

# HEF4021B-Q100

## 8-bit static shift register

Rev. 4 — 21 March 2016

Product data sheet

### 1. General description

The HEF4021B-Q100 is an 8-bit static shift register (parallel-to-serial converter). It has a synchronous serial data input (DS), a clock input (CP) and an asynchronous active HIGH parallel load input (PL). The HEF4021B-Q100 also has eight asynchronous parallel data inputs (D0 to D7) and buffered parallel outputs from the last three stages (Q5 to Q7). Each register stage is a D-type master-slave flip-flop with a set direct (SD) and clear direct (CD) input. Information on D0 to D7 is asynchronously loaded into the register while PL is HIGH, independent of CP and DS. When PL is LOW, data on DS is shifted into the first register position. All the data in the register is shifted one position to the right on the LOW-to-HIGH transition of CP. Schmitt trigger action makes the clock input highly tolerant of slower rise and fall times. It operates over a recommended  $V_{DD}$  power supply range of 3 V to 15 V referenced to  $V_{SS}$  (usually ground). Connect unused inputs must to  $V_{DD}$ ,  $V_{SS}$ , or another input. 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  $+125\text{ }^{\circ}\text{C}$
- Tolerant of slower rise and fall times
- 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. Ordering information

Table 1. Ordering information

All types operate from  $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$ .

Type number	Package		
	Name	Description	Version
HEF4021BT-Q100	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1
HEF4021BTT-Q100	TSSOP16	plastic thin shrink small outline package; 16 leads; body width 4.4 mm	SOT403-1



### 4. Functional diagram

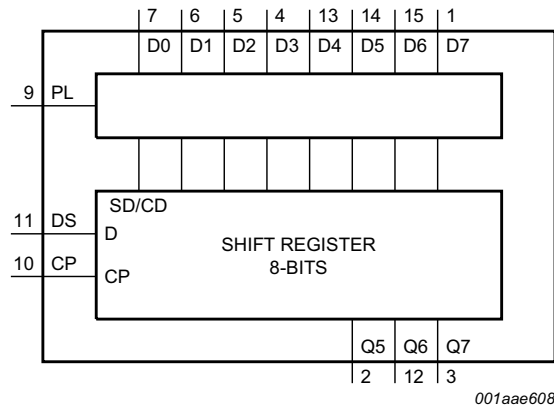


Fig 1. Functional diagram

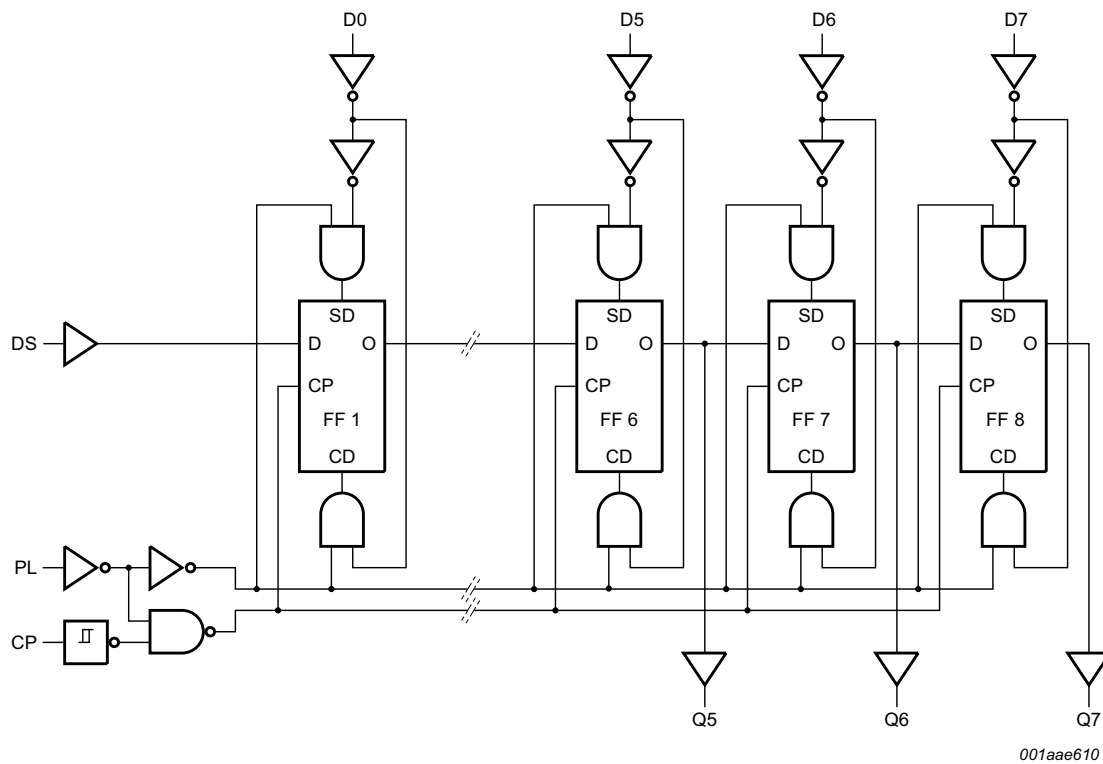
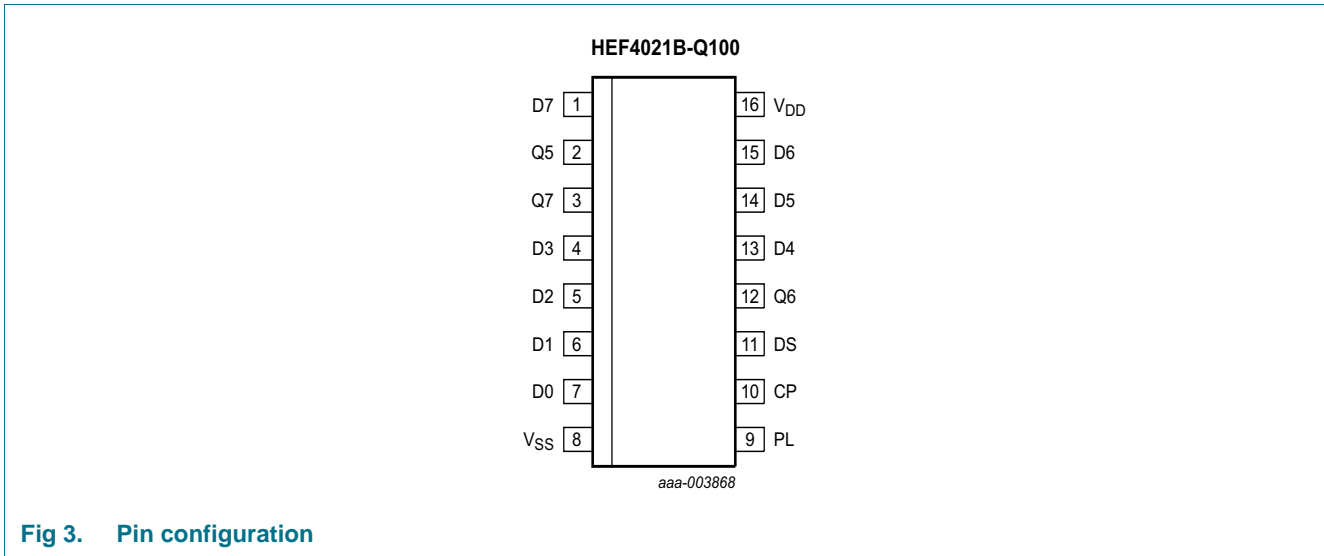


Fig 2. Logic diagram

## 5. Pinning information

### 5.1 Pinning



### 5.2 Pin description

**Table 2. Pin description**

Symbol	Pin	Description
Q5 to Q7	2, 12, 3	buffered parallel output from the last three stages
D0 to D7	7, 6, 5, 4, 13, 14, 15, 1	parallel data input
V <sub>SS</sub>	8	ground supply voltage
PL	9	parallel load input
CP	10	clock input (LOW-to-HIGH edge-triggered)
DS	11	serial data input
V <sub>DD</sub>	16	supply voltage

## 6. Functional description

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

Number of clock transitions	Inputs			Outputs		
	CP	DS	PL	Q5	Q6	Q7
<b>Serial operation</b>						
1	↑	data 1	L	X	X	X
2	↑	data 2	L	X	X	X
3	↑	data 3	L	X	X	X
6	↑	X	L	data 1	X	X
7	↑	X	L	data 2	data 1	X
8	↑	X	L	data 3	data 2	data 1
	↓	X	L	no change	no change	no change
<b>Parallel operation</b>						
	X	X	H	D5	D6	D7

- [1] H = HIGH voltage level; L = LOW voltage level; X = don't care;  
 ↑ = LOW to HIGH clock transition; ↓ = HIGH to LOW clock transition;  
 data n = data (HIGH or LOW) on the DS input at the n<sup>th</sup> ↑ CP transition.

## 7. Limiting values

Table 4. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
V <sub>DD</sub>	supply voltage		-0.5	+18	V
I <sub>IK</sub>	input clamping current	V <sub>I</sub> < -0.5 V or V <sub>I</sub> > V <sub>DD</sub> + 0.5 V	-	±10	mA
V <sub>I</sub>	input voltage		-0.5	V <sub>DD</sub> + 0.5	V
I <sub>OK</sub>	output clamping current	V <sub>O</sub> < -0.5 V or V <sub>O</sub> > V <sub>DD</sub> + 0.5 V	-	±10	mA
I <sub>I/O</sub>	input/output current		-	±10	mA
I <sub>DD</sub>	supply current		-	50	mA
T <sub>stg</sub>	storage temperature		-65	+150	°C
T <sub>amb</sub>	ambient temperature		-40	+125	°C
P <sub>tot</sub>	total power dissipation	T <sub>amb</sub> -40 °C to +125 °C			
		SO16 and TSSOP16 package <sup>[1]</sup>	-	500	mW
P	power dissipation	per output	-	100	mW

- [1] For SO16 package: P<sub>tot</sub> derates linearly with 8 mW/K above 70 °C.  
 For TSSOP16 package: P<sub>tot</sub> derates linearly with 5.5 mW/K above 60 °C.

## 8. Recommended operating conditions

Table 5. Recommended operating conditions

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V <sub>DD</sub>	supply voltage		3	-	15	V
V <sub>I</sub>	input voltage		0	-	V <sub>DD</sub>	V
T <sub>amb</sub>	ambient temperature	in free air	-40	-	+125	°C
Δt/ΔV	input transition rise and fall rate	V <sub>DD</sub> = 5 V	-	-	3.75	μs/V
		V <sub>DD</sub> = 10 V	-	-	0.5	μs/V
		V <sub>DD</sub> = 15 V	-	-	0.08	μs/V

## 9. Static characteristics

Table 6. Static characteristics

V<sub>SS</sub> = 0 V; V<sub>I</sub> = V<sub>SS</sub> or V<sub>DD</sub> unless otherwise specified.

Symbol	Parameter	Conditions	V <sub>DD</sub>	T <sub>amb</sub> = -40 °C		T <sub>amb</sub> = 25 °C		T <sub>amb</sub> = 85 °C		T <sub>amb</sub> = 125 °C		Unit
				Min	Max	Min	Max	Min	Max	Min	Max	
V <sub>IH</sub>	HIGH-level input voltage	I <sub>O</sub>   < 1 μA	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 <sub>IL</sub>	LOW-level input voltage	I <sub>O</sub>   < 1 μA	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
V <sub>OH</sub>	HIGH-level output voltage	I <sub>O</sub>   < 1 μA	5 V	4.95	-	4.95	-	4.95	-	4.95	-	V
			10 V	9.95	-	9.95	-	9.95	-	9.95	-	V
			15 V	14.95	-	14.95	-	14.95	-	14.95	-	V
V <sub>OL</sub>	LOW-level output voltage	I <sub>O</sub>   < 1 μA	5 V	-	0.05	-	0.05	-	0.05	-	0.05	V
			10 V	-	0.05	-	0.05	-	0.05	-	0.05	V
			15 V	-	0.05	-	0.05	-	0.05	-	0.05	V
I <sub>OH</sub>	HIGH-level output current	V <sub>O</sub> = 2.5 V	5 V	-	-1.7	-	-1.4	-	-1.1	-	-1.1	mA
		V <sub>O</sub> = 4.6 V	5 V	-	-0.64	-	-0.5	-	-0.36	-	-0.36	mA
		V <sub>O</sub> = 9.5 V	10 V	-	-1.6	-	-1.3	-	-0.9	-	-0.9	mA
		V <sub>O</sub> = 13.5 V	15 V	-	-4.2	-	-3.4	-	-2.4	-	-2.4	mA
I <sub>OL</sub>	LOW-level output current	V <sub>O</sub> = 0.4 V	5 V	0.64	-	0.5	-	0.36	-	0.36	-	mA
		V <sub>O</sub> = 0.5 V	10 V	1.6	-	1.3	-	0.9	-	0.9	-	mA
		V <sub>O</sub> = 1.5 V	15 V	4.2	-	3.4	-	2.4	-	2.4	-	mA
I <sub>I</sub>	input leakage current	V <sub>DD</sub> = 15 V	15 V	-	±0.1	-	±0.1	-	±1.0	-	±1.0	μA
I <sub>DD</sub>	supply current	I <sub>O</sub> = 0 A	5 V	-	5	-	5	-	150	-	150	μA
			10 V	-	10	-	10	-	300	-	300	μA
			15 V	-	20	-	20	-	600	-	600	μA
C <sub>I</sub>	input capacitance		-	-	-	7.5	-	-	-	-	pF	

## 10. Dynamic characteristics

**Table 7. Dynamic characteristics**
 $V_{SS} = 0\text{ V}$ ;  $T_{amb} = 25\text{ °C}$ ; for test circuit see [Figure 7](#); unless otherwise specified.

Symbol	Parameter	Conditions	V <sub>DD</sub>	Extrapolation formula	Min	Typ	Max	Unit
t <sub>PHL</sub>	HIGH to LOW propagation delay	CP to Qn see <a href="#">Figure 4</a>	5 V <sup>[1]</sup>	98 ns + (0.55 ns/pF)C <sub>L</sub>	-	125	250	ns
			10 V	44 ns + (0.23 ns/pF)C <sub>L</sub>	-	55	110	ns
			15 V	32 ns + (0.16 ns/pF)C <sub>L</sub>	-	40	80	ns
		PL to Qn see <a href="#">Figure 4</a>	5 V	93 ns + (0.55 ns/pF)C <sub>L</sub>	-	120	240	ns
			10 V	44 ns + (0.23 ns/pF)C <sub>L</sub>	-	55	110	ns
			15 V	32 ns + (0.16 ns/pF)C <sub>L</sub>	-	40	80	ns
t <sub>PLH</sub>	LOW to HIGH propagation delay	CP to Qn see <a href="#">Figure 4</a>	5 V <sup>[1]</sup>	88 ns + (0.55 ns/pF)C <sub>L</sub>	-	115	230	ns
			10 V	39 ns + (0.23 ns/pF)C <sub>L</sub>	-	50	100	ns
			15 V	32 ns + (0.16 ns/pF)C <sub>L</sub>	-	40	80	ns
		PL to Qn see <a href="#">Figure 4</a>	5 V	78 ns + (0.55 ns/pF)C <sub>L</sub>	-	105	210	ns
			10 V	39 ns + (0.23 ns/pF)C <sub>L</sub>	-	50	100	ns
			15 V	32 ns + (0.16 ns/pF)C <sub>L</sub>	-	40	80	ns
t <sub>t</sub>	transition time	Qn; see <a href="#">Figure 4</a>	5 V <sup>[1]</sup>	10 ns + (1.00 ns/pF)C <sub>L</sub>	-	60	120	ns
			10 V	9 ns + (0.42 ns/pF)C <sub>L</sub>	-	30	60	ns
			15 V	6 ns + (0.28 ns/pF)C <sub>L</sub>	-	20	40	ns
t <sub>su</sub>	set-up time	DS to CP; see <a href="#">Figure 5</a>	5 V		+25	-15	-	ns
			10 V		+25	-10	-	ns
			15 V		+15	-5	-	ns
		Dn to PL; see <a href="#">Figure 6</a>	5 V		50	25	-	ns
			10 V		30	10	-	ns
			15 V		20	5	-	ns
t <sub>h</sub>	hold time	DS to CP; see <a href="#">Figure 5</a>	5 V		40	20	-	ns
			10 V		20	10	-	ns
			15 V		15	8	-	ns
		Dn to PL; see <a href="#">Figure 6</a>	5 V		+15	-10	-	ns
			10 V		15	0	-	ns
			15 V		15	0	-	ns
t <sub>w</sub>	pulse width	CP = LOW; minimum width; see <a href="#">Figure 5</a>	5 V		70	35	-	ns
			10 V		30	15	-	ns
			15 V		24	12	-	ns
		PL = HIGH; minimum width; see <a href="#">Figure 6</a>	5 V		70	35	-	ns
			10 V		30	15	-	ns
			15 V		24	12	-	ns
t <sub>rec</sub>	recovery time	PL input; see <a href="#">Figure 6</a>	5 V		50	10	-	ns
			10 V		40	5	-	ns
			15 V		35	5	-	ns

**Table 7. Dynamic characteristics ...continued**  
 $V_{SS} = 0\text{ V}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ ; for test circuit see [Figure 7](#); unless otherwise specified.

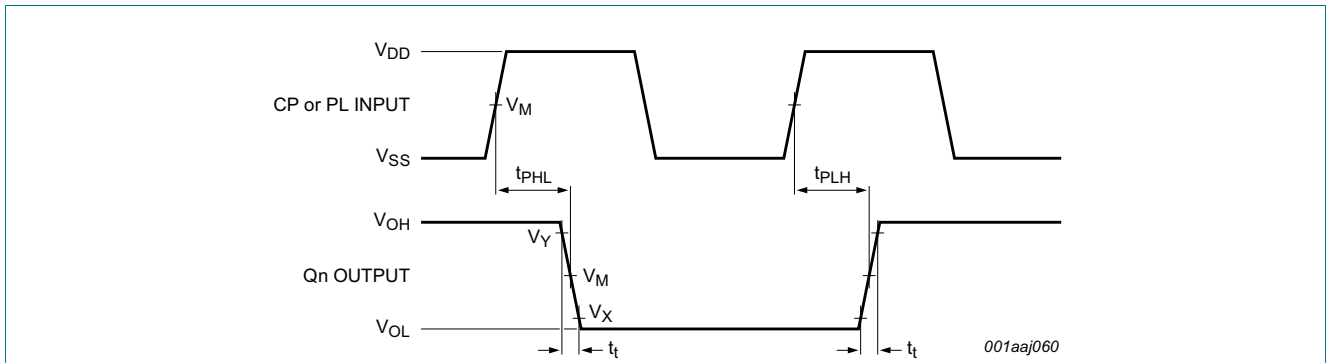
Symbol	Parameter	Conditions	V <sub>DD</sub>	Extrapolation formula	Min	Typ	Max	Unit
f <sub>clk(max)</sub>	maximum clock frequency	CP input; see <a href="#">Figure 5</a>	5 V		6	13	-	MHz
			10 V		15	30	-	MHz
			15 V		20	40	-	MHz

[1] The typical values of the propagation delay and transition times are calculated from the extrapolation formulas shown (C<sub>L</sub> in pF).

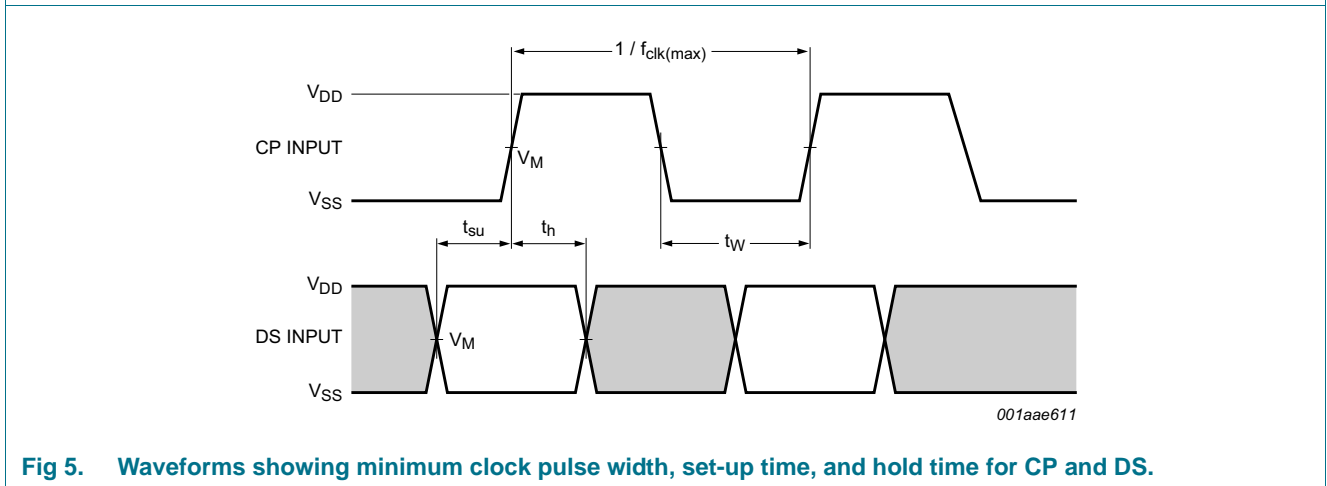
**Table 8. Dynamic power dissipation P<sub>D</sub>**  
 $P_D$  can be calculated from the formulas shown.  $V_{SS} = 0\text{ V}$ ;  $t_r = t_f \leq 20\text{ ns}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

Symbol	Parameter	V <sub>DD</sub>	Typical formula for P <sub>D</sub> (μW)	where:
P <sub>D</sub>	dynamic power dissipation	5 V	$P_D = 900 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	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, V <sub>DD</sub> = supply voltage in V, Σ(f <sub>o</sub> × C <sub>L</sub> ) = sum of the outputs.
		10 V	$P_D = 4300 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	
		15 V	$P_D = 12000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	

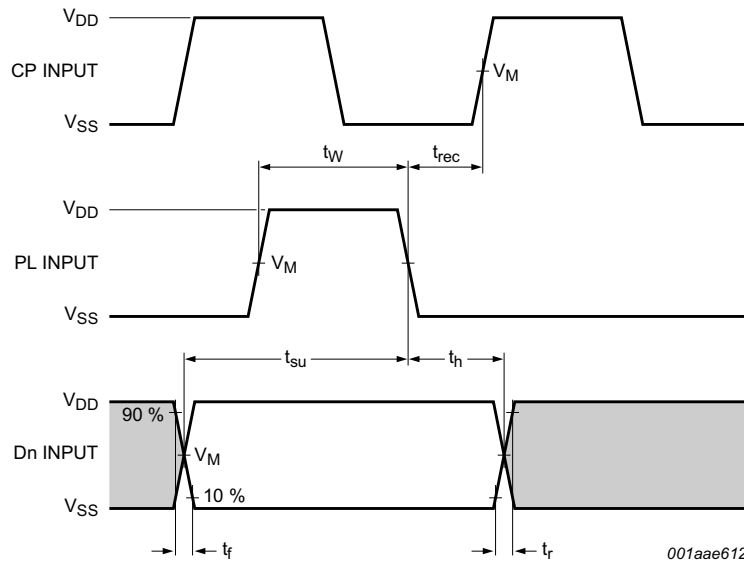
## 11. Waveforms



**Fig 4. Waveforms showing propagation delays for CP and PL inputs to Qn output and Qn transition times**



**Fig 5. Waveforms showing minimum clock pulse width, set-up time, and hold time for CP and DS.**



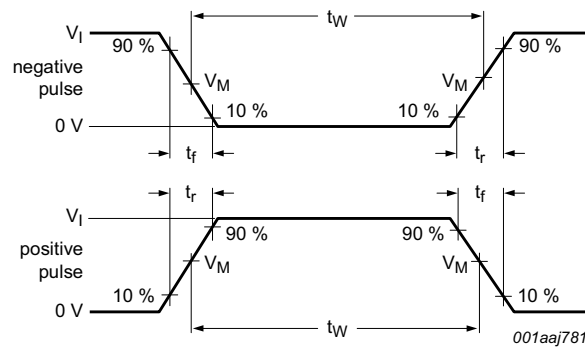
Set-up times and hold times are shown as positive values but may be specified as negative values; Measurement points are given in [Table 9](#).

**Fig 6. Waveforms showing minimum pulse width and recovery time for PL; set-up and hold times for Dn to PL.**

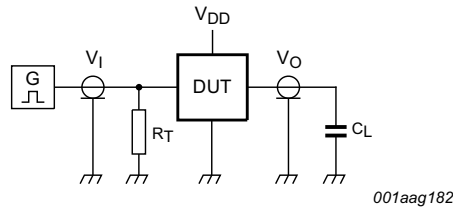
**Table 9. Measurement points**

Supply voltage	Input	Output		
$V_{DD}$	$V_M$	$V_M$	$V_X$	$V_Y$
5 V to 15 V	$0.5V_{DD}$	$0.5V_{DD}$	$0.1V_{DD}$	$0.9V_{DD}$





a. Input waveform



b. Test circuit

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

Definitions for test circuit:

DUT = Device Under Test.

$C_L$  = load capacitance including jig and probe capacitance.

$R_T$  = 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

Supply voltage	Input		Load
$V_{DD}$	$V_I$	$t_r, t_f$	$C_L$
5 V to 15 V	$V_{SS}$ or $V_{DD}$	$\leq 20$ ns	50 pF

12. Package outline

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

SOT109-1

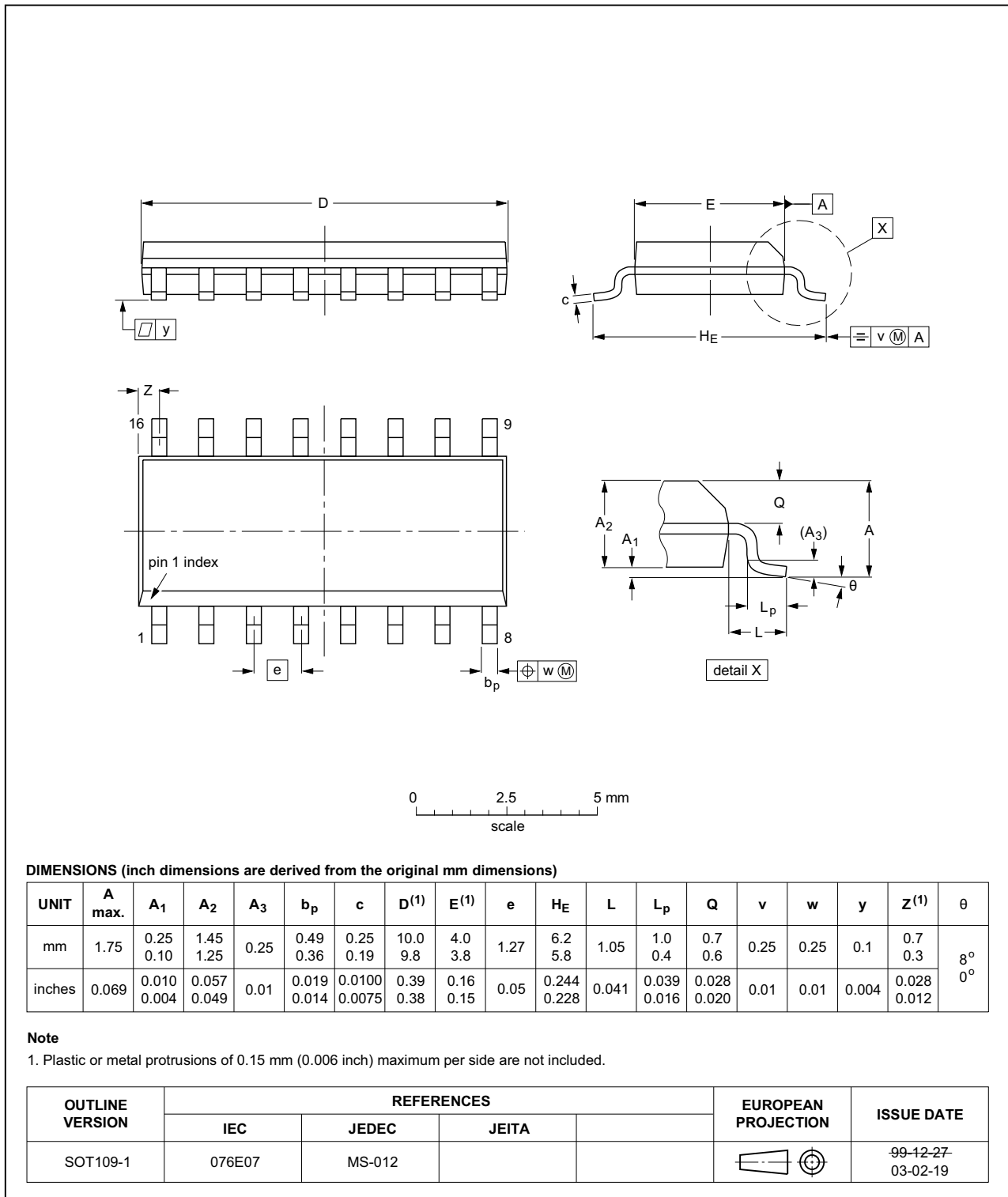


Fig 8. Package outline SOT109-1 (SO16)

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

SOT403-1

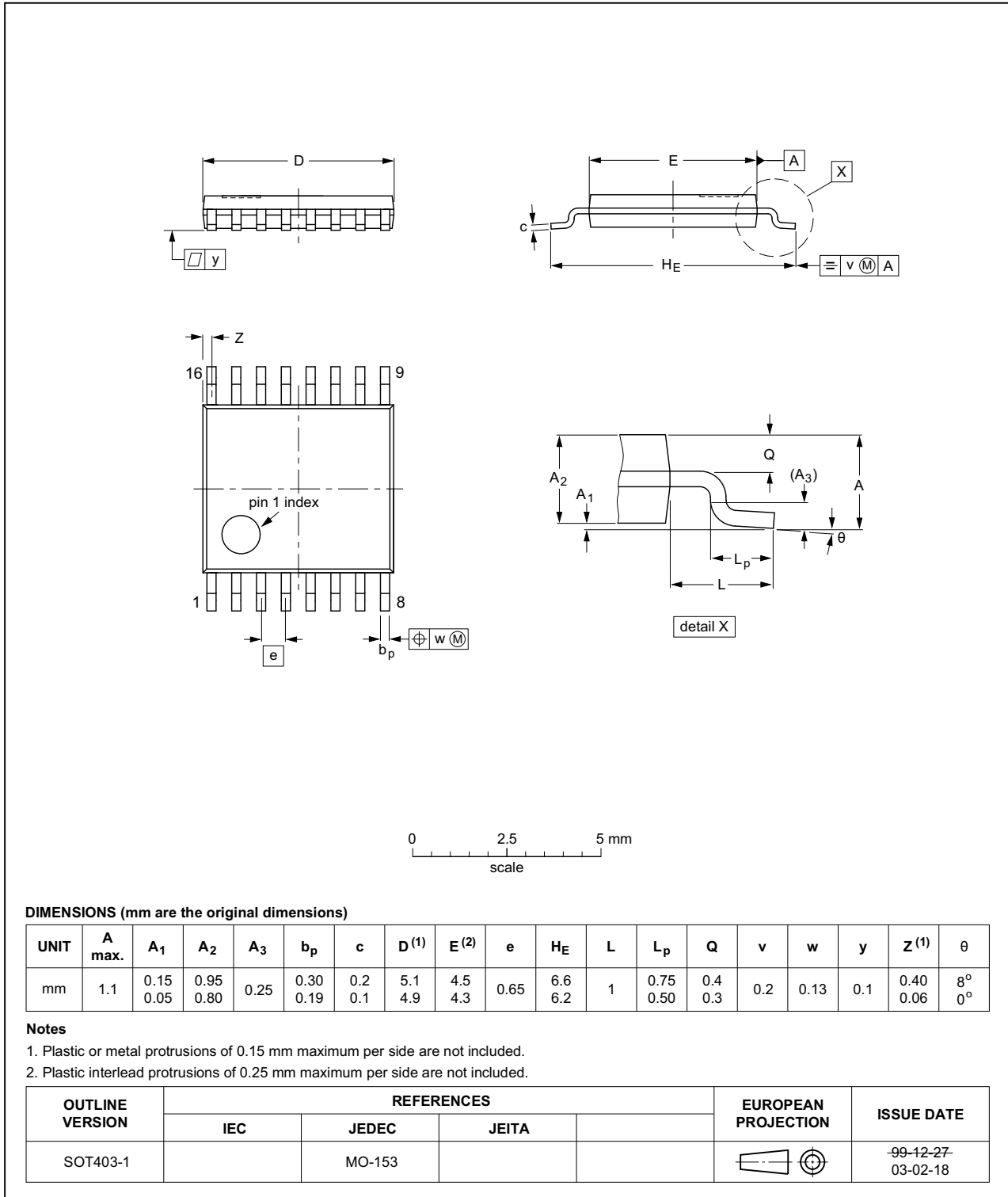


Fig 9. Package outline SOT403-1 (TSSOP16)

## 13. Abbreviations

Table 11. Abbreviations

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

## 14. Revision history

Table 12. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4021B_Q100 v.4	20160321	Product data sheet	-	HEF4021B_Q100 v.3
Modifications:	<ul style="list-style-type: none"> <li>Type number HEF4021BP-Q100 (SOT38-4) removed.</li> </ul>			
HEF4021B_Q100 v.3	20130830	Product data sheet	-	HEF4021B_Q100 v.2
Modifications:	<ul style="list-style-type: none"> <li>HEF4021BTT-Q100 (TSSOP16) added.</li> </ul>			
HEF4021B_Q100 v.2	20130220	Product data sheet	-	HEF4021B_Q100 v.1
Modifications:	<ul style="list-style-type: none"> <li>HEF4021BP-Q100 (DIP16) added.</li> </ul>			
HEF4021B_Q100 v.1	20120807	Product data sheet	-	-

## 15. Legal information

### 15.1 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".

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Date of release: 21 March 2016

Document identifier: HEF4021B\_Q100