

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

## TC74HC40102AP, TC74HC40102AF TC74HC40103AP, TC74HC40103AF

TC74HC40102AP/AF Dual BCD Programmable Down Counter

TC74HC40103AP/AF 8-Bit Binary Programmable Down Counter

The TC74HC40102A and TC74HC40103A are high speed CMOS PROGRAMMABLE DOWN COUNTERS fabricated with silicon gate C<sup>2</sup>MOS technology.

They achieve the high speed operation similar to equivalent LSTTL while maintaining the CMOS low power dissipation.

The output terminal ( $\overline{CO/ZD}$ ) goes to an active low state when the down count reaches zero. Since the TC74HC40102A is designed as a BCD counter, programming up to 99 counts is possible. The TC74HC40103A, with its 8-bit binary construction, can be set to provide up to 255 counts.

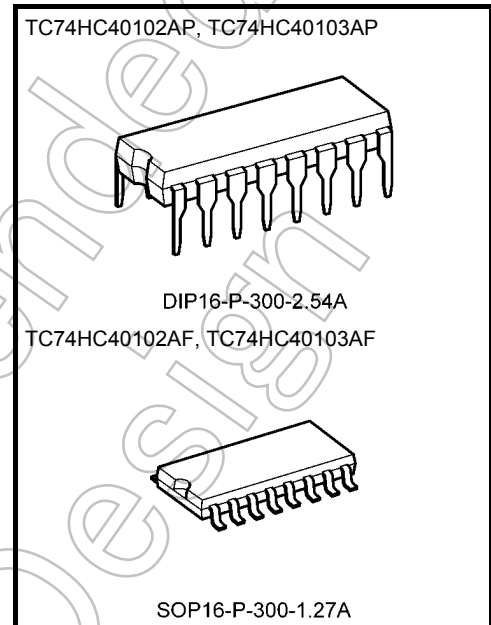
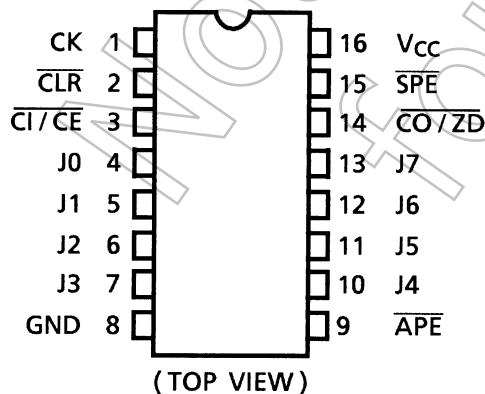
Both devices have Inhibit Clock ( $\overline{CI/CE}$ ), Asynchronous Preset Control ( $\overline{APE}$ ), Synchronous Preset ( $\overline{SPE}$ ) and Clear Control ( $\overline{CLR}$ ) inputs for setting the counter to the maximum counting mode.

All inputs are equipped with protection circuits against static discharge or transient excess voltage.

### Features

- High speed:  $f_{max}$  40 MHz (typ.) at  $V_{CC} = 5$  V
- Low power dissipation:  $I_{CC} = 4$   $\mu$ A (max) at  $T_a = 25^\circ\text{C}$
- High noise immunity:  $V_{NIH} = V_{NIL} = 28\% V_{CC}$  (min)
- Output drive capability: 10 LSTTL loads
- Symmetrical output impedance:  $|I_{OH}| = I_{OL} = 4$  mA (min)
- Balanced propagation delays:  $t_{pLH} \approx t_{pHL}$
- Wide operating voltage range:  $V_{CC}(\text{opr}) = 2$  to 6 V
- Pin and function compatible with 40102B, 40103B

### Pin Assignment



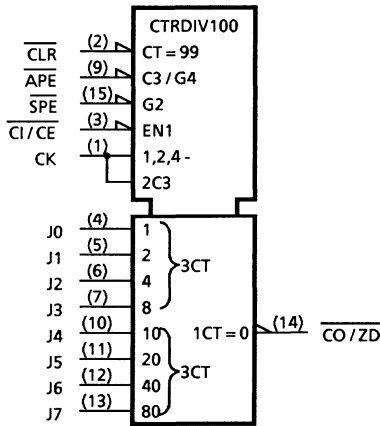
Weight

DIP16-P-300-2.54A	: 1.00 g (typ.)
SOP16-P-300-1.27A	: 0.18 g (typ.)

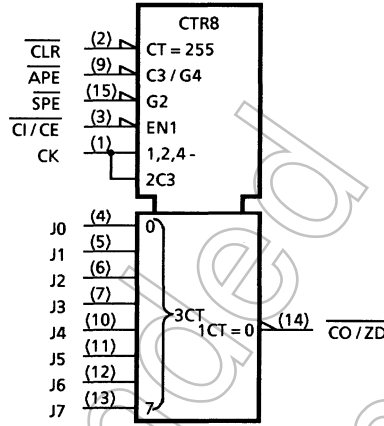
Start of commercial production  
1988-11

IEC Logic Symbol

TC74HC40102A



TC74HC40103A



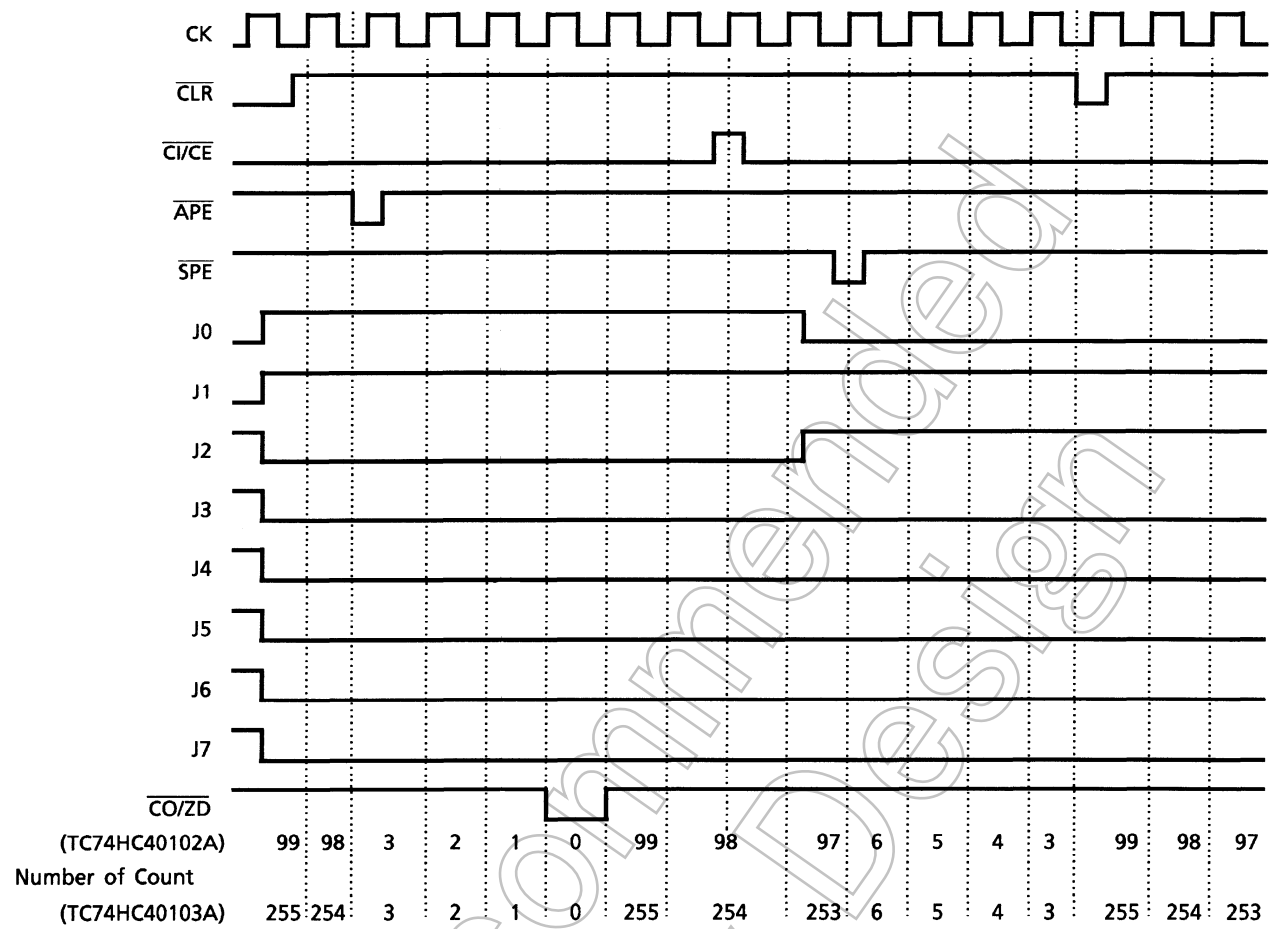
Truth Table

Control Inputs				Mode	Functional Description
CLR	APE	SPE	CI/CE		
H	H	H	H	Count Inhibit	Count is inhibited regardless of other inputs.
H	H	H	L	Regular Count	Down count on the rising edge of CK
H	H	L	X	Synchronous Preset	Input data is preset on the rising edge of CK
H	L	X	X	Asynchronous Preset	Input data is asynchronously preset to CK
L	X	X	X	Clear	Counter is set to maximum count.

X: Don't care

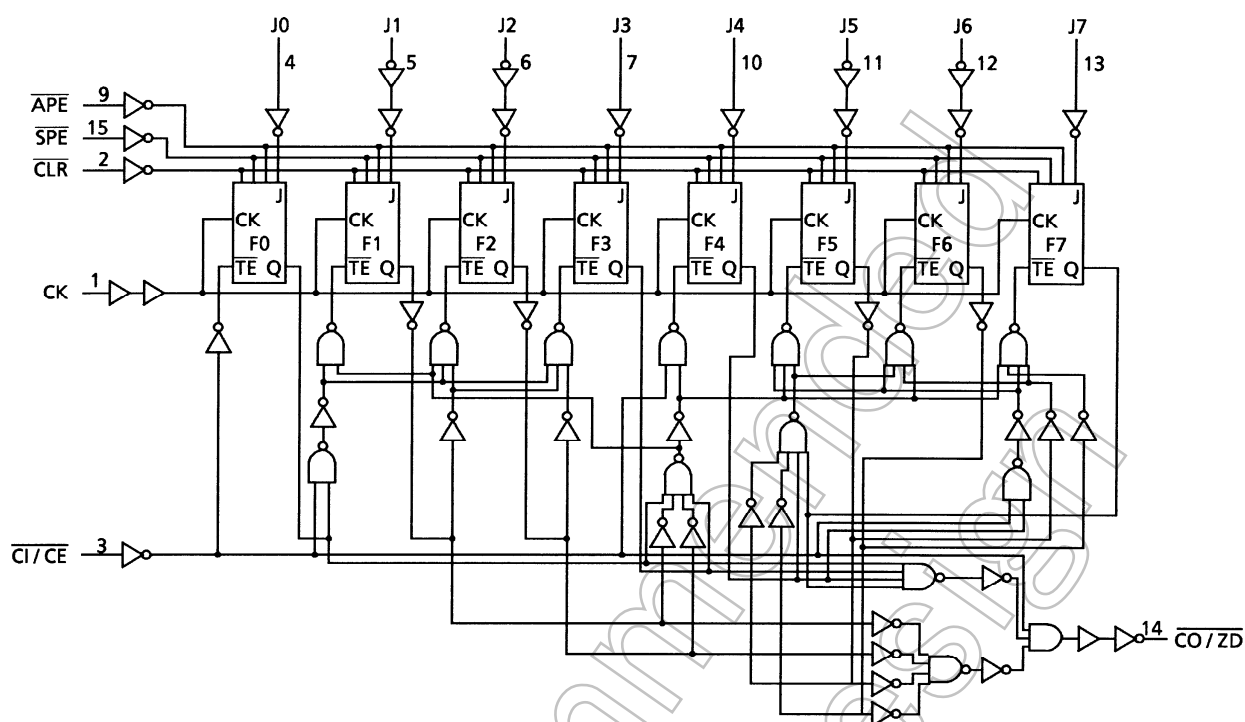
Maximum count: TC74HC40102A "99", TC74HC40103A "255"

Timing Chart

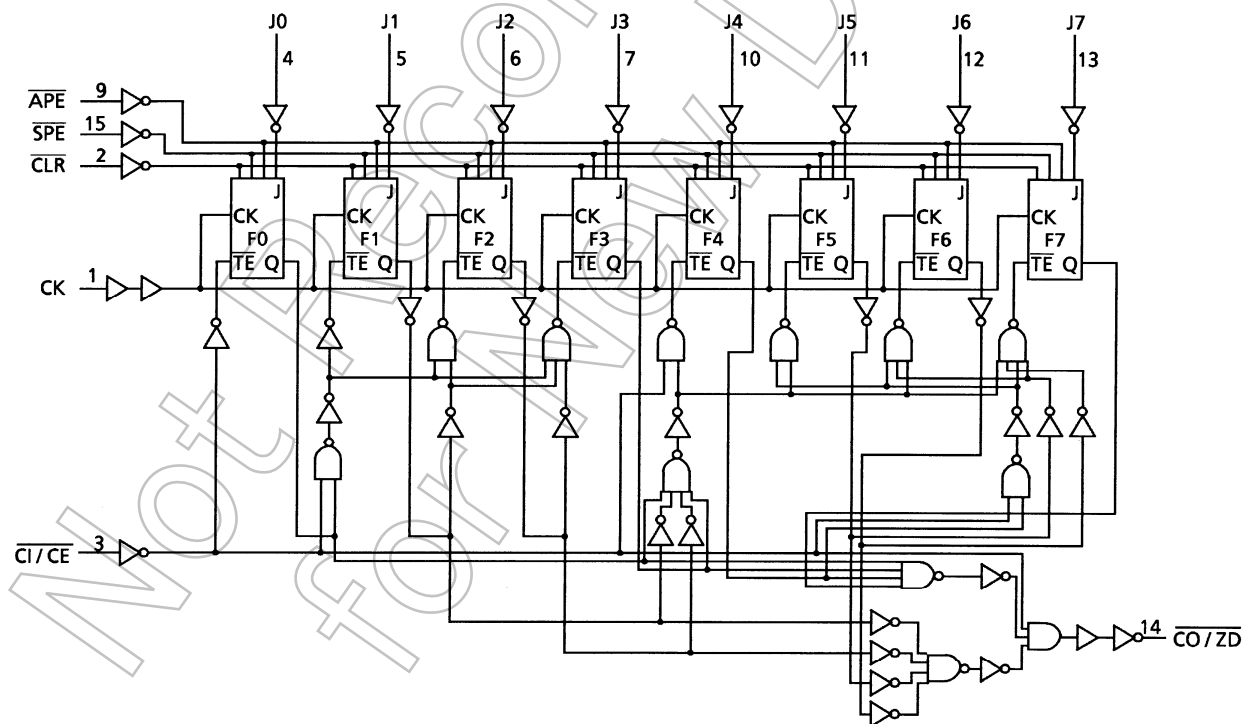


## System Diagram

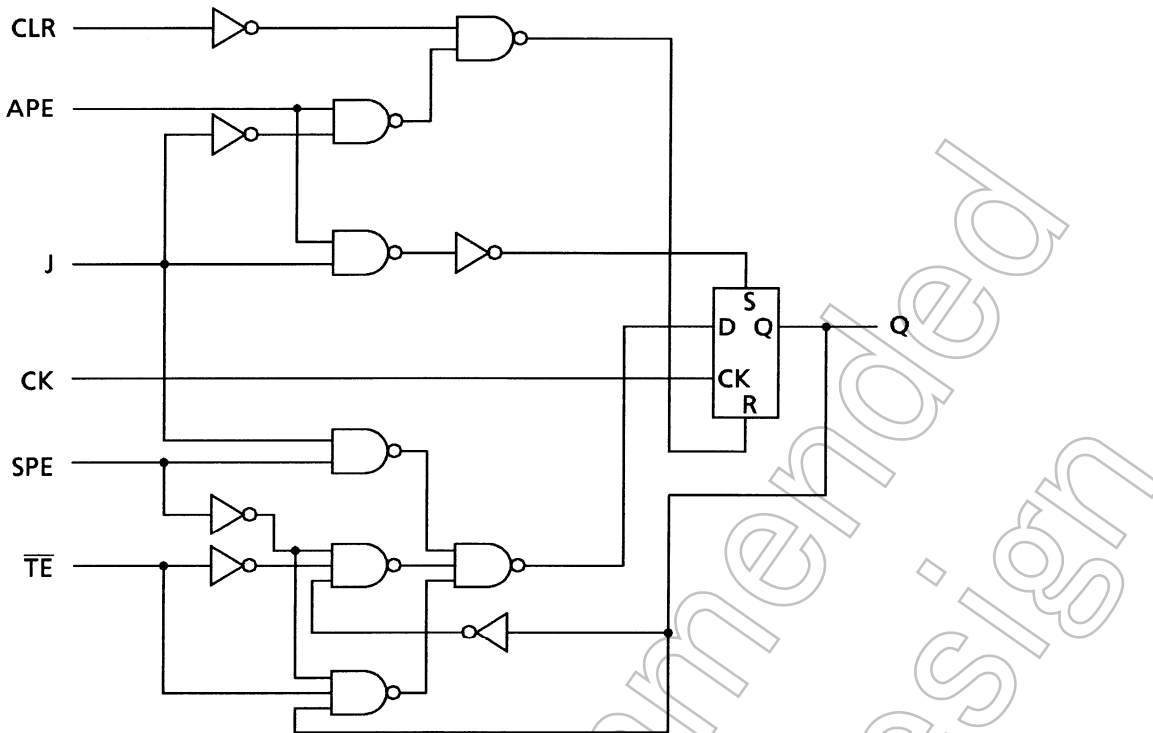
### TC74HC40102A



### TC74HC40103A



## Logic Diagram



Inputs						Output
CLR	APE	SPE	J	$\overline{TE}$	CK	Q
H	X	X	X	X	X	L
L	H	H	H	H	X	H
L	H	H	L	H	X	L
L	L	H	H	X	$\uparrow$	H
L	L	H	L	X	$\uparrow$	L
L	L	L	X	L	$\uparrow$	$\overline{Qn}$
L	L	L	X	L	$\downarrow$	$Qn$
L	L	L	X	H	X	$Qn$

## Function Description

The TC74HC40102A and TC74HC40103A are 8-stage presettable synchronous down counters.

Carry Out/Zero Detect ( $\overline{CO/ZD}$ ) is output at the "L" level for the period of 1 bit when the readout becomes "0". The TC74HC40102A adopts binary coded decimal notation, making setting up to 99 counts possible. While the TC74HC40103A adopts 8-bit binary counter and can set up to 255 counts.

### Count Operation

At the "H" level of control input of  $\overline{CLR}$ ,  $\overline{SPE}$  and  $\overline{APE}$ , the counter carries out down count operation one by one at the rise of pulse given to CK input. Count operation can be inhibited by setting Carry Input/clock Enable ( $\overline{CI/CE}$ ) to the "H" level.

$\overline{CO/ZD}$  is output at the "L" level when the readout becomes "0", but is not output even if the readout becomes "0" when  $\overline{CI/CE}$  is at the "H" level, thus maintaining the "H" level.

Synchronous cascade operation can be carried out by using  $\overline{CI/CE}$  input and  $\overline{CO/ZD}$  output.

The contents of count jump to maximum count (99 for the TC74HC40102A and 255 for the TC74HC40103A) if clock is given when the readout is "0". Therefore, operation of 100-frequency division and that of 256-frequency division are carried out for the TC74HC40102A and TC74HC40103A, respectively, when clock input alone is given without various kinds of preset operation.

## Preset Operation and Reset Operation

When Clear ( $\overline{\text{CLR}}$ ) input is set to the “L” level, the readout is set to the maximum count independently of other inputs. When Asynchronous Preset Enable ( $\overline{\text{APE}}$ ) input is set to the “L” level, readouts given on J0 to J7 can be preset asynchronously to counter independently of inputs other than  $\overline{\text{CLR}}$  input. When Synchronous Preset Enable ( $\overline{\text{SPE}}$ ) is set to the “L” level, the readouts given on J0 to J7 can be preset to counter synchronously with rise of clock.

As to these operation modes, refer to the truth table.

## Absolute Maximum Ratings (Note 1)

Characteristics	Symbol	Rating	Unit
Supply voltage range	$V_{CC}$	-0.5 to 7	V
DC input voltage	$V_{IN}$	-0.5 to $V_{CC} + 0.5$	V
DC 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
DC output current	$I_{OUT}$	$\pm 25$	mA
DC $V_{CC}$ /ground current	$I_{CC}$	$\pm 50$	mA
Power dissipation	$P_D$	500 (DIP) (Note 2)/180 (SOP)	mW
Storage temperature	$T_{stg}$	-65 to 150	°C

Note 1: 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 2: 500 mW in the range of  $T_a = -40$  to  $65^\circ\text{C}$ . From  $T_a = 65$  to  $85^\circ\text{C}$  a derating factor of  $-10 \text{ mW}/^\circ\text{C}$  shall be applied until 300 mW.

## Operating Ranges (Note)

Characteristics	Symbol	Rating	Unit
Supply voltage	$V_{CC}$	2 to 6	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 85	°C
Input rise and fall time	$t_r, t_f$	0 to 1000 ( $V_{CC} = 2.0 \text{ V}$ ) 0 to 500 ( $V_{CC} = 4.5 \text{ V}$ ) 0 to 400 ( $V_{CC} = 6.0 \text{ V}$ )	ns

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.

## Electrical Characteristics

## DC Characteristics

Characteristics	Symbol	Test Condition		Ta = 25°C			Ta = -40 to 85°C		Unit
				V <sub>CC</sub> (V)	Min	Typ.	Max	Min	Max
High-level input voltage	V <sub>IH</sub>	—		2.0 4.5 6.0	1.50 3.15 4.20	— — —	— — —	1.50 3.15 4.20	V
Low-level input voltage	V <sub>IL</sub>	—		2.0 4.5 6.0	— — —	— — —	0.50 1.35 1.80	— — 1.80	V
High-level output voltage	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OH</sub> = -20 µA	2.0 4.5 6.0	1.9 4.4 5.9	2.0 4.5 6.0	— — —	1.9 4.4 5.9	V
			I <sub>OH</sub> = -4 mA	4.5	4.18	4.31	—	4.13	—
			I <sub>OH</sub> = -5.2 mA	6.0	5.68	5.80	—	5.63	—
Low-level output voltage	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 20 µA	2.0 4.5 6.0	— — —	0.0 0.0 0.0	0.1 0.1 0.1	— — —	0.1 0.1 0.1
			I <sub>OL</sub> = 4 mA	4.5	—	0.17	0.26	—	0.33
			I <sub>OL</sub> = 5.2 mA	6.0	—	0.18	0.26	—	0.33
Input leakage current	I <sub>IN</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		6.0	—	—	±0.1	—	±1.0 µA
Quiescent supply current	I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		6.0	—	—	4.0	—	40.0 µA

AC Characteristics (C<sub>L</sub> = 15 pF, V<sub>CC</sub> = 5 V, Ta = 25°C, input: t<sub>r</sub> = t<sub>f</sub> = 6 ns)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Output transition time	t <sub>TLH</sub> t <sub>THL</sub>	—	—	4	8	ns
Propagation delay time (CK- CO/ZD )	t <sub>pLH</sub> t <sub>pHL</sub>	—	—	25	43	ns
Propagation delay time ( APE - CO/ZD )	t <sub>pLH</sub> t <sub>pHL</sub>	—	—	25	49	ns
Propagation delay time ( CI/CE - CO/ZD )	t <sub>pLH</sub> t <sub>pHL</sub>	—	—	10	19	ns
Propagation delay time ( CLR - CO/ZD )	t <sub>pLH</sub>	—	—	24	36	ns
Maximum clock frequency	f <sub>max</sub>	—	23	40	—	MHz

## AC Characteristics ( $C_L = 50 \text{ pF}$ , input: $t_r = t_f = 6 \text{ ns}$ )

Characteristics	Symbol	Test Condition	$V_{CC} \text{ (V)}$	$T_a = 25^\circ\text{C}$			$T_a = -40 \text{ to } 85^\circ\text{C}$		Unit
				Min	Typ.	Max	Min	Max	
Output transition time	$t_{TLH}$ $t_{THL}$	—	2.0	—	30	75	—	95	ns
			4.5	—	8	15	—	19	
			6.0	—	7	13	—	16	
Propagation delay time ( $\overline{\text{CK}} - \overline{\text{CO/ZO}}$ )	$t_{pLH}$ $t_{pHL}$	—	2.0	—	95	245	—	305	ns
			4.5	—	28	49	—	61	
			6.0	—	22	42	—	52	
Propagation delay time ( $\overline{\text{APE}} - \overline{\text{CO/ZO}}$ )	$t_{pLH}$ $t_{pHL}$	—	2.0	—	100	300	—	375	ns
			4.5	—	30	60	—	75	
			6.0	—	25	51	—	64	
Propagation delay time ( $\overline{\text{CI/CE}} - \overline{\text{CO/ZO}}$ )	$t_{pLH}$ $t_{pHL}$	—	2.0	—	38	115	—	145	ns
			4.5	—	13	23	—	29	
			6.0	—	11	20	—	25	
Propagation delay time ( $\overline{\text{CLR}} - \overline{\text{CO/ZO}}$ )	$t_{pLH}$	—	2.0	—	85	240	—	300	ns
			4.5	—	28	48	—	60	
			6.0	—	23	41	—	51	
Maximum clock frequency	$f_{\text{max}}$	—	2.0	4	12	—	3	—	ns
			4.5	20	36	—	16	—	
			6.0	24	42	—	19	—	
Input capacitance	$C_{\text{IN}}$	—	—	—	5	10	—	10	pF
Power dissipation capacitance	$C_{\text{PD}}$ (Note)	—	—	—	48	—	—	—	pF

Note:  $C_{\text{PD}}$  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:

$$I_{\text{CC (opr)}} = C_{\text{PD}} \cdot V_{\text{CC}} \cdot f_{\text{IN}} + I_{\text{CC}}$$

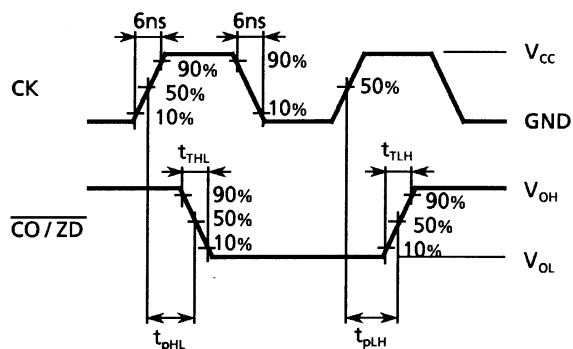


Timing Requirements (input:  $t_r = t_f = 6 \text{ ns}$ )

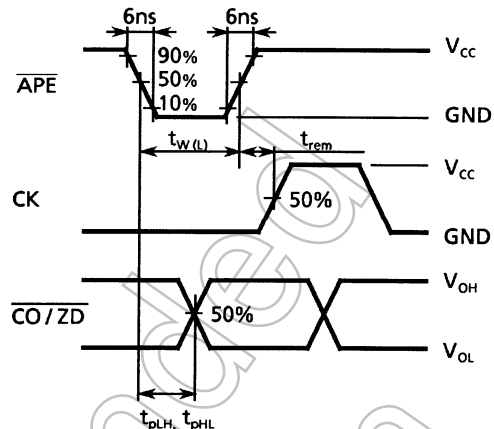
Characteristics	Symbol	Test Condition	Ta = 25°C		Ta = -40 to 85°C	Unit
			V <sub>CC</sub> (V)	Typ.	Limit	
Minimum pulse width (CK)	$t_W$ (H) $t_W$ (L)	—	2.0	—	75	ns
			4.5	—	15	
			6.0	—	13	
Minimum pulse width ( $\overline{\text{CLR}}$ , $\overline{\text{APE}}$ )	$t_W$ (L)	—	2.0	—	75	ns
			4.5	—	15	
			6.0	—	13	
Minimum set-up time ( $\text{SPE} - \text{CK}$ )	$t_s$	—	2.0	—	75	ns
			4.5	—	15	
			6.0	—	13	
Minimum set-up time ( $\overline{\text{CI}}/\overline{\text{CE}} - \text{CK}$ )	$t_s$	—	2.0	—	150	ns
			4.5	—	30	
			6.0	—	26	
Minimum set-up time ( $\text{Jn} - \text{CK}$ )	$t_s$	—	2.0	—	75	ns
			4.5	—	15	
			6.0	—	13	
Minimum set-up time ( $\text{Jn} - \overline{\text{APE}}$ )	$t_s$	—	2.0	—	75	ns
			4.5	—	15	
			6.0	—	13	
Minimum hold time ( $\text{SPE} - \text{CK}$ )	$t_h$	—	2.0	—	0	ns
			4.5	—	0	
			6.0	—	0	
Minimum hold time ( $\overline{\text{CI}}/\overline{\text{CE}} - \text{CK}$ )	$t_h$	—	2.0	—	0	ns
			4.5	—	0	
			6.0	—	0	
Minimum hold time ( $\text{Jn} - \text{CK}$ )	$t_h$	—	2.0	—	0	ns
			4.5	—	0	
			6.0	—	0	
Minimum hold time ( $\text{Jn} - \overline{\text{APE}}$ )	$t_h$	—	2.0	—	0	ns
			4.5	—	0	
			6.0	—	0	
Minimum removal time ( $\overline{\text{CLR}}$ , $\overline{\text{APE}}$ )	$t_{\text{rem}}$	—	2.0	—	75	ns
			4.5	—	15	
			6.0	—	13	
Clock frequency	$f$	—	2.0	—	4	MHz
			4.5	—	20	
			6.0	—	24	

## Switching Characteristics Test Waveform (Note)

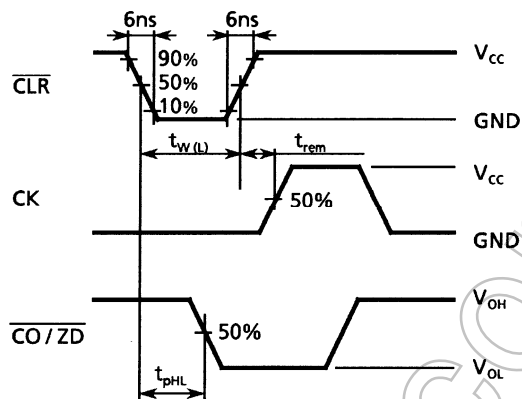
Waveform 1



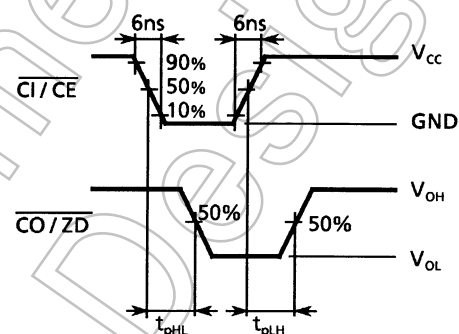
Waveform 2



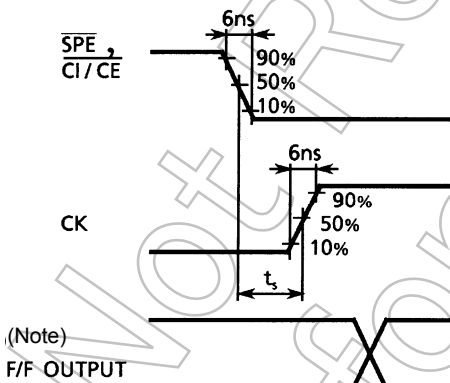
Waveform 3



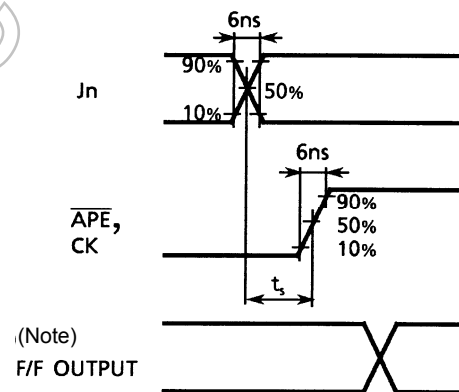
Waveform 4



Waveform 5



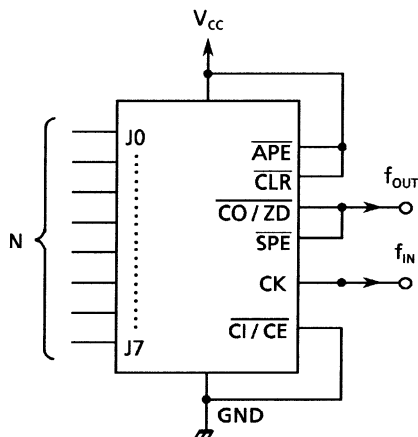
Waveform 6



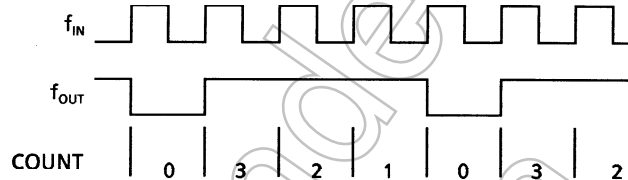
Note: F/F output is internal signal of IC

## Example of Typical Application

### Programmable Divide-by-N Counter

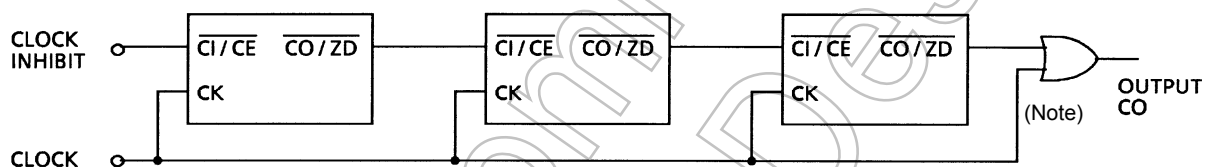


- $f_{OUT} = \frac{f_{IN}}{N+1}$
- Timing chart when N="3"  
(J0, J1 = V<sub>CC</sub>, J2 to J7 = GND)



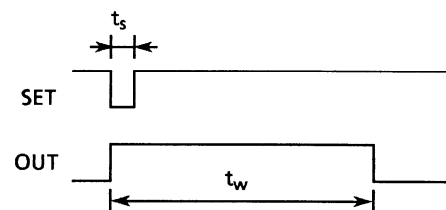
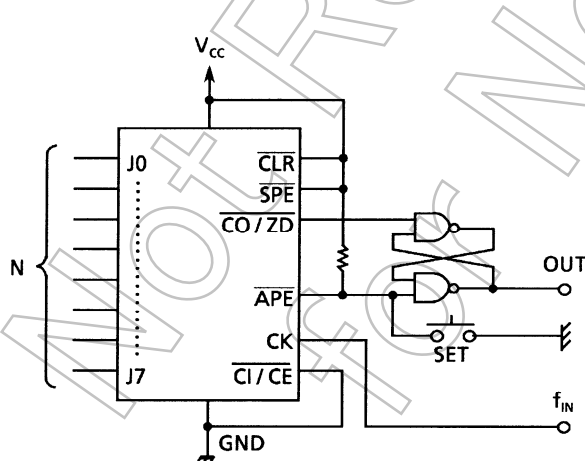
- TC74HC40102A ..... 1/2 to 1/100 are dividable.
- TC74HC40103A ..... 1/2 to 1/256 are dividable.

### Parallel Carry Cascading (Note)



Note: At synchronous cascade connection, huzzerd occurs at C0 output after its second stage when digit place changes, due to delay arrival. Therefore, take gate form TC74HC32A or the like, not form C0 output at the rear stage directly.

### Programmable Timer (Note)



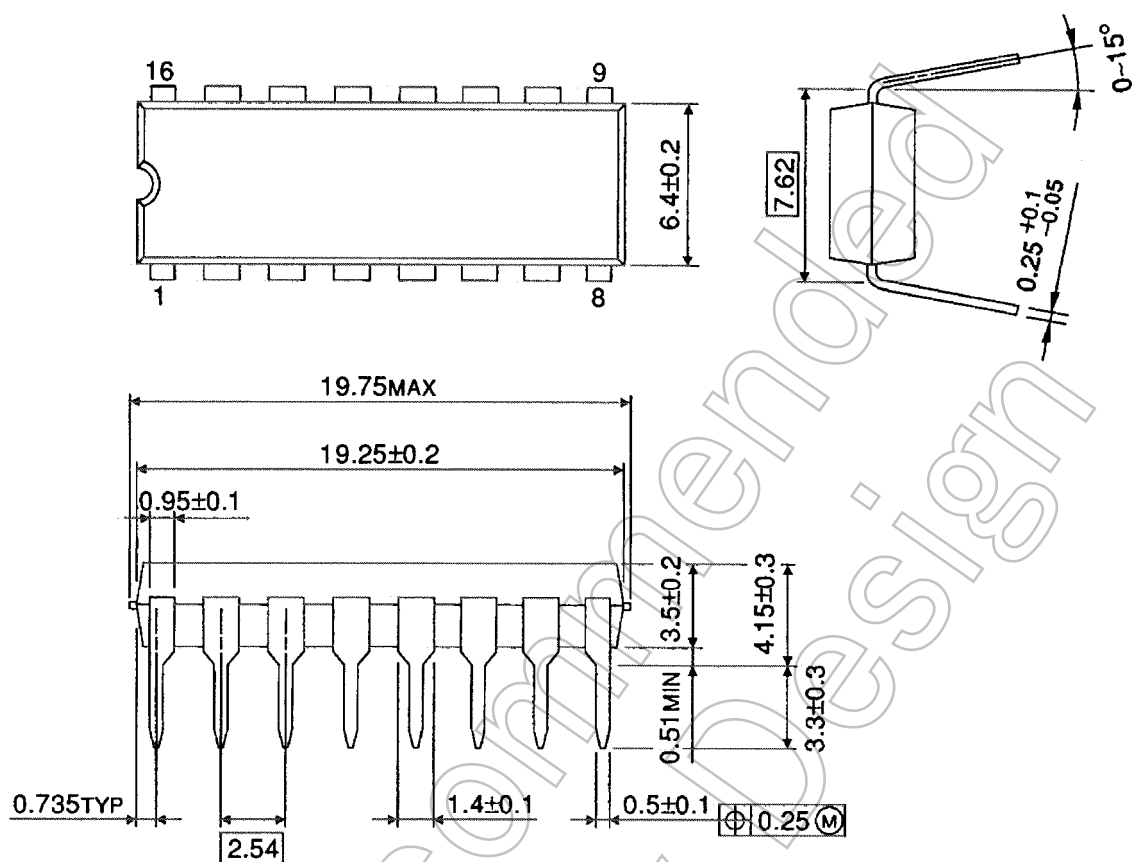
$$t_w = \left( \frac{N}{f_{IN}} + t_s \right)$$

Note: The above formula dose not take into account the phase of ck input.

Therefore, the real pulse width is the distance between the above formula-1/f<sub>IN</sub> to the above formula.

DIP16-P-300-2.54A

Unit : mm

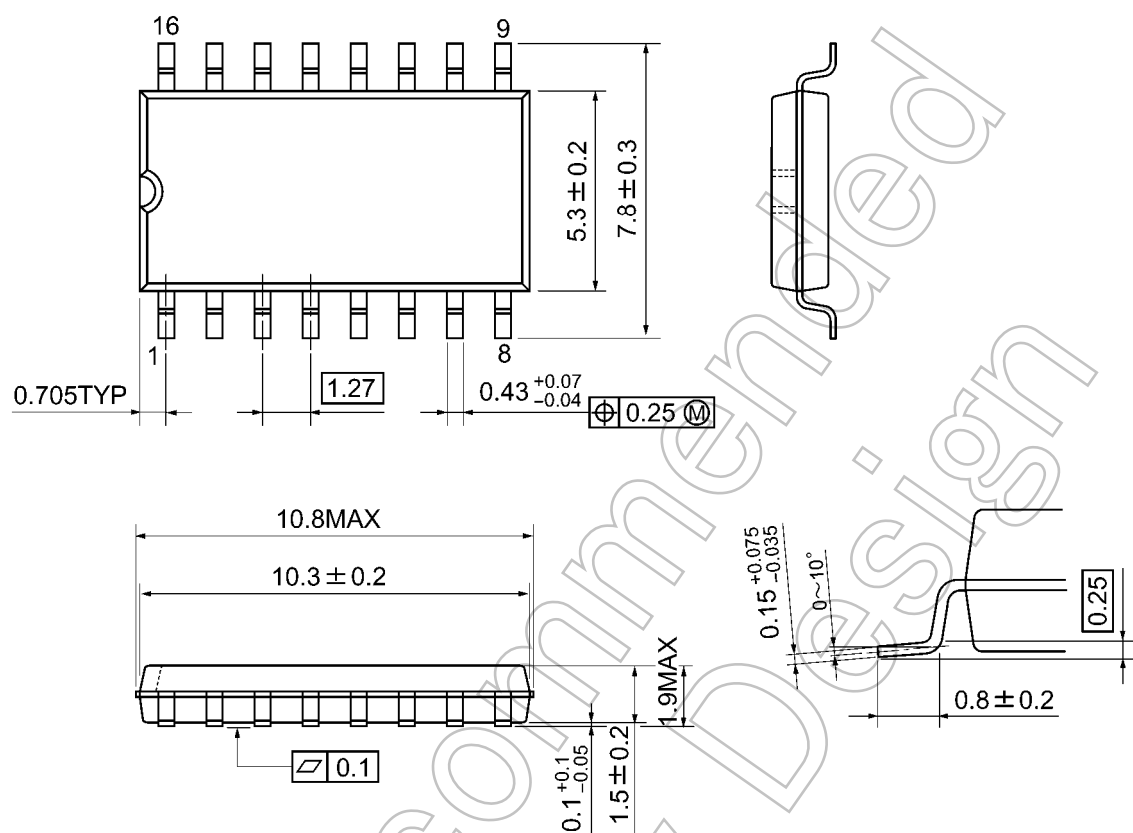


Weight: 1.00 g (typ.)

## Package Dimensions

SOP16-P-300-1.27A

Unit: mm



Weight: 0.18 g (typ.)

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