

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC7MH123AFK,TC7MH221AFK

Dual Monostable Multivibrator

TC7MH123AFK Retriggerable

TC7MH221AFK Non-Retriggerable

The TC7MH123AFK, TC7MH221AFK are advanced high speed CMOS monostable multivibrators fabricated with silicon gate C<sup>2</sup>MOS technology.

There are two trigger inputs,  $\bar{A}$  input (negative edge), and B input (positive edge). These inputs are valid for a slow rise/fall time signal ( $t_r = t_f = 1$  s) as they are schmitt trigger inputs. This device may also be triggered by using  $\bar{CLR}$  input (positive edge).

After triggering, the output stays in a monostable state for a time period determined by the external resistor and capacitor (Rx, Cx). A low level at the  $\bar{CLR}$  input breaks this state.

Limits for Cx and Rx are:

External capacitor, Cx.....No limit

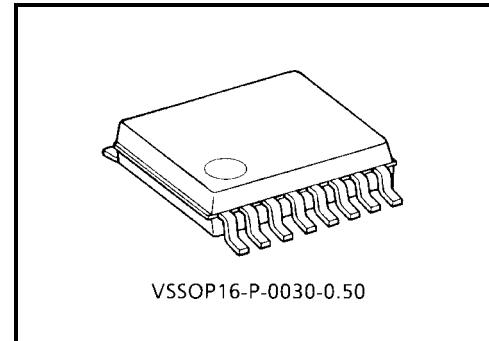
External resistor, Rx .....VCC = 2.0 V more than 5 k $\Omega$

VCC = 3.0 V more than 1 k $\Omega$

An input protection circuit ensures that 0 to 7 V can be applied to the input pins without regard to the supply voltage. This device can be used to interface 5 V to 3 V systems and two supply systems such as battery back up. This circuit prevents device destruction due to mismatched supply and input voltages.

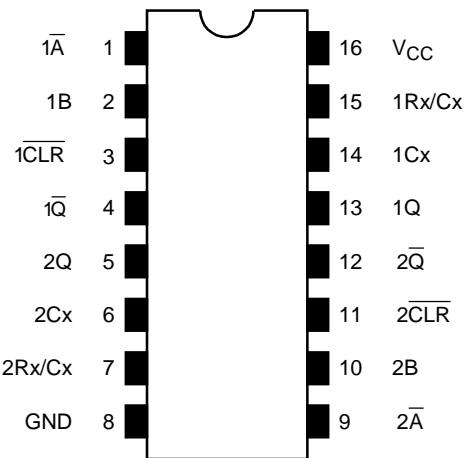
## Features

- High speed:  $t_{pd} = 8.1$  ns (typ.) (VCC = 5 V)
- Low power dissipation: Standby state  $I_{CC} = 4$   $\mu$ A (max) (Ta = 25°C)  
Active state  $I_{CC} = 600$   $\mu$ A (max) (VCC = 5.0 V)
- High noise immunity: VNIH = VNIL = 28% VCC (min)
- Power down protection is equipped with all inputs.
- Balanced propagation delays:  $t_{pLH} \approx t_{pHL}$
- Wide operating voltage range: VCC (opr) = 2~5.5 V
- Pin and function compatible with 74HC123A/221A



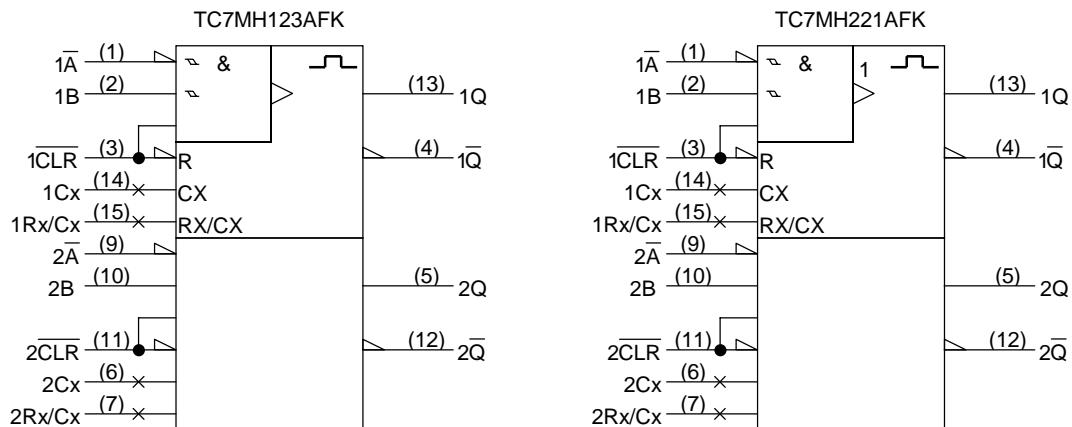
Weight: 0.02 g (typ.)

## Pin Assignment (top view)



Note: When using a single circuit only, please set  $\bar{CLR}$  to L, keep  $Rx/Cx \cdot Q \cdot \bar{Q}$  open and set other pins to either H or L.

## IEC Logic Symbol

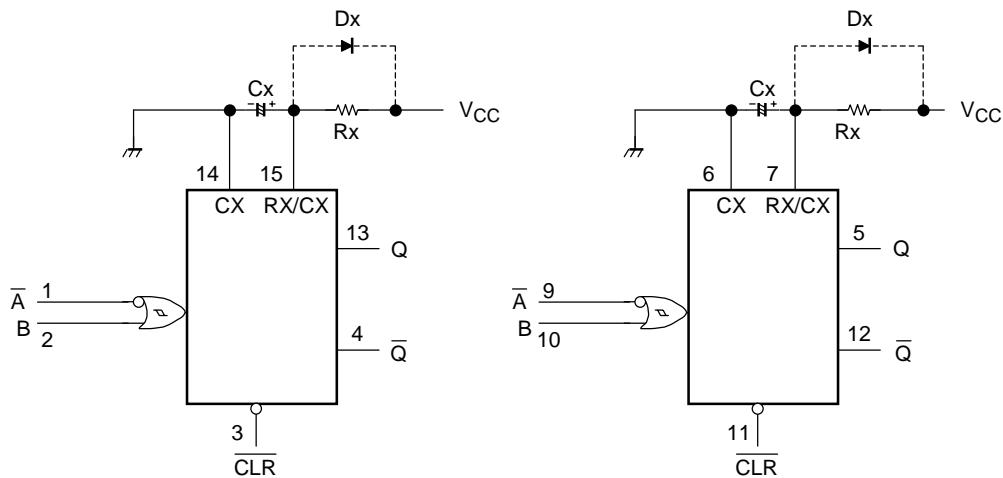


## Truth Table

Inputs			Outputs		Note
$\bar{A}$	B	$\bar{CLR}$	Q	$\bar{Q}$	
$\downarrow$	H	H	$\square$	$\square$	Output enable
X	L	H	L	H	Inhibit
H	X	H	L	H	Inhibit
L	$\uparrow$	H	$\square$	$\square$	Output enable
L	H	$\uparrow$	$\square$	$\square$	Output enable
X	X	L	L	H	Reset

X: Don't care

## Block Diagram



Note1: Cx, Rx, Dx are external capacitor, resistor, and diode, respectively.

Note2: External clamping diode, Dx;

The external capacitor is charged to V<sub>CC</sub> level in the wait state, i.e. when no trigger is applied.

If the supply voltage is turned off, Cx is discharged mainly through the internal (parasitic) diode. If Cx is sufficiently large and V<sub>CC</sub> drops rapidly, there will be some possibility of damaging the IC through inrush current or latch-up. If the capacitance of the supply voltage filter is large enough and V<sub>CC</sub> drops slowly, the inrush current is automatically limited and damage to the IC is avoided.

The maximum value of forward current through the parasitic diode is  $\pm 20$  mA.

In the case of a large Cx, the limit of fall time of the supply voltage is determined as follows:

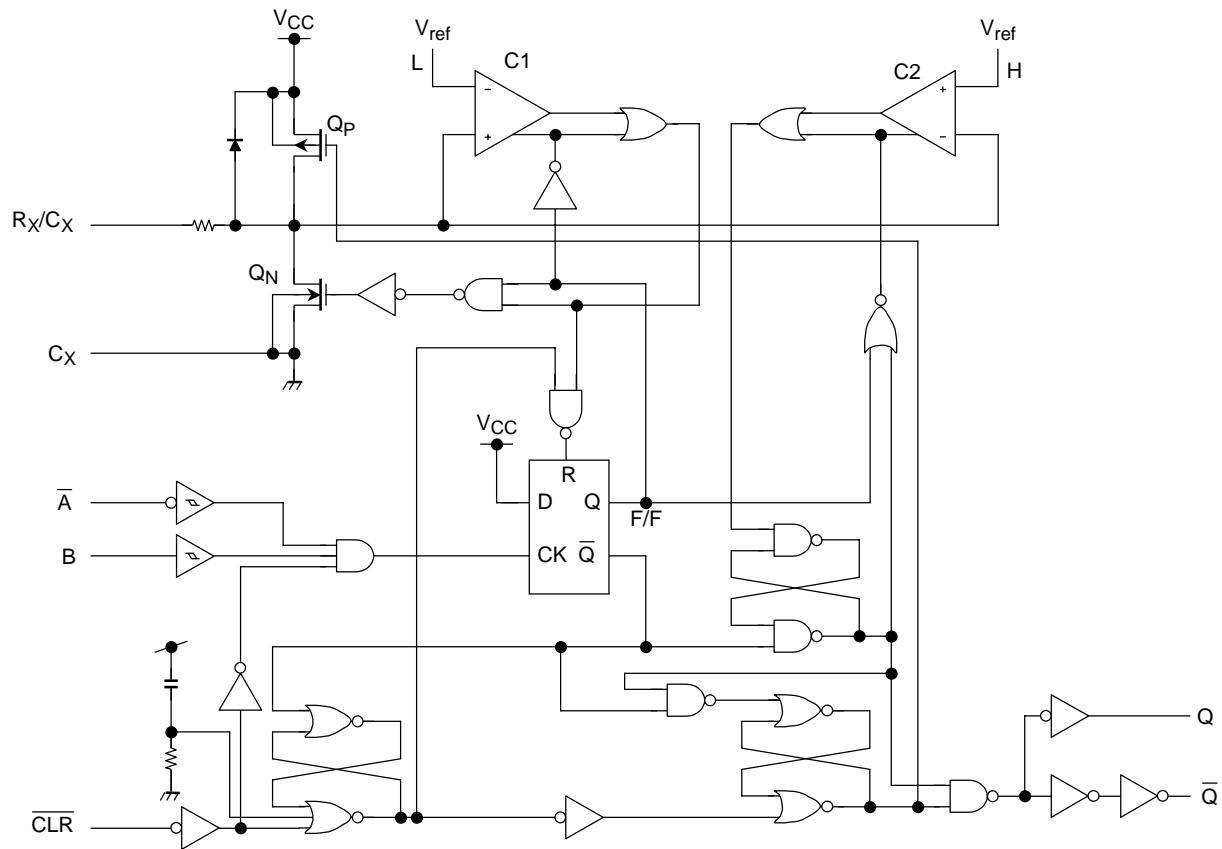
$$t_f \geq (V_{CC} - 0.7) \cdot Cx / 20 \text{ mA}$$

( $t_f$  is the time between the supply voltage turn off and the supply voltage reaching 0.4 V<sub>CC</sub>)

In the even a system does not satisfy the above condition, an external clamping diode (Dx) is needed to protect the IC from rush current.

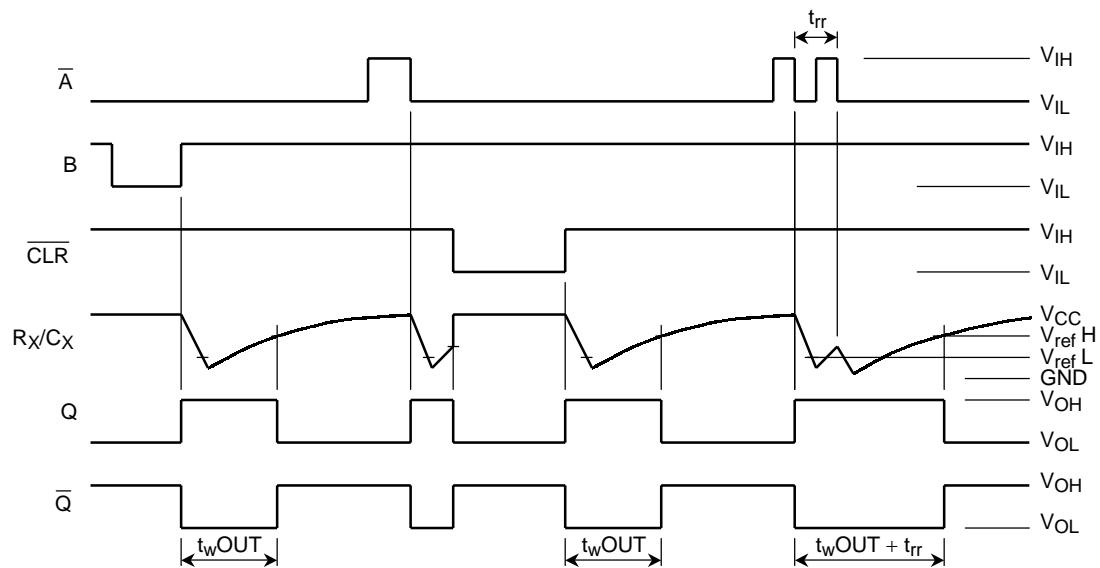
## System Diagram

TC7MH123AFK



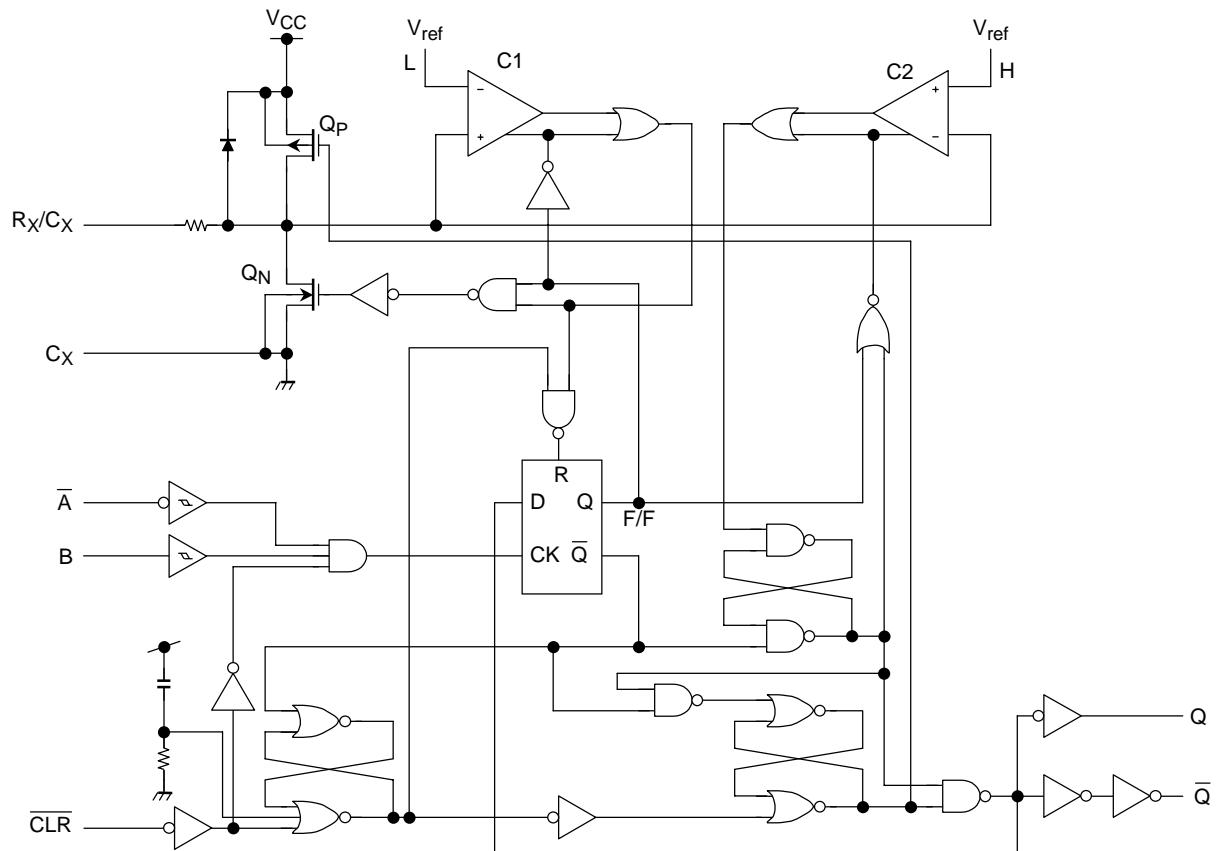
## Timing Chart

TC7MH123AFK



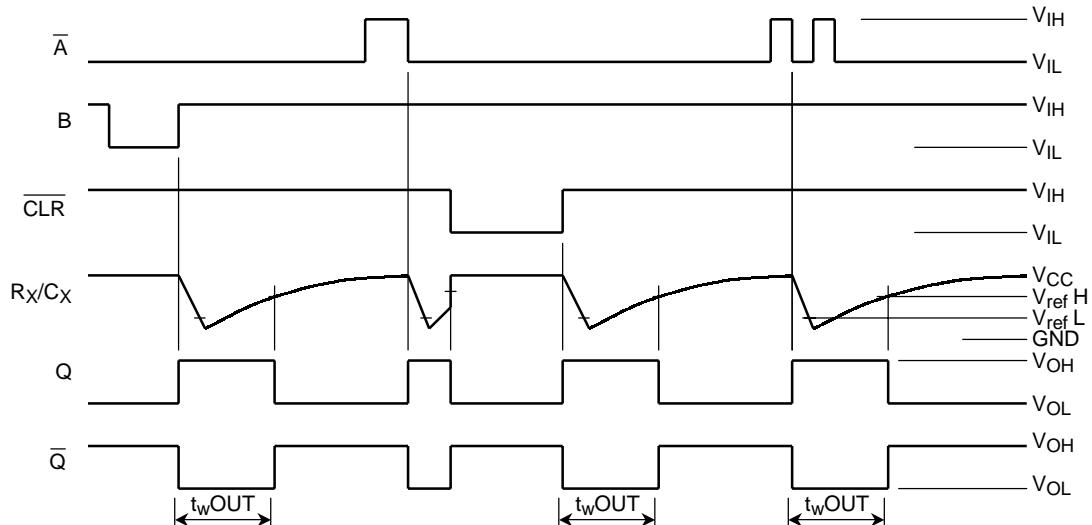
## System Diagram

TC7MH221AFK



## Timing Chart

TC7MH221AFK



## Functional Description

### (1) Stand-by state

The external capacitor (Cx) is fully charged to VCC in the stand-by state. That means, before triggering, the QP and QN transistors which are connected to the Rx/Cx node are in the off state. Two comparators that relate to the timing of the output pulse, and two reference voltage supplies turn off. The total supply current is only leakage current.

### (2) Trigger operation

Trigger operation is effective in any of the following three cases.

- $\overline{A}$  input is low, and the B input has a rising signal
- B input is high, and the  $\overline{A}$  input has a falling signal
- $\overline{A}$  input is low and the B input is high, and the  $\overline{CLR}$  input has a rising signal

After a trigger becomes effective, comparators C1 and C2 start operating, and QN is turned on. The external capacitor discharges through QN. The voltage level at the Rx/Cx node drops. If the Rx/Cx voltage level falls to the internal reference voltage Vref L, the output of C1 becomes low. The flip-flop is then reset and QN turns off. At that moment C1 stops but C2 continues operating.

After QN turns off, the voltage at the Rx/Cx node starts rising at a rate determined by the time constant of external capacitor Cx and resistor Rx.

Upon triggering, output Q becomes high, following some delay time of the internal F/F and gates. It stays high even if the voltage of Rx/Cx changes from falling to rising. When Rx/Cx reaches the internal reference voltage Vref H, the output of C2 becomes low, the output Q goes low and C2 stops its operation. That means, after triggering, when the voltage level of the Rx/Cx node reaches Vref H, the IC returns to its monostable state.

With large values of Cx and Rx, and ignoring the discharge time of the capacitor and internal delays of the IC, the width of the output pulse,  $t_w$  (OUT), is as follows:

$$t_w(\text{OUT}) = 1.0 \text{ Cx Rx}$$

### (3) Retrigger operation (TC7MH123AFK)

When a new trigger is applied to either input A or B while in the monostable state, it is effective only if the IC is charging Cx. The voltage level of the Rx/Cx node then falls to Vref L level again. Therefore the Q output stays high if the next trigger comes in before the time period set by Cx and Rx.

If the new trigger is very close to previous trigger, such as an occurrence during the discharge cycle, it will have no effect.

The minimum time for a trigger to be effective 2nd trigger,  $t_{rr}$  (min), depends on VCC and Cx.

### (4) Reset operation

In normal operation, the  $\overline{CLR}$  input is held high. If  $\overline{CLR}$  is low, a trigger has no effect because the Q output is held low and the trigger control F/F is reset. Also, QP turns on and Cx is charged rapidly to VCC.

This means if  $\overline{CLR}$  is set low, the IC goes into a wait state.

## Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit
Supply voltage range	V <sub>CC</sub>	-0.5~7.0	V
DC input voltage	V <sub>IN</sub>	-0.5~7.0	V
DC output voltage	V <sub>OUT</sub>	-0.5~V <sub>CC</sub> + 0.5	V
Input diode current	I <sub>IK</sub>	-20	mA
Output diode current	I <sub>OK</sub>	±20	mA
DC output current	I <sub>OUT</sub>	±25	mA
DC V <sub>CC</sub> /ground current	I <sub>CC</sub>	±50	mA
Power dissipation	P <sub>D</sub>	180	mW
Storage temperature	T <sub>stg</sub>	-65~150	°C

## Recommended Operating Conditions

Characteristics	Symbol	Rating	Unit
Supply voltage	V <sub>CC</sub>	2.0~5.5	V
Input voltage	V <sub>IN</sub>	0~5.5	V
Output voltage	V <sub>OUT</sub>	0~V <sub>CC</sub>	V
Operating temperature	T <sub>opr</sub>	-40~85	°C
Input rise and fall time (CLR only)	dt/dv	0~100 (V <sub>CC</sub> = 3.3 ± 0.3 V) 0~20 (V <sub>CC</sub> = 5 ± 0.5 V)	ns/V
External capacitor	C <sub>x</sub>	No limitation (Note3)	F
External resistor	R <sub>x</sub>	≥ 5 k (V <sub>CC</sub> = 2.0 V) (Note3) ≥ 1 k (V <sub>CC</sub> ≥ 3.0 V) (Note3)	Ω

Note3: The maximum allowable values of C<sub>x</sub> and R<sub>x</sub> are a function of leakage of capacitor of C<sub>x</sub>, the leakage of TC7MH123A/221A, and leakage due to board layout and surface resistance.  
Susceptibility to externally induced noise signals may occur for R<sub>x</sub> > 1 MΩ.

## Electrical Characteristics

## DC Characteristics

Characteristics		Symbol	Test Condition	V <sub>CC</sub> (V)	Ta = 25°C			Ta = -40~85°C		Unit	
					Min	Typ.	Max	Min	Max		
Input voltage	High level	V <sub>IH</sub>	—	2.0	1.50	—	—	1.50	—	V	
				3.0~5.5	V <sub>CC</sub> × 0.7	—	—	V <sub>CC</sub> × 0.7	—		
	Low level	V <sub>IL</sub>	—	2.0	—	—	0.50	—	0.50		
				3.0~5.5	—	—	V <sub>CC</sub> × 0.3	—	V <sub>CC</sub> × 0.3		
Output voltage	High level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OH</sub> = -50 μA	2.0	1.9	2.0	—	1.9	V	
					3.0	2.9	3.0	—	2.9		
					4.5	4.4	4.5	—	4.4		
				I <sub>OH</sub> = -4 mA	3.0	2.58	—	—	2.48		
				I <sub>OH</sub> = -8 mA	4.5	3.94	—	—	3.80		
	Low level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 50 μA	2.0	—	0	0.1	—	V	
					3.0	—	0	0.1	—		
					4.5	—	0	0.1	—		
				I <sub>OL</sub> = 4 mA	3.0	—	—	0.36	—		
				I <sub>OL</sub> = 8 mA	4.5	—	—	0.36	—		
Input leakage current	I <sub>IN</sub>	V <sub>IN</sub> = 5.5 V or GND		0~5.5	—	—	±0.1	—	±1.0	μA	
Rx/Cx terminal off-state current	I <sub>IN</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		5.5	—	—	±0.25	—	±2.50	μA	
Quiescent supply current	I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		5.5	—	—	4.0	—	40.0	μA	
Active-state supply current (Note4)	I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND Rx/Cx = 0.5 V <sub>CC</sub>	3.0	—	160	250	—	280	—	μA	
			4.5	—	380	500	—	650	—		
			5.5	—	560	750	—	975	—		

Note4: Per circuit

Timing Requirements (Input: t<sub>r</sub> = t<sub>f</sub> = 3 ns)

Characteristics	Symbol	Test Condition	V <sub>CC</sub> (V)	Ta = 25°C		Ta = -40~85°C		Unit
				Typ.	Limit	Typ.	Limit	
Minimum pulse width	t <sub>w</sub> (L) t <sub>w</sub> (H)	—	3.3 ± 0.3	—	5.0	—	5.0	ns
			5.0 ± 0.5	—	5.0	—	5.0	
Minimum clear width ( CLR )	t <sub>w</sub> (L)	—	3.3 ± 0.3	—	5.0	—	5.0	ns
			5.0 ± 0.5	—	5.0	—	5.0	
Minimum retrigger time (Note5)	t <sub>rr</sub>	Rx = 1 kΩ Cx = 100 pF	3.3 ± 0.3	60	—	—	—	ns
			5.0 ± 0.5	39	—	—	—	
		Rx = 1 kΩ Cx = 0.01 μF	3.3 ± 0.3	1.5	—	—	—	μs
			5.0 ± 0.5	1.2	—	—	—	

Note5: For TC7MH123AFK only

AC Characteristics (Input:  $t_r = t_f = 3$  ns)

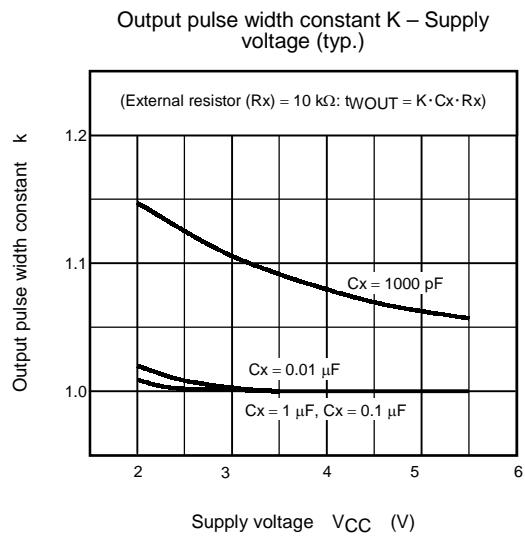
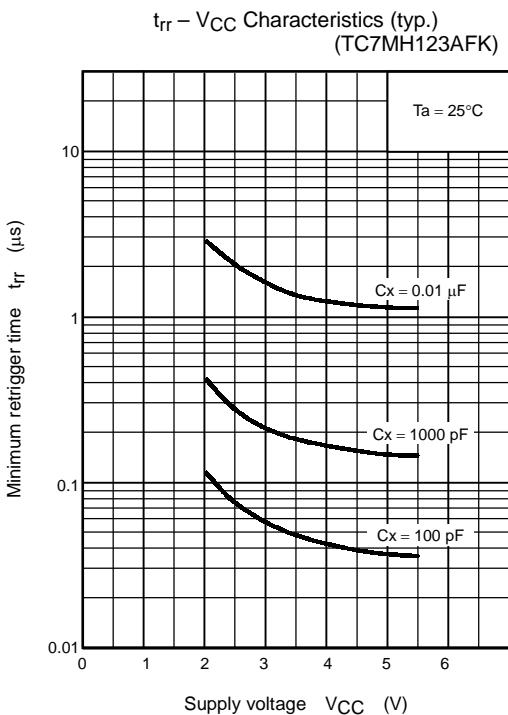
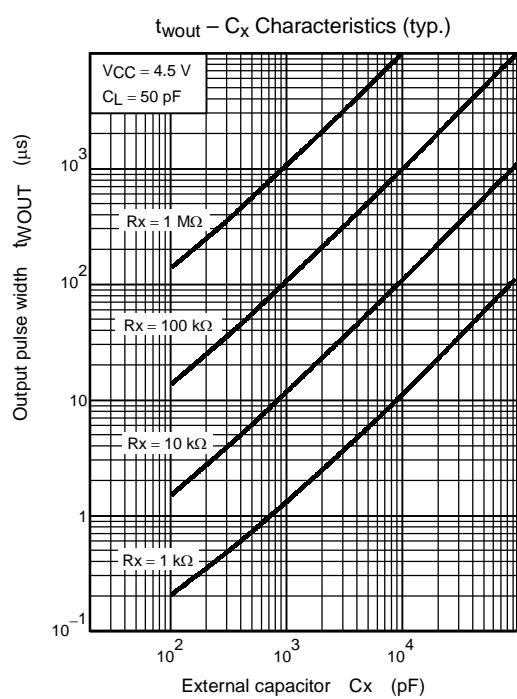
Characteristics	Symbol	Test Condition	Ta = 25°C			Ta = -40~85°C		Unit
			V <sub>CC</sub> (V)	C <sub>L</sub> (pF)	Min	Typ.	Max	
Propagation delay time (A, B-Q, $\bar{Q}$ )	$t_{pLH}$ $t_{pHL}$	—	3.3 ± 0.3	15	—	13.4	20.6	1.0 24.0
				50	—	15.9	24.1	1.0 27.5
			5.0 ± 0.5	15	—	8.1	12.0	1.0 14.0
				50	—	9.6	14.0	1.0 16.0
	$t_{pLH}$ $t_{pHL}$	—	3.3 ± 0.3	15	—	14.5	22.4	1.0 26.0
				50	—	17.0	25.9	1.0 29.5
			5.0 ± 0.5	15	—	8.7	12.9	1.0 15.0
				50	—	10.2	14.9	1.0 17.0
Propagation delay time ( $\bar{CLR}$ trigger-Q, $\bar{Q}$ )	$t_{pLH}$ $t_{pHL}$	—	3.3 ± 0.3	15	—	10.3	15.8	1.0 18.5
				50	—	12.8	19.3	1.0 22.0
			5.0 ± 0.5	15	—	6.3	9.4	1.0 11.0
				50	—	7.8	11.4	1.0 13.0
	$t_{wOUT}$	$C_x = 28$ pF $R_x = 2$ k $\Omega$	3.3 ± 0.3	50	—	160	240	— 300
			5.0 ± 0.5	50	—	133	200	— 240
		$C_x = 0.01$ $\mu$ F $R_x = 10$ k $\Omega$	3.3 ± 0.3	50	90	100	110	90 110
			5.0 ± 0.5	50	90	100	110	90 110
		$C_x = 0.1$ $\mu$ F $R_x = 10$ k $\Omega$	3.3 ± 0.3	50	0.9	1.0	1.1	0.9 1.1
			5.0 ± 0.5	50	0.9	1.0	1.1	0.9 1.1
Output pulse width error between circuits (in same package)	$\Delta t_{wOUT}$	—	—	50	—	±1	—	—
Input capacitance	C <sub>IN</sub>	—	—	—	—	4	10	— 10 pF
Power dissipation capacitance	C <sub>PD</sub>	—	(Note6)	—	73	—	—	— pF

Note6: C<sub>PD</sub> is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load.

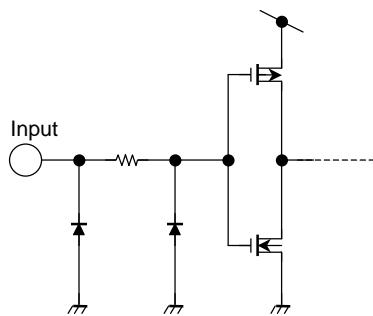
Average operating current can be obtained by the equation:

$$I_{CC}(\text{opr}) = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}' \cdot \text{Duty}/100 + I_{CC}/2 \text{ (per circuit)}$$

(I<sub>CC</sub>': active supply current)  
(Duty: %)



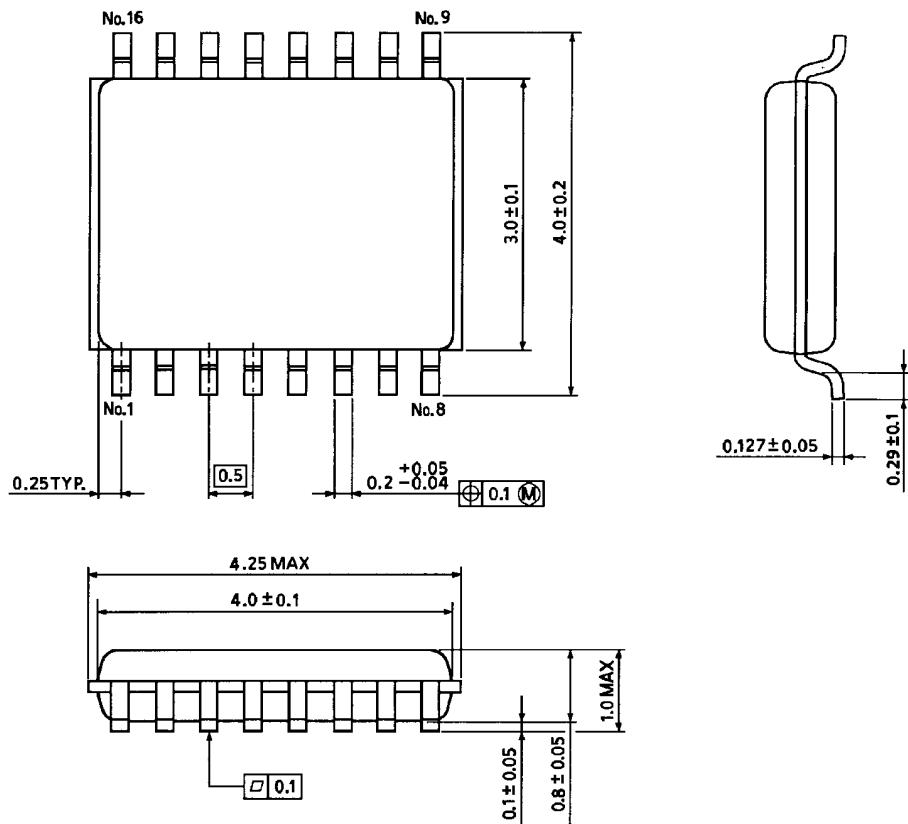
## Input Equivalent Circuit



**Package Dimensions**

VSSOP16-P-0030-0.50

Unit : mm



Weight: 0.02 g (typ.)

## RESTRICTIONS ON PRODUCT USE

000707EBA

- TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing TOSHIBA products, to comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such TOSHIBA products could cause loss of human life, bodily injury or damage to property. In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the "Handling Guide for Semiconductor Devices," or "TOSHIBA Semiconductor Reliability Handbook" etc..
- The TOSHIBA products listed in this document are intended for usage in general electronics applications (computer, personal equipment, office equipment, measuring equipment, industrial robotics, domestic appliances, etc.). These TOSHIBA products are neither intended nor warranted for usage in equipment that requires extraordinarily high quality and/or reliability or a malfunction or failure of which may cause loss of human life or bodily injury ("Unintended Usage"). Unintended Usage include atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, medical instruments, all types of safety devices, etc.. Unintended Usage of TOSHIBA products listed in this document shall be made at the customer's own risk.
- The products described in this document are subject to the foreign exchange and foreign trade laws.
- The information contained herein is presented only as a guide for the applications of our products. No responsibility is assumed by TOSHIBA CORPORATION for any infringements of intellectual property or other rights of the third parties which may result from its use. No license is granted by implication or otherwise under any intellectual property or other rights of TOSHIBA CORPORATION or others.
- The information contained herein is subject to change without notice.