

## 74VHC374 • 74VHCT374

### Octal D Flip-Flop with TRI-STATE® Outputs

#### General Description

The VHC/VHCT374 is an advanced high speed CMOS octal flip-flop with TRI-STATE output fabricated with silicon gate CMOS technology. It achieves the high speed operation similar to equivalent Bipolar Schottky TTL while maintaining the CMOS low power dissipation. This 8-bit D-type flip-flop is controlled by a clock input (CP) and an output enable input ( $\overline{OE}$ ). When the  $\overline{OE}$  input is high, the eight outputs are in a high impedance state.

An input protection circuit ensures that 0V–7V can be applied to the input pins without regard to the supply voltage. This device can be used to interface 5V to 3V systems and two supply systems such as battery back up. This circuit prevents device destruction due to mismatched supply and input voltages.

#### Features

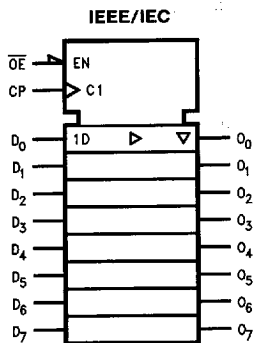
- High noise immunity:  
VHC  $V_{NIH} = V_{NIL} = 28\% V_{CC} (\text{Min})$   
VHCT  $V_{IH} = 2.0V, V_{IL} = 0.8V$
- Power down protection:  
VHC inputs only  
VHCT inputs and outputs
- Low noise:  
VHC  $V_{OLP} = 0.6V (\text{typ})$   
VHCT  $V_{OLP} = 0.8V (\text{typ})$
- Low power dissipation:  
 $I_{CC} = 4 \mu A (\text{Max}) @ T_A = 25^\circ C$
- Balanced propagation delays:  $t_{PLH} \approx t_{PHL}$
- Pin and function compatible with 74HC/HCT374

#### Ordering Code: See Section 6

Commercial	Package Number	Package Description
74VHC374M	M20B	20-Lead Molded JEDEC SOIC
74VHC374SJ	M20D	20-Lead Molded EIAJ SOIC
74VHC374MSC	MSC20	20-Lead Molded EIAJ Type 1 SSOP
74VHC374MTC	MTC20	20-Lead Molded JEDEC Type 1 TSSOP
74VHC374N	N20A	20-Lead Molded DIP
74VHCT374M	M20B	20-Lead Molded JEDEC SOIC
74VHCT374SJ	M20D	20-Lead Molded EIAJ SOIC
74VHCT374MTC	MTC20	20-Lead Molded JEDEC Type 1 TSSOP
74VHCT374N	N20A	20-Lead Molded DIP

Note: Surface mount packages are also available on Tape and Reel. Specify by appending the suffix letter "X" to the ordering code. EIAJ Type 1 SSOP available on Tape and Reel only, order MSCX.

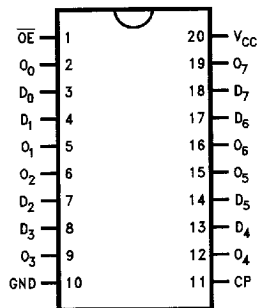
#### Logic Symbol



TL/F/11538-1

#### Connection Diagram

##### Pin Assignment for DIP, SSOP, TSSOP and SOIC





TL/F/11538-2


Pin Names	Description
D <sub>0</sub> –D <sub>7</sub>	Data Inputs
CP	Clock Pulse Input
$\overline{OE}$	TRI-STATE Output
	Enable Input
O <sub>0</sub> –O <sub>7</sub>	TRI-STATE Outputs

## Functional Description

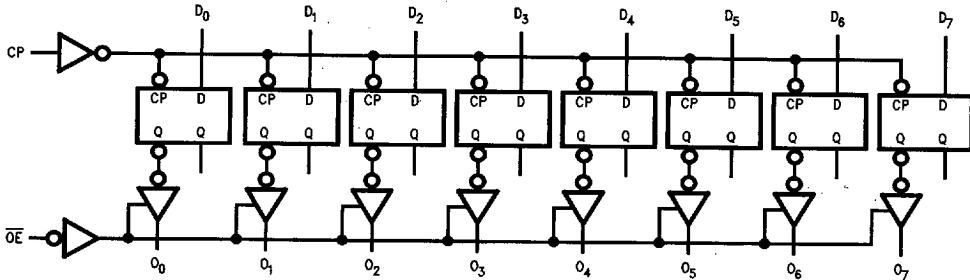
The 'VHC/'VHCT374 consists of eight edge-triggered flip-flops with individual D-type inputs and TRI-STATE true outputs. The buffered clock and buffered Output Enable are common to all flip-flops. The eight flip-flops will store the state of their individual D inputs that meet the setup and hold time requirements on the LOW-to-HIGH Clock (CP) transition. With the Output Enable ( $\overline{OE}$ ) LOW, the contents of the eight flip-flops are available at the outputs. When the  $\overline{OE}$  is HIGH, the outputs go to the high impedance state. Operation of the  $\overline{OE}$  input does not affect the state of the flip-flops.

## Truth Table

Inputs			Outputs
$D_n$	CP	$\overline{OE}$	$O_n$
H		L	H
L		L	L
X	X	H	Z

H = HIGH Voltage Level  
 L = LOW Voltage Level  
 X = Immaterial  
 Z = High Impedance  
 = LOW-to-HIGH Transition

## Logic Diagram



TL/F/11538-3

Please note that this diagram is provided only for the understanding of logic operations and should not be used to estimate propagation delays.

**Absolute Maximum Ratings** (Note 1)

Supply Voltage ( $V_{CC}$ )	-0.5V to +7.0V
DC Input Voltage ( $V_{IN}$ )	-0.5V to +7.0V
DC Output Voltage ( $V_{OUT}$ )	
VHC	-0.5V to $V_{CC} + 0.5V$
VHCT*	-0.5V to +7.0V
Input Diode Current ( $I_{IK}$ )	-20 mA
Output Diode Current (VHC)	$\pm 20$ mA
(VHCT)	-20 mA
DC Output Current ( $I_{OUT}$ )	$\pm 25$ mA
DC $V_{CC}$ /GND Current ( $I_{CC}$ )	$\pm 75$ mA
Storage Temperature ( $T_{STG}$ )	-65°C to +150°C
Lead Temperature ( $T_L$ )	
(Soldering, 10 seconds)	260°C

\* $V_{OUT} > V_{CC}$  only if output is in H or Z state.

Note 1: *Absolute Maximum Ratings are values beyond which the device may be damaged or have its useful life impaired. The databook specifications should be met, without exception, to ensure that the system design is reliable over its power supply, temperature, and output/input loading variables. National does not recommend operation outside databook specifications.*

**Recommended Operating Conditions**

Supply Voltage ( $V_{CC}$ )	
VHC	2.0V to +5.5V
VHCT	4.5V to +5.5V
Input Voltage ( $V_{IN}$ )	0V to +5.5V
Output Voltage ( $V_{OUT}$ )	0V to $V_{CC}$
Operating Temperature ( $T_{OPR}$ )	
74 VHC/VHCT	-40°C to +85°C
Input Rise and Fall Time ( $t_r, t_f$ )	
$V_{CC} = 3.3V \pm 0.3V$ (VHC only)	0 ~ 100 ns/V
$V_{CC} = 5.0V \pm 0.5V$	0 ~ 20 ns/V

**DC Characteristics for 'VHC Family Devices**

Symbol	Parameter	$V_{CC}$ (V)	74VHC			74VHC		Units	Conditions	
			$T_A = 25^\circ\text{C}$			$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$				
			Min	Typ	Max	Min	Max			
$V_{IH}$	High Level Input Voltage	2.0 3.0-5.5	1.50 0.7 $V_{CC}$		1.50 0.7 $V_{CC}$		V			
$V_{IL}$	Low Level Input Voltage	2.0 3.0-5.5		0.50 0.3 $V_{CC}$		0.50 0.3 $V_{CC}$	V			
$V_{OH}$	High Level Output Voltage	2.0	1.9	2.0	1.9		V	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -50 \mu\text{A}$	
		3.0	2.9	3.0	2.9					
		4.5	4.4	4.5	4.4		V		$I_{OH} = -4 \text{ mA}$ $I_{OH} = -8 \text{ mA}$	
		3.0	2.58		2.48					
4.5	3.94		3.80							
$V_{OL}$	Low Level Output Voltage	2.0		0.0	0.1	0.1	V	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 50 \mu\text{A}$	
		3.0		0.0	0.1	0.1				
		4.5		0.0	0.1	0.1	V		$I_{OL} = 4 \text{ mA}$ $I_{OL} = 8 \text{ mA}$	
		3.0			0.36	0.50				
4.5			0.36	0.44						
$I_{OZ}$	TRI-STATE Output Off-State Current	5.5		$\pm 0.25$		$\pm 2.5$	$\mu\text{A}$	$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{OUT} = V_{CC}$ or GND		
$I_{IN}$	Input Leakage Current	0-5.5		$\pm 0.1$		$\pm 1.0$	$\mu\text{A}$	$V_{IN} = 5.5V$ or GND		
$I_{CC}$	Quiescent Supply Current	5.5		4.0		40.0	$\mu\text{A}$	$V_{IN} = V_{CC}$ or GND		

**DC Characteristics for 'VHC Family Devices:** See Section 2 for Waveforms (Continued)

Symbol	Parameter	V <sub>CC</sub> (V)	74VHC		Units	Conditions	Fig. No.
			T <sub>A</sub> = 25°C				
			Typ	Limits			
**V <sub>OLP</sub>	Quiet Output Maximum Dynamic V <sub>OL</sub>	5.0	0.6	0.9	V	C <sub>L</sub> = 50 pF	2-11, 12
**V <sub>OLV</sub>	Quiet Output Minimum Dynamic V <sub>OL</sub>	5.0	-0.6	-0.9	V	C <sub>L</sub> = 50 pF	2-11, 12
**V <sub>IHD</sub>	Minimum High Level Dynamic Input Voltage	5.0	3.5		V	C <sub>L</sub> = 50 pF	2-11, 12
**V <sub>ILD</sub>	Maximum Low Level Dynamic Input Voltage	5.0	1.5		V	C <sub>L</sub> = 50 pF	2-11, 12

\*\*Parameter guaranteed by design.

**DC Characteristics for 'VHCT Family Devices**

Symbol	Parameter	V <sub>CC</sub> (V)	74VHCT			74VHCT		Units	Conditions	
			T <sub>A</sub> = 25°C			T <sub>A</sub> = -40°C to +85°C				
			Min	Typ	Max	Min	Max			
V <sub>IH</sub>	High Level Input Voltage	4.5 5.5	2.0			2.0		V		
V <sub>IL</sub>	Low Level Input Voltage	4.5 5.5			0.8 0.8	0.8 0.8		V		
V <sub>OH</sub>	High Level Output Voltage	4.5	3.15	3.65		3.15		V	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>   I <sub>OH</sub> = -50 μA	
			2.5			2.4		V	I <sub>OH</sub> = -8 mA	
V <sub>OL</sub>	Low Level Output Voltage	4.5		0.0	0.1	0.1		V	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>   I <sub>OH</sub> = -50 μA	
					0.36	0.44		V	I <sub>OH</sub> = -8 mA	
I <sub>OZ</sub>	TRI-STATE Output Off-State Current	5.5			±0.25		±2.5	μA	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> V <sub>OUT</sub> = V <sub>CC</sub> or GND	
I <sub>IN</sub>	Input Leakage Current	0-5.5			±0.1		±1.0	μA	V <sub>IN</sub> = 5.5V or GND	
I <sub>CC</sub>	Quiescent Supply Current	5.5			4.0		40.0	μA	V <sub>IN</sub> = V <sub>CC</sub> or GND	
I <sub>CC</sub> T	Maximum I <sub>CC</sub> /Input	5.5			1.35		1.50	mA	V <sub>IN</sub> = 3.4V Other Inputs = V <sub>CC</sub> or GND	
I <sub>OPD</sub>	Output Leakage Current (Power Down State)	0.0			±0.5		+5.0	μA	V <sub>OUT</sub> = 5.5V	

**DC Characteristics for 'VHCT Family Devices:** See Section 2 for Waveforms (Continued)

Symbol	Parameter	V <sub>CC</sub> (V)	74VHCT		Units	Conditions	Fig. No.
			T <sub>A</sub> = 25°C				
			Typ	Limits			
**V <sub>OLP</sub>	Quiet Output Maximum Dynamic V <sub>OL</sub>	5.0	0.8	1.2	V	C <sub>L</sub> = 50 pF	2-11, 12
**V <sub>OLV</sub>	Quiet Output Minimum Dynamic V <sub>OL</sub>	5.0	-0.8	-1.2	V	C <sub>L</sub> = 50 pF	2-11, 12
**V <sub>IHD</sub>	Minimum High Level Dynamic Input Voltage	5.0		2.0	V	C <sub>L</sub> = 50 pF	2-11, 12
**V <sub>ILD</sub>	Maximum Low Level Dynamic Input Voltage	5.0		0.8	V	C <sub>L</sub> = 50 pF	2-11, 12

\*\*Parameter guaranteed by design.

**AC Electrical Characteristics for 'VHC Family Devices :** See Section 2 for Waveforms

Symbol	Parameter	V <sub>CC</sub> (V)	74VHC			74VHC		Units	Conditions	Fig. No.
			T <sub>A</sub> = 25°C			T <sub>A</sub> = -40°C to +85°C				
			Min	Typ	Max	Min	Max			
t <sub>PLH</sub>	Propagation Delay Time (CP to O <sub>n</sub> )	3.3 ± 0.3	8.1	12.7	1.0	15.0	ns	C <sub>L</sub> = 15 pF	2-5, 6	
t <sub>PHL</sub>			10.6	16.2	1.0	18.5			C <sub>L</sub> = 50 pF	2-5, 6
		5.0 ± 0.5	5.4	8.1	1.0	9.5	ns	C <sub>L</sub> = 15 pF	2-5, 6	
			6.9	10.1	1.0	11.5			C <sub>L</sub> = 50 pF	2-5, 6
t <sub>PZL</sub>	TRI-STATE Output Enable Time	3.3 ± 0.3	7.1	11.0	1.0	13.0	ns	R <sub>L</sub> = 1 kΩ	C <sub>L</sub> = 15 pF	2-7, 8
t <sub>PZH</sub>			9.6	14.5	1.0	16.5			C <sub>L</sub> = 50 pF	2-7, 8
		5.0 ± 0.5	5.1	7.6	1.0	9.0	ns	R <sub>L</sub> = 1 kΩ	C <sub>L</sub> = 15 pF	2-7, 8
			6.6	9.6	1.0	11.0			C <sub>L</sub> = 50 pF	2-7, 8
t <sub>PLZ</sub>	TRI-STATE Output Disable Time	3.3 ± 0.3	10.2	14.0	1.0	16.0	ns	R <sub>L</sub> = 1 kΩ	C <sub>L</sub> = 50 pF	2-7, 8
t <sub>PHZ</sub>		5.0 ± 0.5	6.1	8.8	1.0	10.0			C <sub>L</sub> = 50 pF	2-7, 8
t <sub>OSLH</sub>	Output to Output Skew	3.3 ± 0.3		1.5		1.5	ns	(Note 1)	C <sub>L</sub> = 50 pF	
t <sub>OSHL</sub>		5.0 ± 0.5		1.0		1.0			C <sub>L</sub> = 50 pF	
f <sub>MAX</sub>	Maximum Clock Frequency	3.3 ± 0.3	80	130		70	MHz	V <sub>CC</sub> = Open	C <sub>L</sub> = 15 pF	
			55	85		50			C <sub>L</sub> = 50 pF	
		5.0 ± 0.5	130	185		110			C <sub>L</sub> = 15 pF	
			85	120		75			C <sub>L</sub> = 50 pF	
C <sub>IN</sub>	Input Capacitance		4	10		10	pF	V <sub>CC</sub> = Open		

**AC Electrical Characteristics for 'VHC Family Devices** (Continued)

Symbol	Parameter	V <sub>CC</sub> (V)	74VHC			Units	Conditions	Fig. No.
			T <sub>A</sub> = 25°C					
			Min	Typ	Max			
C <sub>OUT</sub>	Output Capacitance		6			pF	V <sub>CC</sub> = 5.0V	
C <sub>PD</sub>	Power Dissipation Capacitance		32			pF	(Note 2)	

Note 1: Parameter guaranteed by design. t<sub>OSLH</sub> = |t<sub>PLH max</sub> - t<sub>PLH min</sub>|; t<sub>OSHL</sub> = |t<sub>PHL max</sub> - t<sub>PHL min</sub>|

Note 2: 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<sub>CC (opr.)</sub> = C<sub>PD</sub> \* V<sub>CC</sub> \* f<sub>IN</sub> + I<sub>CC/8</sub> (par F/F). The total C<sub>PD</sub> when n pcs. of the Octal D Flip-Flop operates can be calculated by the equation: C<sub>PD (total)</sub> = 20 + 12n.

**AC Operating Requirements for 'VHC Family Devices:** See Section 2 for Waveforms

Symbol	Parameter	V <sub>CC</sub> (V)	74VHC			74VHC		Units	Conditions	Fig. No.
			T <sub>A</sub> = 25°C			T <sub>A</sub> = -40°C to +85°C				
			Min	Typ	Max	Min	Max			
t <sub>W(H)</sub> t <sub>W(L)</sub>	Minimum Pulse Width (CP)	3.3 ± 0.3	5.0			5.5		ns		2-6
		5.0 ± 0.5	5.0			5.0				
t <sub>S</sub>	Minimum Set-Up Time	3.3 ± 0.3	4.5			4.5		ns		2-9
		5.0 ± 0.5	3.0			3.0				
t <sub>H</sub>	Minimum Hold Time	3.3 ± 0.3	2.0			2.0		ns		2-9
		5.0 ± 0.5	2.0			2.0				

**AC Electrical Characteristics for 'VHCT Family Devices:** See Section 2 for Waveforms

Symbol	Parameter	V <sub>CC</sub> (V)	74VHCT			74VHCT		Units	Conditions	Fig. No.
			T <sub>A</sub> = 25°C			T <sub>A</sub> = -40°C to +85°C				
			Min	Typ	Max	Min	Max			
t <sub>PLH</sub> t <sub>PHL</sub>	Propagation Delay Time	5.0 ± 0.5	5.6	9.4	1.0	10.5	ns	C <sub>L</sub> = 15 pF	2-5, 6	
			6.4	10.4	1.0	11.5		C <sub>L</sub> = 50 pF		
t <sub>PZL</sub> t <sub>PZH</sub>	TRI-STATE Output Enable Time	5.0 ± 0.5	6.5	10.2	1.0	11.5	ns	R <sub>L</sub> = 1 kΩ C <sub>L</sub> = 15 pF	2-7, 8	
			7.3	11.2	1.0	12.5		C <sub>L</sub> = 50 pF		
t <sub>PLZ</sub> t <sub>PHZ</sub>	TRI-STATE Output Disable Time	5.0 ± 0.5	7.0	11.2	1.0	12.0	ns	R <sub>L</sub> = 1 kΩ C <sub>L</sub> = 50 pF	2-7, 8	
t <sub>OSLH</sub> t <sub>OSHL</sub>	Output to Output Skew	5.0 ± 0.5	1.0			1.0		(Note 1)		
f <sub>MAX</sub>	Maximum Clock Frequency	5.0 ± 0.5	90	140	80			MHz	C <sub>L</sub> = 15 pF	
			85	130	75				C <sub>L</sub> = 50 pF	
C <sub>IN</sub>	Input Capacitance		4	10	10		pF	V <sub>CC</sub> = Open		

## AC Electrical Characteristics for 'VHCT Family Devices (Continued)

Symbol	Parameter	V <sub>CC</sub> (V)	74VHCT			Units	Conditions	Fig. No.
			T <sub>A</sub> = 25°C					
			Min	Typ	Max			
C <sub>OUT</sub>	Output Capacitance		9			pF	V <sub>CC</sub> = 5.0V	
C <sub>PD</sub>	Power Dissipation Capacitance		27			pF	(Note 2)	

**Note 1:** Parameter guaranteed by design.  $t_{OSLH} = |t_{PLH\ max} - t_{PLH\ min}|$ ;  $t_{OSHL} = |t_{PHL\ max} - t_{PHL\ min}|$

**Note 2:** 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:  $I_{CC\ (opr.)} = C_{PD} * V_{CC} * f_{IN} + I_{CC}/8$  (per F/F).

## AC Operating Requirements for 'VHCT Family Devices: See Section 2 for Waveforms

Symbol	Parameter	V <sub>CC</sub> (V)	74VHCT			74VHCT		Units	Conditions	Fig. No.
			T <sub>A</sub> = 25°C			T <sub>A</sub> = -40°C to +85°C				
			Min	Typ	Max	Min	Max			
t <sub>W(H)</sub> t <sub>W(L)</sub>	Minimum Pulse Width (CP)	5.0 ± 0.5	6.5			6.5		ns		2-6
t <sub>S</sub>	Minimum Set-up Time	5.0 ± 0.5	2.5			2.5		ns		2-9
t <sub>H</sub>	Minimum Hold Time	5.0 ± 0.5	2.5			2.5				