



Integrated Device Technology, Inc.

### 3.3V CMOS 18-BIT REGISTERED TRANSCEIVER

IDT74FCT163501/A/C

#### FEATURES:

- 0.5 MICRON CMOS Technology
- **Typical tsk(o) (Output Skew) < 250ps**
- ESD > 2000V per MIL-STD-883, Method 3015; > 200V using machine model (C = 200pF, R = 0)
- Packages include 25 mil pitch SSOP, 19.6 mil pitch TSSOP and 15.7 mil pitch TVSOP
- Extended commercial range of -40°C to +85°C
- VCC = 3.3V ±0.3V, Normal Range or VCC = 2.7 to 3.6V, Extended Range
- CMOS power levels (0.4µW typ. static)
- Rail-to-Rail output swing for increased noise margin
- Low Ground Bounce (0.3V typ.)
- Inputs (except I/O) can be driven by 3.3V or 5V components

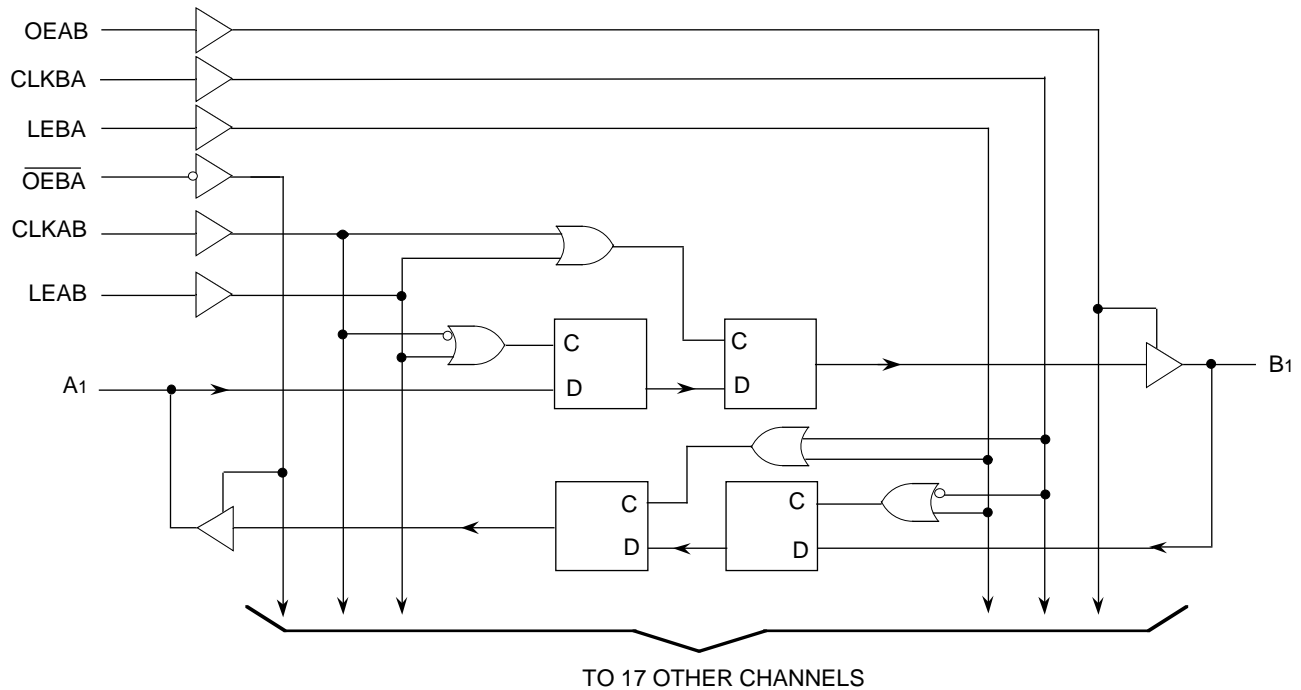
#### DESCRIPTION:

The FCT163501/A/C 18-bit registered transceivers are built using advanced dual metal CMOS technology. These

high-speed, low-power 18-bit registered bus transceivers combine D-type latches and D-type flip-flops to allow data flow in transparent, latched and clocked modes. Data flow in each direction is controlled by output-enable (OEAB and OEBA), latch enable (LEAB and LEBA) and clock (CLKAB and CLKBA) inputs. For A-to-B data flow, the device operates in transparent mode when LEAB is HIGH. When LEAB is LOW, the A data is latched if CLKAB is held at a HIGH or LOW logic level. If LEAB is LOW, the A bus data is stored in the latch/flip-flop on the LOW-to-HIGH transition of CLKAB. OEAB performs the output enable function on the B port. Data flow from B port to A port is similar but requires using OEBA, LEBA and CLKBA. Flow-through organization of signal pins simplifies layout. All inputs are designed with hysteresis for improved noise margin.

The FCT163501/A/C have series current limiting resistors. These offer low ground bounce, minimal undershoot, and controlled output fall times-reducing the need for external series terminating resistors.

#### FUNCTIONAL BLOCK DIAGRAM



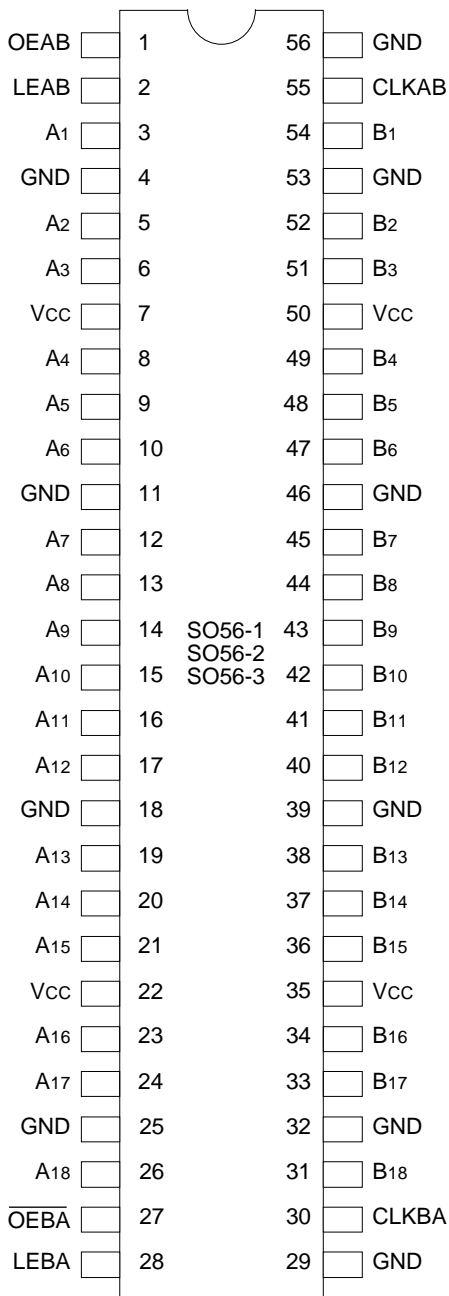
2776 drw 01

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COMMERCIAL TEMPERATURE RANGE

AUGUST 1996

## PIN CONFIGURATIONS



SSOP/  
TSSOP/TVSOP  
TOP VIEW

2776 drw02

## CAPACITANCE (TA = +25°C, f = 1.0MHz)

Symbol	Parameter <sup>(1)</sup>	Conditions	Typ.	Max.	Unit
C <sub>IN</sub>	Input Capacitance	V <sub>IN</sub> = 0V	3.5	6.0	pF
C <sub>I/O</sub>	I/O Capacitance	V <sub>OUT</sub> = 0V	3.5	8.0	pF

2776 Ink 04

**NOTE:**

1. This parameter is measured at characterization but not tested.

## PIN DESCRIPTION

Pin Names	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

2776 tbl 01

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

Symbol	Description	Max.	Unit
V <sub>TERM</sub> <sup>(2)</sup>	Terminal Voltage with Respect to GND	-0.5 to +4.6	V
V <sub>TERM</sub> <sup>(3)</sup>	Terminal Voltage with Respect to GND	-0.5 to +7.0	V
V <sub>TERM</sub> <sup>(4)</sup>	Terminal Voltage with Respect to GND	-0.5 to V <sub>CC</sub> + 0.5	V
T <sub>STG</sub>	Storage Temperature	-65 to +150	°C
I <sub>OUT</sub>	DC Output Current	-60 to +60	mA

**NOTES:**

2776 Ink 03

- Stresses greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.
- V<sub>CC</sub> terminals.
- Input terminals.
- Output and I/O terminals.

## FUNCTION TABLE<sup>(1,4)</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	L	X	B <sup>(2)</sup>	
H	L	H	X	B <sup>(3)</sup>	

**NOTES:**

2776 tbl 02

- A-to-B data flow is shown. B-to-A data flow is similar but uses OEBA, LEBA, and CLKBA.
- Output level before the indicated steady-state input conditions were established.
- Output level before the indicated steady-state input conditions were established, provided that CLKAB was HIGH before LEAB went LOW.
- H = HIGH Voltage Level  
L = LOW Voltage Level  
X = Don't Care  
Z = High Impedance  
↑ = LOW-to-HIGH Transition

## DC ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE

Following Conditions Apply Unless Otherwise Specified:  
Commercial:  $T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $V_{CC} = 2.7\text{V}$  to  $3.6\text{V}$

Symbol	Parameter	Test Conditions <sup>(1)</sup>	Min.	Typ. <sup>(2)</sup>	Max.	Unit	
$V_{IH}$	Input HIGH Level (Input pins)	Guaranteed Logic HIGH Level	2.0	—	5.5	V	
	Input HIGH Level (I/O pins)		2.0	—	$V_{CC}+0.5$		
$V_{IL}$	Input LOW Level (Input and I/O pins)	Guaranteed Logic LOW Level	-0.5	—	0.8	V	
$I_{IH}$	Input HIGH Current (Input pins)	$V_{CC} = \text{Max.}$	$V_I = 5.5\text{V}$	—	—	$\pm 1$	$\mu\text{A}$
	Input HIGH Current (I/O pins)		$V_I = V_{CC}$	—	—	$\pm 1$	
$I_{IL}$	Input LOW Current (Input pins)		$V_I = \text{GND}$	—	—	$\pm 1$	
	Input LOW Current (I/O pins)		$V_I = \text{GND}$	—	—	$\pm 1$	
$I_{OZH}$	High Impedance Output Current (3-State Output pins)	$V_{CC} = \text{Max.}$	$V_O = V_{CC}$	—	—	$\pm 1$	$\mu\text{A}$
$I_{OZL}$			$V_O = \text{GND}$	—	—	$\pm 1$	
$V_{IK}$	Clamp Diode Voltage	$V_{CC} = \text{Min.}, I_{IN} = -18\text{mA}$	—	-0.7	-1.2	V	
$I_{ODH}$	Output HIGH Current	$V_{CC} = 3.3\text{V}, V_{IN} = V_{IH}$ or $V_{IL}, V_O = 1.5\text{V}^{(3)}$	-36	-60	-110	mA	
$I_{ODL}$	Output LOW Current	$V_{CC} = 3.3\text{V}, V_{IN} = V_{IH}$ or $V_{IL}, V_O = 1.5\text{V}^{(3)}$	50	90	200	mA	
$V_{OH}$	Output HIGH Voltage	$V_{CC} = \text{Min.}$	$I_{OH} = -0.1\text{mA}$	$V_{CC}-0.2$	—	—	V
		$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -3\text{mA}$	2.4	3.0	—	
		$V_{CC} = 3.0\text{V}$ $V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -8\text{mA}$	2.4 <sup>(5)</sup>	3.0	—	
$V_{OL}$	Output LOW Voltage	$V_{CC} = \text{Min.}$ $V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 0.1\text{mA}$	—	—	0.2	V
			$I_{OL} = 16\text{mA}$	—	0.2	0.4	
			$I_{OL} = 24\text{mA}$	—	0.3	0.55	
		$V_{CC} = 3.0\text{V}$ $V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 24\text{mA}$	—	0.3	0.50	
$I_{OS}$	Short Circuit Current <sup>(4)</sup>	$V_{CC} = \text{Max.}, V_O = \text{GND}^{(3)}$	-60	-135	-240	mA	
$V_H$	Input Hysteresis	—	—	150	—	mV	
$I_{CCL}$ $I_{CCH}$ $I_{CCZ}$	Quiescent Power Supply Current	$V_{CC} = \text{Max.},$ $V_{IN} = \text{GND}$ or $V_{CC}$	—	0.1	10	$\mu\text{A}$	

**NOTES:**

- For conditions shown as Max. or Min., use appropriate value specified under Electrical Characteristics for the applicable device type.
- Typical values are at  $V_{CC} = 3.3\text{V}, +25^{\circ}\text{C}$  ambient.
- Not more than one output should be tested at one time. Duration of the test should not exceed one second.
- This parameter is guaranteed but not tested.
- $V_{OH} = V_{CC} - 0.6\text{V}$  at rated current.

2776 Ink 05

## POWER SUPPLY CHARACTERISTICS

Symbol	Parameter	Test Conditions <sup>(1)</sup>		Min.	Typ. <sup>(2)</sup>	Max.	Unit
$\Delta I_{CC}$	Quiescent Power Supply Current TTL Inputs HIGH	$V_{CC} = \text{Max.}$	$V_{IN} = V_{CC} - 0.6V^{(3)}$	—	2.0	30	$\mu A$
$I_{CCD}$	Dynamic Power Supply Current <sup>(4)</sup>	$V_{CC} = \text{Max.}$ Outputs Open $OEAB = \overline{OEBA} = V_{CC}$ or GND 50% Duty Cycle One Input Toggling	$V_{IN} = V_{CC}$ $V_{IN} = GND$	—	60	100	$\mu A/$ MHz
$I_C$	Total Power Supply Current <sup>(6)</sup>	$V_{CC} = \text{Max.}$ Outputs Open $f_{CP} = 10\text{MHz (CLKAB)}$ 50% Duty Cycle $OEAB = \overline{OEBA} = V_{CC}$ LEAB = GND $f_i = 5\text{MHz}$ 50% Duty Cycle One Bit Toggling	$V_{IN} = V_{CC}$ $V_{IN} = GND$	—	0.6	1.0	mA
			$V_{IN} = V_{CC} - 0.6V$ $V_{IN} = GND$	—	0.6	1.0	
		$V_{CC} = \text{Max.}$ Outputs Open $f_{CP} = 10\text{MHz (CLKAB)}$ 50% Duty Cycle $OEAB = \overline{OEBA} = V_{CC}$ LEAB = GND $f_i = 2.5\text{MHz}$ 50% Duty Cycle Eighteen Bits Toggling	$V_{IN} = V_{CC}$ $V_{IN} = GND$	—	3.0	5.0 <sup>(5)</sup>	
			$V_{IN} = V_{CC} - 0.6V$ $V_{IN} = GND$	—	3.0	5.3 <sup>(5)</sup>	

### NOTES:

2776 tbi 08

- For conditions shown as max. or min., use appropriate value specified under Electrical Characteristics for the applicable device type.
- Typical values are at  $V_{CC} = 3.3V$ ,  $+25^\circ C$  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 but not tested.
- $I_C = I_{QUIESCENT} + I_{INPUTS} + I_{DYNAMIC}$   
 $I_C = I_{CC} + \Delta I_{CC} D_H N_T + I_{CCD} (f_{CP} N_{CP} / 2 + f_i N_i)$   
 $I_{CC} = \text{Quiescent Current (} I_{CCL}, I_{CCH} \text{ and } I_{CCZ})$   
 $\Delta I_{CC} = \text{Power Supply Current for a TTL High Input}$   
 $D_H = \text{Duty Cycle for TTL Inputs High}$   
 $N_T = \text{Number of TTL Inputs at } D_H$   
 $I_{CCD} = \text{Dynamic Current Caused by an Input Transition Pair (HLH or LHL)}$   
 $f_{CP} = \text{Clock Frequency for Register Devices (Zero for Non-Register Devices)}$   
 $N_{CP} = \text{Number of Clock Inputs at } f_{CP}$   
 $f_i = \text{Input Frequency}$   
 $N_i = \text{Number of Inputs at } f_i$

### SWITCHING CHARACTERISTICS OVER OPERATING RANGE<sup>(4)</sup>

Symbol	Parameter	Condition <sup>(1)</sup>	FCT163501		FCT163501A		FCT163501C		Unit
			Min. <sup>(2)</sup>	Max.	Min. <sup>(2)</sup>	Max.	Min. <sup>(2)</sup>	Max.	
f <sub>MAX</sub>	CLKAB or CLKBA frequency	CL = 50pF	—	100	—	150	—	150	MHz
t <sub>PLH</sub> t <sub>PHL</sub>	Propagation Delay Ax to Bx or Bx to Ax	RL = 500Ω	1.5	6.5	1.5	5.1	1.5	4.6	ns
t <sub>PLH</sub> t <sub>PHL</sub>	Propagation Delay LEBA to Ax, LEAB to Bx		1.5	7.5	1.5	5.6	1.5	5.3	ns
t <sub>PLH</sub> t <sub>PHL</sub>	Propagation Delay CLKBA to Ax, CLKAB to Bx		1.5	8.0	1.5	5.6	1.5	5.3	ns
t <sub>PZH</sub> t <sub>PZL</sub>	Output Enable Time OEBA to Ax, OEAB to Bx		1.5	8.0	1.5	6.0	1.5	5.6	ns
t <sub>PHZ</sub> t <sub>PLZ</sub>	Output Disable Time OEBA to Ax, OEAB to Bx		1.5	7.5	1.5	5.6	1.5	5.2	ns
t <sub>SU</sub>	Set-up Time, HIGH or LOW Ax to CLKAB, Bx to CLKBA		4.0	—	3.0	—	3.0	—	ns
t <sub>H</sub>	Hold Time, HIGH or LOW Ax to CLKAB, Bx to CLKBA		0	—	0	—	0	—	ns
t <sub>SU</sub>	Set-up Time HIGH or LOW Ax to LEAB, Bx to LEBA	Clock LOW	4.0	—	3.0	—	3.0	—	ns
		Clock HIGH	1.5	—	1.5	—	1.5	—	ns
t <sub>H</sub>	Hold Time HIGH or LOW Ax to LEAB, Bx to LEBA		1.5	—	1.5	—	1.5	—	ns
t <sub>w</sub>	LEAB or LEBA Pulse Width HIGH <sup>(5)</sup>		3.0	—	3.0	—	3.0	—	ns
t <sub>w</sub>	CLKAB or CLKBA Pulse Width HIGH or LOW <sup>(5)</sup>		3.0	—	3.0	—	3.0	—	ns
t <sub>SK(o)</sub>	Output Skew <sup>(3)</sup>		—	0.5	—	0.5	—	0.5	ns

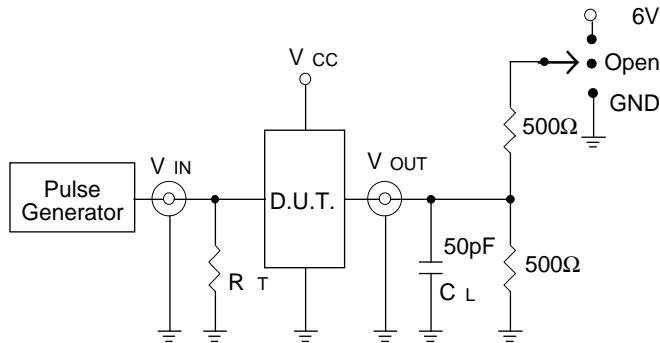
**NOTES:**

1. See test circuit and waveforms.
2. Minimum limits are guaranteed but not tested on Propagation Delays.
3. Skew between any two outputs, of the same package, switching in the same direction. This parameter is guaranteed by design.
4. Propagation Delays and Enable/Disable times are with V<sub>CC</sub> = 3.3V ± 0.3V, Normal Range. For V<sub>CC</sub> = 2.7V to 3.6V, Extended Range, all Propagation Delays and Enable/Disable times should be degraded by 20%.
5. This parameter is guaranteed but not tested.

2776 tbl 07

## TEST CIRCUITS AND WAVEFORMS

### TEST CIRCUITS FOR ALL OUTPUTS



2776 drw 05

### SWITCH POSITION

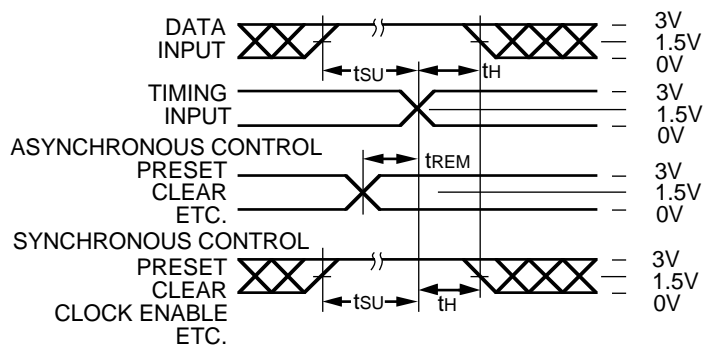
Test	Switch
Open Drain Disable Low Enable Low	6V
Disable High Enable High	GND
All Other tests	Open

#### DEFINITIONS:

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

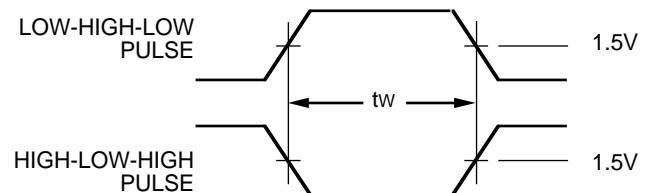
2776 Ink 08

### SET-UP, HOLD AND RELEASE TIMES



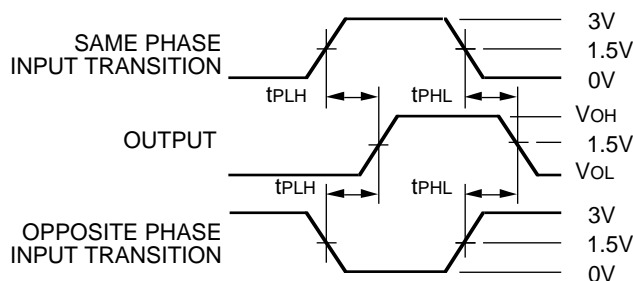
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### PULSE WIDTH



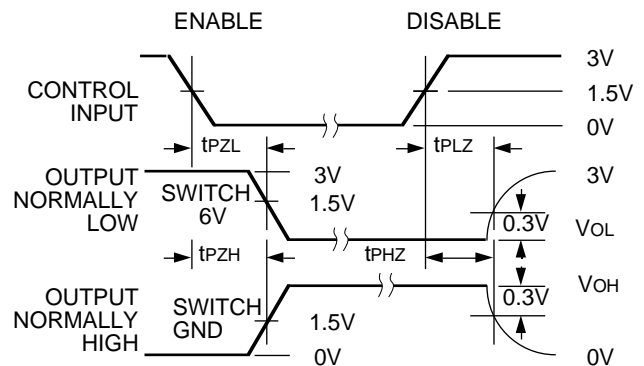
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### PROPAGATION DELAY



2776 drw 08

### ENABLE AND DISABLE TIMES

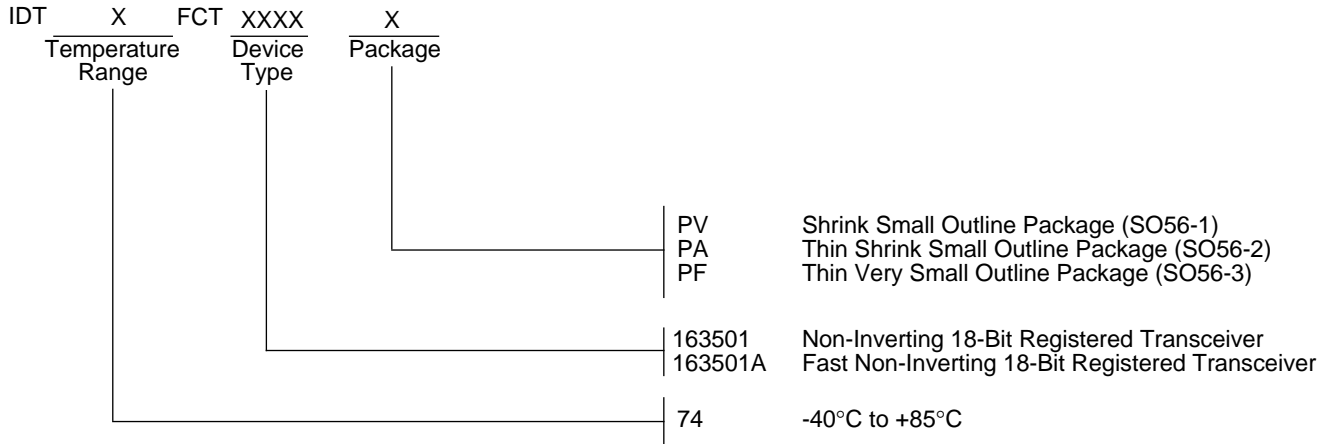


#### NOTES:

- Diagram shown for input Control Enable-LOW and input Control Disable-HIGH.
- Pulse Generator for All Pulses: Rate  $\leq 1.0\text{MHz}$ ;  $t_f \leq 2.5\text{ns}$ ;  $t_r \leq 2.5\text{ns}$ .
- If  $V_{CC}$  is below 3V, input voltage swings should be adjusted not to exceed  $V_{CC}$ .

2776 drw 09

## ORDERING INFORMATION



2776drw 10