin Name	Description
FOWLP12	QFN12 (1.8 × 1.8)	TSSOP14/ QFN14	QFN12 (2 × 2)		
2A	1	14	11	VCCB	B-port Supply Voltage. $1.65V \le V_{VCCB} \le 5.5V$
2B	2	1	12	VCCA	A-port Supply Voltage. $1.08V \le V_{VCCA} \le 3.6V$ and $V_{VCCA} \le V_{VCCB}$.
1A~1D	3~6	2~5	1~4	A1, A2, A3, A4	Input / Output A1~A4. Referenced to V_{VCCA}.
2D	7	7	5	GND	Ground
2C	8	8	6	OE	3-state Output-mode Enable. Pull OE low to place all outputs in 3-state Mode. Referenced to V_{VCCA}.
3A~3D	9~12	10~13	7~10	B1, B2, B3, B4	Input / Output B1~B4. Referenced to V_{VCCB}.
\	\	6,9	\	NC	No Connect

Function Table

Control OE [1]	Outputs
Low Logic Level	3-State
High Logic Level	Normal Operation

Note1: If the OE pin is driven low, the ETS0104 is disabled and the A1~A4, B1~B4 pins (including dynamic drivers) are forced into 3-state.

Block Diagram

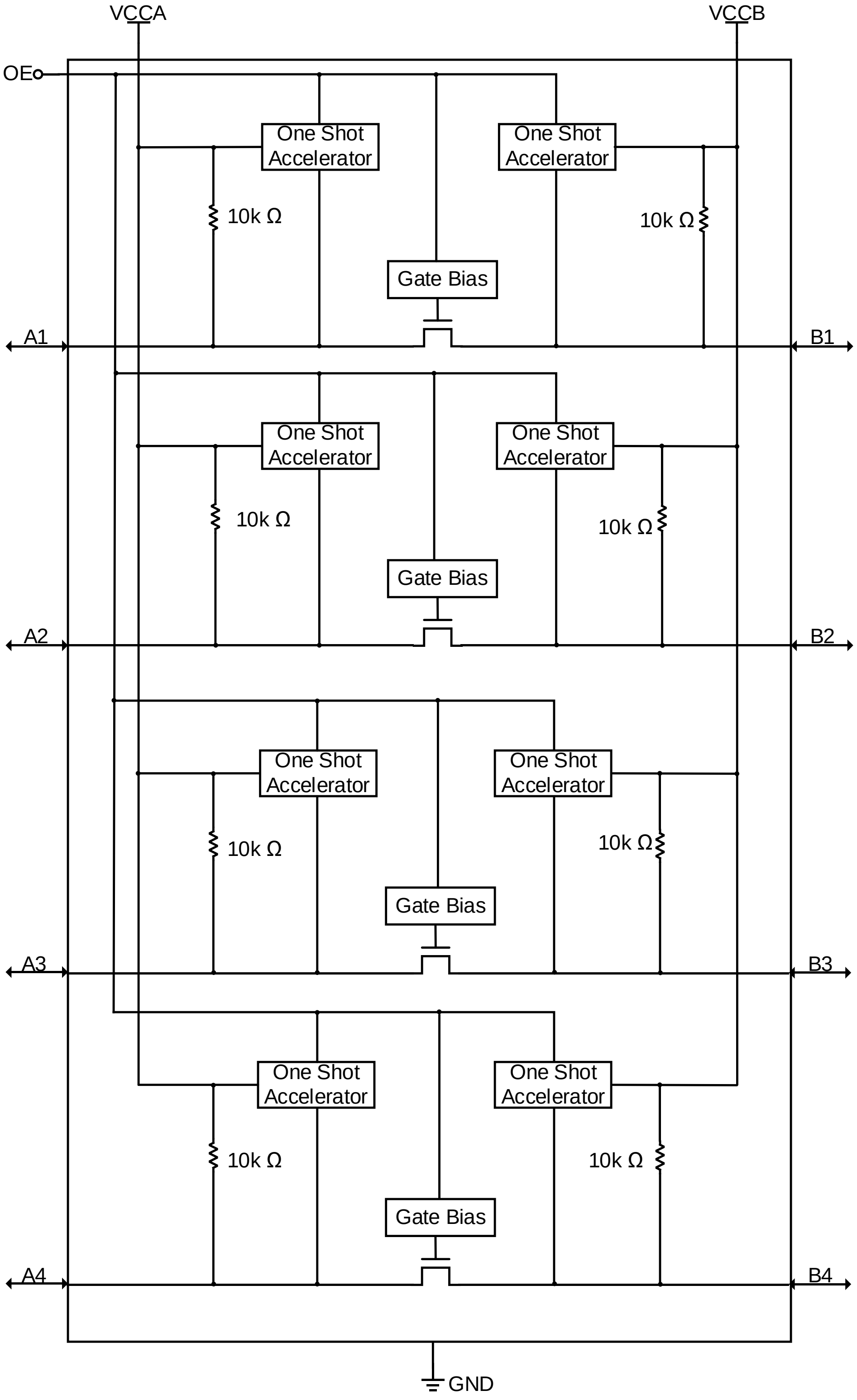


Figure2. Simplified Functional Diagram

Functional Description

Architecture

The ETS0104 architecture does not require a direction-control signal in order to control the direction of data flow from A to B or from B to A.

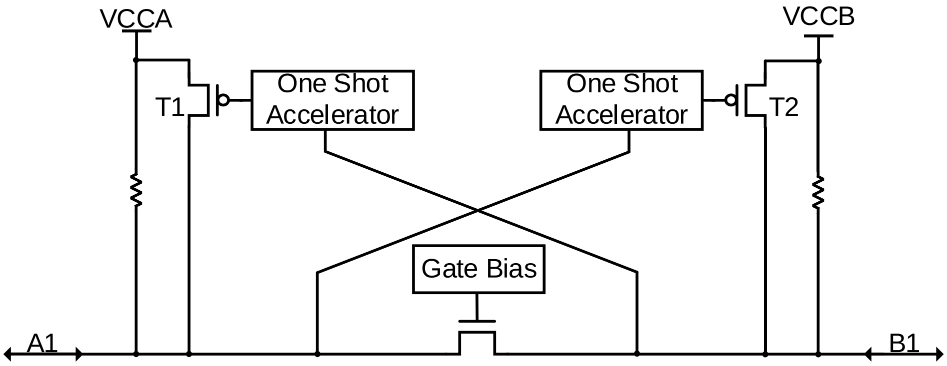


Figure3. Architecture of an ETS0104 Cell

Each A-port I/O has an internal 10kΩ pullup resistor to VCCA, and each B-port I/O has an internal 10kΩ pullup resistor to VCCB. The output one-shots detect rising edges on the A or B ports. During a rising edge, the one-shot turns on the PMOS transistors (T1, T2) for a short duration which speeds up the Low-to-High transition.

Input Driver Requirements

The fall time ($t_{FALL(A)}$, $t_{FALL(B)}$) of a signal depends on the output impedance of the external device driving the data I/Os of the ETS0104 device. Similarly, the t_{PHL} and maximum data rates also depend on the output impedance of the external driver. The values for $t_{FALL(A)}$, $t_{FALL(B)}$, t_{PHL}, and maximum data rates in the data sheet assume that the output impedance of the external driver is less than 50 Ω.

Power-Up / Power-Down Sequencing (1)

ETS0104 is a bi-directional level shift. So, translators offer an advantage in that either VCC may be powered up first. During operation, ensure that $V_{VCCA} \leq V_{VCCB}$ at all times. During power-up sequencing, $V_{VCCA} \geq V_{VCCB}$ does not damage the device, so any power supply can be ramped up first.

Note1: Alternatively, the OE pin can be hardwired to VCCA to save GPIO pins. If OE is hardwired to VCCA, either VCC can be powered up or down first.

Enable and Disable

The ETS0104 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.

Pull-Up and Pull-Down Resistors on I/O Lines

Each A-port I/O has an internal 10kΩ pullup resistor to VCCA, and each B-port I/O has an internal 10kΩ pullup resistor to VCCB. If a smaller value of pullup resistor is required, an external resistor must be added from the I/O to VCCA or VCCB (in parallel with the internal 10 kΩ resistors).

Application Circuits

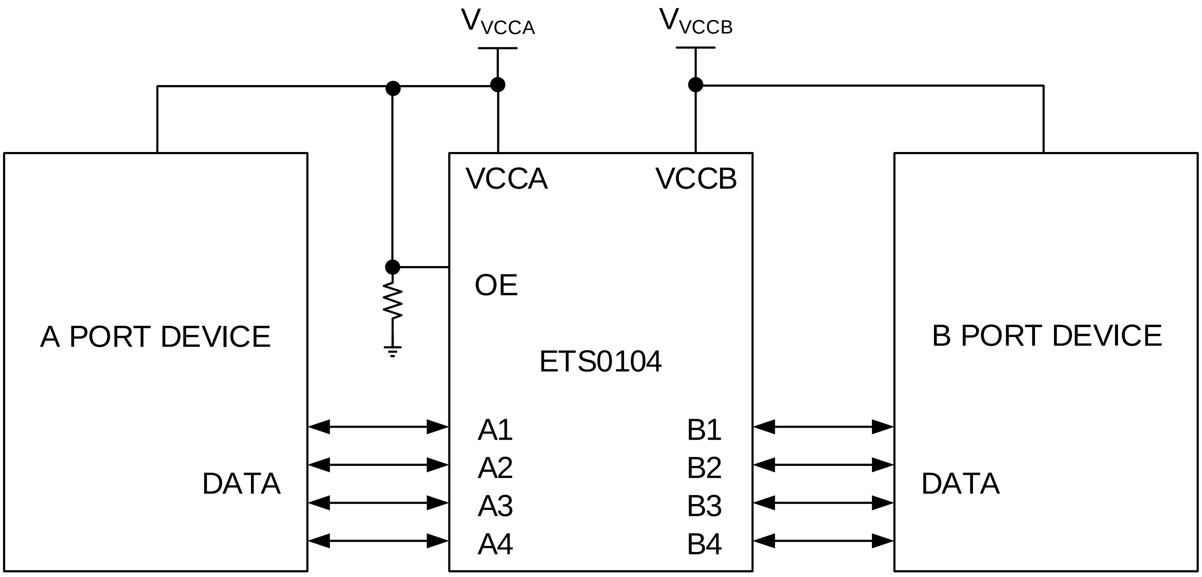


Figure4. Application Circuit [2]

Note2: This electric circuit only supplies for reference.

Application Information

The ETS0104 device can be used in level-translation applications for interfacing devices or systems operating at different interface voltages with one another. The ETS0104 device is optimal for use in applications where an open-drain driver is connected to the data I/Os. The ETS0104 device can also be used in applications where a push-pull driver is connected to the data I/Os.

Absolute Maximum Ratings

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

Symbol	Parameter		Min	Max	Unit
V_{VCCA}	Supply Voltage for VCCA, VCCB Pin		-0.5	4.6	V
V_{VCCB}			-0.5	6.5	V
V_{IN}	DC Input Voltage	A Port	-0.5	4.6	V
		B Port	-0.5	6.5	
		Control Input (OE)	-0.5	4.6	
V_O	Output Voltage	An Outputs 3-State	-0.5	4.6	V
		Bn Outputs 3-State	-0.5	6.5	
		An Outputs Active	-0.5	V_{VCCA} + 0.5	
		Bn Outputs Active	-0.5	V_{VCCB} + 0.5	
I_{IK}	DC Input Clamp Current	At V_{IN} < 0V		-50	mA
I_{OK}	DC Output Clamp Current	At V_O < 0V		-50	
I_O	Continuous Output Current, IO			±50	
I_{VCC}	Continuous Current Through each VCCA, VCCB, or GND			±100	
T_{STG}	Storage Temperature Range		-65	150	°C
V_{ESD}	Electrostatic Discharge Capability	Human Body Model, B Port [(3)]		±5	kV
		Human Body Model, A Port [(3)]		±2	
		Charged Device Mode [(4)]		±1	
I_{LU}	Latch Up Current Maximum Rating [(5)]			100	mA

Note3: HBM tested per JEDEC JS-001;

Note4: CDM tested per JEDEC JS-002;

Note5: Latch Up Current Maximum Rating tested per JEDEC JESD78F;

Recommended Operating Conditions

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

Symbol	Parameter		Min	Max	Unit
V_{VCCA}	Operating Power Supply		1.08	3.6	V
V_{VCCB}			1.65	5.5	
V_{IN}	Input Voltage [6]	A-Port	0	3.6	V
		B-Port	0	5.5	
		Control Input (OE)	0	V_{VCCA}	
T_A	Free Air Operating Temperature		-40	85	°C

Note6: All unused inputs and I/O pins must be held at V_{VCCI} or GND. V_{VCCI} is the V_{CC} associated with the input side.

DC Electrical Characteristics [7]

T_A = -40ºC~85ºC, (unless otherwise noted, all typical values are at T_A = 25°C.)

Symbol	Parameter	Conditions	V_{VCCA}(V)	V_{VCCB}(V)	Min	Typ	Max	Unit
V_{IHA}	High Level Input Voltage, A		1.08~1.95	1.65~5.5	V_{VCCA} - 0.1			V
			1.95~3.6		V_{VCCA} - 0.4			V
V_{IHB}	High Level Input Voltage, B		1.08~3.6	1.65~5.5	V_{VCCB} - 0.4			V
$V_{IH(OE)}$	High Level Input Voltage, OE		1.08~3.6	1.65~5.5	V_{VCCA} * 0.65			V
V_{ILA}	Low Level Input Voltage, A		1.08~3.6	1.65~5.5			0.15	V
V_{ILB}	Low Level Input Voltage, B		1.08~3.6	1.65~5.5			0.15	V
$V_{IL(OE)}$	Low Level Input Voltage, OE		1.08~3.6	1.65~5.5			V_{VCCA} * 0.3	V
V_{OHA}	High Level Output Voltage, A	I_{OH} = -20uA, $V_{I(Bx)} \geq V_{VCCB}$ - 0.4V	1.08~3.6	1.65~5.5	V_{VCCA} * 0.75			V
V_{OHB}	High Level Output Voltage, B	I_{OH} = -20uA, $V_{I(Ax)} \geq V_{VCCA}$ - 0.2V	1.08~3.6	1.65~5.5	V_{VCCB} * 0.75			V
V_{OLA}	Low Level Output Voltage, A	I_{OL} = 1mA, $V_{I(Bx)} \leq 0.15V$	1.08~3.6	1.65~5.5			0.4	V
V_{OLB}	Low Level Output Voltage, B	I_{OL} = 1mA, $V_{I(Ax)} \leq 0.15V$	1.08~3.6	1.65~5.5			0.4	V

DC Electrical Characteristics (Continued) [(7)]

T_A = -40ºC~85ºC, (unless otherwise noted, all typical values are at T_A = 25°C.)

Symbol	Parameter	Conditions	V_{VCCA}(V)	V_{VCCB}(V)	Min	Typ	Max	Unit
$I_{I(OE)}$	Input Leakage Current, OE	OE = V_{IL}	1.08~3.6	1.65~5.5		±1.0	±2.0	uA
I_{OZ}	Off-state Output Current, A or B Port	OE = V_{IL}	1.08~3.6	1.65~5.5		±1.0	±3.0	uA
$I_{VCCA/B}$	Quiescent Supply Current, A port Plus B Port Supply Current	V_I = V_O = Floating, I_O = 0mA	1.08~ V_{VCCB}	1.65~5.5			25	uA
I_{CCA}	Quiescent Supply Current, A Port	V_I = V_O = Floating, I_O = 0mA	1.08~ V_{VCCB}	1.65~5.5			5	uA
			3.6	0			2.2	
			0	5.5			-1	
I_{CCB}	Quiescent Supply Current	V_I = V_O = Floating, I_O = 0mA	1.08~ V_{VCCB}	1.65~5.5			21	uA
			3.6	0			-2.0	
			0	5.5			5	
C_{IN}	Input Capacitance Control Pin (OE)	V_{VCCA} = V_{VCCB} = GND	3.3	3.3		2.5	4	pF
$C_{I/O(An)}$	Input / Output Capacitance, An		3.3	3.3		5	8	pF
$C_{I/O(Bn)}$	Input / Output Capacitance, Bn		3.3	3.3		6	10	pF

Note7: V_{VCCA} must be less than or equal to V_{VCCB}, and V_{VCCA} must not exceed 3.6V.

Dynamic Output Electrical Characteristics

Output Rise/Fall Time, V_{VCCA} = 1.2V ± 0.12V[8]

C_L = 15pF, R_L = 1MΩ, and T_A = -40°C to 85°C.

Symbol	Parameter	Test Condition		Min	Typ	Max	Unit
$t_{RISE(A)}$	Output Rise Time: A Port	Push-pull	V_{VCCB} = 1.8V ± 0.15V		11.4		ns
			V_{VCCB} = 3.3V ± 0.3V		8.4		
			V_{VCCB} = 5.0V ± 0.5V		7		
		Open-drain	V_{VCCB} = 1.8V ± 0.15V		36.6		
			V_{VCCB} = 3.3V ± 0.3V		21.8		
			V_{VCCB} = 5.0V ± 0.5V		16		
$t_{RISE(B)}$	Output Rise Time: B Port	Push-pull	V_{VCCB} = 1.8V ± 0.15V		14.8		ns
			V_{VCCB} = 3.3V ± 0.3V		11		
			V_{VCCB} = 5.0V ± 0.5V		9.4		
		Open-drain	V_{VCCB} = 1.8V ± 0.15V		47.2		
			V_{VCCB} = 3.3V ± 0.3V		35.2		
			V_{VCCB} = 5.0V ± 0.5V		23		
$t_{FALL(A)}$	Output Fall Time: A Port	Push-pull	V_{VCCB} = 1.8V ± 0.15V		9.6		ns
			V_{VCCB} = 3.3V ± 0.3V		9.8		
			V_{VCCB} = 5.0V ± 0.5V		10		
		Open-drain	V_{VCCB} = 1.8V ± 0.15V		7.6		
			V_{VCCB} = 3.3V ± 0.3V		6.4		
			V_{VCCB} = 5.0V ± 0.5V		6.8		
$t_{FALL(B)}$	Output Fall Time: B Port	Push-pull	V_{VCCB} = 1.8V ± 0.15V		10.4		ns
			V_{VCCB} = 3.3V ± 0.3V		14		
			V_{VCCB} = 5.0V ± 0.5V		18		
		Open-drain	V_{VCCB} = 1.8V ± 0.15V		24		
			V_{VCCB} = 3.3V ± 0.3V		34.6		
			V_{VCCB} = 5.0V ± 0.5V		45		

Output Rise/Fall Time, V_{VCCA} = 1.8V ± 0.15V(8)

C_L = 15pF, R_L = 1MΩ, and T_A = -40°C to 85°C.

Symbol	Parameter	Test Condition		Min	Typ	Max	Unit
$t_{RISE(A)}$	Output Rise Time: A Port	Push-pull	V_{VCCB} = 2.5V ± 0.2V		6.2		ns
			V_{VCCB} = 3.3V ± 0.3V		5.3		
			V_{VCCB} = 5.0V ± 0.5V		4.5		
		Open-drain	V_{VCCB} = 2.5V ± 0.2V		24.2		
			V_{VCCB} = 3.3V ± 0.3V		18.8		
			V_{VCCB} = 5.0V ± 0.5V		13.4		
$t_{RISE(B)}$	Output Rise Time: B Port	Push-pull	V_{VCCB} = 2.5V ± 0.2V		9.2		ns
			V_{VCCB} = 3.3V ± 0.3V		7.5		
			V_{VCCB} = 5.0V ± 0.5V		6		
		Open-drain	V_{VCCB} = 2.5V ± 0.2V		30.1		
			V_{VCCB} = 3.3V ± 0.3V		26.8		
			V_{VCCB} = 5.0V ± 0.5V		18.5		
$t_{FALL(A)}$	Output Fall Time: A Port	Push-pull	V_{VCCB} = 2.5V ± 0.2V		8.8		ns
			V_{VCCB} = 3.3V ± 0.3V		8.9		
			V_{VCCB} = 5.0V ± 0.5V		9.1		
		Open-drain	V_{VCCB} = 2.5V ± 0.2V		5.8		
			V_{VCCB} = 3.3V ± 0.3V		5.5		
			V_{VCCB} = 5.0V ± 0.5V		5.5		
$t_{FALL(B)}$	Output Fall Time: B Port	Push-pull	V_{VCCB} = 2.5V ± 0.2V		9.2		ns
			V_{VCCB} = 3.3V ± 0.3V		10.3		
			V_{VCCB} = 5.0V ± 0.5V		12		
		Open-drain	V_{VCCB} = 2.5V ± 0.2V		7.2		
			V_{VCCB} = 3.3V ± 0.3V		8.1		
			V_{VCCB} = 5.0V ± 0.5V		9.4		

Output Rise/Fall Time V_{VCCA} = 2.5V ± 0.2V[8]

C_L = 15pF, R_L = 1MΩ, and T_A = -40°C to 85°C.

Symbol	Parameter	Test Condition		Min	Typ	Max	Unit
$t_{RISE(A)}$	Output Rise Time: A Port	Push-pull	V_{VCCB} = 2.5V ± 0.2V		5.6		ns
			V_{VCCB} = 3.3V ± 0.3V		4.6		
			V_{VCCB} = 5.0V ± 0.5V		3.8		
		Open-drain	V_{VCCB} = 2.5V ± 0.2V		26.8		
			V_{VCCB} = 3.3V ± 0.3V		20		
			V_{VCCB} = 5.0V ± 0.5V		13.8		
$t_{RISE(B)}$	Output Rise Time: B Port	Push-pull	V_{VCCB} = 2.5V ± 0.2V		7.1		ns
			V_{VCCB} = 3.3V ± 0.3V		6.4		
			V_{VCCB} = 5.0V ± 0.5V		5.2		
		Open-drain	V_{VCCB} = 2.5V ± 0.2V		27		
			V_{VCCB} = 3.3V ± 0.3V		24.5		
			V_{VCCB} = 5.0V ± 0.5V		18.3		
$t_{FALL(A)}$	Output Fall Time: A Port	Push-pull	V_{VCCB} = 2.5V ± 0.2V		8.6		ns
			V_{VCCB} = 3.3V ± 0.3V		8.5		
			V_{VCCB} = 5.0V ± 0.5V		8.6		
		Open-drain	V_{VCCB} = 2.5V ± 0.2V		5.6		
			V_{VCCB} = 3.3V ± 0.3V		5.4		
			V_{VCCB} = 5.0V ± 0.5V		5		
$t_{FALL(B)}$	Output Fall Time: B Port	Push-pull	V_{VCCB} = 2.5V ± 0.2V		8.6		ns
			V_{VCCB} = 3.3V ± 0.3V		9		
			V_{VCCB} = 5.0V ± 0.5V		9.5		
		Open-drain	V_{VCCB} = 2.5V ± 0.2V		5.6		
			V_{VCCB} = 3.3V ± 0.3V		6		
			V_{VCCB} = 5.0V ± 0.5V		6.1		

Output Rise/Fall Time V_{VCCA} = 3.3V ± 0.3V[8]

C_L = 15pF, R_L = 1MΩ, and T_A = -40°C to 85°C.

Symbol	Parameter	Test Condition		Min	Typ	Max	Unit
$t_{RISE(A)}$	Output Rise Time: A Port	Push-pull	V_{VCCB} = 3.3V ± 0.3V		4.4		ns
			V_{VCCB} = 5.0V ± 0.5V		3.6		
		Open-drain	V_{VCCB} = 3.3V ± 0.3V		21.8		
			V_{VCCB} = 5.0V ± 0.5V		15.6		
$t_{RISE(B)}$	Output Rise Time: B Port	Push-pull	V_{VCCB} = 3.3V ± 0.3V		5.6		ns
			V_{VCCB} = 5.0V ± 0.5V		4.8		
		Open-drain	V_{VCCB} = 3.3V ± 0.3V		23.4		
			V_{VCCB} = 5.0V ± 0.5V		18.6		
$t_{FALL(A)}$	Output Fall Time: A Port	Push-pull	V_{VCCB} = 3.3V ± 0.3V		8.8		ns
			V_{VCCB} = 5.0V ± 0.5V		8.8		
		Open-drain	V_{VCCB} = 3.3V ± 0.3V		5.2		
			V_{VCCB} = 5.0V ± 0.5V		5		
$t_{FALL(B)}$	Output Fall Time: B Port	Push-pull	V_{VCCB} = 3.3V ± 0.3V		8.8		ns
			V_{VCCB} = 5.0V ± 0.5V		8.4		
		Open-drain	V_{VCCB} = 3.3V ± 0.3V		5.2		
			V_{VCCB} = 5.0V ± 0.5V		5		

Notes8: Output rise and fall times guaranteed by design simulation and characterization; not production tested.

Maximum Data Rate [9]

C_L = 15pF, R_L = 1MΩ, and T_A = -40°C to 85°C.

V_{VCCA}	Condition	V_{VCCB}				Unit
		1.8V ± 0.15V	2.5V ± 0.2V	3.3V ± 0.3V	5V ± 0.5V	
1.2V ± 0.12V	Push-Pull	24	24	24	24	Mbps
	Open-Drain	2	2	2	2	
1.8V ± 0.15V	Push-Pull	52	52	56	60	Mbps
	Open-Drain	2	2	2	2	
2.5V ± 0.2V	Push-Pull	-	52	56	60	Mbps
	Open-Drain	-	2	2	2	
3.3V ± 0.3V	Push-Pull	-	-	56	60	Mbps
	Open-Drain	-	-	2	2	

AC Characteristics -- V_{VCCA} = 1.2V ± 0.12V[10]

C_L = 15pF, R_L = 1MΩ, and T_A = -40°C to 85°C.

Symbol	Parameter	Test Condition		Min	Typ	Max	Unit
$t_{PHL(A-B)}$	Propagation Delay Time (High to Low), from A (Input) to B (Output)	Push-pull	V_{VCCB} = 1.8V ± 0.15V		4.6		ns
			V_{VCCB} = 3.3V ± 0.3V		7.5		
			V_{VCCB} = 5.0V ± 0.5V		10.2		
		Open-drain	V_{VCCB} = 1.8V ± 0.15V		52.4		
			V_{VCCB} = 3.3V ± 0.3V		59.5		
			V_{VCCB} = 5.0V ± 0.5V		66.8		
$t_{PHL(B-A)}$	Propagation Delay Time (High to Low), from B (Input) to A (Output)	Push-pull	V_{VCCB} = 1.8V ± 0.15V		4		ns
			V_{VCCB} = 3.3V ± 0.3V		4		
			V_{VCCB} = 5.0V ± 0.5V		4.2		
		Open-drain	V_{VCCB} = 1.8V ± 0.15V		15		
			V_{VCCB} = 3.3V ± 0.3V		7.4		
			V_{VCCB} = 5.0V ± 0.5V		6		
$t_{PLH(A-B)}$	Propagation Delay Time (Low to High), from A (Input) to B (Output)	Push-pull	V_{VCCB} = 1.8V ± 0.15V		9.4		ns
			V_{VCCB} = 3.3V ± 0.3V		8.8		
			V_{VCCB} = 5.0V ± 0.5V		8.8		
		Open-drain	V_{VCCB} = 1.8V ± 0.15V		80.4		
			V_{VCCB} = 3.3V ± 0.3V		75		
			V_{VCCB} = 5.0V ± 0.5V		70.6		
$t_{PLH(B-A)}$	Propagation Delay Time (Low to High), from B (Input) to A (Output)	Push-pull	V_{VCCB} = 1.8V ± 0.15V		2.4		ns
			V_{VCCB} = 3.3V ± 0.3V		1		
			V_{VCCB} = 5.0V ± 0.5V		0.4		
		Open-drain	V_{VCCB} = 1.8V ± 0.15V		29.2		
			V_{VCCB} = 3.3V ± 0.3V		14.2		
			V_{VCCB} = 5.0V ± 0.5V		9.6		
$t_{en(OE-A)}$ $t_{en(OE-B)}$	Enable Time, from OE (Input) to A or B (Output)	V_{VCCB} = 1.8V ± 0.15V				270	ns
		V_{VCCB} = 3.3V ± 0.3V				260	
		V_{VCCB} = 5.0V ± 0.5V				250	
$t_{dis(OE-A)}$ $t_{dis(OE-B)}$	Disable Time, from OE (Input) to A or B (Output)	V_{VCCB} = 1.8V ± 0.15V				250	ns
		V_{VCCB} = 3.3V ± 0.3V				250	
		V_{VCCB} = 5.0V ± 0.5V				250	
t_{sk}	Channel-to-channel Skew[11]	V_{VCCB} = 1.8V ± 0.15V				1	ns
		V_{VCCB} = 3.3V ± 0.3V				1	
		V_{VCCB} = 5.0V ± 0.5V				1	

AC Characteristics -- V_{VCCA} = 1.8V ± 0.15V[10]

C_L = 15pF, R_L = 1MΩ, and T_A = -40°C to 85°C.

Symbol	Parameter	Test Condition		Min	Typ	Max	Unit
$t_{PHL(A-B)}$	Propagation Delay Time (High to Low), from A (Input) to B (Output)	Push-pull	V_{VCCB} = 2.5V ± 0.2V		3.5		ns
			V_{VCCB} = 3.3V ± 0.3V		4.2		
			V_{VCCB} = 5.0V ± 0.5V		6		
		Open-drain	V_{VCCB} = 2.5V ± 0.2V		15.8		
			V_{VCCB} = 3.3V ± 0.3V		15.4		
			V_{VCCB} = 5.0V ± 0.5V		17		
$t_{PHL(B-A)}$	Propagation Delay Time (High to Low), from B (Input) to A (Output)	Push-pull	V_{VCCB} = 2.5V ± 0.2V		3.4		ns
			V_{VCCB} = 3.3V ± 0.3V		3.5		
			V_{VCCB} = 5.0V ± 0.5V		3.6		
		Open-drain	V_{VCCB} = 2.5V ± 0.2V		8.8		
			V_{VCCB} = 3.3V ± 0.3V		6.8		
			V_{VCCB} = 5.0V ± 0.5V		5.4		
$t_{PLH(A-B)}$	Propagation Delay Time (Low to High), from A (Input) to B (Output)	Push-pull	V_{VCCB} = 2.5V ± 0.2V		4.8		ns
			V_{VCCB} = 3.3V ± 0.3V		4.7		
			V_{VCCB} = 5.0V ± 0.5V		4.6		
		Open-drain	V_{VCCB} = 2.5V ± 0.2V		42		
			V_{VCCB} = 3.3V ± 0.3V		41		
			V_{VCCB} = 5.0V ± 0.5V		38		
$t_{PLH(B-A)}$	Propagation Delay Time (Low to High), from B (Input) to A (Output)	Push-pull	V_{VCCB} = 2.5V ± 0.2V		1.5		ns
			V_{VCCB} = 3.3V ± 0.3V		1		
			V_{VCCB} = 5.0V ± 0.5V		0.5		
		Open-drain	V_{VCCB} = 2.5V ± 0.2V		26.7		
			V_{VCCB} = 3.3V ± 0.3V		19.5		
			V_{VCCB} = 5.0V ± 0.5V		12.8		
$t_{en(OE-A)}$ $t_{en(OE-B)}$	Enable Time, from OE (Input) to A or B (Output)	V_{VCCB} = 2.5V ± 0.2V				240	ns
		V_{VCCB} = 3.3V ± 0.3V				220	
		V_{VCCB} = 5.0V ± 0.5V				200	
$t_{dis(OE-A)}$ $t_{dis(OE-B)}$	Disable Time, from OE (Input) to A or B (Output)	V_{VCCB} = 2.5V ± 0.2V				210	ns
		V_{VCCB} = 3.3V ± 0.3V				250	
		V_{VCCB} = 5.0V ± 0.5V				260	
t_{sk}	Channel-to-channel Skew[11]	V_{VCCB} = 2.5V ± 0.2V				1	ns
		V_{VCCB} = 3.3V ± 0.3V				1	
		V_{VCCB} = 5.0V ± 0.5V				1	

AC Characteristics -- V_{VCCA} = 2.5V ± 0.2V[(10)]

C_L = 15pF, R_L = 1MΩ, and T_A = -40°C to 85°C.

Symbol	Parameter	Test Condition		Min	Typ	Max	Unit
$t_{PHL(A-B)}$	Propagation Delay Time (High to Low), from A (Input) to B (Output)	Push-pull	V_{VCCB} = 2.5V ± 0.2V		3		ns
$t_{PHL(A-B)}$	Propagation Delay Time (High to Low), from A (Input) to B (Output)	Push-pull	V_{VCCB} = 3.3V ± 0.3V		2.8		ns
$t_{PHL(A-B)}$	Propagation Delay Time (High to Low), from A (Input) to B (Output)	Push-pull	V_{VCCB} = 5.0V ± 0.5V		4		ns
$t_{PHL(A-B)}$	Propagation Delay Time (High to Low), from A (Input) to B (Output)	Open-drain	V_{VCCB} = 2.5V ± 0.2V		8.5		ns
$t_{PHL(A-B)}$	Propagation Delay Time (High to Low), from A (Input) to B (Output)	Open-drain	V_{VCCB} = 3.3V ± 0.3V		8.6		ns
$t_{PHL(A-B)}$	Propagation Delay Time (High to Low), from A (Input) to B (Output)	Open-drain	V_{VCCB} = 5.0V ± 0.5V		9.5		ns
$t_{PHL(B-A)}$	Propagation Delay Time (High to Low), from B (Input) to A (Output)	Push-pull	V_{VCCB} = 2.5V ± 0.2V		3		ns
$t_{PHL(B-A)}$	Propagation Delay Time (High to Low), from B (Input) to A (Output)	Push-pull	V_{VCCB} = 3.3V ± 0.3V		3		ns
$t_{PHL(B-A)}$	Propagation Delay Time (High to Low), from B (Input) to A (Output)	Push-pull	V_{VCCB} = 5.0V ± 0.5V		3.2		ns
$t_{PHL(B-A)}$	Propagation Delay Time (High to Low), from B (Input) to A (Output)	Open-drain	V_{VCCB} = 2.5V ± 0.2V		8.6		ns
$t_{PHL(B-A)}$	Propagation Delay Time (High to Low), from B (Input) to A (Output)	Open-drain	V_{VCCB} = 3.3V ± 0.3V		6.4		ns
$t_{PHL(B-A)}$	Propagation Delay Time (High to Low), from B (Input) to A (Output)	Open-drain	V_{VCCB} = 5.0V ± 0.5V		5.2		ns
$t_{PLH(A-B)}$	Propagation Delay Time (Low to High), from A (Input) to B (Output)	Push-pull	V_{VCCB} = 2.5V ± 0.2V		2.5		ns
$t_{PLH(A-B)}$	Propagation Delay Time (Low to High), from A (Input) to B (Output)	Push-pull	V_{VCCB} = 3.3V ± 0.3V		3.2		ns
$t_{PLH(A-B)}$	Propagation Delay Time (Low to High), from A (Input) to B (Output)	Push-pull	V_{VCCB} = 5.0V ± 0.5V		3.4		ns
$t_{PLH(A-B)}$	Propagation Delay Time (Low to High), from A (Input) to B (Output)	Open-drain	V_{VCCB} = 2.5V ± 0.2V		34		ns
$t_{PLH(A-B)}$	Propagation Delay Time (Low to High), from A (Input) to B (Output)	Open-drain	V_{VCCB} = 3.3V ± 0.3V		32.9		ns
$t_{PLH(A-B)}$	Propagation Delay Time (Low to High), from A (Input) to B (Output)	Open-drain	V_{VCCB} = 5.0V ± 0.5V		31		ns
$t_{PLH(B-A)}$	Propagation Delay Time (Low to High), from B (Input) to A (Output)	Push-pull	V_{VCCB} = 2.5V ± 0.2V		2.4		ns
$t_{PLH(B-A)}$	Propagation Delay Time (Low to High), from B (Input) to A (Output)	Push-pull	V_{VCCB} = 3.3V ± 0.3V		1.2		ns
$t_{PLH(B-A)}$	Propagation Delay Time (Low to High), from B (Input) to A (Output)	Push-pull	V_{VCCB} = 5.0V ± 0.5V		0.6		ns
$t_{PLH(B-A)}$	Propagation Delay Time (Low to High), from B (Input) to A (Output)	Open-drain	V_{VCCB} = 2.5V ± 0.2V		35.2		ns
$t_{PLH(B-A)}$	Propagation Delay Time (Low to High), from B (Input) to A (Output)	Open-drain	V_{VCCB} = 3.3V ± 0.3V		26		ns
$t_{PLH(B-A)}$	Propagation Delay Time (Low to High), from B (Input) to A (Output)	Open-drain	V_{VCCB} = 5.0V ± 0.5V		16.8		ns
$t_{en(OE-A)}$ $t_{en(OE-B)}$	Enable Time, from OE (Input) to A or B (Output)	V_{VCCB} = 2.5V ± 0.2V				120	ns
$t_{en(OE-A)}$ $t_{en(OE-B)}$	Enable Time, from OE (Input) to A or B (Output)	V_{VCCB} = 3.3V ± 0.3V				160	ns
$t_{en(OE-A)}$ $t_{en(OE-B)}$	Enable Time, from OE (Input) to A or B (Output)	V_{VCCB} = 5.0V ± 0.5V				160	ns
$t_{dis(OE-A)}$ $t_{dis(OE-B)}$	Disable Time, from OE (Input) to A or B (Output)	V_{VCCB} = 2.5V ± 0.2V				200	ns
$t_{dis(OE-A)}$ $t_{dis(OE-B)}$	Disable Time, from OE (Input) to A or B (Output)	V_{VCCB} = 3.3V ± 0.3V				240	ns
$t_{dis(OE-A)}$ $t_{dis(OE-B)}$	Disable Time, from OE (Input) to A or B (Output)	V_{VCCB} = 5.0V ± 0.5V				250	ns
t_{sk}	Channel-to-channel Skew[(11)]	V_{VCCB} = 2.5V ± 0.2V				1	ns
t_{sk}	Channel-to-channel Skew[(11)]	V_{VCCB} = 3.3V ± 0.3V				1	ns
t_{sk}	Channel-to-channel Skew[(11)]	V_{VCCB} = 5.0V ± 0.5V				1	ns

AC Characteristics -- V_{VCCA} = 3.3V ± 0.3V[10]

C_L = 15pF, R_L = 1MΩ, and T_A = -40°C to 85°C.

Symbol	Parameter	Test Condition		Min	Typ	Max	Unit
$t_{PHL(A-B)}$	Propagation Delay Time (High to Low), from A (Input) to B (Output)	Push-pull	V_{VCCB} = 3.3V ± 0.3V		2.4		ns
			V_{VCCB} = 5.0V ± 0.5V		2.6		
		Open-drain	V_{VCCB} = 3.3V ± 0.3V		6.4		
			V_{VCCB} = 5.0V ± 0.5V		6.6		
$t_{PHL(B-A)}$	Propagation Delay Time (High to Low), from B (Input) to A (Output)	Push-pull	V_{VCCB} = 3.3V ± 0.3V		2.4		ns
			V_{VCCB} = 5.0V ± 0.5V		6.4		
		Open-drain	V_{VCCB} = 3.3V ± 0.3V		3		
			V_{VCCB} = 5.0V ± 0.5V		3		
$t_{PLH(A-B)}$	Propagation Delay Time (Low to High), from A (Input) to B (Output)	Push-pull	V_{VCCB} = 3.3V ± 0.3V		2		ns
			V_{VCCB} = 5.0V ± 0.5V		2.6		
		Open-drain	V_{VCCB} = 3.3V ± 0.3V		30		
			V_{VCCB} = 5.0V ± 0.5V		28		
$t_{PLH(B-A)}$	Propagation Delay Time (Low to High), from B (Input) to A (Output)	Push-pull	V_{VCCB} = 3.3V ± 0.3V		1.8		ns
			V_{VCCB} = 5.0V ± 0.5V		0.8		
		Open-drain	V_{VCCB} = 3.3V ± 0.3V		29		
			V_{VCCB} = 5.0V ± 0.5V		20		
$t_{en(OE-A)}$ $t_{en(OE-B)}$	Enable Time, from OE (Input) to A or B (Output)	V_{VCCB} = 3.3V ± 0.3V				120	ns
		V_{VCCB} = 5.0V ± 0.5V				240	
$t_{dis(OE-A)}$ $t_{dis(OE-B)}$	Disable Time, from OE (Input) to A or B (Output)	V_{VCCB} = 3.3V ± 0.3V				120	ns
		V_{VCCB} = 5.0V ± 0.5V				240	
t_{sk}	Channel-to-channel Skew[11]	V_{VCCB} = 3.3V ± 0.3V				1	ns
		V_{VCCB} = 5.0V ± 0.5V				1	

Note9/10: AC characteristics are guaranteed by design and characterization.

Note11: Skew is the variation of propagation delay between output signals and applies only to output signals on the same port (An or Bn) and switching with the same polarity (Low to High or High to Low). Skew is guaranteed; not production tested.

AC Test Reference Circuit

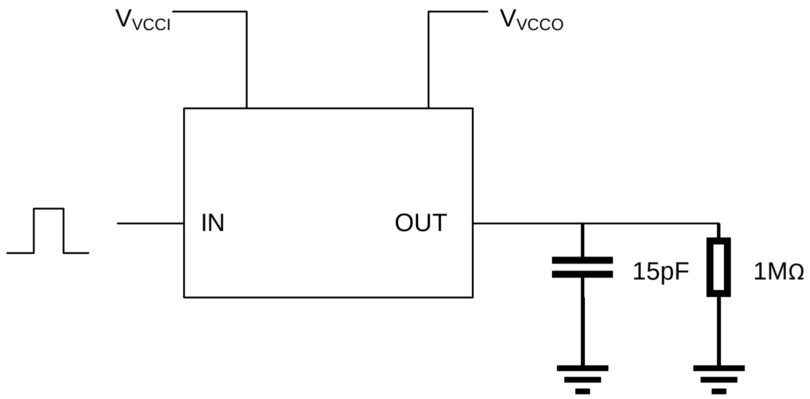


Figure5. AC Test Circuit, Data Rate, Pulse Duration, Propagation Delay, Output Rise-Time and Fall-Time Measurement Using a Push-Pull Drive

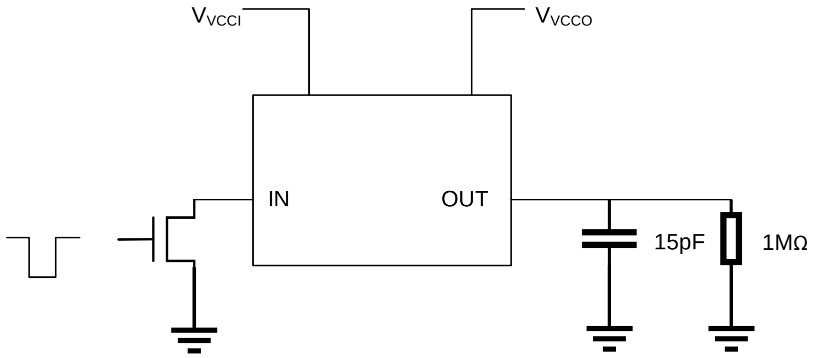
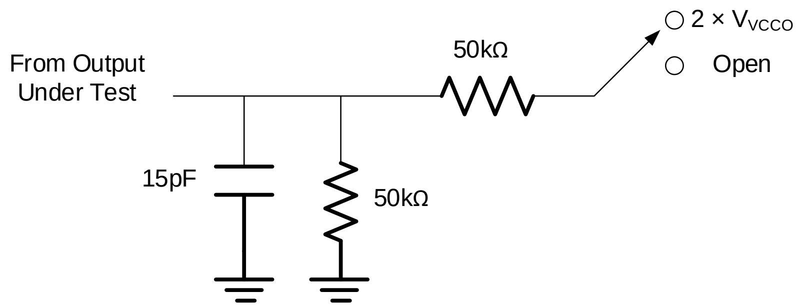


Figure6. AC Test Circuit, Data Rate, Pulse Duration, Propagation Delay, Output Rise-Time and Fall-Time Measurement Using an Open-Drain Driver
(Adding a 1kΩ pull-up resistor to the open-drain driver can enhance the driving capability.)



Test	Switch
t_{PZH}, t_{PHZ}	open
t_{PZL}, t_{PLZ}	$2 \times V_{VCCO}$

Figure7. AC Test Circuit, Load Circuit for Enable-Time and Disable-Time Measurement

AC Test Reference Conditions

Propagation Delay Test Conditions

Test	Input Signal	Output Enable Control
t_{PLH}, t_{PHL}	Data Pulses	V_{VCCA}
t_{PZL} (t_{en}, OE to An, Bn)	Low	Low to High Switch
t_{PZH} (t_{en}, OE to An, Bn)	High	Low to High Switch
t_{PLZ} (t_{dis}, OE to An, Bn)	Low	High to Low Switch
t_{PHZ} (t_{dis}, OE to An, Bn)	High	High to Low Switch

AC Load Conditions

V_{VCCO}	C_L	R_L
1.2 ± 0.12V	15pF	1MΩ
1.8 ± 0.15V	15pF	1MΩ
2.5 ± 0.2V	15pF	1MΩ
3.3 ± 0.3V	15pF	1MΩ
5.0 ± 0.5V	15pF	1MΩ

Timing Diagrams

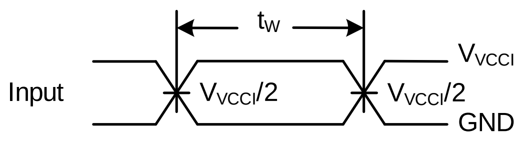
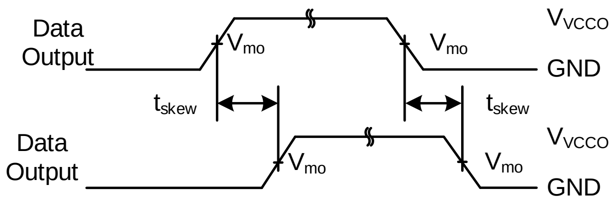


Figure8. Pulse Duration



$T_{skew} = (t_{PHLmax} - t_{PHLmin})$ or $(t_{PLHmax} - t_{PLHmin})$

Figure9. Output Skew Time

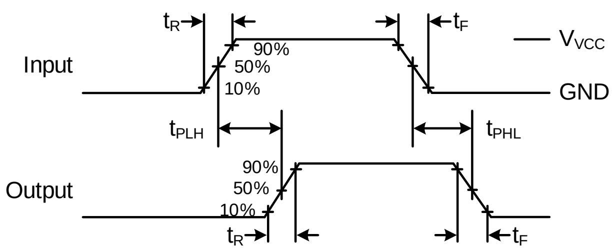


Figure10. Propagation Delay

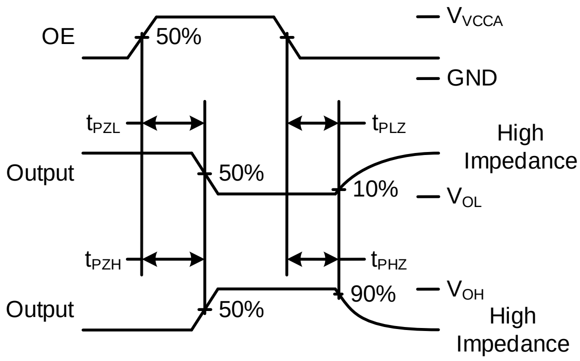


Figure11. Enable and Disable Times

Systems Examples: I3C Usage Considerations

The ETS0104 has bandwidth to support the high speeds needed for I3C, but there are special considerations which are required. Since I3C uses both push-pull and open-drain, it may not be possible to support all I3C applications with a FET-based translator.

I3C Bus Switching

Bus switching is when the bus path is enabled or disabled, but does not translate the bus voltage. External pull-up resistors are not needed for I3C, because the controller enables or disables the pull-up resistor on the SDA line. This presents a unique challenge for FET-based translators, like the ETS0104, because they rely on a pull-up resistor to pull the output side of the switch all the way to supply. For the switching use case, there is no translation, but the enable voltage must be high enough for the switch to stay on for the entire voltage range of the bus (0V to bus voltage).

R_{ON} must be low enough for the full push-pull voltage range. The EN voltage must be at least 1 V_t (~0.6 V) above the maximum desired pass-voltage. This comes out to $V_{EN} \geq V_{BUS} + 0.6V$. Since the switch enable voltage is being directly controlled, the V_{REFA} and V_{REFB} pins are not needed, and can be shorted to ground to improve power consumption.

It is possible to control the EN pin with a voltage equal to V_{BUS}, but external pull-up resistors on the downstream side are a requirement to ensure the bus is pulled entirely to V_{BUS}.

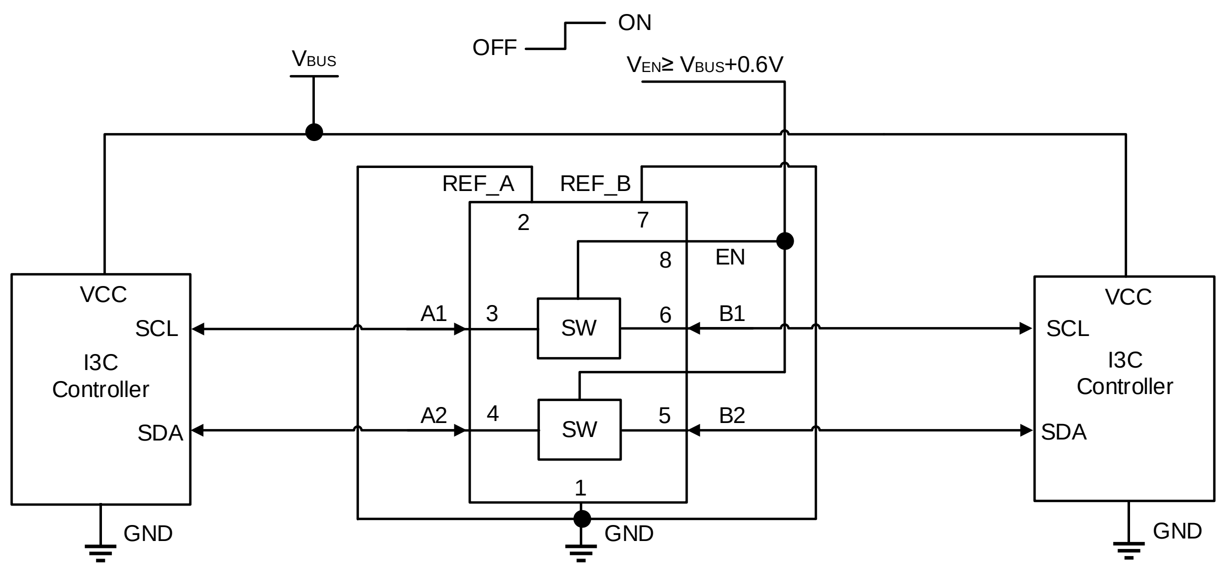


Figure 12. I3C Bus Switching Application (Without Pull-up Resistors)

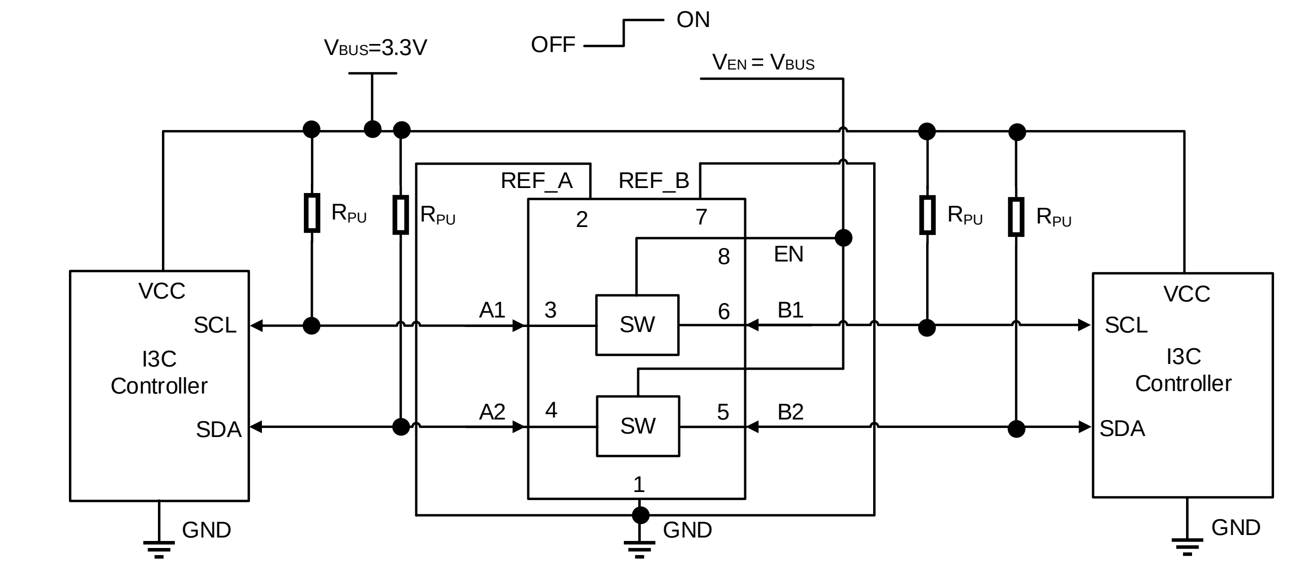


Figure 13. I3C Bus Switching Application (With Pull-up Resistors)

I3C Bus Voltage Translation

Bus voltage translation is when the bus voltage is translated up or down. This presents a unique challenge with I3C for FET-based translators, like the ETS0104, because they rely on a pull-up resistor to translate the voltage up from the low-voltage side. The pull-up resistor selected must be strong enough to meet the timing requirements (based on bus capacitance and translation voltages), but not so strong to violate the V_{IL} requirements of the I3C devices.

The pull-up resistors are needed on both sides. The reason for this is that with the normal translation setup, the switch is "on" when either side's bus voltage drops to roughly V_{PU_1}. This means that the pull-up resistors are required to pull the bus voltage on the high-voltage side from V_{PU_1} to V_{PU_2}. When the device on the high-voltage side is controlling the bus, the switch will turn off at V_{PU_1}. The pull-up resistors on the low-voltage side are used to bleed off any additional current that might "leak" through the switch.

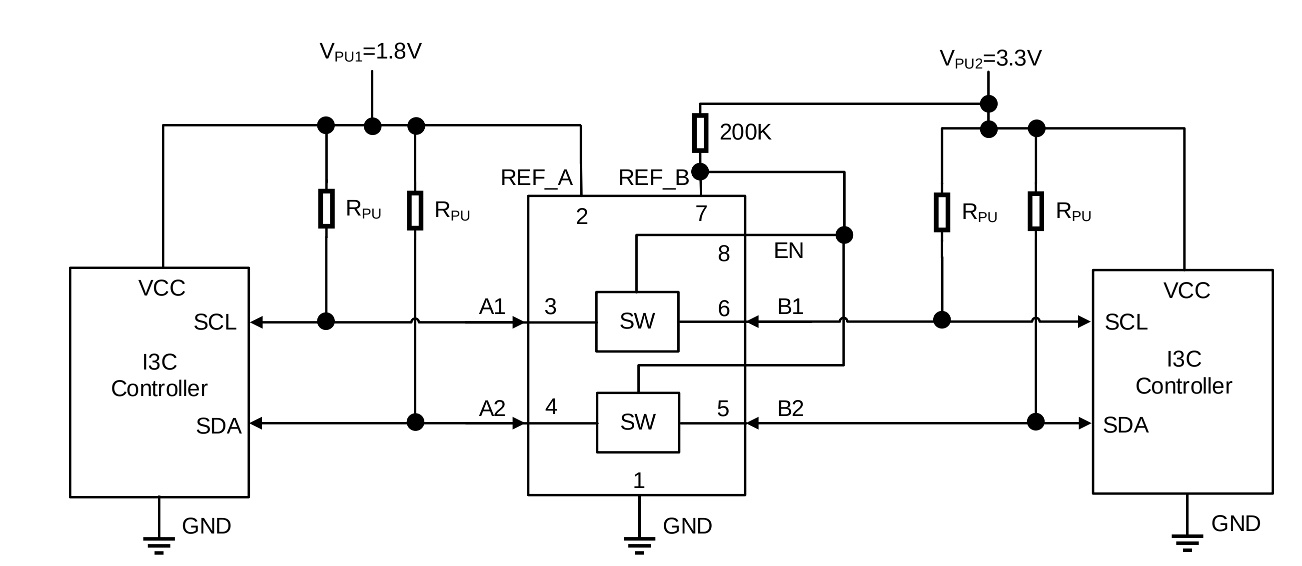
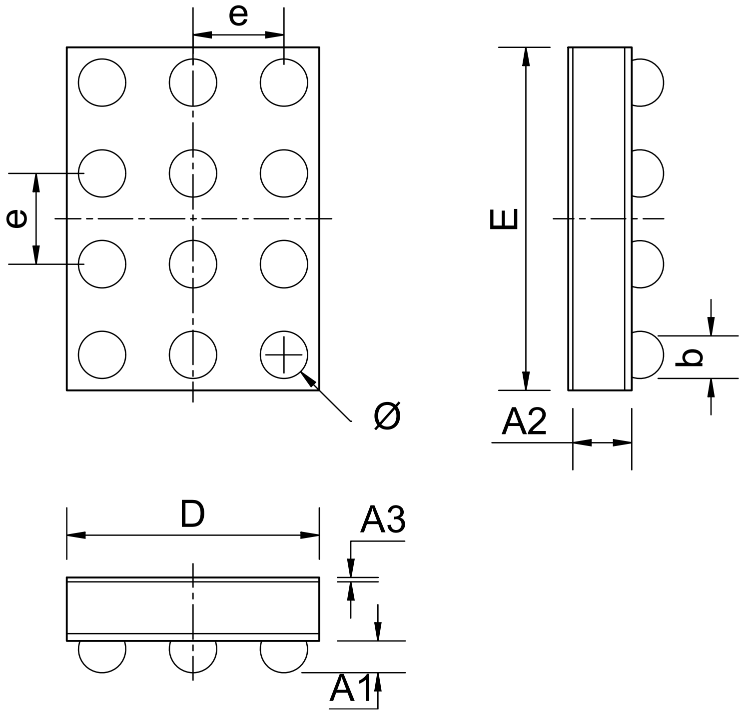


Figure 14. I3C Bus Translation

Package Dimension

FOWLP12(1.91mm × 1.41mm)

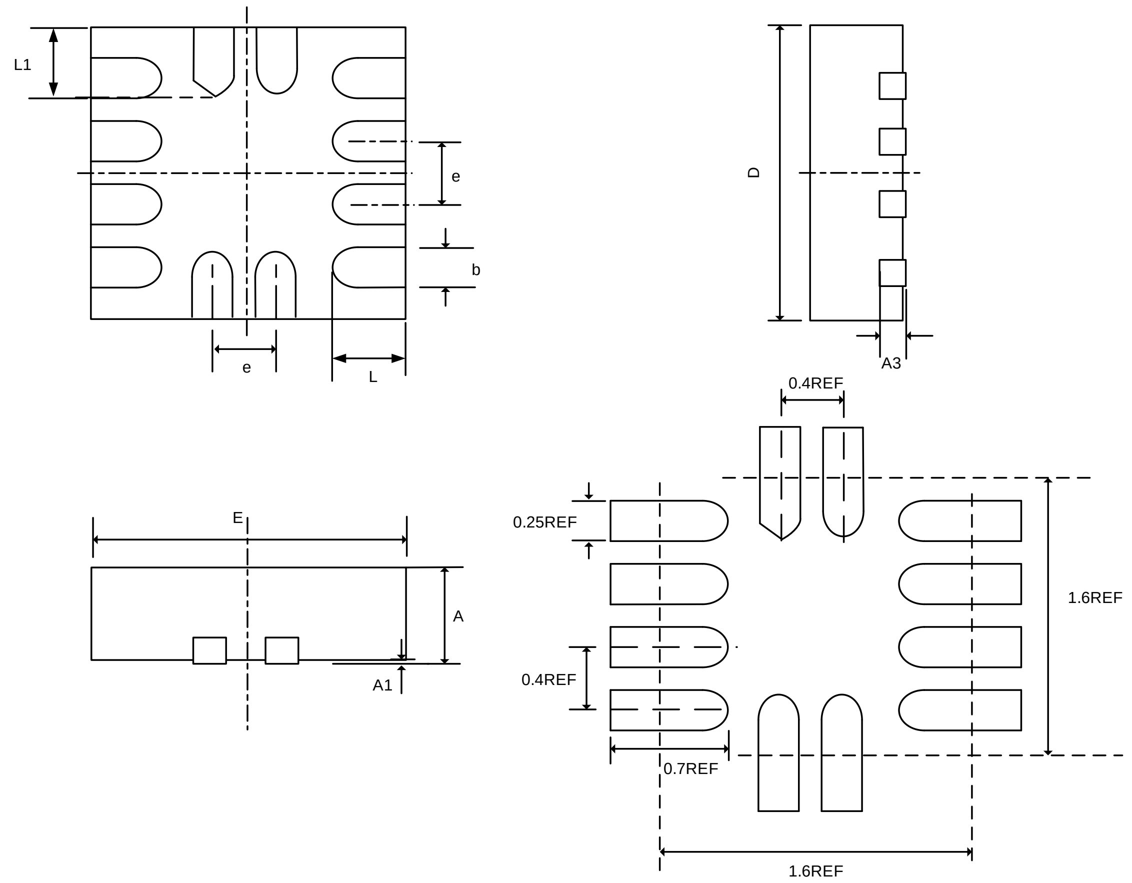


COMMON DIMENSIONS

(Unit: mm)

SYMBOL	MIN	NOM	MAX
A1	0.154	0.174	0.194
A2	0.353	0.381	0.409
A3	0.020	0.025	0.030
b	0.210	0.230	0.250
D	1.86	1.91	1.96
E	1.36	1.41	1.46
e	0.400REF		
Ø	0.230	0.250	0.270

QFN12 (1.8mm × 1.8mm)

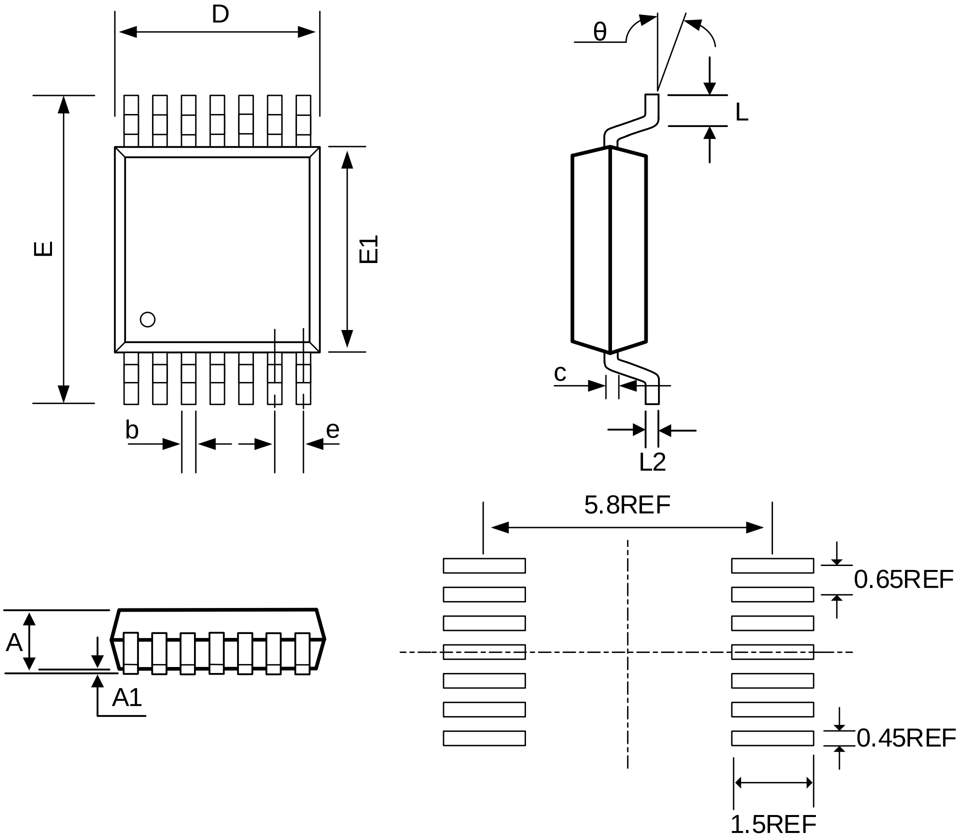


COMMON DIMENSIONS

(Unit: mm)

SYMBOL	Min	Typ	Max
A	0.50	0.55	0.60
A1	0	-	0.05
A3	0.15 REF		
b	0.15	0.20	0.25
D	1.75	1.8	1.85
E	1.75	1.8	1.85
e	0.40 BSC		
L	0.35	0.40	0.45

TSSOP14 (5.0mm × 4.4mm)

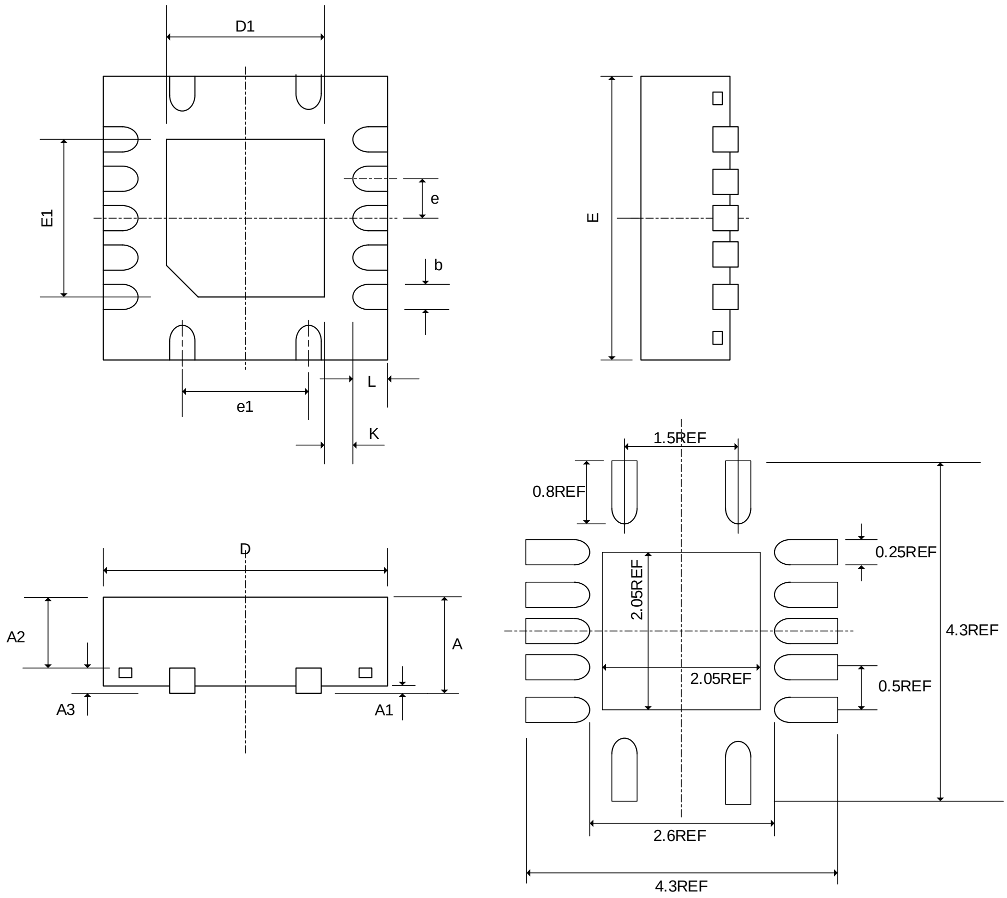


COMMON DIMENSIONS

(Unit: mm)

Symbol	Min	Typ	Max
A	--	--	1.20
A1	0.05	--	0.15
b	0.2	--	0.28
c	0.1	--	0.19
D	4.86	4.96	5.06
E	6.20	6.4	6.60
E1	4.30	4.4	4.50
e		0.65BSC	
L	0.45	0.6	0.75
L2		0.25 REF	
θ	0°		8°

QFN14 (3.5mm × 3.5mm)

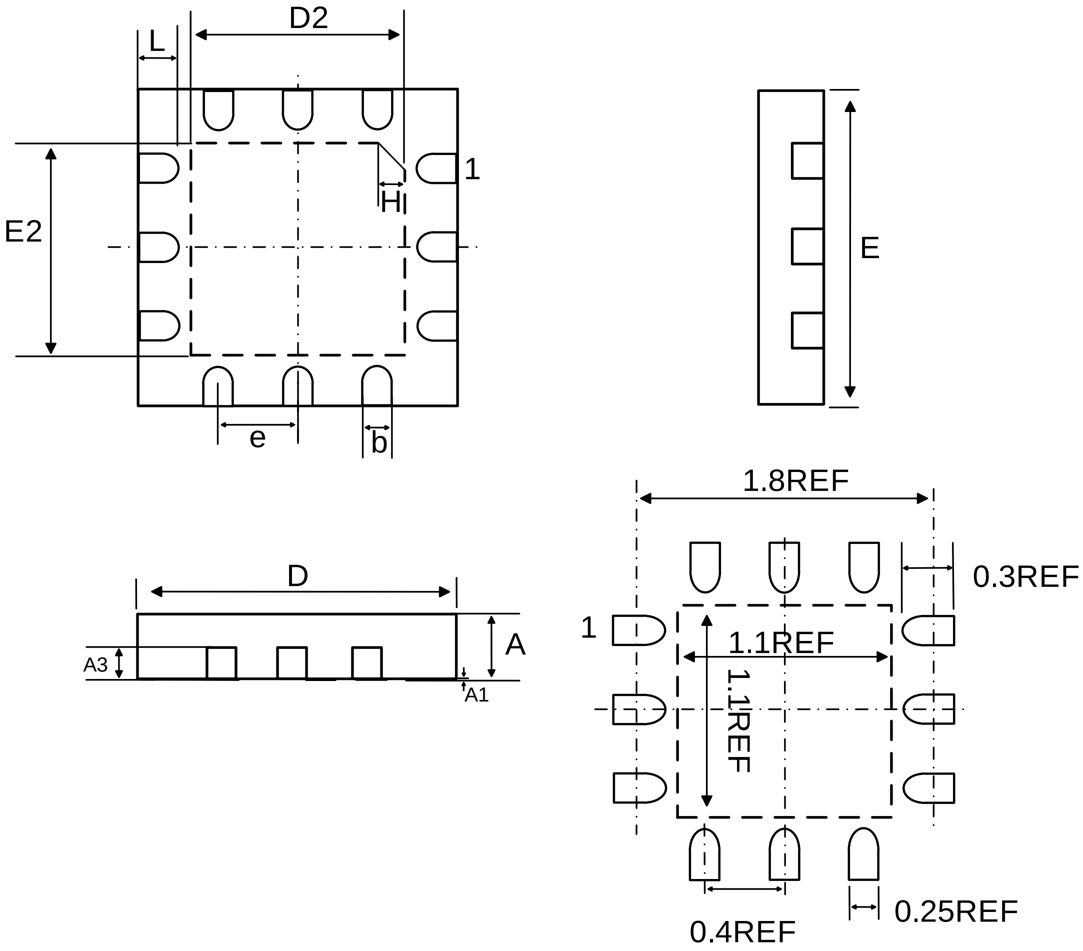


COMMON DIMENSIONS

(Unit: mm)

Symbol	Min	Typ	Max
A	0.8	0.85	0.9
A1	0	0.02	0.05
A2	--	0.65	--
A3	0.203 REF		
b	0.2	0.25	0.3
D	3.5 BSC		
E	3.5 BSC		
e	0.5 BSC		
e1	1.5 BSC		
D1	1.95	2.05	2.15
E1	1.95	2.05	2.15
L	0.3	0.4	0.5
K	0.325 REF		

QFN12 (2.0mm x 2.0mm)



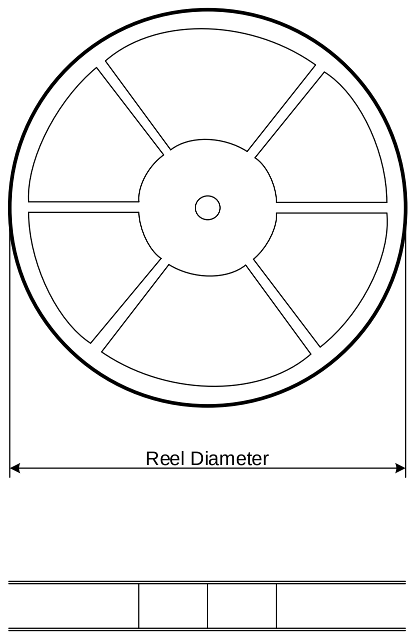
COMMON DIMENSIONS

(Unit: mm)

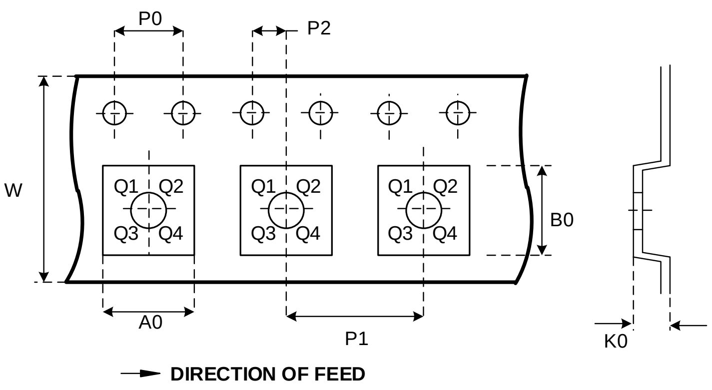
Symbol	Min	Typ	Max
A	0.45	0.50	0.55
A1	-	0.02	0.05
A3	0.152 REF		
b	0.15	0.20	0.25
D	1.90	2.00	2.10
E	1.90	2.00	2.10
D2	1.00	1.10	1.20
E2	1.00	1.10	1.20
e	0.40 BSC		
L	0.15	0.20	0.25
H	0.15	0.20	0.25

Tape and Reel Information

Reel DIMENSIONS



TAPE DIMENSIONS



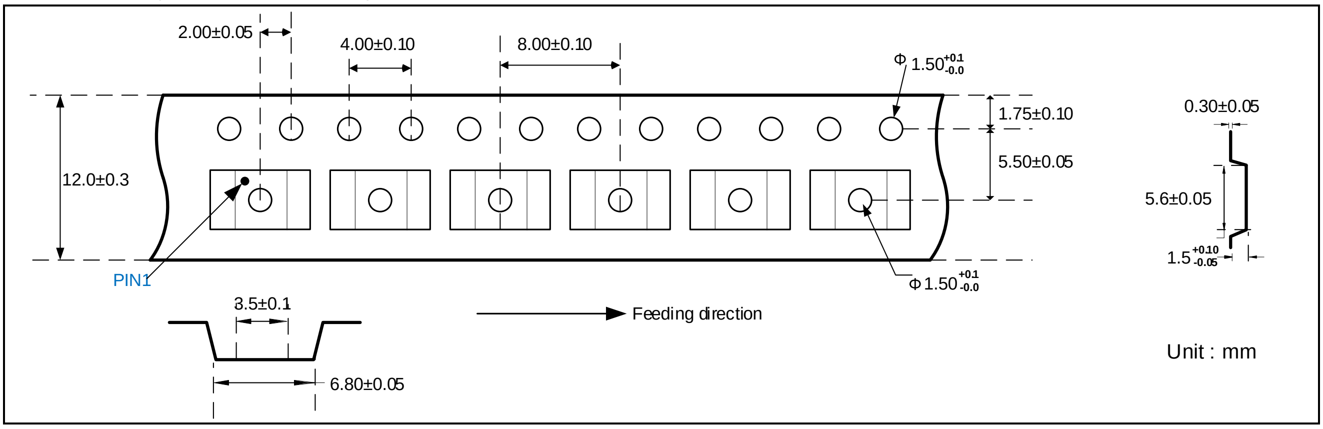
Note12: The above picture is for reference only, please refer to the value in the table below for the actual size.
Note13: For Pin 1 Orientation, please check the phasical reel before use.

Key Parameter List of Tape and Reel

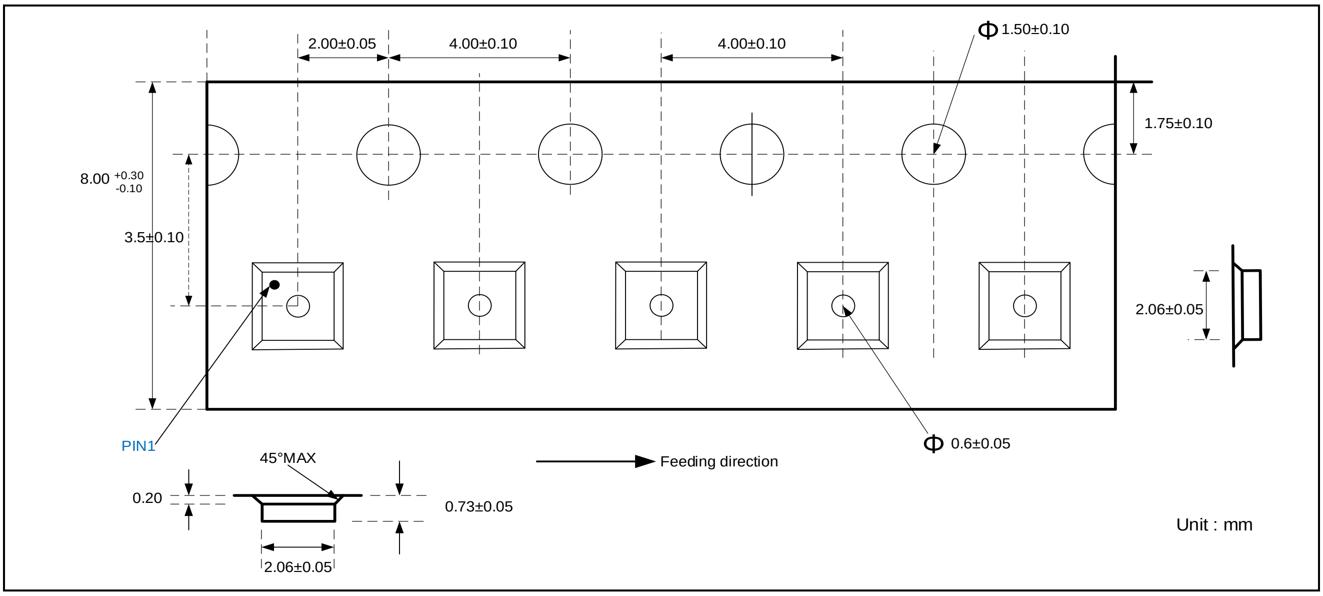
Device Name	Package Type	Unit: mm								Pin 1 Quadrant	Reel Q'ty
		Reel Diameter	A0	B0	K0	P0	P1	P2	W		
ETS0104	FOWLP12	180	1.6	2	0.75	4	4	2	8	Q2	3000
ETS0104Y	QFN14	180	3.8	3.8	1.1	4	8	2	12	Q1	3000
ETS0104Y2	QFN12 （2×2）	180	2.15	2.15	0.88	4	4	2	8	Q1	3000
ETS0104Y3	QFN12 （1.8×1.8）	180	2.06	2.06	0.73	4	4	2	8	Q1	3000
ETS0104V	TSSOP14	330	6.8	5.6	1.5	4	4	2	12	Q1	4000

Tape Information

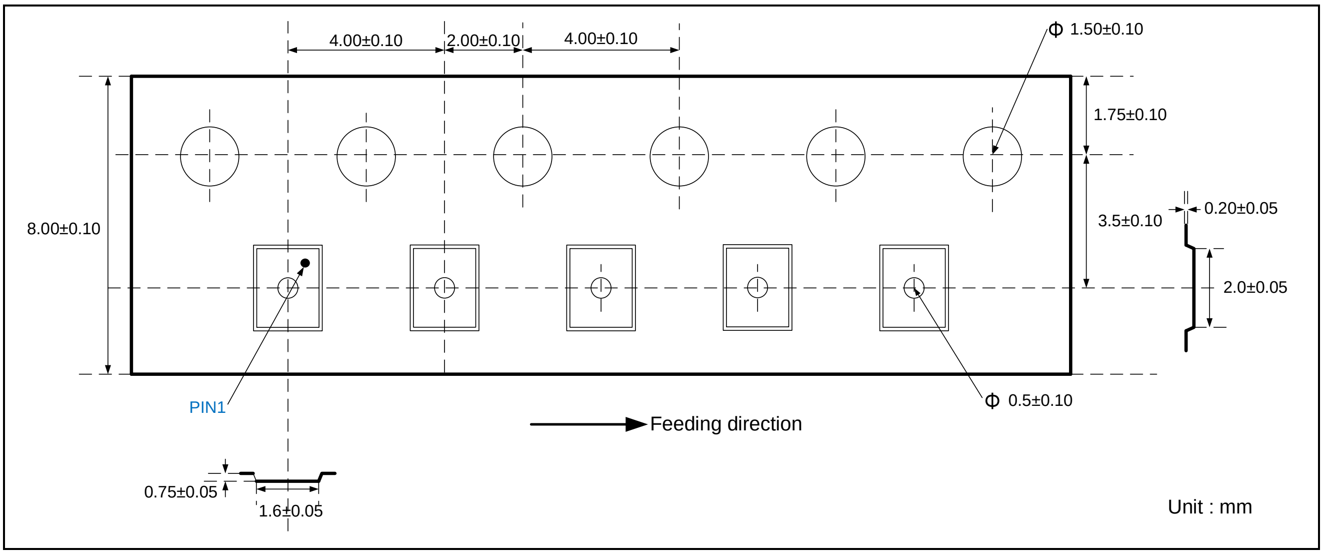
TSSOP14 (5.0mm × 4.4mm)



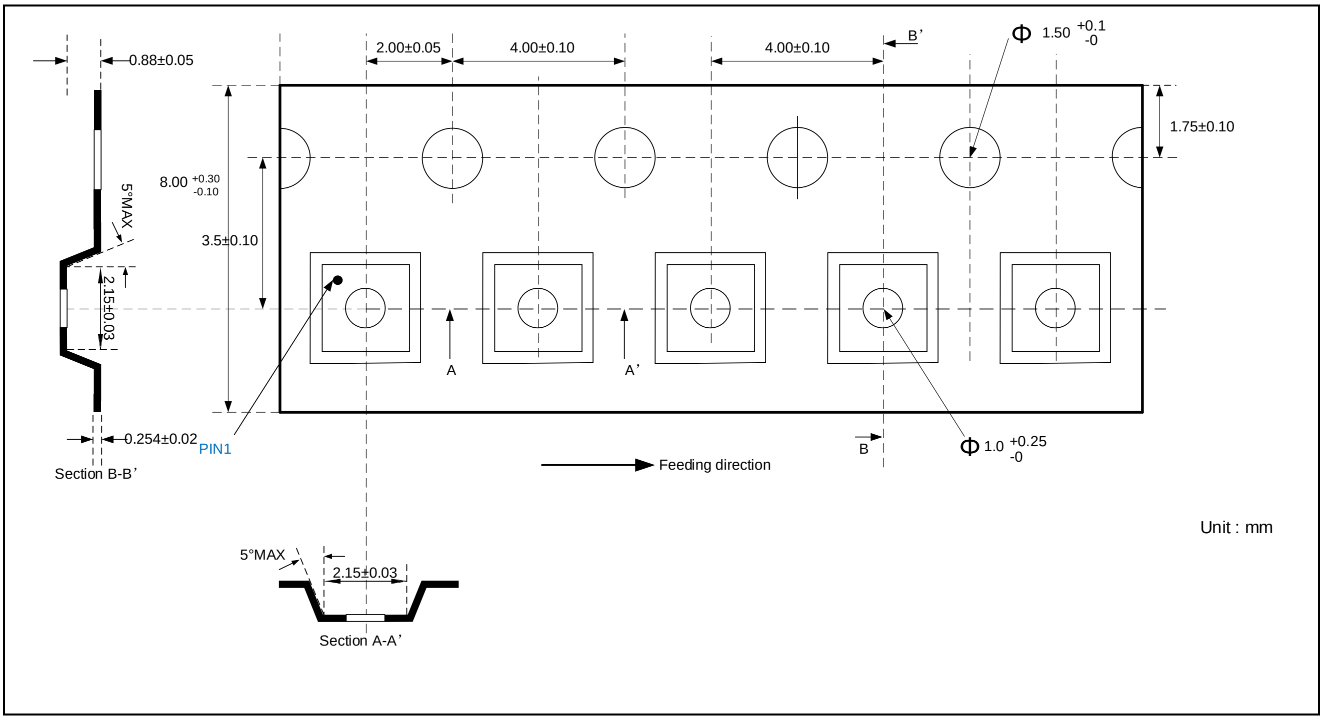
QFN12 (1.8mm × 1.8mm)



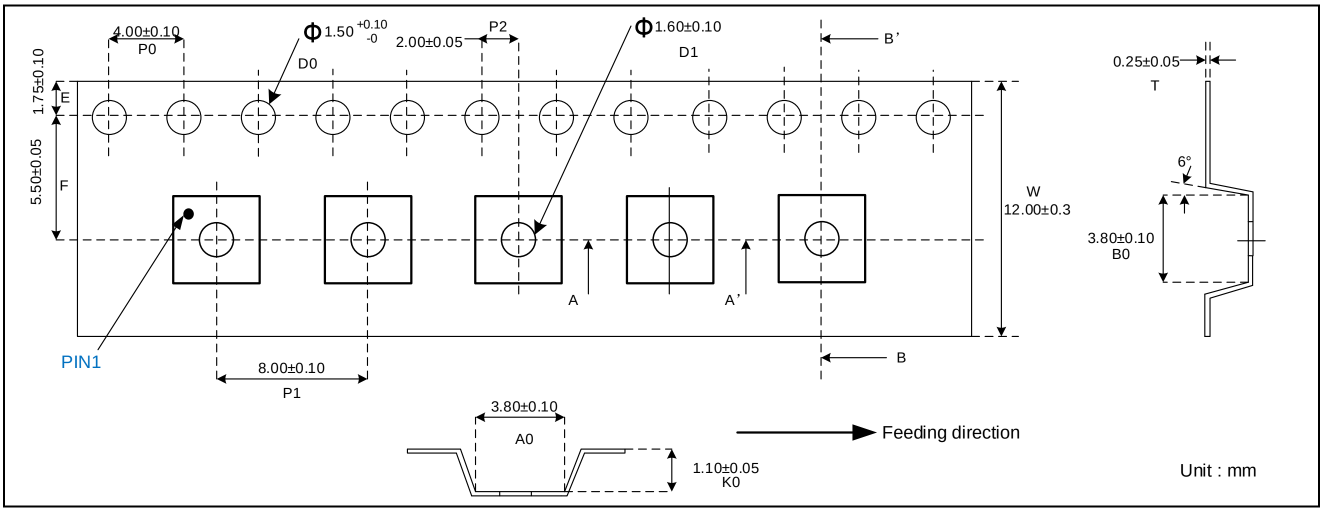
FOWLP12 (1.91mm × 1.41mm)



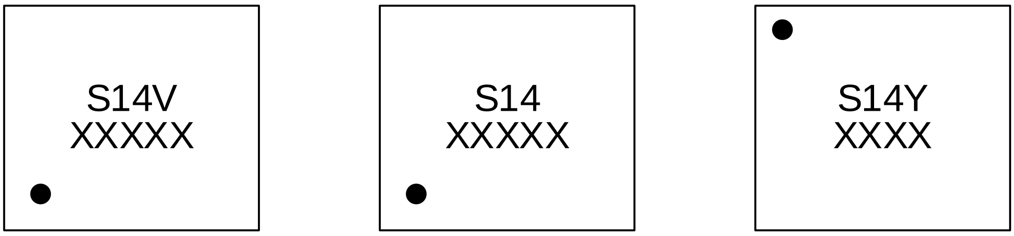
QFN12 (2.0mm × 2.0mm)



QFN14 (3.5mm × 3.5mm)



Marking Information



ETS0104V	ETS0104	ETS0104Y3
S14V = Part Number	S14 = Part Number	S14Y = Part Number
XXXXX = Tracking Number	XXXXX = Tracking Number	XXXX = Tracking Number

Revision History and Checking Table

Version	Date	Revision Item	Modifier	Function & Spec Checking	Package & Tape Checking
1.0	2026-2-10	Official Version	Zhang wang	Ni wentao	Liu jiaying
1.1	2026-3-20	Update Maximum Data Rate	Lu shaojie	Ni wentao	Liu jiaying
1.2	2026-04-08	Update Format, Add FOWLP12 Package	Xu tao	Yang xiaoxu	Liu jiaying
1.3	2026-4-16	Update I3C Description	Wang An Ran	Liu Yi Guo	Liu Jia Ying
1.4	2026-4-16	Update Package	Lu Shao Jie	Liu Yi Guo	Liu Jia Ying
1.4.a	2026-5-8	Update MSL	Lu Shao Jie	Liu Yi Guo	Liu Jia Ying
1.5	2026-6-12	Add Tape Information and Marking Information	Lu Shao Jie	Liu Yi Guo	Liu Jia Ying
1.5.a	2026-7-23	Add Key Parameter List of Tape and Reel	Lu Shao Jie	Liu Yi Guo	Liu Jia Ying