

### FEATURES

- ±15 kV ESD protection on output pins
- 600 Mbps (300 MHz) switching rates
- Flow-through pinout simplifies PCB layout
- 300 ps typical differential skew
- 700 ps maximum differential skew
- 1.5 ns maximum propagation delay
- 3.3 V power supply
- ±355 mV differential signaling
- Low power dissipation: 23 mW typical
- Interoperable with existing 5 V LVDS receivers
- Conforms to TIA/EIA-644 LVDS standards
- Industrial operating temperature range (−40°C to +85°C)
- Available in surface-mount (SOIC) package

### APPLICATIONS

- Backplane data transmission
- Cable data transmission
- Clock distribution

### GENERAL DESCRIPTION

The ADN4661 is a single, CMOS, low voltage differential signaling (LVDS) line driver offering data rates of over 600 Mbps (300 MHz) and ultra-low power consumption. It features a flow-through pinout for easy PCB layout and separation of input and output signals.

The device accepts low voltage TTL/CMOS logic signals and converts them to a differential current output of typically ±3.1 mA for driving a transmission medium such as a twisted-pair cable. The transmitted signal develops a differential voltage of typically ±355 mV across a termination resistor at the receiving end, and this is converted back to a TTL/CMOS logic level by a line receiver.

### FUNCTIONAL BLOCK DIAGRAM

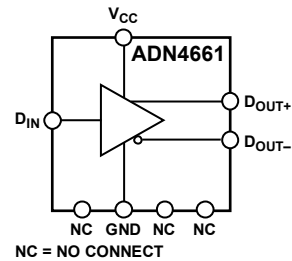


Figure 1.

The ADN4661 and a companion LVDS receiver offer a new solution to high speed point-to-point data transmission, and a low power alternative to emitter-coupled logic (ECL) or positive emitter-coupled logic (PECL).

#### Rev. 0

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**REVISION HISTORY**

12/08—Revision 0: Initial Version

## SPECIFICATIONS

$V_{CC} = 3\text{ V to }3.6\text{ V}$ ;  $R_L = 100\ \Omega$ ;  $C_L = 15\text{ pF to GND}$ ; all specifications  $T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted.

Table 1.

Parameter <sup>1, 2</sup>	Symbol	Min	Typ	Max	Unit	Test Conditions
LVDS OUTPUTS ( $D_{OUT+}$ , $D_{OUT-}$ )						
Differential Output Voltage	$V_{OD}$	250	355	450	mV	See Figure 2 and Figure 4
Change in Magnitude of $V_{OD}$ for Complementary Output States	$\Delta V_{OD}$		1	35	mV	See Figure 2 and Figure 4
Offset Voltage	$V_{OS}$	1.125	1.2	1.375	V	See Figure 2 and Figure 4
Change in Magnitude of $V_{OS}$ for Complementary Output States	$\Delta V_{OS}$		3	25	mV	See Figure 2 and Figure 4
Output High Voltage	$V_{OH}$		1.4	1.6	V	See Figure 2 and Figure 4
Output Low Voltage	$V_{OL}$	0.90	1.1		V	See Figure 2 and Figure 4
INPUTS ( $D_{IN}$ , $V_{CC}$ )						
Input High Voltage	$V_{IH}$	2.0		$V_{CC}$	V	
Input Low Voltage	$V_{IL}$	GND		0.8	V	
Input High Current	$I_{IH}$	-10	$\pm 2$	+10	$\mu\text{A}$	$V_{IN} = 3.3\text{ V or }2.4\text{ V}$
Input Low Current	$I_{IL}$	-10	$\pm 1$	+10	$\mu\text{A}$	$V_{IN} = \text{GND or }0.5\text{ V}$
Input Clamp Voltage	$V_{CL}$	-1.5	-0.6		V	$I_{CL} = -18\text{ mA}$
LVDS OUTPUT PROTECTION ( $D_{OUT+}$ , $D_{OUT-}$ )						
Output Short-Circuit Current <sup>3</sup>	$I_{OS}$		-5.7	-8.0	mA	$D_{IN} = V_{CC}$ , $D_{OUT+} = 0\text{ V}$ or $D_{IN} = \text{GND}$ , $D_{OUT-} = 0\text{ V}$
LVDS OUTPUT LEAKAGE ( $D_{OUT+}$ , $D_{OUT-}$ )						
Power-Off Leakage	$I_{OFF}$	-10	$\pm 1$	+10	$\mu\text{A}$	$V_{OUT} = V_{CC}$ or $\text{GND}$ , $V_{CC} = 0\text{ V}$
POWER SUPPLY						
Supply Current, Unloaded	$I_{CC}$		4.0	8.0	mA	No load, $D_{IN} = V_{CC}$ or $\text{GND}$
Supply Current, Loaded	$I_{CCL}$		7	10	mA	$D_{IN} = V_{CC}$ or $\text{GND}$
ESD PROTECTION						
$D_{OUT+}$ , $D_{OUT-}$ Pins			$\pm 15$		kV	Human body model
All Pins Except $D_{OUT+}$ , $D_{OUT-}$			$\pm 4$		kV	Human body model

<sup>1</sup> Current into device pins is defined as positive. Current out of device pins is defined as negative. All voltages are referenced to ground except  $V_{OD}$ ,  $\Delta V_{OD}$ , and  $\Delta V_{OS}$ .

<sup>2</sup> The ADN4661 is a current mode device and functions within data sheet specifications only when a resistive load is applied to the driver outputs. Typical range is  $90\ \Omega$  to  $110\ \Omega$ .

<sup>3</sup> Output short-circuit current ( $I_{OS}$ ) is specified as magnitude only; minus sign indicates direction only.

# ADN4661

## AC CHARACTERISTICS

$V_{CC} = 3\text{ V to }3.6\text{ V}$ ;  $R_L = 100\ \Omega$ ;  $C_L^1 = 15\text{ pF to GND}$ ; all specifications  $T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted.

**Table 2.**

Parameter <sup>2</sup>	Symbol	Min	Typ	Max	Unit	Conditions/Comments <sup>3, 4</sup>
Differential Propagation Delay High to Low	$t_{PHLD}$	0.3	0.8	1.5	ns	See Figure 3 and Figure 4
Differential Propagation Delay Low to High	$t_{PLHD}$	0.3	1.1	1.5	ns	See Figure 3 and Figure 4
Differential Pulse Skew $ t_{PHLD} - t_{PLHD} ^5$	$t_{SKD1}$	0	0.3	0.7	ns	See Figure 3 and Figure 4
Differential Part-to-Part Skew <sup>6</sup>	$t_{SKD3}$	0		1.0	ns	See Figure 3 and Figure 4
Differential Part-to-Part Skew <sup>7</sup>	$t_{SKD4}$	0		1.2	Ns	See Figure 3 and Figure 4
Rise Time	$t_{TLH}$	0.2	0.5	1.0	ns	See Figure 3 and Figure 4
Fall Time	$t_{THL}$	0.2	0.5	1.0	ns	See Figure 3 and Figure 4
Maximum Operating Frequency <sup>8</sup>	$f_{MAX}$		350		MHz	See Figure 3

<sup>1</sup>  $C_L$  includes probe and jig capacitance.

<sup>2</sup> AC parameters are guaranteed by design and characterization.

<sup>3</sup> Generator waveform for all tests, unless otherwise specified:  $f = 50\text{ MHz}$ ,  $Z_o = 50\ \Omega$ ,  $t_{TLH} \leq 1\text{ ns}$ , and  $t_{THL} \leq 1\text{ ns}$ .

<sup>4</sup> All input voltages are for one channel unless otherwise specified. Other inputs are set to GND.

<sup>5</sup>  $t_{SKD1} = |t_{PHLD} - t_{PLHD}|$  is the magnitude difference in differential propagation delay time between the positive going edge and the negative going edge of the same channel.

<sup>6</sup>  $t_{SKD3}$ , differential part-to-part skew, is defined as the difference between the minimum and maximum specified differential propagation delays. This specification applies to devices at the same  $V_{CC}$  and within  $5^\circ\text{C}$  of each other within the operating temperature range.

<sup>7</sup>  $t_{SKD4}$ , differential part-to-part skew, is the differential channel-to-channel skew of any event between devices. This specification applies to devices over recommended operating temperatures and voltage ranges, and across process distribution.  $t_{SKD4}$  is defined as  $|\text{maximum} - \text{minimum}|$  differential propagation delay.

<sup>8</sup>  $f_{MAX}$  generator input conditions:  $t_{TLH} = t_{THL} < 1\text{ ns}$  (0% to 100%), 50% duty cycle, 0 V to 3 V. Output criteria: duty cycle = 45% to 55%,  $V_{OD} > 250\text{ mV}$ , all channels switching.

## Test Circuits and Timing Diagrams

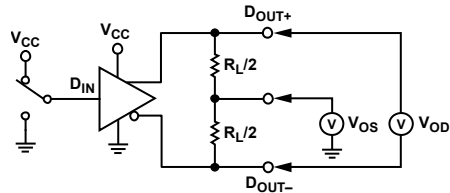
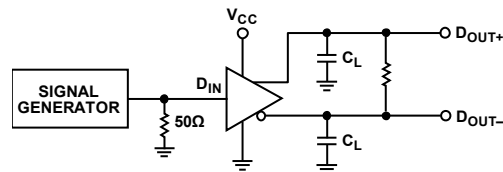


Figure 2. Test Circuit for Driver  $V_{OD}$  and  $V_{OS}$



NOTES  
1.  $C_L$  INCLUDES PROBE AND JIG CAPACITANCE.

Figure 3. Test Circuit for Driver Propagation Delay, Transition Time, and Maximum Operating Frequency

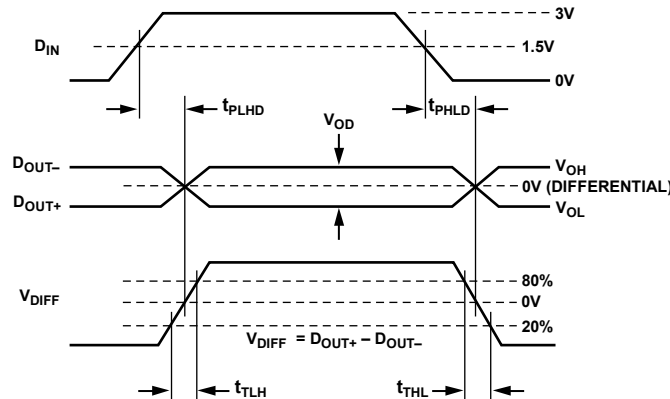


Figure 4. Driver Propagation Delay and Transition Time Waveforms

## ABSOLUTE MAXIMUM RATINGS

$T_A = 25^\circ\text{C}$ , unless otherwise noted. All voltages are relative to their respective ground.

**Table 3.**

Parameter	Rating
$V_{CC}$ to GND	-0.3 V to +4 V
Input Voltage ( $D_{IN}$ ) to GND	-0.3 V to $V_{CC} + 0.3\text{V}$
Output Voltage ( $D_{OUT+}$ , $D_{OUT-}$ ) to GND	-0.3 V to $V_{CC} + 0.3\text{V}$
Short-Circuit Duration ( $D_{OUT+}$ , $D_{OUT-}$ ) to GND	Continuous
Operating Temperature Range	
Industrial	$-40^\circ\text{C}$ to $+85^\circ\text{C}$
Storage Temperature Range	$-65^\circ\text{C}$ to $+150^\circ\text{C}$
Junction Temperature ( $T_J$ max)	$150^\circ\text{C}$
Power Dissipation	$(T_J \text{ max} - T_A)/\theta_{JA}$
SOIC Package	
$\theta_{JA}$ Thermal Impedance	$149.5^\circ\text{C}/\text{W}$
Reflow Soldering Peak Temperature	
Pb-Free	$260^\circ\text{C} \pm 5^\circ\text{C}$

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

### ESD CAUTION



**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

# ADN4661

## PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

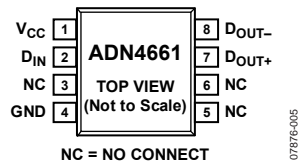


Figure 5. Pin Configuration

Table 4. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	V <sub>CC</sub>	Power Supply Input. The part can be operated from 3.0 V to 3.6 V, and the supply should be decoupled with a 10 $\mu$ F solid tantalum capacitor in parallel with a 0.1 $\mu$ F capacitor to GND.
2	D <sub>IN</sub>	Driver Logic Input.
3	NC	No Connect. This pin should be left unconnected.
4	GND	Ground. Reference point for all circuitry on the part.
5	NC	No Connect. This pin should be left unconnected.
6	NC	No Connect. This pin should be left unconnected.
7	D <sub>OUT+</sub>	Noninverting Output Current Driver. When D <sub>IN</sub> is high, current flows out of D <sub>OUT+</sub> . When D <sub>IN</sub> is low, current flows into D <sub>OUT+</sub> .
8	D <sub>OUT-</sub>	Inverting Output Current Driver. When D <sub>IN</sub> is high, current flows into D <sub>OUT-</sub> . When D <sub>IN</sub> is low, current flows out of D <sub>OUT-</sub> .

# TYPICAL PERFORMANCE CHARACTERISTICS

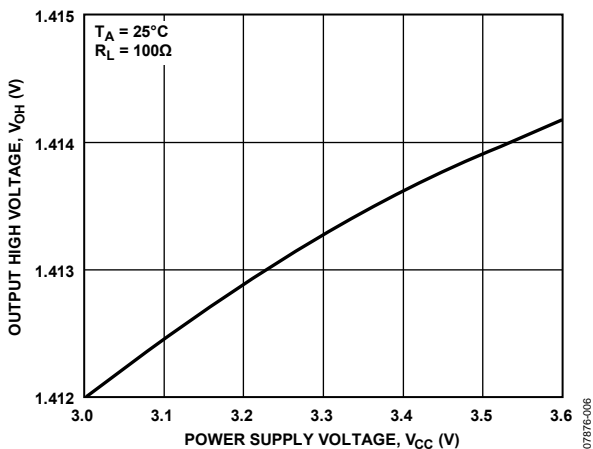


Figure 6. Output High Voltage vs. Power Supply Voltage

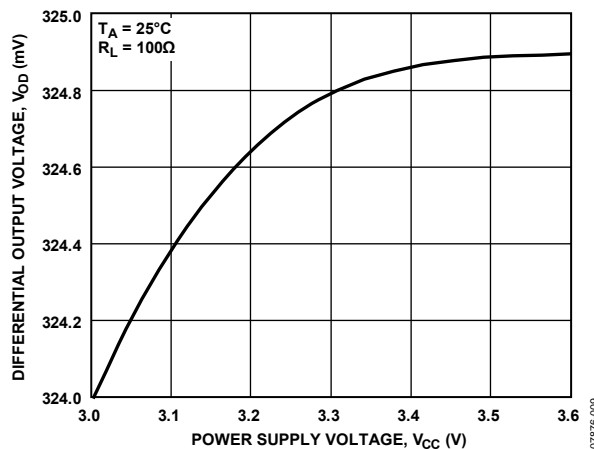


Figure 9. Differential Output Voltage vs. Power Supply Voltage

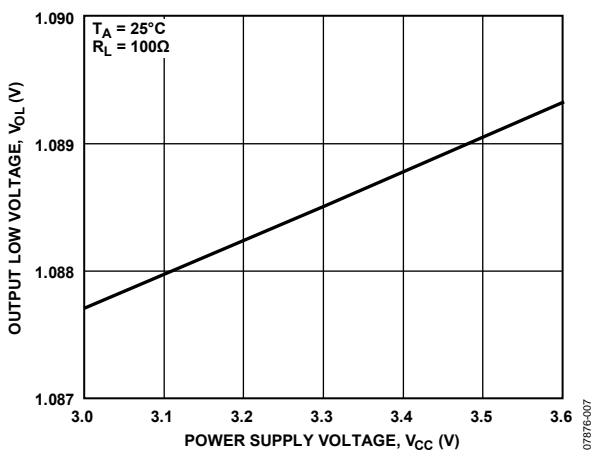


Figure 7. Output Low Voltage vs. Power Supply Voltage

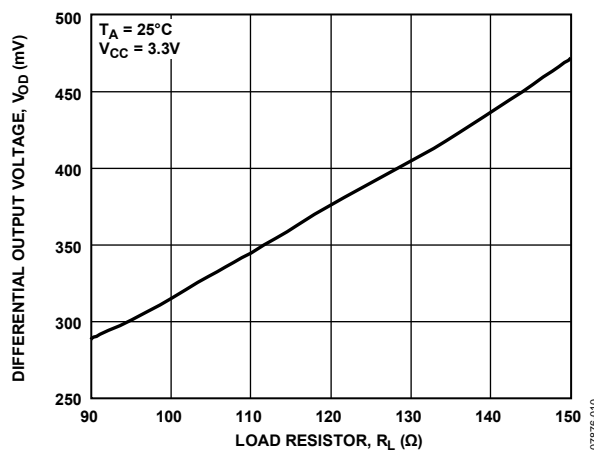


Figure 10. Differential Output Voltage vs. Load Resistor

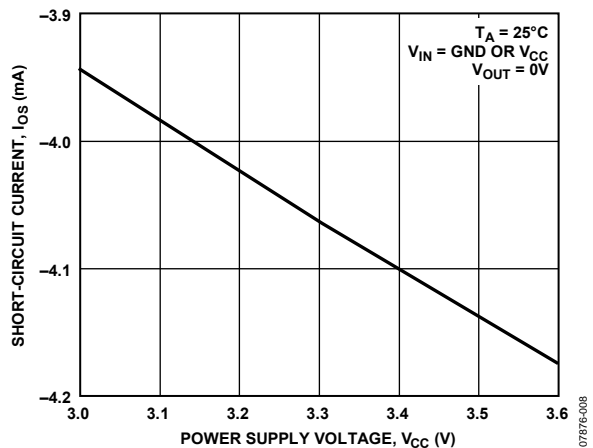


Figure 8. Output Short-Circuit Current vs. Power Supply Voltage

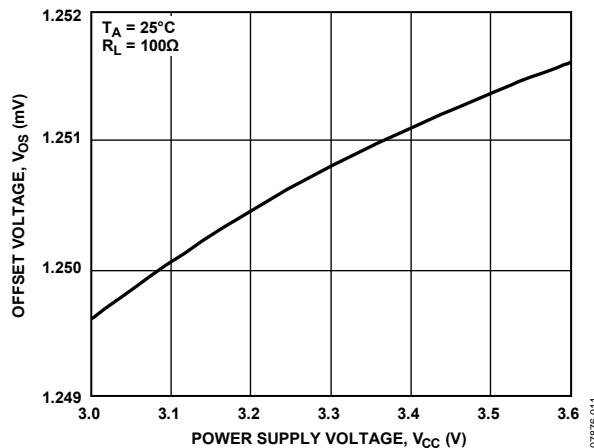


Figure 11. Offset Voltage vs. Power Supply Voltage

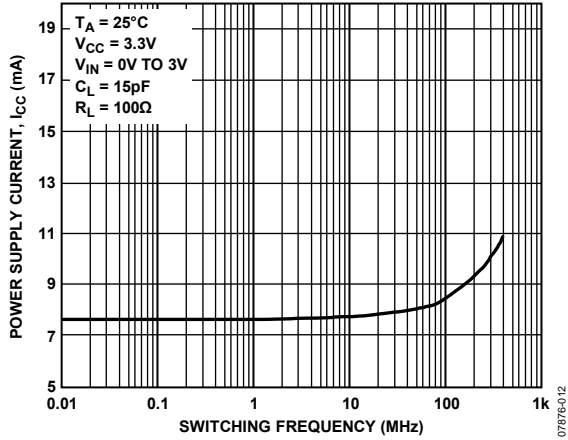


Figure 12. Power Supply Current vs. Switching Frequency

07876-02

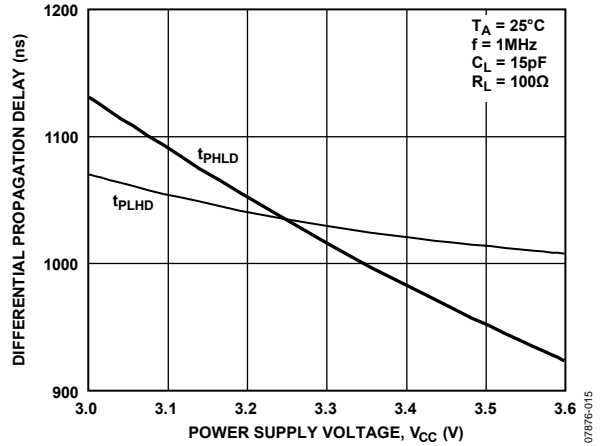


Figure 15. Differential Propagation Delay vs. Power Supply Voltage

07876-015

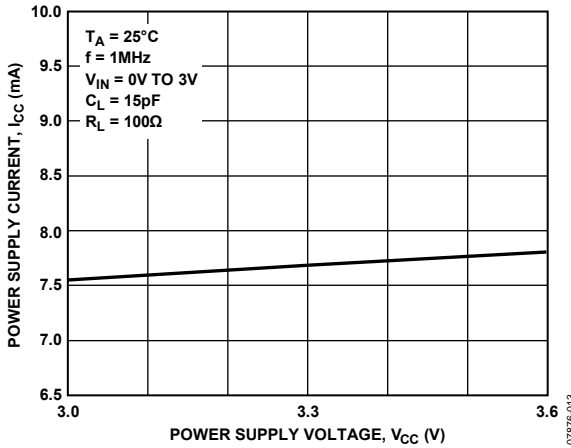


Figure 13. Power Supply Current vs. Power Supply Voltage

07876-013

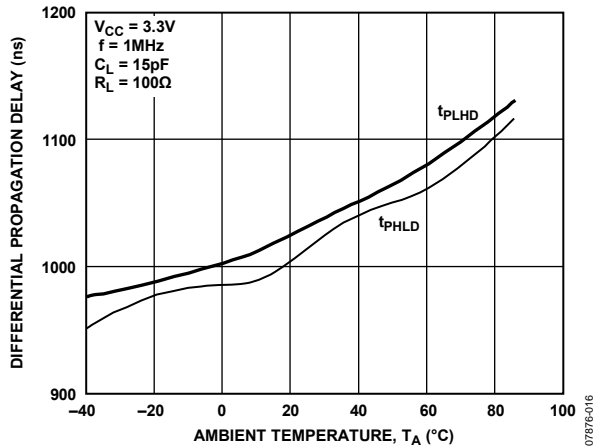


Figure 16. Differential Propagation Delay vs. Ambient Temperature

07876-016

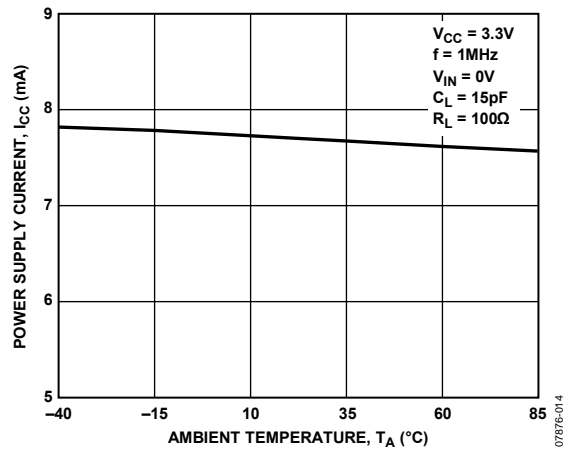


Figure 14. Power Supply Current vs. Ambient Temperature

07876-014

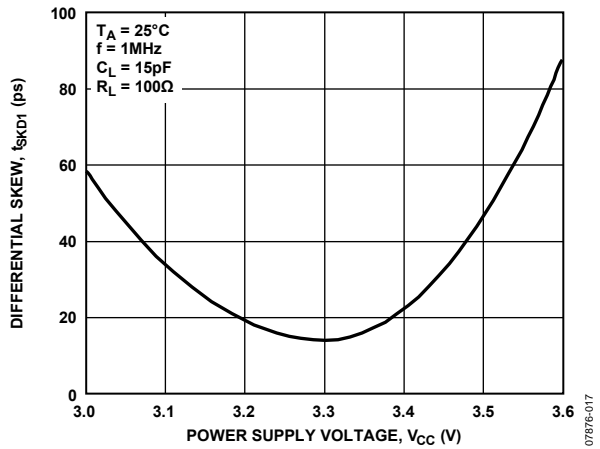


Figure 17. Differential Skew vs. Power Supply Voltage

07876-017



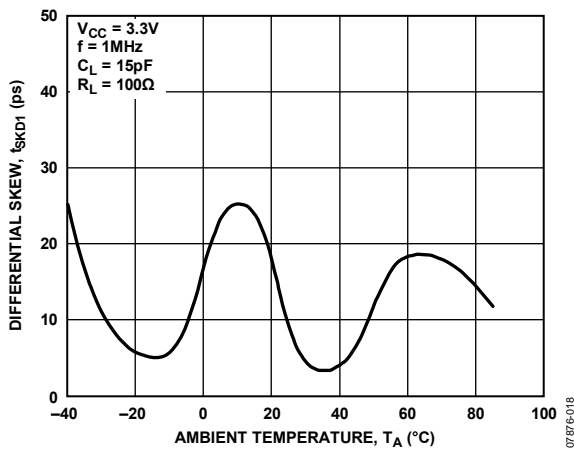


Figure 18. Differential Skew vs. Ambient Temperature

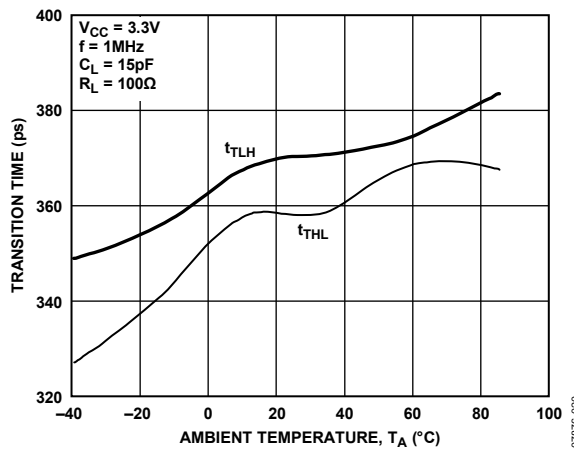


Figure 20. Transition Time vs. Ambient Temperature

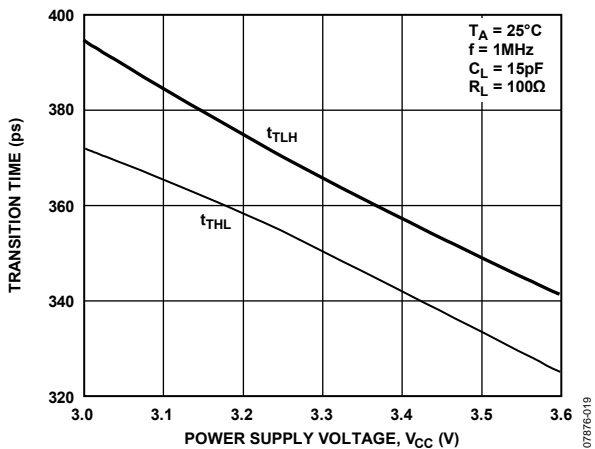


Figure 19. Transition Time vs. Power Supply Voltage

## THEORY OF OPERATION

The ADN4661 is a single line driver for low voltage differential signaling. It takes a single-ended 3 V logic signal and converts it to a differential current output. The data can then be transmitted for considerable distances, over media such as a twisted-pair cable or PCB backplane, to an LVDS receiver, where it develops a voltage across a terminating resistor,  $R_T$ . This resistor is chosen to match the characteristic impedance of the medium, typically around 100  $\Omega$ . The differential voltage is detected by the receiver and converted back into a single-ended logic signal.

When  $D_{IN}$  is high (Logic 1), current flows out of the  $D_{OUT+}$  pin (current source) through  $R_T$  and back to the  $D_{OUT-}$  pin (current sink). At the receiver, this current develops a positive differential voltage across  $R_T$  (with respect to the inverting input) and results in a Logic 1 at the receiver output. When  $D_{IN}$  is low (Logic 0),  $D_{OUT+}$  sinks current and  $D_{OUT-}$  sources current. A negative differential voltage across  $R_T$  results in a Logic 0 at the receiver output.

The output drive current is between  $\pm 2.5$  mA and  $\pm 4.5$  mA (typically  $\pm 3.55$  mA), developing between  $\pm 250$  mV and  $\pm 450$  mV across a 100  $\Omega$  termination resistor. The received voltage is centered around the receiver offset of 1.2 V. Therefore, the noninverting receiver input for Logic 1 is typically  $(1.2 \text{ V} + [355 \text{ mV}/2]) = 1.377 \text{ V}$ , and the inverting receiver input is  $(1.2 \text{ V} - [355 \text{ mV}/2]) = 1.023 \text{ V}$ . For Logic 0, the inverting and noninverting output voltages are reversed. Note that because the differential voltage reverses polarity, the peak-to-peak voltage swing across  $R_T$  is twice the differential voltage.

Current-mode drivers offer considerable advantages over voltage mode drivers such as RS-422 drivers. The operating current remains fairly constant with increased switching frequency, whereas the current of voltage mode drivers increases exponentially in most cases. This is caused by the overlap as internal gates switch between high and low, which causes currents to flow from the device power supply to ground.

A current-mode device simply reverses a constant current between its two outputs, with no significant overlap currents.

This is similar to emitter-coupled logic (ECL) and positive emitter-coupled logic (PECL), but without the high quiescent current of ECL and PECL.

## APPLICATIONS INFORMATION

Figure 21 shows a typical application for point-to-point data transmission using the ADN4661 as the driver and the LVDS receiver.

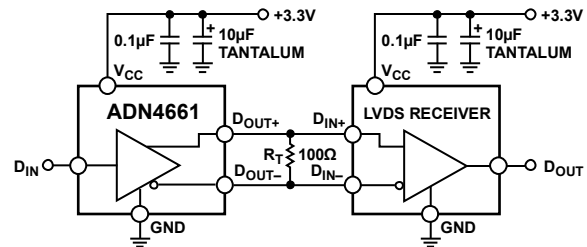
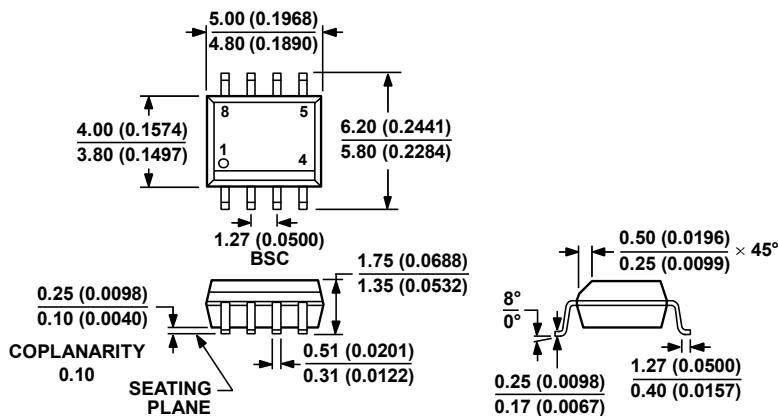


Figure 21. Typical Application Circuit

07976-021

# OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MS-012-AA  
 CONTROLLING DIMENSIONS ARE IN MILLIMETERS; INCH DIMENSIONS  
 (IN PARENTHESES) ARE ROUNDED-OFF MILLIMETER EQUIVALENTS FOR  
 REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

012407-A

Figure 22. 8-Lead Standard Small Outline Package [SOIC\_N]  
 Narrow Body  
 (R-8)

Dimensions shown in millimeters and (inches)

## ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option
ADN4661BRZ <sup>1</sup>	-40°C to +85°C	8-Lead Standard Small Outline Package [SOIC-N]	R-8
ADN4661BRZ-REEL7 <sup>1</sup>	-40°C to +85°C	8-Lead Standard Small Outline Package [SOIC-N]	R-8

<sup>1</sup> Z = RoHS Compliant Part.

**ADN4661**

**NOTES**