



# THE DATASHEET OF 74HCT74



# 74HC7403; 74HCT7403

4-bit x 64-word FIFO register; 3-state

Rev. 4 — 24 September 2012

Product data sheet

## 1. General description

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The 74HC7403; 74HCT7403 is an expandable, First-In First-Out (FIFO) memory organized as 64 words by 4 bits. A guaranteed 15 MHz data-rate makes it ideal for high-speed applications. A higher data-rate can be obtained in applications where the status flags are not used (burst-mode). With separate controls for shift-in (SI) and shift-out ( $\overline{SO}$ ), reading and writing operations are completely independent, allowing synchronous and asynchronous data transfers. Additional controls include a master-reset input ( $\overline{MR}$ ), an output enable input ( $\overline{OE}$ ) and flags. The data-in-ready (DIR) and data-out-ready (DOR) flags indicate the status of the device. Inputs include clamp diodes that enable the use of current limiting resistors to interface inputs to voltages in excess of  $V_{CC}$ .

## 2. Features and benefits

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- Synchronous or asynchronous operation
- 30 MHz (typical) shift-in and shift-out rates
- Readily expandable in word and bit dimensions
- Pinning arranged for easy board layout: input pins directly opposite output pins
- Input levels:
  - ◆ For 74HC7403: CMOS level
  - ◆ For 74HCT7403: TTL level
- 3-state outputs
- Complies with JEDEC standard JESD7A
- ESD protection:
  - ◆ HBM JESD22-A114F exceeds 2 000 V
  - ◆ MM JESD22-A115-A exceeds 200 V
- Multiple package options
- Specified from  $-40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$  and from  $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$

## 3. Applications

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- High-speed disc or tape controller
- Communications buffer

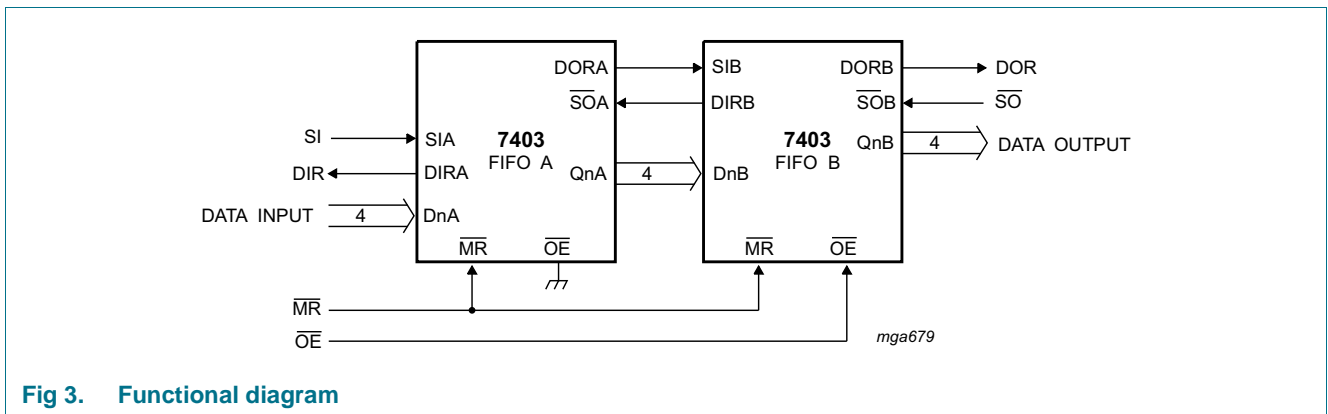
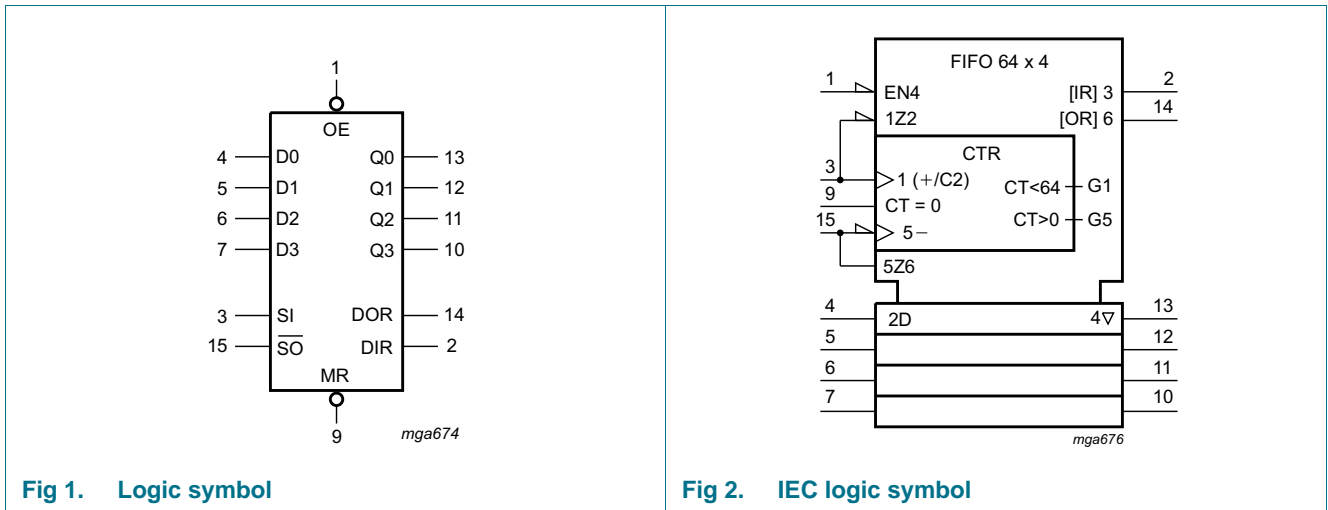


## 4. Ordering information

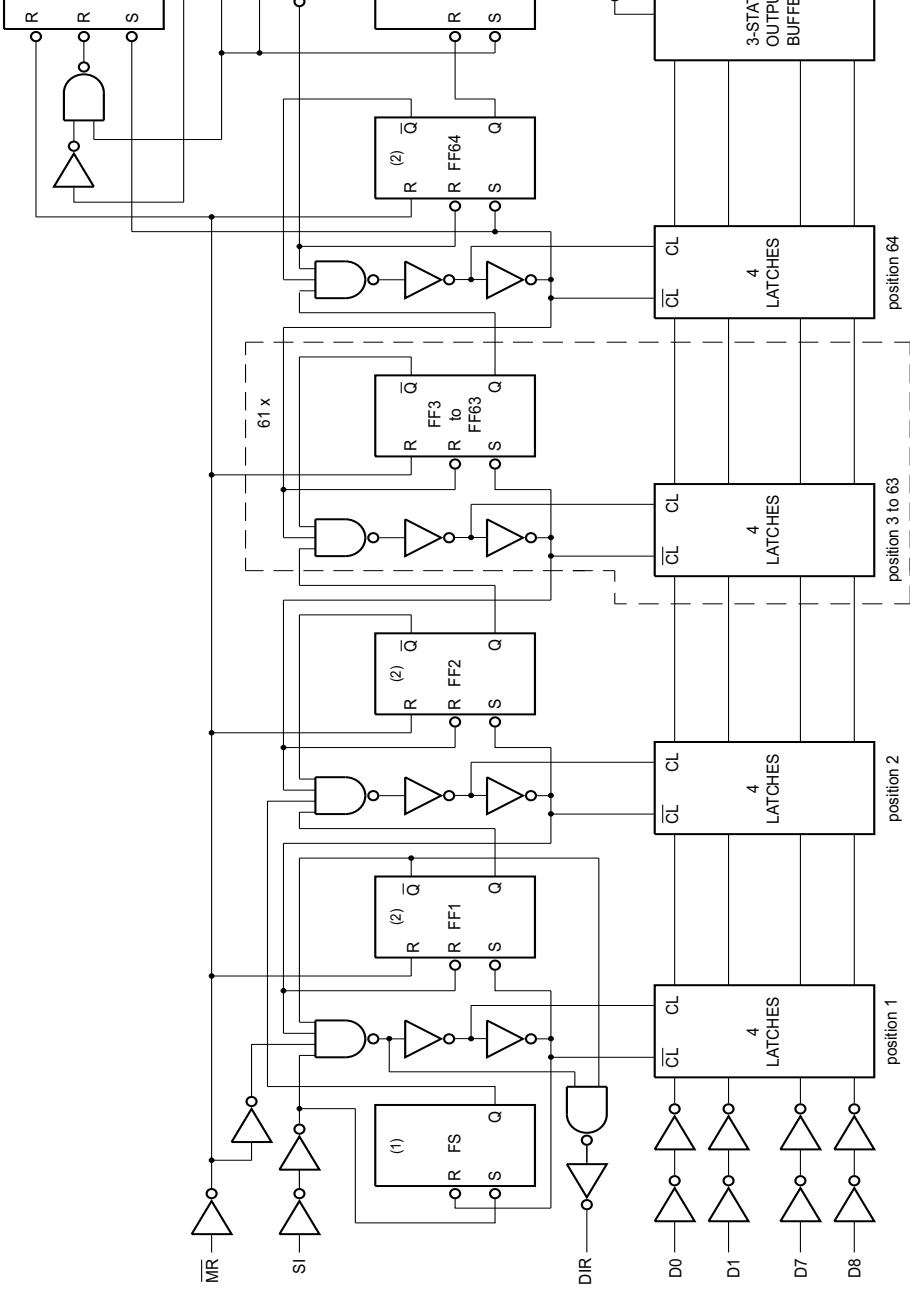
Table 1. Ordering information

Type number	Package			Version
	Temperature range	Name	Description	
74HC7403N	-40 °C to +125 °C	DIP16	plastic dual in-line package; 16 leads (300 mil)	SOT38-4
74HCT7403N				
74HC7403D	-40 °C to +125 °C	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1
74HCT7403D				

## 5. Functional diagram



**Fig 3. Functional diagram**

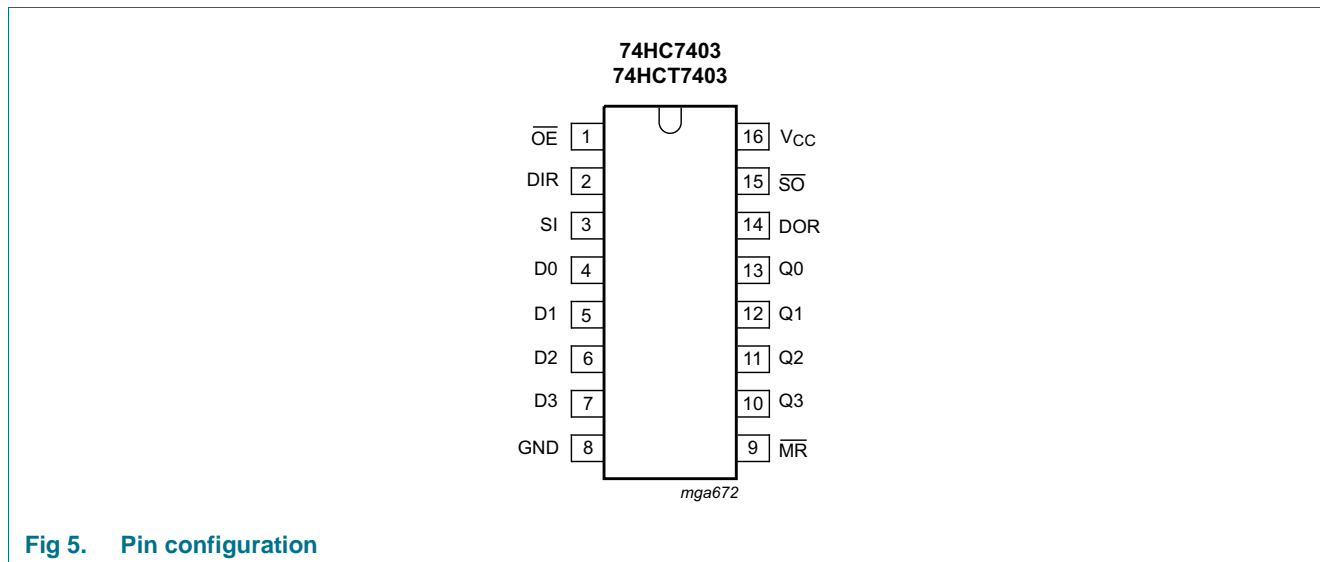


LOW on  $\bar{S}$  input of the flip-flops FS, FB and FP sets Q output to HIGH independent of state on  $\bar{R}$  input  
 LOW on  $\bar{R}$  input of FF1 to FF64 sets Q output to LOW independent of state on  $\bar{S}$  input

**Fig 4. Logic diagram**

## 6. Pinning information

### 6.1 Pinning



### 6.2 Pin description

**Table 2. Pin description**

Symbol	Pin	Description
$\overline{\text{OE}}$	1	output enable input (active LOW)
DIR	2	data-in-ready output
SI	3	shift-in input (active HIGH)
D0 to D3	4, 5, 6, 7	parallel data input
GND	8	ground (0 V)
$\overline{\text{MR}}$	9	asynchronous master-reset input (active LOW)
Q0 to Q3	13, 12, 11, 10	data output
DOR	14	data-out-ready output
$\overline{\text{SO}}$	15	shift-out input (active LOW)
V <sub>CC</sub>	16	supply voltage

## 7. Functional description

A DIR flag indicates the input stage status, either empty and ready to receive data (DIR = HIGH) or full and busy (DIR = LOW). When DIR and SI are HIGH, data present at D0 to D3 is shifted into the input stage; once complete DIR goes LOW. When SI is set LOW, data is automatically shifted to the output stage or to the last empty location. DIR set HIGH indicates a FIFO which can receive data.

A DOR flag indicates the output stage status, either data available (DOR = HIGH) or busy (DOR = LOW). When  $\overline{SO}$  and DOR are HIGH, data is available at the outputs (Q0 to Q3). When  $\overline{SO}$  is set LOW new data may be shifted into the output stage, once complete DOR is set HIGH.

### 7.1 Expanded format

The DOR and DIR signals are used to allow the 74HC7403; 74HCT7403 to be cascaded. Both parallel and serial expansion is possible. (see [Figure 18](#)).

Serial expansion is only possible with typical devices.

#### 7.1.1 Parallel expansion

Parallel expansion is accomplished by logically ANDing the DOR and DIR signals to form a composite signal.

#### 7.1.2 Serial expansion

Serial expansion is accomplished by:

- Tying the data outputs of the first device to the data inputs of the second device.
- Connecting the DOR pin of the first device to the SI pin of the second device.
- Connecting the  $\overline{SO}$  pin of the first device to the DIR pin of the second device.

## 8. Limiting values

**Table 3. 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	
$V_{CC}$	supply voltage		-0.5	+7	V	
$I_{IK}$	input clamping current	$V_I < -0.5\text{ V}$ or $V_I > V_{CC} + 0.5\text{ V}$	-	$\pm 20$	mA	
$I_{OK}$	output clamping current	$V_O < -0.5\text{ V}$ or $V_O > V_{CC} + 0.5\text{ V}$	-	$\pm 20$	mA	
$I_O$	output current	$V_O = -0.5\text{ V}$ to $(V_{CC} + 0.5\text{ V})$	-	$\pm 35$	mA	
$I_{CC}$	supply current		-	+70	mA	
$I_{GND}$	ground current		-	-70	mA	
$T_{stg}$	storage temperature		-65	+150	°C	
$P_{tot}$	total power dissipation	DIP16 package	[1]	-	750	mW
		SO16 package	[2]	-	500	mW

[1] For DIP16 packages: above 70 °C the value of  $P_{tot}$  derates linearly with 12 mW/K.

[2] For SO16 packages: above 70 °C the value of  $P_{tot}$  derates linearly with 8 mW/K.

## 9. Recommended operating conditions

**Table 4. Recommended operating conditions**

Voltages are referenced to GND (ground = 0 V)

Symbol	Parameter	Conditions	74HC7403			74HCT7403			Unit
			Min	Typ	Max	Min	Typ	Max	
V <sub>CC</sub>	supply voltage		2.0	5.0	6.0	4.5	5.0	5.5	V
V <sub>I</sub>	input voltage		0	-	V <sub>CC</sub>	0	-	V <sub>CC</sub>	V
V <sub>O</sub>	output voltage		0	-	V <sub>CC</sub>	0	-	V <sub>CC</sub>	V
T <sub>amb</sub>	ambient temperature		-40	+25	+125	-40	+25	+125	°C
Δt/ΔV	input transition rise and fall rate	V <sub>CC</sub> = 2.0 V	-	-	625	-	-	-	ns/V
		V <sub>CC</sub> = 4.5 V	-	1.67	139	-	1.67	139	ns/V
		V <sub>CC</sub> = 6.0 V	-	-	83	-	-	-	ns/V

## 10. Static characteristics

**Table 5. Static characteristics**

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

Symbol	Parameter	Conditions	25 °C			-40 °C to +85 °C		-40 °C to +125 °C		Unit
			Min	Typ	Max	Min	Max	Min	Max	
<b>74HC7403</b>										
V <sub>IH</sub>	HIGH-level input voltage	V <sub>CC</sub> = 2.0 V	1.5	1.2	-	1.5	-	1.5	-	V
		V <sub>CC</sub> = 4.5 V	3.15	2.4	-	3.15	-	3.15	-	V
		V <sub>CC</sub> = 6.0 V	4.2	3.2	-	4.2	-	4.2	-	V
V <sub>IL</sub>	LOW-level input voltage	V <sub>CC</sub> = 2.0 V	-	0.8	0.5	-	0.5	-	0.5	V
		V <sub>CC</sub> = 4.5 V	-	2.1	1.35	-	1.35	-	1.35	V
		V <sub>CC</sub> = 6.0 V	-	2.8	1.8	-	1.8	-	1.8	V
V <sub>OH</sub>	HIGH-level output voltage	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub>								
		I <sub>O</sub> = -20 μA; V <sub>CC</sub> = 2.0 V	1.9	2.0	-	1.9	-	1.9	-	V
		I <sub>O</sub> = -20 μA; V <sub>CC</sub> = 4.5 V	4.4	4.5	-	4.4	-	4.4	-	V
		I <sub>O</sub> = -20 μA; V <sub>CC</sub> = 6.0 V	5.9	6.0	-	5.9	-	5.9	-	V
		I <sub>O</sub> = -8 mA; V <sub>CC</sub> = 4.5 V	3.98	4.32	-	3.84	-	3.7	-	V
		I <sub>O</sub> = -10 mA; V <sub>CC</sub> = 6.0 V	5.48	5.81	-	5.34	-	5.2	-	V
V <sub>OL</sub>	LOW-level output voltage	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub>								
		I <sub>O</sub> = 20 μA; V <sub>CC</sub> = 2.0 V	-	0	0.1	-	0.1	-	0.1	V
		I <sub>O</sub> = 20 μA; V <sub>CC</sub> = 4.5 V	-	0	0.1	-	0.1	-	0.1	V
		I <sub>O</sub> = 20 μA; V <sub>CC</sub> = 6.0 V	-	0	0.1	-	0.1	-	0.1	V
		I <sub>O</sub> = 8 mA; V <sub>CC</sub> = 4.5 V	-	0.15	0.26	-	0.33	-	0.4	V
		I <sub>O</sub> = 10 mA; V <sub>CC</sub> = 6.0 V	-	0.15	0.26	-	0.33	-	0.4	V
I <sub>I</sub>	input leakage current	V <sub>I</sub> = V <sub>CC</sub> or GND; V <sub>CC</sub> = 6.0 V	-	-	±0.1	-	±1.0	-	±1.0	μA
I <sub>OZ</sub>	OFF-state output current	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> ; V <sub>O</sub> = V <sub>CC</sub> or GND; V <sub>CC</sub> = 6.0 V	-	-	±0.5	-	±5.0	-	±10.0	μA

**Table 5. Static characteristics ...continued**

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

Symbol	Parameter	Conditions	25 °C			-40 °C to +85 °C		-40 °C to +125 °C		Unit
			Min	Typ	Max	Min	Max	Min	Max	
I <sub>CC</sub>	supply current	V <sub>I</sub> = V <sub>CC</sub> or GND; I <sub>O</sub> = 0 A; V <sub>CC</sub> = 6.0 V	-	-	50	-	500	-	1000	μA
C <sub>I</sub>	input capacitance		-	3.5	-					pF
<b>74HCT7403</b>										
V <sub>IH</sub>	HIGH-level input voltage	V <sub>CC</sub> = 4.5 V to 5.5 V	2.0	1.6	-	2.0	-	2.0	-	V
V <sub>IL</sub>	LOW-level input voltage	V <sub>CC</sub> = 4.5 V to 5.5 V	-	1.2	0.8	-	0.8	-	0.8	V
V <sub>OH</sub>	HIGH-level output voltage	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> ; V <sub>CC</sub> = 4.5 V								
		I <sub>O</sub> = -20 μA	4.4	4.5	-	4.4	-	4.4	-	V
		I <sub>O</sub> = -8 mA	3.98	4.32	-	3.84	-	3.7	-	V
V <sub>OL</sub>	LOW-level output voltage	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> ; V <sub>CC</sub> = 4.5 V								
		I <sub>O</sub> = 20 μA	-	0	0.1	-	0.1	-	0.1	V
		I <sub>O</sub> = 8 mA	-	0.15	0.26	-	0.33	-	0.4	V
I <sub>I</sub>	input leakage current	V <sub>I</sub> = V <sub>CC</sub> or GND; V <sub>CC</sub> = 5.5 V	-	-	±0.1	-	±1.0	-	±1.0	μA
I <sub>OZ</sub>	OFF-state output current	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> ; V <sub>CC</sub> = 5.5 V; V <sub>O</sub> = V <sub>CC</sub> or GND per input pin; other inputs at V <sub>CC</sub> or GND; I <sub>O</sub> = 0 A	-	-	±0.5	-	±5.0	-	±10	μA
I <sub>CC</sub>	supply current	V <sub>I</sub> = V <sub>CC</sub> or GND; I <sub>O</sub> = 0 A; V <sub>CC</sub> = 5.5 V	-	-	50	-	500	-	1000	μA
ΔI <sub>CC</sub>	additional supply current	V <sub>I</sub> = V <sub>CC</sub> - 2.1 V; other inputs at V <sub>CC</sub> or GND; V <sub>CC</sub> = 4.5 V to 5.5 V; I <sub>O</sub> = 0 A								
		per input pin; Dn inputs	-	75	270	-	338	-	368	μA
		per input pin; $\overline{OE}$ input	-	100	360	-	450	-	490	μA
		per input pin; SI input	-	150	540	-	675	-	735	μA
		per input pin; $\overline{MR}$ input	-	150	540	-	675	-	735	μA
		per input pin; $\overline{SO}$ input	-	150	540	-	675	-	735	μA
C <sub>I</sub>	input capacitance		-	3.5	-					pF

## 11. Dynamic characteristics

**Table 6. Dynamic characteristics**

Voltages are referenced to GND (ground = 0 V);  $C_L = 50$  pF unless otherwise specified; for test circuit see [Figure 17](#).

Symbol	Parameter	Conditions	25 °C			-40 °C to +85 °C		-40 °C to +125 °C		Unit
			Min	Typ	Max	Min	Max	Min	Max	
<b>74HC7403</b>										
$t_{pd}$	propagation delay	$\overline{MR}$ to DIR or DOR; see <a href="#">Figure 8</a> <sup>[1]</sup>								
		$V_{CC} = 2.0$ V	-	69	210	-	265	-	315	ns
		$V_{CC} = 4.5$ V	-	25	42	-	53	-	63	ns
		$V_{CC} = 6.0$ V	-	20	36	-	45	-	54	ns
		SI to DIR; see <a href="#">Figure 6</a> <sup>[1]</sup>								
		$V_{CC} = 2.0$ V	-	66	205	-	255	-	310	ns
		$V_{CC} = 4.5$ V	-	24	41	-	51	-	62	ns
		$V_{CC} = 5$ V; $C_L = 15$ pF	-	15	-	-	-	-	-	ns
		$V_{CC} = 6.0$ V	-	19	35	-	43	-	53	ns
		$\overline{SO}$ to DOR; see <a href="#">Figure 9</a> <sup>[1]</sup>								
		$V_{CC} = 2.0$ V	-	94	290	-	365	-	435	ns
		$V_{CC} = 4.5$ V	-	34	58	-	73	-	87	ns
		$V_{CC} = 5$ V; $C_L = 15$ pF	-	15	-	-	-	-	-	ns
		$V_{CC} = 6.0$ V	-	27	49	-	62	-	74	ns
		DOR to Qn; see <a href="#">Figure 10</a> <sup>[1]</sup>								
		$V_{CC} = 2.0$ V	-	11	35	-	45	-	55	ns
$V_{CC} = 4.5$ V	-	4	7	-	9	-	11	ns		
$V_{CC} = 6.0$ V	-	3	6	-	8	-	9	ns		
$\overline{SO}$ to Qn; see <a href="#">Figure 14</a> <sup>[1]</sup>										
$V_{CC} = 2.0$ V	-	105	325	-	406	-	488	ns		
$V_{CC} = 4.5$ V	-	38	65	-	81	-	98	ns		
$V_{CC} = 6.0$ V	-	30	55	-	69	-	83	ns		
$t_{PHL}$	HIGH to LOW propagation delay	$\overline{MR}$ to Qn; see <a href="#">Figure 8</a>								
		$V_{CC} = 2.0$ V	-	52	160	-	200	-	240	ns
		$V_{CC} = 4.5$ V	-	19	32	-	40	-	48	ns
		$V_{CC} = 6.0$ V	-	15	27	-	34	-	41	ns
$t_{PLH}$	LOW to HIGH propagation delay	SI to DOR; see <a href="#">Figure 10</a> <sup>[5]</sup>								
		$V_{CC} = 2.0$ V	-	2.2	7	-	8.8	-	10.5	$\mu$ s
		$V_{CC} = 4.5$ V	-	0.8	1.4	-	1.8	-	2.1	$\mu$ s
		$V_{CC} = 6.0$ V	-	0.6	1.2	-	1.5	-	1.8	$\mu$ s
	$\overline{SO}$ to DIR; see <a href="#">Figure 7</a> <sup>[6]</sup>									
	$V_{CC} = 2.0$ V	-	2.8	9	-	11.2	-	13.5	$\mu$ s	
	$V_{CC} = 4.5$ V	-	1.0	1.8	-	2.2	-	2.7	$\mu$ s	
	$V_{CC} = 6.0$ V	-	0.8	1.5	-	1.9	-	2.3	$\mu$ s	

**Table 6. Dynamic characteristics ...continued**

Voltages are referenced to GND (ground = 0 V);  $C_L = 50$  pF unless otherwise specified; for test circuit see [Figure 17](#).

Symbol	Parameter	Conditions	25 °C			-40 °C to +85 °C		-40 °C to +125 °C		Unit	
			Min	Typ	Max	Min	Max	Min	Max		
$t_{en}$	enable time	$\overline{OE}$ to Qn; see <a href="#">Figure 16</a> <a href="#">[2]</a>									
		$V_{CC} = 2.0$ V	-	44	150	-	190	-	225	ns	
		$V_{CC} = 4.5$ V	-	16	30	-	38	-	45	ns	
		$V_{CC} = 6.0$ V	-	13	26	-	32	-	38	ns	
$t_{dis}$	disable time	$\overline{OE}$ to Qn; see <a href="#">Figure 16</a> <a href="#">[3]</a>									
		$V_{CC} = 2.0$ V	-	50	150	-	190	-	225	ns	
		$V_{CC} = 4.5$ V	-	18	30	-	38	-	45	ns	
		$V_{CC} = 6.0$ V	-	14	26	-	33	-	38	ns	
$t_t$	transition time	Qn; see <a href="#">Figure 14</a> <a href="#">[4]</a>									
		$V_{CC} = 2.0$ V	-	14	60	-	75	-	90	ns	
		$V_{CC} = 4.5$ V	-	5	12	-	15	-	18	ns	
		$V_{CC} = 6.0$ V	-	4	10	-	13	-	15	ns	
$t_w$	pulse width	SI HIGH or LOW; see <a href="#">Figure 6</a>									
		$V_{CC} = 2.0$ V	35	11	-	45	-	55	-	ns	
		$V_{CC} = 4.5$ V	7	4	-	9	-	11	-	ns	
		$V_{CC} = 6.0$ V	6	3	-	8	-	9	-	ns	
		SO HIGH or LOW; see <a href="#">Figure 9</a>									
		$V_{CC} = 2.0$ V	70	22	-	90	-	105	-	ns	
		$V_{CC} = 4.5$ V	14	8	-	18	-	21	-	ns	
		$V_{CC} = 6.0$ V	12	6	-	15	-	18	-	ns	
		DIR HIGH; see <a href="#">Figure 7</a>									
		$V_{CC} = 2.0$ V	10	41	130	8	165	8	195	ns	
		$V_{CC} = 4.5$ V	5	15	26	4	33	4	39	ns	
		$V_{CC} = 6.0$ V	4	12	22	3	28	3	23	ns	
		DOR HIGH; see <a href="#">Figure 10</a>									
		$V_{CC} = 2.0$ V	14	52	160	12	200	12	240	ns	
		$V_{CC} = 4.5$ V	7	19	32	6	40	6	48	ns	
		$V_{CC} = 6.0$ V	6	15	27	5	34	5	41	ns	
$\overline{MR}$ LOW; see <a href="#">Figure 8</a>											
$V_{CC} = 2.0$ V	120	39	-	150	-	180	-	ns			
$V_{CC} = 4.5$ V	24	14	-	30	-	36	-	ns			
$V_{CC} = 6.0$ V	20	11	-	26	-	31	-	ns			
$t_{rec}$	recovery time	$\overline{MR}$ to SI; see <a href="#">Figure 15</a>									
		$V_{CC} = 2.0$ V	80	24	-	100	-	120	-	ns	
		$V_{CC} = 4.5$ V	16	8	-	20	-	24	-	ns	
		$V_{CC} = 6.0$ V	14	7	-	17	-	20	-	ns	

**Table 6. Dynamic characteristics ...continued**

Voltages are referenced to GND (ground = 0 V);  $C_L = 50$  pF unless otherwise specified; for test circuit see [Figure 17](#).

Symbol	Parameter	Conditions	25 °C			-40 °C to +85 °C		-40 °C to +125 °C		Unit
			Min	Typ	Max	Min	Max	Min	Max	
$t_{su}$	set-up time	Dn to SI; see <a href="#">Figure 13</a>								
		$V_{CC} = 2.0$ V	-8	-36	-	-6	-	-6	-	ns
		$V_{CC} = 4.5$ V	-4	-13	-	-3	-	-3	-	ns
		$V_{CC} = 6.0$ V	-3	-10	-	-3	-	-3	-	ns
$t_h$	hold time	Dn to SI; see <a href="#">Figure 13</a>								
		$V_{CC} = 2.0$ V	135	44	-	170	-	205	-	ns
		$V_{CC} = 4.5$ V	27	16	-	34	-	41	-	ns
		$V_{CC} = 6.0$ V	23	13	-	29	-	35	-	ns
$f_{max}$	maximum frequency	SI, $\overline{SO}$ burst mode; see <a href="#">Figure 11</a> and <a href="#">Figure 12</a>								
		$V_{CC} = 2.0$ V	3.6	9.9	-	2.8	-	2.4	-	MHz
		$V_{CC} = 4.5$ V	18	30	-	14	-	12	-	MHz
		$V_{CC} = 5$ V; $C_L = 15$ pF	-	30	-	-	-	-	-	MHz
		$V_{CC} = 6.0$ V	21	36	-	16	-	14	-	MHz
		SI, $\overline{SO}$ using flags; see <a href="#">Figure 6</a> and <a href="#">Figure 9</a>								
		$V_{CC} = 2.0$ V	3.6	9.9	-	2.8	-	2.4	-	MHz
		$V_{CC} = 4.5$ V	18	30	-	14	-	12	-	MHz
		$V_{CC} = 5$ V; $C_L = 15$ pF	-	30	-	-	-	-	-	MHz
		$V_{CC} = 6.0$ V	21	36	-	16	-	14	-	MHz
		SI, $\overline{SO}$ cascaded; see <a href="#">Figure 6</a> and <a href="#">Figure 9</a>								
		$V_{CC} = 2.0$ V	-	7.6	-	-	-	-	-	MHz
		$V_{CC} = 4.5$ V	-	23	-	-	-	-	-	MHz
$V_{CC} = 6.0$ V	-	27	-	-	-	-	-	MHz		
$C_{PD}$	power dissipation capacitance	$V_I = \text{GND to } V_{CC}$	<a href="#">[7]</a>	-	475	-	-	-	-	pF

**Table 6. Dynamic characteristics ...continued**

Voltages are referenced to GND (ground = 0 V);  $C_L = 50$  pF unless otherwise specified; for test circuit see [Figure 17](#).

Symbol	Parameter	Conditions	25 °C			-40 °C to +85 °C		-40 °C to +125 °C		Unit
			Min	Typ	Max	Min	Max	Min	Max	
<b>74HCT7403</b>										
$t_{pd}$	propagation delay	$\overline{MR}$ to DIR or DOR; see <a href="#">Figure 8</a> <sup>[1]</sup>								
		$V_{CC} = 4.5$ V	-	30	51	-	53	-	63	ns
		SI to DIR; see <a href="#">Figure 6</a> <sup>[1]</sup>								
		$V_{CC} = 4.5$ V	-	25	43	-	54	-	65	ns
		$V_{CC} = 5$ V; $C_L = 15$ pF	-	17	-	-	-	-	-	ns
		$\overline{SO}$ to DOR; see <a href="#">Figure 9</a> <sup>[1]</sup>								
		$V_{CC} = 4.5$ V	-	36	61	-	76	-	92	ns
		$V_{CC} = 5$ V; $C_L = 15$ pF	-	17	-	-	-	-	-	ns
		DOR to Qn; see <a href="#">Figure 10</a> <sup>[1]</sup>								
$V_{CC} = 4.5$ V	-	7	12	-	15	-	18	ns		
$t_{PHL}$	HIGH to LOW propagation delay	$\overline{SO}$ to Qn; see <a href="#">Figure 14</a> <sup>[1]</sup>								
		$V_{CC} = 4.5$ V	-	42	72	-	90	-	108	ns
		$\overline{MR}$ to Qn; see <a href="#">Figure 8</a>								
$V_{CC} = 4.5$ V	-	22	38	-	48	-	57	ns		
$t_{PLH}$	LOW to HIGH propagation delay	SI to DOR; see <a href="#">Figure 10</a> <sup>[5]</sup>								
		$V_{CC} = 4.5$ V	-	0.8	1.4	-	1.75	-	2.1	$\mu$ s
		$\overline{SO}$ to DIR; see <a href="#">Figure 7</a> <sup>[6]</sup>								
$V_{CC} = 4.5$ V	-	1.0	1.8	-	2.25	-	2.7	$\mu$ s		
$t_{en}$	enable time	$\overline{OE}$ to Qn; see <a href="#">Figure 16</a> <sup>[2]</sup>								
		$V_{CC} = 4.5$ V	-	16	30	-	38	-	45	ns
$t_{dis}$	disable time	$\overline{OE}$ to Qn; see <a href="#">Figure 16</a> <sup>[3]</sup>								
		$V_{CC} = 4.5$ V	-	19	30	-	38	-	45	ns
$t_t$	transition time	Qn; see <a href="#">Figure 14</a> <sup>[4]</sup>								
		$V_{CC} = 4.5$ V	-	5	12	-	15	-	18	ns
$t_W$	pulse width	SI HIGH or LOW; see <a href="#">Figure 6</a>								
		$V_{CC} = 4.5$ V	9	5	-	6	-	8	-	ns
		$\overline{SO}$ HIGH or LOW; see <a href="#">Figure 9</a>								
		$V_{CC} = 4.5$ V	14	8	-	18	-	21	-	ns
		DIR HIGH; see <a href="#">Figure 7</a>								
		$V_{CC} = 4.5$ V	5	17	29	4	36	4	44	ns
		DOR HIGH; see <a href="#">Figure 10</a>								
		$V_{CC} = 4.5$ V	7	21	36	6	45	6	54	ns
$t_W$	pulse width	$\overline{MR}$ LOW; see <a href="#">Figure 8</a>								
		$V_{CC} = 4.5$ V	26	15	-	33	-	39	-	ns

**Table 6. Dynamic characteristics ...continued**

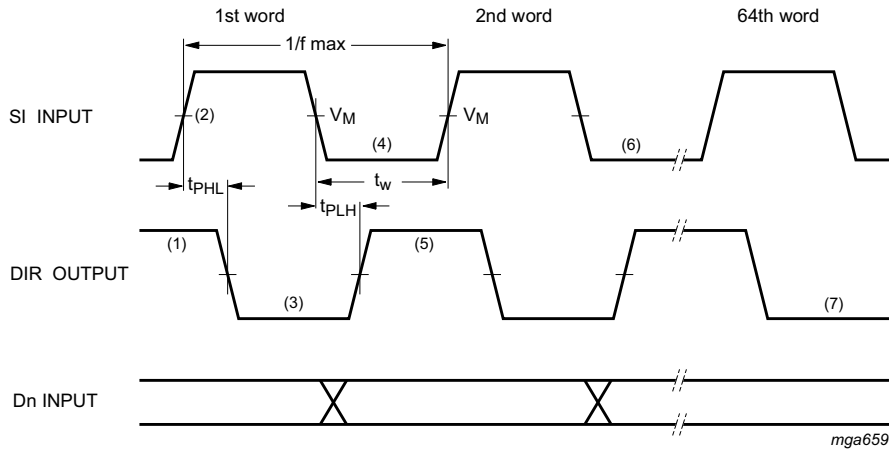
Voltages are referenced to GND (ground = 0 V);  $C_L = 50$  pF unless otherwise specified; for test circuit see [Figure 17](#).

Symbol	Parameter	Conditions	25 °C			-40 °C to +85 °C		-40 °C to +125 °C		Unit
			Min	Typ	Max	Min	Max	Min	Max	
$t_{rec}$	recovery time	$\overline{MR}$ to SI; see <a href="#">Figure 15</a>								
		$V_{CC} = 4.5$ V	18	10	-	23	-	27	-	ns
$t_{su}$	set-up time	Dn to SI; see <a href="#">Figure 13</a>								
		$V_{CC} = 4.5$ V	-5	-16	-	-4	-	-4	-	ns
$t_h$	hold time	Dn to SI; see <a href="#">Figure 13</a>								
		$V_{CC} = 4.5$ V	30	18	-	38	-	45	-	ns
$f_{max}$	maximum frequency	SI, $\overline{SO}$ burst mode; see <a href="#">Figure 11</a> and <a href="#">Figure 12</a>								
		$V_{CC} = 4.5$ V	18	30	-	14	-	12	-	MHz
		$V_{CC} = 5$ V; $C_L = 15$ pF	-	30	-	-	-	-	-	MHz
		SI, $\overline{SO}$ using flags; see <a href="#">Figure 6</a> and <a href="#">Figure 9</a>								
		$V_{CC} = 4.5$ V	18	30	-	14	-	12	-	MHz
		$V_{CC} = 5$ V; $C_L = 15$ pF	-	30	-	-	-	-	-	MHz
$C_{PD}$	power dissipation capacitance	SI, $\overline{SO}$ cascaded; see <a href="#">Figure 6</a> and <a href="#">Figure 9</a>								
		$V_I = GND$ to $V_{CC} - 1.5$ V	[7]	-	490	-	-	-	-	pF

- [1]  $t_{pd}$  is the same as  $t_{PLH}$  and  $t_{PHL}$ .
- [2]  $t_{en}$  is the same as  $t_{PZH}$  and  $t_{PZL}$ .
- [3]  $t_{dis}$  is the same as  $t_{PLZ}$  and  $t_{PHZ}$ .
- [4]  $t_t$  is the same as  $t_{THL}$  and  $t_{TLH}$ .
- [5] This is the ripple through delay.
- [6] This is the bubble-up delay.
- [7]  $C_{PD}$  is used to determine the dynamic power dissipation ( $P_D$  in  $\mu W$ ).  
 $P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \sum(C_L \times V_{CC}^2 \times f_o)$  where:  
 $f_i$  = input frequency in MHz;  
 $f_o$  = output frequency in MHz;  
 $C_L$  = output load capacitance in pF;  
 $V_{CC}$  = supply voltage in V;  
 $N$  = number of inputs switching;  
 $\sum(C_L \times V_{CC}^2 \times f_o)$  = sum of outputs.

12. Waveforms

12.1 Shifting in sequence FIFO empty to FIFO full



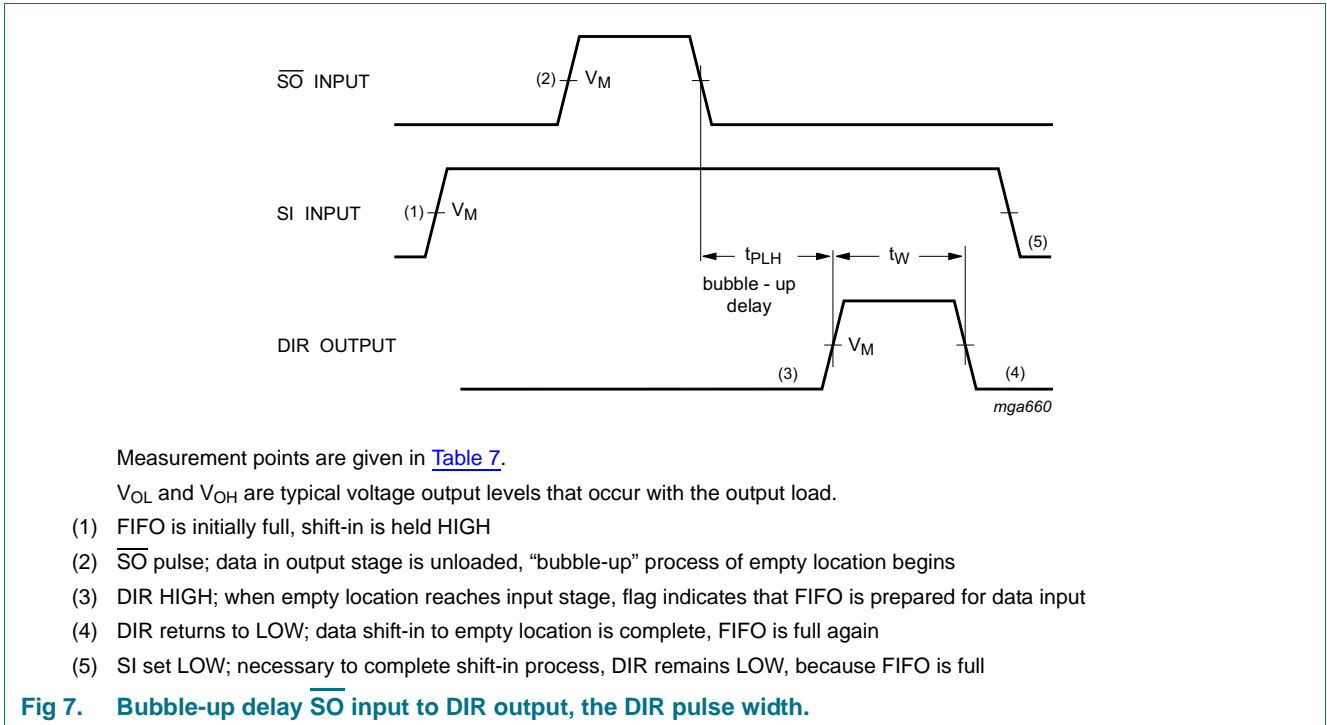
Measurement points are given in [Table 7](#).

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

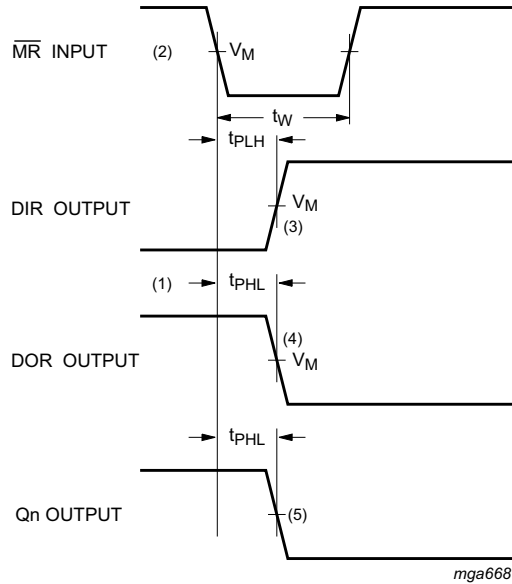
- (1) DIR initially HIGH; FIFO is prepared for valid data
- (2) SI set HIGH; data loaded into input stage
- (3) DIR goes LOW; input stage "busy"
- (4) SI set LOW; data from first location "ripple through"
- (5) DIR goes HIGH; status flag indicates FIFO prepared for additional data
- (6) Repeat process to load 2<sup>nd</sup> word through to 64<sup>th</sup> word into FIFO; DIR remains LOW; with attempt to shift into full FIFO, no data transfer occurs.

Fig 6. Propagation delay SI input to DIR output, the SI pulse width and the SI maximum frequency

12.2 With FIFO full; SI held HIGH in anticipation of empty location



12.3 Master reset applied with FIFO full



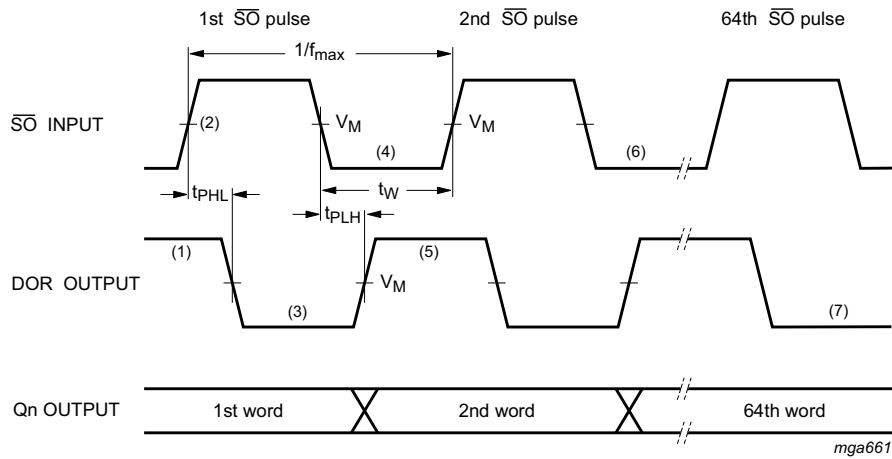
Measurement points are given in [Table 7](#).

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

- (1) DIR LOW; output ready HIGH; assume that FIFO is full
- (2)  $\overline{MR}$  pulse LOW; clears FIFO
- (3) DIR goes HIGH; flag indicates input prepared for valid data
- (4) DOR goes LOW; flag indicates FIFO empty
- (5) Qn outputs go LOW (only last bit is reset)

**Fig 8. Propagation delay  $\overline{MR}$  input to DIR output, DOR output and Qn outputs and the  $\overline{MR}$  pulse width.**

12.4  $\overline{S\bar{O}}$  input to DOR output propagation delay



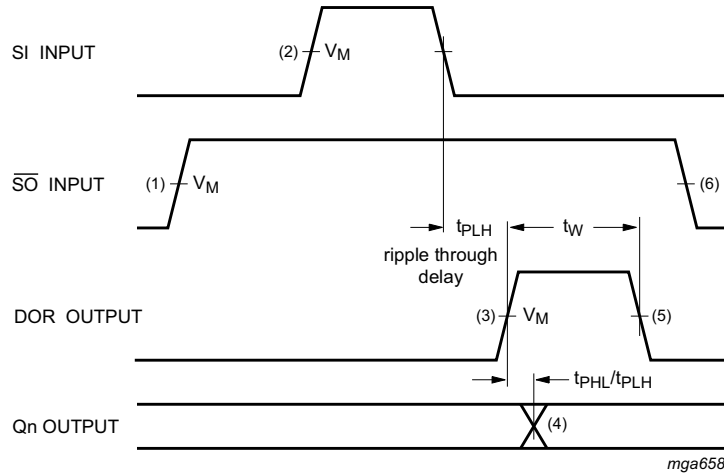
Measurement points are given in [Table 7](#).

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

- (1) DOR HIGH; no data transfer in progress, valid data is present at the output stage
- (2)  $\overline{S\bar{O}}$  set HIGH; result in DOR going LOW
- (3) DOR goes LOW; output stage "busy"
- (4)  $\overline{S\bar{O}}$  set LOW; data in the input stage is unloaded, and new data replaces it as empty location "bubbles-up" to input stage
- (5) DOR goes HIGH; transfer process completed, valid data present at output after the specified propagation delay
- (6) Repeat process to unload the 3<sup>rd</sup> through the 64<sup>th</sup> word from FIFO
- (7) DOR remains LOW; FIFO is empty

Fig 9. Propagation delay  $\overline{S\bar{O}}$  input to DOR output, the  $\overline{S\bar{O}}$  pulse width and the  $\overline{S\bar{O}}$  maximum frequency.

12.5 With FIFO empty;  $\overline{SO}$  is held HIGH in anticipation



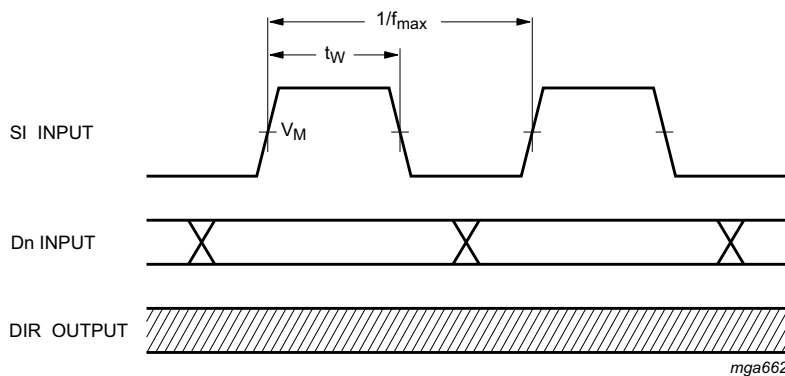
Measurement points are given in [Table 7](#).

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

- (1) FIFO is initially empty.  $\overline{SO}$  is held HIGH.
- (2) SI pulse; loads data into FIFO and initiates ripple through process
- (3) DOR flag signals the arrival of valid data at the output stage
- (4) Output transition; data arrives at output stage after the specified propagation delay between the rising and falling edge of the DOR pulse to the Qn output
- (5) DOR goes LOW; data shift-out is completed, FIFO is empty again
- (6)  $\overline{SO}$  set LOW; necessary to complete shift-out process. DOR remains LOW, because FIFO is empty

Fig 10. Ripple through delay SI input to DOR output, propagation delay DOR input to Qn outputs and the DOR pulse width

12.6 Shift-in operation; high speed burst mode



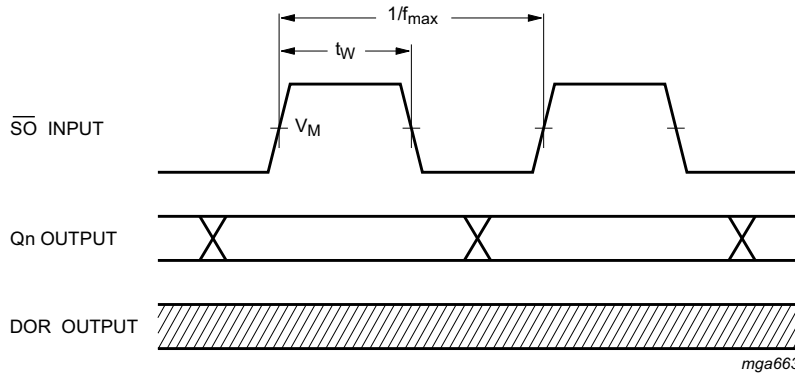
Measurement points are given in [Table 7](#).

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

In the high-speed mode, the burst-in rate is determined by the minimum shift-in HIGH and shift-in LOW specifications. The DIR status flag is a “don’t care” condition, and a shift-in pulse can be applied regardless of the flag. An SI pulse which would overflow the storage capacity of the FIFO is ignored.

Fig 11. The SI pulse width and the SI maximum frequency

12.7 Shift-out operation; high speed burst mode



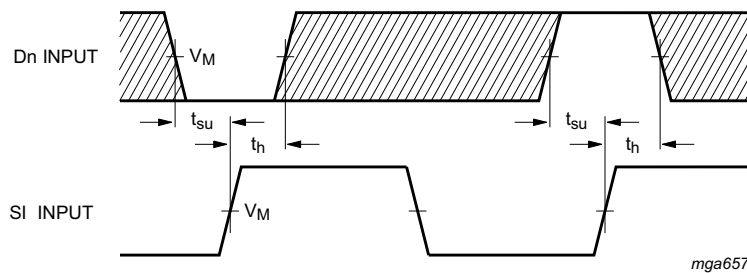
Measurement points are given in [Table 7](#).

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

In the high-speed mode, the burst rate is determined by the minimum shift-out HIGH and shift-out LOW specifications. The DOR flag is a "don't care" condition, and an  $\overline{SO}$  pulse can be applied without regard to the flag.

Fig 12. The  $\overline{SO}$  pulse width and the  $\overline{SO}$  maximum frequency

12.8 Set-up and hold times



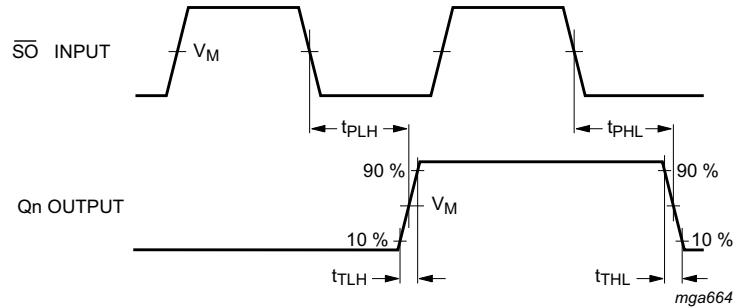
Measurement points are given in [Table 7](#).

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

The shaded areas indicate when the output is permitted to change for predictable output performance

Fig 13. Set-up and hold times

12.9  $\overline{SO}$  input to Qn outputs propagation delay

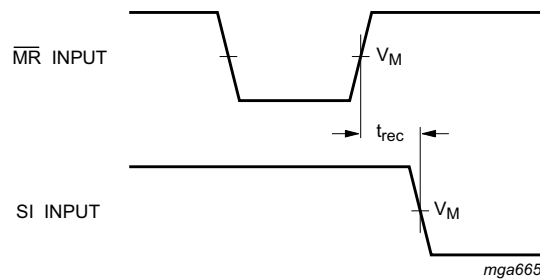


Measurement points are given in [Table 7](#).

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

Fig 14. Propagation delay  $\overline{SO}$  input to Qn outputs and the output transition time

12.10  $\overline{MR}$  to SI recovery time

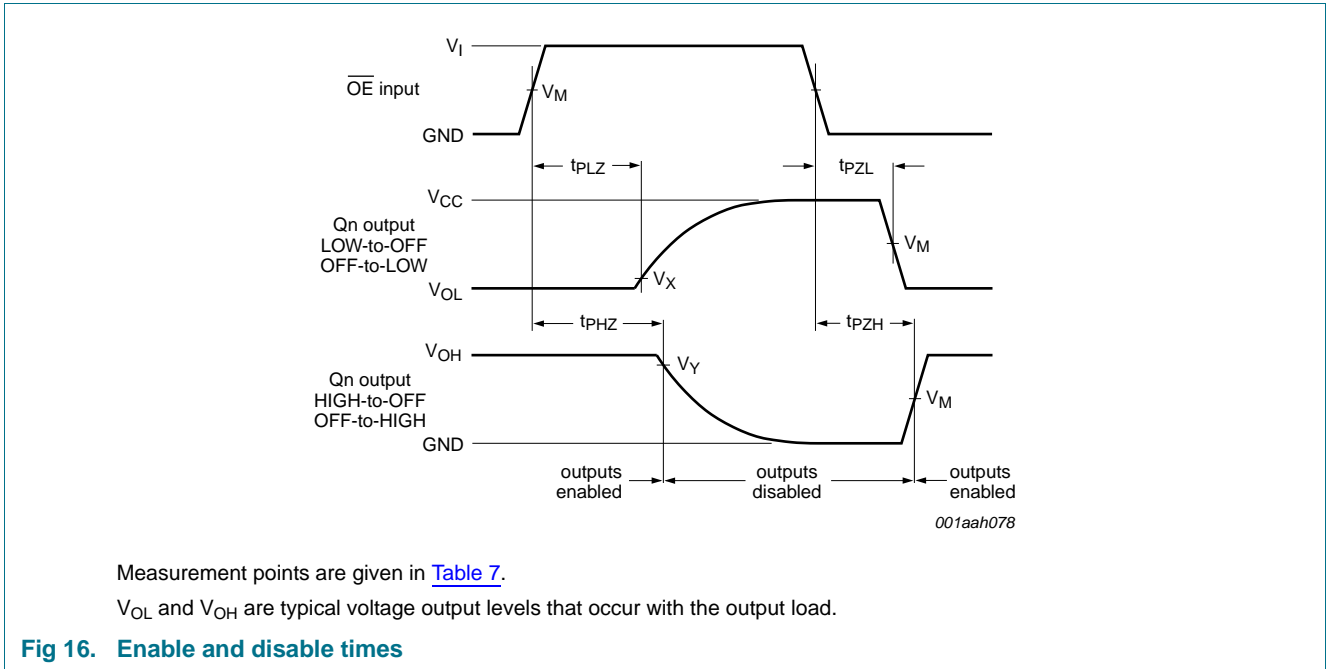


Measurement points are given in [Table 7](#).

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

Fig 15.  $\overline{MR}$  to SI recovery time

12.11 Enable and disable times



12.12 Test circuit for measuring switching times

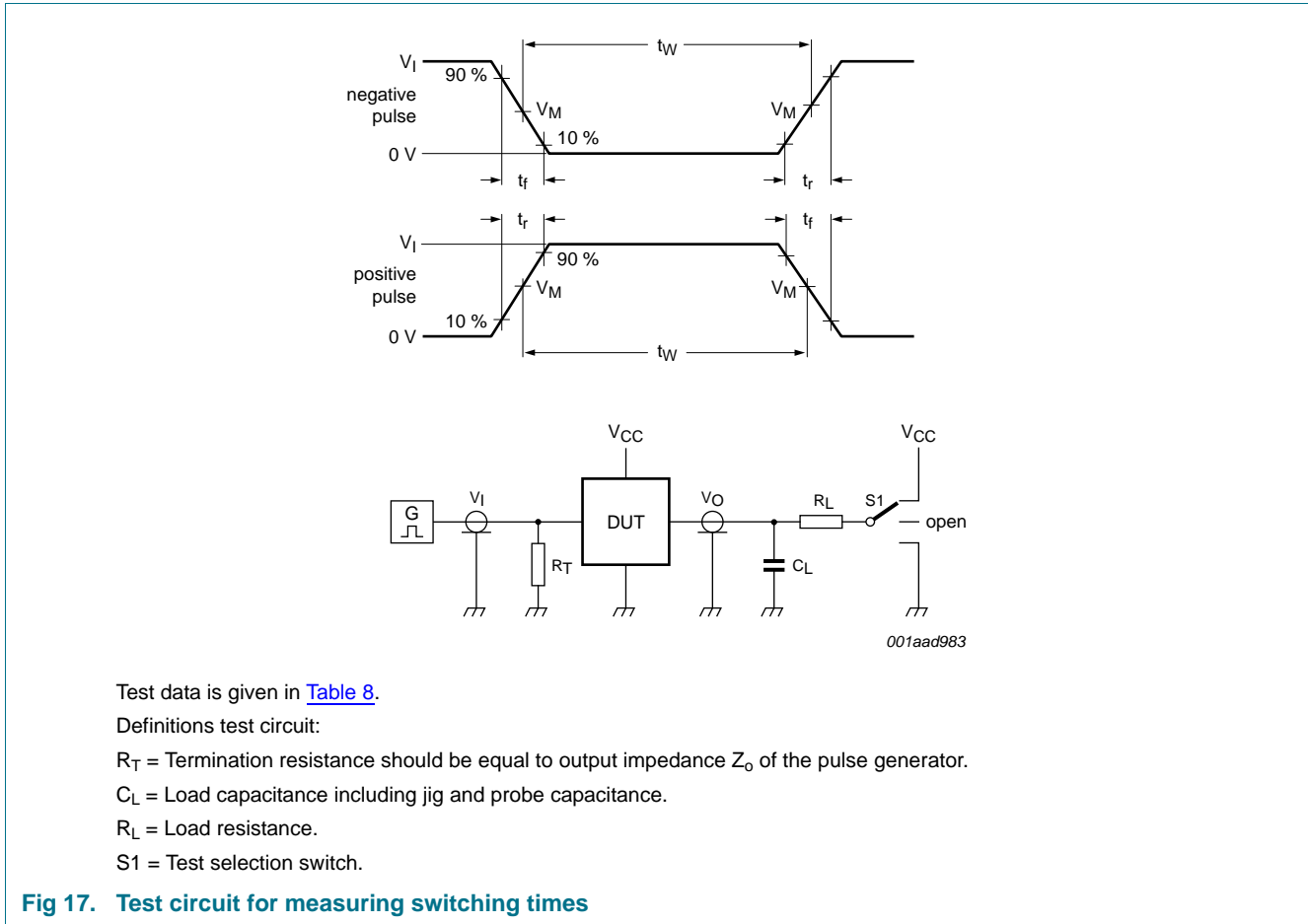


Table 7. Measurement points

Type	Input		Output		
	$V_M$		$V_M$	$V_X$	$V_Y$
74HC7403	$0.5V_{CC}$		$0.5V_{CC}$	$0.1V_{CC}$	$0.9V_{CC}$
74HCT7403	1.3 V		1.3 V	$0.1V_{CC}$	$0.9V_{CC}$

Table 8. Test data

Type	Input		Load		S1 position		
	$V_I$	$t_r, t_f$	$C_L$	$R_L$	$t_{PHL}, t_{PLH}$	$t_{PZH}, t_{PHZ}$	$t_{PZL}, t_{PLZ}$
74HC7403	$V_{CC}$	6 ns	15 pF, 50 pF	1 k $\Omega$	open	GND	$V_{CC}$
74HCT7403	3 V	6 ns	15 pF, 50 pF	1 k $\Omega$	open	GND	$V_{CC}$

13. Application information

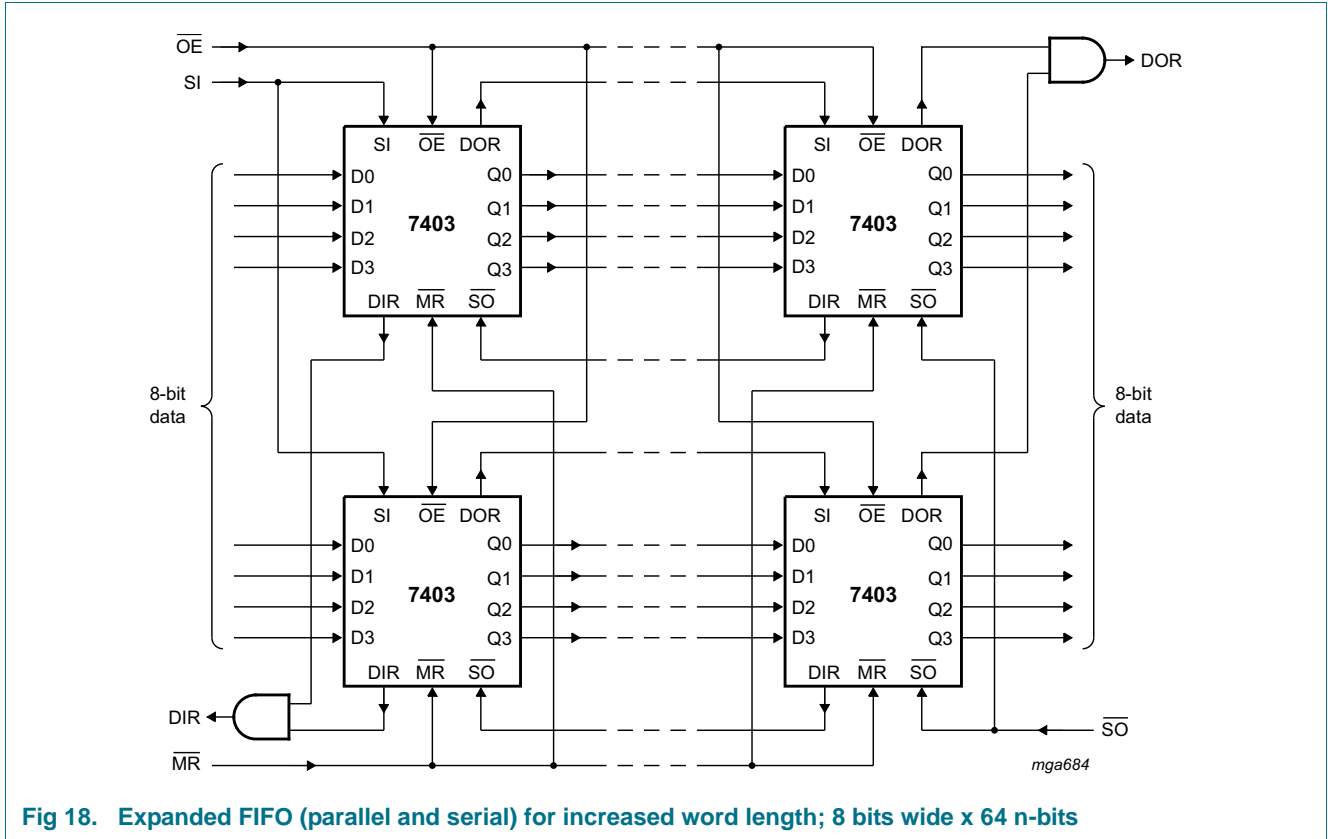
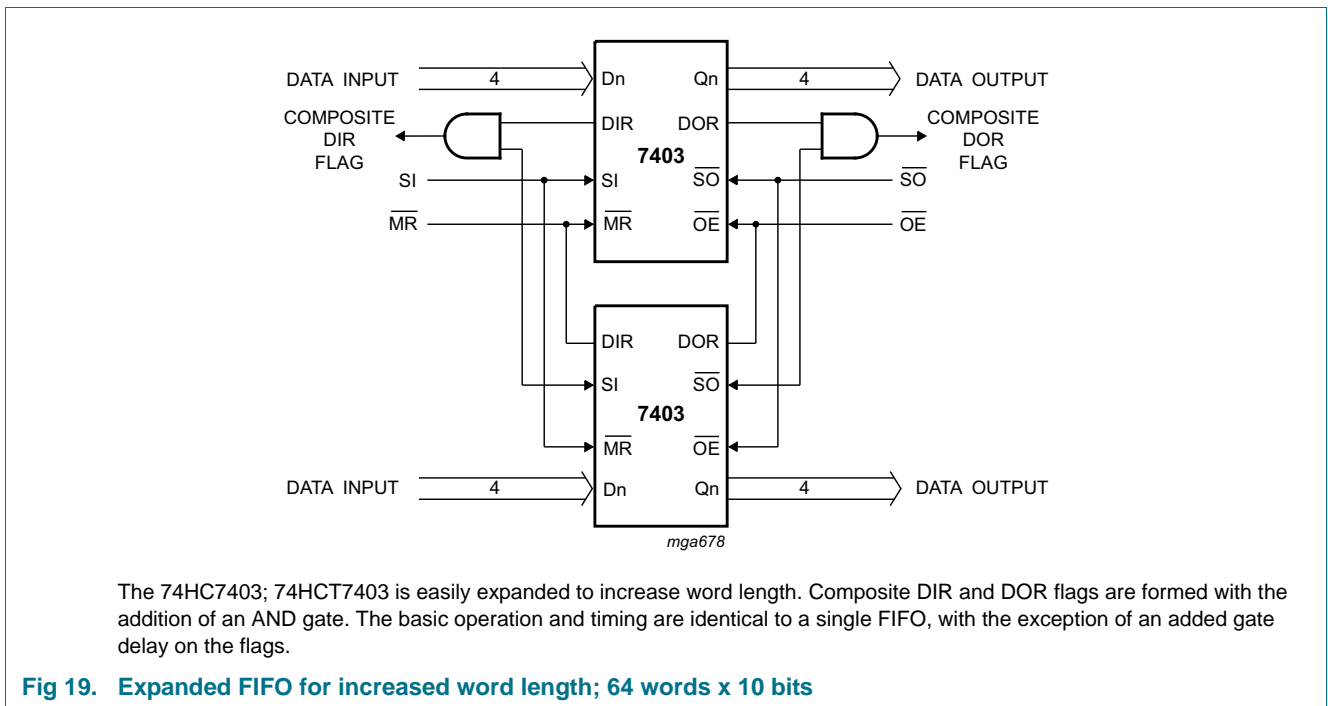
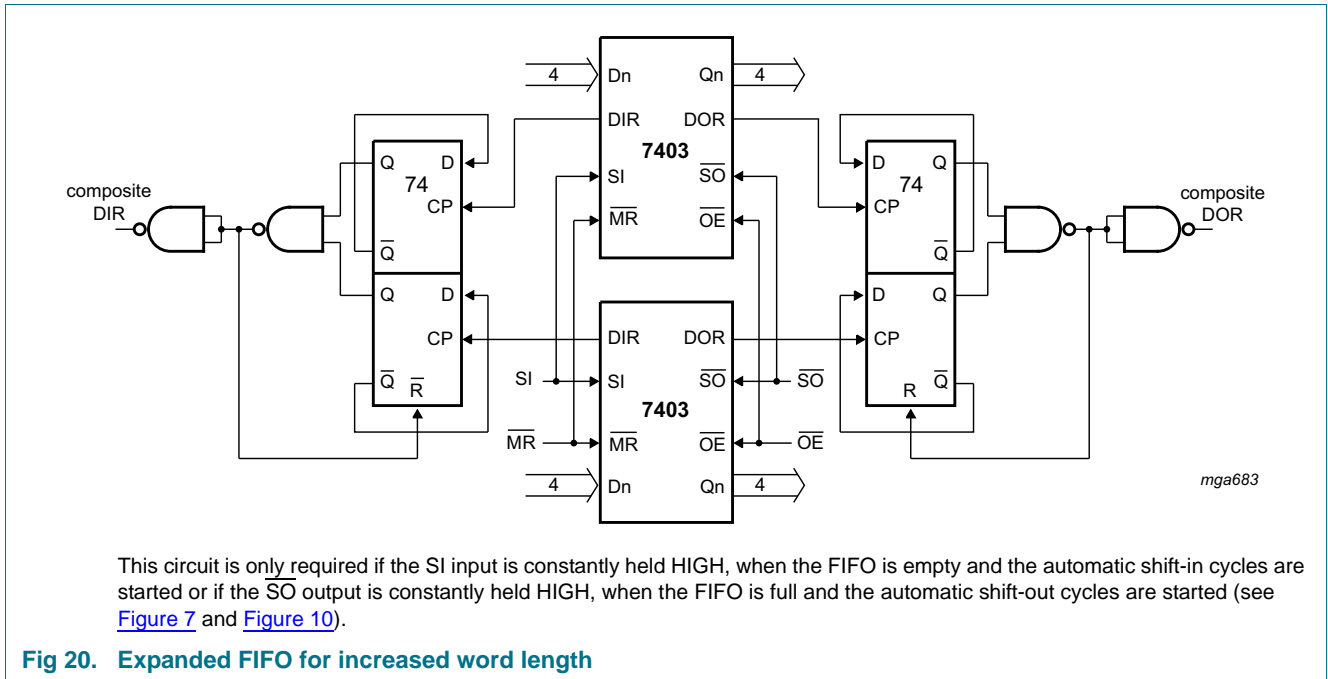


Fig 18. Expanded FIFO (parallel and serial) for increased word length; 8 bits wide x 64 n-bits



The 74HC7403; 74HCT7403 is easily expanded to increase word length. Composite DIR and DOR flags are formed with the addition of an AND gate. The basic operation and timing are identical to a single FIFO, with the exception of an added gate delay on the flags.

Fig 19. Expanded FIFO for increased word length; 64 words x 10 bits

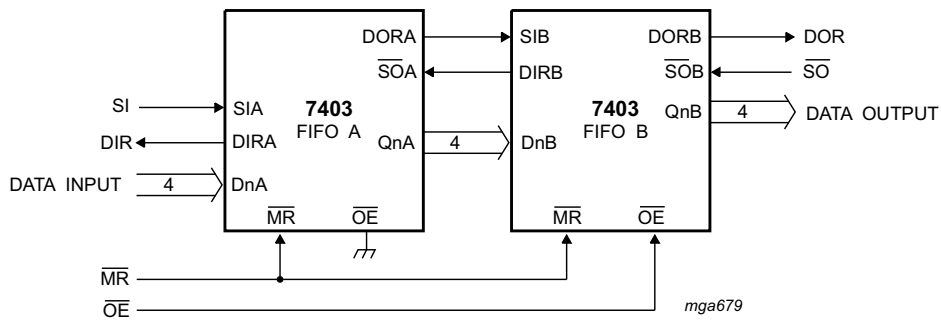


### 13.1 Expanded format

[Figure 21](#) shows two cascaded FIFOs providing a capacity of 128 words x 4 bits.

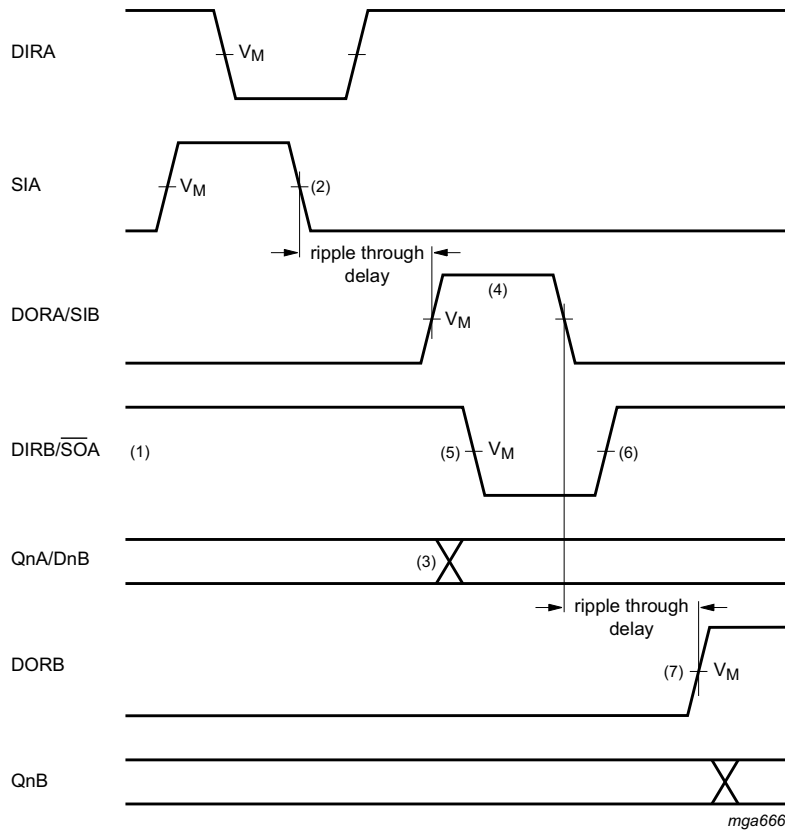
[Figure 22](#) shows the signals on the nodes of both FIFOs after the application of the SI pulse, when both FIFOs are initially empty. After a ripple through delay, data arrives at the output of FIFOA. Due to  $\overline{SOA}$  being HIGH, a DORA pulse is generated. The requirements of SIB and DnB are satisfied by the DORA pulse width and the timing between the rising edge of DORA and QnA. After a second ripple through delay data arrives at the output of FIFOB.

[Figure 23](#) shows the signals on the nodes of both FIFOs after the application of the  $\overline{SOB}$  pulse, when both FIFOs are initially full. After a bubble-up delay, a DIRB pulse is generated, which acts as a  $\overline{SOA}$  pulse for FIFOA. One word is transferred from the output of FIFOA to the input of FIFOB. The requirements of the  $\overline{SOA}$  pulse for FIFOA is satisfied by the pulse width of DORB. After a second bubble-up delay, an empty space arrives at DnA, at which time DIRA goes HIGH. [Figure 24](#) shows the waveforms at all external nodes of both FIFOs during a complete shift-in and shift-out sequence.



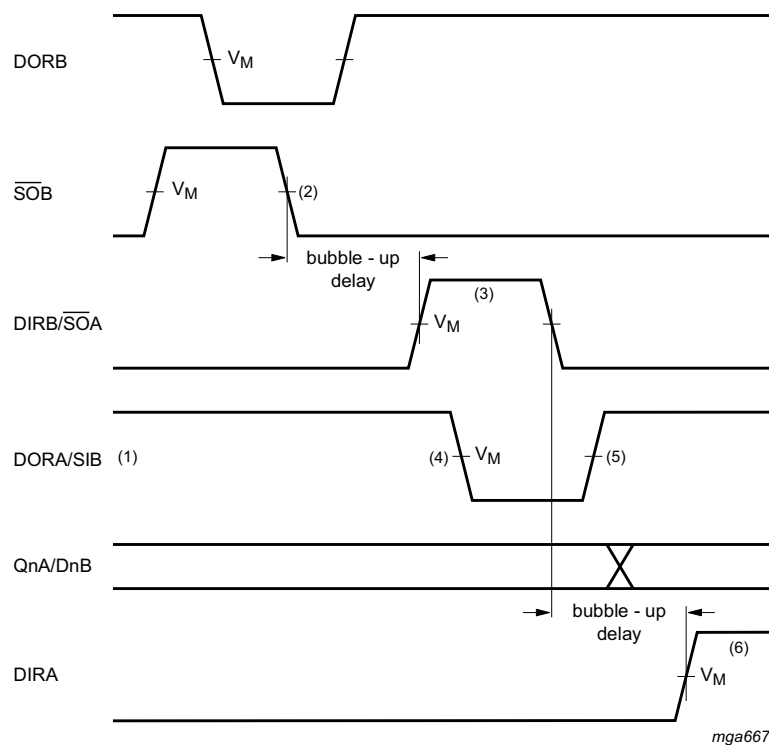
The 74HC7403; 74HCT7403 is easily cascaded to increase word capacity without external circuitry. In cascaded format, all necessary communications are handled by the FIFOs. [Figure 22](#) and [Figure 23](#) demonstrate the communication timing between FIFOA and FIFOB. [Figure 24](#) provides an overview of pulses and timing of two cascaded FIFOs, when shifted full and shifted empty again.

**Fig 21. Cascading for increased word capacity; 128 words x 4 bits**



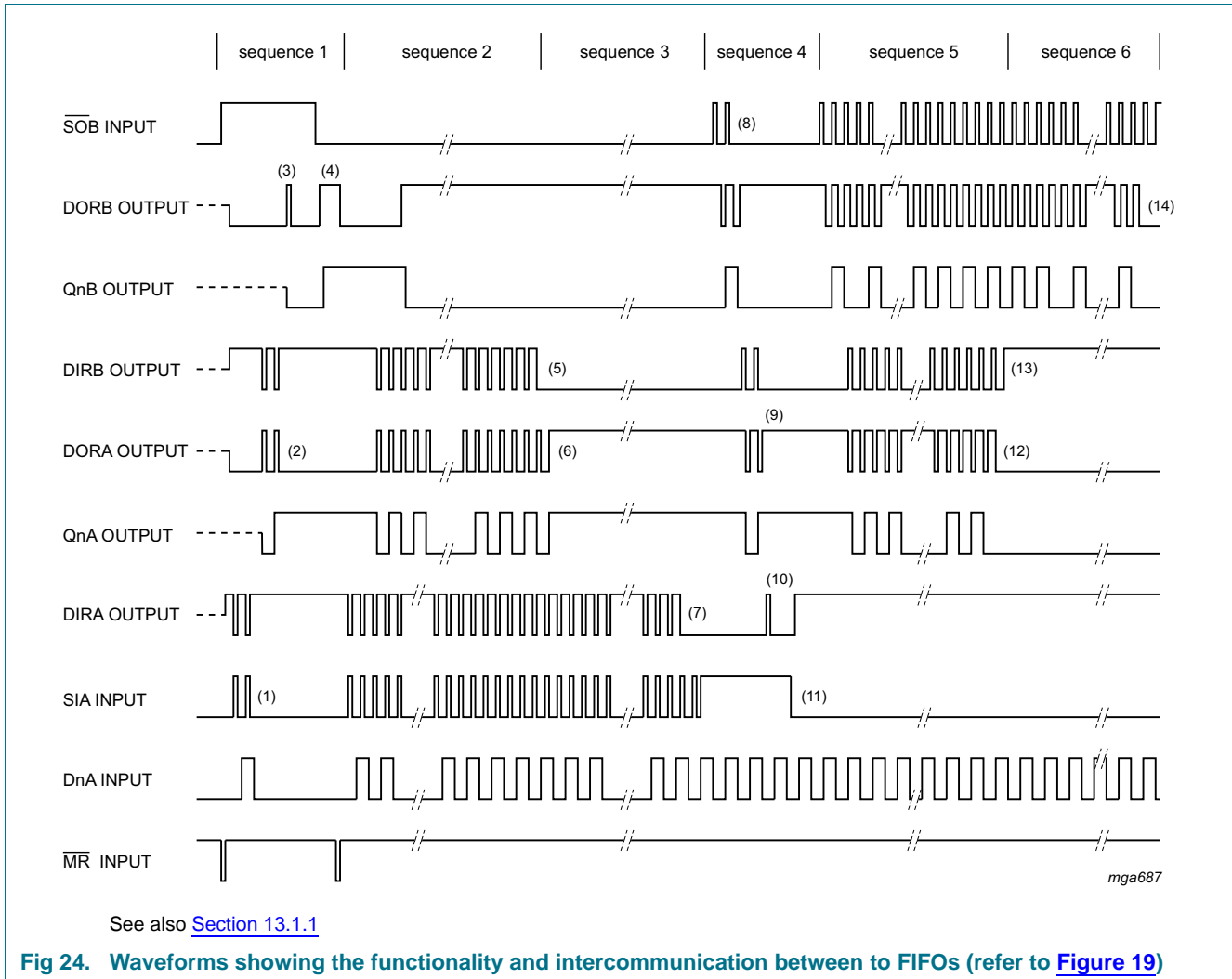
- (1) FIFOA and FIFOB are initially empty,  $\overline{SOA}$  held HIGH in anticipation of data
- (2) Load one word into FIFOA; SI pulse; applied. results in DIR pulse
- (3) Data-out A/ data-in B transition; valid data arrives at FIFOA output stage after a specified delay of the DOR flag, meeting data input set-up requirements of FIFOB.
- (4) DORA and SIB pulse HIGH; (ripple through delay after SIA LOW) data is unloaded from FIFOA as a result of the data output ready pulse, data is shifted into FIFOB
- (5) DIRB and  $\overline{SOA}$  go LOW; flag indicates that input stage of FIFOB is busy, shift-out of FIFOA is complete
- (6) DIRB and  $\overline{SOA}$  go HIGH automatically; the input stage of FIFOB is again able to receive data,  $\overline{SO}$  is held HIGH in anticipation of additional data
- (7) DORB goes HIGH; (ripple through delay after SIB LOW) valid data is present one propagation delay later at the FIFOB output stage

Fig 22. FIFO to FIFO communication; input timing under empty condition



- (1) FIFOA and FIFOB initially full, SIB held HIGH in anticipation of shifting in new data as an empty location bubbles-up
- (2) Unload one word from FIFOB;  $\overline{SÖ}$  pulse applied, results in DOR pulse
- (3) DIRB and  $\overline{SÖA}$  pulse HIGH; (bubble-up delay after  $\overline{SÖB}$  LOW) data is loaded into FIFOB as a result of the DIR pulse, data is shifted out of FIFOA
- (4) DORA and SIB go LOW; flag indicates that the output stage of FIFOA is busy, shift-in of FIFOB is complete
- (5) DORA and SIB go HIGH; flag indicates that valid data is again available at FIFOA output stage, SIB is held HIGH, awaiting bubble-up of empty location.
- (6) DIRA goes HIGH; (bubble-up delay after  $\overline{SÖA}$  LOW) an empty location is present at input stage of FIFOA

**Fig 23. FIFO to FIFO communication; output timing under full condition**



**13.1.1 Sequence 1 (both FIFOs empty, starting SHIFT-IN process)**

After an  $\overline{MR}$  pulse has been applied, FIFOA and FIFOB are empty. The DOR flags of FIFOA and FIFOB go LOW due to no valid data being present at the outputs. The DIR flags are set HIGH due to the FIFOs being ready to accept data.  $\overline{SOB}$  is held HIGH and two SIA pulses are applied (1). These pulses allow two data words to ripple through the output stage of FIFOA and the input stage of FIFOB (2). When data arrives at the output of FIFOB, a DORB pulse is generated (3). When  $\overline{SOB}$  goes LOW, the first bit is shifted out and a second bit ripples through to the output after which DORB goes high (4).

**13.1.2 Sequence 2 (FIFOB runs full)**

After the  $\overline{MR}$  pulse, a series of 64 SI pulses are applied. When 64 words are shifted in, DIRB remains LOW due to FIFOB being full (5). DORA goes LOW due to FIFOA being empty.

### 13.1.3 Sequence 3 (FIFOA runs full)

When 65 words are shifted in, DORA remains HIGH due to valid data remaining at the output of FIFOA. QnA remains HIGH, being the polarity of the 65<sup>th</sup> word (6). After the 128<sup>th</sup> SI pulse, DIR remains LOW and both FIFOs are full (7). Additional pulses have no effect.

### 13.1.4 Sequence 4 (both FIFOs full, starting SHIFT-OUT)

SIA is held HIGH and two  $\overline{\text{SOB}}$  pulses are applied (8). These pulses shift out two words and thus allow two empty locations to bubble-up to the input stage of FIFOB, and proceed to FIFOA (9). When the first empty location arrives at the input of FIFOA, a DIRA pulse is generated (10) and a new word is shifted into FIFOA. SIA is made LOW and now the second empty location reaches the input stage of FIFOA, after which DIRA remains HIGH (11).

### 13.1.5 Sequence 5 (FIFOA runs empty)

At the start of sequence 5 FIFOA contains 63 valid words due to two words being shifted out and one word being shifted in, in sequence 4. And additional series of  $\overline{\text{SOB}}$  pulses are applied. After 63  $\overline{\text{SOB}}$  pulses, all words from FIFOA are shifted in FIFOB. DORA remains LOW (12).

### 13.1.6 Sequence 6 (FIFOB runs empty)

After the next  $\overline{\text{SOB}}$  pulse, DIRB remains HIGH due to the input stage of FIFOB being empty. After another 63  $\overline{\text{SOB}}$  pulses, DORB remains LOW due to both FIFOs being empty (14). Additional  $\overline{\text{SOB}}$  pulses have no effect. The last word remains available at the output Qn.

14. Package outline

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

SOT38-4

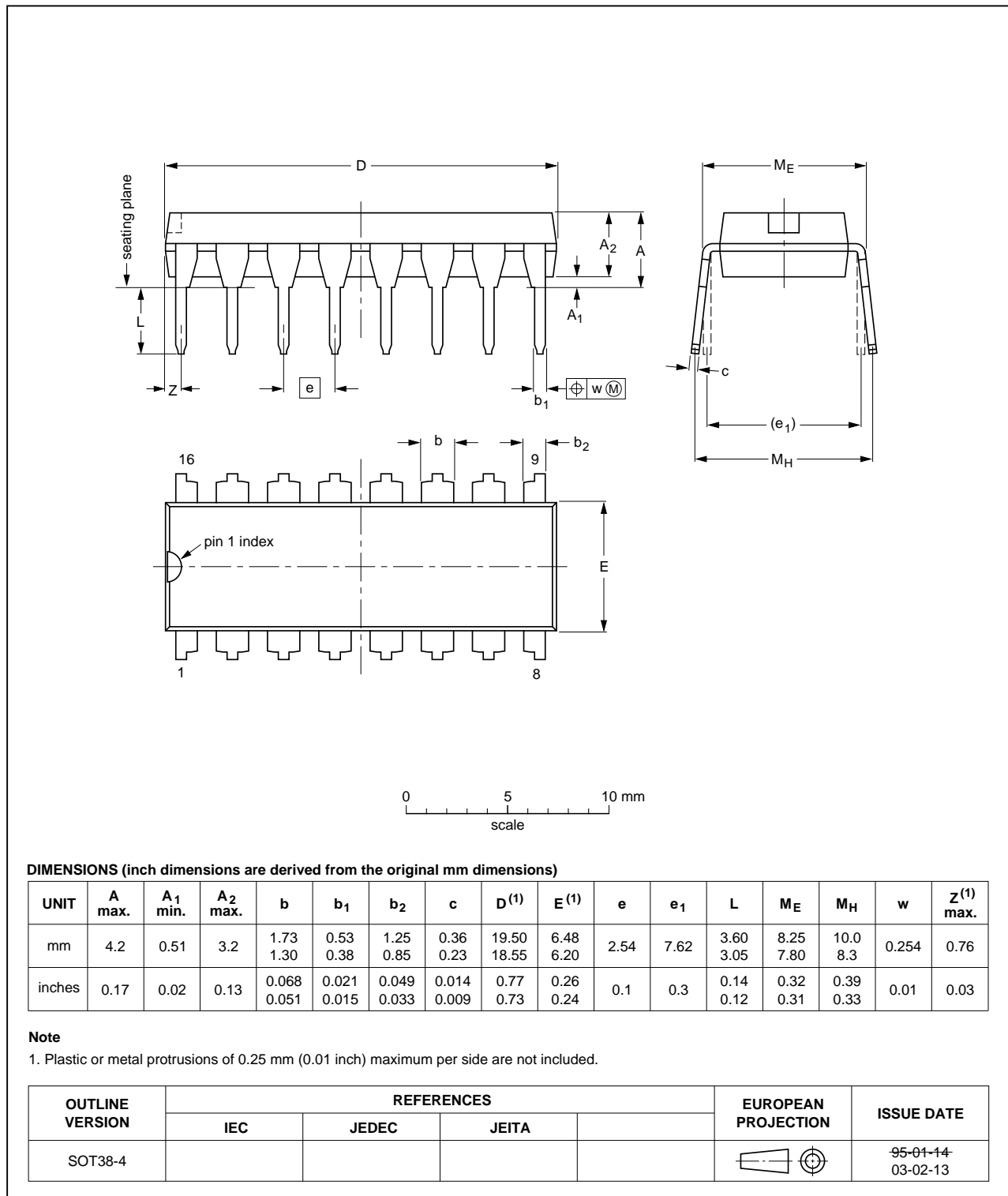


Fig 25. Package outline SOT38-4 (DIP16)

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

SOT109-1

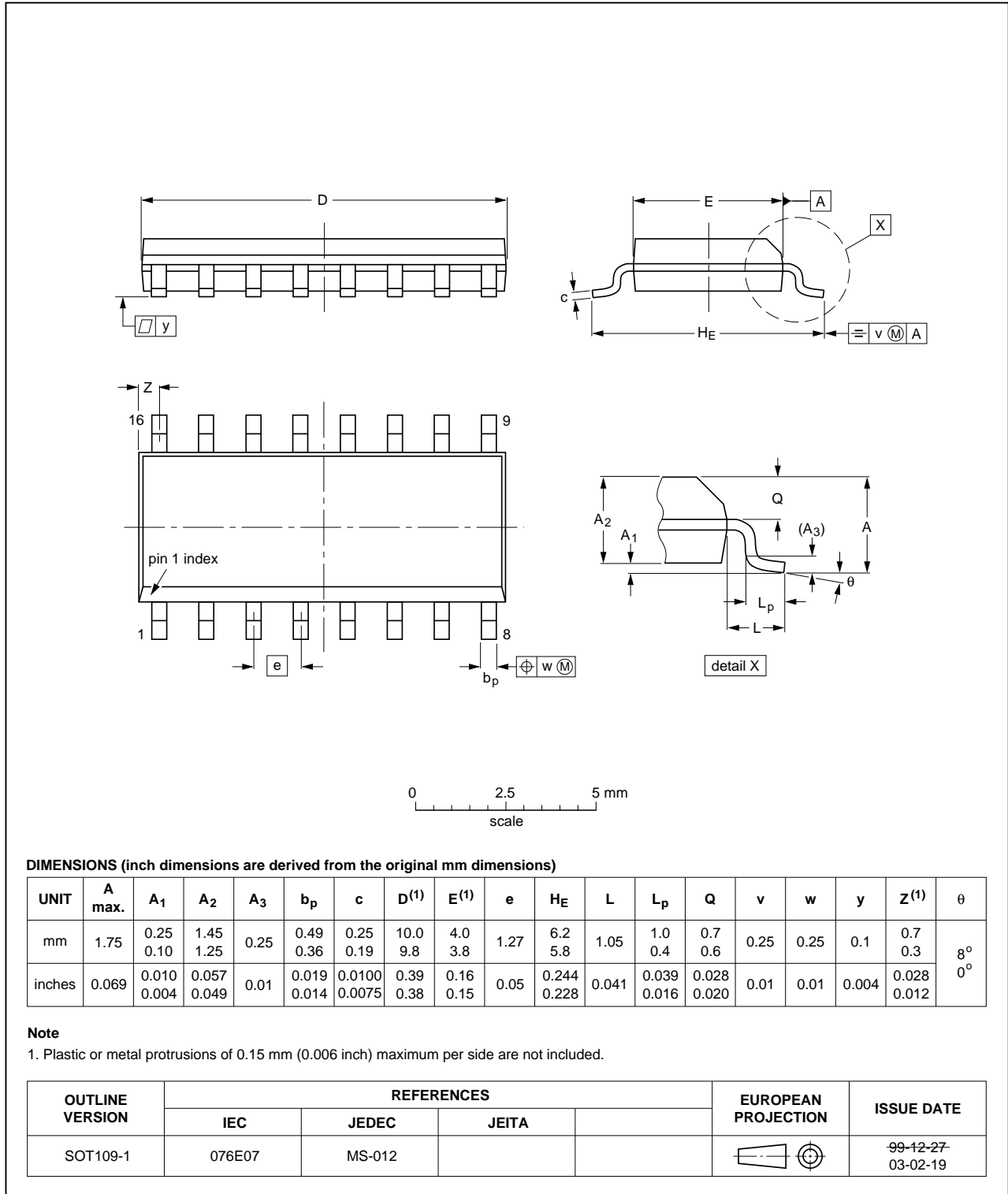


Fig 26. Package outline SOT109-1 (SO16)

## 15. Abbreviations

Table 9. Abbreviations

Acronym	Description
CMOS	Complementary Metal Oxide Semiconductor
ESD	ElectroStatic Discharge
HBM	Human Body Model
MM	Machine Model
TTL	Transistor-Transistor Logic
FIFO	First In First Out

## 16. Revision history

Table 10. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
74HC_HCT7403 v.4	20120924	Product data sheet	-	74HC_HCT7403_CNV v.3
Modifications:				
				<ul style="list-style-type: none"><li>• The format of this data sheet has been redesigned to comply with the new identity guidelines of NXP Semiconductors.</li><li>• Legal texts have been adapted to the new company name where appropriate.</li></ul>
74HC_HCT7403_CNV v.3	19970916	Product specification	-	-

## 17. Legal information

### 17.1 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.
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[2] The term 'short data sheet' is explained in section "Definitions".

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