



# High Speed CMOS 3.3V 18-Bit Registered Transceivers

QS74LCX16501

## FEATURES/BENEFITS

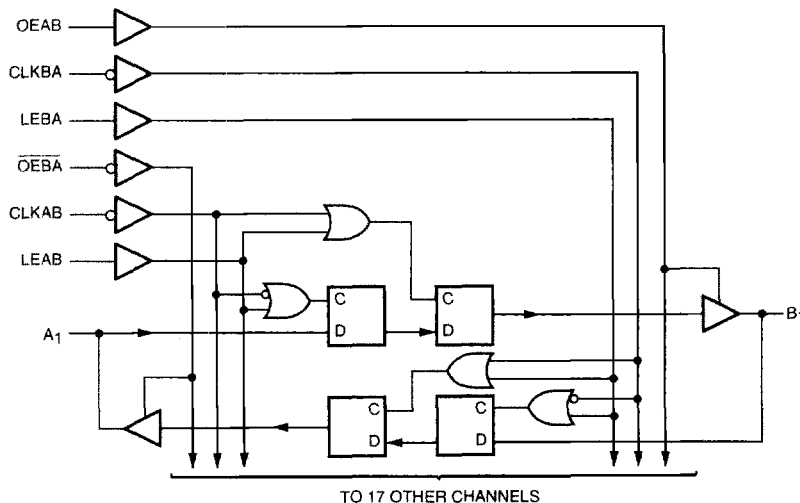
- 5V tolerant inputs and outputs
- Industry standard pinouts
- $10\mu\text{A}$   $I_{\text{CCQ}}$  quiescent power supply current
- Hot insertable
- 2.0V – 3.6V  $V_{\text{CC}}$  supply operation
- $\pm 24\text{mA}$  balanced output drive
- Meets or exceeds JEDEC Standard 36 specifications
- $t_{\text{PD}} = 4.6\text{ns}$
- Input hysteresis for noise immunity
- Multiple power and ground pins for low noise
- Operating temperature range:  
–40°C to +85°C
- Latch-up performance exceeds 500mA
- ESD performance:  
Human body model > 2000V  
Machine model > 200V
- Packages available:  
56-pin TSSOP  
56-pin SSOP

## DESCRIPTION

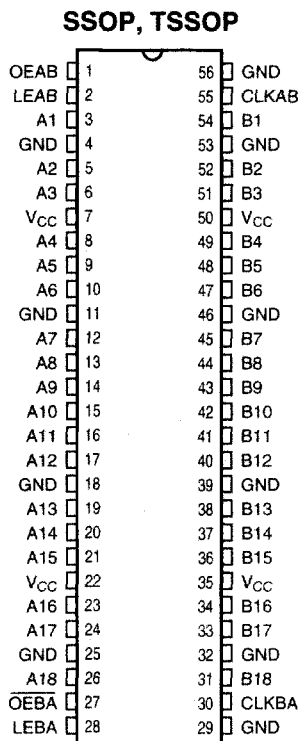
The LCX16501 is an 18-bit registered bus transceiver with three-state outputs that are ideal for driving address and data buses. These high-speed, low-power registered transceivers combine D-type latches and D-type flip-flops to allow data flow in transparent, latched and clocked modes. The 3.3V LCX family features low power, low switching noise, and fast switching speeds for low power portable applications as well as high-end advanced workstation applications. 5V tolerant inputs and outputs allow this LCX product to be used in mixed 5V and 3.3V applications. Easy board layout is facilitated by the use of flow-through pinouts and byte enable controls provide architectural flexibility for systems designers. To accommodate hot-plug or live insertion applications, of this product is designed not to load an active bus when  $V_{\text{CC}}$  is removed.

3

Figure 1. Functional Block Diagram



**Figure 2. Pin Configuration**  
(All Pins Top View)



**Table 1. Pin Description**

Name	Description
OEAB	A-to-B Output Enable Input
$\overline{OEBA}$	B-to-A Output Enable Input (Active Low)
LEAB	A-to-B Latch Enable Input
LEBA	B-to-A Latch Enable Input
CLKAB	A-to-B Clock Input
CLKBA	B-to-A Clock Input
Ax	A-to-B Data Inputs or B-to-A 3-State Outputs
Bx	B-to-A Data Inputs or A-to-B 3-State Outputs

**Table 2. Function Table <sup>(1)</sup>**

Inputs				Outputs
OEAB	LEAB	CLKAB	Ax	Bx
L	X	X	X	Z
H	H	X	L	L
H	H	X	H	H
H	L	↑	L	L
H	L	↑	H	H
H	L	H	X	B <sup>(2)</sup>
H	L	L	X	B <sup>(3)</sup>

**Notes:**

1. A-to-B data flow is shown. B-to-A data flow is similar but uses  $\overline{OEBA}$ , LEBA, and CLKBA.
2. Output level before the indicated steady-state input conditions were established.
3. Output level before the indicated steady-state input conditions were established, provided that CLKAB was LOW before LEAB went LOW.

**Table 3. Capacitance**

Symbol	Pins	Typ	Unit	Conditions
$C_{IN}$	Input Capacitance	7.0	pF	$V_{IN} = 0V, V_{OUT} = 0V, f = 1MHz$
$C_{I/O}$	I/O Capacitance	8.0	pF	$V_{IN} = 0V, V_{OUT} = 0V, f = 1MHz$
$C_{PD}$	Power Dissipation Capacitance	25	pF	$V_{CC} = 3.3V, V_{IN} = 0 \text{ or } V_{CC}$ $f = 10MHz$

**Note:** Capacitance is characterized but not production tested.

**Table 4. Absolute Maximum Ratings**

Supply Voltage to Ground .....	-0.5V to +7.0V
DC Output Voltage $V_{OUT}$	
Outputs HIGH-Z .....	-0.5V to +7.0V
Outputs Active .....	-0.5V to $V_{CC} + 0.5V$
DC Input Voltage $V_{IN}$ .....	-0.5V to +7.0V
DC Input Diode Current with $V_{IN} < 0$ .....	-50mA
DC Output Diode Current	
$V_O < 0$ .....	-50mA
$V_O > V_{CC}$ .....	+50mA
DC Output Source/Sink Current ( $I_{OH}/I_{OL}$ ) .....	$\pm 50mA$
DC Supply Current per Supply Pin .....	$\pm 100mA$
DC Ground Current per Ground Pin .....	$\pm 100mA$
$T_{STG}$ Storage Temperature .....	-65° to +150°C

**Note:** Stresses greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to this device resulting in functional or reliability type failures.

**Table 5. Recommended Operating Conditions**

Symbol	Parameter	Min	Max	Unit
$V_{CC}$	Supply Voltage, Operating	2.0	3.6	V
	Supply Voltage, Data Retention Only	1.5	3.6	
$V_{IN}$	Input Voltage	0	5.5	V
$V_{OUT}$	Output Voltage in Active State	0	$V_{CC}$	V
	Output Voltage in "OFF" State	0	5.5	
$I_{OH}/I_{OL}$	Output Current	$V_{CC} = 3.0 - 3.6V$	$\pm 24$	mA
		$V_{CC} = 2.7V$	$\pm 12$	
$\Delta t/\Delta V$	Input Transition Slew Rate	—	10	ns/V
$T_A$	Operating Free Air Temperature	-40	+85	°C

**Table 6. DC Electrical Characteristics Over Operating Range**Industrial Temperature Range,  $T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ 

Symbol	Parameter	Test Conditions	Min	Typ <sup>(1)</sup>	Max	Unit
$V_{IH}$	Input HIGH Voltage	Logic HIGH for All Inputs	2.0	—	—	V
$V_{IL}$	Input LOW Voltage	Logic LOW for All Inputs	—	—	0.8	V
$V_{OH}$	Output HIGH Voltage	$V_{CC} = 2.7\text{V}$ , $I_{OH} = -100\mu\text{A}$ $V_{CC} = 2.7\text{V}$ , $I_{OH} = -12\text{mA}$ $V_{CC} = 3.0\text{V}$ , $I_{OH} = -18\text{mA}$ $V_{CC} = 3.0\text{V}$ , $I_{OH} = -24\text{mA}$	$V_{CC}-0.2$ 2.2 2.4 2.2	— — — —	— — — —	V
$V_{OL}$	Output LOW Voltage	$V_{CC} = 2.7\text{V}$ , $I_{OL} = 100\mu\text{A}$ $V_{CC} = 2.7\text{V}$ , $I_{OL} = 12\text{mA}$ $V_{CC} = 3.0\text{V}$ , $I_{OL} = 16\text{mA}$ $V_{CC} = 3.0\text{V}$ , $I_{OL} = 24\text{mA}$	— — — —	— — — —	0.2 0.4 0.4 0.5	V
$\Delta V_T$	Input Hysteresis <sup>(2)</sup>	$V_{TLH} - V_{THL}$ for All Inputs	—	150	—	mV
$I_I$	Input Leakage Current	$V_I = 0\text{V}$ , $V_I = 5.5\text{V}$	—	—	$\pm 1.0$	$\mu\text{A}$
$I_{OZ}$	High-Z I/O Leakage	$V_O = 0\text{V}$ , $V_O = 5.5\text{V}$ $V_I = V_{IH}$ or $V_{IL}$	—	—	$\pm 1.0$	$\mu\text{A}$
$I_{OS}$	Short Circuit Current <sup>(2,3)</sup>	$V_{CC} = 3.6\text{V}$ , $V_O = \text{GND}$	-60	—	-240	mA
$I_{OFF}$	Power Off Leakage	$V_{CC} = 0\text{V}$ , $V_I$ or $V_O = 5.5\text{V}$	—	—	10	$\mu\text{A}$
$V_{IK}$	Input Clamp Voltage	$V_{CC} = 2.7\text{V}$ , $I_{IN} = -18\text{mA}$	—	-0.7	-1.2	V

**Notes:** 1. Typical values are at  $V_{CC} = 3.3\text{V}$ , and  $T_A = 25^{\circ}\text{C}$ .

2. These parameters are guaranteed by characterization but not production tested.

3. Not more than one output should be tested at one time. Duration of test should not exceed one second.

**Table 7. Power Supply Characteristics**

Symbol	Parameter	Test Conditions <sup>(1)</sup>	Typ <sup>(2)</sup>	Max	Unit	
$I_{CC}$	Quiescent Power Supply Current	$V_{CC} = 3.6V$ , Freq. = 0 $V_{IN} = GND$ or $V_{CC}$	0.1	10	$\mu A$	
$\Delta I_{CC}$	Supply Current per Input @ TTL HIGH	$V_{CC} = 3.6V$ , $V_{IN} = V_{CC} - 0.6V$ <sup>(3)</sup>	2.0	30	$\mu A$	
$I_{CCD}$	Supply Current per Input per MHz <sup>(4)</sup>	$V_{CC} = 3.6V$ , Outputs Open One Bit Toggling @ 50% Duty Cycle OEAB = OEBA = $V_{CC}$ LEAB = GND	$V_{IN} = V_{CC}$ $V_{IN} = GND$	100	130	$\mu A$ / MHz
$I_C$	Total Power Supply Current <sup>(6)</sup>	$V_{CC} = 3.6V$ , Outputs Open One Bit Toggling @ 50% Duty Cycle $f_{CP} = 10MHz$ (CLKAB) OEAB = OEBA = $V_{CC}$ LEAB = GND $f_i = 5MHz$	$V_{IN} = V_{CC} - 0.6V$ $V_{IN} = GND$	0.5 <sup>(5)</sup>	0.8 <sup>(5)</sup>	mA
		$V_{CC} = 3.6V$ , Outputs Open Eighteen Bits Toggling @ 50% Duty Cycle $f_{CP} = 10MHz$ (CLKAB) OEAB = OEBA = $V_{CC}$ LEAB = GND $f_i = 2.5MHz$	$V_{IN} = V_{CC} - 0.6V$ $V_{IN} = GND$	4.6 <sup>(5)</sup>	6.2 <sup>(5)</sup>	mA

3

**Notes:**

- For conditions shown as Min. or Max., use the appropriate values specified under Recommended Operating Conditions for applicable device type.
- Typical values are at  $V_{CC} = 3.3V$ , +25°C ambient.
- Per TTL driven input. All Other Inputs at  $V_{CC}$  or GND.
- This parameter is not directly testable, but is derived for use in Total Power Supply Calculations.
- Values for these conditions are examples of the  $I_{CC}$  formula. These limits are guaranteed by design but not tested.
- $I_C = I_{QUIESCENT} + I_{INPUTS} + I_{DYNAMIC}$   
 $I_C = I_{CCQ} + \Delta I_{CC} D_H N_T + I_{CCD} f N_O$   
 $I_{CCQ}$  = Quiescent Current ( $I_{CCL}$ ,  $I_{CCH}$ , and  $I_{CCZ}$ ).  
 $\Delta I_{CC}$  = Power Supply Current for a TTL-High Input ( $V_{IN} = V_{CC} - 0.6V$ ).  
 $D_H$  = Duty Cycle for TTL High Inputs.  
 $N_T$  = Number of TTL High Inputs.  
 $I_{CCD}$  = Dynamic Current Caused by an Input Transition Pair (HLH or LHL).  
 $f$  = Average Switching Frequency per Output.  
 $N_O$  = Number of Outputs Switching.

**Table 8. Dynamic Switching Characteristics<sup>(1)</sup>**

Symbol	Parameter	Conditions	$V_{CC}$ (V)	$T_A = 25^\circ C$	Units
				Typical	
$V_{OLP}$	Quiet Output Dynamic Peak $V_{OL}$	$C_L = 50pF$ , $V_{IH} = 3.3V$ , $V_{IL} = 0V$	3.3	0.8	V
$V_{OLV}$	Quiet Output Dynamic Valley $V_{OL}$	$C_L = 50pF$ , $V_{IH} = 3.3V$ , $V_{IL} = 0V$	3.3	0.8	V

**Note:**

- Characterized but not production tested.

**Table 9. Switching Characteristics Over Operating Range**Industrial Temperature Range,  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$  $C_{\text{LOAD}} = 50\text{pF}$ ,  $R_{\text{LOAD}} = 500\Omega$  unless otherwise noted.

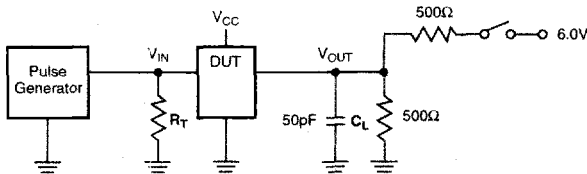
Symbol	Description <sup>(1)</sup>	LCX16501				LCX16501C		Unit	
		$V_{\text{CC}} = 3.3 \pm 0.3\text{V}$		$V_{\text{CC}} = 2.7\text{V}^{(2)}$		$V_{\text{CC}} = 3.3 \pm 0.3\text{V}$			
		Min.	Max.	Min.	Max.	Min.	Max.		
$f_{\text{MAX}}$	CLKAB or CLKBA Frequency <sup>(2)</sup>	170	—	—	—	170	—	MHz	
$t_{\text{PHL}}$ $t_{\text{PLH}}$	Propagation Delay Ax to Bx or Bx to Ax	1.5	6.0	1.5	7.0	1.5	4.6	ns	
$t_{\text{PHL}}$ $t_{\text{PLH}}$	Propagation Delay LEBA to Ax, LEAB to Bx	1.5	7.0	1.5	8.0	1.5	5.3	ns	
$t_{\text{PHL}}$ $t_{\text{PLH}}$	Propagation Delay CLKBA to Ax, CLKAB to Bx	1.5	6.7	1.5	8.0	1.5	5.3	ns	
$t_{\text{PZH}}$ $t_{\text{PZL}}$	Output Enable Time $\overline{\text{OEBA}}$ to Ax, OEAB to Bx	1.5	7.2	1.5	8.2	1.5	5.6	ns	
$t_{\text{PHZ}}$ $t_{\text{PLZ}}$	Output Disable Time <sup>(2)</sup> $\overline{\text{OEBA}}$ to Ax, OEAB to Bx	1.5	7.0	1.5	8.0	1.5	5.2	ns	
$t_{\text{SU}}$	Setup Time HIGH or LOW Ax to CLKAB, Bx to CLKBA	2.5	—	3.0	—	3.0	—	ns	
$t_{\text{H}}$	Hold Time HIGH or LOW Ax to CLKAB, Bx to CLKBA	0	—	0	—	0	—	ns	
$t_{\text{SU}}$	Setup Time HIGH or Low Ax to LEAB Bx to LEBA	Clock LOW	2.5	—	2.5	—	1.5	—	ns
		Clock HIGH	2.5	—	2.5	—	2.0	—	ns
$t_{\text{H}}$	Hold Time HIGH or LOW Ax to LEAB, Bx to LEBA	1.5	—	1.5	—	1.5	—	ns	
$t_{\text{W}}$	Pulse Width <sup>(2)</sup>	3.0	—	3.0	—	3.0	—	ns	
$t_{\text{SK(O)}}$	Output Skew <sup>(3)</sup>	—	0.5	—	0.5	—	0.5	ns	

**Notes:**

1. See test circuit and waveforms. Minimum Limits are guaranteed but not tested on Propagation Delays.
2. Guaranteed by characterization.
3. Skew between any two outputs, of the same package, switching in the same direction. This parameter is guaranteed by characterization but not production tested.

TEST CIRCUIT AND WAVEFORMS

Figure 3. Test Circuit



SWITCH POSITION

Test	Switch
Open Drain	
Disable LOW	6V
Enable LOW	
Disable HIGH	GND
Enable HIGH	
All Other Inputs	Open

DEFINITIONS:

$C_L$  = Load capacitance: includes jig and probe capacitance.  
 $R_T$  = Termination resistance: should be equal to  $Z_{OUT}$  of the Pulse generator.

Figure 4. Setup, Hold, and Release Timing

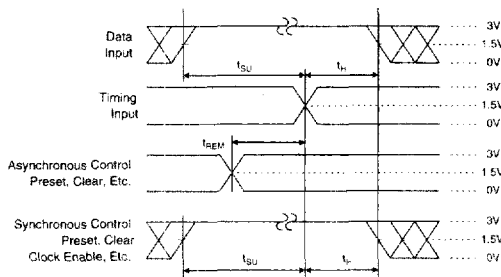


Figure 6. Pulse Width

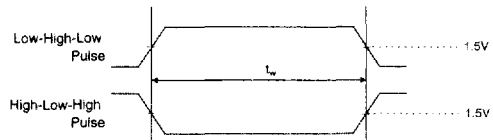


Figure 5. Enable and Disable Timing

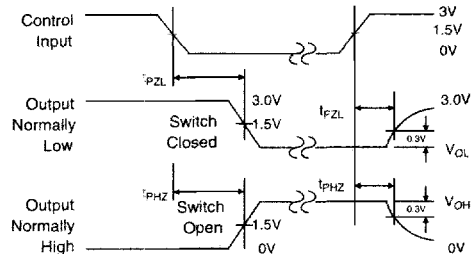
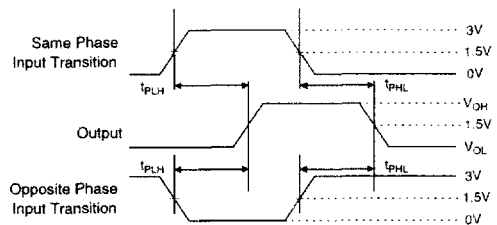


Figure 7. Propagation Delay



Notes:

1. Input Control Enable = LOW and input Control Disable = HIGH.
2. Pulse Generator for All Pulses: Rate  $\leq$  1.0MHz;  
 $Z_{OUT} \leq 50\Omega$ ;  $t_F$ ,  $t_R \leq 2.5$ ns.