

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

TC7MH161FK, TC7MH163FK

Synchronous Presetable 4-Bit Binary Counter

TC7MH161FK Asynchronous Clear

TC7MH163FK Synchronous Clear

The TC7MH161FK and 163FK are advanced high speed CMOS synchronous presetable 4-bit binary counters fabricated with silicon gate C²MOS technology.

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

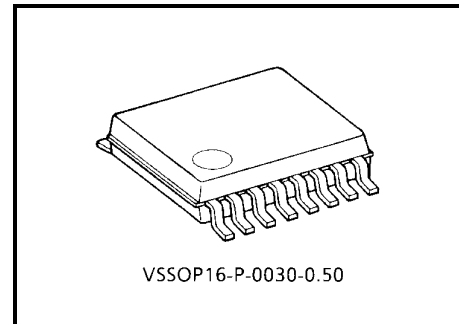
The CK input is active on the rising edge. Both \overline{LOAD} and \overline{CLR} inputs are active on low logic level.

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

The clear function of the TC7MH163FK is synchronous to CK, while the TC7MH161FK 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.

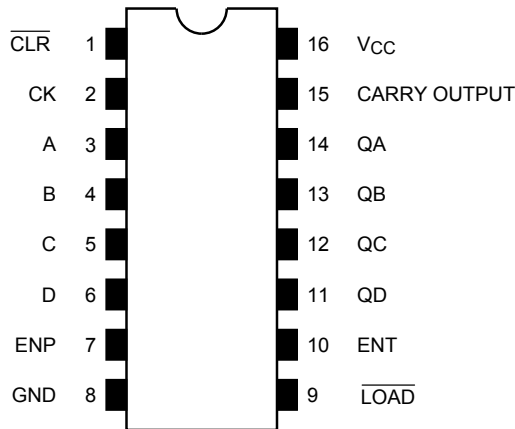


Weight: 0.02 g (typ.)

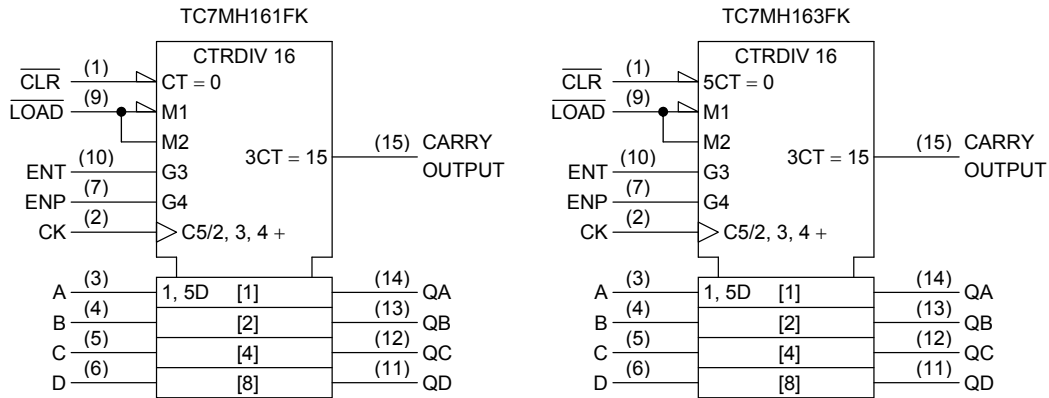
Features

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

Pin Assignment (top view)



IEC Logic Symbol



Truth Table

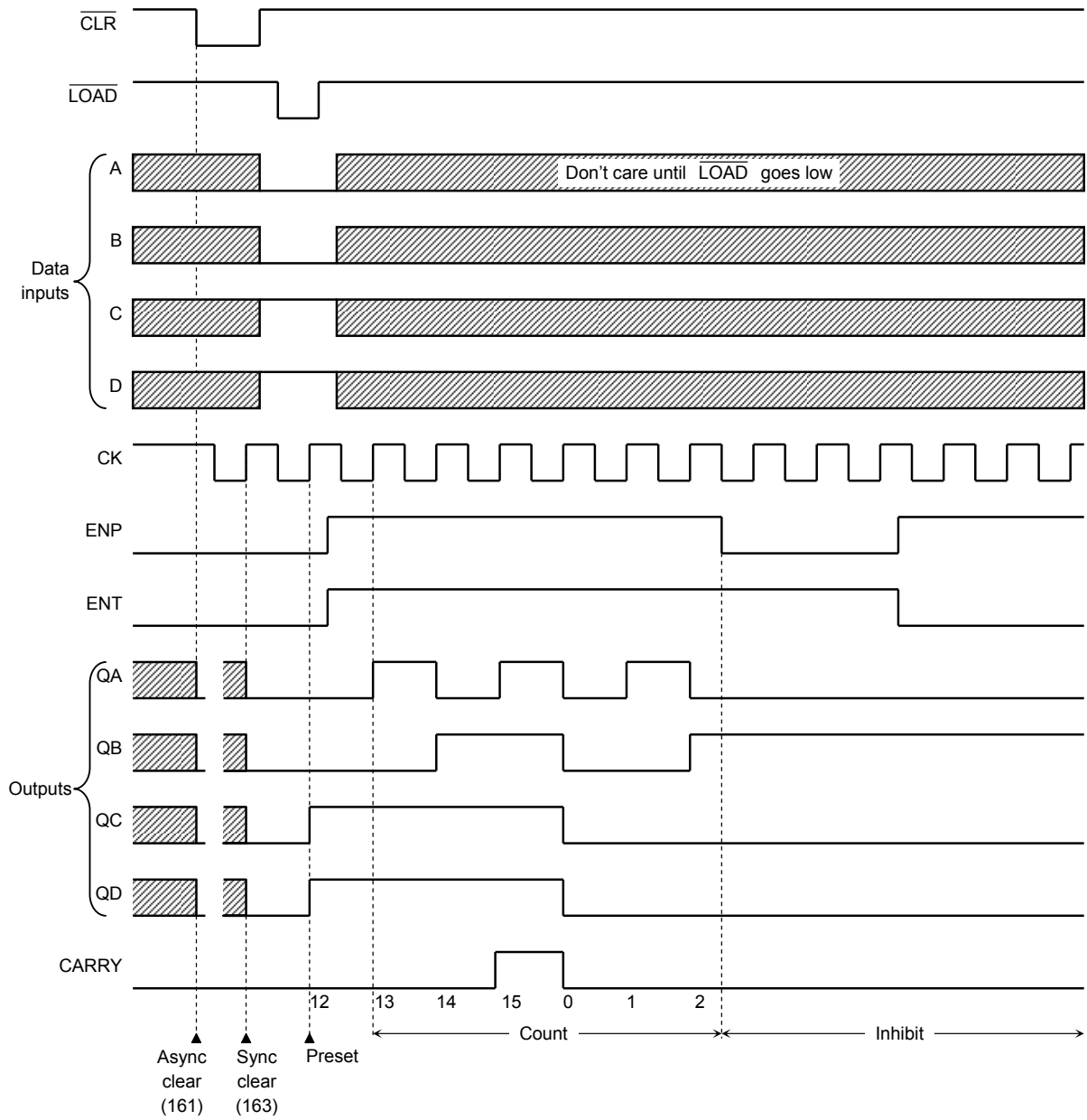
TC7MH161FK					TC7MH163FK					Outputs				Function
Inputs					Inputs					QA	QB	QC	QD	
$\overline{\text{CLR}}$	$\overline{\text{LD}}$	ENP	ENT	CK	$\overline{\text{CLR}}$	$\overline{\text{LD}}$	ENP	ENT	CK	QA	QB	QC	QD	
L	X	X	X	X	L	X	X	X	\uparrow	L	L	L	L	Reset to "0"
H	L	X	X	\uparrow	H	L	X	X	\uparrow	A	B	C	D	Reset data.
H	H	X	L	\uparrow	H	H	X	L	\uparrow	No change				No count
H	H	L	X	\uparrow	H	H	L	X	\uparrow	No change				No count
H	H	H	H	\uparrow	H	H	H	H	\uparrow	Count up				Count
H	X	X	X	\downarrow	X	X	X	X	\downarrow	No change				No count

X: Don't care

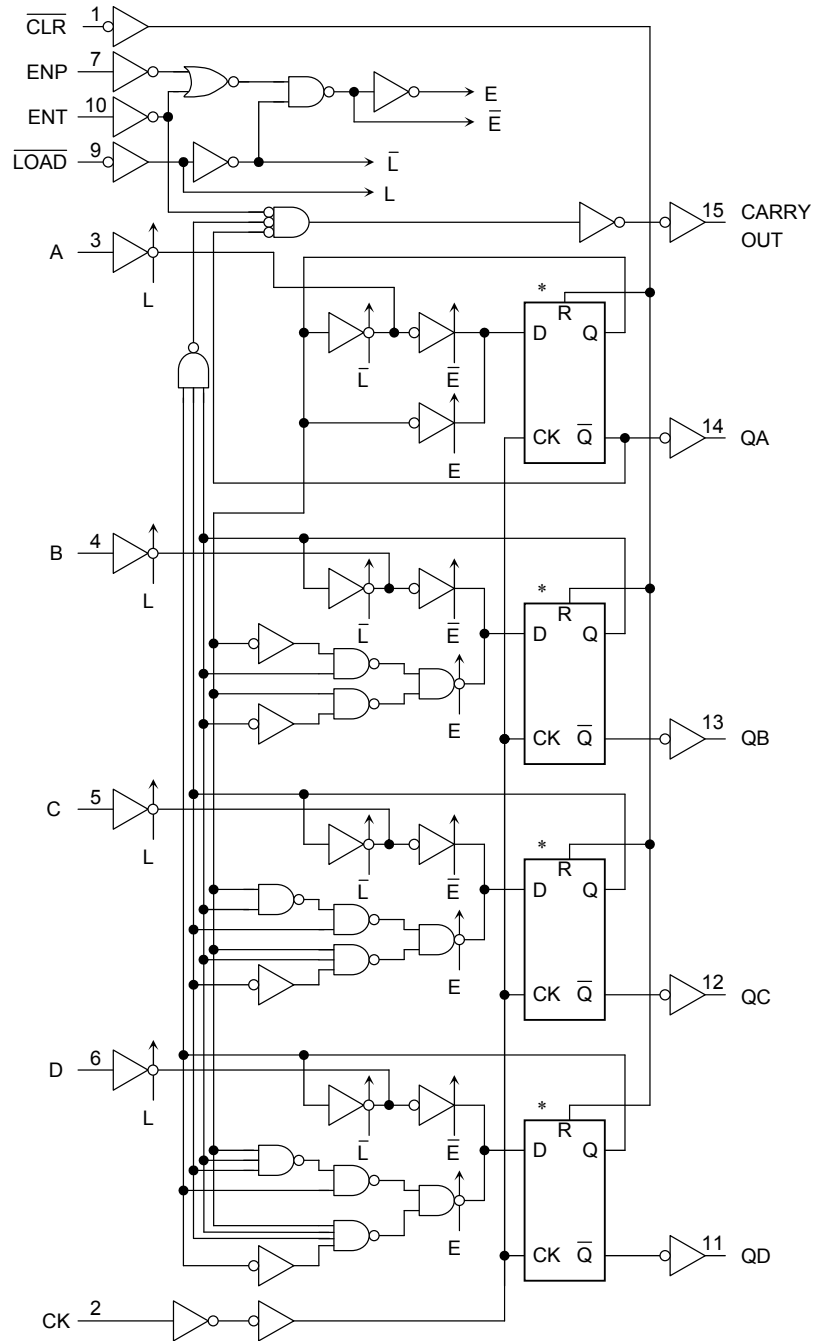
A, B, C, D: Logic level of data inputs

Carry: $\text{CARRY} = \text{ENT} \cdot \text{QA} \cdot \text{QB} \cdot \text{QC} \cdot \text{QD}$

Timing Chart



System Diagram



*: Truth table of internal F/F

TC7MH161FK					TC7MH163FK				
D	CK	R	Q	\bar{Q}	D	CK	R	Q	\bar{Q}
X	X	H	L	H	X	\uparrow	H	L	H
L	\uparrow	L	L	H	L	\uparrow	L	L	H
H	\uparrow	L	H	L	H	\uparrow	L	H	L
X	\downarrow	L	No change		X	\downarrow	X	No change	

X: Don't care

Absolute Maximum Ratings (Note)

Characteristics	Symbol	Rating	Unit
Supply voltage range	V_{CC}	-0.5~7.0	V
DC input voltage	V_{IN}	-0.5~7.0	V
DC output voltage	V_{OUT}	-0.5~ $V_{CC} + 0.5$	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}	-65~150	°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 Ranges (Note)

Characteristics	Symbol	Rating	Unit
Supply voltage	V_{CC}	2.0~5.5	V
Input voltage	V_{IN}	0~5.5	V
Output voltage	V_{OUT}	0~ V_{CC}	V
Operating temperature	T_{opr}	-40~85	°C
Input rise and fall time	dt/dv	0~100 ($V_{CC} = 3.3 \pm 0.3$ V)	ns/V
		0~20 ($V_{CC} = 5 \pm 0.5$ 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	$T_a = 25^\circ\text{C}$			$T_a = -40 \sim 85^\circ\text{C}$		Unit			
			V_{CC} (V)	Min	Typ.	Max	Min		Max		
Input voltage	High level	V_{IH}	2.0	1.50	—	—	1.50	V			
			3.0~5.5	$V_{CC} \times 0.7$	—	—	$V_{CC} \times 0.7$				
	Low level	V_{IL}	2.0	—	—	0.50	—		0.50		
			3.0~5.5	—	—	$V_{CC} \times 0.3$	—		$V_{CC} \times 0.3$		
Output voltage	High level	V_{OH} $V_{IN} = V_{IH}$ or V_{IL}	$I_{OH} = -50 \mu\text{A}$	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			
				3.0	2.58	—	—	2.48			
		$I_{OH} = -8 \text{ mA}$	4.5	3.94	—	—	3.80				
	Low level	V_{OL} $V_{IN} = V_{IH}$ or V_{IL}	$I_{OL} = 50 \mu\text{A}$	2.0	—	0	0.1	—		0.1	
				3.0	—	0	0.1	—		0.1	
				4.5	—	0	0.1	—		0.1	
				$I_{OL} = 4 \text{ mA}$	3.0	—	—	0.36		—	0.44
				$I_{OL} = 8 \text{ mA}$	4.5	—	—	0.36		—	0.44
Input leakage current	I_{IN}	$V_{IN} = 5.5 \text{ V}$ or GND	0~5.5	—	—	±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: $t_r = t_f = 3 \text{ ns}$)

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

Note 1: for TC7MH161FK only

Note 2: for TC7MH163FK only

AC Characteristics (Input: $t_r = t_f = 3 \text{ ns}$)

Characteristics	Symbol	Test Condition			Ta = 25°C			Ta = -40~85°C		Unit
			VCC (V)	CL (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 ($\overline{\text{CLR}}-Q$)	t_{pHL}	Figure 4 (Note 2)	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 ($\overline{\text{CLR}}-CARRY$)	t_{pHL}	Figure 4 (Note 2)	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:

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

$C_{QA} \sim C_{QD}$ and C_{CO} are the capacitance QA~QD and CARRY OUT, respectively.
 f_{CK} is the input frequency of the CK.

Note 2: for TC7MH161FK only

AC Test Waveform

Count Mode

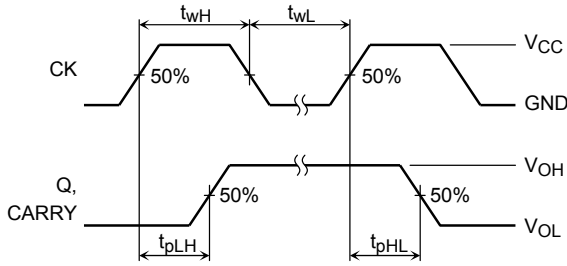


Figure 1

Preset Mode

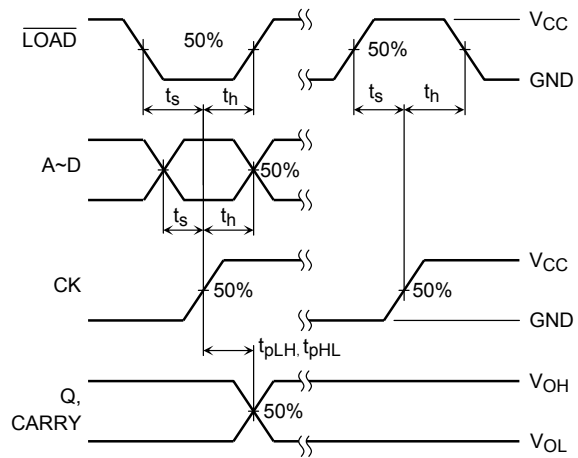


Figure 2

Count Enable Mode

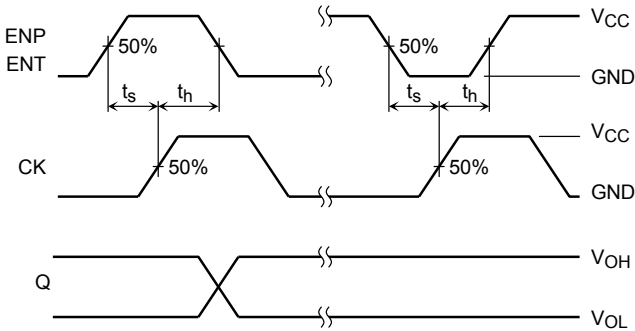


Figure 3

Clear Mode (TC7MH161FK)

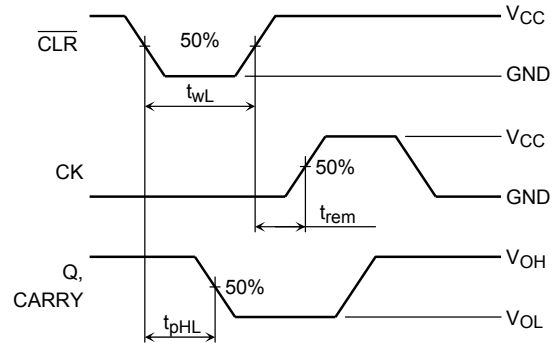


Figure 4

Clear Mode (TC7MH163FK)

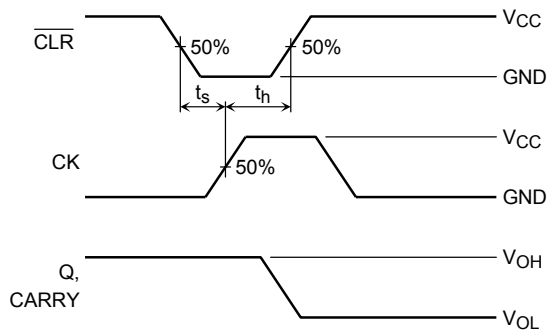


Figure 5

Cascade Mode (fix maximum count)

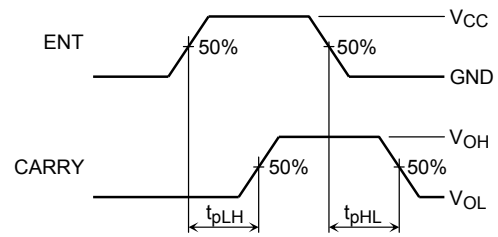
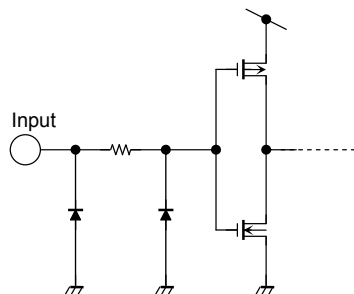


Figure 6

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

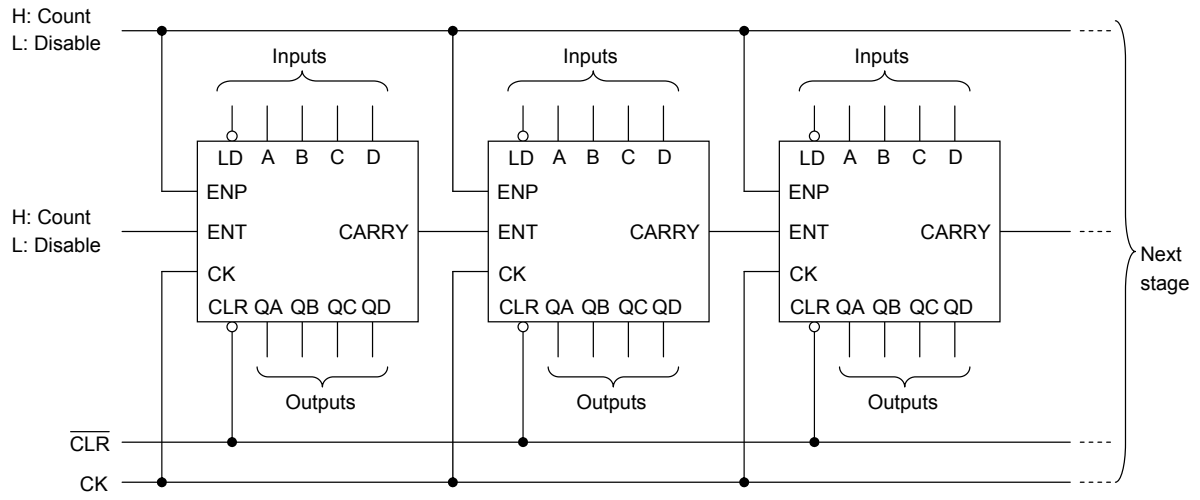
Characteristics	Symbol	Test Condition	Ta = 25°C		Unit	
			V _{CC} (V)	Typ.		Limit
Quiet output maximum dynamic V _{OL}	V _{OLP}	C _L = 50 pF	5.0	0.4	0.8	V
Quiet output minimum dynamic V _{OL}	V _{OLV}	C _L = 50 pF	5.0	-0.4	-0.8	V
Minimum high level dynamic input voltage V _{IH}	V _{IHD}	C _L = 50 pF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

Input Equivalent Circuit



Typical Application

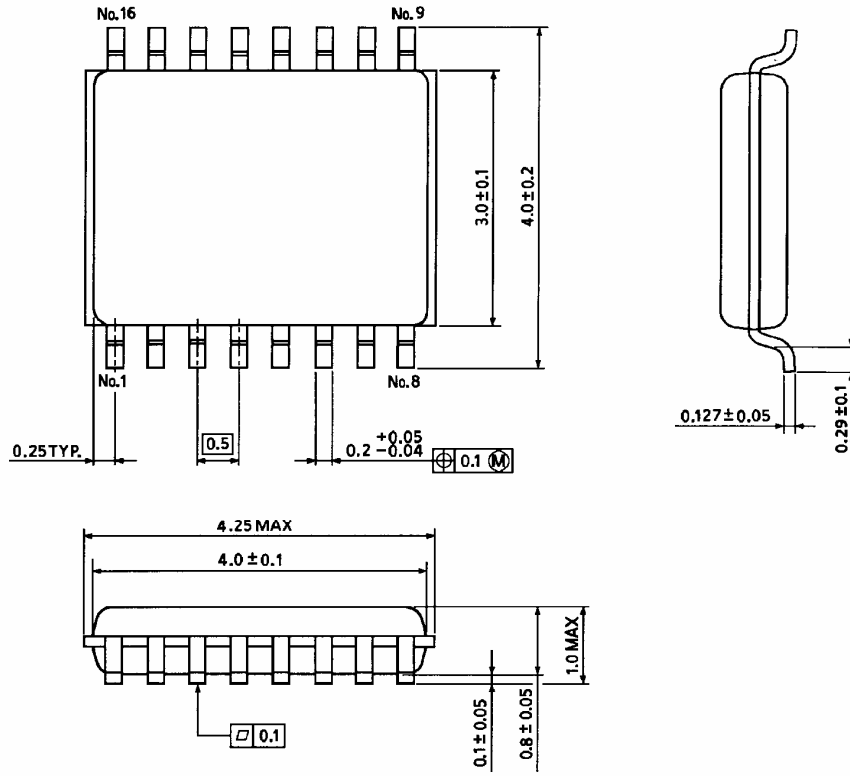
Parallel Carry N-Bit Counter



Package Dimensions

VSSOP16-P-0030-0.50

Unit : mm



Weight: 0.02 g (typ.)

RESTRICTIONS ON PRODUCT USE

20070701-EN GENERAL

- The information contained herein is subject to change without notice.
- 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 shall not be used or embedded to any downstream products of which manufacture, use and/or sale are prohibited under any applicable laws and regulations.
- The information contained herein is presented only as a guide for the applications of our products. No responsibility is assumed by TOSHIBA for any infringements of patents or other rights of the third parties which may result from its use. No license is granted by implication or otherwise under any patents or other rights of TOSHIBA or the third parties.
- Please contact your sales representative for product-by-product details in this document regarding RoHS compatibility. Please use these products in this document in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances. Toshiba assumes no liability for damage or losses occurring as a result of noncompliance with applicable laws and regulations.