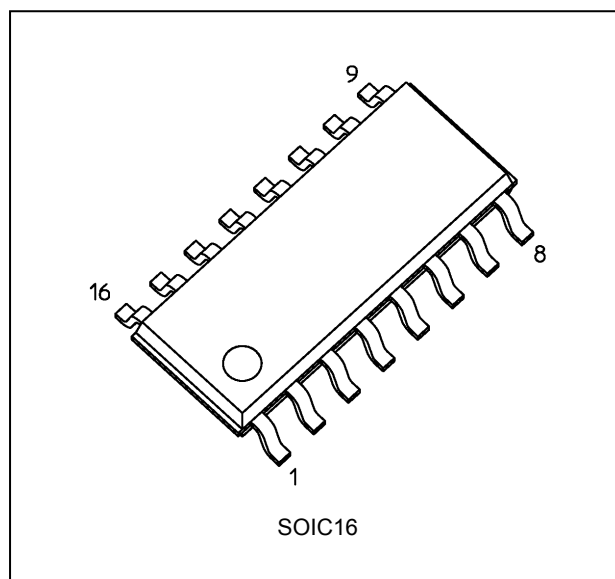
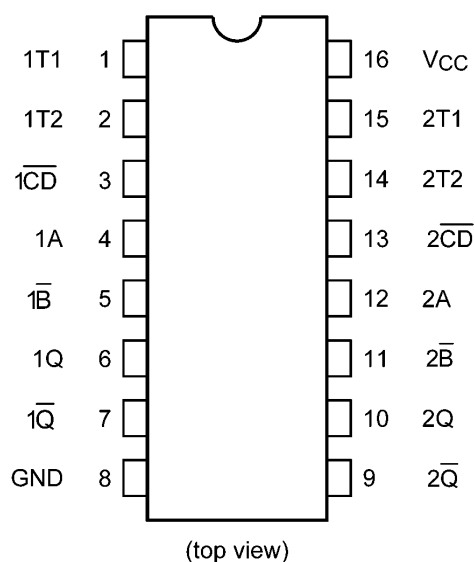


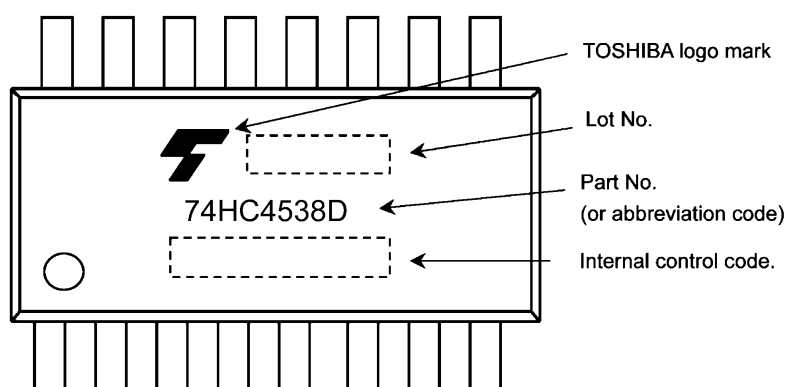
## 4. Packaging



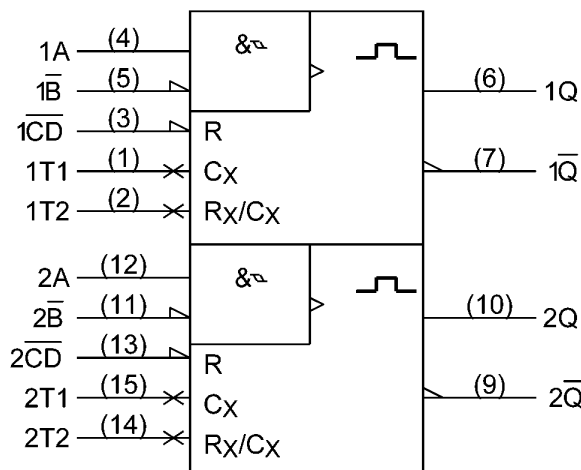
## 5. Pin Assignment









## 6. Marking



7. IEC Logic Symbol

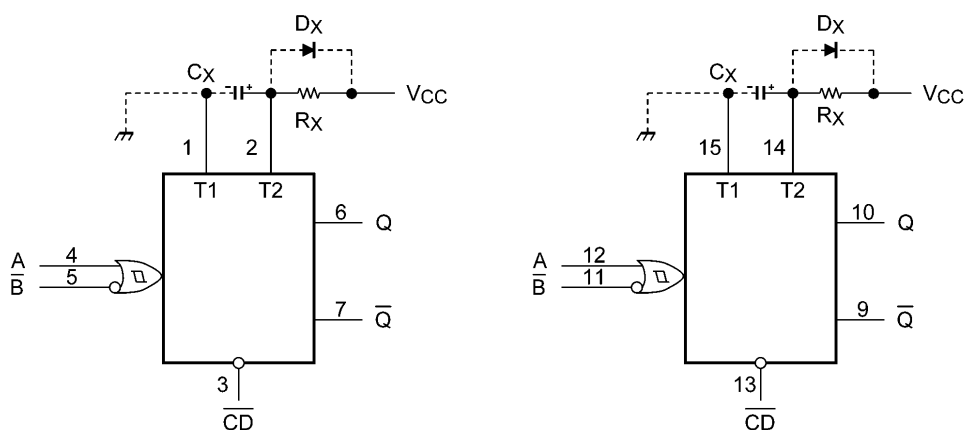


8. Truth Table

Inputs			Outputs		Note
A	$\overline{B}$	$\overline{CD}$	Q	$\overline{Q}$	
	H	H			Output Enable
X	L	H	L	H	Inhibit
H	X	H	L	H	Inhibit
L		H			Output Enable
X	X	L	L	H	Reset

X: Don't care

## 9. Block Diagram



- (1)  $C_X$ ,  $R_X$ ,  $D_X$  are external  
Capacitor, resistor, and diode, respectively.
- (2) External clamping diode,  $D_X$ :

The external capacitor is charged to  $V_{CC}$  level in the wait state, i.e. when no trigger is applied. Supply voltage is turned off and  $C_X$  is discharged mainly through the internal (parasitic) diode. If  $C_X$  is sufficiently large and  $V_{CC}$  drops rapidly, there will be some possibility of damaging the IC by rush current or latch-up. If the capacitance of the supply voltage filter is large enough and  $V_{CC}$  drops slowly, the rush 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.

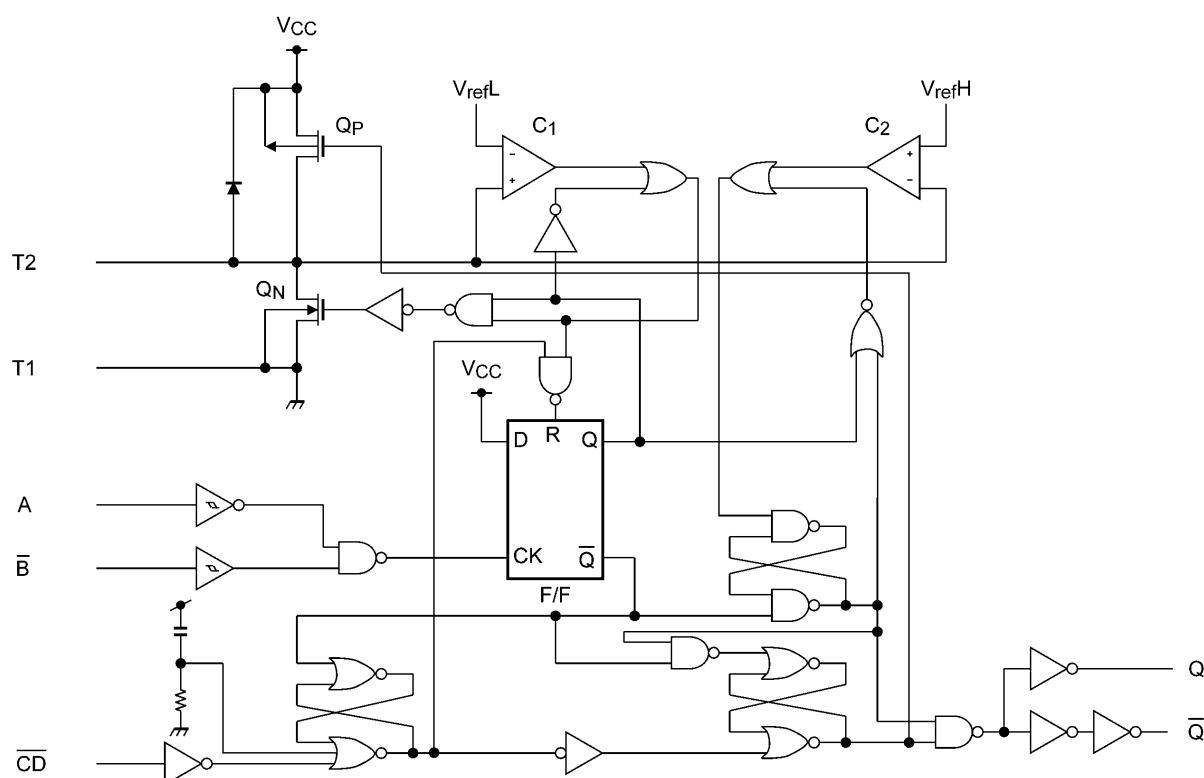
In the case of a large  $C_X$ , the limitation of fall time of the supply voltage is determined as follows:

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

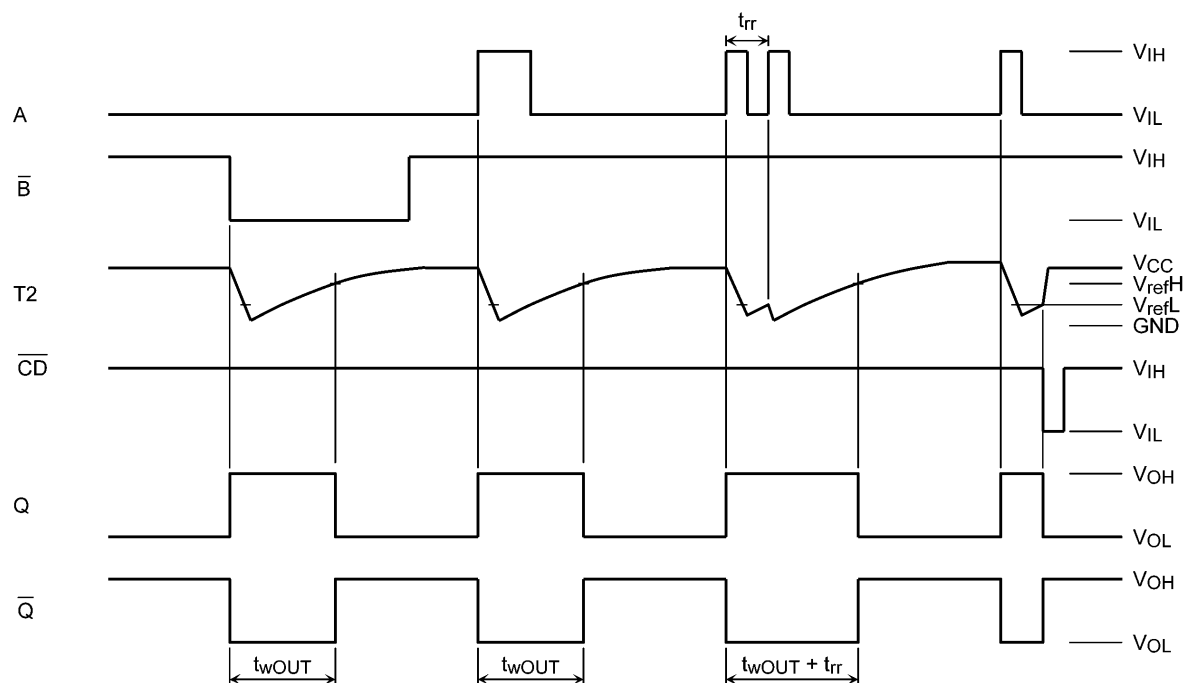
( $t_f$  is the time from the voltage supply turning off to the level of supply voltage reaching  $0.4 V_{CC}$ .)

In the case of a system that does not satisfy the above condition, an external clamping diode is needed to protect the IC from rush current.

# 10. System Diagram



# 11. Timing Chart



## 12. Functional Description

### (1) Stand-by state

The external capacitor is fully charge to  $V_{CC}$  in the stand-by state. That means, before triggering,  $Q_P$  and  $Q_N$  transistors which are connected to the T2 node are in the off state. Two comparators that relate to the timing of the output pulse, and two reference voltage supplies stop their operation. The total supply current is only leakage current.

### (2) Trigger operation

Trigger operation is effective in either of the following two cases. One is the condition where the A input is low, and the  $\overline{B}$  input has a falling signal. The other, where the  $\overline{B}$  input is high, and the A input has a rising signal.

After trigger becomes effective, comparators  $C_1$  and  $C_2$  start operating, and  $Q_N$  is turned on. The external capacitor discharges through  $Q_N$ . The voltage level at the T2 node drops. If the T2 voltage level falls to the internal reference voltage  $V_{refL}$ , the output of  $C_1$  becomes low. The flip-flop is then reset and  $Q_N$  turns off. At that moment  $C_1$  stops but  $C_2$  continues operating.

After  $Q_N$  turns off, the voltage at T2 start rising at a rate determined by the time constant of external capacitor  $C_X$  and resistor  $R_X$ .

After the triggering, output Q becomes high, following some delay time of the internal F/F and gates. It stays high even if the voltage of T2 changes from falling to rising. When T2 reaches the internal reference voltage  $V_{refH}$ , the output of  $C_2$  becomes low, the output Q goes low and  $C_2$  stops its operation. That means, after triggering, when the voltage level of T2 reaches  $V_{refH}$ , the IC returns to its MONOSTABLE state.

In the case of large value of  $C_X$  and  $R_X$ , and ignoring the discharge time of the capacitor and internal delays of the IC, the width of the output pulse, ( $t_{wOUT}$ ), is as follows:

$$t_{wOUT} = 0.7 \times C_X \times R_X$$

### (3) Retrigger operation

When another new trigger is applied to input A or  $\overline{B}$  while in the MONOSTABLE state, it is effective only if the IC is charging  $C_X$ . The voltage level of T2 then falls to  $V_{refL}$  level again.

Therefore the Q output stays high if the next trigger comes in before the time period set by  $C_X$  and  $R_X$ .

If the 2<sup>nd</sup> trigger is very close to previous trigger, such as application during the discharge cycle, the 2<sup>nd</sup> trigger will not be effective.

The minimum time for effective 2<sup>nd</sup> trigger,  $t_{tr}$  (min), depends on  $V_{CC}$  and  $C_X$ .

### (4) Reset operation

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

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

## 13. Absolute Maximum Ratings (Note)

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	$V_{CC}$		-0.5 to 7.0	V
Input voltage	$V_{IN}$		-0.5 to $V_{CC} + 0.5$	V
Output voltage	$V_{OUT}$		-0.5 to $V_{CC} + 0.5$	V
Input diode current	$I_{IK}$		$\pm 20$	mA
Output diode current	$I_{OK}$		$\pm 20$	mA
Output current	$I_{OUT}$		$\pm 25$	mA
$V_{CC}$ /ground current	$I_{CC}$		$\pm 50$	mA
Power dissipation	$P_D$	(Note 1)	500	mW
Storage temperature	$T_{stg}$		-65 to 150	°C

Note: Exceeding any of the absolute maximum ratings, even briefly, lead to deterioration in IC performance or even destruction.

Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings and the operating ranges.

Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook ("Handling Precautions"/"Derating Concept and Methods") and individual reliability data (i.e. reliability test report and estimated failure rate, etc).

Note 1:  $P_D$  derates linearly with -8 mW/°C above 85°C.

## 14. Operating Ranges (Note)

Characteristics	Symbol	Note	Test Condition	Rating	Unit
Supply voltage	$V_{CC}$		—	2.0 to 6.0	V
Input voltage	$V_{IN}$		—	0 to $V_{CC}$	V
Output voltage	$V_{OUT}$		—	0 to $V_{CC}$	V
Operating temperature	$T_{opr}$		—	-40 to 125	°C
Input rise and fall times (CD only)	$t_r, t_f$		$V_{CC} = 4.5 \text{ V}$	0 to 50	$\mu\text{s}$
External capacitor	$C_X$	(Note 1)	—	No limitation	F
External resistor	$R_X$	(Note 1)	$V_{CC} = 2.0 \text{ V}$	$\geq 5 \text{ k}$	$\Omega$
			$V_{CC} \geq 3.0 \text{ V}$	$\geq 1 \text{ k}$	

Note: The operating ranges must be maintained to ensure the normal operation of the device.

Unused inputs must be tied to either  $V_{CC}$  or GND.

Note 1: The maximum allowable values of  $C_X$  and  $R_X$  are a function of leakage of capacitor  $C_X$ , the leakage of 74HC4538D, and leakage due to board layout and surface resistance.

Susceptibility to externally induced noise signals may occur for  $R_X > 1 \text{ M}\Omega$ .

## 15. Electrical Characteristics

15.1. DC Characteristics (Unless otherwise specified,  $T_a = 25\text{ }^{\circ}\text{C}$ )

Characteristics	Symbol	Test Condition		$V_{CC}$ (V)	Min	Typ.	Max	Unit
High-level input voltage	$V_{IH}$	—		2.0	1.50	—	—	V
				4.5	3.15	—	—	
				6.0	4.20	—	—	V
Low-level input voltage	$V_{IL}$	—		2.0	—	—	0.50	V
				4.5	—	—	1.35	
				6.0	—	—	1.80	V
High-level output voltage (Q, $\bar{Q}$ )	$V_{OH}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -20\text{ }\mu\text{A}$	2.0	1.9	2.0	—	V
				4.5	4.4	4.5	—	
				6.0	5.9	6.0	—	
			$I_{OH} = -4\text{ mA}$	4.5	4.18	4.31	—	
			$I_{OH} = -5.2\text{ mA}$	6.0	5.68	5.80	—	
Low-level output voltage (Q, $\bar{Q}$ )	$V_{OL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 20\text{ }\mu\text{A}$	2.0	—	0.0	0.1	V
				4.5	—	0.0	0.1	
				6.0	—	0.0	0.1	
			$I_{OL} = 4\text{ mA}$	4.5	—	0.17	0.26	V
			$I_{OL} = 5.2\text{ mA}$	6.0	—	0.18	0.26	
Input leakage current	$I_{IN}$	$V_{IN} = V_{CC}$ or GND		6.0	—	—	$\pm 0.1$	$\mu\text{A}$
T2 terminal input leakage current	$I_{IN}$	$V_{IN} = V_{CC}$ or GND		6.0	—	—	$\pm 0.5$	$\mu\text{A}$
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND		6.0	—	—	4.0	$\mu\text{A}$
Active-state supply current (per circuit)	$I_{CC(opr)}$	$V_{IN} = V_{CC}$ or GND T2 ext = $0.25 V_{CC}$		2.0	—	40	120	$\mu\text{A}$
				4.5	—	250	350	
				6.0	—	450	600	

15.2. DC Characteristics (Unless otherwise specified,  $T_a = -40$  to  $85\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Test Condition		$V_{CC}$ (V)	Min	Max	Unit
High-level input voltage	$V_{IH}$	—		2.0	1.50	—	V
				4.5	3.15	—	
				6.0	4.20	—	
Low-level input voltage	$V_{IL}$	—		2.0	—	0.50	V
				4.5	—	1.35	
				6.0	—	1.80	
High-level output voltage (Q, $\bar{Q}$ )	$V_{OH}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -20\text{ }\mu\text{A}$	2.0	1.9	—	V
				4.5	4.4	—	
				6.0	5.9	—	
			$I_{OH} = -4\text{ mA}$	4.5	4.13	—	
			$I_{OH} = -5.2\text{ mA}$	6.0	5.63	—	
Low-level output voltage (Q, $\bar{Q}$ )	$V_{OL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 20\text{ }\mu\text{A}$	2.0	—	0.1	V
				4.5	—	0.1	
				6.0	—	0.1	
			$I_{OL} = 4\text{ mA}$	4.5	—	0.33	
			$I_{OL} = 5.2\text{ mA}$	6.0	—	0.33	V
Input leakage current	$I_{IN}$	$V_{IN} = V_{CC}$ or GND		6.0	—	$\pm 1.0$	$\mu\text{A}$
T2 terminal input leakage current	$I_{IN}$	$V_{IN} = V_{CC}$ or GND		6.0	—	$\pm 5.0$	$\mu\text{A}$
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND		6.0	—	40.0	$\mu\text{A}$
Active-state supply current (per circuit)	$I_{CC(opr)}$	$V_{IN} = V_{CC}$ or GND T2 ext = $0.25 V_{CC}$		2.0	—	160	$\mu\text{A}$
				4.5	—	400	
				6.0	—	800	

15.3. DC Characteristics (Unless otherwise specified,  $T_a = -40$  to  $125\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Test Condition		$V_{CC}$ (V)	Min	Max	Unit
High-level input voltage	$V_{IH}$	—		2.0	1.50	—	V
				4.5	3.15	—	
				6.0	4.20	—	
Low-level input voltage	$V_{IL}$	—		2.0	—	0.50	V
				4.5	—	1.35	
				6.0	—	1.80	
High-level output voltage (Q, $\bar{Q}$ )	$V_{OH}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -20\text{ }\mu\text{A}$	2.0	1.9	—	V
				4.5	4.4	—	
				6.0	5.9	—	
			$I_{OH} = -4\text{ mA}$	4.5	3.7	—	
			$I_{OH} = -5.2\text{ mA}$	6.0	5.2	—	
Low-level output voltage (Q, $\bar{Q}$ )	$V_{OL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 20\text{ }\mu\text{A}$	2.0	—	0.1	V
				4.5	—	0.1	
				6.0	—	0.1	
			$I_{OL} = 4\text{ mA}$	4.5	—	0.4	
			$I_{OL} = 5.2\text{ mA}$	6.0	—	0.4	
Input leakage current	$I_{IN}$	$V_{IN} = V_{CC}$ or GND		6.0	—	$\pm 1.0$	$\mu\text{A}$
T2 terminal input leakage current	$I_{IN}$	$V_{IN} = V_{CC}$ or GND		6.0	—	$\pm 10.0$	$\mu\text{A}$
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND		6.0	—	80.0	$\mu\text{A}$
Active-state supply current (per circuit)	$I_{CC(opr)}$	$V_{IN} = V_{CC}$ or GND T2 ext = $0.25 V_{CC}$		2.0	—	160	$\mu\text{A}$
				4.5	—	400	
				6.0	—	800	



**15.4. Timing Requirements (Unless otherwise specified,  $T_a = 25\text{ }^{\circ}\text{C}$ , Input:  $t_r = t_f = 6\text{ ns}$ )**

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Typ.	Limit	Unit
Minimum pulse width (A, $\overline{B}$ )	$t_{w(L)}, t_{w(H)}$	—	2.0	—	75	ns
			4.5	—	15	
			6.0	—	13	
Minimum pulse width ( $\overline{CD}$ )	$t_{w(L)}$	—	2.0	—	75	ns
			4.5	—	15	
			6.0	—	13	
Minimum removal time	$t_{rem}$	—	2.0	—	25	ns
			4.5	—	5	
			6.0	—	4	
Minimum retrigger time	$t_{rr}$	$R_X = 1\text{ k}\Omega$ , $C_X = 100\text{ pF}$	2.0	60	—	ns
			4.5	25	—	
			6.0	20	—	
		$R_X = 1\text{ k}\Omega$ , $C_X = 0.01\text{ }\mu\text{F}$	2.0	1.8	—	$\mu\text{s}$
			4.5	0.8	—	
			6.0	0.7	—	

**15.5. Timing Requirements  
(Unless otherwise specified,  $T_a = -40\text{ to }85\text{ }^{\circ}\text{C}$ , Input:  $t_r = t_f = 6\text{ ns}$ )**

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Limit	Unit
Minimum pulse width (A, $\overline{B}$ )	$t_{w(L)}, t_{w(H)}$	—	2.0	95	ns
			4.5	19	
			6.0	16	
Minimum pulse width ( $\overline{CD}$ )	$t_{w(L)}$	—	2.0	95	ns
			4.5	19	
			6.0	16	
Minimum removal time	$t_{rem}$	—	2.0	30	ns
			4.5	6	
			6.0	5	

**15.6. Timing Requirements  
(Unless otherwise specified,  $T_a = -40\text{ to }125\text{ }^{\circ}\text{C}$ , Input:  $t_r = t_f = 6\text{ ns}$ )**

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Limit	Unit
Minimum pulse width (A, $\overline{B}$ )	$t_{w(L)}, t_{w(H)}$	—	2.0	110	ns
			4.5	22	
			6.0	19	
Minimum pulse width ( $\overline{CD}$ )	$t_{w(L)}$	—	2.0	135	ns
			4.5	27	
			6.0	23	
Minimum removal time	$t_{rem}$	—	2.0	40	ns
			4.5	8	
			6.0	7	

## 15.7. AC Characteristics

(Unless otherwise specified,  $C_L = 15 \text{ pF}$ ,  $V_{CC} = 5 \text{ V}$ ,  $T_a = 25 \text{ }^\circ\text{C}$ , Input:  $t_r = t_f = 6 \text{ ns}$ )

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Output transition time	$t_{TLH}, t_{THL}$	—	—	6	12	ns
Propagation delay time (A, $\overline{B}$ - Q, $\overline{Q}$ )	$t_{PLH}, t_{PHL}$	—	—	25	44	
Propagation delay time ( $\overline{CD}$ - Q, $\overline{Q}$ )	$t_{PLH}, t_{PHL}$	—	—	25	44	

15.8. AC Characteristics (Unless otherwise specified,  $C_L = 50 \text{ pF}$ ,  $T_a = 25 \text{ }^\circ\text{C}$ , Input:  $t_r = t_f = 6 \text{ ns}$ )

Characteristics	Symbol	Note	Test Condition	$V_{CC}$ (V)	Min	Typ.	Max	Unit
Output transition time	$t_{TLH}, t_{THL}$		—	2.0	—	30	75	ns
				4.5	—	8	15	
				6.0	—	7	13	
Propagation delay time (A, $\overline{B}$ - Q, $\overline{Q}$ )	$t_{PLH}, t_{PHL}$		—	2.0	—	120	250	ns
				4.5	—	30	50	
				6.0	—	25	43	
Propagation delay time ( $\overline{CD}$ - Q, $\overline{Q}$ )	$t_{PLH}, t_{PHL}$		—	2.0	—	120	250	ns
				4.5	—	30	50	
				6.0	—	25	43	
Output pulse width	$t_{WOUT}$		$C_X = 0 \text{ F}$ $R_X = 5 \text{ k}\Omega$ ( $V_{CC} = 2.0 \text{ V}$ ) $R_X = 1 \text{ k}\Omega$ ( $V_{CC} = 4.5 \text{ V}, 6.0 \text{ V}$ )	2.0	—	540	1200	ns
				4.5	—	180	250	
				6.0	—	150	200	
			$C_X = 0.01 \text{ }\mu\text{F}$ $R_X = 10 \text{ k}\Omega$	2.0	70	83	96	$\mu\text{s}$
				4.5	69	77	85	
				6.0	69	77	85	
			$C_X = 0.1 \text{ }\mu\text{F}$ $R_X = 10 \text{ k}\Omega$	2.0	0.73	0.79	0.85	ms
				4.5	0.71	0.75	0.79	
				6.0	0.71	0.75	0.79	
Output pulse width error between circuits (in same package)	$\Delta t_{WOUT}$		—	—	$\pm 1$	—	—	%
Input capacitance	$C_{IN}$		—	—	5	10	—	pF
Power dissipation capacitance	$C_{PD}$	(Note 1)	—	—	40	—	—	pF

Note 1:  $C_{PD}$  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.

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

( $I_{CC'}$ : Active supply current),

(Duty: %)

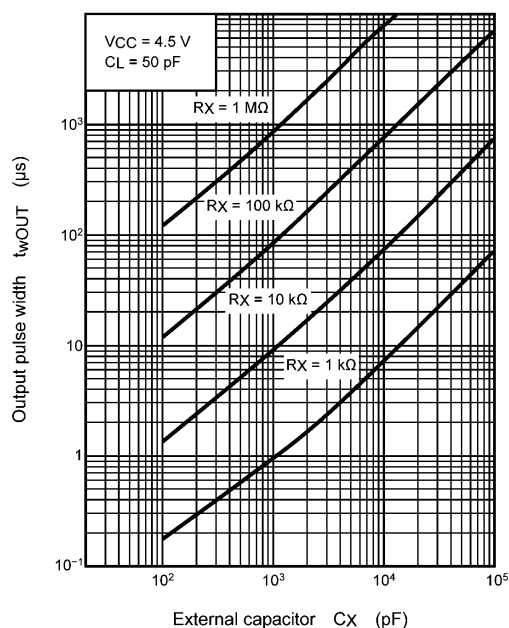
**15.9. AC Characteristics (Unless otherwise specified,  $C_L = 50 \text{ pF}$ ,  $T_a = -40 \text{ to } 85 \text{ }^\circ\text{C}$ ,  
Input:  $t_r = t_f = 6 \text{ ns}$ )**

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Min	Max	Unit
Output transition time	$t_{TLH}, t_{THL}$	—	2.0	—	95	ns
			4.5	—	19	
			6.0	—	16	
Propagation delay time (A, $\bar{B}$ - Q, $\bar{Q}$ )	$t_{PLH}, t_{PHL}$	—	2.0	—	315	ns
			4.5	—	63	
			6.0	—	54	
Propagation delay time (CD - Q, $\bar{Q}$ )	$t_{PLH}, t_{PHL}$	—	2.0	—	315	ns
			4.5	—	63	
			6.0	—	54	
Output pulse width	$t_{WOUT}$	$C_X = 0 \text{ F}$ $R_X = 5 \text{ k}\Omega$ ( $V_{CC} = 2.0 \text{ V}$ ) $R_X = 1 \text{ k}\Omega$ ( $V_{CC} = 4.5 \text{ V}, 6.0 \text{ V}$ )	2.0	—	1500	ns
			4.5	—	320	ns
			6.0	—	260	ns
		$C_X = 0.01 \text{ }\mu\text{F}$ $R_X = 10 \text{ k}\Omega$	2.0	70	96	$\mu\text{s}$
			4.5	69	85	$\mu\text{s}$
			6.0	69	85	$\mu\text{s}$
		$C_X = 0.1 \text{ }\mu\text{F}$ $R_X = 10 \text{ k}\Omega$	2.0	0.71	0.86	ms
			4.5	0.70	0.80	ms
			6.0	0.70	0.80	ms
Input capacitance	$C_{IN}$	—		—	10	pF

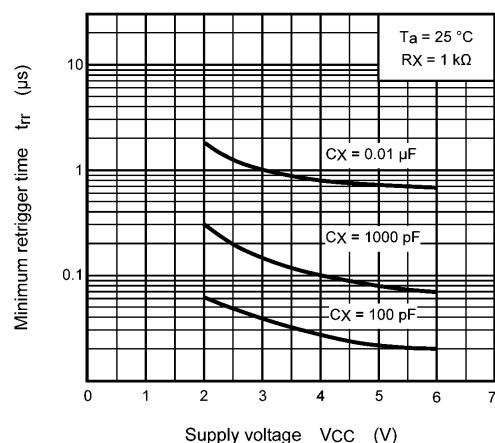
**15.10. AC Characteristics (Unless otherwise specified,  $C_L = 50 \text{ pF}$ ,  $T_a = -40 \text{ to } 125 \text{ }^\circ\text{C}$ ,  
Input:  $t_r = t_f = 6 \text{ ns}$ )**

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Min	Max	Unit
Output transition time	$t_{TLH}, t_{THL}$	—	2.0	—	110	ns
			4.5	—	22	
			6.0	—	19	
Propagation delay time (A, $\bar{B}$ - Q, $\bar{Q}$ )	$t_{PLH}, t_{PHL}$	—	2.0	—	380	ns
			4.5	—	76	
			6.0	—	65	
Propagation delay time (CD - Q, $\bar{Q}$ )	$t_{PLH}, t_{PHL}$	—	2.0	—	380	ns
			4.5	—	76	
			6.0	—	65	
Output pulse width	$t_{WOUT}$	$C_X = 0 \text{ F}$ $R_X = 5 \text{ k}\Omega$ ( $V_{CC} = 2.0 \text{ V}$ ) $R_X = 1 \text{ k}\Omega$ ( $V_{CC} = 4.5 \text{ V}, 6.0 \text{ V}$ )	2.0	—	1500	ns
			4.5	—	320	
			6.0	—	260	
		$C_X = 0.01 \text{ }\mu\text{F}$ $R_X = 10 \text{ k}\Omega$	2.0	70	96	$\mu\text{s}$
			4.5	69	85	
			6.0	69	85	
		$C_X = 0.1 \text{ }\mu\text{F}$ $R_X = 10 \text{ k}\Omega$	2.0	0.71	0.87	ms
			4.5	0.70	0.81	
			6.0	0.70	0.81	

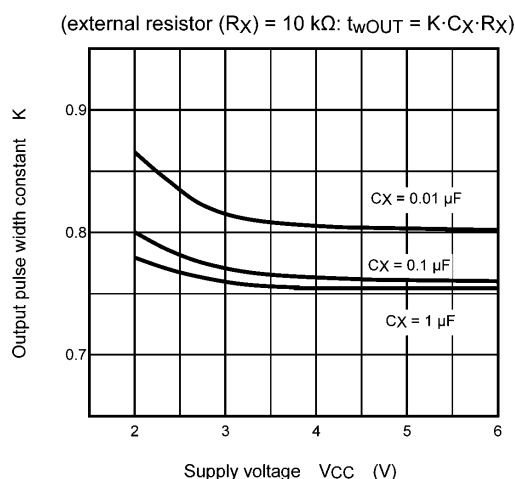
# 16. Characteristics Curves (Note)



**Fig. 16.1  $t_{wOUT} - C_X$  (typ.)**



**Fig. 16.2  $t_r - V_{CC}$  (typ.)**



**Fig. 16.3 Output Pulse Width Constant K - Supply Voltage (typ.)**

Note: The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.



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