

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC7MH175FK

## Quad D-Type Flip-Flop with Clear

The TC7MH175FK is an advanced high speed CMOS quad D-type flip-flop fabricated with silicon gate C<sup>2</sup>MOS technology.

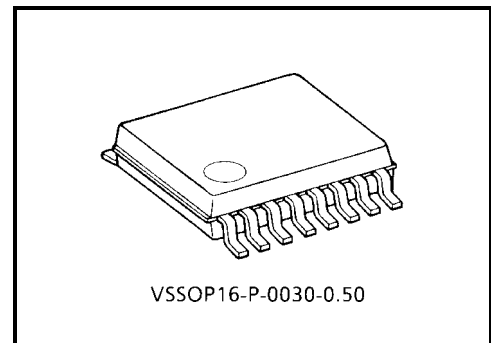
It achieves the high speed operation similar to equivalent bipolar schottky TTL while maintaining the CMOS low power dissipation.

These four flip-flops are controlled by a clock input (CK) and a clear input ( $\overline{\text{CLR}}$ ).

The information data applied to the D inputs (D1 thru D4) are transferred to the outputs (Q1 thru Q4 and  $\overline{\text{Q}}$ 1 thru  $\overline{\text{Q}}$ 4) on the positive-going edge of the clock pulse.

When the  $\overline{\text{CLR}}$  input is held low, the Q outputs are at the low logic level and the  $\overline{\text{Q}}$  outputs are at the high logic level, regardless of other input conditions.

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.

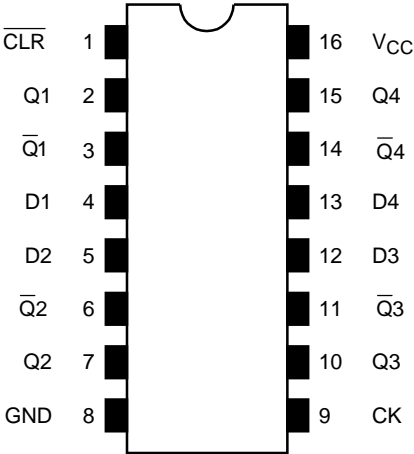


Weight: 0.02 g (typ.)

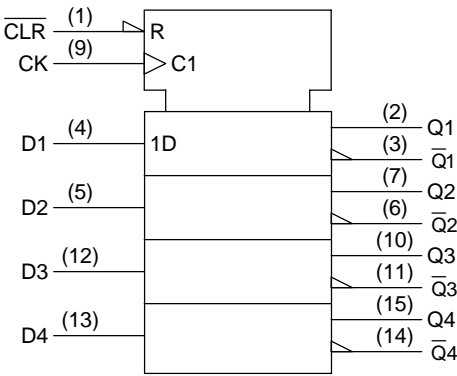
## Features

- High speed:  $f_{\text{max}} = 210 \text{ MHz}$  (typ.) ( $V_{\text{CC}} = 5 \text{ V}$ )
- Low power dissipation:  $I_{\text{CC}} = 4 \mu\text{A}$  (max) ( $T_a = 25^\circ\text{C}$ )
- High noise immunity:  $V_{\text{NIH}} = V_{\text{NIL}} = 28\% V_{\text{CC}}$  (min)
- Power down protection is provided on all inputs.
- Balanced propagation delays:  $t_{\text{PLH}} \approx t_{\text{PHL}}$
- Wide operating voltage range:  $V_{\text{CC (opr)}} = 2 \sim 5.5 \text{ V}$
- Low noise:  $V_{\text{OLP}} = 0.8 \text{ V}$  (max)
- Pin and function compatible with 74ALS175

Pin Assignment (top view)



IEC Logic Symbol

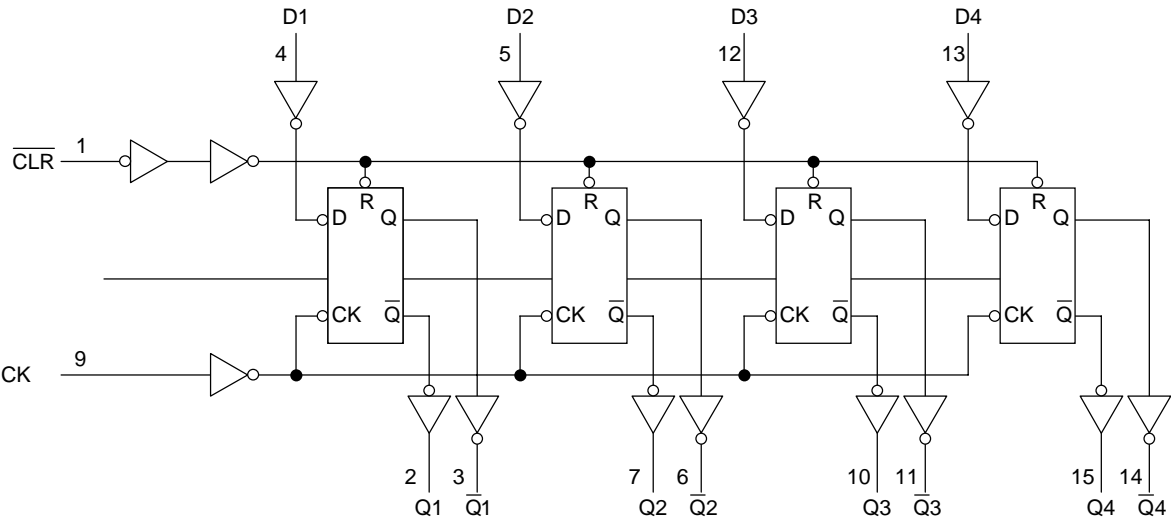


Truth Table

Inputs			Outputs		Function
$\overline{\text{CLR}}$	D	CK	Q	$\overline{\text{Q}}$	
L	X	X	L	H	Clear
H	L		L	H	—
H	H		H	L	—
H	X		$Q_n$	$\overline{Q}_n$	No change

X: Don't care

System Diagram



## Maximum Ratings

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 ( $V_{CC} = 3.3 \pm 0.3$ V)	ns/V
		0~20 ( $V_{CC} = 5 \pm 0.5$ V)	

## Electrical Characteristics

## DC Characteristics

Characteristics		Symbol	Test Condition		V <sub>CC</sub> (V)	Ta = 25°C			Ta = -40~85°C		Unit
					Min	Typ.	Max	Min	Max		
Input voltage	High level	V <sub>IH</sub>	—		2.0	1.50	—	—	1.50	—	V
					3.0~5.5	V <sub>CC</sub> × 0.7	—	—	V <sub>CC</sub> × 0.7	—	
	Low level	V <sub>IL</sub>	—		2.0	—	—	0.50	—	0.50	
					3.0~5.5	—	—	V <sub>CC</sub> × 0.3	—	V <sub>CC</sub> × 0.3	
Output voltage	High level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OH</sub> = -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 <sub>OH</sub> = -4 mA	3.0	2.58	—	—	2.48	—	
					I <sub>OH</sub> = -8 mA	4.5	3.94	—	—	3.80	
	Low level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 50 μA	2.0	—	0	0.1	—	0.1	
					3.0	—	0	0.1	—	0.1	
					4.5	—	0	0.1	—	0.1	
				I <sub>OL</sub> = 4 mA	3.0	—	—	0.36	—	0.44	
					I <sub>OL</sub> = 8 mA	4.5	—	—	0.36	—	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 5.5 V or GND	0~5.5	—	—	±0.1	—	±1.0	μA	
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND	5.5	—	—	4.0	—	40.0	μA	

Timing Requirements (Input:  $t_r = t_f = 3 \text{ ns}$ )

Characteristics	Symbol	Test Condition	Ta = 25°C		Ta = -40~85°C		Unit
			V <sub>CC</sub> (V)	Typ.	Limit	Limit	
Minimum pulse width (CK)	$t_w(L)$ $t_w(H)$	—	$3.3 \pm 0.3$	—	5.0	5.0	ns
			$5.0 \pm 0.5$	—	5.0	5.0	
Minimum pulse width ( $\overline{\text{CLR}}$ )	$t_w(L)$	—	$3.3 \pm 0.3$	—	5.0	5.0	ns
			$5.0 \pm 0.5$	—	5.0	5.0	
Minimum set-up time	$t_s$	—	$3.3 \pm 0.3$	—	5.0	5.0	ns
			$5.0 \pm 0.5$	—	4.0	4.0	
Minimum hold time	$t_h$	—	$3.3 \pm 0.3$	—	1.0	1.0	ns
			$5.0 \pm 0.5$	—	1.0	1.0	
Minimum removal time ( $\overline{\text{CLR}}$ )	$t_{\text{rem}}$	—	$3.3 \pm 0.3$	—	5.0	5.0	ns
			$5.0 \pm 0.5$	—	5.0	5.0	

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

Characteristics	Symbol	Test Condition			Ta = 25°C			Ta = -40~85°C		Unit
			V <sub>CC</sub> (V)	C <sub>L</sub> (pF)	Min	Typ.	Max	Min	Max	
Propagation delay time (CK-Q)	$t_{\text{pLH}}$ $t_{\text{pHL}}$	—	$3.3 \pm 0.3$	15	—	7.5	11.5	1.0	13.5	ns
				50	—	10.0	15.0	1.0	17.0	
			$5.0 \pm 0.5$	15	—	4.8	7.3	1.0	8.5	
				50	—	6.3	9.3	1.0	10.5	
Propagation delay time ( $\overline{\text{CLR}}$ -Q)	$t_{\text{pHL}}$	—	$3.3 \pm 0.3$	15	—	6.3	10.1	1.0	12.0	ns
				50	—	8.8	13.6	1.0	15.5	
			$5.0 \pm 0.5$	15	—	4.3	6.4	1.0	7.5	
				50	—	5.8	8.4	1.0	9.5	
Maximum clock frequency	$f_{\text{max}}$	—	$3.3 \pm 0.3$	15	90	140	—	75	—	MHz
				50	50	75	—	45	—	
			$5.0 \pm 0.5$	15	150	210	—	125	—	
				50	85	115	—	75	—	
Output to output skew	$t_{\text{osLH}}$ $t_{\text{osHL}}$	(Note1)	$3.3 \pm 0.3$	50	—	—	1.5	—	1.5	ns
			$5.0 \pm 0.5$	50	—	—	1.0	—	1.0	
Input capacitance	C <sub>IN</sub>	—	—	—	—	4	10	—	10	pF
Power dissipation capacitance	C <sub>PD</sub>	(Note2)	—	—	—	44	—	—	—	pF

Note1: Parameter guaranteed by design.

$$t_{\text{osLH}} = |t_{\text{pLHm}} - t_{\text{pLHn}}|, t_{\text{osHL}} = |t_{\text{pHLm}} - t_{\text{pHLn}}|$$

Note2: C<sub>PD</sub> 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:

$$I_{\text{CC (opr)}} = C_{\text{PD}} \cdot V_{\text{CC}} \cdot f_{\text{IN}} + I_{\text{CC}}/4 \text{ (per bit)}$$

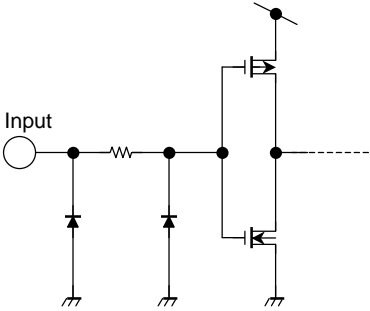
And the total C<sub>PD</sub> when n pcs of flip-flop operate can be gained by the following equation:

$$C_{\text{PD (total)}} = 30 + 14 \cdot n$$

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

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

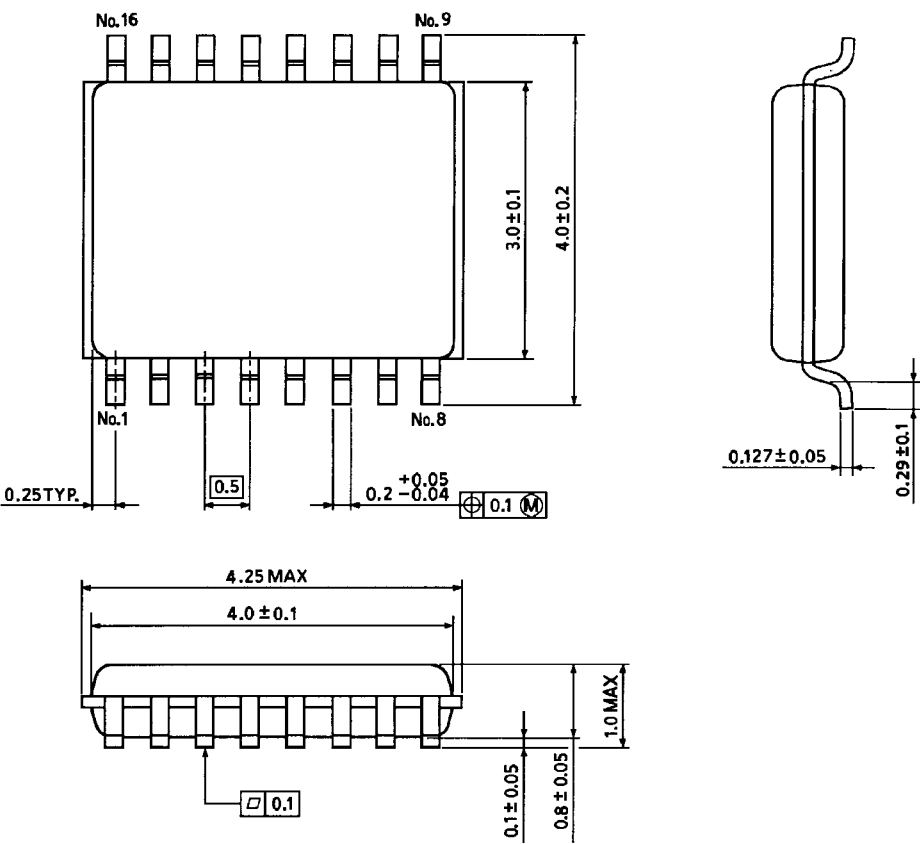
Input Equivalent Circuit



Package Dimensions

VSSOP16-P-0030-0.50

Unit : mm



Weight: 0.02 g (typ.)

**RESTRICTIONS ON PRODUCT USE**

000707EBA

- 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 are subject to the foreign exchange and foreign trade laws.
- The information contained herein is presented only as a guide for the applications of our products. No responsibility is assumed by TOSHIBA CORPORATION for any infringements of intellectual property or other rights of the third parties which may result from its use. No license is granted by implication or otherwise under any intellectual property or other rights of TOSHIBA CORPORATION or others.
- The information contained herein is subject to change without notice.