TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

TC74VHC161F, TC74VHC161FN, TC74VHC161FT,TC74VHC161FK
TC74VHC163F, TC74VHC163FN, TC74VHC163FT,TC74VHC163FK

Synchronous Presettable 4-Bit Counter

TC74VHC161F/FN/FT/FK Binary, Asynchronous Clear

TC74VHC163F/FN/FT/FK Binary, Synchronous Clear

The TC74VHC 161 and 163 are advanced high speed CMOS SYNCHRONOUS PRESETTABLE 4 BIT BINARY COUNTERs fabricated with silicon gate C^2MOS technology.

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

The CK input is active on the rising edge. Both $\overline{LOAD}$ and $\overline{CLR}$ inputs are active on low logic level.

Presetting of each IC's is synchronous to the rising edge of CK.

The clear function of the TC74VHC163 is synchronous to CK, while the TC74VHC161 are cleared asynchronously.

Two enable inputs (ENP and ENT) and CARRY OUTPUT are provided to enable easy cascading of counters, which facilitates easy implementation of n-bit counters without using external gates.

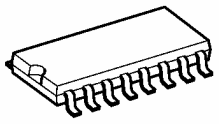
An input protection circuit ensures that 0 to 5.5 V can be applied to the input pins without regard to the supply voltage. This device can be used to interface 5 V to 3 V systems and two supply systems such as battery back up. This circuit prevents device destruction due to mismatched supply and input voltages.

Features

- High speed: f_{max} = 185 MHz (typ.) at V_{CC} = 5 V
- Low power dissipation: I_{CC} = 4 μA (max) at Ta = 25°C
- High noise immunity: $V_{NIH} = V_{NIL}$ = 28% V_{CC} (min)
- Power down protection is provided on all inputs.
- Balanced propagation delays: $t_{pLH} \simeq t_{pHL}$
- Wide operating voltage range: V_{CC} (opr) = 2 to 5.5 V
- Low noise: V_{OLP} = 0.8 V (max)
- Pin and function compatible with 74ALS161/163

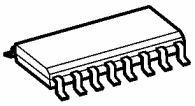
Note: xxxFN (JEDEC SOP) is not available in Japan.

TC74VHC161F, TC74VHC163F



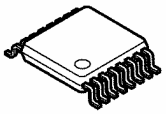
SOP16-P-300-1.27A

TC74VHC161FN, TC74VHC163FN



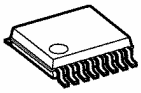
SOL16-P-150-1.27

TC74VHC161FT, TC74VHC163FT



TSSOP16-P-0044-0.65A

TC74VHC161FK, TC74VHC163FK

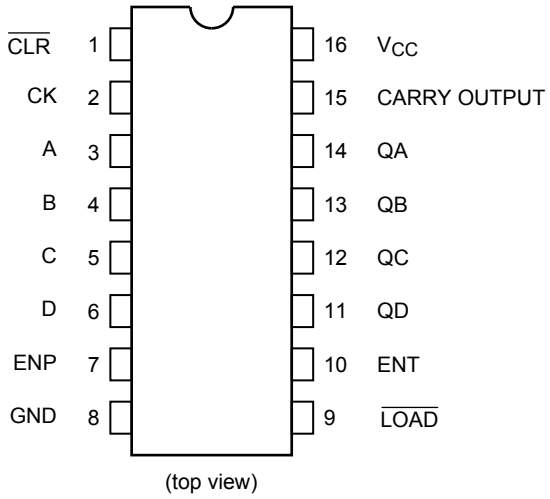


VSSOP16-P-0030-0.50

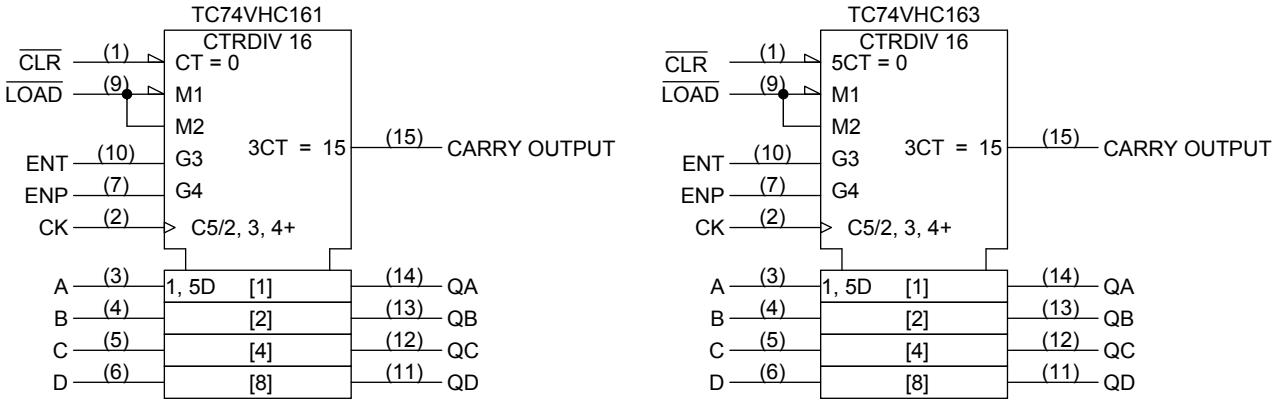
Weight

SOP16-P-300-1.27A	: 0.18 g (typ.)
SOL16-P-150-1.27	: 0.13 g (typ.)
TSSOP16-P-0044-0.65A	: 0.06 g (typ.)
VSSOP16-P-0030-0.50	: 0.02 g (typ.)

Pin Assignment



IEC Logic Symbol



Truth Table (Note)

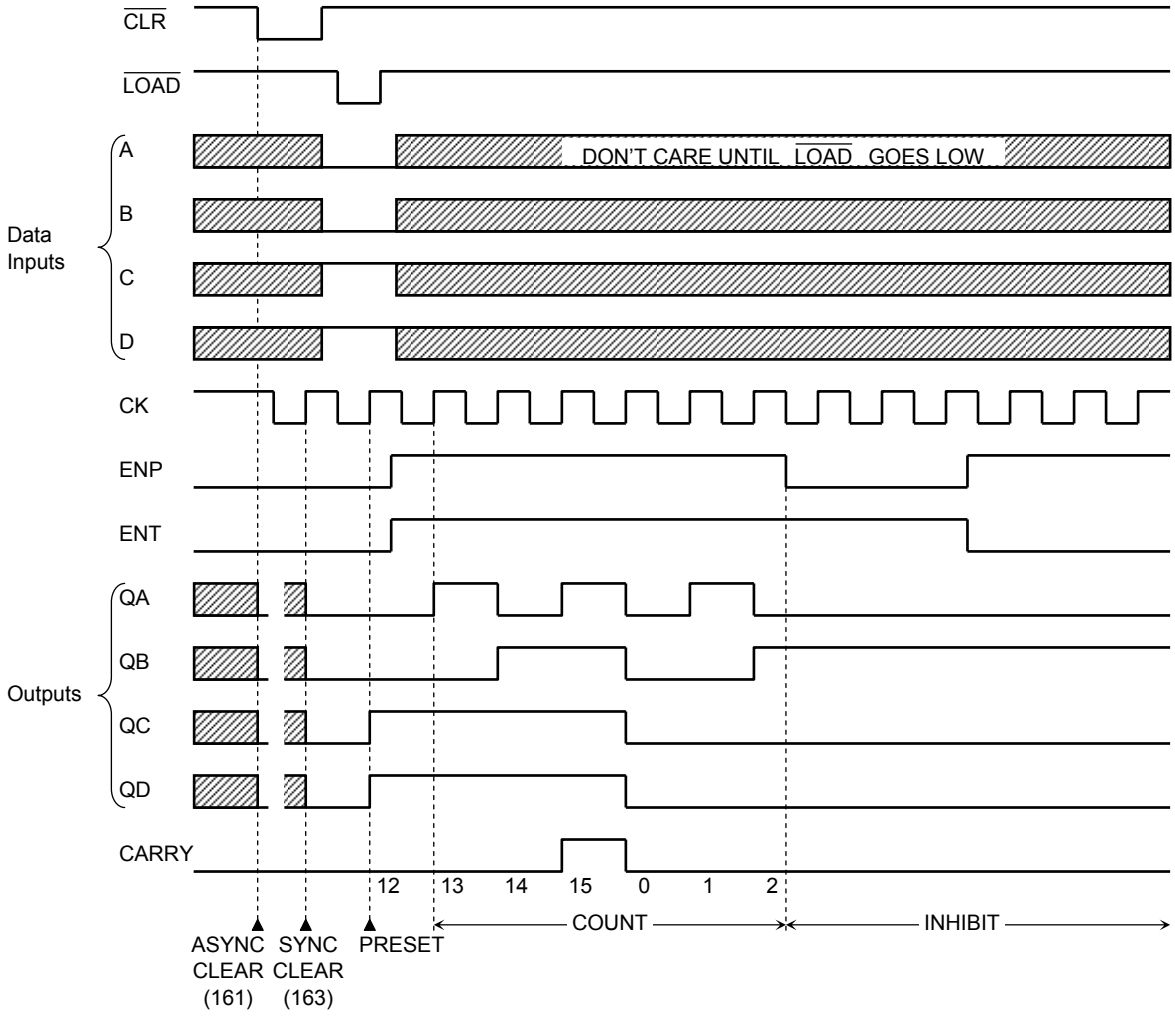
TC74VHC161					TC74VHC163					Outputs				Function
Inputs					Inputs									
$\overline{CLR}$	$\overline{LD}$	ENP	ENT	CK	$\overline{CLR}$	$\overline{LD}$	ENP	ENT	CK	QA	QB	QC	QD	
L	X	X	X	X	L	X	X	X	↑	L	L	L	L	Reset to “0”
H	L	X	X	↑	H	L	X	X	↑	A	B	C	D	Preset Data
H	H	X	L	↑	H	H	X	L	↑	No Change				No Count
H	H	L	X	↑	H	H	L	X	↑	No Change				No Count
H	H	H	H	↑	H	H	H	H	↑	Count Up				Count
H	X	X	X	↓	X	X	X	X	↓	No Change				No Count

Note: X: Don’t care

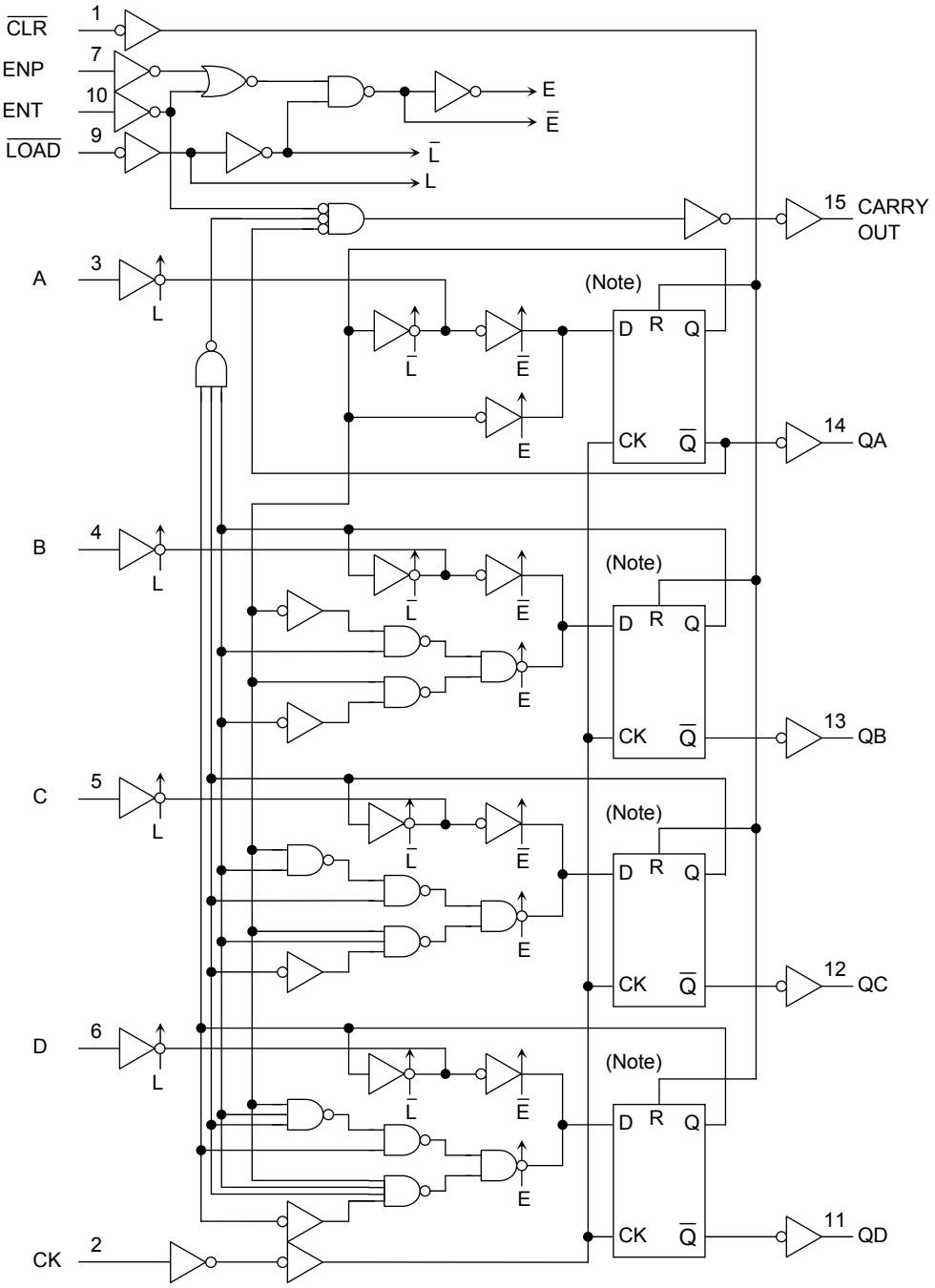
A, B, C, D: Logic level of data inputs

Carry: CARRY = ENT·QA·QB·QC·QD

Timing Chart



System Diagram



Note: Truth table of internal F/F

TC74VHC161					TC74VHC163				
D	CK	R	Q	$\overline{Q}$	D	CK	R	Q	$\overline{Q}$
X	X	H	L	H	X	↑	H	L	H
L	↑	L	L	H	L	↑	L	L	H
H	↑	L	H	L	H	↑	L	H	L
X	↓	L	No Change		X	↓	X	No Change	

X: Don't care

Absolute Maximum Ratings (Note)

Characteristics	Symbol	Rating	Unit
Supply voltage range	V_{CC}	−0.5 to 7.0	V
DC input voltage	V_{IN}	−0.5 to 7.0	V
DC output voltage	V_{OUT}	−0.5 to V_{CC} + 0.5	V
Input diode current	I_{IK}	−20	mA
Output diode current	I_{OK}	±20	mA
DC output current	I_{OUT}	±25	mA
DC V_{CC}/ground current	I_{CC}	±50	mA
Power dissipation	P_D	180	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).

Operating Range (Note)

Characteristics	Symbol	Rating	Unit
Supply voltage	V_{CC}	2.0 to 5.5	V
Input voltage	V_{IN}	0 to 5.5	V
Output voltage	V_{OUT}	0 to V_{CC}	V
Operating temperature	T_{opr}	−40 to 85	°C
Input rise and fall time	dt/dv	0 to 100 (V_{CC} = 3.3 ± 0.3 V) 0 to 20 (V_{CC} = 5 ± 0.5 V)	ns/V

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		V_{CC} (V)	Ta = 25°C Min	Ta = 25°C Typ.	Ta = 25°C Max	Ta = −40 to 85°C Min	Ta = −40 to 85°C Max	Unit
High-level input voltage	V_{IH}	—		2.0	1.50	—	—	1.50	—	V
				3.0 to 5.5	V_{CC} × 0.7	—	—	V_{CC} × 0.7	—	
Low-level input voltage	V_{IL}	—		2.0	—	—	0.50	—	0.50	V
				3.0 to 5.5	—	—	V_{CC} × 0.3	—	V_{CC} × 0.3	
High-level output voltage	V_{OH}	V_{IN} = V_{IH} or V_{IL}	I_{OH} = −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_{OH} = −4 mA	3.0	2.58	—	—	2.48	—	
			I_{OH} = −8 mA	4.5	3.94	—	—	3.80	—	
Low-level output voltage	V_{OL}	V_{IN} = V_{IH} or V_{IL}	I_{OL} = 50 μA	2.0	—	0.0	0.1	—	0.1	V
				3.0	—	0.0	0.1	—	0.1	
				4.5	—	0.0	0.1	—	0.1	
			I_{OL} = 4 mA	3.0	—	—	0.36	—	0.44	
			I_{OL} = 8 mA	4.5	—	—	0.36	—	0.44	
Input leakage current	I_{IN}	V_{IN} = 5.5 or GND		0 to 5.5	—	—	±0.1	—	±1.0	μA
Quiescent supply current	I_{CC}	V_{IN} = V_{CC} or GND		5.5	—	—	4.0	—	40.0	μA

Timing Requirements (input: $t_r = t_f = 3$ ns)

Characteristics	Symbol	Test Condition		Ta = 25°C	Ta = −40 to 85°C	Unit
			V_{CC} (V)	Limit	Limit	
Minimum pulse width (CK)	$t_{w\,(L)}$ $t_{w\,(H)}$	Figure 1	3.3 ± 0.3 5.0 ± 0.5	5.0 5.0	5.0 5.0	ns
Minimum pulse width ($\overline{CLR}$) (Note1)	$t_{w\,(L)}$	Figure 4	3.3 ± 0.3 5.0 ± 0.5	5.0 5.0	5.0 5.0	ns
Minimum set-up time (A, B, C, D)	t_s	Figure 2	3.3 ± 0.3 5.0 ± 0.5	5.5 4.5	6.5 4.5	ns
Minimum set-up time ($\overline{LOAD}$)	t_s	Figure 2	3.3 ± 0.3 5.0 ± 0.5	8.0 5.0	9.5 6.0	ns
Minimum set-up time (ENT, ENP)	t_s	Figure 3	3.3 ± 0.3 5.0 ± 0.5	7.5 5.0	9.0 6.0	ns
Minimum set-up time ($\overline{CLR}$) (Note 2)	t_s	Figure 5	3.3 ± 0.3 5.0 ± 0.5	4.0 3.5	4.0 3.5	ns
Minimum hold time	t_h	Figure 2, Figure 3	3.3 ± 0.3 5.0 ± 0.5	1.0 1.0	1.0 1.0	ns
Minimum hold time ($\overline{CLR}$) (Note 2)	t_h	Figure 5	3.3 ± 0.3 5.0 ± 0.5	1.0 1.5	1.0 1.5	ns
Minimum removal time ($\overline{CLR}$) (Note 1)	t_{rem}	Figure 4	3.3 ± 0.3 5.0 ± 0.5	2.5 1.5	2.5 1.5	ns

Note 1: For TC74VHC161 only

Note 2: For TC74VHC163 only

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

Characteristics	Symbol	Test Condition			Ta = 25°C			Ta = −40 to 85°C		Unit
			V_{CC} (V)	C_L (pF)	Min	Typ.	Max	Min	Max	
Propagation delay time (CK-Q)	t_{pLH} t_{pHL}	Figure 1, Figure 2	3.3 ± 0.3	15	—	8.3	12.8	1.0	15.0	ns
				50	—	10.8	16.3	1.0	18.5	
			5.0 ± 0.5	15	—	4.9	8.1	1.0	9.5	
				50	—	6.4	10.1	1.0	11.5	
Propagation delay time (CK-CARRY, count-mode)	t_{pLH} t_{pHL}	Figure 1	3.3 ± 0.3	15	—	8.7	13.6	1.0	16.0	ns
				50	—	11.2	17.1	1.0	19.5	
			5.0 ± 0.5	15	—	4.9	8.1	1.0	9.5	
				50	—	6.4	10.1	1.0	11.5	
Propagation delay time (CK-CARRY, preset-mode)	t_{pLH} t_{pHL}	Figure 2	3.3 ± 0.3	15	—	11.0	17.2	1.0	20.0	ns
				50	—	13.5	20.7	1.0	23.5	
			5.0 ± 0.5	15	—	6.2	10.3	1.0	12.0	
				50	—	7.7	12.3	1.0	14.0	
Propagation delay time (ENT-CARRY)	t_{pLH} t_{pHL}	Figure 6	3.3 ± 0.3	15	—	7.5	12.3	1.0	14.5	ns
				50	—	10.5	15.8	1.0	18.0	
			5.0 ± 0.5	15	—	4.9	8.1	1.0	9.5	
				50	—	6.4	10.1	1.0	11.5	
Propagation delay time ($\overline{CLR}$ -Q) (Note 2)	t_{pHL}	Figure 4	3.3 ± 0.3	15	—	8.9	13.6	1.0	16.0	ns
				50	—	11.2	17.1	1.0	19.5	
			5.0 ± 0.5	15	—	5.5	9.0	1.0	10.5	
				50	—	7.0	11.0	1.0	12.5	
Propagation delay time ($\overline{CLR}$ -CARRY) (Note 2)	t_{pHL}	Figure 4	3.3 ± 0.3	15	—	8.4	13.2	1.0	15.5	ns
				50	—	10.9	16.7	1.0	19.0	
			5.0 ± 0.5	15	—	5.0	8.6	1.0	10.0	
				50	—	6.5	10.6	1.0	12.0	
Maximum clock frequency	f_{max}	—	3.3 ± 0.3	15	80	130	—	70	—	MHz
				50	55	85	—	50	—	
			5.0 ± 0.5	15	135	185	—	115	—	
				50	95	125	—	85	—	
Input capacitance	C_{IN}	—			—	4	10	—	10	pF
Power dissipation capacitance	C_{PD}	(Note 1)			—	23	—	—	—	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:

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

When the outputs drive a capacitive load, total current consumption is the sum of C_{PD}, and ΔI_{CC} which is obtained from the following formula:

$$\Delta I_{CC} = f_{CK} \cdot V_{CC} \left(\frac{C_{QA}}{2} + \frac{C_{QB}}{4} + \frac{C_{QC}}{8} + \frac{C_{QD}}{16} + \frac{C_{CO}}{16} \right)$$

C_{QA} to C_{QD} and C_{CO} are the capacitances at QA to QD and CARRY OUT, respectively.

f_{CK} is the input frequency of the CK.

Note 2: For TC74VHC161 only

Switching Characteristics Test Waveform

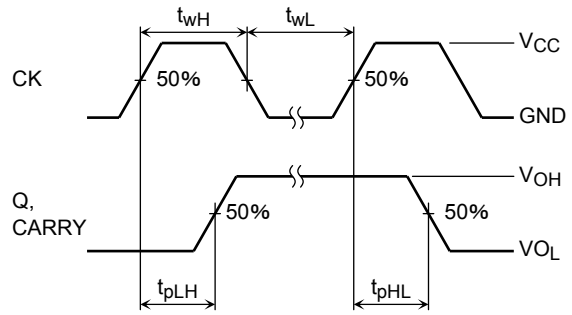


Figure 1 Count Mode

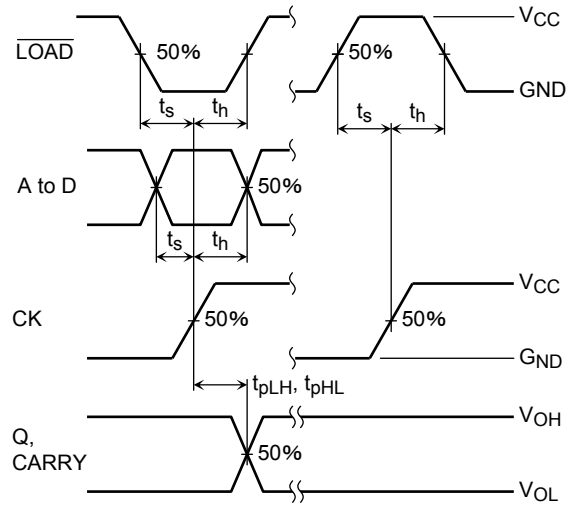


Figure 2 Preset Mode

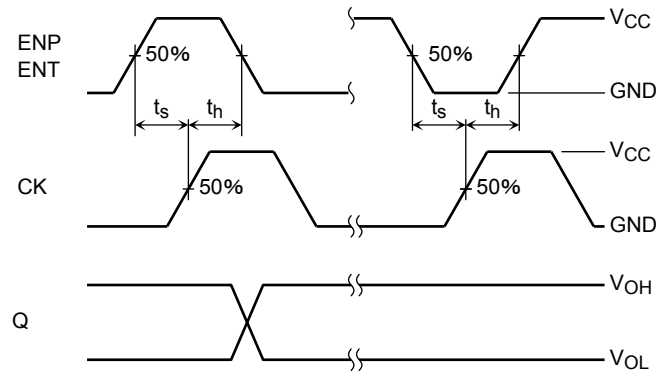


Figure 3 Count Enable Mode

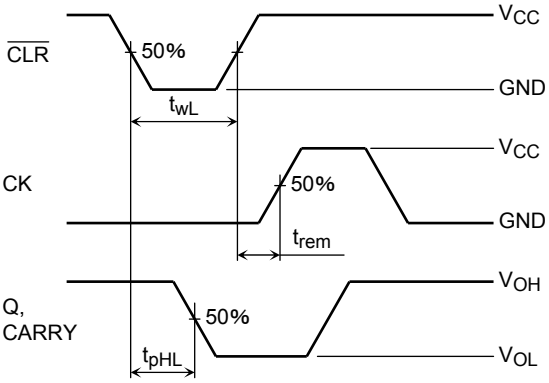


Figure 4 Clear Mode (TC74VHC161)

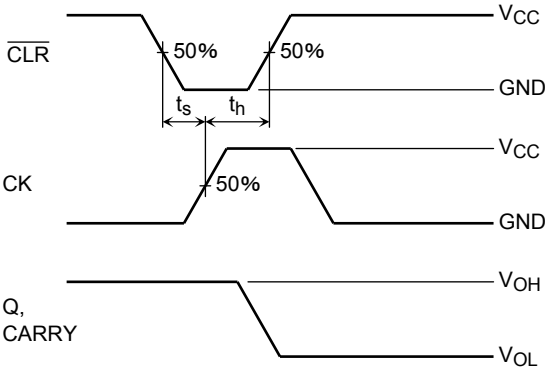


Figure 5 Clear Mode (TC74VHC163)

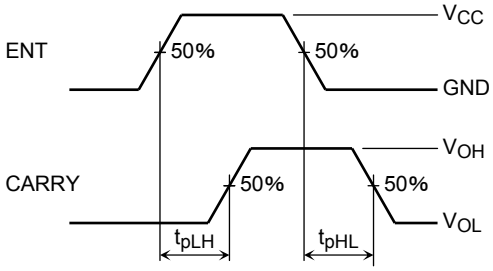
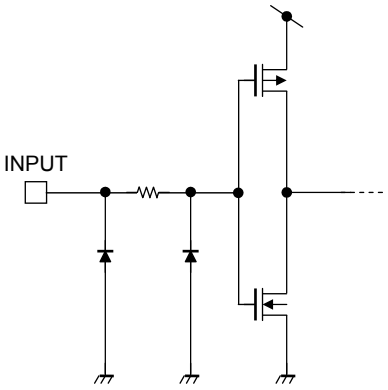


Figure 6 Cascade Mode (fix maximum count)

Noise Characteristics (input: $t_r = t_f = 3$ ns)

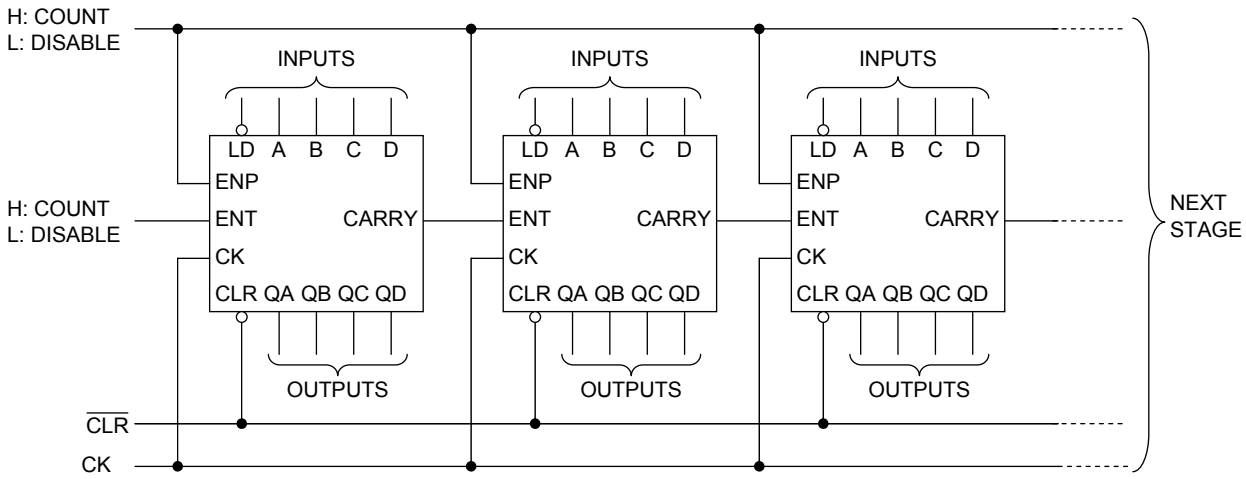
Characteristics	Symbol	Test Condition	Ta = 25°C		Unit
		V_{CC} (V)	Typ.	Max	
Quiet output maximum dynamic V_{OL}	V_{OLP}	C_L = 50 pF	5.0	0.4	0.8	V
Quiet output minimum dynamic V_{OL}	V_{OLV}	C_L = 50 pF	5.0	−0.4	−0.8	V
Minimum high level dynamic input voltage	V_{IHD}	C_L = 50 pF	5.0	—	3.5	V
Maximum low level dynamic input voltage	V_{ILD}	C_L = 50 pF	5.0	—	1.5	V

Input Equivalent Circuit



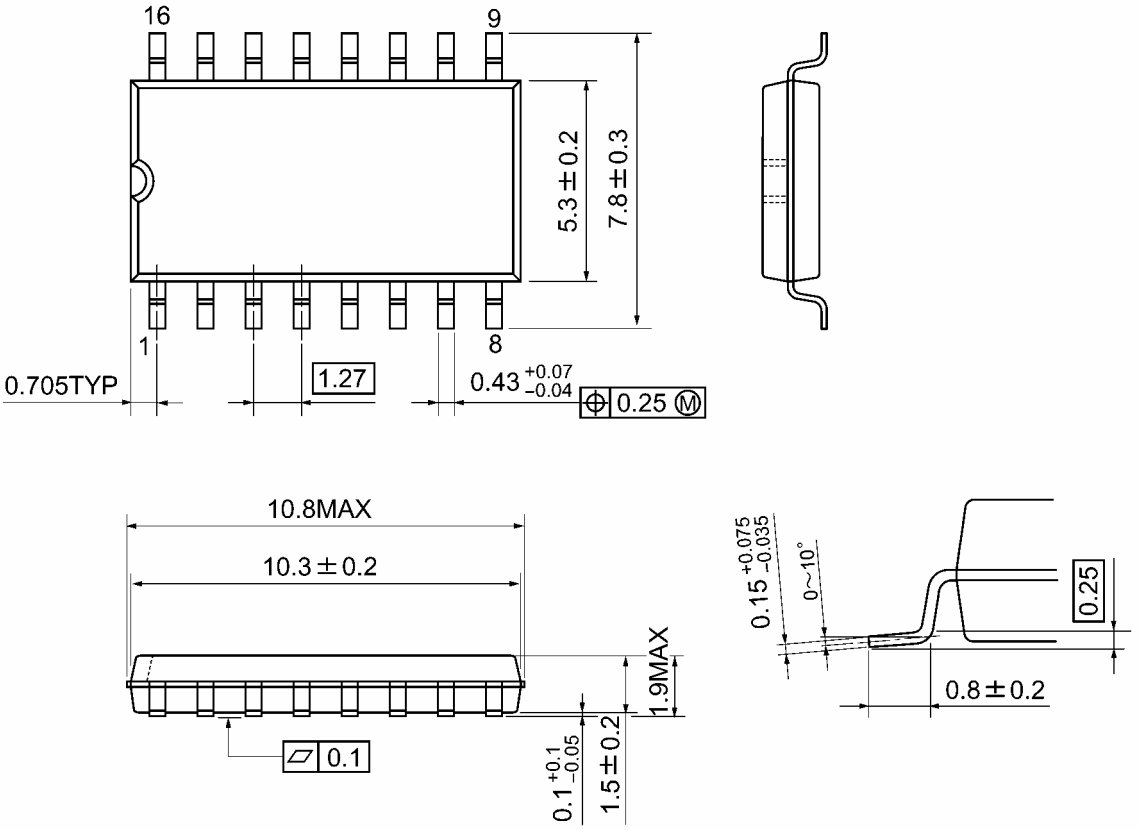
Typical Application

Parallel Carry N-Bit Counter



Package Dimensions

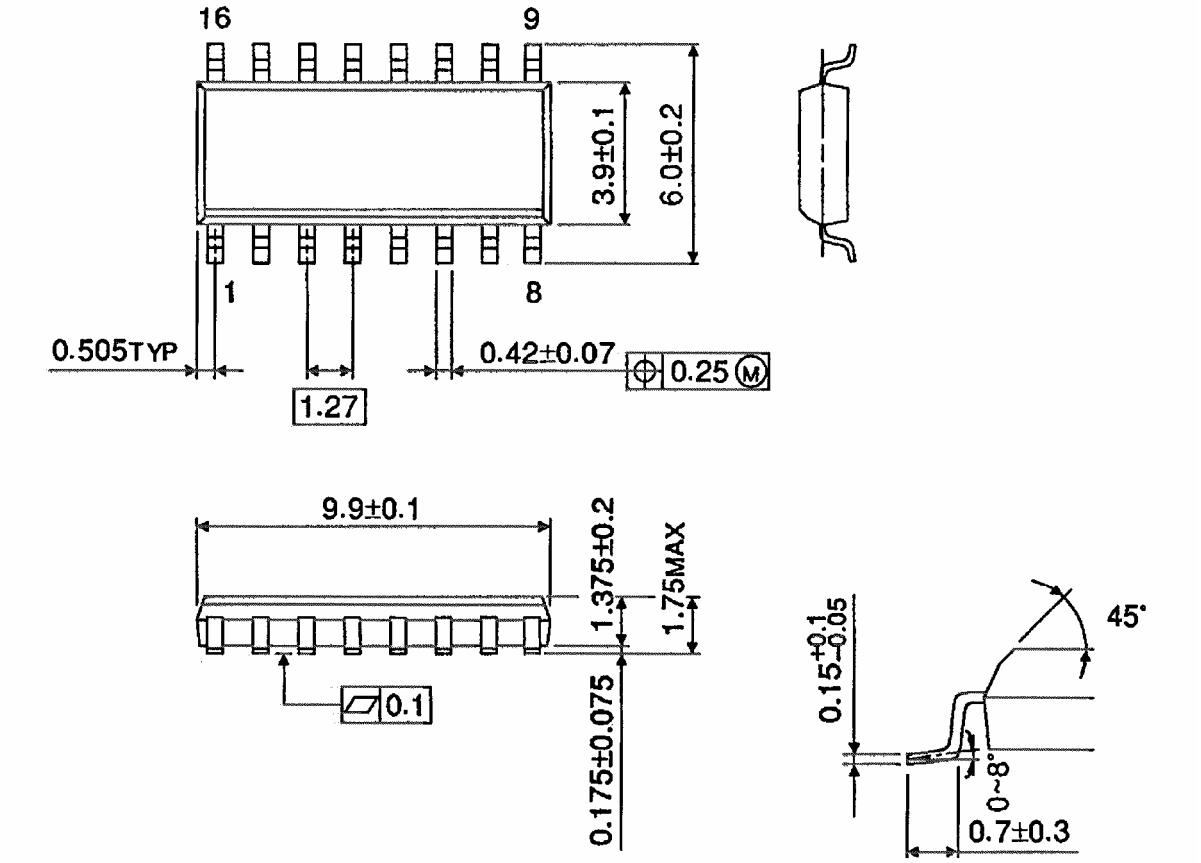
SOP16-P-300-1.27A Unit: mm



Weight: 0.18 g (typ.)

Package Dimensions (Note)

SOL16-P-150-1.27 Unit : mm

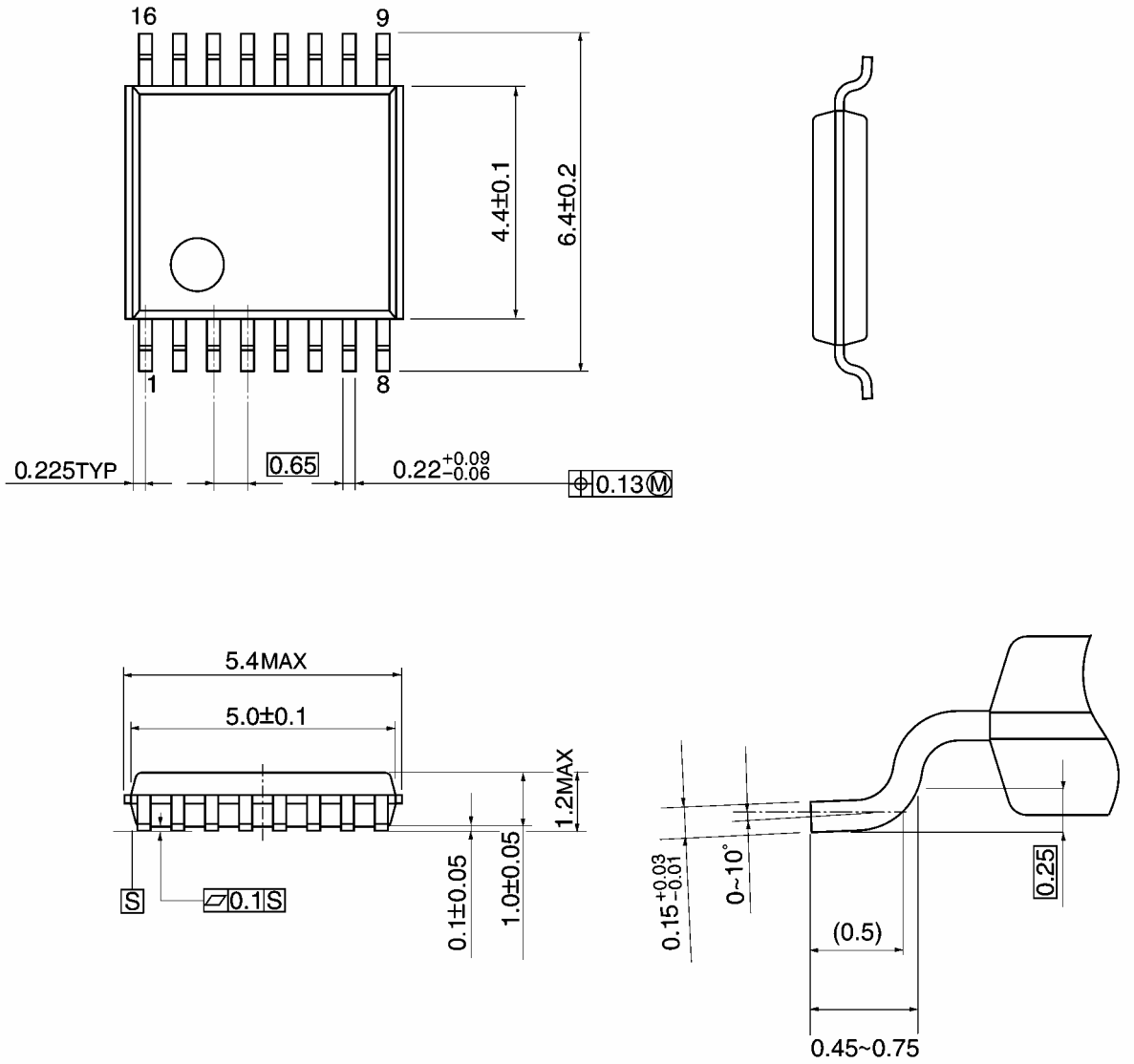


Note: This package is not available in Japan.

Weight: 0.13 g (typ.)

Package Dimensions

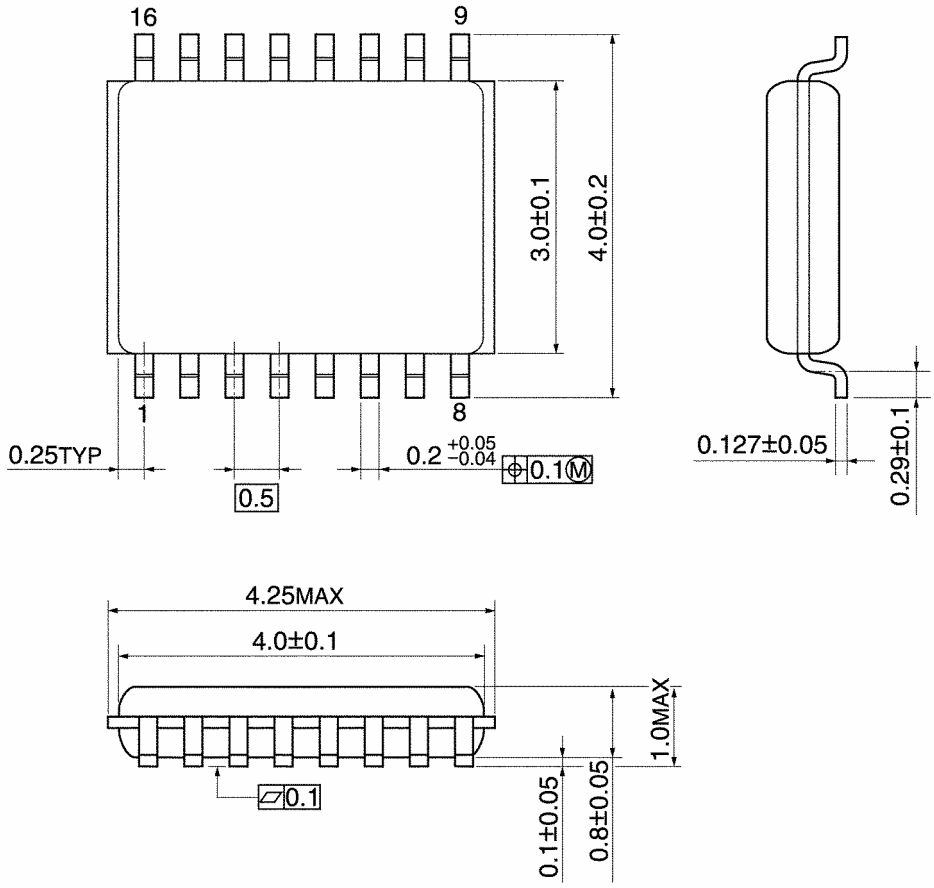
TSSOP16-P-0044-0.65A Unit: mm



Weight: 0.06 g (typ.)

Package Dimensions

VSSOP16-P-0030-0.50 Unit: mm



Weight: 0.02 g (typ.)

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20070701-EN GENERAL

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