

# HEF4051B

## 8-channel analog multiplexer/demultiplexer

Rev. 10 — 17 November 2011

Product data sheet

### 1. General description

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The HEF4051B is an 8-channel analog multiplexer/demultiplexer with three address inputs (S1 to S3), an active LOW enable input ( $\overline{E}$ ), eight independent inputs/outputs (Y0 to Y7) and a common input/output (Z). The device contains eight bidirectional analog switches, each with one side connected to an independent input/output (Y0 to Y7) and the other side connected to a common input/output (Z). With  $\overline{E}$  LOW, one of the eight switches is selected (low-impedance ON-state) by S1 to S3. With  $\overline{E}$  HIGH, all switches are in the high-impedance OFF-state, independent of S1 to S3. If break before make is needed, then it is necessary to use the enable input.

$V_{DD}$  and  $V_{SS}$  are the supply voltage connections for the digital control inputs (S1 to S3, and  $\overline{E}$ ). The  $V_{DD}$  to  $V_{SS}$  range is 3 V to 15 V. The analog inputs/outputs (Y0 to Y7, and Z) can swing between  $V_{DD}$  as a positive limit and  $V_{EE}$  as a negative limit.  $V_{DD} - V_{EE}$  may not exceed 15 V. Unused inputs must be connected to  $V_{DD}$ ,  $V_{SS}$ , or another input. For operation as a digital multiplexer/demultiplexer,  $V_{EE}$  is connected to  $V_{SS}$  (typically ground).  $V_{EE}$  and  $V_{SS}$  are the supply voltage connections for the switches.

### 2. Features and benefits

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- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- Specified from  $-40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$  and  $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$
- Complies with JEDEC standard JESD 13-B

### 3. Applications

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- Analog multiplexing and demultiplexing
- Digital multiplexing and demultiplexing
- Signal gating

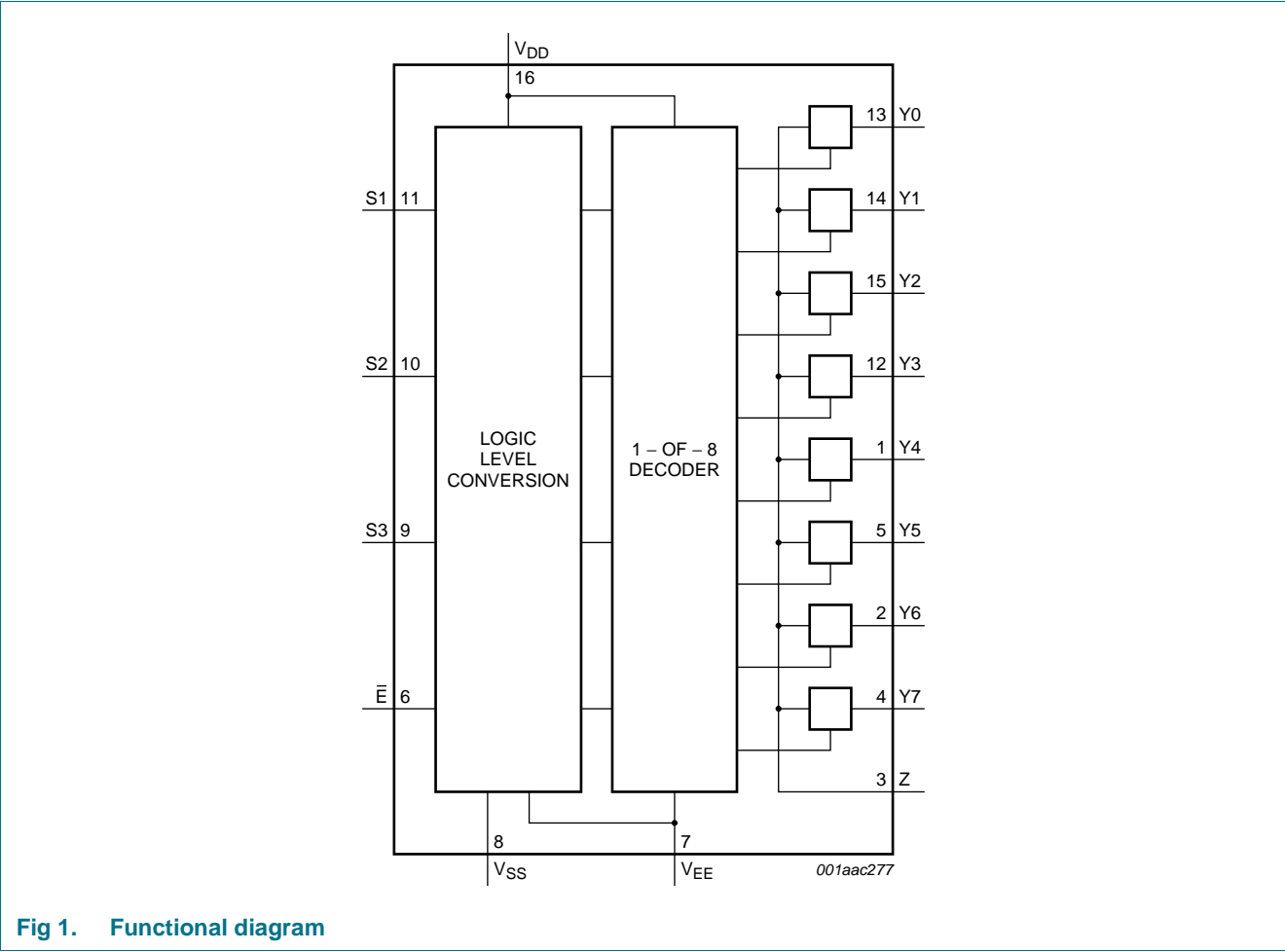


4. Ordering information

Table 1. Ordering information  
All types operate from -40 °C to +125 °C.

Type number	Package		Version
	Name	Description	
HEF4051BP	DIP16	plastic dual in-line package; 16 leads (300 mil)	SOT38-4
HEF4051BT	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1
HEF4051BTS	SSOP16	plastic shrink small outline package; 16 leads; body width 5.3 mm	SOT338-1
HEF4051BTT	TSSOP16	plastic thin shrink small outline package; 16 leads; body width 4.4 mm	SOT403-1

5. Functional diagram



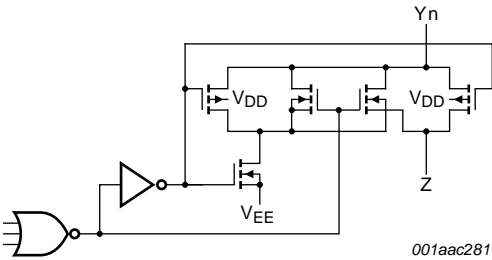


Fig 2. Schematic diagram (one switch)

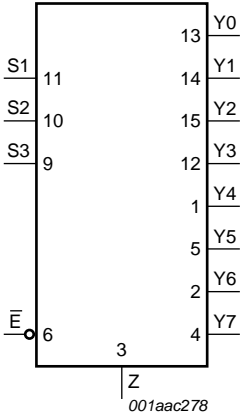


Fig 3. Logic symbol

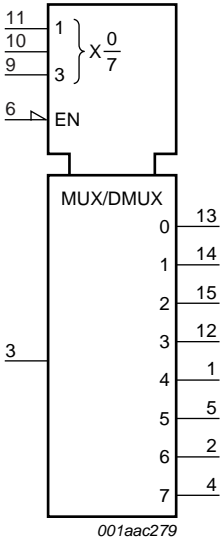


Fig 4. IEC logic symbol

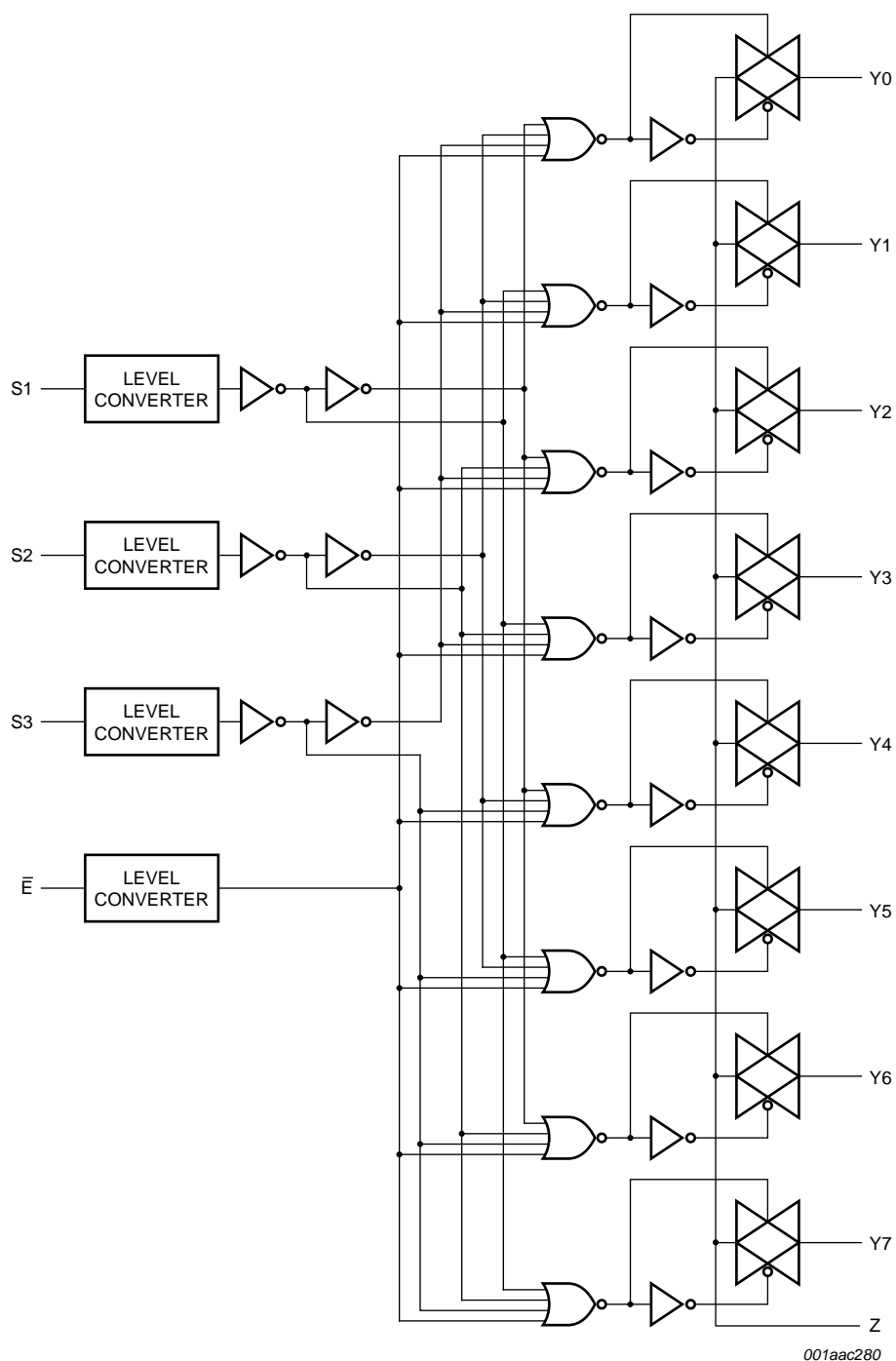


Fig 5. Logic diagram

6. Pinning information

6.1 Pinning

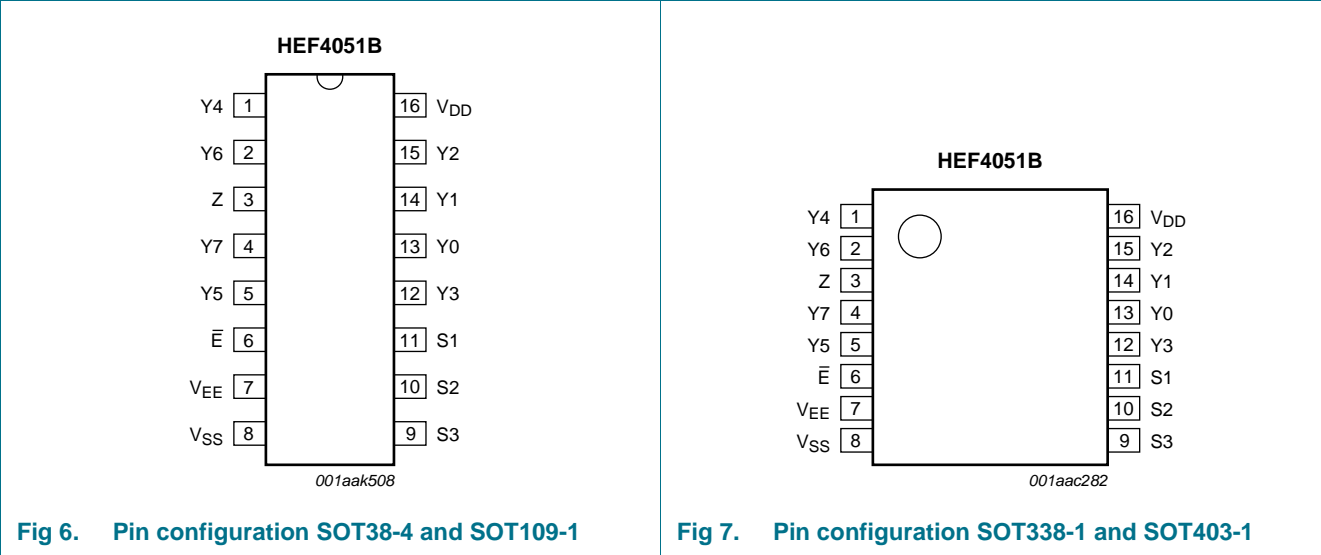


Fig 6. Pin configuration SOT38-4 and SOT109-1

Fig 7. Pin configuration SOT338-1 and SOT403-1

6.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
$\bar{E}$	6	enable input (active LOW)
V <sub>EE</sub>	7	supply voltage
V <sub>SS</sub>	8	ground supply voltage
S1, S2, S3	11, 10, 9	select input
Y0, Y1, Y2, Y3, Y4, Y5, Y6, Y7	13, 14, 15, 12, 1, 5, 2, 4	independent input or output
Z	3	common output or input
V <sub>DD</sub>	16	supply voltage

## 7. Functional description

### 7.1 Function table

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

Input				Channel ON
$\overline{E}$	S3	S2	S1	
L	L	L	L	Y0 to Z
L	L	L	H	Y1 to Z
L	L	H	L	Y2 to Z
L	L	H	H	Y3 to Z
L	H	L	L	Y4 to Z
L	H	L	H	Y5 to Z
L	H	H	L	Y6 to Z
L	H	H	H	Y7 to Z
H	X	X	X	switches off

- [1] H = HIGH voltage level;  
L = LOW voltage level;  
X = don't care.

## 8. 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
$V_{DD}$	supply voltage		-0.5	+18	V
$V_{EE}$	supply voltage	referenced to $V_{DD}$	<sup>[1]</sup> -18	+0.5	V
$I_{IK}$	input clamping current	pins Sn and $\overline{E}$ ; $V_I < -0.5$ V or $V_I > V_{DD} + 0.5$ V	-	$\pm 10$	mA
$V_I$	input voltage		-0.5	$V_{DD} + 0.5$	V
$I_{I/O}$	input/output current		-	$\pm 10$	mA
$I_{DD}$	supply current		-	50	mA
$T_{stg}$	storage temperature		-65	+150	°C
$T_{amb}$	ambient temperature		-40	+125	°C
$P_{tot}$	total power dissipation	$T_{amb} = -40$ °C to +125 °C	<sup>[2]</sup>		
		DIP16 package	-	750	mW
		SO16 package	-	500	mW
		SSOP16 package	-	500	mW
		TSSOP16 package	-	500	mW
P	power dissipation	per output	-	100	mW

- [1] To avoid drawing  $V_{DD}$  current out of terminal Z, when switch current flows into terminals Y, the voltage drop across the bidirectional switch must not exceed 0.4 V. If the switch current flows into terminal Z, no  $V_{DD}$  current will flow out of terminals Y, and in this case there is no limit for the voltage drop across the switch, but the voltages at Y and Z may not exceed  $V_{DD}$  or  $V_{EE}$ .
- [2] For DIP16 package:  $P_{tot}$  derates linearly with 12 mW/K above 70 °C.

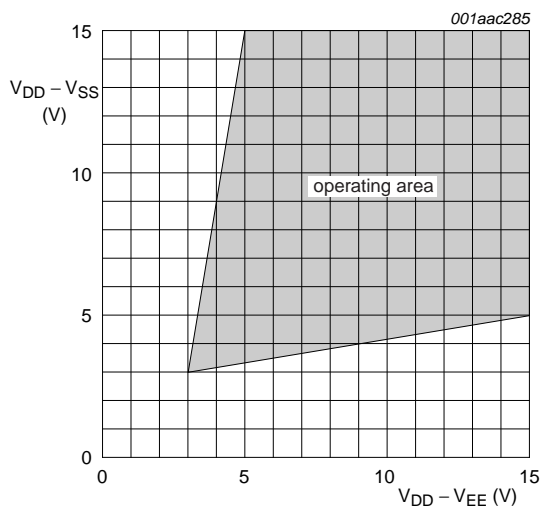
For SO16 package:  $P_{tot}$  derates linearly with 8 mW/K above 70 °C.

For SSOP16 and TSSOP16 packages:  $P_{tot}$  derates linearly with 5.5 mW/K above 60 °C.

## 9. Recommended operating conditions

**Table 5. Recommended operating conditions**

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{DD}$	supply voltage	see <a href="#">Figure 8</a>	3	-	15	V
$V_I$	input voltage		0	-	$V_{DD}$	V
$T_{amb}$	ambient temperature	in free air	-40	-	+125	°C
$\Delta t/\Delta V$	input transition rise and fall rate	$V_{DD} = 5\text{ V}$	-	-	3.75	$\mu\text{s/V}$
		$V_{DD} = 10\text{ V}$	-	-	0.5	$\mu\text{s/V}$
		$V_{DD} = 15\text{ V}$	-	-	0.08	$\mu\text{s/V}$



**Fig 8. Operating area as a function of the supply voltages**

## 10. Static characteristics

**Table 6. Static characteristics**

$V_{SS} = V_{EE} = 0\text{ V}$ ;  $V_I = V_{SS}$  or  $V_{DD}$  unless otherwise specified.

Symbol	Parameter	Conditions	$V_{DD}$	$T_{amb} = -40\text{ °C}$		$T_{amb} = 25\text{ °C}$		$T_{amb} = 85\text{ °C}$		$T_{amb} = 125\text{ °C}$		Unit
				Min	Max	Min	Max	Min	Max	Min	Max	
$V_{IH}$	HIGH-level input voltage	$ I_O  < 1\text{ }\mu\text{A}$	5 V	3.5	-	3.5	-	3.5	-	3.5	-	V
			10 V	7.0	-	7.0	-	7.0	-	7.0	-	V
			15 V	11.0	-	11.0	-	11.0	-	11.0	-	V
$V_{IL}$	LOW-level input voltage	$ I_O  < 1\text{ }\mu\text{A}$	5 V	-	1.5	-	1.5	-	1.5	-	1.5	V
			10 V	-	3.0	-	3.0	-	3.0	-	3.0	V
			15 V	-	4.0	-	4.0	-	4.0	-	4.0	V
$I_I$	input leakage current		15 V	-	$\pm 0.1$	-	$\pm 0.1$	-	$\pm 1.0$	-	$\pm 1.0$	$\mu\text{A}$

Table 6. Static characteristics ...continued  
 $V_{SS} = V_{EE} = 0\text{ V}$ ;  $V_I = V_{SS}$  or  $V_{DD}$  unless otherwise specified.

Symbol	Parameter	Conditions	$V_{DD}$	$T_{\text{amb}} = -40\text{ }^{\circ}\text{C}$		$T_{\text{amb}} = 25\text{ }^{\circ}\text{C}$		$T_{\text{amb}} = 85\text{ }^{\circ}\text{C}$		$T_{\text{amb}} = 125\text{ }^{\circ}\text{C}$		Unit
				Min	Max	Min	Max	Min	Max	Min	Max	
$I_{S(\text{OFF})}$	OFF-state leakage current	Z port; all channels OFF; see Figure 9	15 V	-	-	-	1000	-	-	-	-	nA
		Y port; per channel; see Figure 10	15 V	-	-	-	200	-	-	-	-	nA
$I_{DD}$	supply current	$I_O = 0\text{ A}$	5 V	-	5	-	5	-	150	-	150	$\mu\text{A}$
			10 V	-	10	-	10	-	300	-	300	$\mu\text{A}$
			15 V	-	20	-	20	-	600	-	600	$\mu\text{A}$
$C_I$	input capacitance	$S_n, \bar{E}$ inputs	-	-	-	-	7.5	-	-	-	-	pF

10.1 Test circuits

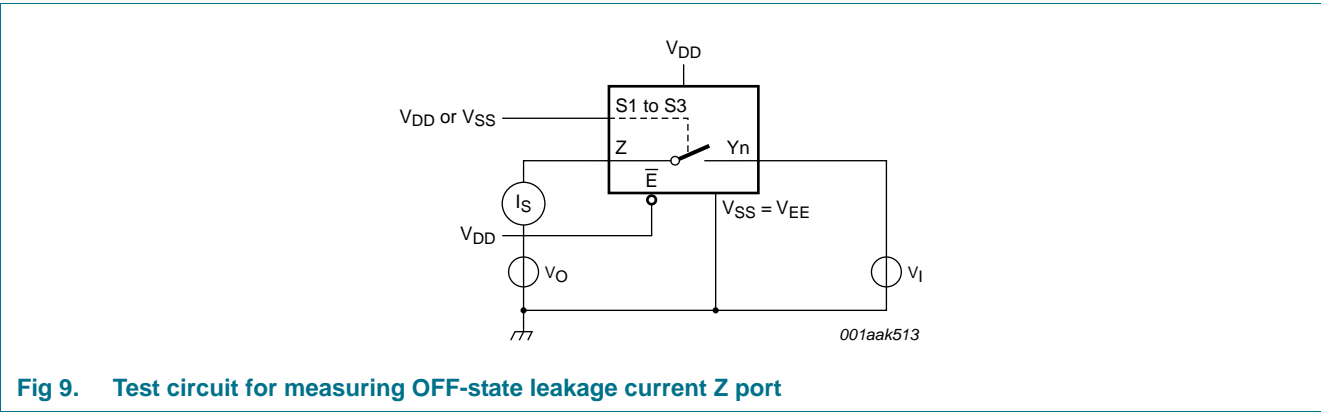


Fig 9. Test circuit for measuring OFF-state leakage current Z port

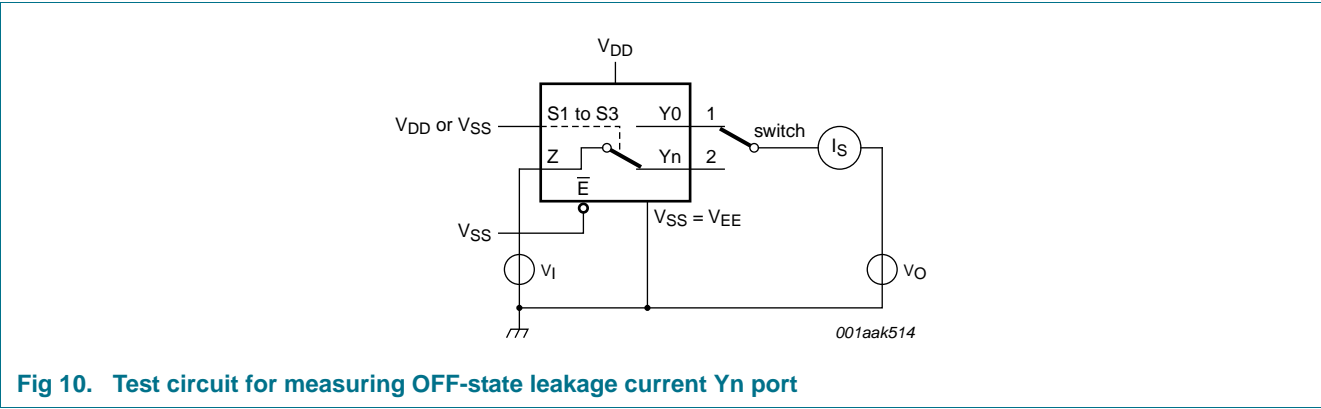


Fig 10. Test circuit for measuring OFF-state leakage current Yn port

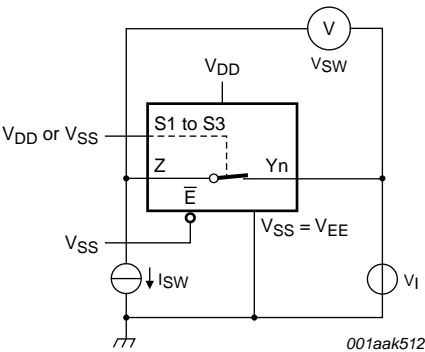


10.2 ON resistance

Table 7. ON resistance  
 $T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $I_{SW} = 200\text{ }\mu\text{A}$ ;  $V_{SS} = V_{EE} = 0\text{ V}$ .

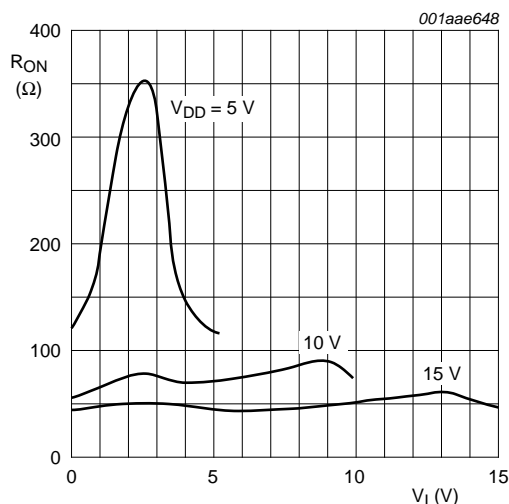
Symbol	Parameter	Conditions	$V_{DD} - V_{EE}$	Typ	Max	Unit
$R_{ON(peak)}$	ON resistance (peak)	$V_I = 0\text{ V}$ to $V_{DD} - V_{EE}$ ; see <a href="#">Figure 11</a> and <a href="#">Figure 12</a>	5 V	350	2500	$\Omega$
			10 V	80	245	$\Omega$
			15 V	60	175	$\Omega$
$R_{ON(rail)}$	ON resistance (rail)	$V_I = 0\text{ V}$ ; see <a href="#">Figure 11</a> and <a href="#">Figure 12</a>	5 V	115	340	$\Omega$
			10 V	50	160	$\Omega$
			15 V	40	115	$\Omega$
		$V_I = V_{DD} - V_{EE}$ ; see <a href="#">Figure 11</a> and <a href="#">Figure 12</a>	5 V	120	365	$\Omega$
			10 V	65	200	$\Omega$
			15 V	50	155	$\Omega$
$\Delta R_{ON}$	ON resistance mismatch between channels	$V_I = 0\text{ V}$ to $V_{DD} - V_{EE}$ ; see <a href="#">Figure 11</a>	5 V	25	-	$\Omega$
			10 V	10	-	$\Omega$
			15 V	5	-	$\Omega$

10.2.1 ON resistance waveform and test circuit



$R_{ON} = V_{SW} / I_{SW}$ .

Fig 11. Test circuit for measuring  $R_{ON}$

Fig 12. Typical  $R_{ON}$  as a function of input voltage

## 11. Dynamic characteristics

Table 8. Dynamic characteristics

$T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $V_{SS} = V_{EE} = 0\text{ V}$ ; for test circuit see [Figure 16](#).

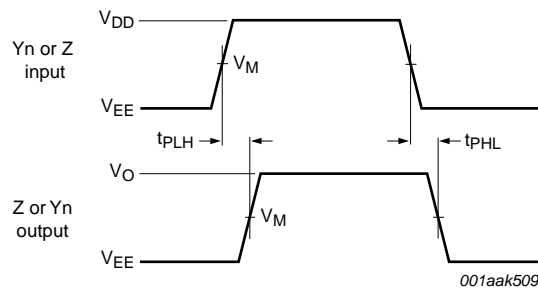
Symbol	Parameter	Conditions	$V_{DD}$	Typ	Max	Unit
$t_{PHL}$	HIGH to LOW propagation delay	$Y_n, Z$ to $Z, Y_n$ ; see <a href="#">Figure 13</a>	5 V	15	30	ns
			10 V	5	10	ns
			15 V	5	10	ns
		$S_n$ to $Y_n, Z$ ; see <a href="#">Figure 14</a>	5 V	150	300	ns
			10 V	60	120	ns
			15 V	45	90	ns
$t_{PLH}$	LOW to HIGH propagation delay	$Y_n, Z$ to $Z, Y_n$ ; see <a href="#">Figure 13</a>	5 V	15	30	ns
			10 V	5	10	ns
			15 V	5	10	ns
		$S_n$ to $Y_n, Z$ ; see <a href="#">Figure 14</a>	5 V	150	300	ns
			10 V	65	130	ns
			15 V	45	90	ns
$t_{PHZ}$	HIGH to OFF-state propagation delay	$\bar{E}$ to $Y_n, Z$ ; see <a href="#">Figure 15</a>	5 V	120	240	ns
			10 V	90	180	ns
			15 V	85	170	ns
$t_{PZH}$	OFF-state to HIGH propagation delay	$\bar{E}$ to $Y_n, Z$ ; see <a href="#">Figure 15</a>	5 V	140	280	ns
			10 V	55	110	ns
			15 V	40	80	ns
$t_{PLZ}$	LOW to OFF-state propagation delay	$\bar{E}$ to $Y_n, Z$ ; see <a href="#">Figure 15</a>	5 V	145	290	ns
			10 V	120	240	ns
			15 V	115	230	ns

**Table 8. Dynamic characteristics ...continued**

$T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $V_{SS} = V_{EE} = 0\text{ V}$ ; for test circuit see [Figure 16](#).

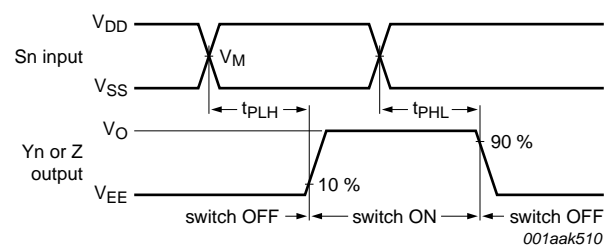
Symbol	Parameter	Conditions	V <sub>DD</sub>	Typ	Max	Unit
t <sub>PZL</sub>	OFF-state to LOW propagation delay	$\overline{E}$ to Yn, Z; see <a href="#">Figure 15</a>	5 V	140	280	ns
			10 V	55	110	ns
			15 V	40	80	ns

## 11.1 Waveforms and test circuit



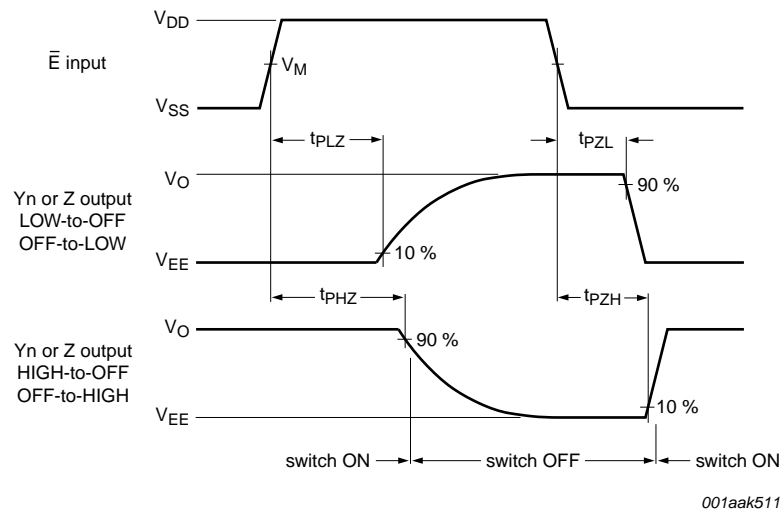
Measurement points are given in [Table 9](#).

**Fig 13. Yn, Z to Z, Yn propagation delays**



Measurement points are given in [Table 9](#).

**Fig 14. Sn to Yn, Z propagation delays**

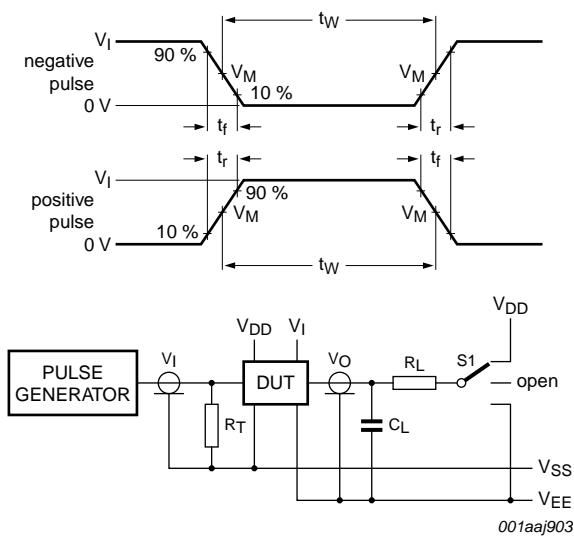


Measurement points are given in [Table 9](#).

**Fig 15. Enable and disable times**

### Table 9. Measurement points

Supply voltage	Input	Output
$V_{DD}$	$V_M$	$V_M$
5 V to 15 V	$0.5V_{DD}$	$0.5V_{DD}$



Test data is given in [Table 10](#).

Definitions:

DUT = Device Under Test.

$R_T$  = Termination resistance should be equal to output impedance  $Z_o$  of the pulse generator.

$C_L$  = Load capacitance including test jig and probe.

$R_L$  = Load resistance.

Fig 16. Test circuit for measuring switching times

Table 10. Test data

Input				Load		S1 position				
Yn, Z	Sn and $\bar{E}$	$t_r, t_f$	$V_M$	$C_L$	$R_L$	$t_{PHL}$ [1]	$t_{PLH}$	$t_{PZH}, t_{PHZ}$	$t_{PZL}, t_{PLZ}$	other
$V_{DD}$ or $V_{EE}$	$V_{DD}$ or $V_{SS}$	$\leq 20$ ns	$0.5V_{DD}$	50 pF	10 k $\Omega$	$V_{DD}$ or $V_{EE}$	$V_{EE}$	$V_{EE}$	$V_{DD}$	$V_{EE}$

[1] For Yn to Z or Z to Yn propagation delays use  $V_{EE}$ . For Sn to Yn or Z propagation delays use  $V_{DD}$ .

## 11.2 Additional dynamic parameters

**Table 11. Additional dynamic characteristics**

$V_{SS} = V_{EE} = 0\text{ V}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

Symbol	Parameter	Conditions	$V_{DD}$	Typ	Max	Unit
THD	total harmonic distortion	see <a href="#">Figure 17</a> ; $R_L = 10\text{ k}\Omega$ ; $C_L = 15\text{ pF}$ ; channel ON; $V_I = 0.5V_{DD}$ (p-p); $f_i = 1\text{ kHz}$	5 V	[1] 0.25	-	%
			10 V	[1] 0.04	-	%
			15 V	[1] 0.04	-	%
$f_{(-3\text{dB})}$	–3 dB frequency response	see <a href="#">Figure 18</a> ; $R_L = 1\text{ k}\Omega$ ; $C_L = 5\text{ pF}$ ; channel ON; $V_I = 0.5V_{DD}$ (p-p)	5 V	[1] 13	-	MHz
			10 V	[1] 40	-	MHz
			15 V	[1] 70	-	MHz
$\alpha_{iso}$	isolation (OFF-state)	see <a href="#">Figure 19</a> ; $f_i = 1\text{ MHz}$ ; $R_L = 1\text{ k}\Omega$ ; $C_L = 5\text{ pF}$ ; channel OFF; $V_I = 0.5V_{DD}$ (p-p)	10 V	[1] –50	-	dB
$V_{ct}$	crosstalk voltage	digital inputs to switch; see <a href="#">Figure 20</a> ; $R_L = 10\text{ k}\Omega$ ; $C_L = 15\text{ pF}$ ; $E$ or $S_n = V_{DD}$ (square-wave)	10 V	50	-	mV
Xtalk	crosstalk	between switches; see <a href="#">Figure 21</a> ; $f_i = 1\text{ MHz}$ ; $R_L = 1\text{ k}\Omega$ ; $V_I = 0.5V_{DD}$ (p-p)	10 V	[1] –50	-	dB

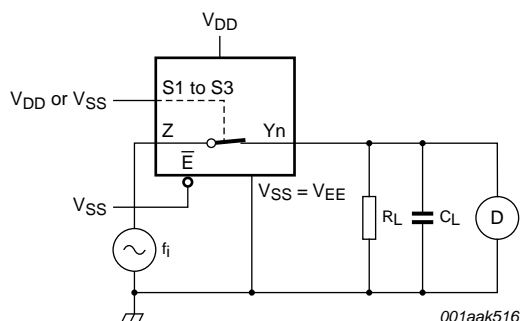
[1]  $f_i$  is biased at  $0.5 V_{DD}$ ;  $V_I = 0.5V_{DD}$  (p-p).

**Table 12. Dynamic power dissipation  $P_D$**

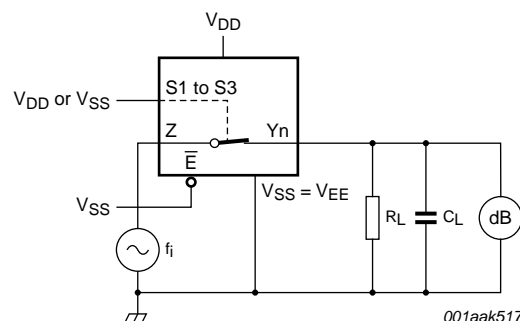
$P_D$  can be calculated from the formulas shown;  $V_{EE} = V_{SS} = 0\text{ V}$ ;  $t_r = t_f \leq 20\text{ ns}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

Symbol	Parameter	$V_{DD}$	Typical formula for $P_D$ ( $\mu\text{W}$ )	where:
$P_D$	dynamic power dissipation	5 V	$P_D = 1000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	$f_i$ = input frequency in MHz;
		10 V	$P_D = 5500 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	$f_o$ = output frequency in MHz;
		15 V	$P_D = 15000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	$C_L$ = output load capacitance in pF; $V_{DD}$ = supply voltage in V; $\Sigma(C_L \times f_o)$ = sum of the outputs.

### 11.2.1 Test circuits



**Fig 17. Test circuit for measuring total harmonic distortion**



**Fig 18. Test circuit for measuring frequency response**

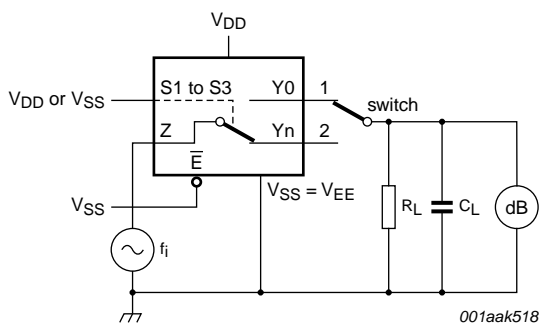
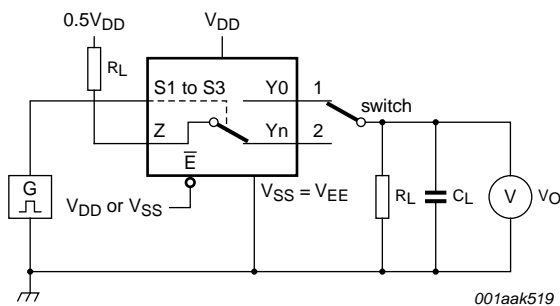
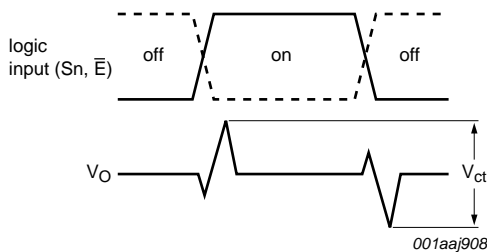


Fig 19. Test circuit for measuring isolation (OFF-state)

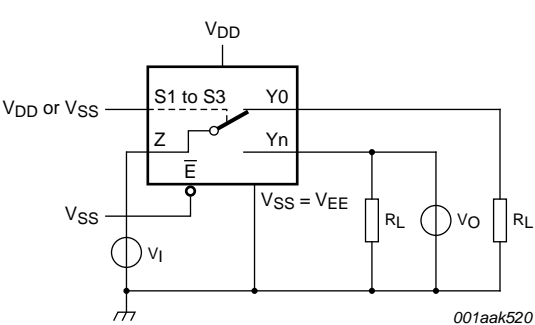


a. Test circuit

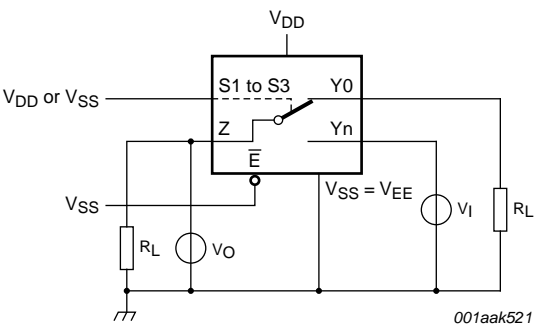


b. Input and output pulse definitions

Fig 20. Test circuit for measuring crosstalk voltage between digital inputs and switch



a. Switch closed condition



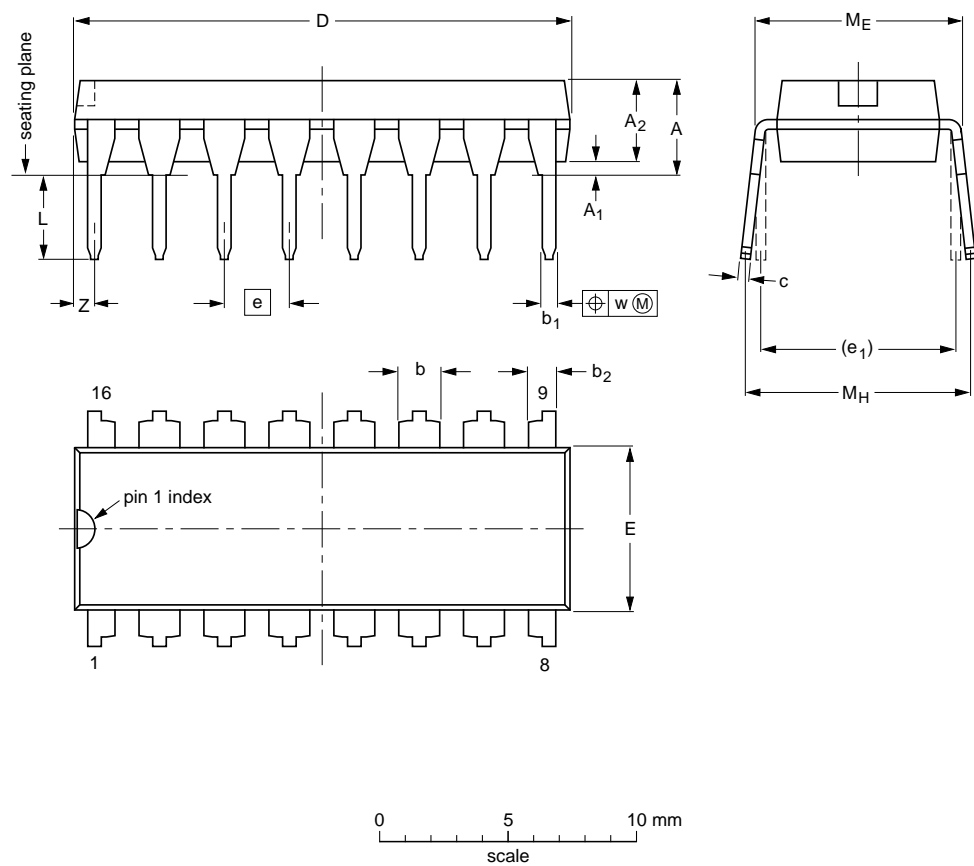
b. Switch open condition

Fig 21. Test circuit for measuring crosstalk between switches

12. Package outline

DIP16: plastic dual in-line package; 16 leads (300 mil)

SOT38-4



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

UNIT	A max.	A <sub>1</sub> min.	A <sub>2</sub> max.	b	b <sub>1</sub>	b <sub>2</sub>	c	D <sup>(1)</sup>	E <sup>(1)</sup>	e	e <sub>1</sub>	L	M <sub>E</sub>	M <sub>H</sub>	w	Z <sup>(1)</sup> max.
mm	4.2	0.51	3.2	1.73 1.30	0.53 0.38	1.25 0.85	0.36 0.23	19.50 18.55	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	0.76
inches	0.17	0.02	0.13	0.068 0.051	0.021 0.015	0.049 0.033	0.014 0.009	0.77 0.73	0.26 0.24	0.1	0.3	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.03

**Note**  
1. Plastic or metal protrusions of 0.25 mm (0.01 inch) maximum per side are not included.

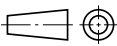
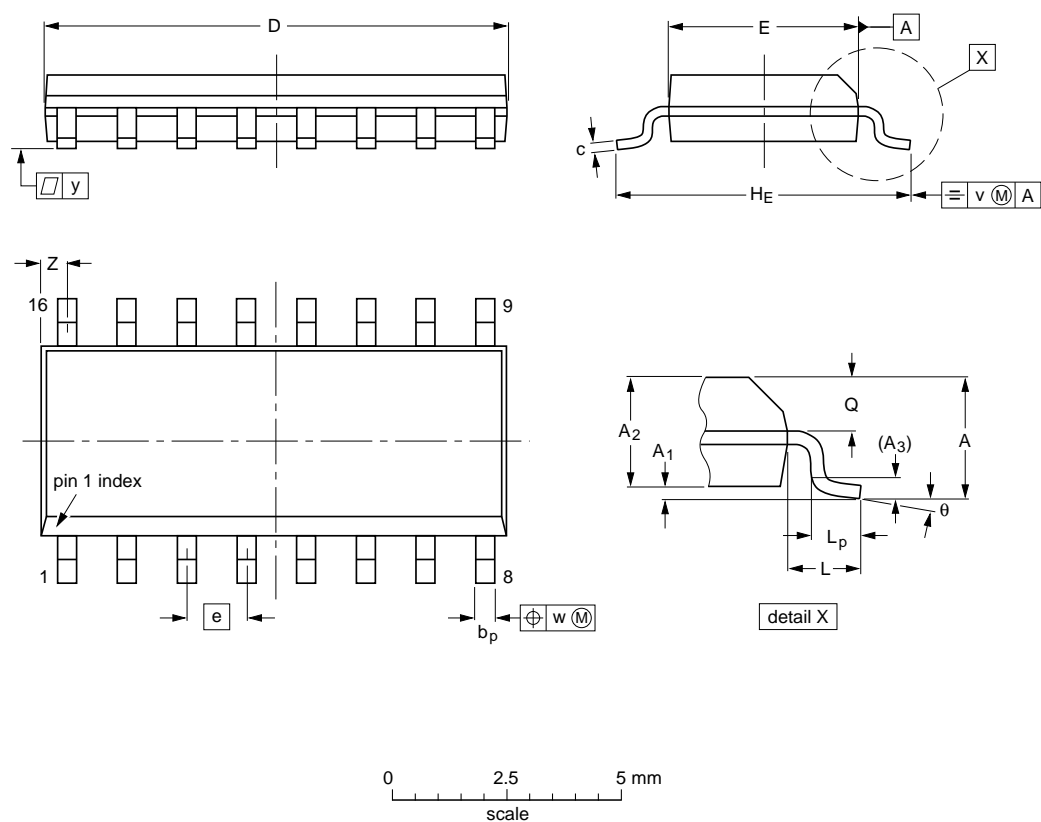
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT38-4						95-01-14 03-02-13

Fig 22. Package outline SOT38-4 (DIP16)



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

SOT109-1



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

UNIT	A max.	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b <sub>p</sub>	c	D <sup>(1)</sup>	E <sup>(1)</sup>	e	H <sub>E</sub>	L	L <sub>p</sub>	Q	v	w	y	Z <sup>(1)</sup>	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	10.0 9.8	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° 0°
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.39 0.38	0.16 0.15	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.020	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			
SOT109-1	076E07	MS-012				99-12-27 03-02-19

Fig 23. Package outline SOT109-1 (SO16)

SSOP16: plastic shrink small outline package; 16 leads; body width 5.3 mm

SOT338-1

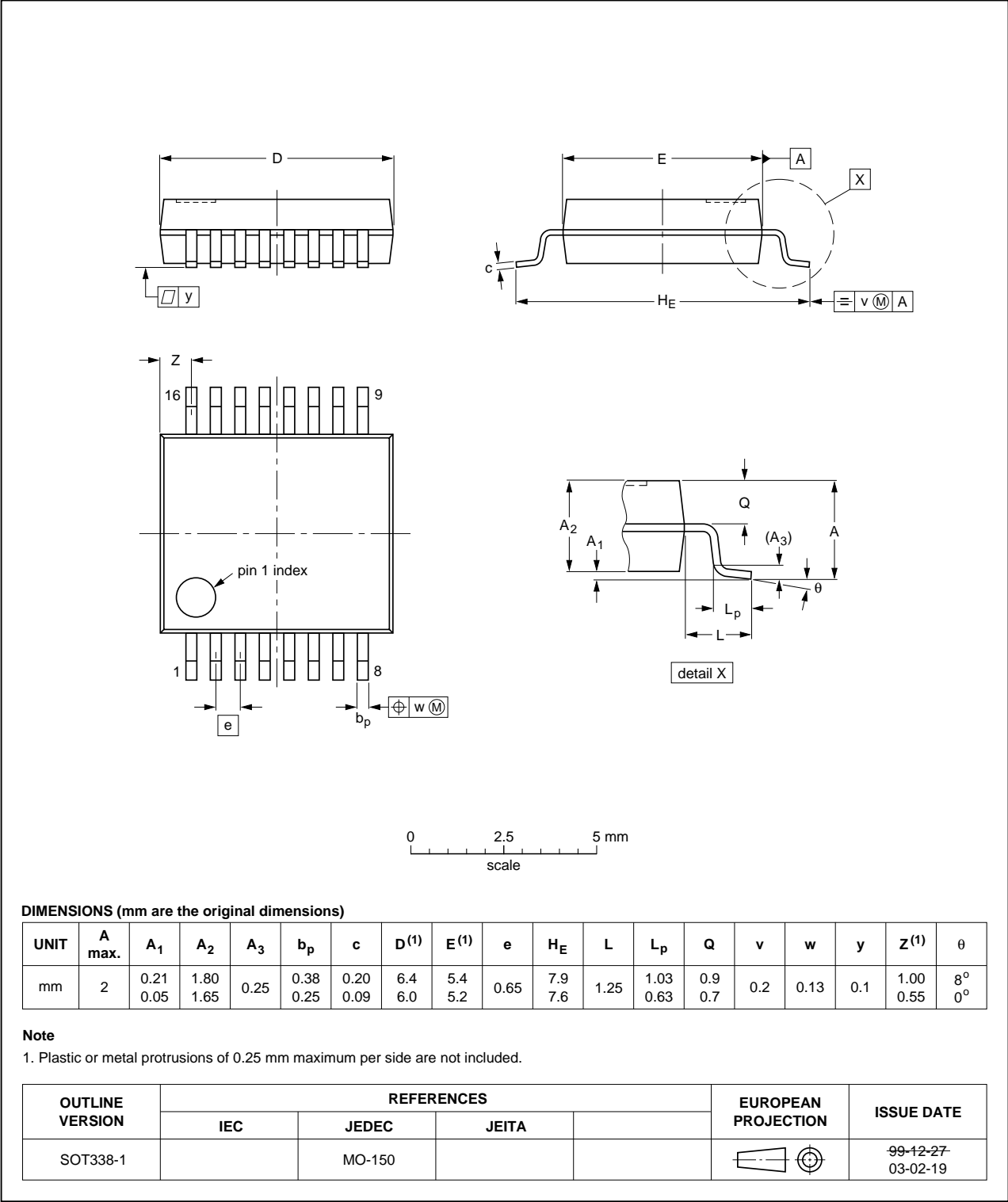


Fig 24. Package outline SOT338-1 (SSOP16)

TSSOP16: plastic thin shrink small outline package; 16 leads; body width 4.4 mm

SOT403-1

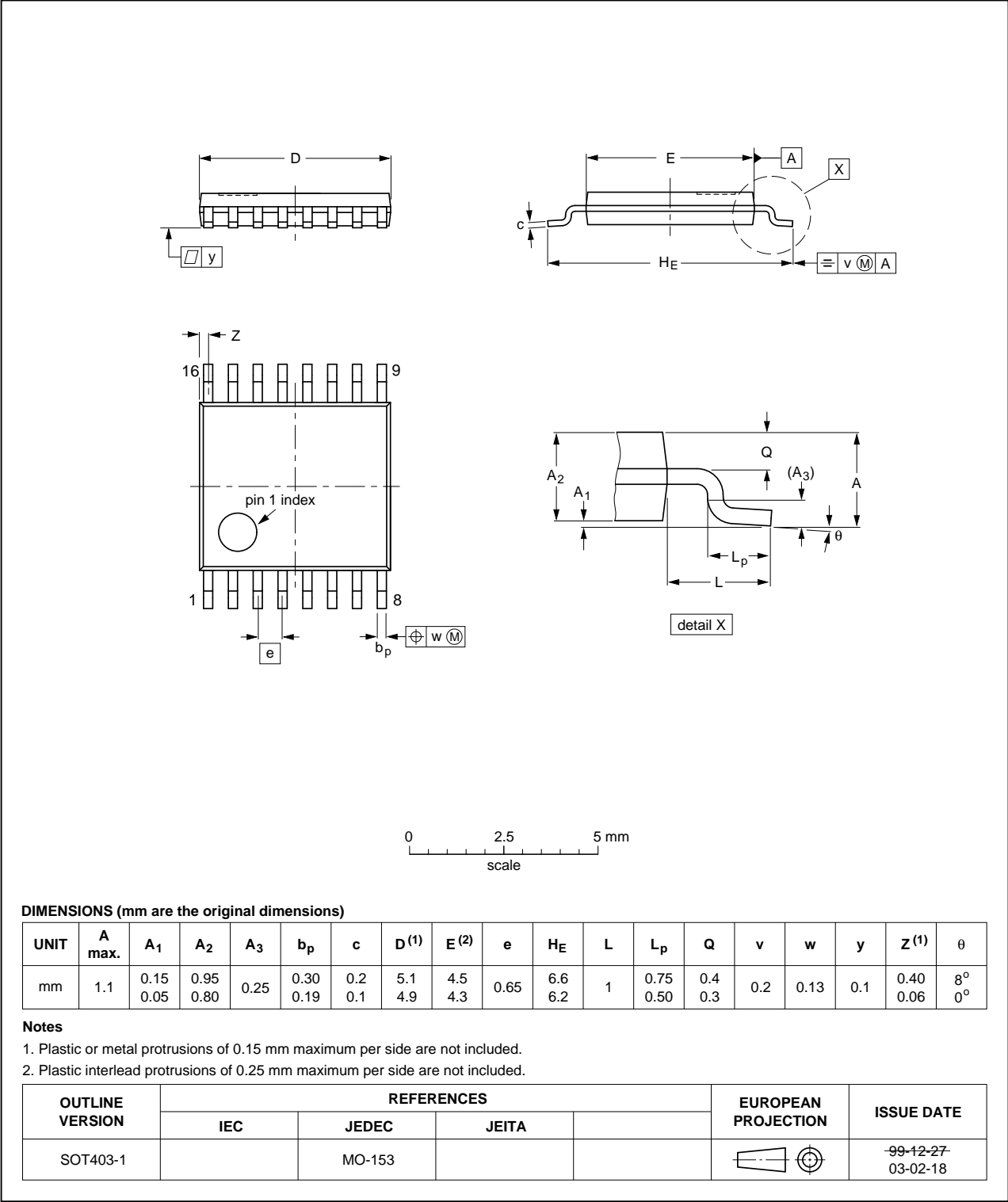


Fig 25. Package outline SOT403-1 (TSSOP16)

## 13. Revision history

**Table 13. Revision history**

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4051B v.10	20111117	Product data sheet	-	HEF4051B v.9
Modifications:	<ul style="list-style-type: none"><li>• Legal pages updated.</li><li>• Changes in “General description”, “Features and benefits” and “Applications”.</li></ul>			
HEF4051B v.9	20100325	Product data sheet	-	HEF4051B v.8
HEF4051B v.8	20100301	Product data sheet	-	HEF4051B v.7
HEF4051B v.7	20091127	Product data sheet	-	HEF4051B v.6
HEF4051B v.6	20090924	Product data sheet	-	HEF4051B v.5
HEF4051B v.5	20090826	Product data sheet	-	HEF4051B v.4
HEF4051B v.4	20050112	Product data sheet	-	HEF4051B_CNv v.3
HEF4051B_CNv v.3	19950101	Product specification	-	HEF4051B_CNv v.2
HEF4051B_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.nxp.com>.

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