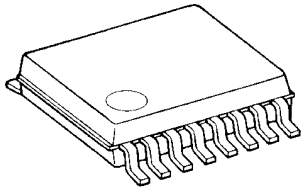
TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

TC7MH161FK, TC7MH163FK

Synchronous Presettable 4-Bit Binary Counter

TC7MH161FK Asynchronous Clear

TC7MH163FK Synchronous Clear



VSSOP16-P-0030-0.50

Weight: 0.02 g (typ.)

The TC7MH161FK and 163FK 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 TC7MH163FK is synchronous to CK, while the TC7MH161FK are cleared asynchronously.

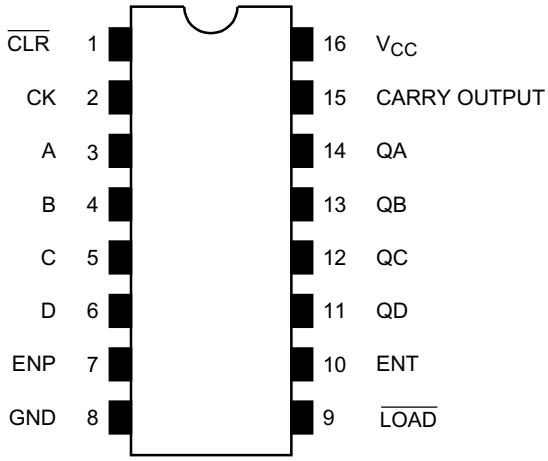
Two enable inputs (ENP and ENT) and CARRY OUTPUT are provided to enable easy cascading of counters, which facilitates easy implementation of n-bit counters without using external gates.

An input protection circuit ensures that 0 to 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.

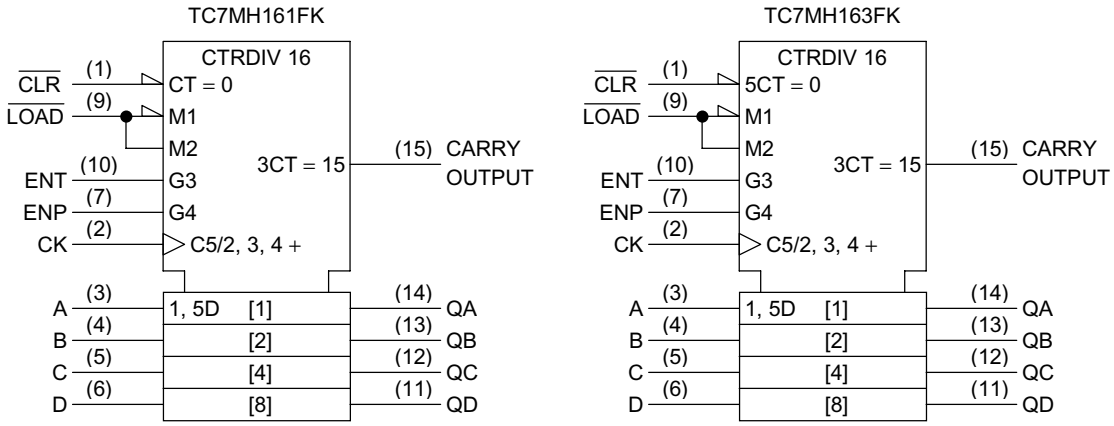
Features

- High speed: f_{max} = 185 MHz (typ.) (V_{CC} = 5 V)
- Low power dissipation: I_{CC} = 4 μA (max) (Ta = 25°C)
- High noise immunity: $V_{NIH} = V_{NIL}$ = 28% V_{CC} (min)
- Power down protection is equipped with all inputs.
- Balanced propagation delays: $t_{pLH} \simeq t_{pHL}$
- Wide operating voltage range: $V_{CC\ (opr)}$ = 2~5.5 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

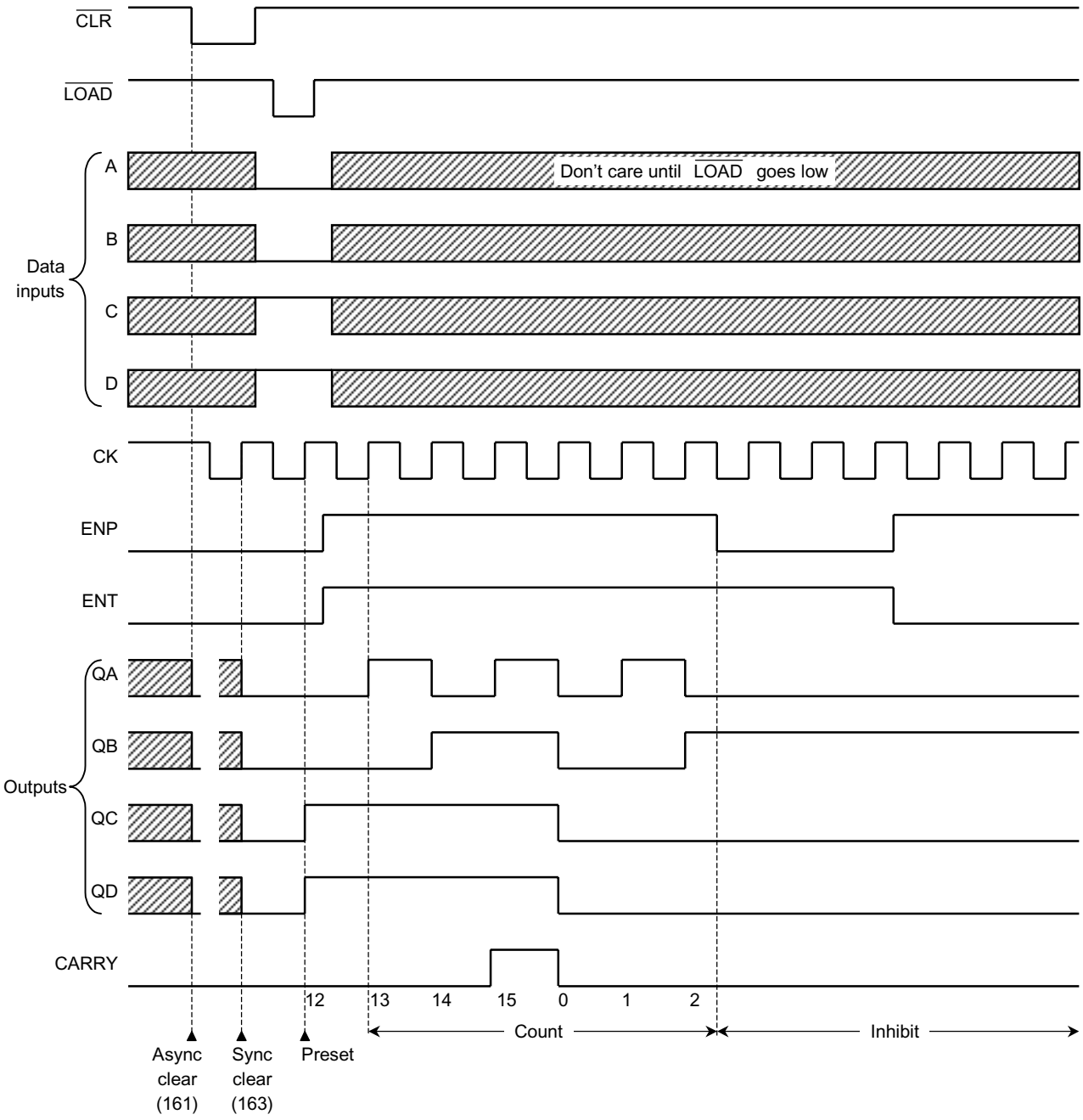
TC7MH161FK					TC7MH163FK					Outputs				Function
Inputs					Inputs									
$\overline{CLR}$	$\overline{LD}$	ENP	ENT	CK	$\overline{CLR}$	$\overline{LD}$	ENP	ENT	CK	QA	QB	QC	QD	
L	X	X	X	X	L	X	X	X	↑	L	L	L	L	Reset to “0”
H	L	X	X	↑	H	L	X	X	↑	A	B	C	D	Reset data.
H	H	X	L	↑	H	H	X	L	↑	No change				No count
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

X: Don’t care

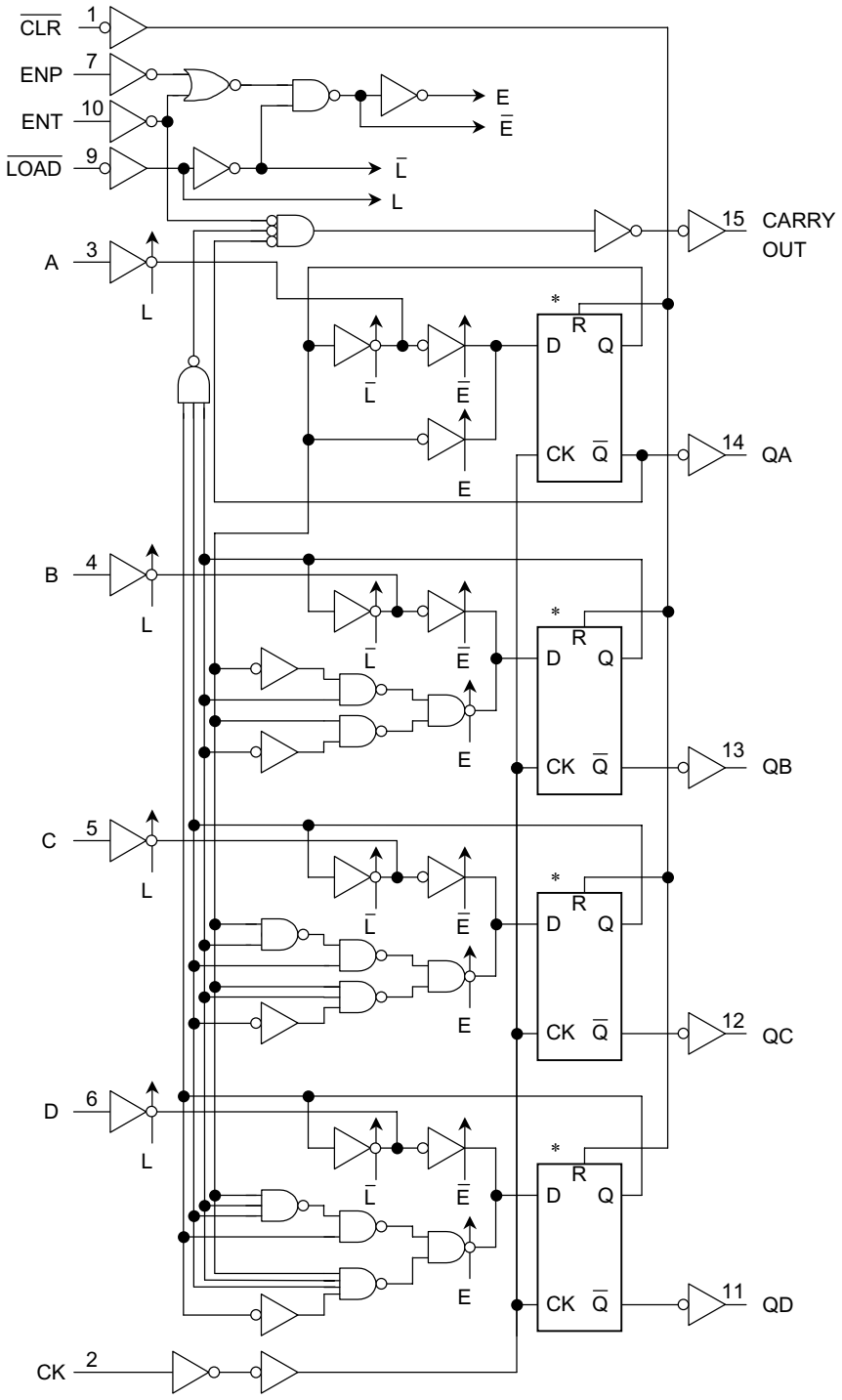
A, B, C, D: Logic level of data inputs

Carry: CARRY = ENT·QA·QB·QC·QD

Timing Chart



System Diagram



*:Truth table of internal F/F

TC7MH161FK					TC7MH163FK				
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

Maximum Ratings (Ta = 25°C)

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

Recommended Operating Conditions

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 ± 0.3 V) 0~20 (V_{CC} = 5 ± 0.5 V)	ns/V

Electrical Characteristics

DC Characteristics

Characteristics		Symbol	Test Condition			Ta = 25°C			Ta = −40~85°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} × 0.7	—	—	V_{CC} × 0.7	—	
	Low level	V_{IL}	—		2.0	—	—	0.50	—	0.50	
					3.0~5.5	—	—	V_{CC} × 0.3	—	V_{CC} × 0.3	
Output voltage	High level	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	V_{OL}	V_{IN} = V_{IH} or V_{IL}	I_{OL} = 50 μA	2.0	—	0	0.1	—	0.1	
					3.0	—	0	0.1	—	0.1	
					4.5	—	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 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: $t_r = t_f = 3$ ns)

Characteristics	Symbol	Test Condition	V_{CC} (V)	Ta = 25°C Limit	Ta = −40~85°C Limit	Unit
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 (Note1)	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 (Note2)	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 (Note2)	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 (Note1)	3.3 ± 0.3	2.5	2.5	ns
			5.0 ± 0.5	1.5	1.5	

Note1: for TC7MH161FK only

Note2: for TC7MH163FK only

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

Characteristics	Symbol	Test Condition			Ta = 25°C			Ta = −40~85°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)	t_{pHL}	Figure 4 (Note4)	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)	t_{pHL}	Figure 4 (Note4)	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}	(Note3)			—	23	—	—	—	pF

Note3: 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}~C_{QD} and C_{CO} are the capacitance QA~QD and CARRY OUT, respectively.
f_{CK} is the input frequency of the CK.

Note4: for TC7MH161FK only

AC Test Waveform

Count Mode

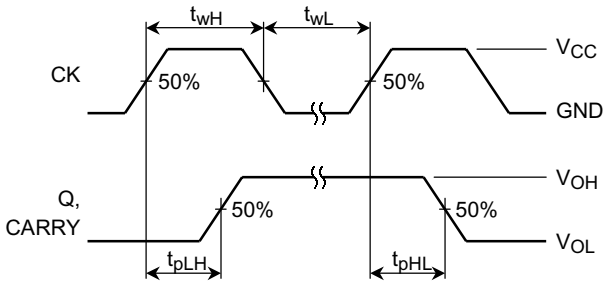


Figure 1

Preset Mode

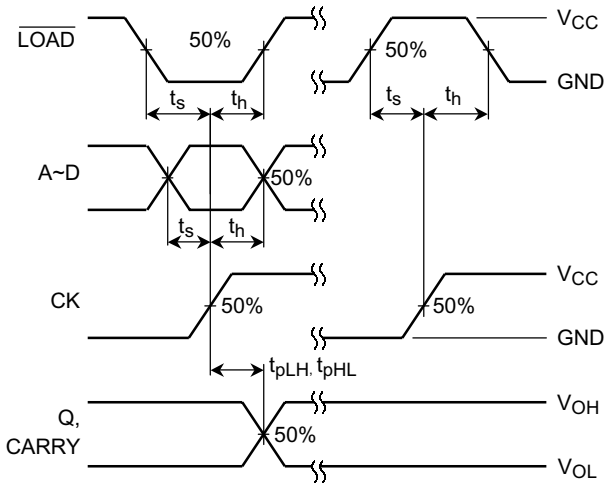


Figure 2

Count Enable Mode

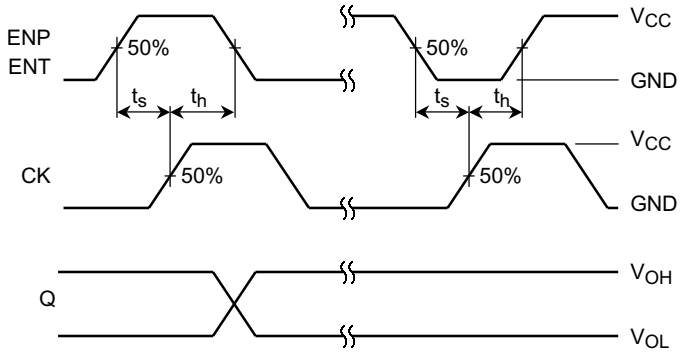


Figure 3

Clear Mode (TC7MH161FK)

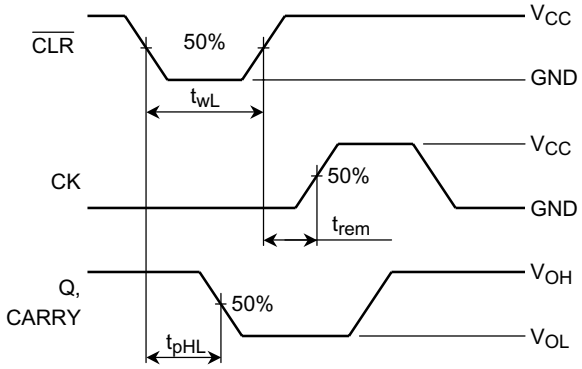


Figure 4

Clear Mode (TC7MH163FK)

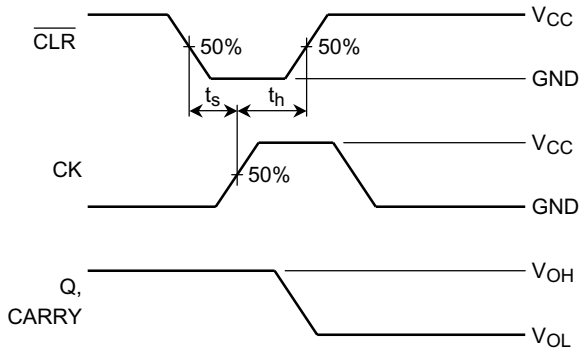


Figure 5

Cascade Mode (fix maximum count)

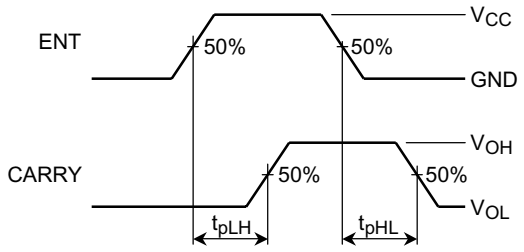
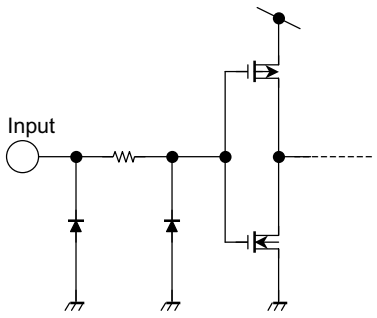


Figure 6

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

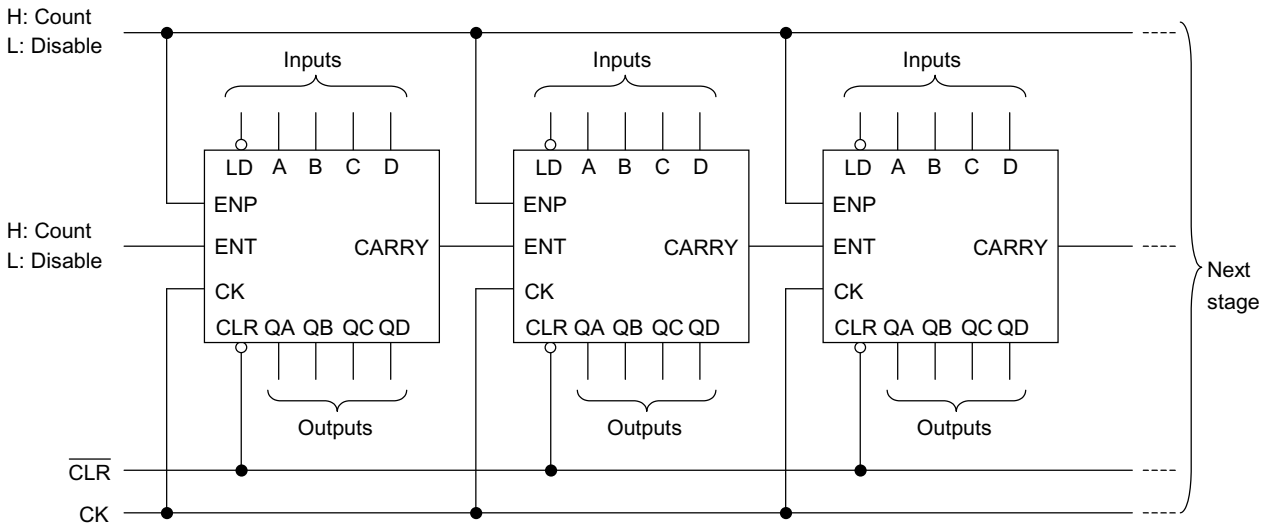
Characteristics	Symbol	Test Condition	Ta = 25°C			Unit
			V_{CC} (V)	Typ.	Limit	
Quiet output maximum dynamic V_{OL}	V_{OLP}	C_L = 50 pF	5.0	0.4	0.8	V
Quiet output minimum dynamic V_{OL}	V_{OLV}	C_L = 50 pF	5.0	–0.4	–0.8	V
Minimum high level dynamic input voltage V_{IH}	V_{IHD}	C_L = 50 pF	5.0	—	3.5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

Input Equivalent Circuit



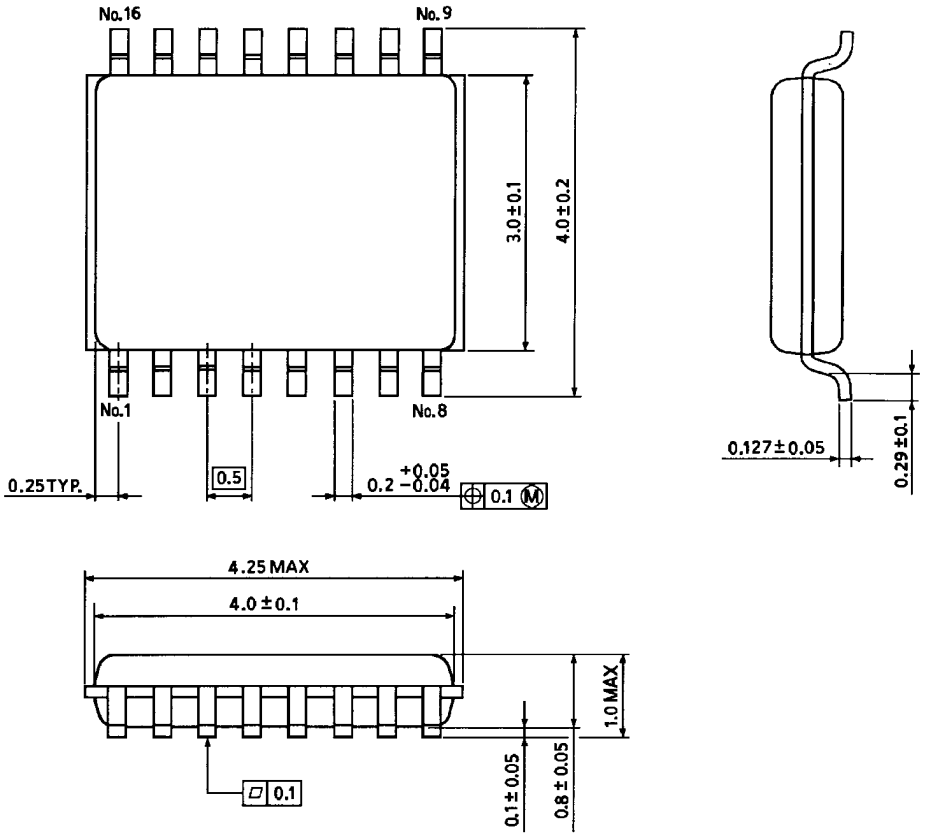
Typical Application

Parallel Carry N-Bit Counter



Package Dimensions

VSSOP16-P-0030-0.50 Unit : mm



Weight: 0.02 g (typ.)