



**THE DATASHEET OF  
DS96176CN**



# DS96176

*DS96176 RS-485/RS-422 Differential Bus Transceiver*



Literature Number: SNLS393A

# DS96176

## RS-485/RS-422 Differential Bus Transceiver

### General Description

The DS96176 Differential Bus Transceiver is a monolithic integrated circuit designed for bidirectional data communication on balanced multipoint bus transmission lines. The transceiver meets EIA Standard RS-485 as well as RS-422A.

The DS96176 combines a TRI-STATE® differential line driver and a differential input line receiver, both of which operate from a single 5.0V power supply. The driver and receiver have an active Enable that can be externally connected to function as a direction control. The driver differential outputs and the receiver differential inputs are internally connected to form differential input/output (I/O) bus ports that are designed to offer minimum loading to the bus whenever the driver is disabled or when  $V_{CC} = 0V$ . These ports feature wide positive and negative common mode voltage ranges, making the device suitable for multipoint applications in noisy environments.

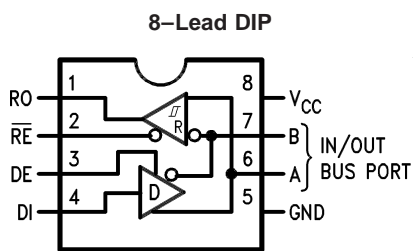
The driver is designed to handle loads up to 60 mA of sink or source current. The driver features positive and negative current-limiting and thermal shutdown for protection from line fault conditions. Thermal shutdown is designed to occur at junction temperature of approximately 160°C. The receiver features a typical input impedance of 15 k $\Omega$ , an input sensitivity of  $\pm 200$  mV, and a typical input hysteresis of 50 mV.

The DS96176 can be used in transmission line applications employing the DS96172 and the DS96174 quad differential line drivers and the DS96173 and DS96175 quad differential line receivers.

### Features

- Bidirectional transceiver
- Meets EIA Standard RS-422A and RS-485
- Designed for multipoint transmission
- TRI-STATE driver and receiver enables
- Individual driver and receiver enables
- Wide positive and negative input/output bus voltage ranges
- Driver output capability  $\pm 60$  mA Maximum
- Thermal shutdown protection
- Driver positive and Negative current-limiting
- High impedance receiver input
- Receiver input sensitivity of  $\pm 200$  mV
- Receiver input hysteresis of 50 mV typical
- Operates from single 5.0V supply
- Low power requirements

### Connection Diagram



Top View  
Order Number DS96176CN  
See NS Package Number N08E

### Function Table

#### Driver

Input	Enable	Outputs	
DI	DE	A	B
H	H	H	L
L	H	L	H
X	L	Z	Z

#### Receiver

Differential Inputs	Enable	Output
A-B	$\overline{RE}$	R
$V_{ID} \geq 0.2V$	L	H
$V_{ID} \leq -0.2V$	L	L
X	H	Z

H = High Level  
L = Low Level  
X = Immaterial  
Z = High Impedance (off)

**Absolute Maximum Ratings** (Note 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Storage Temperature Range	
Molded DIP	-65°C to +150°C
Lead Temperature	
Molded DIP (soldering, 10 sec.)	265°C
Maximum Power Dissipation (Note 1) at 25°C	
Molded Package	930 mW
Supply Voltage	7.0V
Differential Input Voltage	+15V/-10V
Enable Input Voltage	5.5V

**Recommended Operating Conditions**

	Min	Typ	Max	Units
Supply Voltage ( $V_{CC}$ )	4.75	5.0	5.25	V
Voltage at Any Bus Terminal (Separately or Common Mode)	-7.0		12	V
Differential Input Voltage ( $V_{ID}$ )			±12	V
Output Current HIGH ( $I_{OH}$ )				
Driver			-60	mA
Receiver			-400	µA
Output Current LOW ( $I_{OL}$ )				
Driver			60	mA
Receiver			16	mA
Operating Temperature ( $T_A$ )	0	25	70	°C

Note 1: Derate molded DIP package 7.5 mW/°C above 25°C.

**Electrical Characteristics** (Notes 3, 4)

Over recommended temperature, common mode input voltage, and supply voltage ranges, unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Units	
<b>DRIVER SECTION</b>							
$V_{IH}$	Input Voltage HIGH		2.0			V	
$V_{IL}$	Input Voltage LOW				0.8	V	
$V_{OH}$	Output Voltage HIGH	$I_{OH} = -20$ mA		3.1		V	
$V_{OL}$	Output Voltage LOW	$I_{OL} = 20$ mA		0.85		V	
$V_{IC}$	Input Clamp Voltage	$I_I = -18$ mA			-1.5	V	
$ V_{OD1} $	Differential Output Voltage	$I_O = 0$ mA			6.0	V	
$ V_{OD2} $	Differential Output Voltage	$R_L = 100\Omega$ , Figure 1	2.0	2.25		V	
		$R_L = 54\Omega$ , Figure 1 and Figure 2	1.5	2.0			
$\Delta V_{OD2} $	Change in Magnitude of Differential Output Voltage (Note 5)	$R_L = 54\Omega$ $V_{CM} = 0V$ Figure 1 and Figure 2			±0.2	V	
		$R_L = 100\Omega$ Figure 1					
$V_{OC}$	Common Mode Output Voltage (Note 6)	$R_L = 54\Omega$ or $100\Omega$ , Figure 1			3.0	V	
$\Delta V_{OC} $	Change in Magnitude of Common Mode Output Voltage (Note 5)				±0.2	V	
$I_O$	Output Current (Note 5) (Includes Receiver $I_I$ )	Output Disabled					
		$V_O = 12V$ $V_O = -7.0V$			1.0 -0.8	mA	
$I_{IH}$	Input Current HIGH	$V_I = 2.4V$			20	µA	
$I_{IL}$	Input Current LOW	$V_I = 0.4V$			-100	µA	
$I_{OS}$	Short Circuit Output Current (Note 10)	$V_O = -7.0V$			-250	mA	
		$V_O = 0V$			-150		
		$V_O = V_{CC}$			150		
		$V_O = 12V$			250		
$I_{CC}$	Supply Current	No Load	Outputs Enabled			35	mA
			Outputs Disabled			40	
<b>RECEIVER SECTION</b>							
$V_{TH}$	Differential Input High Threshold Voltage	$V_O = 2.7V$ , $I_O = -0.4$ mA			0.2	V	
$V_{TL}$	Differential Input Low Threshold Voltage (Note 7)	$V_O = 0.5V$ , $I_O = 8.0$ mA	-0.2			V	
$V_{T+} - V_{T-}$	Hysteresis (Note 8)	$V_{CM} = 0V$		50		mV	
$V_{IH}$	Enable Input Voltage HIGH		2.0			V	
$V_{IL}$	Enable Input Voltage LOW				0.8	V	
$V_{IC}$	Enable Input Clamp Voltage	$I_I = -18$ mA			-1.5	V	

## Electrical Characteristics (Notes 3, 4) (Continued)

Over recommended temperature, common mode input voltage, and supply voltage ranges, unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>RECEIVER SECTION</b>						
$V_{OH}$	Output Voltage HIGH	$V_{ID} = 200\text{ mV}$ , $I_{OH} = -400\text{ }\mu\text{A}$ , <i>Figure 3</i>	2.7			V
$V_{OL}$	Output Voltage LOW	$V_{ID} = -200\text{ mV}$ , <i>Figure 3</i>	$I_{OL} = 8.0\text{ mA}$		0.45	V
			$I_{OL} = 16\text{ mA}$		0.50	
$I_{OZ}$	High Impedance State Output	$V_O = 0.45\text{V to }2.4\text{V}$			$\pm 20$	$\mu\text{A}$
$I_I$	Line Input Current (Note 9)	Other Input = 0V	$V_I = 12\text{V}$		1.0	mA
			$V_I = -7.0\text{V}$		0.8	
$I_{IH}$	Enable Input Current HIGH	$V_{IH} = 2.7\text{V}$			20	$\mu\text{A}$
$I_{IL}$	Enable Input Current LOW	$V_{IL} = 0.4\text{V}$			-100	$\mu\text{A}$
$R_I$	Input Resistance			12		k $\Omega$
$I_{OS}$	Short Circuit Output Current	(Note 10)	-15		-85	mA
$I_{CC}$	Supply Current (Total Package)	No Load	Outputs Enabled		40	mA
			Outputs Disabled			

## Driver Switching Characteristics

$V_{CC} = 5\text{V}$ ,  $T_A = 25^\circ\text{C}$

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{DD}$	Differential Output Delay Time	$R_L = 60\Omega$ , <i>Figure 4</i>		15	25	ns
$t_{TD}$	Differential Output Transition Time	$R_L = 60\Omega$ , <i>Figure 4</i>		15	25	ns
$t_{PLH}$	Propagation Delay Time, Low-to-High Level Output	$R_L = 27\Omega$ , <i>Figure 5</i>		12	20	ns
$t_{PHL}$	Propagation Delay Time, High-to-Low Level Output	$R_L = 27\Omega$ , <i>Figure 5</i>		12	20	ns
$t_{PZH}$	Output Enable Time to High Level	$R_L = 110\Omega$ , <i>Figure 6</i>		25	35	ns
$t_{PZL}$	Output Enable Time to Low Level	$R_L = 110\Omega$ , <i>Figure 7</i>		25	35	ns
$t_{PHZ}$	Output Disable Time from High Level	$R_L = 110\Omega$ , <i>Figure 6</i>		20	25	ns
$t_{PLZ}$	Output Disable Time from Low Level	$R_L = 110\Omega$ , <i>Figure 7</i>		29	35	ns

## Receiver Switching Characteristics

$V_{CC} = 5.0\text{V}$ ,  $T_A = 25^\circ\text{C}$

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{PLH}$	Propagation Delay Time, Low-to-High Level Output	$V_{ID} = 0\text{V to }3.0\text{V}$ $C_L = 15\text{ pF}$ , <i>Figure 8</i>		16	25	ns
$t_{PHL}$	Propagation Delay Time, High-to-Low Level Output			16	25	ns
$t_{PZH}$	Output Enable Time to High Level	$C_L = 15\text{ pF}$ , <i>Figure 9</i>		15	22	ns
$t_{PZL}$	Output Enable Time to Low Level			15	22	ns
$t_{PHZ}$	Output Disable Time from High Level	$C_L = 5.0\text{ pF}$ , <i>Figure 9</i>		14	30	ns
$t_{PLZ}$	Output Disable Time from Low Level			24	40	ns

**Note 2:** "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the devices should be operated at these limits. The tables of "Electrical Characteristics" provide conditions for actual operation.

**Note 3:** Unless otherwise specified min/max limits apply across the  $0^\circ\text{C}$  to  $+70^\circ\text{C}$  range for the DS96176. All typicals are given for  $V_{CC} = 5\text{V}$  and  $T_A = 25^\circ\text{C}$ .

**Note 4:** All currents into the device pins are positive; all currents out of the device pins are negative. All voltages are referenced to ground unless otherwise specified.

**Note 5:**  $\Delta|V_{OD}|$  and  $\Delta|V_{OC}|$  are the changes in magnitude of  $V_{OD}$  and  $V_{OC}$ , respectively, that occur when the input is changed from a high level to a low level.

**Note 6:** In EIA Standards RS-422A and RS-485,  $V_{OC}$ , which is the average of the two output voltages with respect to ground, is called output offset voltage,  $V_{OS}$ .

**Note 7:** The algebraic convention, where the less positive (more negative) limit is designated minimum, is used in this data sheet for common mode input voltage and threshold voltage levels only.

## Receiver Switching Characteristics (Continued)

**Note 8:** Hysteresis is the difference between the positive-going input threshold voltage  $V_{T+}$ , and the negative-going input threshold voltage,  $V_{T-}$ .

**Note 9:** Refer to EIA Standard RS-485 for exact conditions.

**Note 10:** Only one output at a time should be shorted.

### Parameter Measurement Information

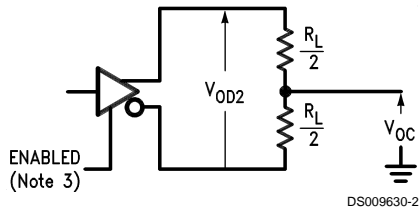


FIGURE 1. Driver  $V_{OD}$  and  $V_{OC}$

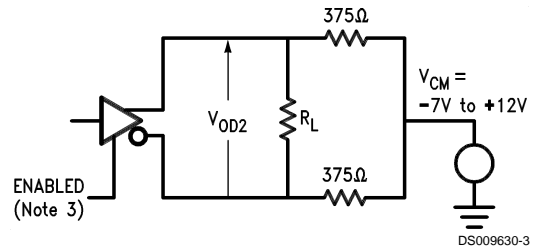


FIGURE 2. Driver  $V_{OD}$  with Varying Common Mode Voltage

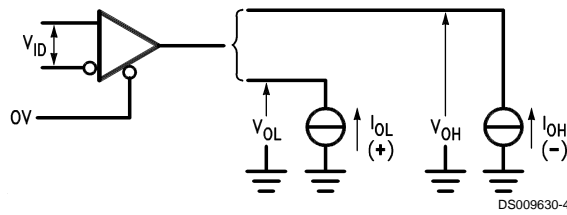


FIGURE 3. Receiver  $V_{OH}$  and  $V_{OL}$

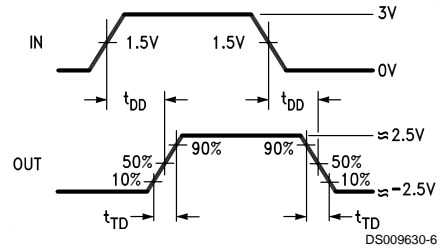
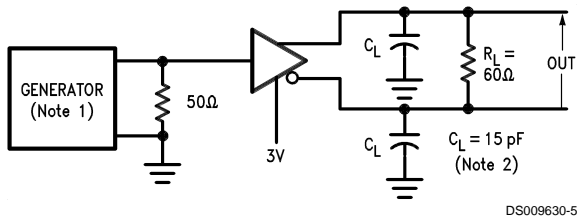


FIGURE 4. Driver Differential Output Delay and Transition Times

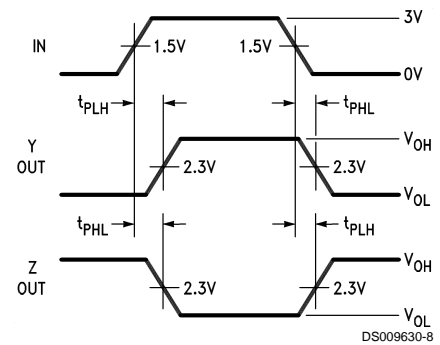
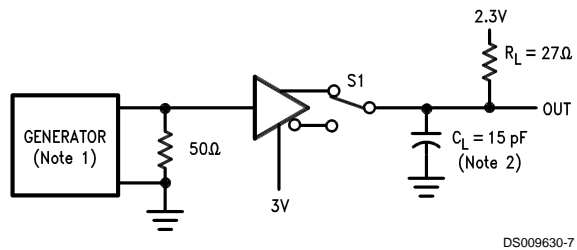
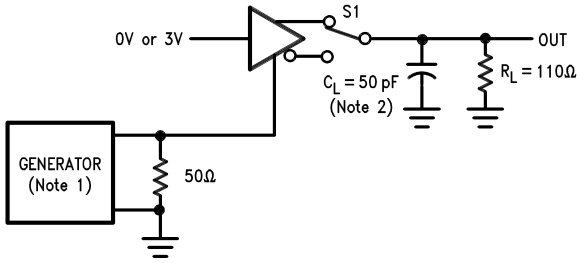


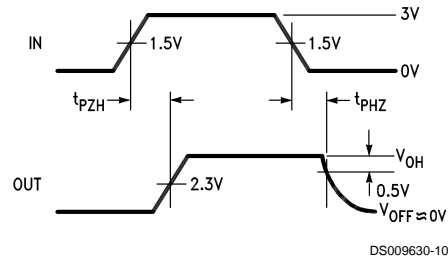
FIGURE 5. Driver Propagation Times

Parameter Measurement Information (Continued)

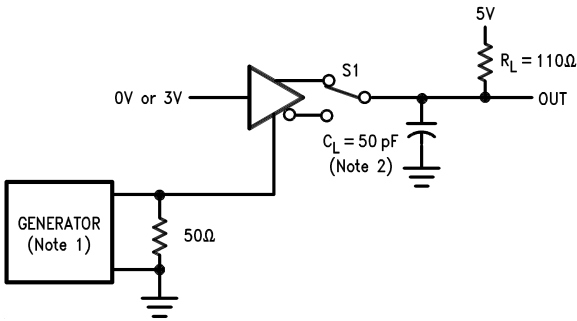


DS009630-9

FIGURE 6. Driver Enable and Disable Times ( $t_{PZH}$ ,  $t_{PHZ}$ )

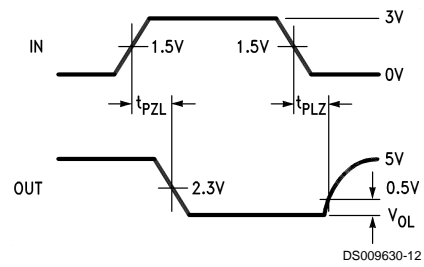


DS009630-10

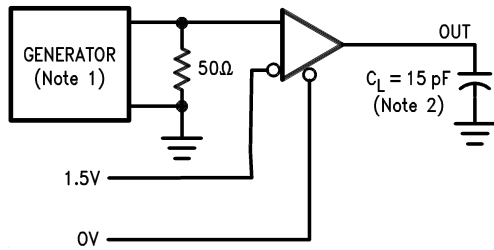


DS009630-11

FIGURE 7. Driver Enable and Disable Times ( $t_{PZL}$ ,  $t_{PLZ}$ )

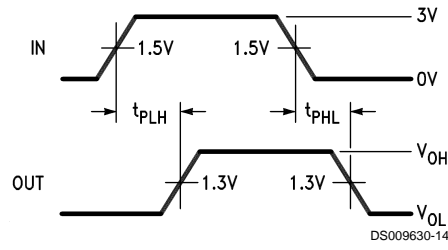


DS009630-12



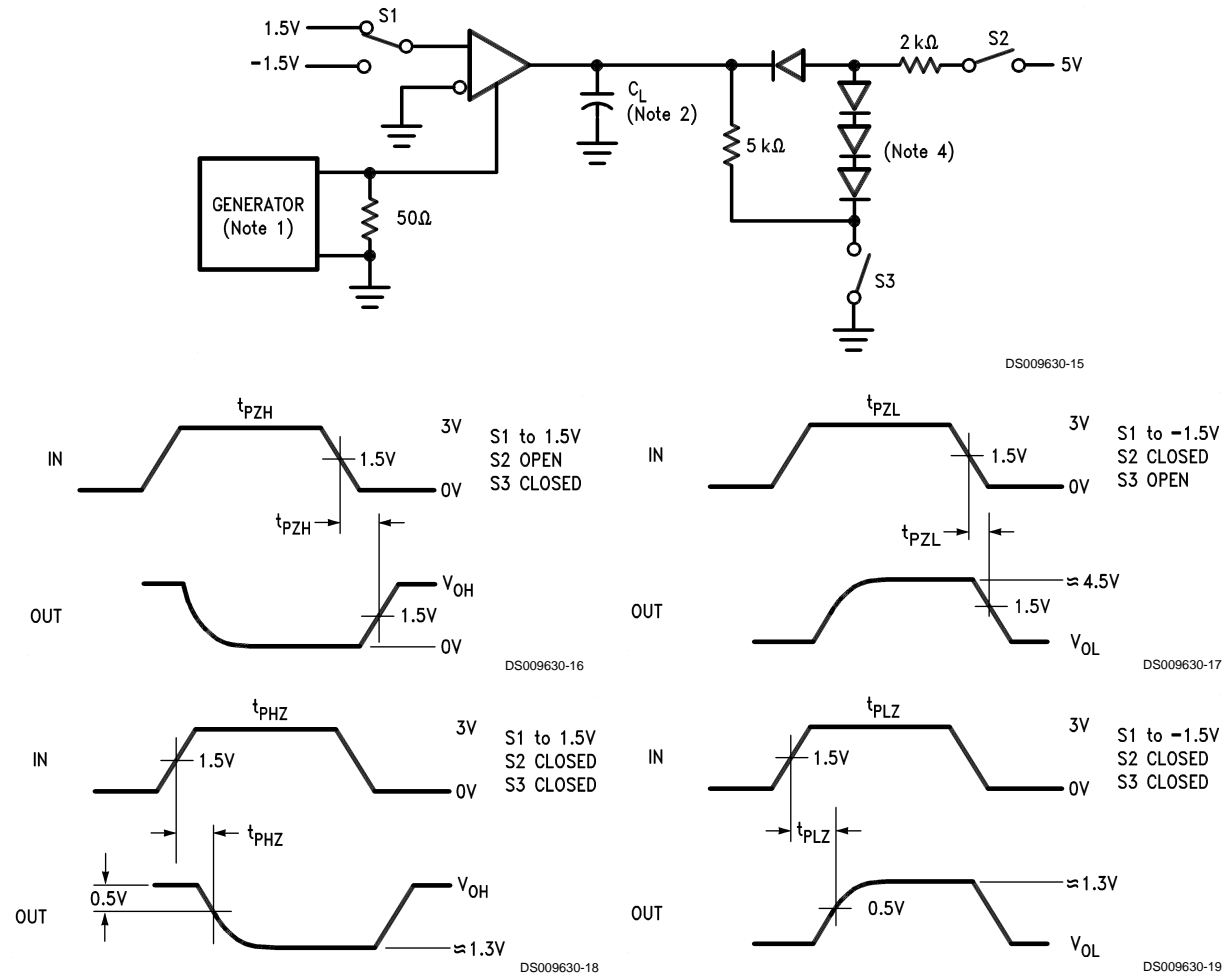
DS009630-13

FIGURE 8. Receiver Propagation Delay Times



DS009630-14

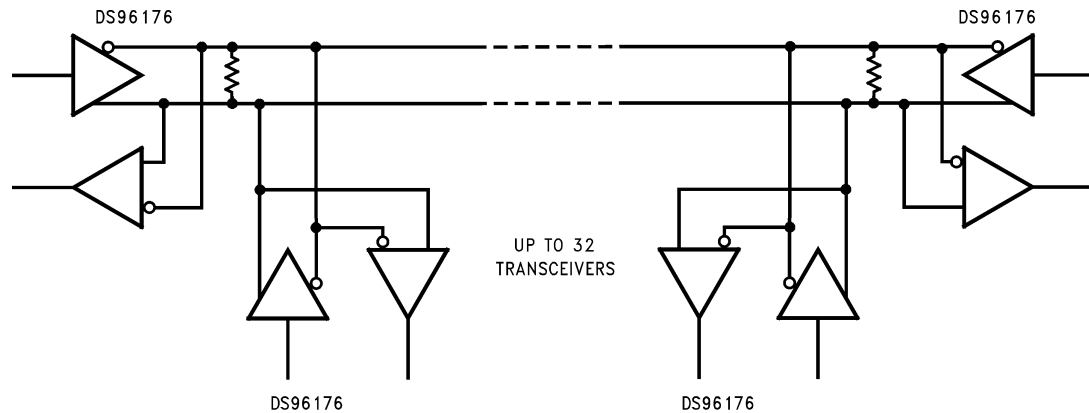
Parameter Measurement Information (Continued)



- Note 11:** The input pulse is supplied by a generator having the following characteristics: PRR = 1.0 MHz, 50% duty cycle,  $t_r \leq 6.0$  ns,  $Z_O = 50\Omega$ .
- Note 12:**  $C_L$  includes probe and stray capacitance.
- Note 13:** DS96176 Driver enable is Active-High.
- Note 14:** All diodes are 1N916 or equivalent.

FIGURE 9. Receiver Enable and Disable Times

Typical Application

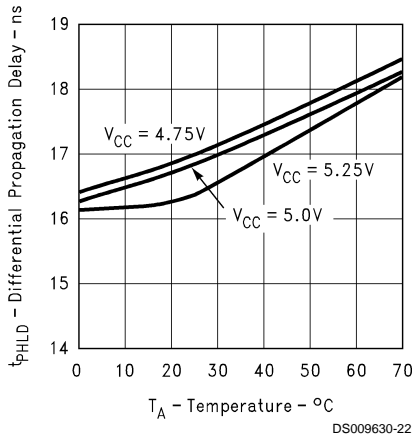


- Note:** The line length should be terminated at both ends of its characteristic impedance. Stub lengths off the main line should be kept as short as possible.

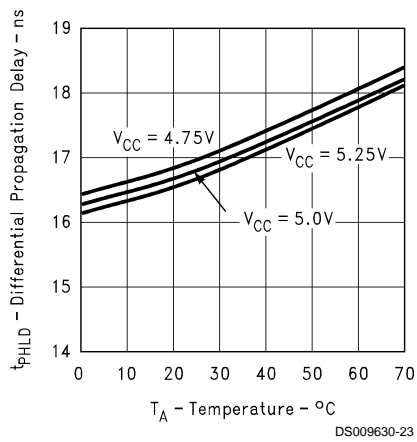
FIGURE 10.

# Typical Performance Characteristics

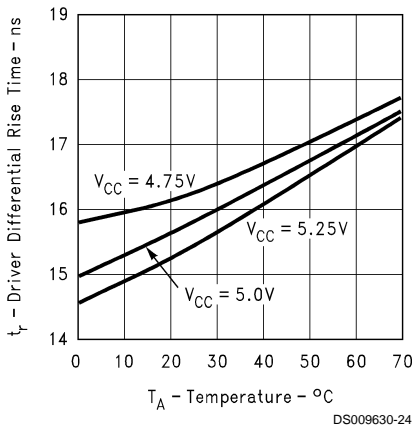
**Driver Differential Propagation Delay vs  $V_{CC}$  vs Temperature**



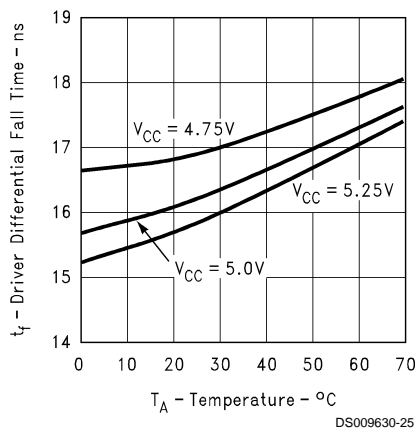
**Driver Differential Propagation Delay vs  $V_{CC}$  vs Temperature**



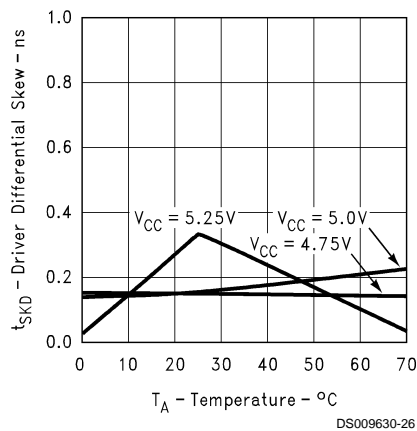
**Driver Differential Rise Time vs  $V_{CC}$  vs Temperature**



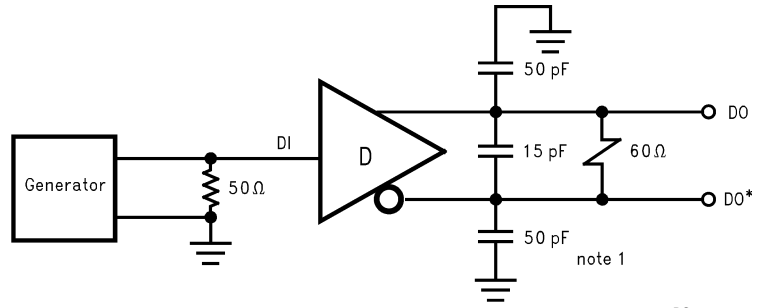
**Driver Differential Fall Time vs  $V_{CC}$  vs Temperature**



**Driver Skew vs  $V_{CC}$  vs Temperature ( $t_{PLDH} - t_{PHLD}$ )**

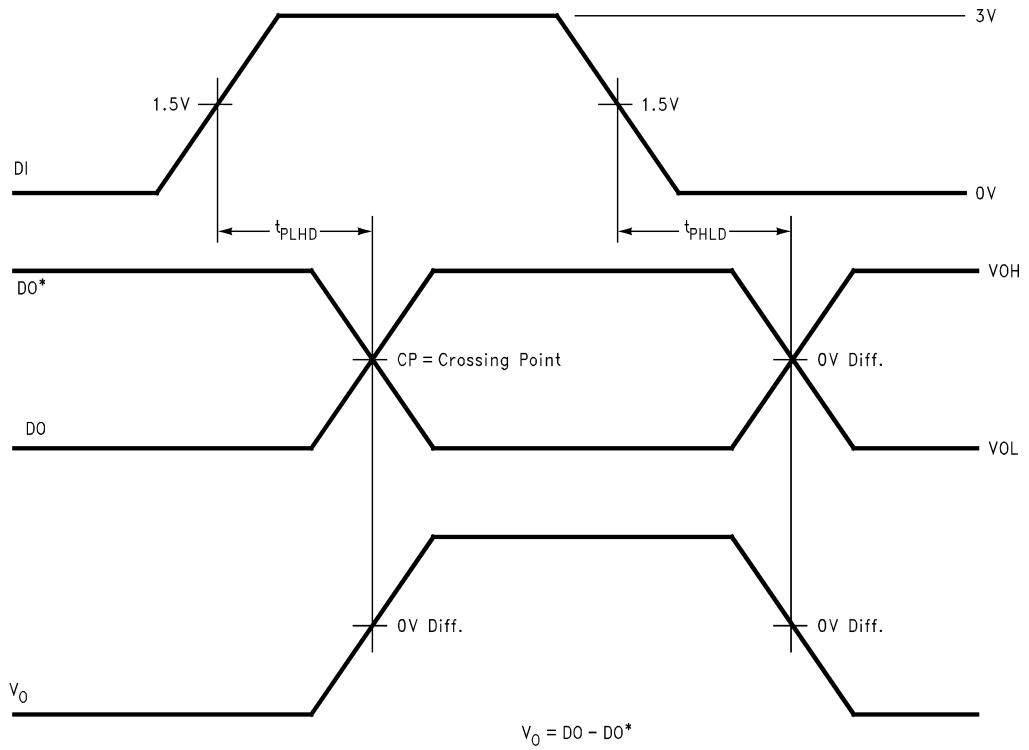


Typical Performance Characteristics (Continued)



DS009630-27

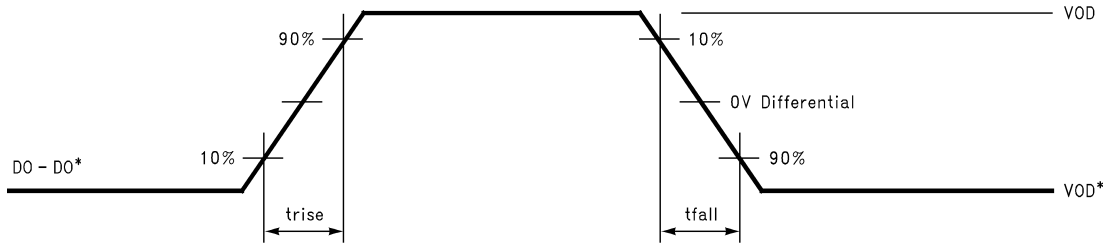
FIGURE 11. Typical Curve Driver Propagation Delay Test Circuit



DS009630-28

FIGURE 12. Typical Curve Driver Differential Propagation Delay Timing

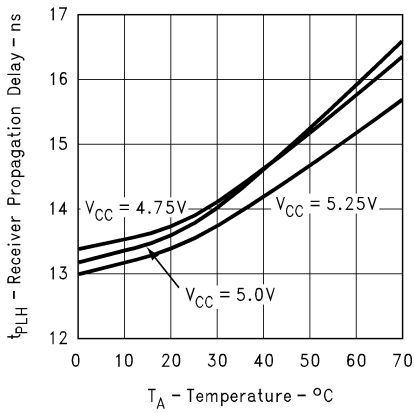
# Typical Performance Curves



DS009630-29

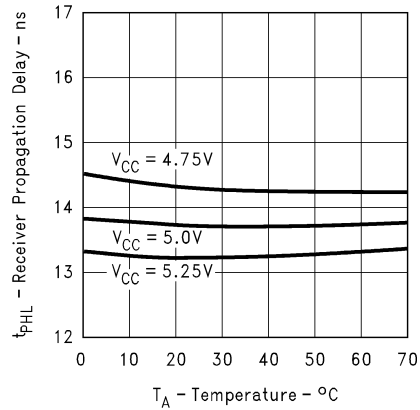
FIGURE 13. Typical Curve Driver Differential Rise and Fall Times

## Receiver Propagation Delay vs $V_{CC}$ vs Temperature



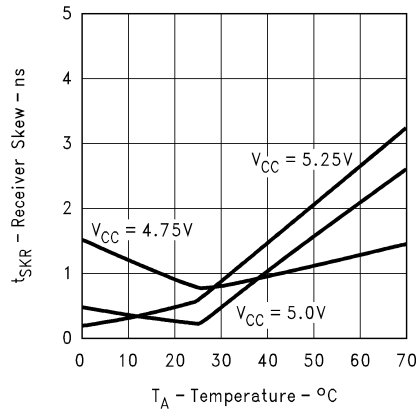
DS009630-30

## Receiver Propagation Delay vs $V_{CC}$ vs Temperature

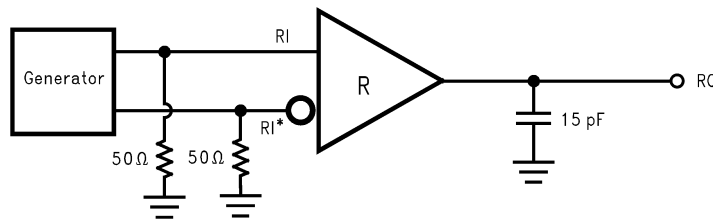


DS009630-31

## Receiver Skew vs $V_{CC}$ vs Temperature ( $t_{PLH} - t_{PHL}$ )



DS009630-32



DS009630-33

FIGURE 14. Typical Curve Receiver Differential Propagation Delay Test Circuit

# Typical Performance Curves (Continued)

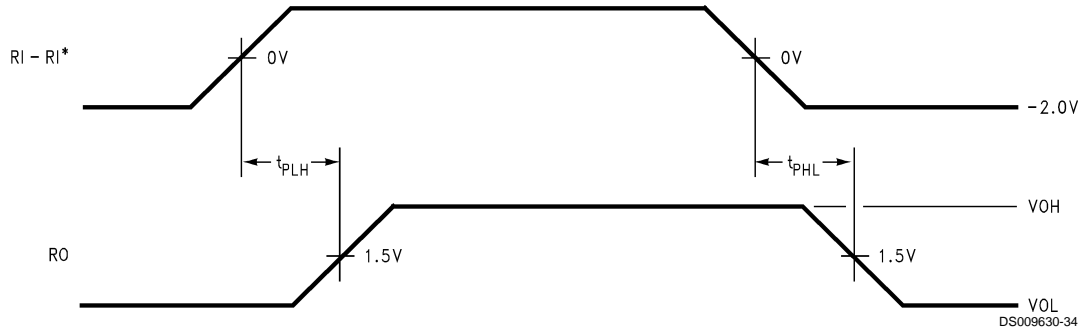
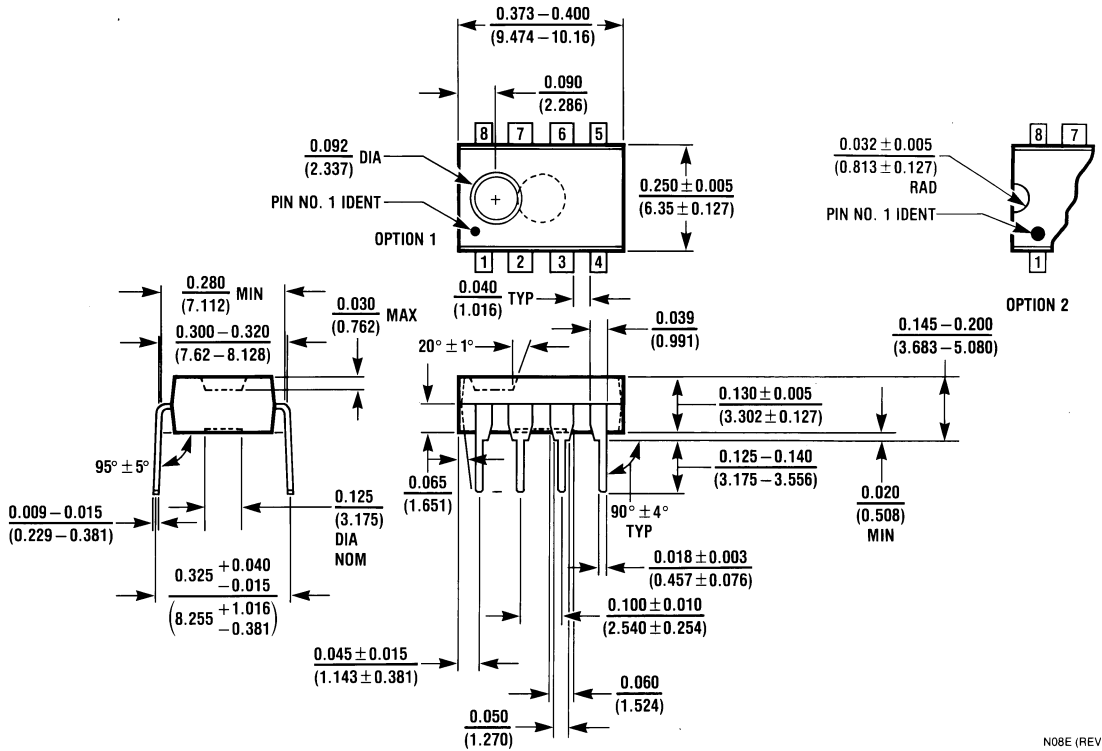


FIGURE 15. Typical Curve Receiver Propagation Delay Timing

**Physical Dimensions** inches (millimeters) unless otherwise noted



**Molded Dual-In-Line Package (N)**  
**Order Number DS96176CN**  
**NS Package Number N08E**

N08E (REV F)

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**National Semiconductor Corporation**  
 Americas  
 Email: support@nsc.com

**National Semiconductor Europe**  
 Fax: +49 (0) 180-530 85 86  
 Email: europe.support@nsc.com  
 Deutsch Tel: +49 (0) 69 9508 6208  
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DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
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