

HEF4053B-Q100

Triple single-pole double-throw analog switch

Rev. 1 — 22 February 2013

Product data sheet

1. General description

The HEF4053B-Q100 is a triple single-pole double-throw (SPDT) analog switch, suitable for use as an analog or digital multiplexer/demultiplexer. Each switch has a digital select input (S_n), two independent inputs/outputs (nY_0 and nY_1) and a common input/output (nZ). All three switches share an enable input (\bar{E}). A HIGH on \bar{E} causes all switches into the high-impedance OFF-state, independent of S_n .

V_{DD} and V_{SS} are the supply voltage connections for the digital control inputs (S_n and \bar{E}). The V_{DD} to V_{SS} range is 3 V to 15 V. The analog inputs/outputs (nY_0 , nY_1 and nZ) 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.

This product has been qualified to the Automotive Electronics Council (AEC) standard Q100 (Grade 1) and is suitable for use in automotive applications.

2. Features and benefits

- Automotive product qualification in accordance with AEC-Q100 (Grade 1)
 - ◆ Specified from $-40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$ and from $-40\text{ }^{\circ}\text{C}$ to $+125\text{ }^{\circ}\text{C}$
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- ESD protection:
 - ◆ MIL-STD-883, method 3015 exceeds 2000 V
 - ◆ HBM JESD22-A114F exceeds 2000 V
 - ◆ MM JESD22-A115-A exceeds 200 V ($C = 200\text{ pF}$, $R = 0\text{ }\Omega$)
- Complies with JEDEC standard JESD 13-B

3. Applications

- 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	
HEF4053BT-Q100	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1
HEF4053BTT-Q100	TSSOP16	plastic thin shrink small outline package; 16 leads; body width 4.4 mm	SOT403-1

5. Functional diagram

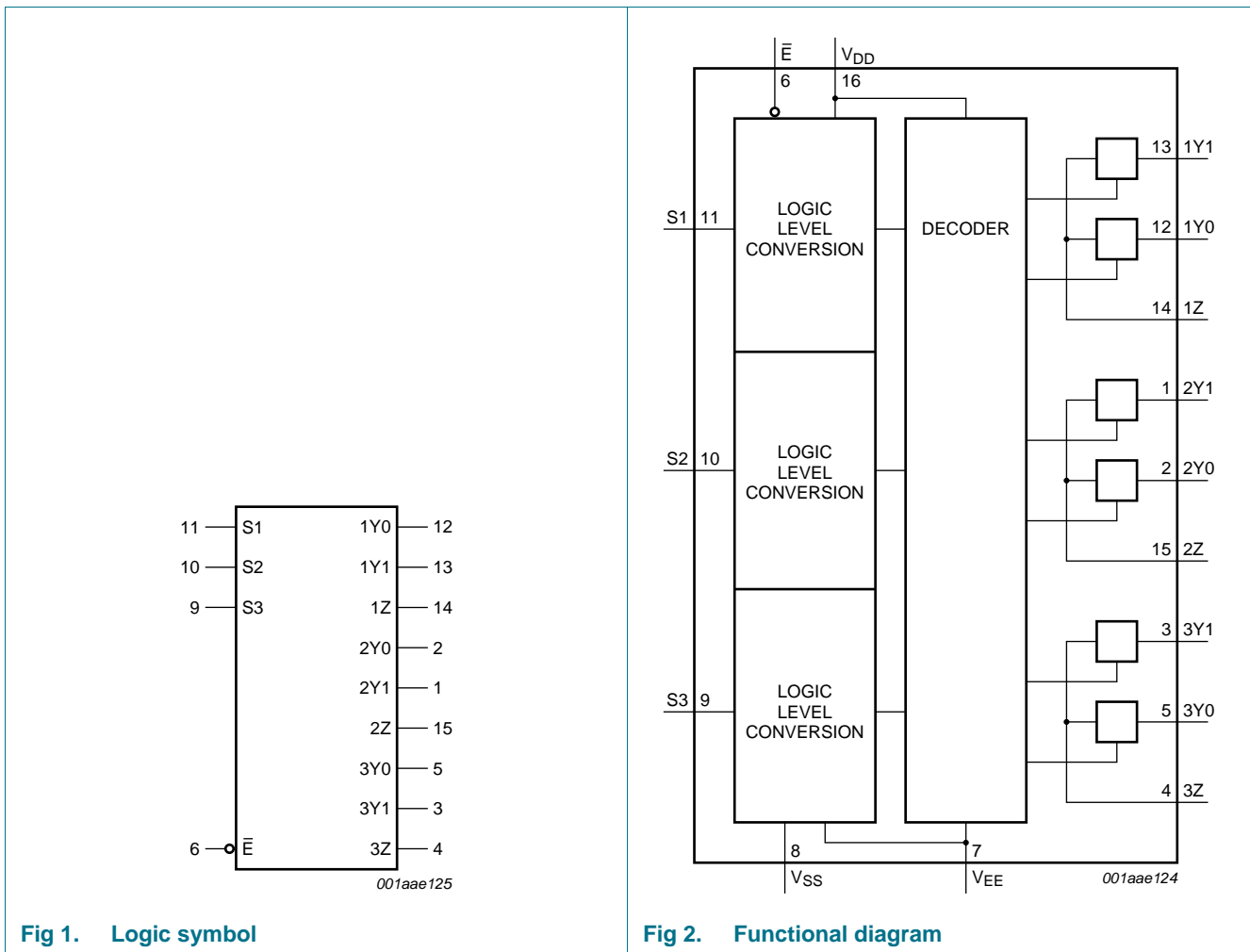


Fig 1. Logic symbol

Fig 2. Functional diagram

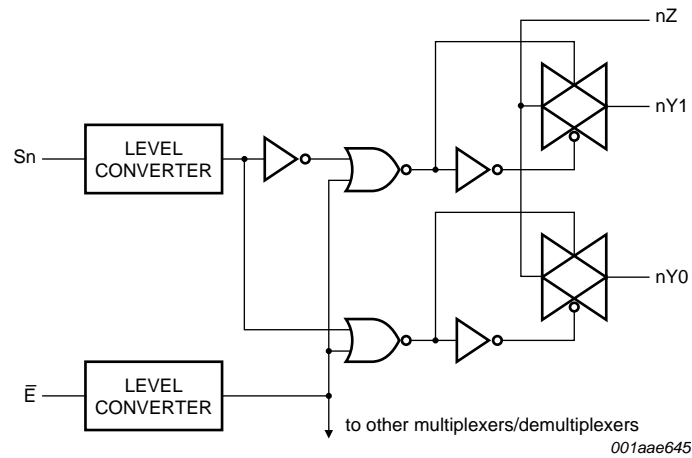


Fig 3. Logic diagram (one multiplexer/demultiplexer)

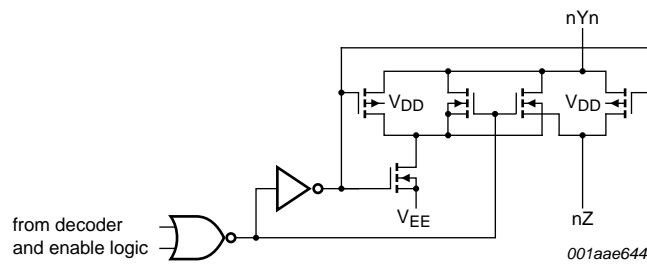


Fig 4. Schematic diagram (one switch)

6. Pinning information

6.1 Pinning

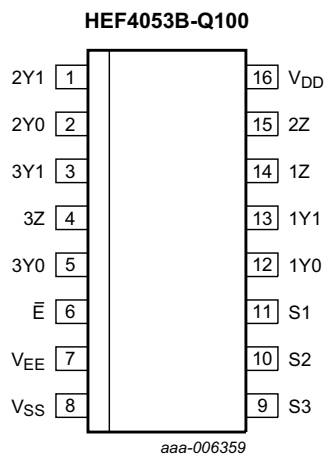


Fig 5. Pin configuration for SOT109-1 (SO16)

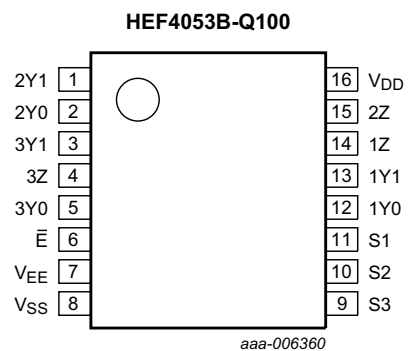


Fig 6. Pin configuration for SOT403-1 (TSSOP16)

6.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
\bar{E}	6	enable input (active LOW)
V_{EE}	7	supply voltage
V_{SS}	8	ground supply voltage
S1, S2, S3	11, 10, 9	select input
1Y0, 2Y0, 3Y0	12, 2, 5	independent input or output
1Y1, 2Y1, 3Y1	13, 1, 3	independent input or output
1Z, 2Z, 3Z	14, 15, 4	independent output or input
V_{DD}	16	supply voltage

7. Functional description

Table 3. Function table [1]

Inputs		Channel on
\bar{E}	Sn	
L	L	nY0 to nZ
L	H	nY1 to nZ
H	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}	[1] -18	+0.5	V
I_{IK}	input clamping current	pins Sn and \bar{E} ; $V_I < -0.5$ V or $V_I > V_{DD} + 0.5$ V	-	± 10	mA
V_I	input voltage		-0.5	$V_{DD} + 0.5$	V
$I_{I/O}$	input/output current		-	± 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	[2]		
		SO16 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 nYn, 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 nYn, and in this case there is no limit for the voltage drop across the switch, but the voltages at nYn and Z may not exceed V_{DD} or V_{EE} .

[2] For SO16 package: P_{tot} derates linearly with 8 mW/K above 70 °C.
 For TSSOP16 package: 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 Figure 7	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	$\mu\text{s/V}$

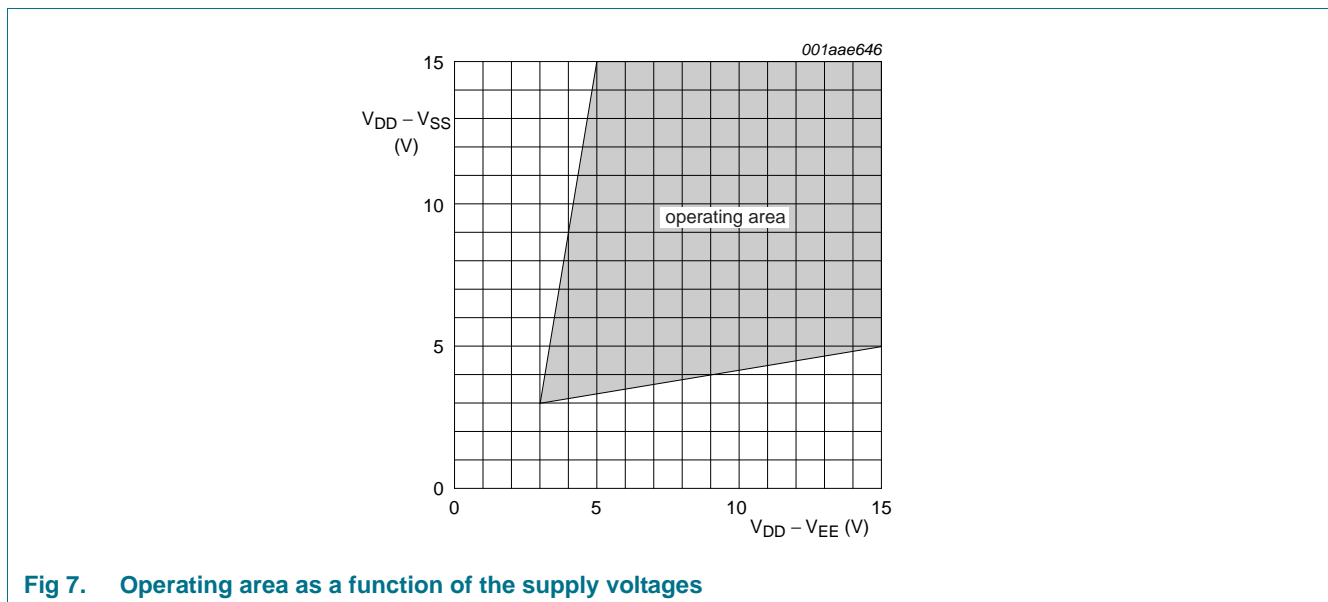


Fig 7. Operating area as a function of the supply voltages

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\ \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\ \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	-	± 0.1	-	± 0.1	-	± 1.0	-	± 1.0	μA

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}	$T_{amb} = -40\text{ }^\circ\text{C}$		$T_{amb} = 25\text{ }^\circ\text{C}$		$T_{amb} = 85\text{ }^\circ\text{C}$		$T_{amb} = 125\text{ }^\circ\text{C}$		Unit
				Min	Max	Min	Max	Min	Max	Min	Max	
$I_{S(OFF)}$	OFF-state leakage current	Z port; all channels OFF; see Figure 8	15 V	-	-	-	1000	-	-	-	-	nA
		Y port; per channel; see Figure 9	15 V	-	-	-	200	-	-	-	-	nA
I_{DD}	supply current	$I_O = 0\text{ A}$	5 V	-	5	-	5	-	150	-	150	μA
			10 V	-	10	-	10	-	300	-	300	μA
			15 V	-	20	-	20	-	600	-	600	μA
C_I	input capacitance	S_n, \bar{E} inputs	-	-	-	7.5	-	-	-	-	pF	

10.1 Test circuits

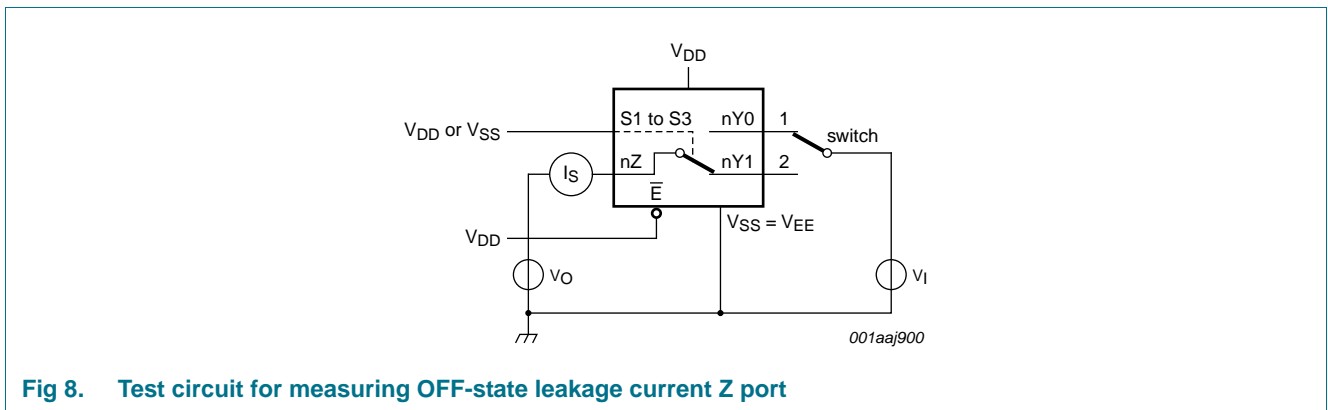


Fig 8. Test circuit for measuring OFF-state leakage current Z port

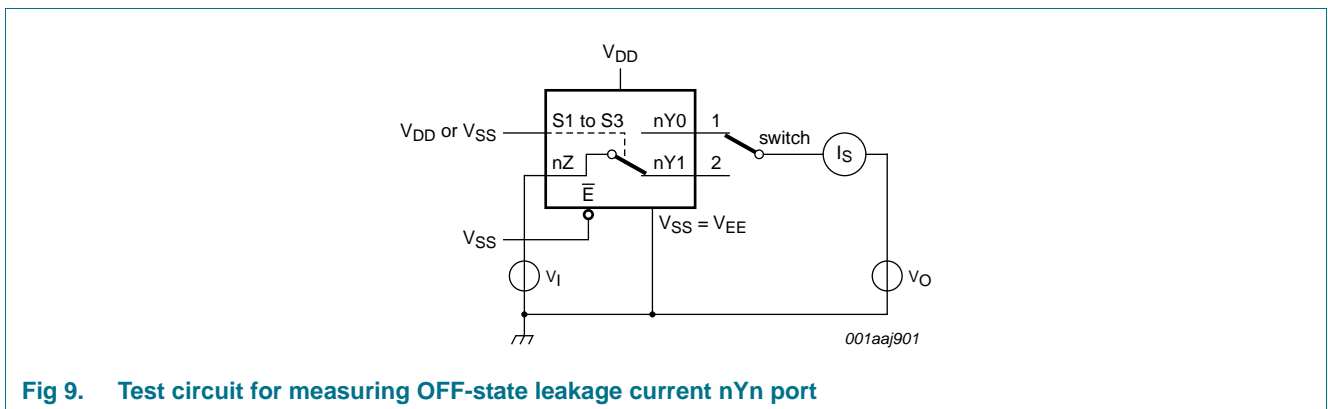


Fig 9. Test circuit for measuring OFF-state leakage current nYn port

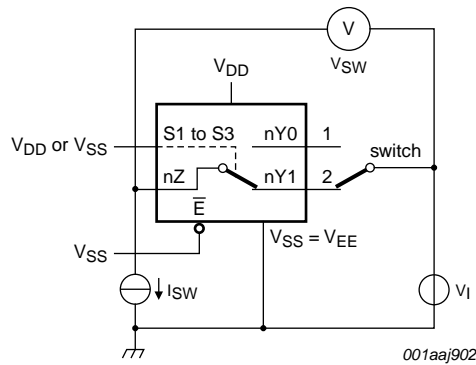
10.2 ON resistance

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
$R_{ON(\text{peak})}$	ON resistance (peak)	$V_I = 0\text{ V}$ to $V_{DD} - V_{EE}$; see Figure 10 and Figure 11	5 V	350	2500	Ω
			10 V	80	245	Ω
			15 V	60	175	Ω
$R_{ON(\text{rail})}$	ON resistance (rail)	$V_I = 0\text{ V}$; see Figure 10 and Figure 11	5 V	115	340	Ω
			10 V	50	160	Ω
			15 V	40	115	Ω
		$V_I = V_{DD} - V_{EE}$; see Figure 10 and Figure 11	5 V	120	365	Ω
			10 V	65	200	Ω
			15 V	50	155	Ω
ΔR_{ON}	ON resistance mismatch between channels	$V_I = 0\text{ V}$ to $V_{DD} - V_{EE}$; see Figure 10	5 V	25	-	Ω
			10 V	10	-	Ω
			15 V	5	-	Ω

10.2.1 ON resistance waveform and test circuit



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

Fig 10. Test circuit for measuring R_{ON}

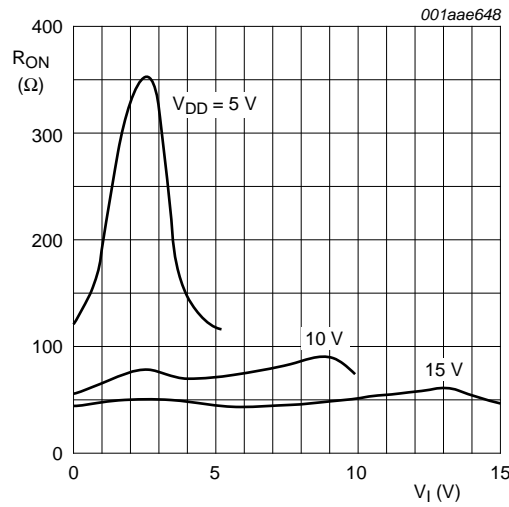


Fig 11. Typical R_{ON} as a function of input voltage

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 15](#).

Symbol	Parameter	Conditions	V_{DD}	Typ	Max	Unit
t_{PHL}	HIGH to LOW propagation delay	nYn, nZ to nZ, nYn; see Figure 12	5 V	10	20	ns
			10 V	5	10	ns
			15 V	5	10	ns
		Sn to nYn, nZ; see Figure 13	5 V	200	400	ns
			10 V	85	170	ns
			15 V	65	130	ns
t_{PLH}	LOW to HIGH propagation delay	nYn, nZ to nZ, nYn; see Figure 12	5 V	15	30	ns
			10 V	5	10	ns
			15 V	5	10	ns
		Sn to nYn, nZ; see Figure 13	5 V	275	555	ns
			10 V	100	200	ns
			15 V	65	130	ns
t_{PHZ}	HIGH to OFF-state propagation delay	\bar{E} to nYn, nZ; see Figure 14	5 V	200	400	ns
			10 V	115	230	ns
			15 V	110	220	ns
t_{PZH}	OFF-state to HIGH propagation delay	\bar{E} to nYn, nZ; see Figure 14	5 V	260	525	ns
			10 V	95	190	ns
			15 V	65	130	ns
t_{PLZ}	LOW to OFF-state propagation delay	\bar{E} to nYn, nZ; see Figure 14	5 V	200	400	ns
			10 V	120	245	ns
			15 V	110	215	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 15](#).

Symbol	Parameter	Conditions	V_{DD}	Typ	Max	Unit
t_{PZL}	OFF-state to LOW propagation delay	\bar{E} to nYn, nZ; see Figure 14	5 V	280	565	ns
			10 V	105	205	ns
			15 V	70	140	ns

11.1 Waveforms and test circuit

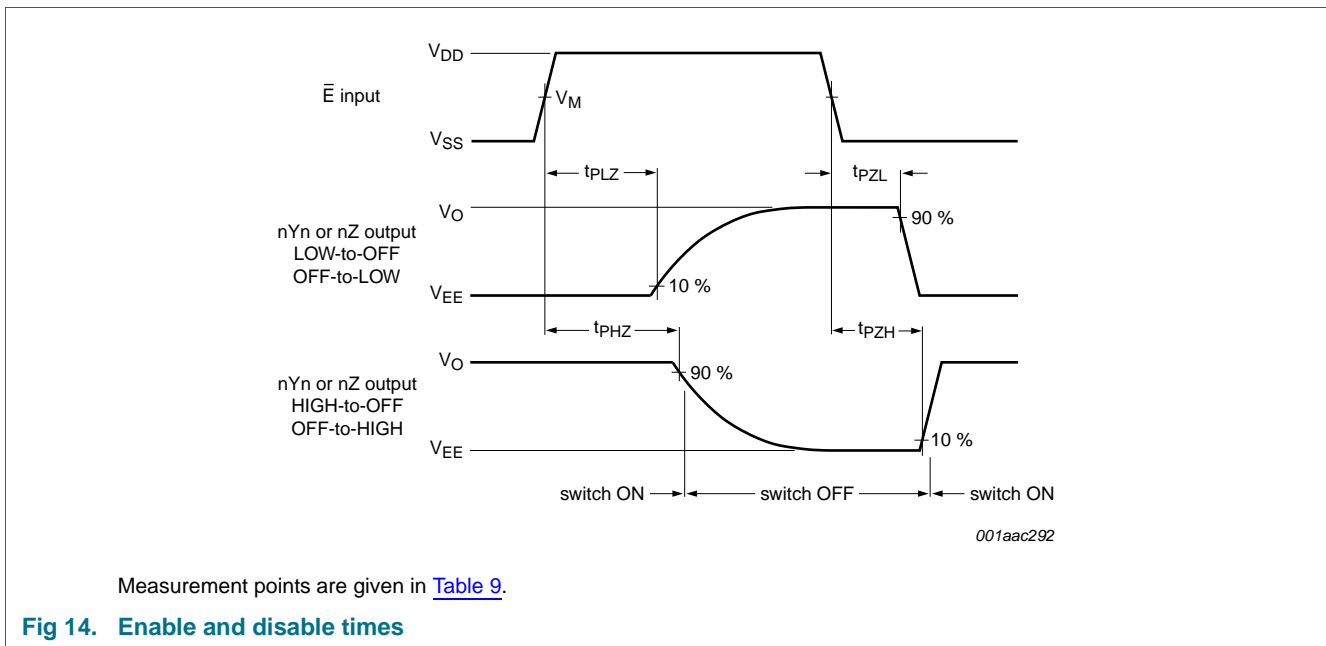
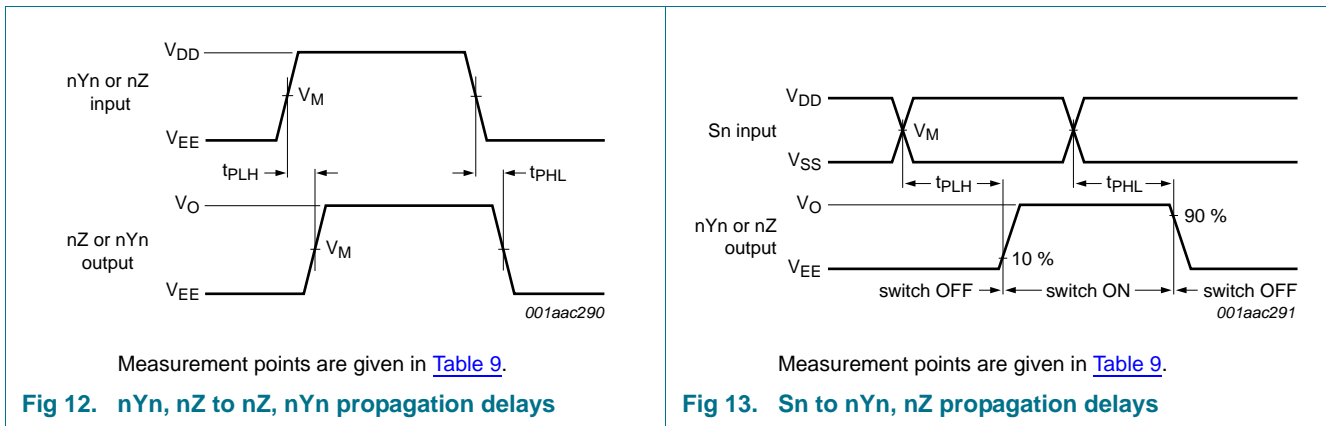
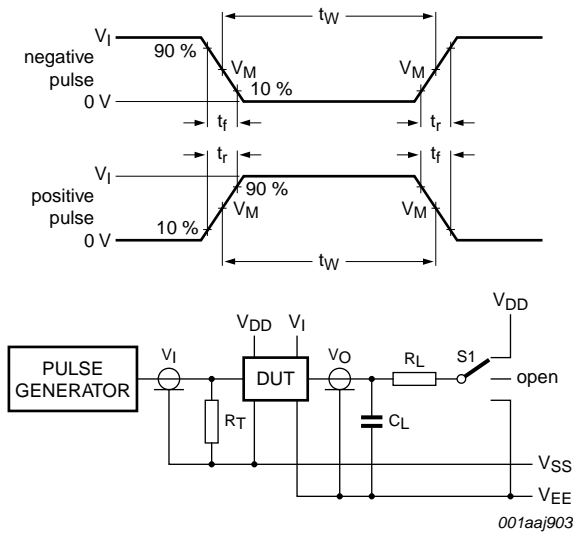


Table 9. Measurement points

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 15. Test circuit for measuring switching times

Table 10. Test data

Input				Load		S1 position				
nYn, nZ	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}	≤ 20 ns	$0.5V_{DD}$	50 pF	10 k Ω	V_{DD} or V_{EE}	V_{EE}	V_{EE}	V_{DD}	V_{EE}

[1] For nYn to nZ or nZ to nYn propagation delays use V_{EE} . For Sn to nYn or nZ 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 Figure 16 ; $R_L = 10\text{ k}\Omega$; $C_L = 15\text{ pF}$; 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	-	%
$f_{(-3dB)}$	-3 dB frequency response	see Figure 17 ; $R_L = 1\text{ k}\Omega$; $C_L = 5\text{ pF}$; channel ON; $V_I = 0.5V_{DD}$ (p-p)	5 V	[1] 13	-	MHz
			10 V	[1] 40	-	MHz
			15 V	[1] 70	-	MHz
α_{iso}	isolation (OFF-state)	see Figure 18 ; $f_i = 1\text{ MHz}$; $R_L = 1\text{ k}\Omega$; $C_L = 5\text{ pF}$; channel OFF; $V_I = 0.5V_{DD}$ (p-p)	10 V	[1] -50	-	dB
V_{ct}	crosstalk voltage	digital inputs to switch; see Figure 19 ; $R_L = 10\text{ k}\Omega$; $C_L = 15\text{ pF}$; E or $S_n = V_{DD}$ (square-wave)	10 V	50	-	mV
Xtalk	crosstalk	between switches; see Figure 20 ; $f_i = 1\text{ MHz}$; $R_L = 1\text{ k}\Omega$; $V_I = 0.5V_{DD}$ (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 (μW)	where:
P_D	dynamic power dissipation	5 V	$P_D = 2500 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	f_i = input frequency in MHz;
		10 V	$P_D = 11500 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	f_o = output frequency in MHz;
		15 V	$P_D = 29000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	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

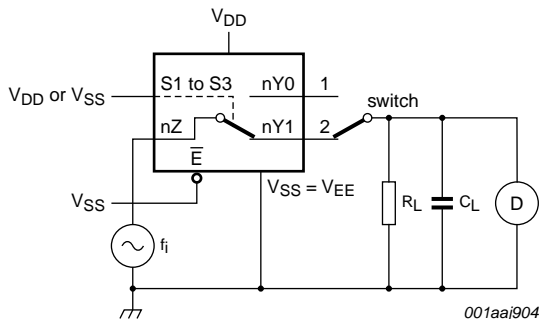


Fig 16. Test circuit for measuring total harmonic distortion

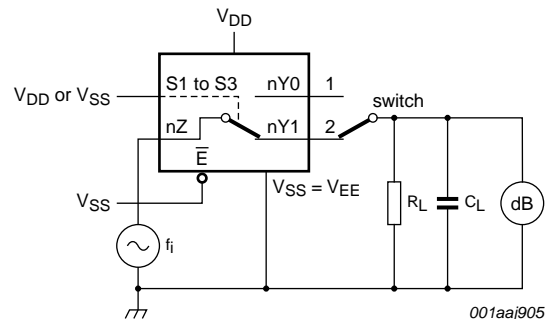


Fig 17. Test circuit for measuring frequency response

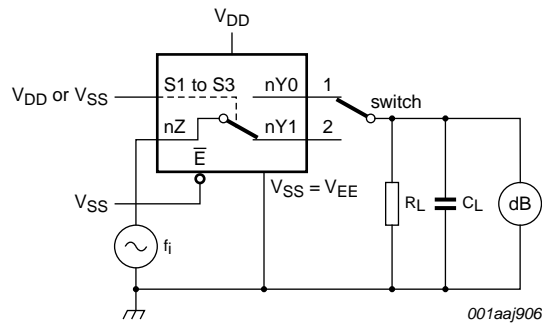
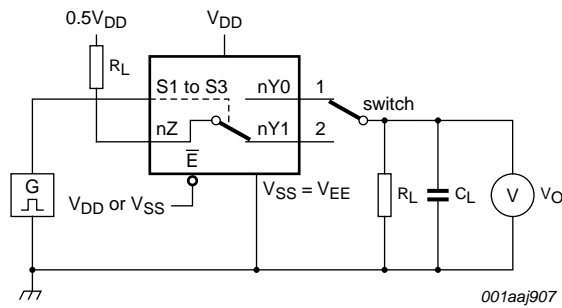
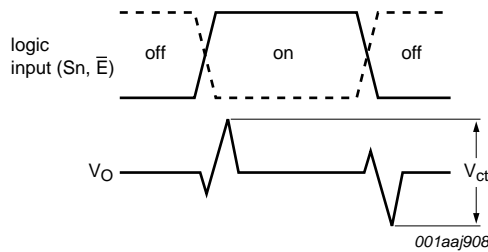


Fig 18. Test circuit for measuring isolation (OFF-state)

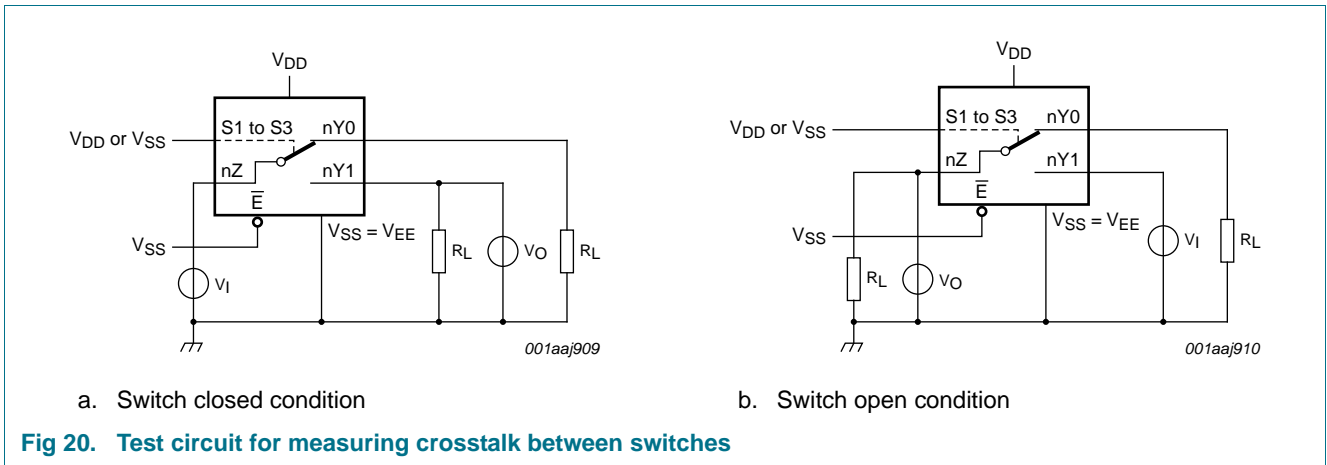


a. Test circuit



b. Input and output pulse definitions

Fig 19. Test circuit for measuring crosstalk voltage between digital inputs and switch



12. Package outline

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

SOT109-1

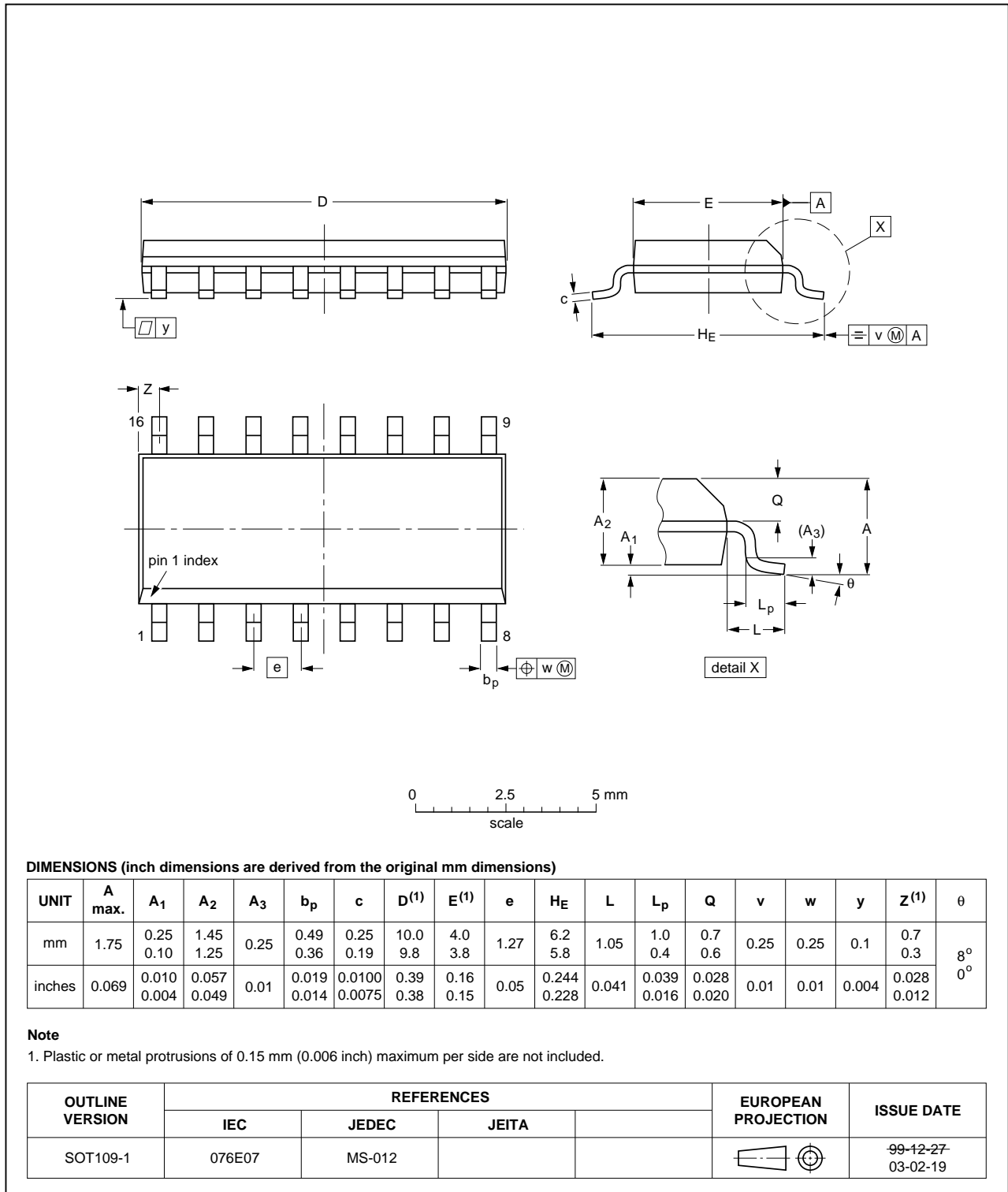


Fig 21. Package outline SOT109-1 (SO16)

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

SOT403-1

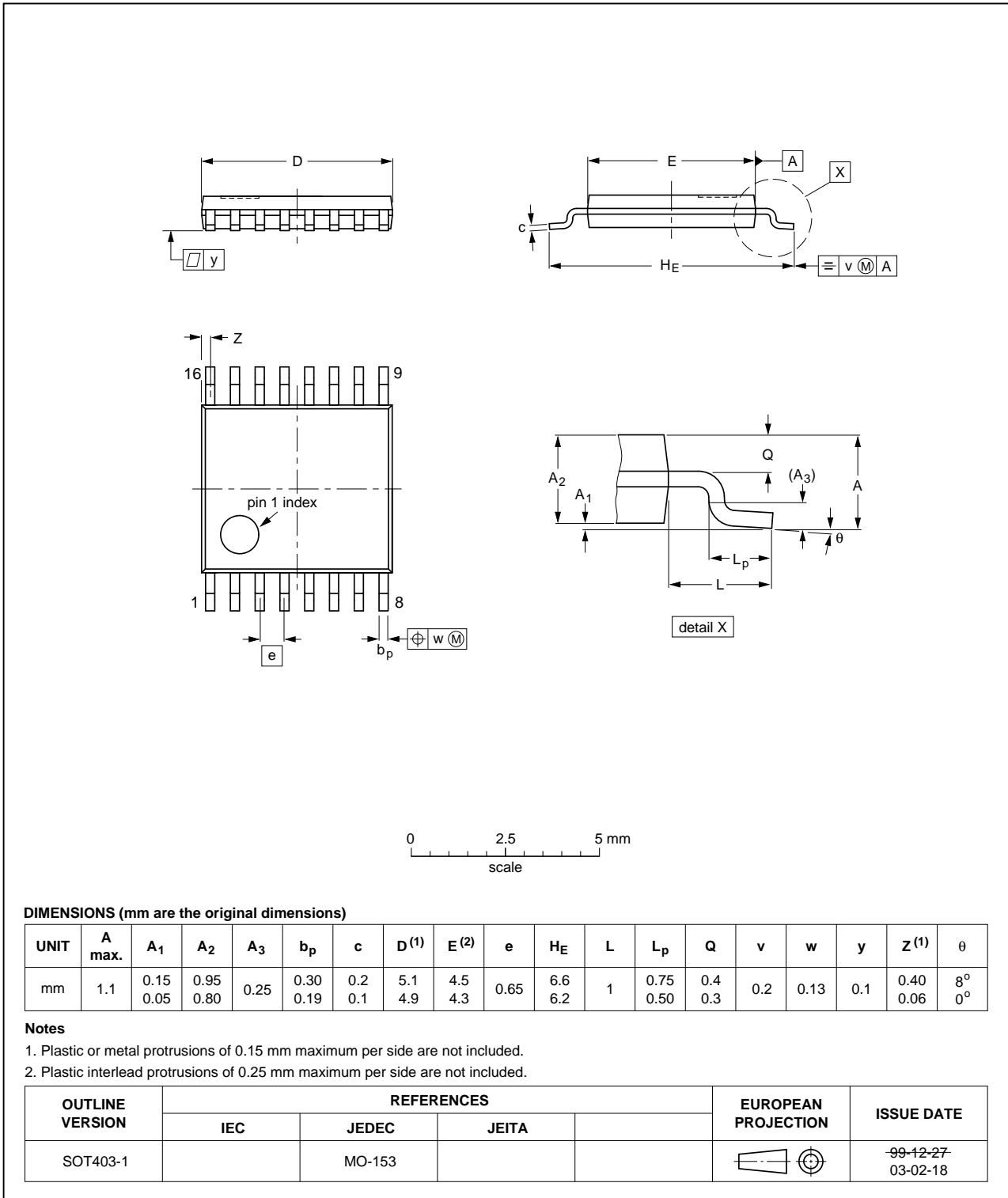


Fig 22. Package outline SOT403-1 (TSSOP16)

13. Abbreviations

Table 13. Abbreviations

Acronym	Description
HBM	Human Body Model
ESD	ElectroStatic Discharge
MM	Machine Model
MIL	Military

14. Revision history

Table 14. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4053B_Q100 v.1	20130222	Product data sheet	-	-

15. Legal information

15.1 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".

[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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