

# HEF4017B-Q100

## 5-stage Johnson decade counter

Rev. 1 — 4 June 2014

Product data sheet

### 1. General description

The HEF4017B-Q100 is a 5-stage Johnson decade counter with ten spike-free decoded active HIGH outputs (Q0 to Q9), an active LOW carry output from the most significant flip-flop ( $\overline{Q5-9}$ ), active HIGH and active LOW clock inputs (CP0,  $\overline{CP1}$ ) and an overriding asynchronous master reset input (MR).

The counter is advanced by either a LOW-to-HIGH transition at CP0 while  $\overline{CP1}$  is LOW or a HIGH-to-LOW transition at  $\overline{CP1}$  while CP0 is HIGH (see [Table 3](#)).

When cascading counters, the  $\overline{Q5-9}$  output, which is LOW while the counter is in states 5, 6, 7, 8, and 9, can be used to drive the CP0 input of the next counter. A HIGH on MR resets the counter to zero (Q0 =  $\overline{Q5-9}$  = HIGH; Q1 to Q9 = LOW) independent of the clock inputs (CP0,  $\overline{CP1}$ ).

Automatic counter code correction is provided by an internal circuit: following any illegal code the counter returns to a proper counting mode within 11 clock pulses.

Schmitt trigger action makes the clock inputs 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). Unused inputs must be connected 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  $+125\text{ }^{\circ}\text{C}$
- Automatic counter correction
- Tolerant of slow clock rise and fall times
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- ESD protection:
  - ◆ MIL-STD-883C, 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		Version
	Name	Description	
HEF4017BT-Q100	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1

4. Functional diagram

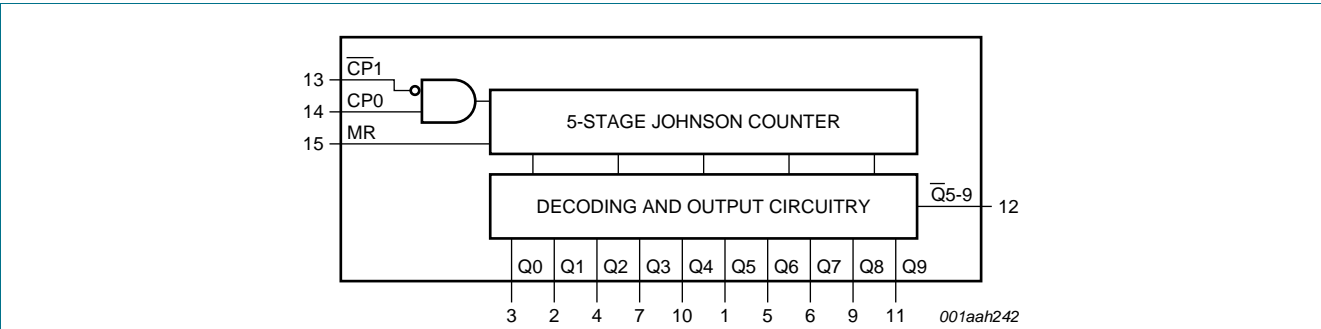


Fig 1. Functional diagram

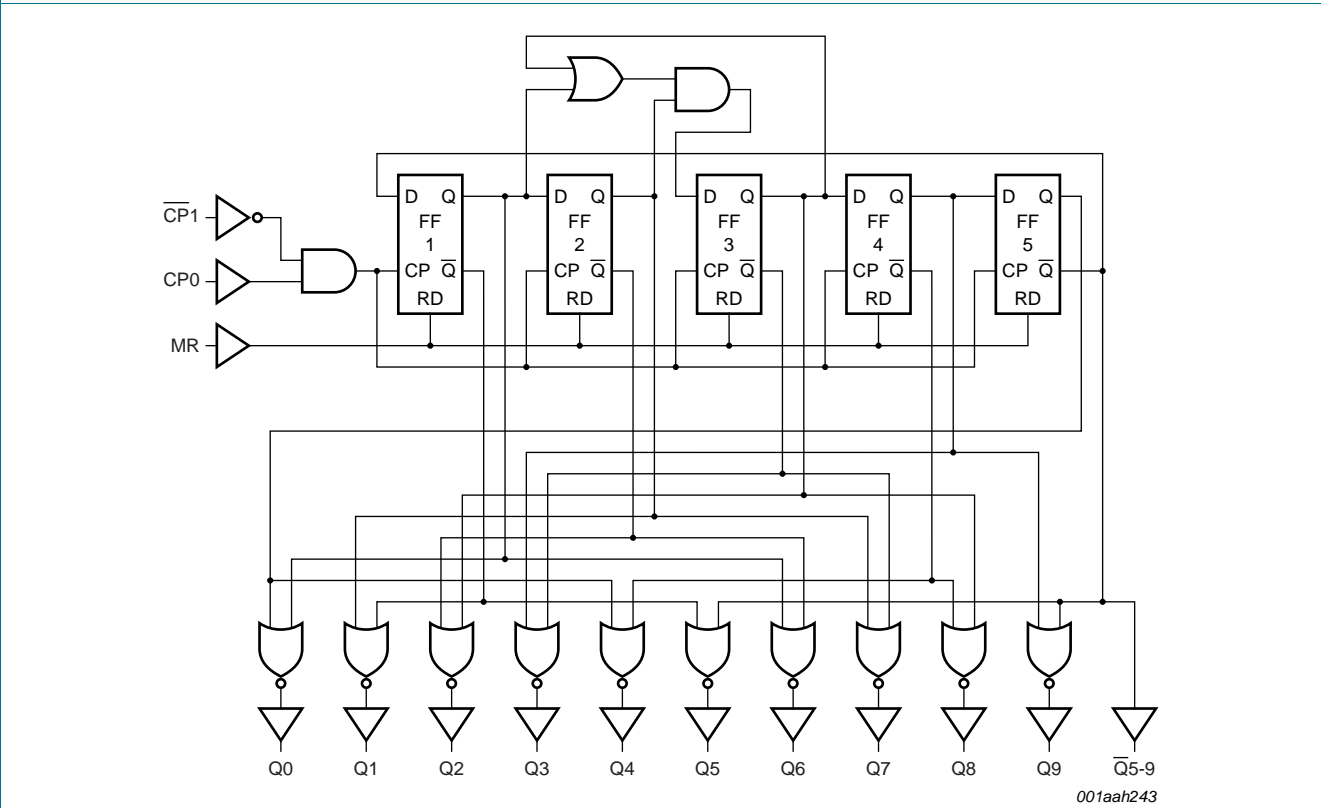


Fig 2. Logic diagram

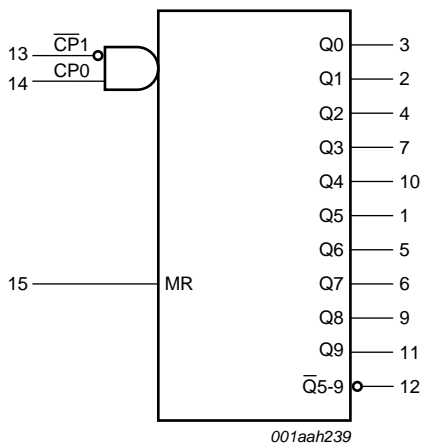


Fig 3. Logic symbol

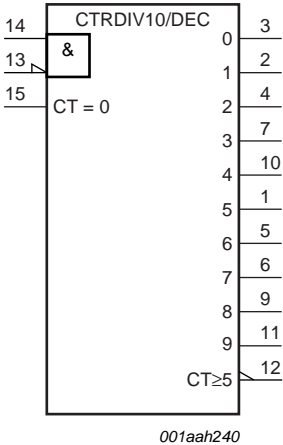


Fig 4. IEE logic symbol

5. Pinning information

5.1 Pinning

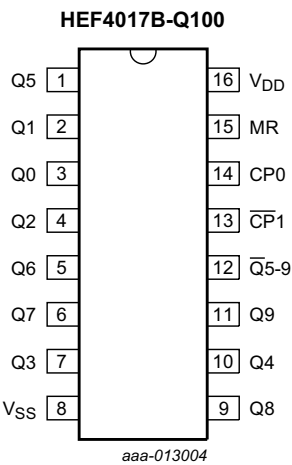


Fig 5. Pin configuration

## 5.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
Q0 to Q9	3, 2, 4, 7, 10, 1, 5, 6, 9, 11	decoded output
V <sub>SS</sub>	8	ground supply voltage
$\overline{Q}5-9$	12	carry output (active LOW)
$\overline{CP}1$	13	clock input (HIGH-to-LOW edge-triggered)
CP0	14	clock input (LOW-to-HIGH edge-triggered)
MR	15	master reset input
V <sub>DD</sub>	16	supply voltage

## 6. Functional description

Table 3. Function table [\[1\]](#)

MR	CP0	$\overline{CP}1$	Operation
H	X	X	Q0 = $\overline{Q}5-9$ = H; Q1 to Q9 = L
L	H	↓	counter advances
L	↑	L	counter advances
L	L	X	no change
L	X	H	no change
L	H	↑	no change
L	↓	L	no change

[1] H = HIGH voltage level; L = LOW voltage level; X = don't care;  
 ↑ = positive-going transition; ↓ = negative-going transition.

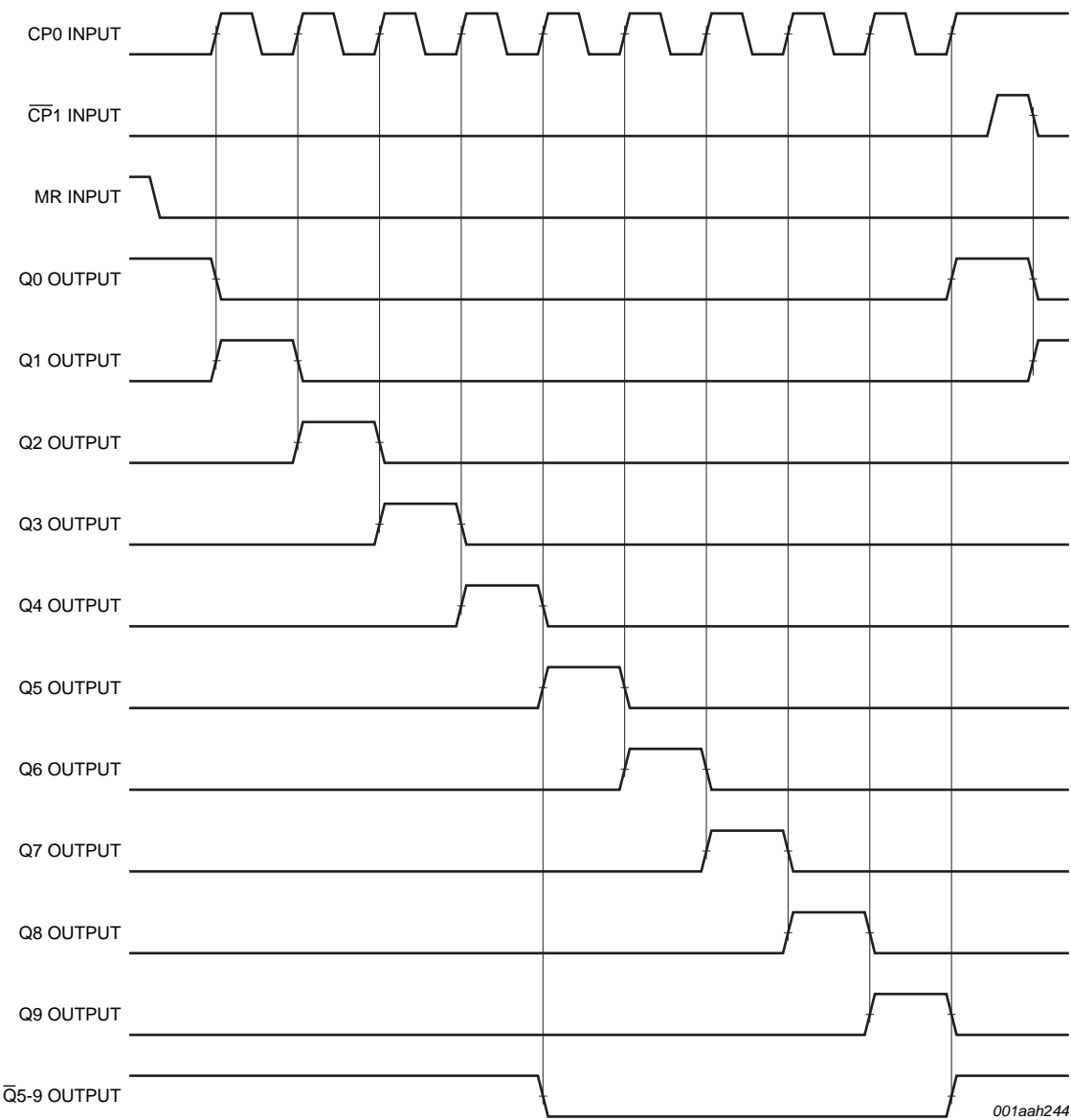


Fig 6. Timing diagram

## 7. Limiting values

**Table 4. Limiting values**

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

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{DD}$	supply voltage		-0.5	+18	V
$I_{IK}$	input clamping current	$V_I < -0.5\text{ V}$ or $V_I > V_{DD} + 0.5\text{ V}$	-	$\pm 10$	mA
$V_I$	input voltage		-0.5	$V_{DD} + 0.5$	V
$I_{OK}$	output clamping current	$V_O < -0.5\text{ V}$ or $V_O > V_{DD} + 0.5\text{ V}$	-	$\pm 10$	mA
$I_{IO}$	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	$T_{amb} = -40\text{ °C to }+125\text{ °C}$ [1]	-	500	mW
$P$	power dissipation	per output	-	100	mW

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

## 8. Recommended operating conditions

**Table 5. Recommended operating conditions**

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{DD}$	supply voltage		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	$\mu\text{s/V}$

## 9. Static characteristics

**Table 6. Static characteristics**

$V_{SS} = 0\text{ V}$ ;  $V_I = V_{SS}$  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
$V_{OH}$	HIGH-level output voltage	$ I_O  < 1\text{ }\mu\text{A}$ ; $V_I = V_{SS}$ or $V_{DD}$	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
$V_{OL}$	LOW-level output voltage	$ I_O  < 1\text{ }\mu\text{A}$ ; $V_I = V_{SS}$ or $V_{DD}$	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
$I_{OH}$	HIGH-level output current	$V_O = 2.5\text{ V}$	5 V	-	-1.7	-	-1.4	-	-1.1	-	-1.1	mA
		$V_O = 4.6\text{ V}$	5 V	-	-0.64	-	-0.5	-	-0.36	-	-0.36	mA
		$V_O = 9.5\text{ V}$	10 V	-	-1.6	-	-1.3	-	-0.9	-	-0.9	mA
		$V_O = 13.5\text{ V}$	15 V	-	-4.2	-	-3.4	-	-2.4	-	-2.4	mA
$I_{OL}$	LOW-level output current	$V_O = 0.4\text{ V}$	5 V	0.64	-	0.5	-	0.36	-	0.36	-	mA
		$V_O = 0.5\text{ V}$	10 V	1.6	-	1.3	-	0.9	-	0.9	-	mA
		$V_O = 1.5\text{ V}$	15 V	4.2	-	3.4	-	2.4	-	2.4	-	mA
$I_I$	input leakage current		15 V	-	$\pm 0.1$	-	$\pm 0.1$	-	$\pm 1.0$	-	$\pm 1.0$	$\mu\text{A}$
$I_{DD}$	supply current	$I_O = 0\text{ A}$ ; $V_I = V_{SS}$ or $V_{DD}$	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		-	-	-	-	7.5	-	-	-	-	pF

## 10. Dynamic characteristics

**Table 7. Dynamic characteristics**

$T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $V_{SS} = 0\text{ V}$ ; for test circuit see [Figure 10](#)

Symbol	Parameter	Conditions	$V_{DD}$	Extrapolation formula <sup>[1]</sup>	Min	Typ	Max	Unit
$t_{PHL}$	HIGH to LOW propagation delay	CP0, $\overline{CP1} \rightarrow Q0$ to Q9; see <a href="#">Figure 7</a>	5 V	$113\text{ ns} + (0.55\text{ ns/pF})C_L$	-	140	280	ns
			10 V	$44\text{ ns} + (0.23\text{ ns/pF})C_L$	-	55	110	ns
			15 V	$32\text{ ns} + (0.16\text{ ns/pF})C_L$	-	40	80	ns
		CP0, $\overline{CP1} \rightarrow \overline{Q5-9}$ ; see <a href="#">Figure 7</a>	5 V	$118\text{ ns} + (0.55\text{ ns/pF})C_L$	-	145	290	ns
			10 V	$44\text{ ns} + (0.23\text{ ns/pF})C_L$	-	55	110	ns
			15 V	$32\text{ ns} + (0.16\text{ ns/pF})C_L$	-	40	80	ns
		MR $\rightarrow Q1$ to Q9; see <a href="#">Figure 8</a>	5 V	$88\text{ ns} + (0.55\text{ ns/pF})C_L$	-	115	230	ns
			10 V	$39\text{ ns} + (0.23\text{ ns/pF})C_L$	-	50	100	ns
			15 V	$27\text{ ns} + (0.16\text{ ns/pF})C_L$	-	35	70	ns
$t_{PLH}$	LOW to HIGH propagation delay	CP0, $\overline{CP1} \rightarrow Q0$ to Q9; see <a href="#">Figure 7</a>	5 V	$98\text{ ns} + (0.55\text{ ns/pF})C_L$	-	125	250	ns
			10 V	$39\text{ ns} + (0.23\text{ ns/pF})C_L$	-	50	100	ns
			15 V	$32\text{ ns} + (0.16\text{ ns/pF})C_L$	-	40	80	ns
		CP0, $\overline{CP1} \rightarrow \overline{Q5-9}$ ; see <a href="#">Figure 7</a>	5 V	$98\text{ ns} + (0.55\text{ ns/pF})C_L$	-	125	250	ns
			10 V	$39\text{ ns} + (0.23\text{ ns/pF})C_L$	-	50	100	ns
			15 V	$32\text{ ns} + (0.16\text{ ns/pF})C_L$	-	40	80	ns
		MR $\rightarrow \overline{Q5-9}$ ; see <a href="#">Figure 8</a>	5 V	$83\text{ ns} + (0.55\text{ ns/pF})C_L$	-	110	220	ns
			10 V	$34\text{ ns} + (0.23\text{ ns/pF})C_L$	-	45	90	ns
			15 V	$27\text{ ns} + (0.16\text{ ns/pF})C_L$	-	35	70	ns
		MR $\rightarrow Q0$ ; see <a href="#">Figure 8</a>	5 V	$103\text{ ns} + (0.55\text{ ns/pF})C_L$	-	130	260	ns
			10 V	$44\text{ ns} + (0.23\text{ ns/pF})C_L$	-	55	105	ns
			15 V	$32\text{ ns} + (0.16\text{ ns/pF})C_L$	-	40	75	ns
$t_t$	transition time	see <a href="#">Figure 7</a>	5 V	$10\text{ ns} + (1.00\text{ ns/pF})C_L$	-	60	120	ns
			10 V	$9\text{ ns} + (0.42\text{ ns/pF})C_L$	-	30	60	ns
			15 V	$6\text{ ns} + (0.28\text{ ns/pF})C_L$	-	20	40	ns
$t_h$	hold time	CP0 $\rightarrow \overline{CP1}$ ; see <a href="#">Figure 9</a>	5 V		90	45	-	ns
			10 V		40	20	-	ns
			15 V		20	10	-	ns
		$\overline{CP1} \rightarrow CP0$ ; see <a href="#">Figure 9</a>	5 V		80	40	-	ns
			10 V		40	20	-	ns
			15 V		30	10	-	ns



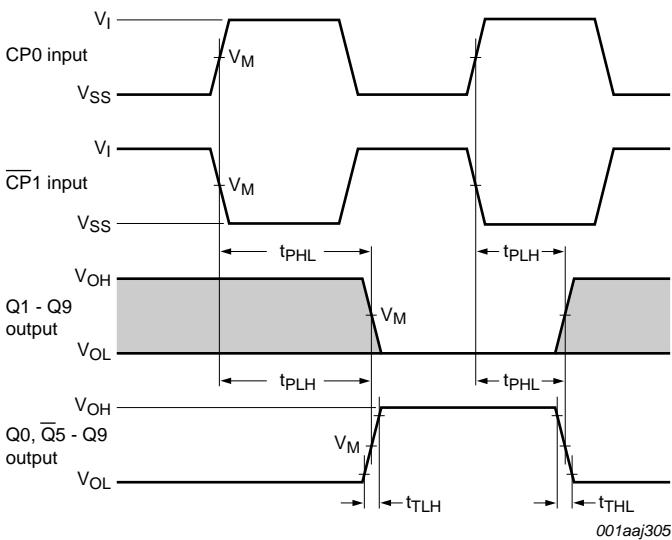
**Table 7. Dynamic characteristics ...continued** $T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $V_{SS} = 0\text{ V}$ ; for test circuit see [Figure 10](#)

Symbol	Parameter	Conditions	V <sub>DD</sub>	Extrapolation formula <sup>[1]</sup>	Min	Typ	Max	Unit
t <sub>w</sub>	pulse width	CP0 input LOW; minimum width; see <a href="#">Figure 8</a>	5 V		80	40	-	ns
			10 V		40	20	-	ns
			15 V		30	15	-	ns
		CP1 input HIGH; minimum width; see <a href="#">Figure 8</a>	5 V		80	40	-	ns
			10 V		40	20	-	ns
			15 V		30	15	-	ns
		MR input HIGH; minimum width; see <a href="#">Figure 8</a>	5 V		50	25	-	ns
			10 V		30	15	-	ns
			15 V		20	10	-	ns
t <sub>rec</sub>	recovery time	MR input; see <a href="#">Figure 8</a>	5 V		60	30	-	ns
			10 V		30	15	-	ns
			15 V		20	10	-	ns
f <sub>max</sub>	maximum frequency	see <a href="#">Figure 8</a>	5 V		6	12	-	MHz
			10 V		12	30	-	MHz
			15 V		15	30	-	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).[2] t<sub>t</sub> is the same as t<sub>THL</sub> and t<sub>TLH</sub>.**Table 8. Dynamic power dissipation P<sub>D</sub>** $P_D$  can be calculated from the formulas shown.  $V_{SS} = 0\text{ V}$ ;  $t_r = t_f \leq 20\text{ ns}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

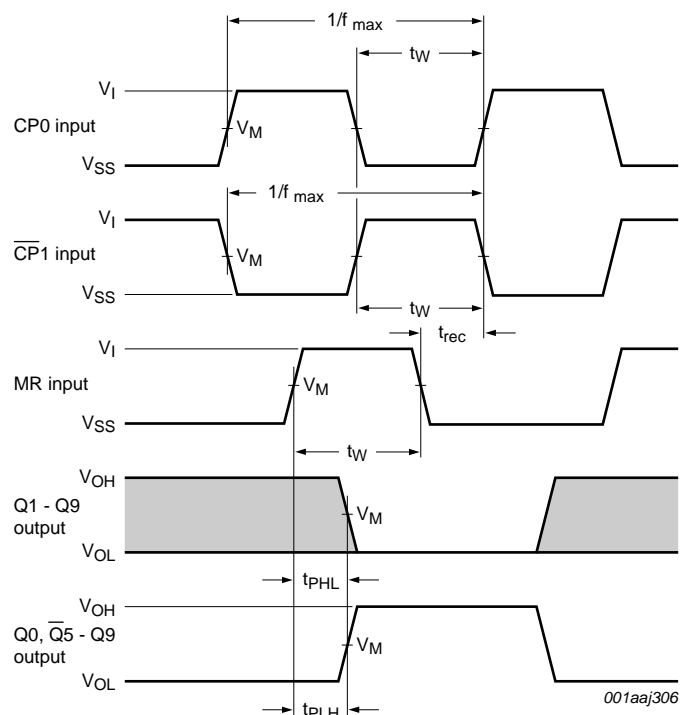
Symbol	Parameter	V <sub>DD</sub>	Typical formula for P <sub>D</sub> (μW)	where:
P <sub>D</sub>	dynamic power dissipation	5 V	$P_D = 500 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	f <sub>i</sub> = input frequency in MHz; f <sub>o</sub> = output frequency in MHz; C <sub>L</sub> = output load capacitance in pF; V <sub>DD</sub> = supply voltage in V; Σ(C <sub>L</sub> × f <sub>o</sub> ) = sum of the outputs.
		10 V	$P_D = 2200 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	
		15 V	$P_D = 6000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	

11. Waveforms



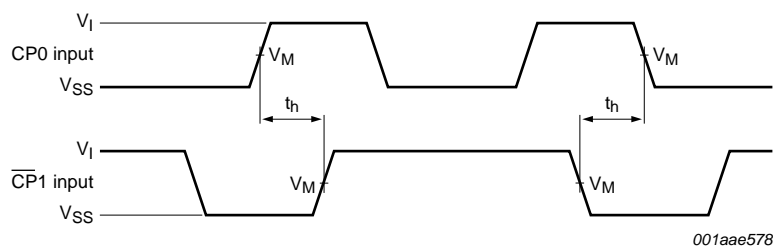
Conditions:  $\overline{CP1} = \text{LOW}$ , while CP0 triggers on a LOW-to-HIGH transition.  $\overline{CP1}$  triggers on a HIGH-to-LOW transition; The shaded areas indicate where the output state is set by the input count. Measurement points given in Table 9.

Fig 7. Waveforms showing the propagation delays for CP0,  $\overline{CP1}$  to Qn,  $\overline{Q}5$ -9 outputs and the output transition times



Conditions:  $\overline{CP1} = \text{LOW}$ , while CP0 triggers on a LOW-to-HIGH transition,  $t_W$  and  $t_{rec}$  are measured when CP0 = HIGH and CP1 triggers on a HIGH-to-LOW transition.  
The shaded areas indicate where the output state is set by the input count.  
Measurement points given in [Table 9](#).

**Fig 8.** Waveforms showing the minimum pulse width for CP0, CP1 and MR input; the maximum frequency for CP0 and CP1 input; the recovery time for MR and the MR input to Qn and Q5-9 output propagation delays

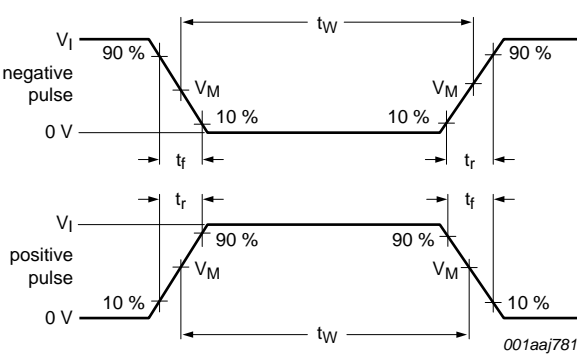


Hold times are shown as positive values, but may be specified as negative values;  
Measurement points given in [Table 9](#).

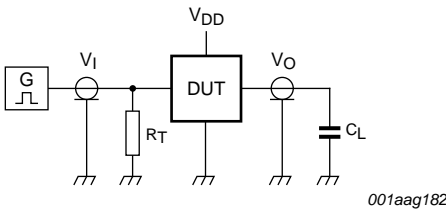
**Fig 9.** Waveforms showing hold times for CP0 to CP1 and CP1 to CP0

**Table 9.** Measurement points

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



a. Input waveforms



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 10. Test circuit for measuring switching times

Table 10. Test data

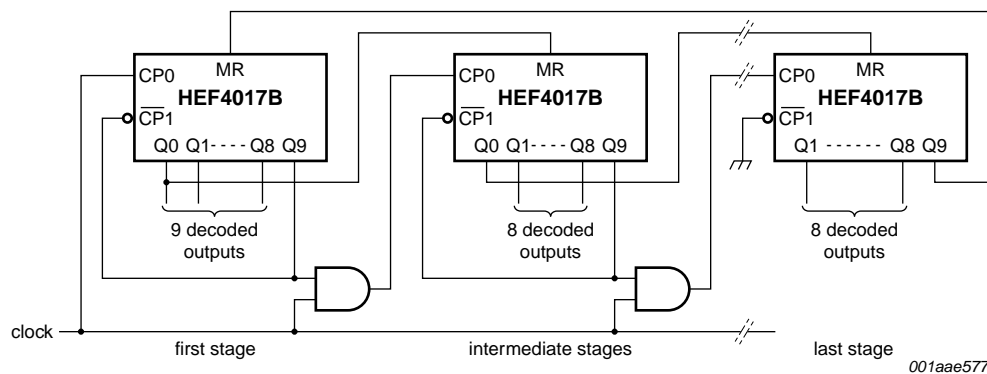
Supply voltage	Input		Load
$V_{DD}$	$V_I$	$t_r, t_f$	$C_L$
5 V to 15 V	$V_{SS}$ or $V_{DD}$	$\leq 20$ ns	50 pF

## 12. Application information

Some examples of applications for the HEF4017B-Q100 are:

- Decade counter with decimal decoding
- 1 out of n decoding counter (when cascaded)
- Sequential controller
- Timer

[Figure 11](#) shows a technique for extending the number of decoded output states for the HEF4017B-Q100. Decoded outputs are sequential within each stage and from stage to stage, with no dead time (except propagation delay).



Enabling the counter on  $\overline{CP1}$  when CP0 is HIGH, or on CP0 when  $\overline{CP1}$  is LOW, causes an extra count.

**Fig 11. Counter expansion**

13. Package outline

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

SOT109-1

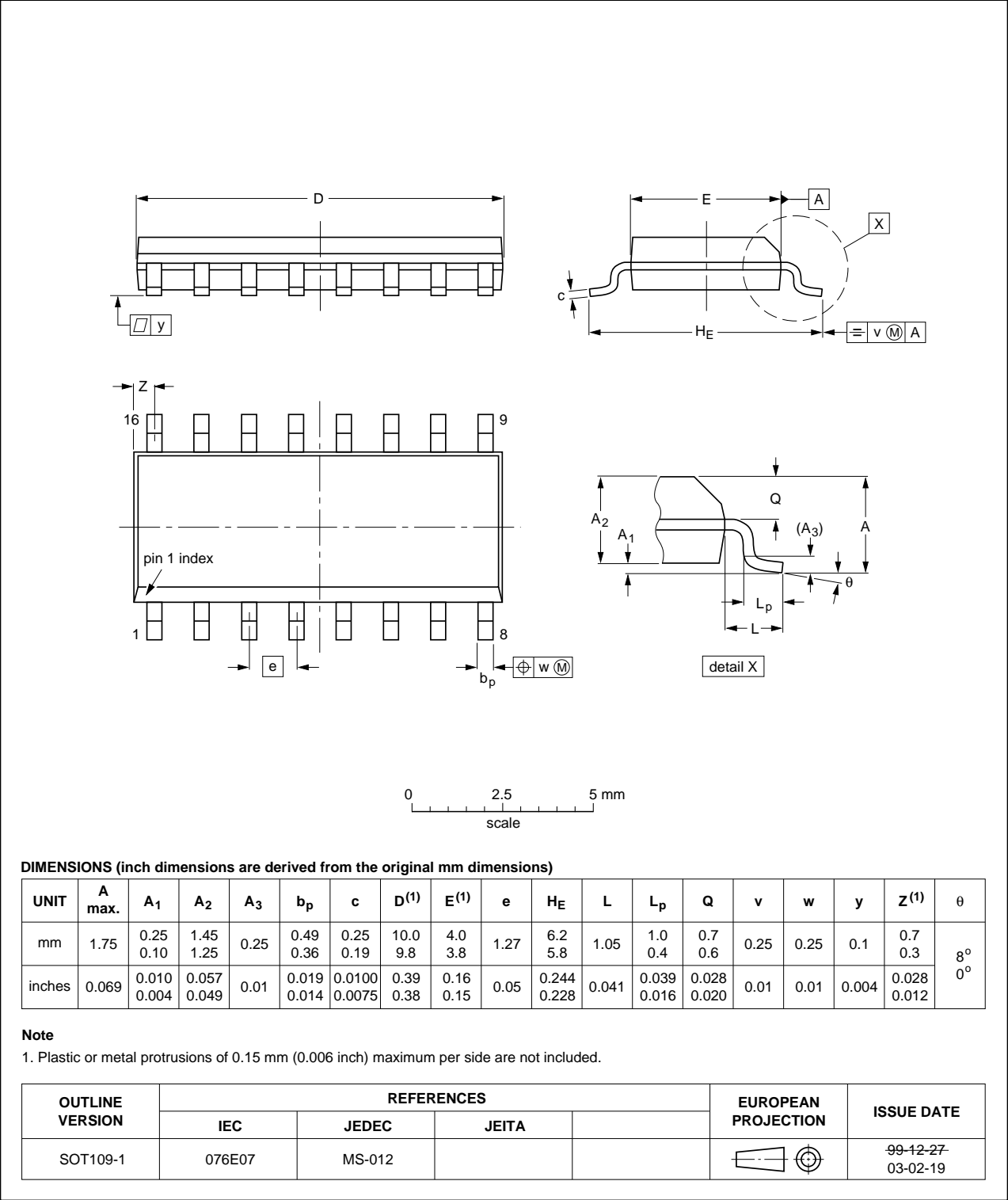


Fig 12. Package outline SOT109-1 (SO16)

## 14. Revision history

Table 11. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4017B_Q100 v.1	20140604	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".

[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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