# Low-Voltage CMOS 16-Bit D-Type Flip-Flop

## With 5 V-Tolerant Inputs and Outputs (3-State, Non-Inverting)

The MC74LCX16374 is a high performance, non–inverting 16–bit D–type flip–flop operating from a 2.3 V to 3.6 V supply. The device is byte controlled. Each byte has separate Output Enable and Clock Pulse inputs. These control pins can be tied together for full 16–bit operation. High impedance TTL compatible inputs significantly reduce current loading to input drivers while TTL compatible outputs offer improved switching noise performance. A  $V_{\rm I}$  specification of 5.5 V allows MC74LCX16374 inputs to be safely driven from 5.0 V devices.

The MC74LCX16374 consists of 16 edge–triggered flip–flops with individual D–type inputs and 5.0 V–tolerant 3–state true outputs. The buffered clocks (CPn) and buffered Output Enables ( $\overline{OEn}$ ) are common to all flip–flops within the respective byte. The flip–flops will store the state of individual D inputs that meet the setup and hold time requirements on the LOW–to–HIGH Clock (CP) transition. With the  $\overline{OE}$  LOW, the contents of the flip–flops are available at the outputs. When the  $\overline{OE}$  is HIGH, the outputs go to the high impedance state. The  $\overline{OE}$  input level does not affect the operation of the flip–flops.

#### **Features**

- Designed for 2.3 to 3.6 V V<sub>CC</sub> Operation
- 6.2 ns Maximum t<sub>pd</sub>
- 5.0 V Tolerant Interface Capability With 5.0 V TTL Logic
- Supports Live Insertion and Withdrawal
- $I_{OFF}$  Specification Guarantees High Impedance When  $V_{CC} = 0 V$
- LVTTL Compatible
- LVCMOS Compatible
- 24 mA Balanced Output Sink and Source Capability
- Near Zero Static Supply Current in All Three Logic States (20 μA) Substantially Reduces System Power Requirements
- Latchup Performance Exceeds 500 mA
- ESD Performance:
  - ♦ Human Body Model >2000 V
  - ◆ Machine Model >200 V
- These Devices are Pb-Free and are RoHS Compliant



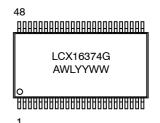
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TSSOP-48 DT SUFFIX CASE 1201

#### **MARKING DIAGRAM**



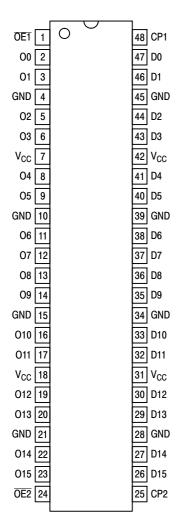
A = Assembly Location

WL = Wafer Lot YY = Year

WW = Work Week
G = Pb-Free Package

## **ORDERING INFORMATION**

See detailed ordering and shipping information in the package dimensions section on page 3 of this data sheet.



<u>OE2</u> <u>24</u> OE1 25 CP1 CP2 nCP nCP 47 36 D D D0 -D8 nCP nCP 46 35 D1 D D9 D nCP nCP 44 33 D D10 D D2 nCP nCP 43 32 D3 D11 D D nCP nCP 30 D12 -D4 D D nCP nCP 013 40 D13 -D5 D D nCP nCP 38 27 D D D6 D14 nCF nCP 37 26 D D D15 -

Figure 1. Pinout: 48-Lead (Top View)

Figure 2. Logic Diagram

Table 1. PIN NAMES

Pins	Function
<del>OEn</del>	Output Enable Inputs
CPn	Clock Pulse Inputs
D0-D15	Inputs
O0-O15	Outputs

## **TRUTH TABLE**

	Inputs		Outputs	Inputs			Outputs
CP1	OE1	D0:7	O0:7	CP2	OE2	D8:15	O8:15
1	L	Н	Н	1	L	Н	Н
1	L	L	L	1	L	L	L
L	L	Х	00	L	L	Х	00
Х	Н	Х	Z	Х	Н	Х	Z

H = High Voltage Level

L = Low Voltage Level

Z = High Impedance State

<sup>↑ =</sup> Low-to-High Transition

X = High or Low Voltage Level and Transitions Are Acceptable; for I<sub>CC</sub> reasons, DO NOT FLOAT Inputs

### **ORDERING INFORMATION**

Device	Package	Shipping <sup>†</sup>
MC74LCX16374DTG	TSSOP-48*	39 Units / Rail
MC74LCX16374DTRG	TSSOP-48* 2500 / TSSOP-48*	
M74LCX16374DTR2G	TSSOP-48*	2500 / Tape & Reel

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

### **MAXIMUM RATINGS**

Symbol	Parameter	Condition	Value	Units
V <sub>CC</sub>	DC Supply Voltage		-0.5 to +7.0	V
VI	DC Input Voltage		$-0.5 \le V_{I} \le +7.0$	V
Vo	DC Output Voltage	Output in 3-State	$-0.5 \le V_0 \le +7.0$	V
		Output in HIGH or LOW State. (Note 1)	$-0.5 \le V_{O} \le V_{CC} + 0.5$	V
I <sub>IK</sub>	DC Input Diode Current	V <sub>I</sub> < GND	-50	mA
I <sub>OK</sub>	DC Output Diode Current	V <sub>O</sub> < GND	-50	mA
		V <sub>O</sub> > V <sub>CC</sub>	+50	mA
Io	DC Output Source/Sink Current		±50	mA
I <sub>CC</sub>	DC Supply Current Per Supply Pin		±100	mA
I <sub>GND</sub>	DC Ground Current Per Ground Pin		±100	mA
T <sub>STG</sub>	Storage Temperature Range		-65 to +150	°C

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

## RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Min	Тур	Max	Units
V <sub>CC</sub>	Supply Voltage Operating Data Retention Only	2.0 1.5	2.5, 3.3 2.5, 3.3	3.6 3.6	V
VI	Input Voltage	0		5.5	V
Vo	Output Voltage (HIGH or LOW State) (3-State)	0		V <sub>CC</sub> 5.5	V
I <sub>OH</sub>	HIGH Level Output Current V <sub>CC</sub> = 3.0 V - 3.6 V V <sub>CC</sub> = 2.7 V - 3.0 V V <sub>CC</sub> = 2.3 V - 2.7 V			-24 -12 -8	mA
I <sub>OL</sub>	LOW Level Output Current  V <sub>CC</sub> = 3.0 V - 3.6 V  V <sub>CC</sub> = 2.7 V - 3.0 V  V <sub>CC</sub> = 2.3 V - 2.7 V			+24 +12 +8	mA
T <sub>A</sub>	Operating Free-Air Temperature	-55		+125	°C
Δt/ΔV	Input Transition Rise or Fall Rate, $V_{IN}$ from 0.8 V to 2.0 V, $V_{CC}$ = 3.0 V	0		10	ns/V

<sup>\*</sup>This package is inherently Pb-Free.

<sup>1.</sup> IO absolute maximum rating must be observed.

## DC ELECTRICAL CHARACTERISTICS

			T <sub>A</sub> = -55°C			
Symbol	Characteristic	Condition	Min	Max	Units	
V <sub>IH</sub>	HIGH Level Input Voltage (Note 2)	2.3 V ≤ V <sub>CC</sub> ≤ 2.7 V	1.7		V	
		2.7 V ≤ V <sub>CC</sub> ≤ 3.6 V	2.0			
V <sub>IL</sub>	LOW Level Input Voltage (Note 2)	2.3 V ≤ V <sub>CC</sub> ≤ 2.7 V		0.7	V	
		2.7 V ≤ V <sub>CC</sub> ≤ 3.6 V		0.8		
V <sub>OH</sub>	HIGH Level Output Voltage	$2.3 \text{ V} \le \text{V}_{CC} \le 3.6 \text{ V}; \text{I}_{OL} = 100 \mu\text{A}$	V <sub>CC</sub> - 0.2		V	
		$V_{CC} = 2.3 \text{ V; } I_{OH} = -8 \text{ mA}$	1.8			
		V <sub>CC</sub> = 2.7 V; I <sub>OH</sub> = -12 mA	2.2			
		V <sub>CC</sub> = 3.0 V; I <sub>OH</sub> = -18 mA	2.4			
		V <sub>CC</sub> = 3.0 V; I <sub>OH</sub> = -24 mA	2.2			
V <sub>OL</sub>	LOW Level Output Voltage	$2.3 \text{ V} \le \text{V}_{CC} \le 3.6 \text{ V}; \text{I}_{OL} = 100 \mu\text{A}$		0.2	V	
		V <sub>CC</sub> = 2.3 V; I <sub>OL</sub> = 8 mA		0.6		
		V <sub>CC</sub> = 2.7 V; I <sub>OL</sub> = 12 mA		0.4		
		V <sub>CC</sub> = 3.0 V; I <sub>OL</sub> = 16 mA		0.4		
		V <sub>CC</sub> = 3.0 V; I <sub>OL</sub> = 24 mA		0.55		
I <sub>I</sub>	Input Leakage Current	$2.3 \text{ V} \le \text{V}_{CC} \le 3.6 \text{ V}; 0 \text{ V} \le \text{V}_{I} \le 5.5 \text{ V}$		±5.0	μА	
I <sub>OZ</sub>	3-State Output Current	$2.3 \leq V_{CC} \leq 3.6 \text{ V}; \ 0V \leq V_O \leq 5.5 \text{ V}; \\ V_I = V_{IH} \text{ or V }_{IL}$		±5.0	μΑ	
I <sub>OFF</sub>	Power-Off Leakage Current	V <sub>CC</sub> = 0 V; V <sub>I</sub> or V <sub>O</sub> = 5.5 V		10	μΑ	
Icc	Quiescent Supply Current	$2.3 \le V_{CC} \le 3.6 \text{ V}; V_I = \text{GND or } V_{CC}$		20	μΑ	
		$2.3 \le V_{CC} \le 3.6 \text{ V}; \ 3.6 \le V_I \text{ or } V_O \le 5.5 \text{ V}$		±20	μΑ	
$\Delta I_{CC}$	Increase in I <sub>CC</sub> per Input	$2.3 \le V_{CC} \le 3.6 \text{ V}; V_{IH} = V_{CC} - 0.6 \text{ V}$		500	μΑ	

<sup>2.</sup> These values of  $V_{\parallel}$  are used to test DC electrical characteristics only.

## AC CHARACTERISTICS ( $t_R$ = $t_F$ = 2.5 ns; $C_L$ = 50 pF; $R_L$ = 500 $\Omega$ )

					T <sub>A</sub> = -55°C	to +125°C	;		
			V <sub>CC</sub> = 3.3 C <sub>L</sub> =	V ± 0.3 V 50 pF	V <sub>CC</sub> = C <sub>L</sub> = 5			0 V ± 0.2 V 30 pF	
Symbol	Parameter	Waveform	Min	Max	Min	Max	Min	Max	Units
f <sub>max</sub>	Clock Pulse Frequency	1	170						MHz
t <sub>PLH</sub>	Propagation Delay CP to O <sub>n</sub>	1	1.5 1.5	6.2 6.2	1.5 1.5	6.5 6.5	1.5 1.5	7.4 7.4	ns
t <sub>PZH</sub>	Output Enable Time to High and Low Level	2	1.5 1.5	6.1 6.1	1.5 1.5	6.3 6.3	1.5 1.5	7.9 7.9	ns
t <sub>PHZ</sub>	Output Disable Time From High and Low Level	2	1.5 1.5	6.0 6.0	1.5 1.5	6.2 6.2	1.5 1.5	7.2 7.2	ns
t <sub>s</sub>	Setup Time, HIGH or LOW D <sup>n</sup> to CP	1	2.5		2.5		3.0		ns
t <sub>h</sub>	Hold Time, HIGH or LOW Dn to CP	1	1.5		1.5		2.0		ns
t <sub>w</sub>	CP Pulse Width, HIGH	3	3.0		3.0		3.5		ns
toshl toslh	Output-to-Output Skew (Note 3)			1.0 1.0					ns

<sup>3.</sup> Skew is defined as the absolute value of the difference between the actual propagation delay for any two separate outputs of the same device. The specification applies to any outputs switching in the same direction, either HIGH-to-LOW (t<sub>OSHL</sub>) or LOW-to-HIGH (t<sub>OSLH</sub>); parameter guaranteed by design.

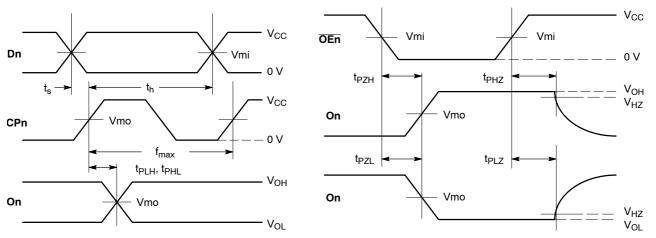
## **DYNAMIC SWITCHING CHARACTERISTICS**

			T <sub>A</sub> = +25°C		<b>C</b>	
Symbol	Characteristic	Condition	Min	Тур	Max	Units
V <sub>OLP</sub>	Dynamic LOW Peak Voltage (Note 4)	$\begin{array}{c} V_{CC} = 3.3 \text{ V}, \text{ C}_{L} = 50 \text{ pF}, \text{ V}_{IH} = 3.3 \text{ V}, \text{ V}_{IL} = 0 \text{ V} \\ V_{CC} = 2.5 \text{ V}, \text{ C}_{L} = 30 \text{ pF}, \text{ V}_{IH} = 2.5 \text{ V}, \text{ V}_{IL} = 0 \text{ V} \end{array}$		0.8 0.6		V
V <sub>OLV</sub>	Dynamic LOW Valley Voltage (Note 4)	$V_{CC} = 3.3 \text{ V}, C_L = 50 \text{ pF}, V_{IH} = 3.3 \text{ V}, V_{IL} = 0 \text{ V}$ $V_{CC} = 2.5 \text{ V}, C_L = 30 \text{ pF}, V_{IH} = 2.5 \text{ V}, V_{IL} = 0 \text{ V}$		-0.8 -0.6		V

<sup>4.</sup> Number of outputs defined as "n". Measured with "n-1" outputs switching from HIGH-to-LOW or LOW-to-HIGH. The remaining output is measured in the LOW state.

### **CAPACITIVE CHARACTERISTICS**

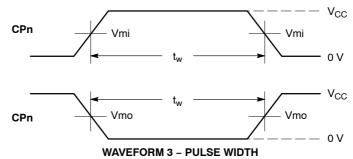
Symbol	Parameter	Condition	Typical	Units
C <sub>IN</sub>	Input Capacitance	$V_{CC}$ = 3.3 V, $V_{I}$ = 0 V or $V_{CC}$	7	pF
C <sub>OUT</sub>	Output Capacitance	$V_{CC}$ = 3.3 V, $V_{I}$ = 0 V or $V_{CC}$	8	pF
C <sub>PD</sub>	Power Dissipation Capacitance	10 MHz, $V_{CC}$ = 3.3 V, $V_{I}$ = 0 V or $V_{CC}$	20	pF



## WAVEFORM 1 - PROPAGATION DELAYS, SETUP AND HOLD TIMES

 $t_{\rm R} = t_{\rm F} = 2.5 \text{ ns}, 10\% \text{ to } 90\%; f = 1 \text{ MHz}; t_{\rm W} = 500 \text{ ns}$ 

WAVEFORM 2 – OUTPUT ENABLE AND DISABLE TIMES  $t_{R}=t_{F}=2.5 \text{ ns}, 10\% \text{ to } 90\%; f=1 \text{ MHz}; t_{W}=500 \text{ ns}$ 



 $t_R = t_F = 2.5$  ns (or fast as required) from 10% to 90%; Output requirements:  $V_{OL} \le 0.8$  V,  $V_{OH} \ge 2.0$  V

Figure 3. AC Waveforms

**Table 2. AC WAVEFORMS** 

	V <sub>CC</sub>				
Symbol	3.3 V ± 0.3 V	2.7 V	2.5 V $\pm$ 0.2 V		
Vmi	1.5 V	1.5 V	V <sub>CC</sub> / 2		
Vmo	1.5 V	1.5 V	V <sub>CC</sub> / 2		
V <sub>HZ</sub>	V <sub>OL</sub> + 0.3 V	V <sub>OL</sub> + 0.3 V	V <sub>OL</sub> + 0.15 V		
V <sub>LZ</sub>	V <sub>OH</sub> – 0.3 V	V <sub>OH</sub> – 0.3 V	V <sub>OH</sub> – 0.15 V		

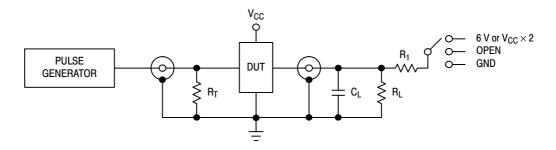


Figure 4. Test Circuit

**Table 3. TEST CIRCUIT** 

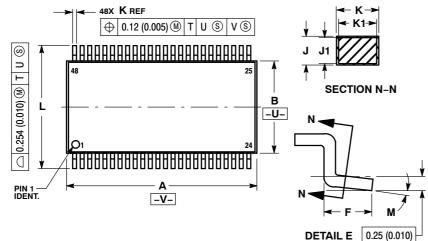
Test	Switch
t <sub>PLH</sub> , t <sub>PHL</sub>	Open
t <sub>PZL</sub> , t <sub>PLZ</sub>	6 V at $V_{CC} = 3.3 \pm 0.3 \text{ V}$ 6 V at $V_{CC} = 2.5 \pm 0.2 \text{ V}$
Open Collector/Drain t <sub>PLH</sub> and t <sub>PHL</sub>	6 V
t <sub>PZH</sub> , t <sub>PHZ</sub>	GND

 $C_L=50$  pF at  $V_{CC}=3.3\pm0.3$  V or equivalent (includes jig and probe capacitance)  $C_L=30$  pF at  $V_{CC}=2.5\pm0.2$  V or equivalent (includes jig and probe capacitance)  $R_L=R_1=500$   $\Omega$  or equivalent  $R_T=Z_{OUT}$  of pulse generator (typically 50  $\Omega$ )

### PACKAGE DIMENSIONS

## TSSOP-48 **DT SUFFIX**

CASE 1201-01 **ISSUE B** 

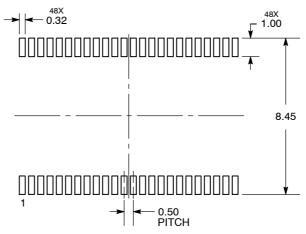


- DIMENSIONING AND TOLERANCING PER
- ANSI Y14.5M, 1982. CONTROLLING DIMENSION: MILLIMETER.
- DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS
- SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
  DIMENSION K DOES NOT INCLUDE DAMBAR
  PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE K DIMENSION AT MAXIMUM MATERIAL CONDITION.
- MAXIMUM MATERIAL CONDITION.
  TERMINAL NUMBERS ARE SHOWN FOR
  REFERENCE ONLY.
  DIMENSIONS A AND B ARE TO BE
  DETERMINED AT DATUM PLANE -W-.

	MILLIN	IETERS	INC	HES	
DIM	MIN	MAX	MIN	MAX	
Α	12.40	12.60	0.488	0.496	
В	6.00	6.20	0.236	0.244	
С		1.10		0.043	
D	0.05 0.15 0.002		0.002	0.006	
F	0.50	0.75	0.020	0.030	
G	0.50	BSC	0.0197 BSC		
Н	0.37		0.015		
J	0.09	0.20	0.004	0.008	
J1	0.09	0.16	0.004	0.006	
Κ	0.17	0.27	0.007	0.011	
K1	0.17	0.23	0.007	0.009	
L	7.95	8.25	0.313	0.325	
М	0 0	00	0 0	00	

## ☐ 0.076 (0.003) **DETAIL E** -T- SEATING PLANE

#### **RECOMMENDED SOLDERING FOOTPRINT**



**DIMENSIONS: MILLIMETERS** 

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