

# HEF4104B

## Quad low-to-high voltage translator with 3-state outputs

Rev. 9 — 29 March 2016

Product data sheet

### 1. General description

The HEF4104B is a quad low voltage-to-high voltage translator with 3-state outputs. It provides the capability of interfacing low voltage circuits to high voltage circuits. For example low voltage Local Oxidation Complementary MOS (LOC MOS) and Transistor-Transistor Logic (TTL) to high voltage LOC MOS. It has four data inputs (A0 to A3), an active HIGH output enable input (OE), four data outputs (B0 to B3) and their complements ( $\overline{B0}$  to  $\overline{B3}$ ).

With OE = HIGH, the outputs B0 to B3 and  $\overline{B0}$  to  $\overline{B3}$  are in the low impedance ON-state, either HIGH or LOW as determined by the inputs A0 to A3. With OE = LOW, the outputs B0 to B3 and  $\overline{B0}$  to  $\overline{B3}$  are in the high-impedance OFF-state.

It uses a common negative supply ( $V_{SS}$ ) and separate positive supplies for the inputs ( $V_{DD(A)}$ ) and the outputs ( $V_{DD(B)}$ ).  $V_{DD(A)}$  must always be less than or equal to  $V_{DD(B)}$ , even during power turn-on and turn-off. For the permissible operating range of  $V_{DD(A)}$  and  $V_{DD(B)}$  see [Figure 4](#).

Each input protection circuit is terminated between  $V_{DD(B)}$  and  $V_{SS}$ . This allows the input signals to be driven from any potential between  $V_{DD(B)}$  and  $V_{SS}$ , without regard to current limiting. When driving from potentials greater than  $V_{DD(B)}$  or less than  $V_{SS}$ , the current at each input must be limited to 10 mA.

It operates over a recommended  $V_{DD}$  power supply range of 3 V to 15 V referenced to  $V_{SS}$  (usually ground). Unused inputs must be connected to  $V_{DD}$ ,  $V_{SS}$ , or another input.

### 2. Features and benefits

- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- Inputs and outputs are protected against electrostatic effects
- Specified from  $-40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$
- Complies with JEDEC standard JESD 13-B

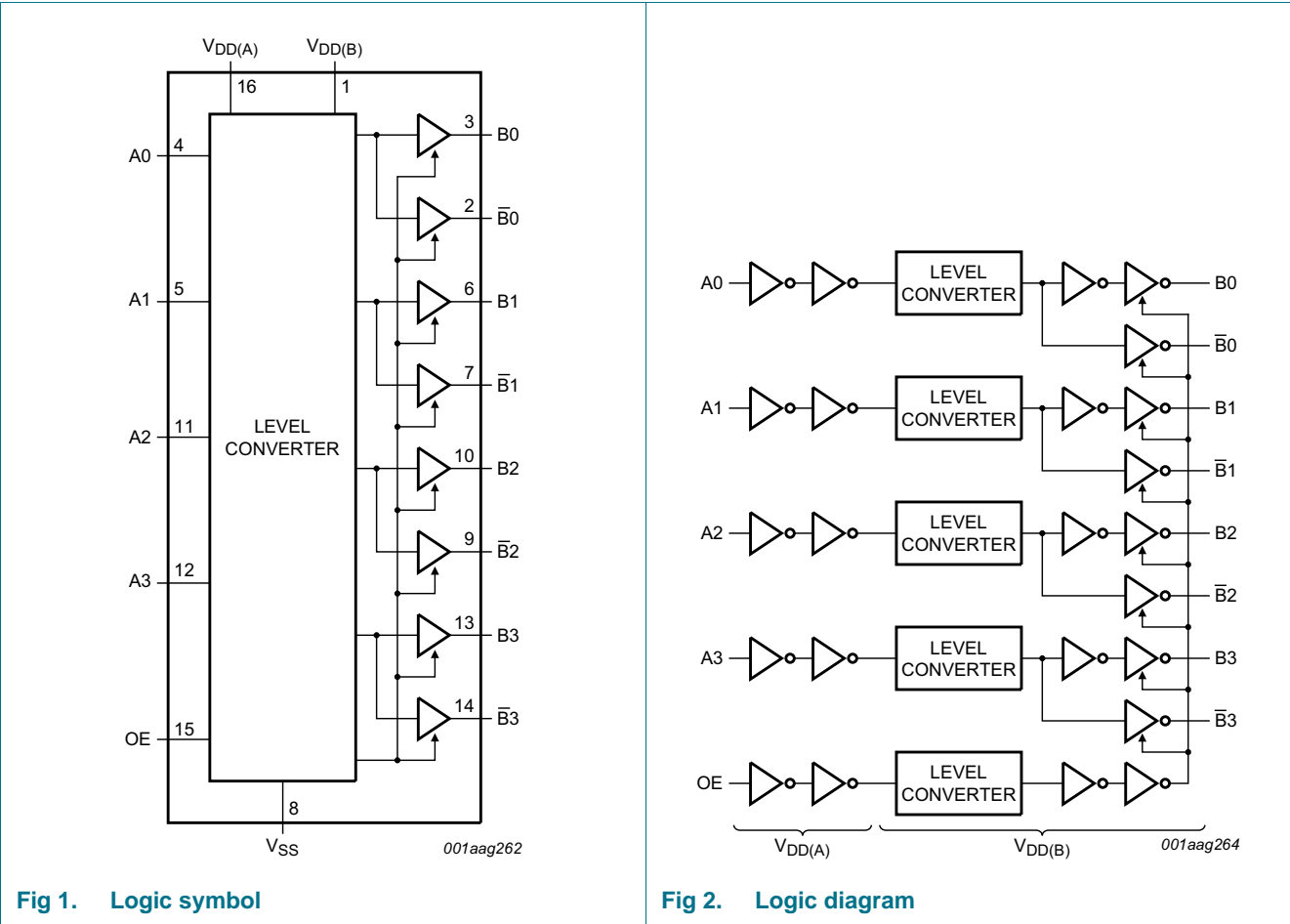
### 3. Ordering information

**Table 1.** Ordering information

All types operate from  $-40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$ .

Type number	Package		
	Name	Description	Version
HEF4104BT	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1

4. Functional diagram



The logic diagram shows the internal structure of the HEF4104B. It consists of four identical stages, one for each bit (0, 1, 2, 3). Each stage takes an input A<sub>i</sub> and produces two outputs: B<sub>i</sub> and B̄<sub>i</sub>. The input A<sub>i</sub> is first inverted by a CMOS inverter. The output of this inverter then passes through a "LEVEL CONVERTER" block. The output of the level converter is connected to the inputs of two more CMOS inverters. The outputs of these two inverters are B<sub>i</sub> and B̄<sub>i</sub>. The power supply pins are indicated at the bottom: VDD(A) for the input inverters and VDD(B) for the output inverters. The identifier "001aag264" is at the bottom right.

5. Pinning information

5.1 Pinning

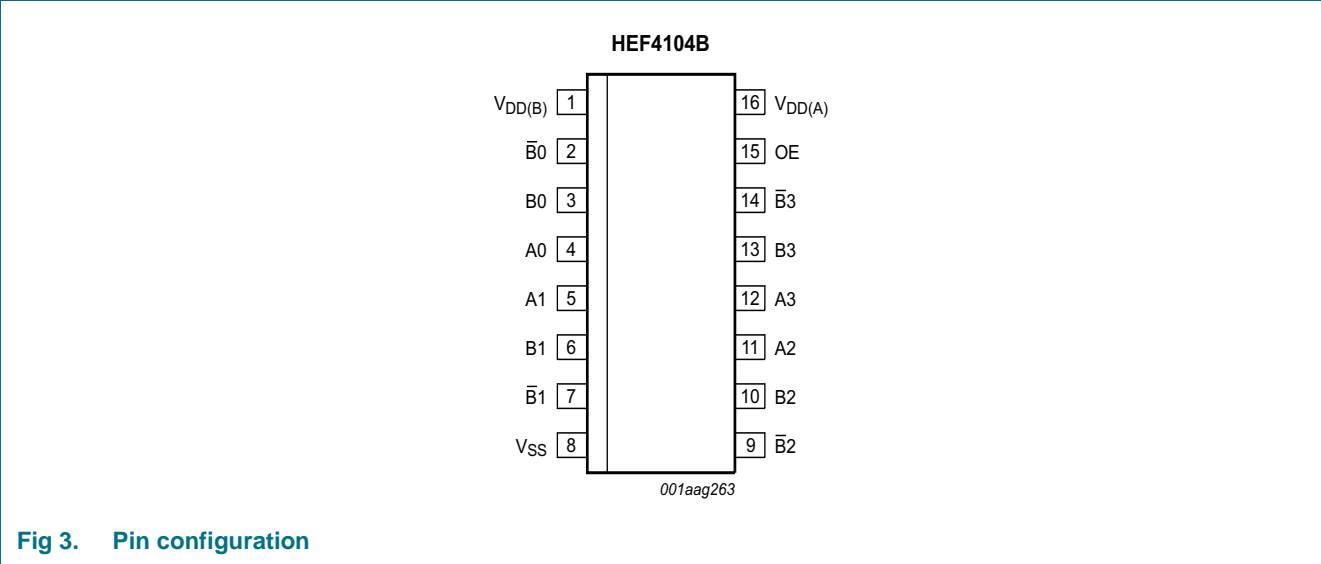


Fig 3. Pin configuration

5.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
$V_{DD}(B)$	1	supply voltage port B
$\overline{B}0$ to $\overline{B}3$	2, 7, 9, 14	complementary data output
$B0$ to $B3$	3, 6, 10, 13	data output
$A0$ to $A3$	4, 5, 11, 12	data input
$V_{SS}$	8	common negative supply voltage (0 V)
$OE$	15	output enable input
$V_{DD}(A)$	16	supply voltage port A

6. Functional description

Table 3. Function table<sup>[1]</sup>

Control	Output	
$OE$	$B_n$	$\overline{B}_n$
H	$A_n$	$\overline{A}_n$
L	Z	Z

[1] H = HIGH voltage level; L = LOW voltage level; Z = high-impedance OFF-state.

## 7. Limiting values

**Table 4. Limiting values**

In accordance with the Absolute Maximum Rating System (IEC 60134). Voltages are referenced to  $V_{SS} = 0$  V (ground).

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{DD(A)}$	supply voltage A	port A; $V_{DD(A)} \leq V_{DD(B)}$	-0.5	+18	V
$V_{DD(B)}$	supply voltage B	port B; $V_{DD(B)} \geq V_{DD(A)}$	-0.5	+18	V
$I_{IK}$	input clamping current	$V_I < -0.5$ V or $V_I > V_{DD(A)} + 0.5$ V	-	$\pm 10$	mA
$V_I$	input voltage		-0.5	$V_{DD(A)} + 0.5$	V
$I_{OK}$	output clamping current	$V_O < -0.5$ V or $V_O > V_{DD(B)} + 0.5$ V	-	$\pm 10$	mA
$I_{I/O}$	input/output current		-	$\pm 10$	mA
$I_{DD}$	supply current	[1]	-	50	mA
$T_{stg}$	storage temperature		-65	+150	°C
$T_{amb}$	ambient temperature		-40	+85	°C
$P_{tot}$	total power dissipation	$T_{amb} = -40$ °C to +85 °C			
		SO16 [2]	-	500	mW
$P$	power dissipation	per output	-	100	mW

[1]  $I_{DD}$  is the combined current of  $I_{DD(A)}$  and  $I_{DD(B)}$ .

[2] For SO16 packages: above  $T_{amb} = 70$  °C,  $P_{tot}$  derates linearly at 8 mW/K.

## 8. Recommended operating conditions

**Table 5. Recommended operating conditions**

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{DD(A)}$	supply voltage A		3	-	$\leq V_{DD(B)}$	V
$V_{DD(B)}$	supply voltage B		$\geq V_{DD(A)}$	-	15	V
$V_I$	input voltage		0	-	$V_{DD(A)}$	V
$T_{amb}$	ambient temperature	in free air	-40	-	+85	°C
$\Delta t/\Delta V$	input transition rise and fall rate	$V_{DD(A)} = 5$ V	-	-	3.75	$\mu\text{s/V}$
		$V_{DD(A)} = 10$ V	-	-	0.5	$\mu\text{s/V}$
		$V_{DD(A)} = 15$ V	-	-	0.08	$\mu\text{s/V}$

## 9. Static characteristics

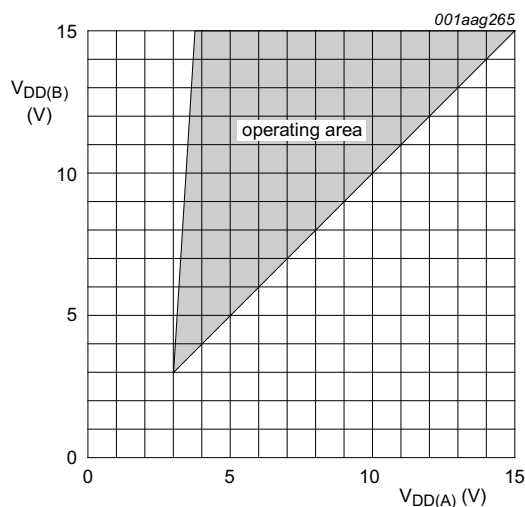
**Table 6. Static characteristics**

$V_{DD(A)} = V_{DD(B)}$ ;  $V_{SS} = 0$  V;  $V_I = V_{SS}$  or  $V_{DD(A)}$ ; unless otherwise specified.

Symbol	Parameter	Conditions	$V_{DD}$ <sup>[1]</sup>	$T_{amb} = -40$ °C		$T_{amb} = +25$ °C		$T_{amb} = +85$ °C		Unit
				Min	Max	Min	Max	Min	Max	
$V_{IH}$	HIGH-level input voltage	$ I_O  < 1$ $\mu$ A	5 V	3.5	-	3.5	-	3.5	-	V
			10 V	7.0	-	7.0	-	7.0	-	V
			15 V	11.0	-	11.0	-	11.0	-	V
$V_{IL}$	LOW-level input voltage	$ I_O  < 1$ $\mu$ A	5 V	-	1.5	-	1.5	-	1.5	V
			10 V	-	3.0	-	3.0	-	3.0	V
			15 V	-	4.0	-	4.0	-	4.0	V
$V_{OH}$	HIGH-level output voltage	$ I_O  < 1$ $\mu$ A	5 V	4.95	-	4.95	-	4.95	-	V
			10 V	9.95	-	9.95	-	9.95	-	V
			15 V	14.95	-	14.95	-	14.95	-	V
$V_{OL}$	LOW-level output voltage	$ I_O  < 1$ $\mu$ A	5 V	-	0.05	-	0.05	-	0.05	V
			10 V	-	0.05	-	0.05	-	0.05	V
			15 V	-	0.05	-	0.05	-	0.05	V
$I_{OH}$	HIGH-level output current	$V_O = 2.5$ V	5 V	-	-1.7	-	-1.4	-	-1.1	mA
		$V_O = 4.6$ V	5 V	-	-0.52	-	-0.44	-	-0.36	mA
		$V_O = 9.5$ V	10 V	-	-1.3	-	-1.1	-	-0.9	mA
		$V_O = 13.5$ V	15 V	-	-3.6	-	-3.0	-	-2.4	mA
$I_{OL}$	LOW-level output current	$V_O = 0.4$ V	5 V	0.52	-	0.44	-	0.36	-	mA
		$V_O = 0.5$ V	10 V	1.3	-	1.1	-	0.9	-	mA
		$V_O = 1.5$ V	15 V	3.6	-	3.0	-	2.4	-	mA
$I_I$	input leakage current		15 V	-	$\pm 0.3$	-	$\pm 0.3$	-	$\pm 1.0$	$\mu$ A
$I_{DD}$	supply current	all valid input combinations; $I_O = 0$ A	5 V <sup>[2]</sup>	-	20	-	20	-	150	$\mu$ A
			10 V	-	40	-	40	-	300	$\mu$ A
			15 V	-	80	-	80	-	600	$\mu$ A
$I_{OZ}$	OFF-state output current	HIGH level; $V_O = V_{DD(B)}$	15 V	-	1.6	-	1.6	-	12.0	$\mu$ A
		LOW level; $V_O = V_{SS}$	15 V	-	-1.6	-	-1.6	-	-12.0	$\mu$ A
$C_I$	input capacitance	digital inputs	-	-	-	-	7.5	-	-	pF

[1]  $V_{DD}$  is the same as  $V_{DD(A)}$  and  $V_{DD(B)}$ .

[2]  $I_{DD}$  is the combined current of  $I_{DD(A)}$  and  $I_{DD(B)}$ .



The shaded area shows the permissible operating range.

Fig 4.  $V_{DD(B)}$  as a function of  $V_{DD(A)}$

## 10. Dynamic characteristics

Table 7. Dynamic characteristics

$T_{amb} = 25\text{ }^{\circ}\text{C}$ ; for test circuit see [Figure 7](#); unless otherwise specified.

Symbol	Parameter	Conditions	Extrapolation formula <sup>[1]</sup>	Min	Typ	Max	Unit
$t_{PHL}$	HIGH to LOW propagation delay	An to Bn, $\overline{Bn}$ ; see <a href="#">Figure 5</a>					
		$V_{DD(A)} = V_{DD(B)} = 5\text{ V}$	$143\text{ ns} + (0.55\text{ ns/pF})C_L$	-	170	340	ns
		$V_{DD(A)} = V_{DD(B)} = 10\text{ V}$	$69\text{ ns} + (0.23\text{ ns/pF})C_L$	-	80	160	ns
		$V_{DD(A)} = V_{DD(B)} = 15\text{ V}$	$57\text{ ns} + (0.16\text{ ns/pF})C_L$	-	65	135	ns
$t_{PLH}$	LOW to HIGH propagation delay	An to Bn, $\overline{Bn}$ ; see <a href="#">Figure 5</a>					
		$V_{DD(A)} = V_{DD(B)} = 5\text{ V}$	$143\text{ ns} + (0.55\text{ ns/pF})C_L$	-	170	340	ns
		$V_{DD(A)} = V_{DD(B)} = 10\text{ V}$	$69\text{ ns} + (0.23\text{ ns/pF})C_L$	-	80	160	ns
		$V_{DD(A)} = V_{DD(B)} = 15\text{ V}$	$62\text{ ns} + (0.16\text{ ns/pF})C_L$	-	70	140	ns
$t_{THL}$	HIGH to LOW output transition time	Bn or $\overline{Bn}$ ; see <a href="#">Figure 6</a>					
		$V_{DD(A)} = V_{DD(B)} = 5\text{ V}$	$10\text{ ns} + (1.00\text{ ns/pF})C_L$	-	60	120	ns
		$V_{DD(A)} = V_{DD(B)} = 10\text{ V}$	$9\text{ ns} + (0.42\text{ ns/pF})C_L$	-	30	60	ns
		$V_{DD(A)} = V_{DD(B)} = 15\text{ V}$	$6\text{ ns} + (0.28\text{ ns/pF})C_L$	-	20	40	ns
$t_{TLH}$	LOW to HIGH output transition time	Bn or $\overline{Bn}$ ; see <a href="#">Figure 6</a>					
		$V_{DD(A)} = V_{DD(B)} = 5\text{ V}$	$10\text{ ns} + (1.00\text{ ns/pF})C_L$	-	60	120	ns
		$V_{DD(A)} = V_{DD(B)} = 10\text{ V}$	$9\text{ ns} + (0.42\text{ ns/pF})C_L$	-	30	60	ns
		$V_{DD(A)} = V_{DD(B)} = 15\text{ V}$	$6\text{ ns} + (0.28\text{ ns/pF})C_L$	-	20	40	ns
$t_{PHZ}$	HIGH to OFF-state propagation delay	OE to Bn, $\overline{Bn}$ ; see <a href="#">Figure 6</a>					
		$V_{DD(A)} = V_{DD(B)} = 5\text{ V}$		-	70	135	ns
		$V_{DD(A)} = V_{DD(B)} = 10\text{ V}$		-	55	110	ns
		$V_{DD(A)} = V_{DD(B)} = 15\text{ V}$		-	60	120	ns

**Table 7. Dynamic characteristics ...continued** $T_{amb} = 25\text{ }^{\circ}\text{C}$ ; for test circuit see [Figure 7](#); unless otherwise specified.

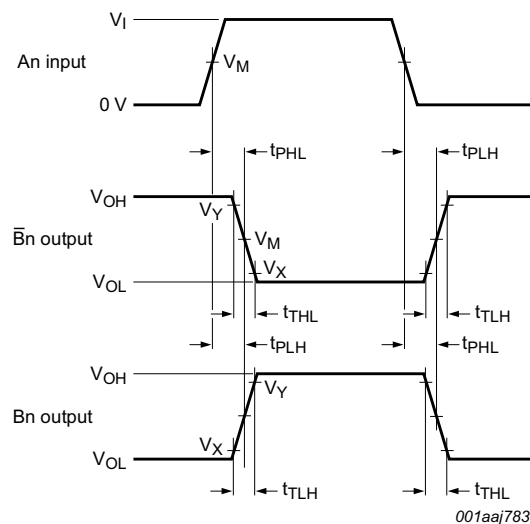
Symbol	Parameter	Conditions	Extrapolation formula <sup>[1]</sup>	Min	Typ	Max	Unit
t <sub>PLZ</sub>	LOW to OFF-state propagation delay	OE to Bn, $\overline{\text{Bn}}$ ; see <a href="#">Figure 6</a>					
		V <sub>DD(A)</sub> = V <sub>DD(B)</sub> = 5 V		-	70	135	ns
		V <sub>DD(A)</sub> = V <sub>DD(B)</sub> = 10 V		-	55	105	ns
		V <sub>DD(A)</sub> = V <sub>DD(B)</sub> = 15 V		-	55	110	ns
t <sub>PZH</sub>	OFF-state to HIGH propagation delay	OE to Bn, $\overline{\text{Bn}}$ ; see <a href="#">Figure 6</a>					
		V <sub>DD(A)</sub> = V <sub>DD(B)</sub> = 5 V		-	195	395	ns
		V <sub>DD(A)</sub> = V <sub>DD(B)</sub> = 10 V		-	95	195	ns
		V <sub>DD(A)</sub> = V <sub>DD(B)</sub> = 15 V		-	80	165	ns
t <sub>PZL</sub>	OFF-state to LOW propagation delay	OE to Bn, $\overline{\text{Bn}}$ ; see <a href="#">Figure 6</a>					
		V <sub>DD(A)</sub> = V <sub>DD(B)</sub> = 5 V		-	195	395	ns
		V <sub>DD(A)</sub> = V <sub>DD(B)</sub> = 10 V		-	95	190	ns
		V <sub>DD(A)</sub> = V <sub>DD(B)</sub> = 15 V		-	80	160	ns

[1] Typical value of the propagation delay and output transition time can be calculated with the extrapolation formula (C<sub>L</sub> in pF).**Table 8. Dynamic power dissipation** $V_{DD(A)} = V_{DD(B)}$ ;  $V_{SS} = 0\text{ V}$ ;  $t_r = t_f \leq 20\text{ ns}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

Symbol	Parameter	V <sub>DD</sub> <sup>[1]</sup>	Typical formula (μW)	where
P <sub>D</sub>	dynamic power dissipation	5 V	$P_D = 3000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	f <sub>i</sub> = input frequency in MHz; f <sub>o</sub> = output frequency in MHz; C <sub>L</sub> = output load capacitance in pF; Σ(f <sub>o</sub> × C <sub>L</sub> ) = sum of the outputs; V <sub>DD</sub> = supply voltage in V.
		10 V	$P_D = 12200 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	
		15 V	$P_D = 31000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	

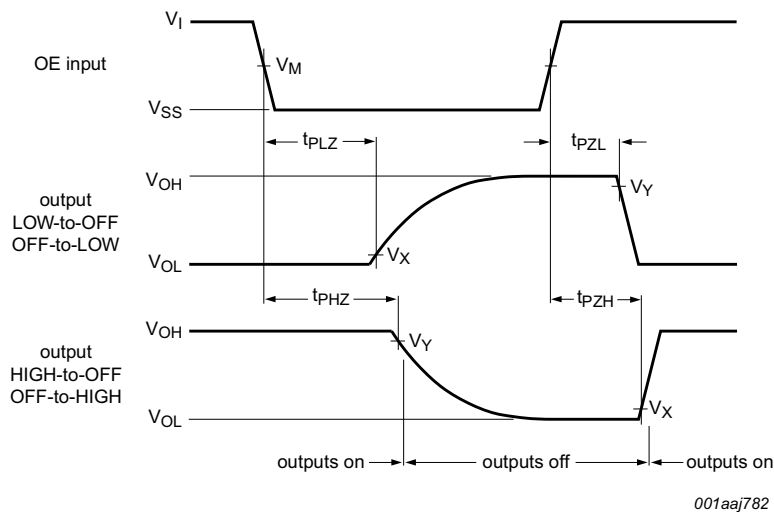
[1] V<sub>DD</sub> is the same as V<sub>DD(A)</sub> and V<sub>DD(B)</sub>.

11. Waveforms



Measurement points are given in [Table 9](#).  
Logic levels: V<sub>OL</sub> and V<sub>OH</sub> are typical output voltage levels that occur with the output load.

Fig 5. Data input (An) to data output (Bn, B̄n) propagation delays and output transition times



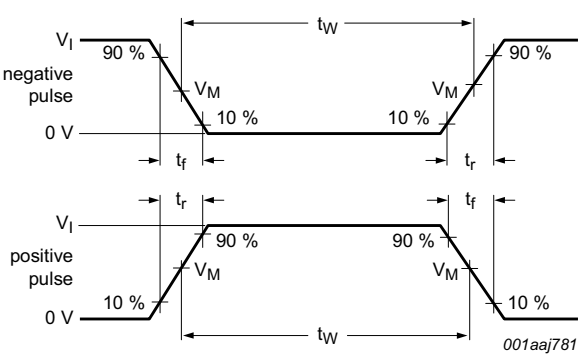
Measurement points are given in [Table 9](#).  
Logic levels: V<sub>OL</sub> and V<sub>OH</sub> are typical output voltage levels that occur with the output load.

Fig 6. Enable and disable times

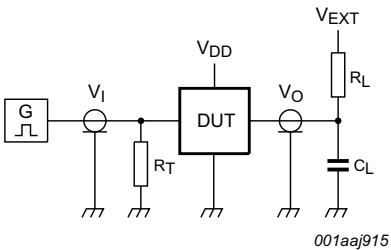
Table 9. Measurement points

Input		Output		
V <sub>I</sub>	V <sub>M</sub>	V <sub>M</sub>	V <sub>X</sub>	V <sub>Y</sub>
V <sub>SS</sub> or V <sub>DD(A)</sub>	0.5V <sub>DD(A)</sub>	0.5V <sub>DD(B)</sub>	0.1V <sub>DD(B)</sub>	0.9V <sub>DD(B)</sub>





a. Input waveforms



b. Test circuit

Test data given in [Table 10](#).  
Definitions for test circuit:  
DUT = Device Under Test.  
 $C_L$  = load capacitance including jig and probe capacitance.  
 $R_L$  = load resistance.  
 $R_T$  = termination resistance should be equal to the output impedance  $Z_o$  of the pulse generator.

Fig 7. Test circuit for measuring switching times

Table 10. Test data

Supplies	Input	Load		$V_{EXT}$		
$V_{DD(A)} = V_{DD(B)}$	$t_r, t_f$	$R_L$	$C_L$	$t_{PHL}, t_{PLH}$	$t_{PZL}, t_{PLZ}$	$t_{PZH}, t_{PHZ}$
5 V to 15 V	$\leq 20$ ns	1 k $\Omega$	50 pF	open	$V_{DD(B)}$	$V_{SS}$

12. Package outline

SO16: plastic small outline package; 16 leads; body width 3.9 mm

SOT109-1

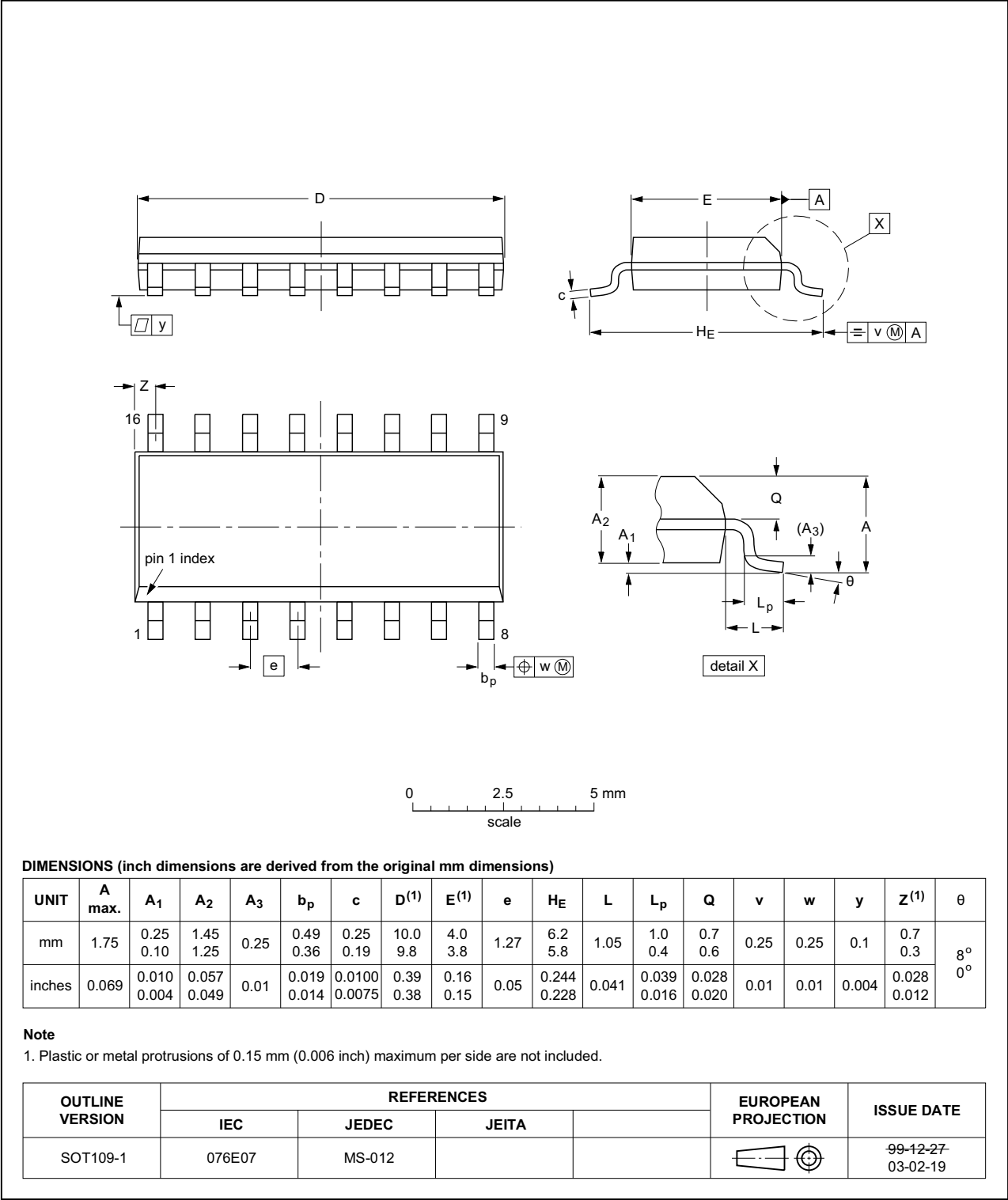


Fig 8. Package outline SOT109-1 (SO16)

## 13. Revision history

Table 11. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4104B v.9	20160329	Product data sheet	-	HEF4104B v.8
Modifications:	<ul style="list-style-type: none"> <li>Type number HEF4104BP (SOT38-4) removed.</li> </ul>			
HEF4104B v.8	20111111	Product data sheet	-	HEF4104B v.7
Modifications:	<ul style="list-style-type: none"> <li>Section Applications removed</li> <li><a href="#">Table 6</a>: I<sub>OH</sub> minimum values changed to maximum</li> </ul>			
HEF4104B v.7	20091216	Product data sheet	-	HEF4104B v.6
HEF4104B v.6	20091102	Product data sheet	-	HEF4104B v.5
HEF4104B v.5	20090728	Product data sheet	-	HEF4104B v.4
HEF4104B v.4	20090305	Product data sheet	-	HEF4104B_CNV v.3
HEF4104B_CNV v.3	19950101	Product specification	-	HEF4104B_CNV v.2
HEF4104B_CNV v.2	19950101	Product specification	-	-

## 14. Legal information

### 14.1 Data sheet status

Document status <sup>[1][2]</sup>	Product status <sup>[3]</sup>	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".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL <http://www.nexperia.com>.

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