NTB0104

Dual supply translating transceiver; auto direction sensing; 3-state

Rev. 1 — 26 October 2010 Product data sheet

1. General description

The NTB0104 is a 4-bit, dual supply translating transceiver with auto direction sensing, that enables bidirectional voltage level translation. It features two data input-output ports (An and Bn), one output enable input (OE) and two supply pins ($V_{CC(A)}$ and $V_{CC(B)}$). $V_{CC(A)}$ can be supplied at any voltage between 1.2 V and 3.6 V and $V_{CC(B)}$ can be supplied at any voltage between 1.65 V and 5.5 V, making the device suitable for translating between any of the low voltage nodes (1.2 V, 1.5 V, 1.8 V, 2.5 V, 3.3 V and 5.0 V).

Pins An and OE are referenced to $V_{CC(A)}$ and pins Bn are referenced to $V_{CC(B)}$. A LOW level at pin OE causes the outputs to assume a high-impedance OFF-state. This device is fully specified for partial power-down applications using I_{OFF}. The I_{OFF} circuitry disables the output, preventing the damaging backflow current through the device when it is powered down.

2. Features and benefits

- Wide supply voltage range:
  - $V_{CC(A)}$: 1.2 V to 3.6 V and $V_{CC(B)}$: 1.65 V to 5.5 V
- I_{OFF} circuitry provides partial Power-down mode operation
- Inputs accept voltages up to 5.5 V
- ESD protection:
  - HBM JESD22-A114E Class 2 exceeds 2500 V for A port
  - HBM JESD22-A114E Class 3B exceeds 15000 V for B port
  - MM JESD22-A115-A exceeds 200 V
  - CDM JESD22-C101E exceeds 1500 V
- Latch-up performance exceeds 100 mA per JESD 78B Class II
- Multiple package options
- Specified from –40 °C to +85 °C and –40 °C to +125 °C

3. Ordering information

Table 1. Ordering information

Type number	Package			
	Temperature range	Name	Description	Version
NTB0104D	–40 °C to +125 °C	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1
NTB0104PW	–40 °C to +125 °C	TSSOP14	plastic thin shrink small outline package; 14 leads; body width 4.4 mm	SOT402-1
NTB0104BQ	–40 °C to +125 °C	DHVQFN14	plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 14 terminals; body 2.5 × 3 × 0.85 mm	SOT762-1
NTB0104GU16	–40 °C to +125 °C	XQFN16	plastic, extremely thin quad flat package; no leads; 16 terminals; body 1.80 × 2.60 × 0.50 mm	SOT1161-1
NTB0104GU12	–40 °C to +125 °C	XQFN12	plastic, extremely thin quad flat package; no leads; 12 terminals; body 1.70 × 2.0 × 0.50 mm	SOT1174

4. Marking

Table 2. Marking

Type number	Marking code
NTB0104D	NTB0104D
NTB0104PW	NTB0104
NTB0104BQ	B0104
NTB0104GU16	t4
NTB0104GU12	t4

5. Functional diagram

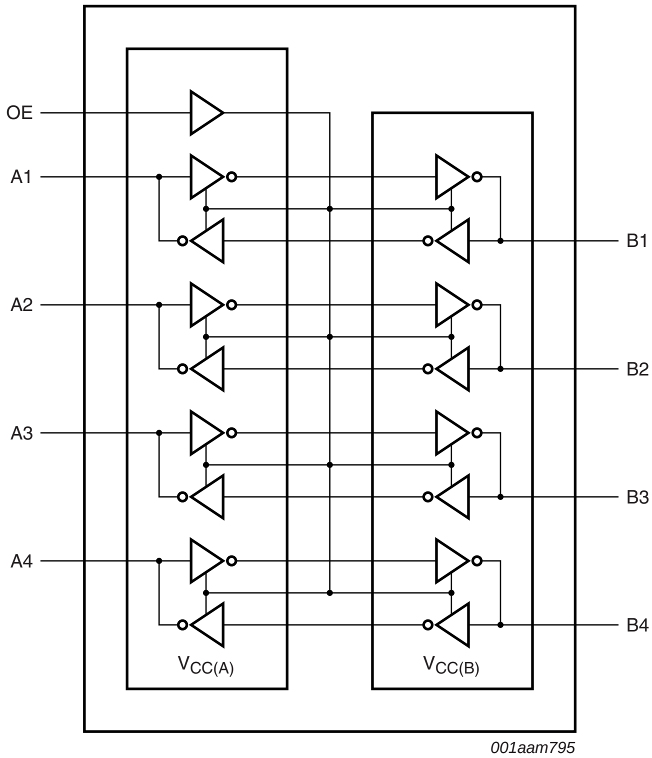


Fig 1. Logic symbol

6. Pinning information

6.1 Pinning

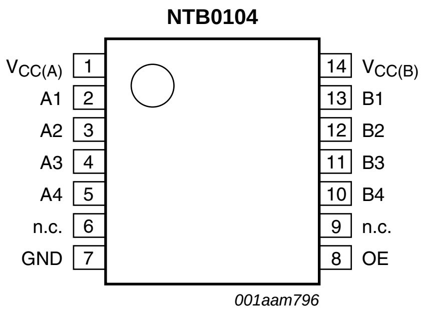
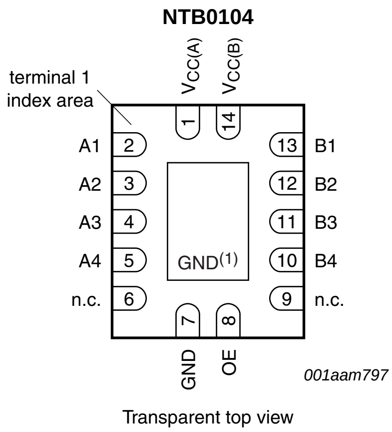


Fig 2. Pin configuration SO14 (SOT108-1) and TSSOP14 (SOT402-1)



(1) This is not a supply pin, the substrate is attached to this pad using conductive die attach material. There is no electrical or mechanical requirement to solder this pad however if it is soldered the solder land should remain floating or be connected to GND.

Fig 3. Pin configuration DHVQFN14 (SOT762-1)

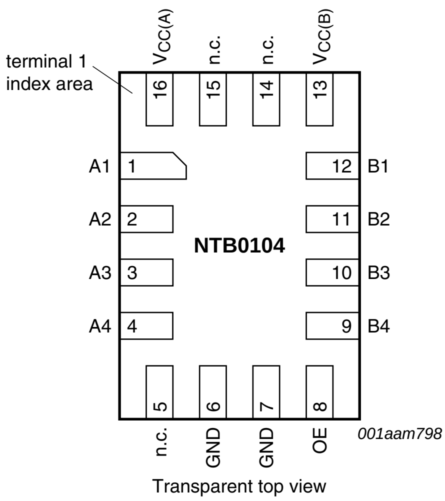


Fig 4. Pin configuration XQFN16 (SOT1161-1)

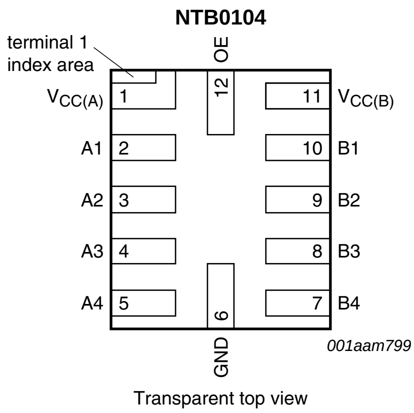


Fig 5. Pin configuration XQFN12 (SOT1174)

6.2 Pin description

Table 3. Pin description

Symbol	Pin			Description
	SOT108-1, SOT402-1 and SOT762-1	SOT1161-1	SOT1174	
$V_{CC(A)}$	1	16	1	supply voltage A
A1, A2, A3, A4	2, 3, 4, 5	1, 2, 3, 4	2, 3, 4, 5	data input or output (referenced to $V_{CC(A)}$)
n.c.	6, 9	5, 14, 15	-	not connected
GND	7	6, 7	6	ground (0 V)
OE	8	8	12	output enable input (active HIGH; referenced to $V_{CC(A)}$)
B4, B3, B2, B1	10, 11, 12, 13	9, 10, 11, 12	7, 8, 9, 10	data input or output (referenced to $V_{CC(B)}$)
$V_{CC(B)}$	14	13	11	supply voltage B

7. Functional description

Table 4. Function table[1]

Supply voltage		Input	Input/output	
$V_{CC(A)}$	$V_{CC(B)}$	OE	An	Bn
1.2 V to $V_{CC(B)}$	1.65 V to 5.5 V	L	Z	Z
1.2 V to $V_{CC(B)}$	1.65 V to 5.5 V	H	input or output	output or input
GND[2]	GND[2]	X	Z	Z

[1] H = HIGH voltage level; L = LOW voltage level; X = don't care; Z = high-impedance OFF-state.

[2] When either $V_{CC(A)}$ or $V_{CC(B)}$ is at GND level, the device goes into power-down mode.

8. Limiting values

Table 5. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134). Voltages are referenced to GND (ground = 0 V).

Symbol	Parameter	Conditions		Min	Max	Unit
$V_{CC(A)}$	supply voltage A			–0.5	+6.5	V
$V_{CC(B)}$	supply voltage B			–0.5	+6.5	V
V_I	input voltage		[1]	–0.5	+6.5	V
V_O	output voltage	Active mode	[1][2][3]	–0.5	V_{CCO} + 0.5	V
		Power-down or 3-state mode	[1]	–0.5	+6.5	V
I_{IK}	input clamping current	V_I < 0 V		–50	-	mA
I_{OK}	output clamping current	V_O < 0 V		–50	-	mA
I_O	output current	V_O = 0 V to V_{CCO}	[2]	-	±50	mA
I_{CC}	supply current	$I_{CC(A)}$ or $I_{CC(B)}$		-	100	mA
I_{GND}	ground current			–100	-	mA
T_{stg}	storage temperature			–65	+150	°C

Table 5. Limiting values *...continued*
In accordance with the Absolute Maximum Rating System (IEC 60134). Voltages are referenced to GND (ground = 0 V).

Symbol	Parameter	Conditions		Min	Max	Unit
P_{tot}	total power dissipation	T_{amb} = –40 °C to +125 °C	[4]	-	250	mW

[1] The minimum input and minimum output voltage ratings may be exceeded if the input and output current ratings are observed.

[2] V_{CCO} is the supply voltage associated with the output.

[3] V_{CCO} + 0.5 V should not exceed 6.5 V.

[4] For SO14 packages: above 70 °C the value of P_{tot} derates linearly at 8 mW/K.
For TSSOP14 packages: above 60 °C the value of P_{tot} derates linearly at 5.5 mW/K.
For DHVQFN14 packages: above 60 °C the value of P_{tot} derates linearly at 4.5 mW/K.
For XQFN12 packages: above 128 °C the value of P_{tot} derates linearly with 11.5 mW/K.
For XQFN16 packages: above 135 the value of P_{tot} derates linearly at 16.9 mW/K.

9. Recommended operating conditions

Table 6. Recommended operating conditions[1][2]

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{CC(A)}$	supply voltage A		1.2	3.6	V
$V_{CC(B)}$	supply voltage B		1.65	5.5	V
V_I	input voltage		0	5.5	V
V_O	output voltage	Power-down or 3-state mode; $V_{CC(A)}$ = 1.2 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V			
		A port	0	3.6	V
		B port	0	5.5	V
T_{amb}	ambient temperature		–40	+125	°C
$\Delta t/\Delta V$	input transition rise and fall rate	$V_{CC(A)}$ = 1.2 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V	-	40	ns/V

[1] The A and B sides of an unused I/O pair must be held in the same state, both at V_{CCI} or both at GND.

[2] $V_{CC(A)}$ must be less than or equal to $V_{CC(B)}$.

10. Static characteristics

Table 7. Typical static characteristics
At recommended operating conditions; voltages are referenced to GND (ground = 0 V); T_{amb} = 25 °C.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{OH}	HIGH-level output voltage	A port; $V_{CC(A)}$ = 1.2 V; I_O = –20 μA		-	1.1	-	V
V_{OL}	LOW-level output voltage	A port; $V_{CC(A)}$ = 1.2 V; I_O = 20 μA		-	0.09	-	V
I_I	input leakage current	OE input; V_I = 0 V to 3.6 V; $V_{CC(A)}$ = 1.2 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V		-	-	±1	μA
I_{OZ}	OFF-state output current	A or B port; V_O = 0 V to V_{CCO}; $V_{CC(A)}$ = 1.2 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V	[1]	-	-	±1	μA

Table 7. Typical static characteristics *...continued*

At recommended operating conditions; voltages are referenced to GND (ground = 0 V); T_{amb} = 25 °C.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
I_{OFF}	power-off leakage current	A port; V_I or V_O = 0 V to 3.6 V; $V_{CC(A)}$ = 0 V; $V_{CC(B)}$ = 0 V to 5.5 V		-	-	±1	μA
		B port; V_I or V_O = 0 V to 5.5 V; $V_{CC(B)}$ = 0 V; $V_{CC(A)}$ = 0 V to 3.6 V		-	-	±1	μA
I_{CC}	supply current	V_I = 0 V or V_{CCI}; I_O = 0 A	[2]				
		$I_{CC(A)}$; $V_{CC(A)}$ = 1.2 V; $V_{CC(B)}$ = 1.65 V to 5.5 V		-	0.05	-	μA
		$I_{CC(B)}$; $V_{CC(A)}$ = 1.2 V; $V_{CC(B)}$ = 1.65 V to 5.5 V		-	3.3	-	μA
		$I_{CC(A)}$ + $I_{CC(B)}$; $V_{CC(A)}$ = 1.2 V; $V_{CC(B)}$ = 1.65 V to 5.5 V		-	3.5	-	μA
C_I	input capacitance	OE input; $V_{CC(A)}$ = 1.2 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V		-	2.8	-	pF
$C_{I/O}$	input/output capacitance	A port; $V_{CC(A)}$ = 1.2 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V		-	4.0	-	pF
		B port; $V_{CC(A)}$ = 1.2 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V		-	7.5	-	pF

[1] V_{CCO} is the supply voltage associated with the output.

[2] V_{CCI} is the supply voltage associated with the input.

Table 8. Static characteristics

At recommended operating conditions; voltages are referenced to GND (ground = 0 V).

Symbol	Parameter	Conditions		−40 °C to +85 °C		−40 °C to +125 °C		Unit
				Min	Max	Min	Max	
V_{IH}	HIGH-level input voltage	A or B port and OE input	[1]					
		$V_{CC(A)}$ = 1.2 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V		0.65V_{CCI}	-	0.65V_{CCI}	-	V
V_{IL}	LOW-level input voltage	A or B port and OE input	[1]					
		$V_{CC(A)}$ = 1.2 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V		-	0.35V_{CCI}	-	0.35V_{CCI}	V
V_{OH}	HIGH-level output voltage	I_O = −20 μA	[2]					
		A port; $V_{CC(A)}$ = 1.4 V to 3.6 V		V_{CCO} − 0.4	-	V_{CCO} − 0.4	-	V
		B port; $V_{CC(B)}$ = 1.65 V to 5.5 V		V_{CCO} − 0.4	-	V_{CCO} − 0.4	-	V
V_{OL}	LOW-level output voltage	I_O = 20 μA	[2]					
		A port; $V_{CC(A)}$ = 1.4 V to 3.6 V		-	0.4	-	0.4	V
		B port; $V_{CC(B)}$ = 1.65 V to 5.5 V		-	0.4	-	0.4	V
I_I	input leakage current	OE input; V_I = 0 V to 3.6 V; $V_{CC(A)}$ = 1.2 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V		-	±2	-	±5	μA
I_{OZ}	OFF-state output current	A or B port; V_O = 0 V or V_{CCO}; $V_{CC(A)}$ = 1.2 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V	[2]	-	±2	-	±10	μA
I_{OFF}	power-off leakage current	A port; V_I or V_O = 0 V to 3.6 V; $V_{CC(A)}$ = 0 V; $V_{CC(B)}$ = 0 V to 5.5 V		-	±2	-	±10	μA
		B port; V_I or V_O = 0 V to 5.5 V; $V_{CC(B)}$ = 0 V; $V_{CC(A)}$ = 0 V to 3.6 V		-	±2	-	±10	μA

Table 8. Static characteristics *...continued*

At recommended operating conditions; voltages are referenced to GND (ground = 0 V).

Symbol	Parameter	Conditions		−40 °C to +85 °C		−40 °C to +125 °C		Unit
				Min	Max	Min	Max	
I_{CC}	supply current	V_I = 0 V or V_{CCI}; I_O = 0 A	[1]					
		$I_{CC(A)}$						
		OE = LOW; $V_{CC(A)}$ = 1.4 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V		-	5	-	15	μA
		OE = HIGH; $V_{CC(A)}$ = 1.4 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V		-	5	-	20	μA
		$V_{CC(A)}$ = 3.6 V; $V_{CC(B)}$ = 0 V		-	2	-	15	μA
		$V_{CC(A)}$ = 0 V; $V_{CC(B)}$ = 5.5 V		-	−2	-	−15	μA
		$I_{CC(B)}$						
		OE = LOW; $V_{CC(A)}$ = 1.4 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V		-	5	-	15	μA
		OE = HIGH; $V_{CC(A)}$ = 1.4 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V		-	5	-	20	μA
		$V_{CC(A)}$ = 3.6 V; $V_{CC(B)}$ = 0 V		-	−2	-	−15	μA
		$V_{CC(A)}$ = 0 V; $V_{CC(B)}$ = 5.5 V		-	2	-	15	μA
		$I_{CC(A)} + I_{CC(B)}$						
		$V_{CC(A)}$ = 1.4 V to 3.6 V; $V_{CC(B)}$ = 1.65 V to 5.5 V		-	10	-	40	μA

[1] V_{CCI} is the supply voltage associated with the input.

[2] V_{CCO} is the supply voltage associated with the output.

11. Dynamic characteristics

Table 9. Typical dynamic characteristics for temperature 25 °C[1]

Voltages are referenced to GND (ground = 0 V); for test circuit see Figure 8; for waveforms see Figure 6 and Figure 7.

Symbol	Parameter	Conditions		$V_{CC(B)}$				Unit
				1.8 V	2.5 V	3.3 V	5.0 V	
$V_{CC(A)}$ = 1.2 V; T_{amb} = 25 °C								
t_{pd}	propagation delay	A to B		5.9	4.8	4.4	4.2	ns
		B to A		5.6	4.8	4.5	4.4	ns
t_{en}	enable time	OE to A, B		0.5	0.5	0.5	0.5	μs
t_{dis}	disable time	OE to A; no external load	[2]	8.3	8.3	8.3	8.3	ns
		OE to B; no external load	[2]	10.4	9.4	9.3	8.8	ns
		OE to A		81	69	83	68	ns
		OE to B		81	69	83	68	ns
t_t	transition time	A port		4.0	4.0	4.1	4.1	ns
		B port		2.6	2.0	1.7	1.4	ns

Table 9. Typical dynamic characteristics for temperature 25 °C[1] *…continued*

Voltages are referenced to GND (ground = 0 V); for test circuit see Figure 8; for waveforms see Figure 6 and Figure 7.

Symbol	Parameter	Conditions		$V_{CC(B)}$				Unit
				1.8 V	2.5 V	3.3 V	5.0 V	
$t_{sk(o)}$	skew	between channels	[3]	0.2	0.2	0.2	0.2	ns
t_W	pulse width	data inputs		15	13	13	13	ns
f_{data}	data rate			70	80	80	80	Mbps

[1] t_{pd} is the same as t_{PLH} and t_{PHL}.
t_{en} is the same as t_{PZL} and t_{PZH}.
t_{dis} is the same as t_{PLZ} and t_{PHZ}.
t_t is the same as t_{THL} and t_{TLH}

[2] Delay between OE going LOW and when the outputs are actually disabled.

[3] Skew between any two outputs of the same package switching in the same direction.

Table 10. Dynamic characteristics for temperature range −40 °C to +85 °C[1]

Voltages are referenced to GND (ground = 0 V); for test circuit see Figure 8; for wave forms see Figure 6 and Figure 7.

Symbol	Parameter	Conditions		$V_{CC(B)}$								Unit
				1.8 V ± 0.15 V		2.5 V ± 0.2 V		3.3 V ± 0.3 V		5.0 V ± 0.5 V		
				Min	Max	Min	Max	Min	Max	Min	Max	
$V_{CC(A)}$ = 1.5 V ± 0.1 V												
t_{pd}	propagation delay	A to B		1.4	12.9	1.2	10.1	1.1	10.0	0.8	9.9	ns
		B to A		0.9	14.2	0.7	12.0	0.4	11.7	0.3	13.7	ns
t_{en}	enable time	OE to A, B		-	1.0	-	1.0	-	1.0	-	1.0	µs
t_{dis}	disable time	OE to A; no external load	[2]	1.0	12.9	1.0	12.9	1.0	12.9	1.0	12.9	ns
		OE to B; no external load	[2]	1.0	18.7	1.0	15.8	1.0	15.1	1.0	14.4	ns
		OE to A		-	320	-	260	-	260	-	280	ns
		OE to B		-	200	-	200	-	200	-	200	ns
t_t	transition time	A port		0.9	5.1	0.9	5.1	0.9	5.1	0.9	5.1	ns
		B port		0.9	4.7	0.6	3.2	0.5	2.5	0.4	2.7	ns
$t_{sk(o)}$	skew	between channels	[3]	-	0.5	-	0.5	-	0.5	-	0.5	ns
t_W	pulse width	data inputs		25	-	25	-	25	-	25	-	ns
f_{data}	data rate			-	40	-	40	-	40	-	40	Mbps
$V_{CC(A)}$ = 1.8 V ± 0.15 V												
t_{pd}	propagation delay	A to B		1.6	11.0	1.4	7.7	1.3	6.8	1.2	6.5	ns
		B to A		1.5	12.0	1.3	8.4	1.0	7.6	0.9	7.1	ns
t_{en}	enable time	OE to A, B		-	1.0	-	1.0	-	1.0	-	1.0	µs
t_{dis}	disable time	OE to A; no external load	[2]	1.0	11.7	1.0	11.7	1.0	11.7	1.0	11.7	ns
		OE to B; no external load	[2]	1.0	16.9	1.0	14.5	1.0	13.7	1.0	12.7	ns
		OE to A		-	260	-	230	-	230	-	230	ns
		OE to B		-	200	-	200	-	200	-	200	ns
t_t	transition time	A port		0.8	4.1	0.8	4.1	0.8	4.1	0.8	4.1	ns
		B port		0.9	4.7	0.6	3.2	0.5	2.5	0.4	2.7	ns
$t_{sk(o)}$	skew	between channels	[3]	-	0.5	-	0.5	-	0.5	-	0.5	ns
t_W	pulse width	data inputs		20	-	17	-	17	-	17	-	ns

Table 10. Dynamic characteristics for temperature range −40 °C to +85 °C[1] *…continued*

Voltages are referenced to GND (ground = 0 V); for test circuit see Figure 8; for wave forms see Figure 6 and Figure 7.

Symbol	Parameter	Conditions		$V_{CC(B)}$								Unit
				1.8 V ± 0.15 V		2.5 V ± 0.2 V		3.3 V ± 0.3 V		5.0 V ± 0.5 V		
				Min	Max	Min	Max	Min	Max	Min	Max	
f_{data}	data rate			-	49	-	60	-	60	-	60	Mbps
$V_{CC(A)}$ = 2.5 V ± 0.2 V												
t_{pd}	propagation delay	A to B		-	-	1.1	6.3	1.0	5.2	0.9	4.7	ns
		B to A		-	-	1.2	6.6	1.1	5.1	0.9	4.4	ns
t_{en}	enable time	OE to A, B		-	-	-	1.0	-	1.0	-	1.0	μs
t_{dis}	disable time	OE to A; no external load	[2]	-	-	1.0	9.7	1.0	9.7	1.0	9.7	ns
		OE to B; no external load	[2]	-	-	1.0	12.9	1.0	12.0	1.0	11.0	ns
		OE to A		-	-	-	200	-	200	-	200	ns
		OE to B		-	-	-	200	-	200	-	200	ns
t_t	transition time	A port		-	-	0.7	3.0	0.7	3.0	0.7	3.0	ns
		B port		-	-	0.7	3.2	0.5	2.5	0.4	2.7	ns
$t_{sk(o)}$	skew	between channels	[3]	-	-	-	0.5	-	0.5	-	0.5	ns
t_W	pulse width	data inputs		-	-	12	-	10	-	10	-	ns
f_{data}	data rate			-	-	-	85	-	100	-	100	Mbps
$V_{CC(A)}$ = 3.3 V ± 0.3 V												
t_{pd}	propagation delay	A to B		-	-	-	-	0.9	4.7	0.8	4.0	ns
		B to A		-	-	-	-	1.0	4.9	0.9	3.8	ns
t_{en}	enable time	OE to A, B		-	-	-	-	-	1.0	-	1.0	μs
t_{dis}	disable time	OE to A; no external load	[2]	-	-	-	-	1.0	9.4	1.0	9.4	ns
		OE to B; no external load	[2]	-	-	-	-	1.0	11.3	1.0	10.4	ns
		OE to A		-	-	-	-	-	260	-	260	ns
		OE to B		-	-	-	-	-	200	-	200	ns
t_t	transition time	A port		-	-	-	-	0.7	2.5	0.7	2.5	ns
		B port		-	-	-	-	0.5	2.5	0.4	2.7	ns
$t_{sk(o)}$	skew	between channels	[3]	-	-	-	-	-	0.5	-	0.5	ns
t_W	pulse width	data inputs		-	-	-	-	10	-	10	-	ns
f_{data}	data rate			-	-	-	-	-	100	-	100	Mbps

[1] t_{pd} is the same as t_{PLH} and t_{PHL}.
t_{en} is the same as t_{PZL} and t_{PZH}.
t_{dis} is the same as t_{PLZ} and t_{PHZ}.
t_t is the same as t_{THL} and t_{TLH}

[2] Delay between OE going LOW and when the outputs are actually disabled.

[3] Skew between any two outputs of the same package switching in the same direction.

Table 11. Dynamic characteristics for temperature range −40 °C to +125 °C[1]
Voltages are referenced to GND (ground = 0 V); for test circuit see Figure 8; for wave forms see Figure 6 and Figure 7.

Symbol	Parameter	Conditions		$V_{CC(B)}$								Unit
				1.8 V ± 0.15 V		2.5 V ± 0.2 V		3.3 V ± 0.3 V		5.0 V ± 0.5 V		
				Min	Max	Min	Max	Min	Max	Min	Max	
$V_{CC(A)}$ = 1.5 V ± 0.1 V												
t_{pd}	propagation delay	A to B		1.4	15.9	1.2	13.1	1.1	13.0	0.8	12.9	ns
		B to A		0.9	17.2	0.7	15.0	0.4	14.7	0.3	16.7	ns
t_{en}	enable time	OE to A, B		-	1.0	-	1.0	-	1.0	-	1.0	μs
t_{dis}	disable time	OE to A; no external load	[2]	1.0	13.5	1.0	13.5	1.0	13.5	1.0	13.5	ns
		OE to B; no external load	[2]	1.0	19.9	1.0	16.8	1.0	16.1	1.0	15.2	ns
		OE to A		-	340	-	280	-	280	-	300	ns
		OE to B		-	220	-	220	-	220	-	220	ns
t_t	transition time	A port		0.9	7.1	0.9	7.1	0.9	7.1	0.9	7.1	ns
		B port		0.9	6.5	0.6	5.2	0.5	4.8	0.4	4.7	ns
$t_{sk(o)}$	skew	between channels	[3]	-	0.5	-	0.5	-	0.5	-	0.5	ns
t_W	pulse width	data inputs		25	-	25	-	25	-	25	-	ns
f_{data}	data rate			-	40	-	40	-	40	-	40	Mbps
$V_{CC(A)}$ = 1.8 V ± 0.15 V												
t_{pd}	propagation delay	A to B		1.6	14.0	1.4	10.7	1.3	9.8	1.2	9.5	ns
		B to A		1.5	15.0	1.3	11.4	1.0	10.6	0.9	10.1	ns
t_{en}	enable time	OE to A, B		-	1.0	-	1.0	-	1.0	-	1.0	μs
t_{dis}	disable time	OE to A; no external load	[2]	1.0	12.3	1.0	12.3	1.0	12.3	1.0	12.3	ns
		OE to B; no external load	[2]	1.0	18.1	1.0	15.3	1.0	14.5	1.0	13.5	ns
		OE to A		-	280	-	250	-	250	-	250	ns
		OE to B		-	220	-	220	-	220	-	220	ns
t_t	transition time	A port		0.8	6.2	0.8	6.1	0.8	6.1	0.8	6.1	ns
		B port		0.9	5.8	0.6	5.2	0.5	4.8	0.4	4.7	ns
$t_{sk(o)}$	skew	between channels	[3]	-	0.5	-	0.5	-	0.5	-	0.5	ns
t_W	pulse width	data inputs		22	-	19	-	19	-	19	-	ns
f_{data}	data rate			-	45	-	55	-	55	-	55	Mbps
$V_{CC(A)}$ = 2.5 V ± 0.2 V												
t_{pd}	propagation delay	A to B		-	-	1.1	9.3	1.0	8.2	0.9	7.7	ns
		B to A		-	-	1.2	9.6	1.1	8.1	0.9	7.4	ns
t_{en}	enable time	OE to A, B		-	-	-	1.0	-	1.0	-	1.0	μs
t_{dis}	disable time	OE to A; no external load	[2]	-	-	1.0	10.1	1.0	10.1	1.0	10.1	ns
		OE to B; no external load	[2]	-	-	1.0	13.5	1.0	12.7	1.0	11.7	ns
		OE to A		-	-	-	220	-	220	-	220	ns
		OE to B		-	-	-	220	-	220	-	220	ns
t_t	transition time	A port		-	-	0.7	5.0	0.7	5.0	0.7	5.0	ns
		B port		-	-	0.7	4.6	0.5	4.8	0.4	4.7	ns
$t_{sk(o)}$	skew	between channels	[3]	-	-	-	0.5	-	0.5	-	0.5	ns
t_W	pulse width	data inputs;		-	-	14	-	13	-	10	-	ns

Table 11. Dynamic characteristics for temperature range −40 °C to +125 °C[1]
Voltages are referenced to GND (ground = 0 V); for test circuit see Figure 8; for wave forms see Figure 6 and Figure 7.

Symbol	Parameter	Conditions		$V_{CC(B)}$								Unit
				1.8 V ± 0.15 V		2.5 V ± 0.2 V		3.3 V ± 0.3 V		5.0 V ± 0.5 V		
				Min	Max	Min	Max	Min	Max	Min	Max	
f_{data}	data rate			-	-	-	75	-	80	-	100	Mbps
$V_{CC(A)}$ = 3.3 V ± 0.3 V												
t_{pd}	propagation delay	A to B		-	-	-	-	0.9	7.7	0.8	7.0	ns
		B to A		-	-	-	-	1.0	7.9	0.9	6.8	ns
t_{en}	enable time	OE to A, B		-	-	-	-	-	1.0	-	1.0	µs
t_{dis}	disable time	OE to A; no external load	[2]	-	-	-	-	1.0	9.9	1.0	9.9	ns
		OE to B; no external load	[2]	-	-	-	-	1.0	12.1	1.0	10.9	ns
		OE to A		-	-	-	-	-	280	-	280	ns
		OE to B		-	-	-	-	-	220	-	220	ns
t_t	transition time	A port		-	-	-	-	0.7	4.5	0.7	4.5	ns
		B port		-	-	-	-	0.5	4.1	0.4	4.7	ns
$t_{sk(o)}$	skew	between channels	[3]	-	-	-	-	-	0.5	-	0.5	ns
t_W	pulse width	data inputs		-	-	-	-	10	-	10	-	ns
f_{data}	data rate			-	-	-	-	-	100	-	100	Mbps

[1] t_{pd} is the same as t_{PLH} and t_{PHL}.
t_{en} is the same as t_{PZL} and t_{PZH}.
t_{dis} is the same as t_{PLZ} and t_{PHZ}.
t_t is the same as t_{THL} and t_{TLH}

[2] Delay between OE going LOW and when the outputs are actually disabled.

[3] Skew between any two outputs of the same package switching in the same direction.

Table 12. Typical power dissipation capacitance

Voltages are referenced to GND (ground = 0 V).[1][2]

Symbol	Parameter	Conditions	$V_{CC(A)}$							Unit
			1.2 V	1.2 V	1.5 V	1.8 V	2.5 V	2.5 V	3.3 V	
			$V_{CC(B)}$							
			1.8 V	5.0 V	1.8 V	1.8 V	2.5 V	5.0 V	3.3 V to 5.0 V	
T_{amb} = 25 °C										
C_{PD}	power dissipation capacitance	outputs enabled; OE = $V_{CC(A)}$								
		A port: (direction A to B)	5	5	5	5	5	5	5	pF
		A port: (direction B to A)	8	8	8	8	8	8	8	pF
		B port: (direction A to B)	18	18	18	18	18	18	18	pF
		B port: (direction B to A)	13	16	12	12	12	12	13	pF
		outputs disabled; OE = GND								
		A port: (direction A to B)	0.12	0.12	0.04	0.05	0.08	0.08	0.07	pF
		A port: (direction B to A)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	pF
		B port: (direction A to B)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	pF
		B port: (direction B to A)	0.07	0.09	0.07	0.07	0.05	0.09	0.09	pF

[1] C_{PD} is used to determine the dynamic power dissipation (P_D in μW).

$P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \Sigma(C_L \times V_{CC}^2 \times f_o)$ where:

f_i = input frequency in MHz;

f_o = output frequency in MHz;

C_L = load capacitance in pF;

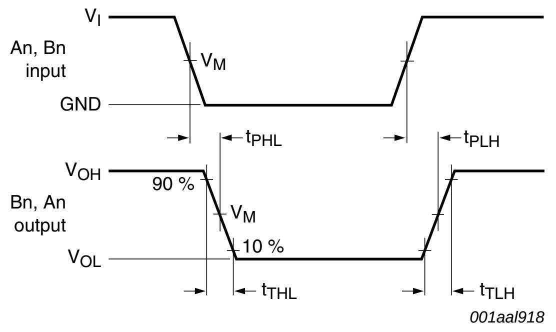
V_{CC} = supply voltage in V;

N = number of inputs switching;

$\Sigma(C_L \times V_{CC}^2 \times f_o)$ = sum of the outputs.

[2] f_i = 10 MHz; V_I = GND to V_{CC}; $t_r = t_f$ = 1 ns; C_L = 0 pF; $R_L = \infty\ \Omega$.

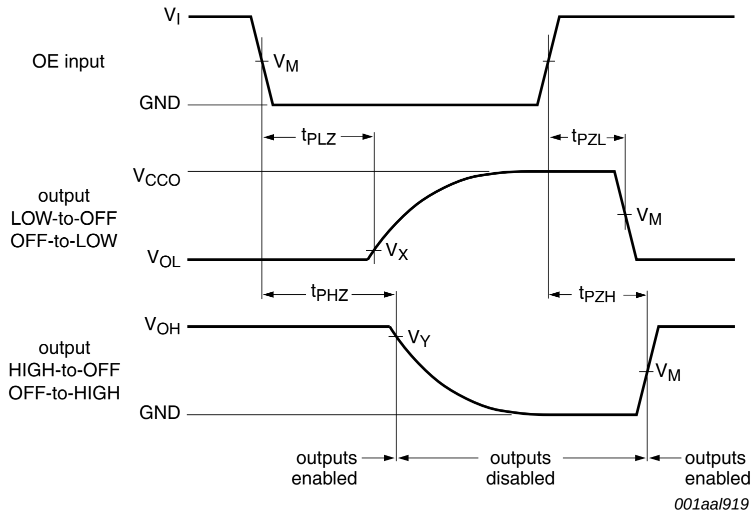
12. Waveforms



Measurement points are given in Table 13.

V_{OL} and V_{OH} are typical output voltage levels that occur with the output load.

Fig 6. The data input (An, Bn) to data output (Bn, An) propagation delay times



Measurement points are given in Table 13.

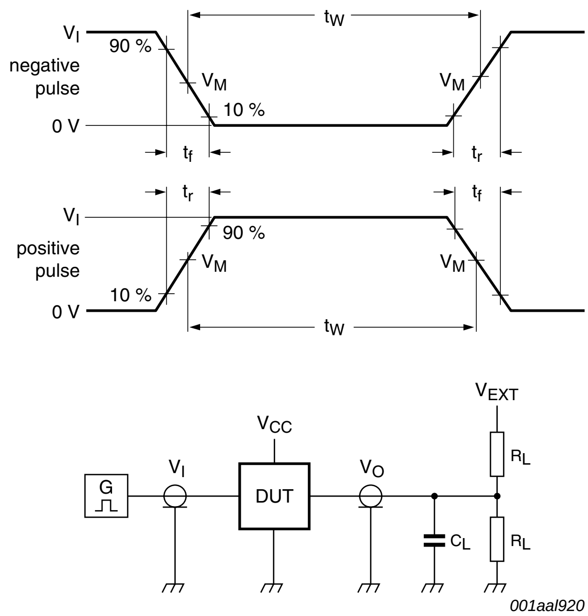
V_{OL} and V_{OH} are typical output voltage levels that occur with the output load.

Fig 7. Enable and disable times

Table 13. Measurement points[1]

Supply voltage	Input	Output		
V_{CCO}	V_M	V_M	V_X	V_Y
1.2 V	$0.5V_{CCI}$	$0.5V_{CCO}$	V_{OL} + 0.1 V	V_{OH} − 0.1 V
1.5 V ± 0.1 V	$0.5V_{CCI}$	$0.5V_{CCO}$	V_{OL} + 0.1 V	V_{OH} − 0.1 V
1.8 V ± 0.15 V	$0.5V_{CCI}$	$0.5V_{CCO}$	V_{OL} + 0.15 V	V_{OH} − 0.15 V
2.5 V ± 0.2 V	$0.5V_{CCI}$	$0.5V_{CCO}$	V_{OL} + 0.15 V	V_{OH} − 0.15 V
3.3 V ± 0.3 V	$0.5V_{CCI}$	$0.5V_{CCO}$	V_{OL} + 0.3 V	V_{OH} − 0.3 V
5.0 V ± 0.5 V	$0.5V_{CCI}$	$0.5V_{CCO}$	V_{OL} + 0.3 V	V_{OH} − 0.3 V

[1] V_{CCI} is the supply voltage associated with the input and V_{CCO} is the supply voltage associated with the output.



Test data is given in Table 14.

All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz; Z_O = 50 Ω; dV/dt ≥ 1.0 V/ns.

R_L = Load resistance.

C_L = Load capacitance including jig and probe capacitance.

V_{EXT} = External voltage for measuring switching times.

Fig 8. Test circuit for measuring switching times

Table 14. Test data

Supply voltage		Input		Load		V_{EXT}		
$V_{CC(A)}$	$V_{CC(B)}$	V_I[1]	Δt/ΔV	C_L	R_L[2]	t_{PLH}, t_{PHL}	t_{PZH}, t_{PHZ}	t_{PZL}, t_{PLZ}[3]
1.2 V to 3.6 V	1.65 V to 5.5 V	V_{CCI}	≤ 1.0 ns/V	15 pF	50 kΩ, 1 MΩ	open	open	$2V_{CCO}$

[1] V_{CCI} is the supply voltage associated with the input.

[2] For measuring data rate, pulse width, propagation delay and output rise and fall measurements, R_L = 1 MΩ; for measuring enable and disable times, R_L = 50 KΩ.

[3] V_{CCO} is the supply voltage associated with the output.

13. Application information

13.1 Applications

Voltage level-translation applications. The NTB0104 can be used to interface between devices or systems operating at different supply voltages. See Figure 9 for a typical operating circuit using the NTB0104.

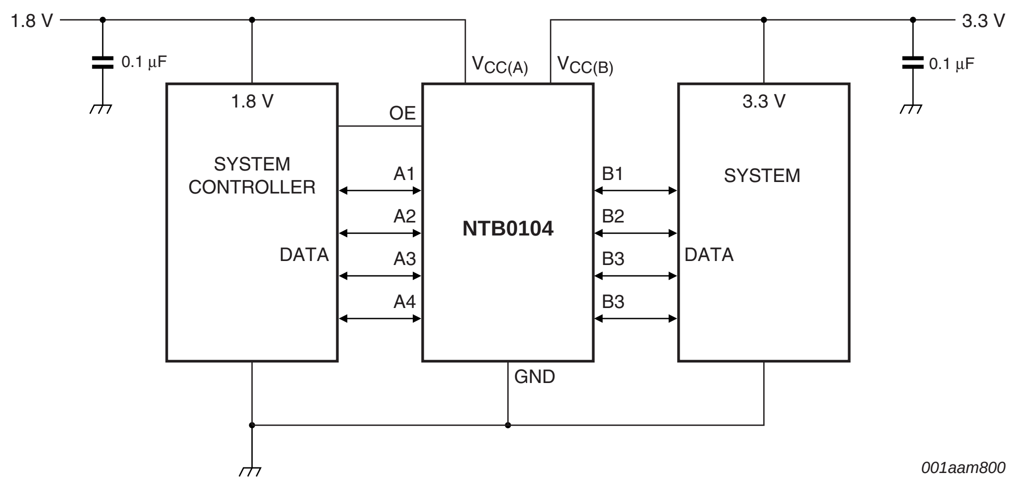


Fig 9. Typical operating circuit

13.2 Architecture

The architecture of the NTB0104 is shown in Figure 10. The device does not require an extra input signal to control the direction of data flow from A to B or from B to A. In a static state, the output drivers of the NTB0104 can maintain a defined output level, but the output architecture is designed to be weak, so that they can be overdriven by an external driver when data on the bus starts flowing in the opposite direction. The output one shots detect rising or falling edges on the A or B ports. During a rising edge, the one shots turn on the PMOS transistors (T1, T3) for a short duration, accelerating the low-to-high transition. Similarly, during a falling edge, the one shots turn on the NMOS transistors (T2, T4) for a short duration, accelerating the high-to-low transition. During output transitions the typical output impedance is 70 Ω at V_{CCO} = 1.2 V to 1.8 V, 50 Ω at V_{CCO} = 1.8 V to 3.3 V and 40 Ω at V_{CCO} = 3.3 V to 5.0 V.

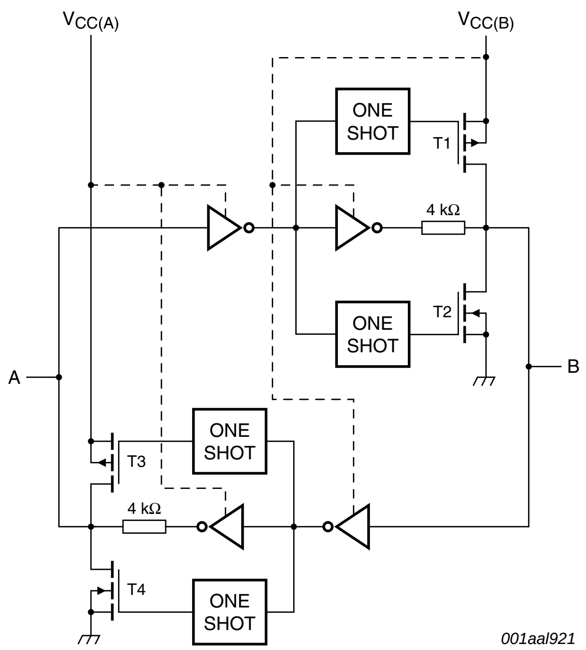
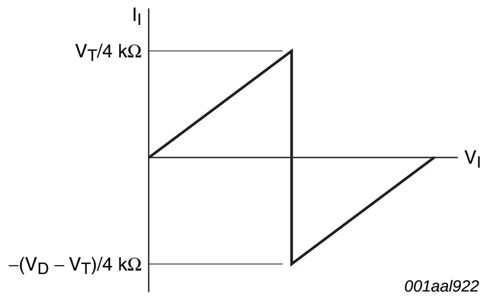


Fig 10. Architecture of NTB0104 I/O cell (one channel)

13.3 Input driver requirements

For correct operation, the device driving the data I/Os of the NTB0104 must have a minimum drive capability of ±2 mA See Figure 11 for a plot of typical input current versus input voltage.



V_T: input threshold voltage of the NTB0104 (typically V_{CCI} / 2).

V_D: supply voltage of the external driver.

Fig 11. Typical input current versus input voltage graph

13.4 Power up

During operation $V_{CC(A)}$ must never be higher than $V_{CC(B)}$, however during power-up $V_{CC(A)} \geq V_{CC(B)}$ does not damage the device, so either power supply can be ramped up first. There is no special power-up sequencing required. The NTB0104 includes circuitry that disables all output ports when either $V_{CC(A)}$ or $V_{CC(B)}$ is switched off.

13.5 Enable and disable

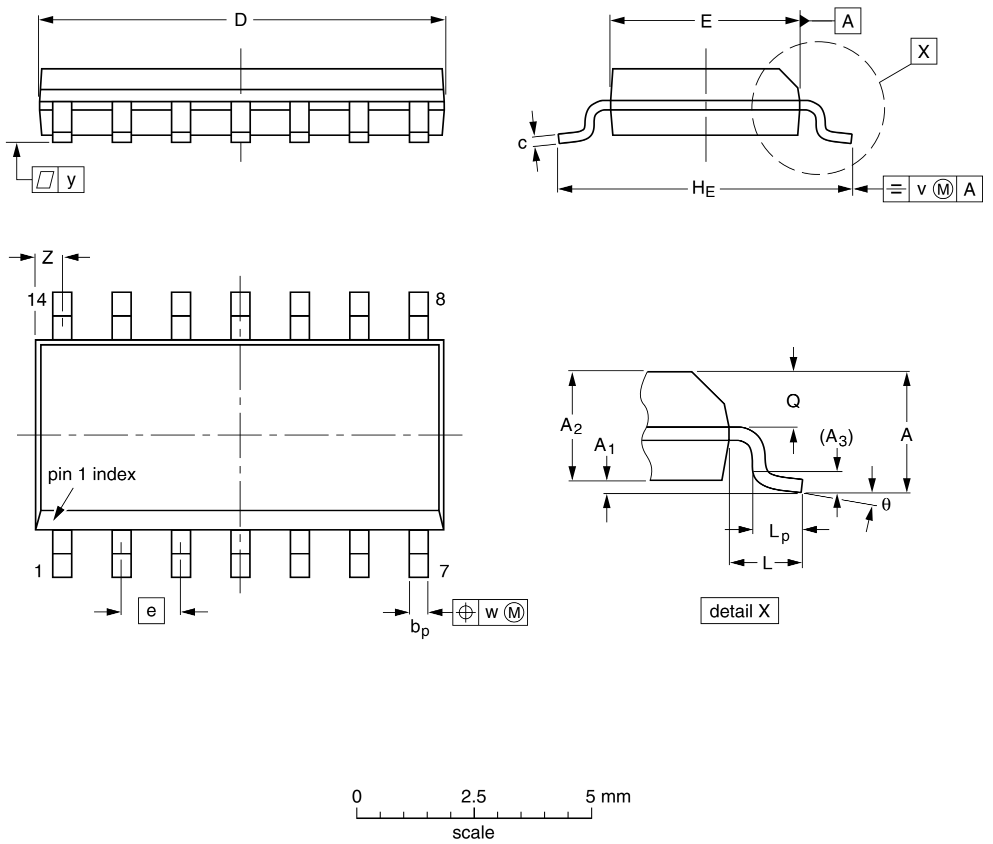
An output enable input (OE) is used to disable the device. Setting OE = LOW causes all I/Os to assume the high-impedance OFF-state. The disable time (t_{dis} with no external load) indicates the delay between when OE goes LOW and when outputs actually become disabled. The enable time (t_{en}) indicates the amount of time the user must allow for one one-shot circuitry to become operational after OE is taken HIGH. To ensure the high-impedance OFF-state during power-up or power-down, pin 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.

13.6 Pull-up or pull-down resistors on I/O lines

As mentioned previously the NTB0104 is designed with low static drive strength to drive capacitive loads of up to 70 pF. To avoid output contention issues, any pull-up or pull-down resistors used must be kept higher than 50 kΩ. For this reason the NTB0104 is not recommended for use in open drain driver applications such as 1-Wire or I^2C. For these applications, the NTS0104 level translator is recommended.

14. Package outline

SO14: plastic small outline package; 14 leads; body width 3.9 mm **SOT108-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(1)}$	e	H_E	L	L_p	Q	v	w	y	$Z^{(1)}$	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	8.75 8.55	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8^{o} 0^{o}
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.35 0.34	0.16 0.15	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

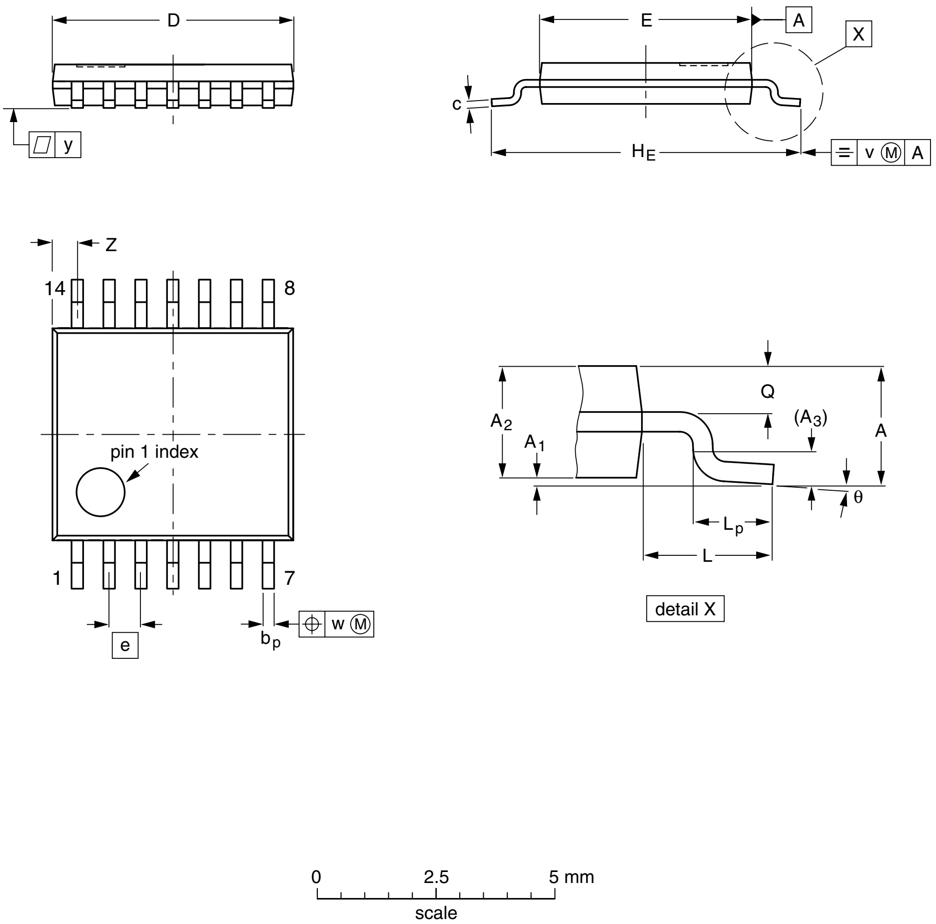
Note

1. Plastic or metal protrusions of 0.15 mm (0.006 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT108-1	076E06	MS-012				~~99-12-27~~ 03-02-19

Fig 12. Package outline SOT108-1 (SO14)

TSSOP14: plastic thin shrink small outline package; 14 leads; body width 4.4 mm **SOT402-1**



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D (1)	E (2)	e	H_E	L	L_p	Q	v	w	y	Z (1)	θ
mm	1.1	0.15 0.05	0.95 0.80	0.25	0.30 0.19	0.2 0.1	5.1 4.9	4.5 4.3	0.65	6.6 6.2	1	0.75 0.50	0.4 0.3	0.2	0.13	0.1	0.72 0.38	8° 0°

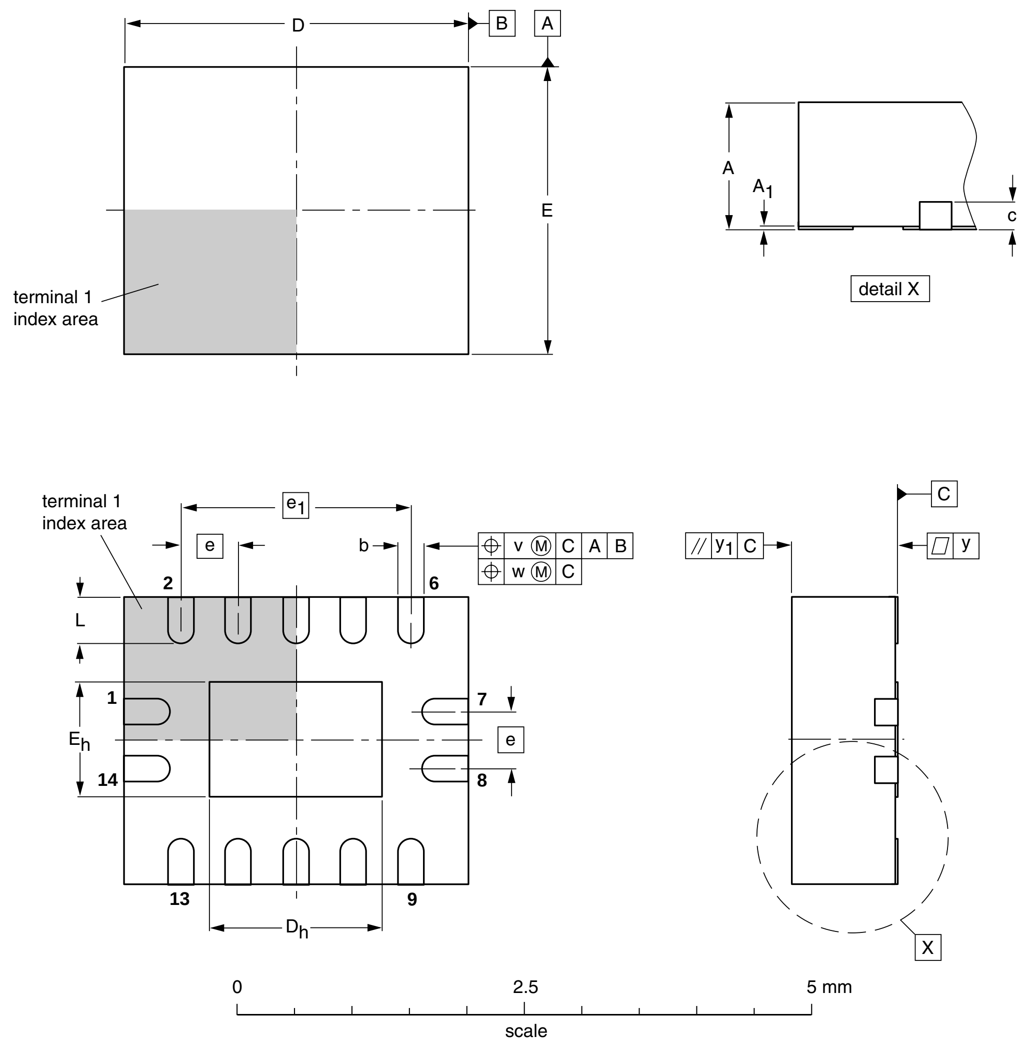
Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT402-1		MO-153				~~99-12-27~~ 03-02-18

Fig 13. Package outline SOT402-1 (TSSOP14)

DHVQFN14: plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 14 terminals; body 2.5 x 3 x 0.85 mm **SOT762-1**



DIMENSIONS (mm are the original dimensions)

UNIT	A(1) max.	A_1	b	c	D(1)	D_h	E(1)	E_h	e	e_1	L	v	w	y	y_1
mm	1	0.05 0.00	0.30 0.18	0.2	3.1 2.9	1.65 1.35	2.6 2.4	1.15 0.85	0.5	2	0.5 0.3	0.1	0.05	0.05	0.1

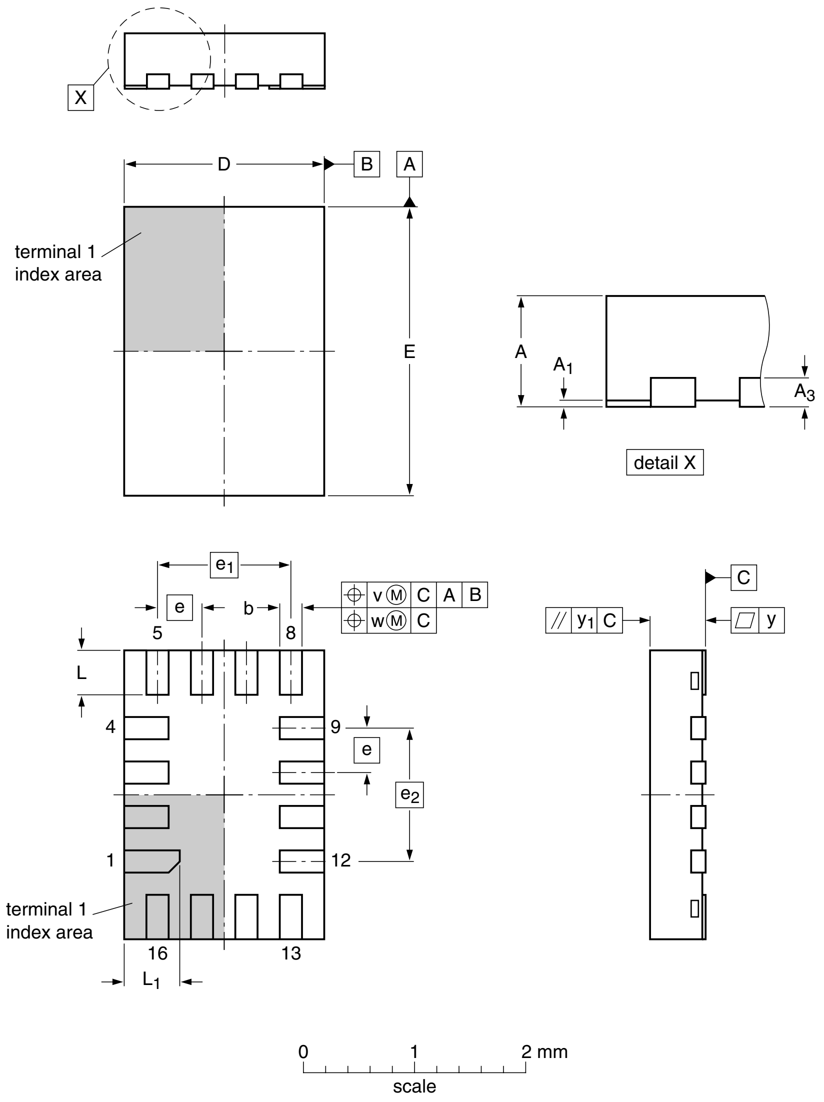
Note

1. Plastic or metal protrusions of 0.075 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT762-1	- - -	MO-241	- - -			~~02-10-17~~ 03-01-27

Fig 14. Package outline SOT762-1 (DHVQFN14)

XQFN16: plastic, extremely thin quad flat package; no leads;
16 terminals; body 1.80 x 2.60 x 0.50 mm **SOT1161-1**



Dimensions

Unit[1]		A	A_1	A_3	b	D	E	e	e_1	e_2	L	L_1	v	w	y	y_1
	max	0.5	0.05		0.25	1.9	2.7				0.45	0.55				
mm	nom			0.127	0.20	1.8	2.6	0.4	1.2	1.2	0.40	0.50	0.1	0.05	0.05	0.05
	min		0.00		0.15	1.7	2.5				0.35	0.45				

Note
1. Plastic or metal protrusions of 0.075 mm maximum per side are not included.

sot1161-1_po

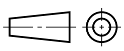
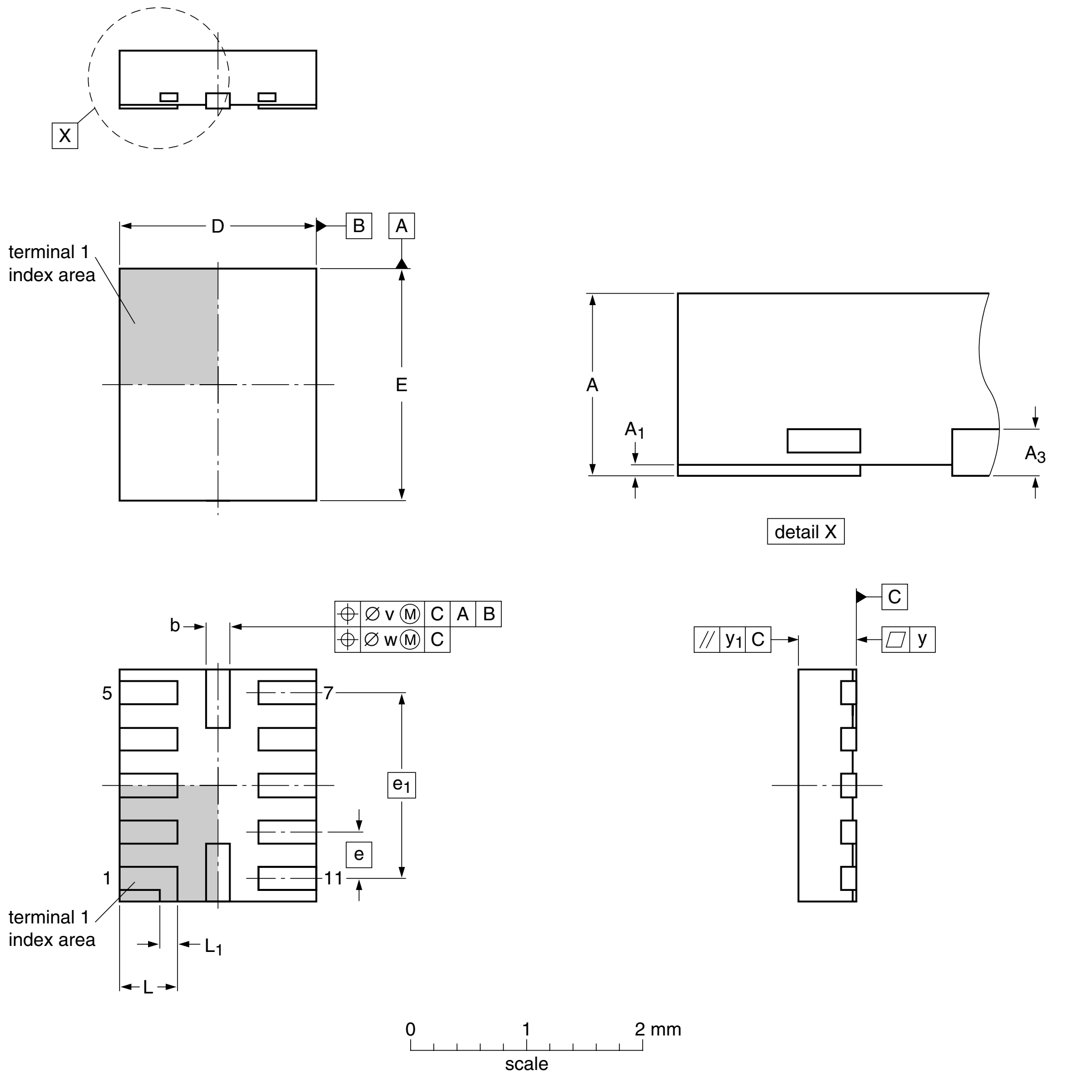
Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOT1161-1	- - -	- - -	- - -			~~09-12-28~~ 09-12-29

Fig 15. Package outline SOT1161-1 (XQFN16)

XQFN12: plastic, extremely thin quad flat package; no leads;
12 terminals; body 1.70 x 2.00 x 0.50 mm **SOT1174-1**



Dimensions

Unit(1)		A	A_1	A_3	b	D	E	e	e_1	L	L_1	v	w	y	y_1
mm	max	0.5	0.05		0.25	1.8	2.1			0.55					
	nom			0.127	0.20	1.7	2.0	0.4	1.6	0.50	0.15	0.1	0.05	0.05	0.05
	min		0.00		0.15	1.6	1.9			0.45					

Note
1. Plastic or metal protrusions of 0.075 mm maximum per side are not included.

sot1174-1_po

Outline version	References: IEC	JEDEC	JEITA		European projection	Issue date
SOT1174-1	- - -	MO-288	- - -			10-04-07 10-04-21

Fig 16. Package outline SOT1174 (XQFN12)

15. Abbreviations

Table 15. Abbreviations

Acronym	Description
CDM	Charged Device Model
CMOS	Complementary Metal Oxide Semiconductor
DUT	Device Under Test
ESD	ElectroStatic Discharge
HBM	Human Body Model
MM	Machine Model

16. Revision history

Table 16. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
NTB0104 v.1	20101026	Product data sheet	-	-

17. Legal information

17.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

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