

# SN75LBC976 9-CHANNEL DIFFERENTIAL TRANSCEIVER

SLLS133D – AUGUST 1992 – REVISED MAY 1995

- Nine Differential Channels for the Data and Control Paths of the Differential Small Computer Systems Interface (SCSI) and Intelligent Peripheral Interface (IPI-2)
- Meets or Exceeds the Requirements of ANSI Standard RS-485 and ISO 8482:1987(E)
- Packaged in Shrink Small-Outline Package With 25-mil Terminal Pitch
- Designed to Operate at 10 Million Transfers Per Second
- Low Disabled Supply Current  
1.4 mA Typical
- Thermal-Shutdown Protection
- Power-Up/Power-Down Glitch Protection
- Positive and Negative Output-Current Limiting
- Open-Circuit Fail-Safe Receiver Design

## description

The SN75LBC976 is a nine-channel differential transceiver based on the 75LBC176 LinASIC™ cell. Use of TI's LinBiCMOS™† process technology allows the power reduction necessary to integrate nine differential transceivers. On-chip enabling logic makes this device applicable for the data path (eight data bits plus parity) and the control path (nine bits) for both the Small Computer Systems Interface (SCSI) and the Intelligent Peripheral Interface (IPI-2) standard data interfaces.

The SN75LBC976 is packaged in a shrink small-outline package (DL) with improved thermal characteristics using heat-sink terminals. This package is ideal for low-profile, space-restricted applications such as hard disk drives.

The switching speed and testing capabilities of the SN75LBC976 are sufficient to transfer data over the data bus at 10 million transfers per second. Each of the nine channels conforms to the requirements of the ANSI RS-485 and ISO 8482:1987(E) standards referenced by ANSI X3.129-1986 (IPI), ANSI X3.131-1993 (SCSI-2), and the proposed SCSI-3 standards.

The SN75LBC976 is characterized for operation from 0°C to 70°C.

## DL PACKAGE (TOP VIEW)

GND	1	56	CDE2
BSR	2	55	CDE1
CRE	3	54	CDE0
1A	4	53	9B+
1DE/RE	5	52	9B-
2A	6	51	8B+
2DE/RE	7	50	8B-
3A	8	49	7B+
3DE/RE	9	48	7B-
4A	10	47	6B+
4DE/RE	11	46	6B-
V <sub>CC</sub>	12	45	V <sub>CC</sub>
GND	13	44	GND
GND	14	43	GND
GND	15	42	GND
GND	16	41	GND
GND	17	40	GND
V <sub>CC</sub>	18	39	V <sub>CC</sub>
5A	19	38	5B+
5DE/RE	20	37	5B-
6A	21	36	4B+
6DE/RE	22	35	4B-
7A	23	34	3B+
7DE/RE	24	33	3B-
8A	25	32	2B+
8DE/RE	26	31	2B-
9A	27	30	1B+
9DE/RE	28	29	1B-

Pins 13 through 17 and 40 through 44 are connected together to the package lead frame and signal ground.

† Patent pending

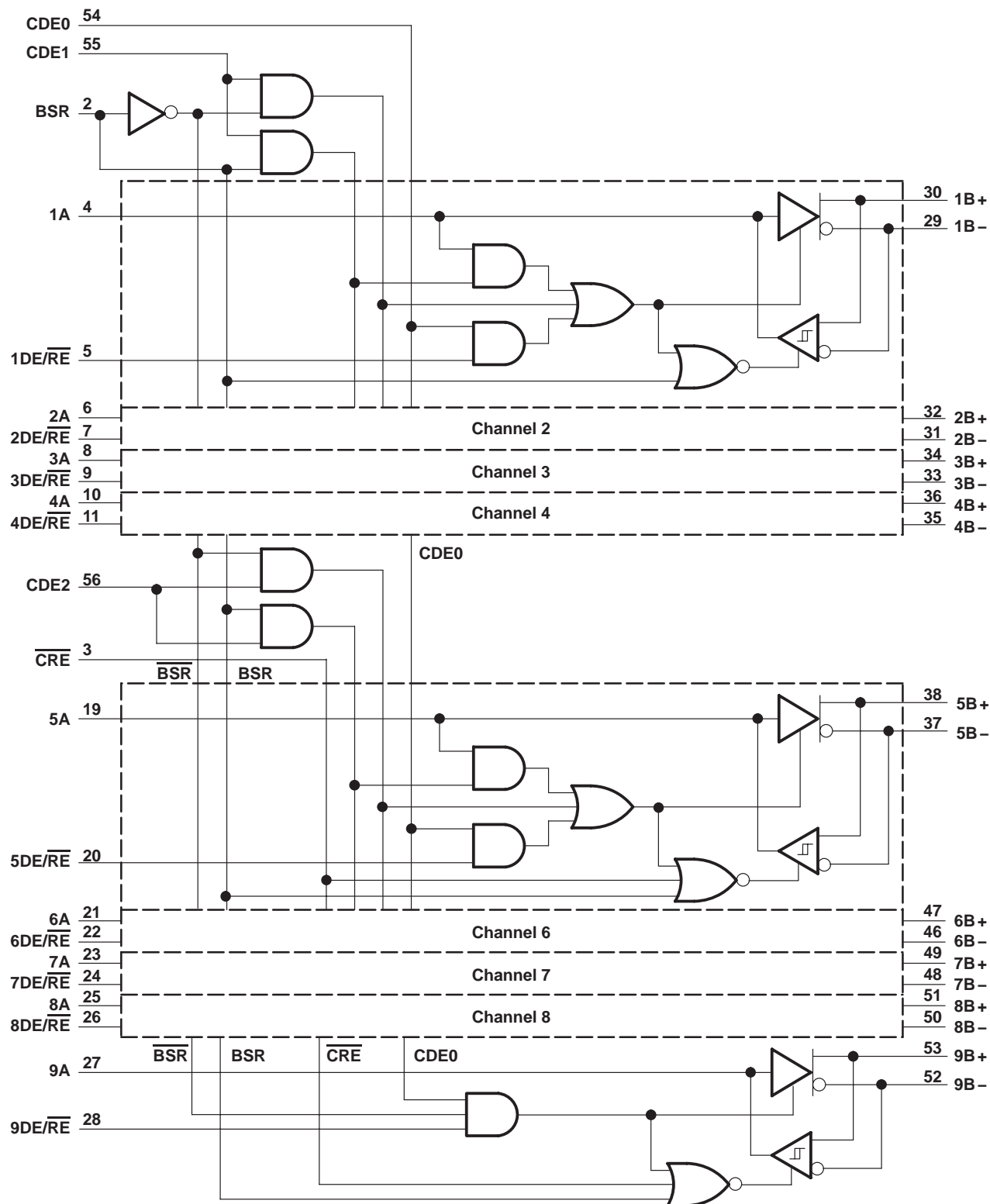
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### logic diagram (positive logic)<sup>†</sup>

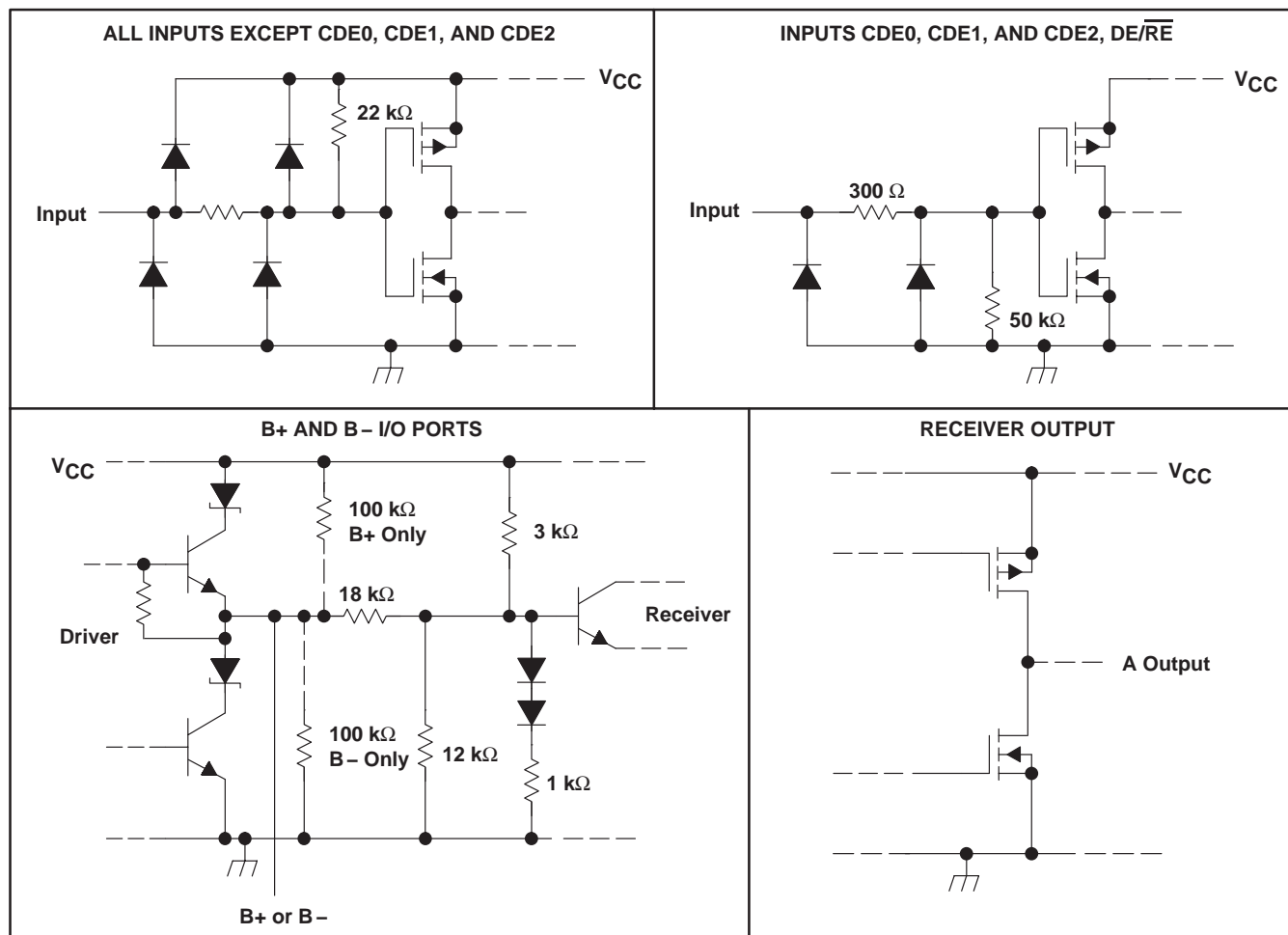


<sup>†</sup> For additional logic diagrams, see Application Information, Table 1 and Figures 7 through 44.



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## schematics of inputs and outputs



## absolute maximum ratings over operating free-air temperature range (unless otherwise noted)<sup>†</sup>

Supply voltage range, V <sub>CC</sub> (see Note 1)	–0.3 V to 7 V
Bus voltage range	–10 V to 15 V
Data I/O and control (A-side) voltage range	–0.3 V to 7 V
Continuous power dissipation	internally limited
Operating free-air temperature range, T <sub>A</sub>	0°C to 70°C
Storage temperature range, T <sub>stg</sub>	–65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

<sup>†</sup> Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: All voltage values are with respect to GND.

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### recommended operating conditions

		MIN	NOM	MAX	UNIT
Supply voltage, V <sub>CC</sub>		4.75	5	5.25	V
Voltage at any bus terminal (separately or common-mode), V <sub>O</sub> , V <sub>I</sub> , or V <sub>IC</sub>	B + or B –	12			V
		–7			
High-level input voltage, V <sub>IH</sub>	All except B + and B –	2			V
Low-level input voltage, V <sub>IL</sub>	All except B + and B –	0.8			V
High-level output current, I <sub>OH</sub>	B + or B –	–60			mA
	A	–8			mA
Low-level output current, I <sub>OL</sub>	B + or B –	60			mA
	A	8			mA
Operating free-air temperature, T <sub>A</sub>		0		70	°C

### device electrical characteristics over recommended ranges of operating conditions (unless otherwise noted)

PARAMETER			TEST CONDITIONS		MIN	TYP†	MAX	UNIT
I <sub>IH</sub>	High-level input current	BSR, A, DE/ $\overline{RE}$ , and $\overline{CRE}$	See Figure 1	V <sub>IH</sub> = 2 V			–200	μA
		CDE0, CDE1, and CDE2					100	μA
I <sub>IL</sub>	Low-level input current	BSR, A, DE/ $\overline{RE}$ , and $\overline{CRE}$		V <sub>IL</sub> = 0.8 V			–200	μA
		CDE0, CDE1, and CDE2					100	μA
I <sub>CC</sub>	Supply current	All drivers and receivers disabled	BSR and CDE0 at 5 V, Other inputs at 0 V			1.4	3	mA
		All receivers enabled	No load, V <sub>ID</sub> = 5 V, All other inputs at 0 V			29	45	mA
		All drivers enabled	BSR at 0 V, No load, All other inputs at 5 V			4.8	10	mA
C <sub>O</sub>	Bus port output capacitance		B+ or B–			16		pF
C <sub>pd</sub>	Power dissipation capacitance‡		One driver			460		pF
			One receiver			50		pF

† All typical values are at  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ .

‡  $C_{pd}$  determines the no-load dynamic current consumption;  $I_S = C_{pd} \cdot V_{CC} \cdot f + I_{CC}$ .

### driver electrical characteristics over recommended ranges of operating conditions (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$ V_{OD} $ Differential output voltage	$V_{test} = -7\text{ V to }12\text{ V}$ , See Figure 2	1	2		V
$I_{OS}$ Output short-circuit current	See Figure 3			±250	mA
$I_{OZ}$ High-impedance-state output current	See receiver input current				

**receiver electrical characteristics over recommended ranges of operating conditions (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	MIN	TYP†	MAX	UNIT
V <sub>OH</sub>	High-level output voltage	V <sub>ID</sub> = 200 mV, See Figure 1		2.5		V
V <sub>OL</sub>	Low-level output voltage	V <sub>ID</sub> = –200 mV, See Figure 1			0.8	V
V <sub>IT+</sub>	Positive-going input threshold voltage	I <sub>OH</sub> = –8 mA, See Figure 1			0.2	V
V <sub>IT–</sub>	Negative-going input threshold voltage	I <sub>OL</sub> = 8 mA, See Figure 1	–0.2			V
V <sub>hys</sub>	Receiver input hysteresis voltage (V <sub>IT+</sub> – V <sub>IT–</sub> )			45		mV
I <sub>I</sub>	Receiver input current	B+ and B– V <sub>I</sub> = 12 V, Other input at 0 V, V <sub>CC</sub> = 5 V, See Figure 1		0.7	1	mA
				0.8	1	
				–0.5	–0.8	mA
				–0.4	–0.8	
I <sub>OZ</sub>	High-impedance-state output current	See Figure 1			–200	μA
					50	

**driver switching characteristics over recommended operating conditions (unless otherwise noted) (see Figure 4)**

PARAMETER		TEST CONDITIONS	MIN	TYP†	MAX	UNIT
t <sub>d(OD)</sub>	Differential delay time, high- to low-level output (t <sub>d(ODH)</sub> ) or low- to high-level output (t <sub>d(ODL)</sub> )		7.6		19.6	ns
		V <sub>CC</sub> = 5 V, T <sub>A</sub> = 25°C	9.1		17.1	
		V <sub>CC</sub> = 5 V, T <sub>A</sub> = 70°C	11.5		19.5	
t <sub>sk(lim)</sub>	Skew limit, the maximum difference in propagation delay times between any two drivers on any two devices				12	ns
		V <sub>CC</sub> = 5 V, See Note 2			8	
t <sub>sk(p)</sub>	Pulse skew ( t <sub>d(ODL)</sub> – t <sub>d(ODH)</sub>  )			0	6	ns
t <sub>t</sub>	Transition time (t <sub>r</sub> or t <sub>f</sub> )			10		ns

† All typical values are at V<sub>CC</sub> = 5 V, T<sub>A</sub> = 25°C.

NOTE 2: This specification applies to any 5°C band within the operating temperature range.

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**receiver switching characteristics over recommended operating conditions (see Figure 5) (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
$t_{pd}$ Propagation delay time, high- to low-level output ( $t_{PLH}$ ) or low- to high-level output ( $t_{PHL}$ )		21.5		33	ns
	$V_{CC} = 5\text{ V}$ , $T_A = 25^\circ\text{C}$	22.6		31.6	
	$V_{CC} = 5\text{ V}$ , $T_A = 70^\circ\text{C}$	23.4		32.4	
$t_{sk(lim)}$ Skew limit, the maximum difference in propagation delay times between any two drivers on any two devices				12	ns
	$V_{CC} = 5\text{ V}$ , See Note 2			9	
$t_{sk(p)}$ Pulse skew ( $ t_{PHL} - t_{PLH} $ )			2	6	ns
$t_t$ Transition time ( $t_r$ or $t_f$ )			3		ns

† All typical values are at  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ .

NOTE 2: This specification applies to any  $5^\circ\text{C}$  band within the operating temperature range.

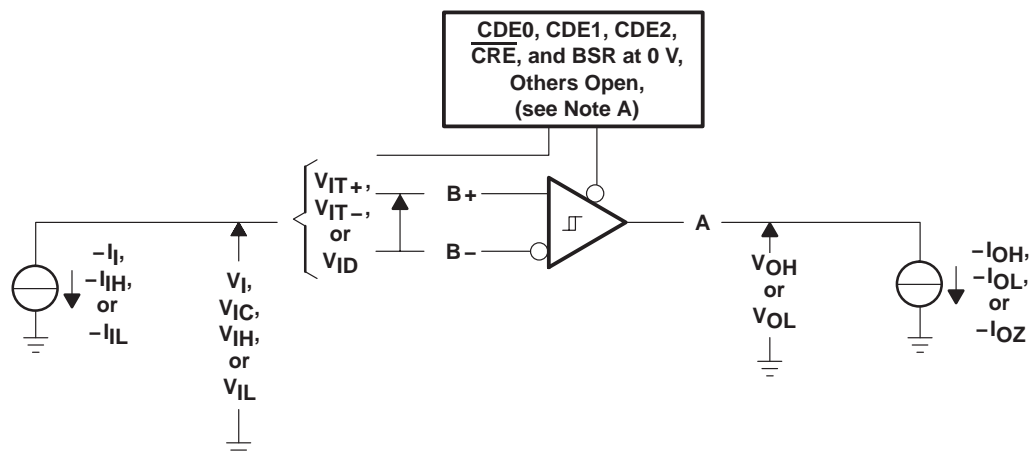
**transceiver switching characteristics over recommended operating conditions**

PARAMETER	TEST CONDITIONS	MIN	MAX	UNIT
$t_{en(RXL)}$ Enable time, transmit-to-receive to low-level output	See Figure 6		150	ns
$t_{en(RXH)}$ Enable time, transmit-to-receive to high-level output			150	ns
$t_{en(TXL)}$ Enable time, receive-to-transmit to low-level output			80	ns
$t_{en(TXH)}$ Enable time, receive-to-transmit to high-level output			80	ns
$t_{su}$ Setup time, CDE0, CDE1, CDE2, BSR, or $\overline{\text{CRE}}$ to active input(s) or output(s)		150		ns

**thermal characteristics**

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$R_{\theta JA}$ Junction-to-free-air thermal resistance	Board mounted, No air flow		50		$^\circ\text{C}/\text{W}$
$R_{\theta JC}$ Junction-to-case thermal resistance			12		$^\circ\text{C}/\text{W}$

### PARAMETER MEASUREMENT INFORMATION



NOTE A: For the  $I_{OZ}$  measurement, BSR is at 5 V and CDE0, CDE1, and CDE2 are at 0 V.

**Figure 1. Receiver Test Circuit and Input Conditions**

PARAMETER MEASUREMENT INFORMATION

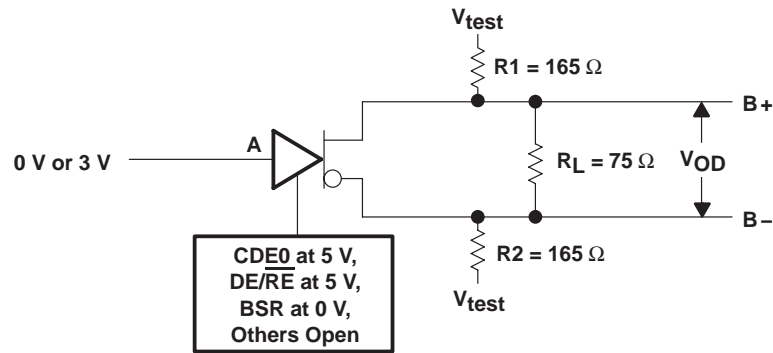
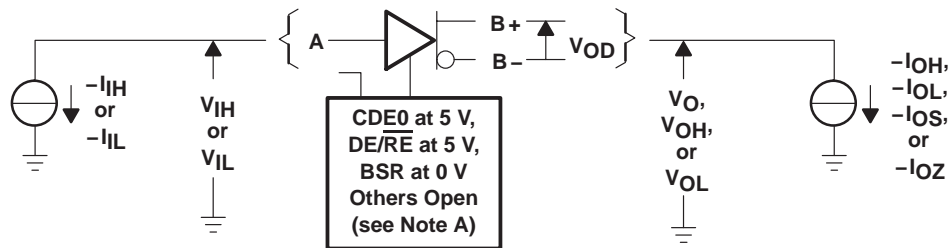


Figure 2. Driver  $V_{OD}$  Test Circuit



NOTE A: For the  $I_{OZ}$  test, the BSR input is at 5 V and all others are at 0 V.

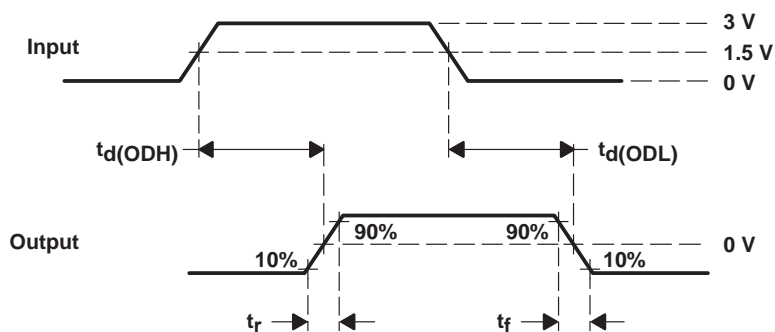
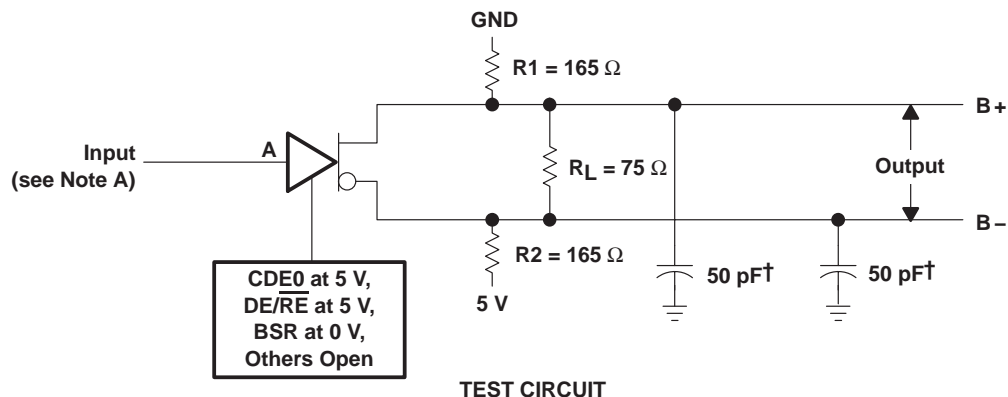
Figure 3. Driver Test Circuit and Input Conditions

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### PARAMETER MEASUREMENT INFORMATION



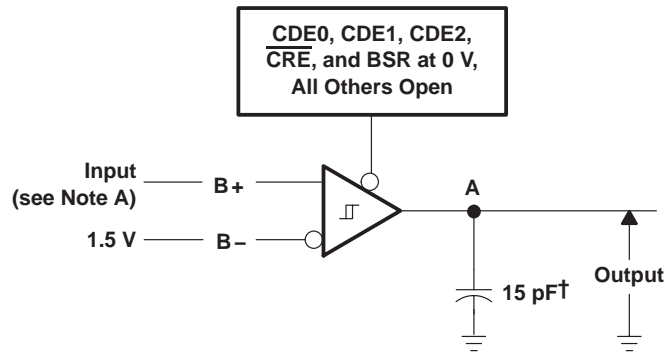
† Includes probe and jig capacitance.

NOTE A: The input is provided by a pulse generator with an output of 0 to 3 V, PRR of 1 MHz, 50% duty cycle,  $t_r$  and  $t_f < 6$  ns, and  $Z_O = 50 \Omega$ .

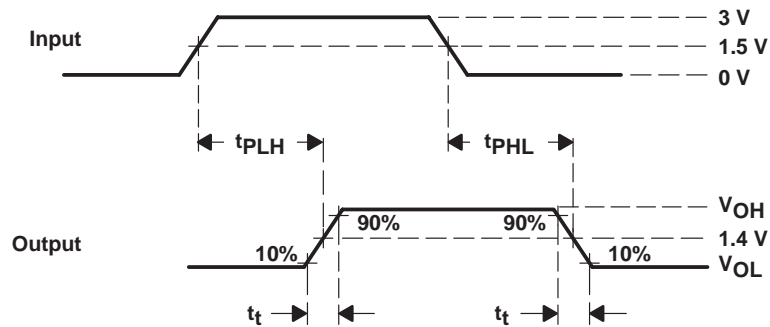
Figure 4. Driver Test Circuit and Voltage Waveforms



## PARAMETER MEASUREMENT INFORMATION



### TEST CIRCUIT



### VOLTAGE WAVEFORMS

† Includes probe and jig capacitance.

NOTE A: The input is provided by a pulse generator with an output of 0 to 3 V, PRR of 1 MHz, 50% duty cycle,  $t_r$  and  $t_f < 6$  ns, and  $Z_O = 50 \Omega$ .

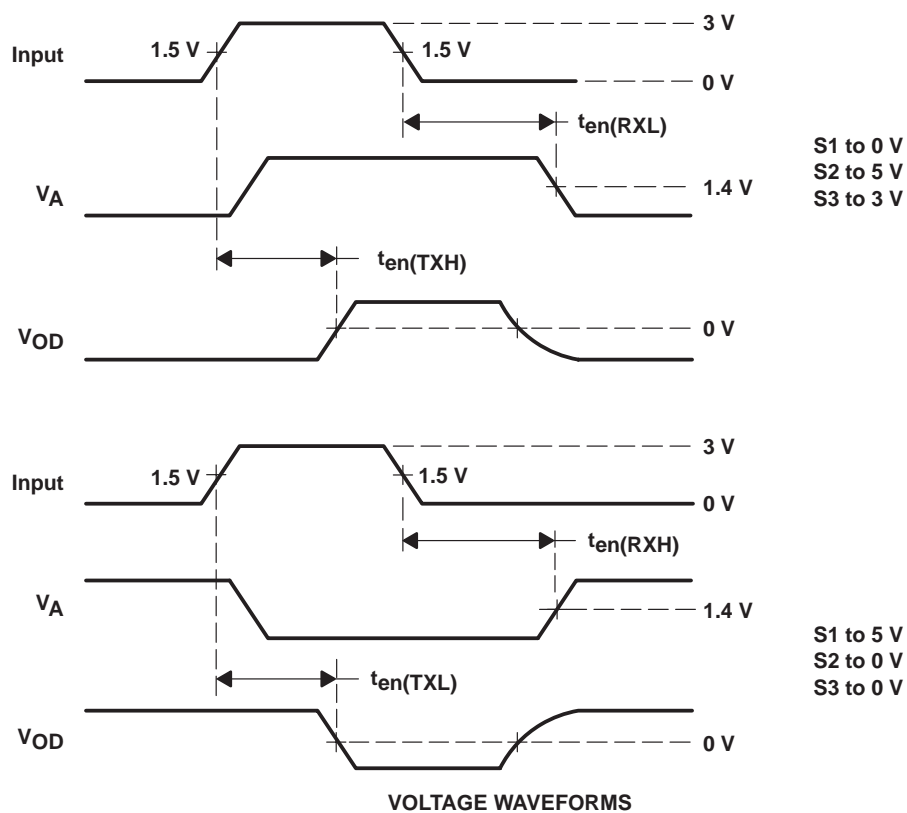
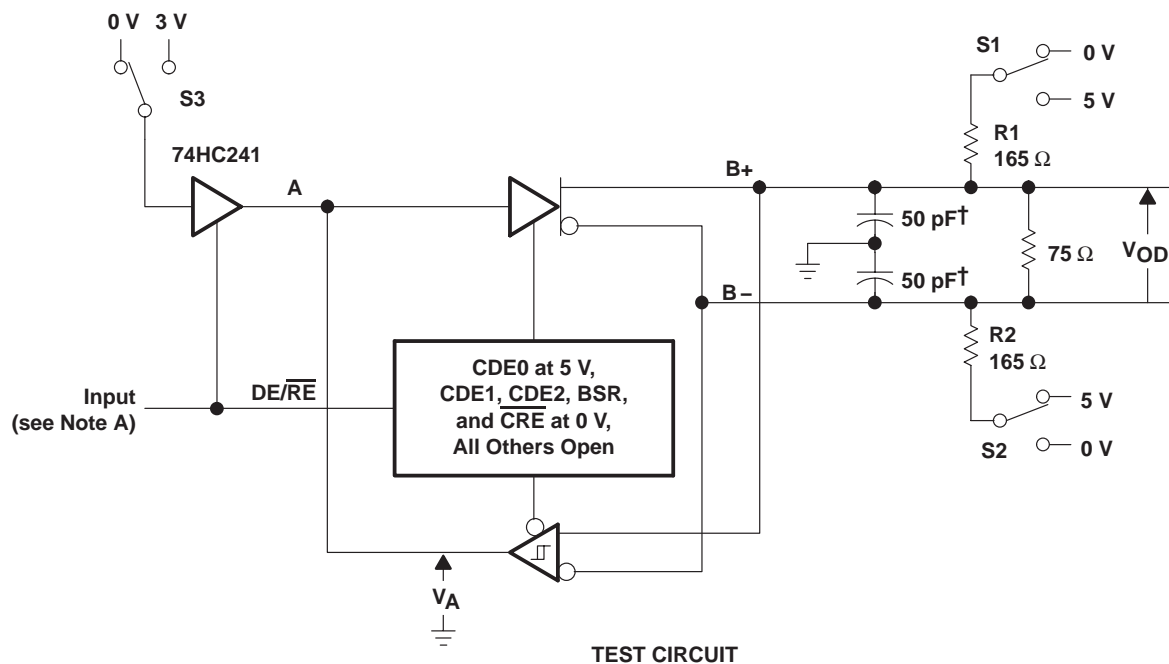
**Figure 5. Receiver Test Circuit and Voltage Waveforms**

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### PARAMETER MEASUREMENT INFORMATION



† Includes probe and jig capacitance.

NOTE A: The input is provided by a pulse generator with an output of 0 to 3 V, PRR of 1 MHz, 50% duty cycle,  $t_r$  and  $t_f < 6$  ns, and  $Z_O = 50 \Omega$ .

Figure 6. Enable Time Test Circuit and Voltage Waveforms



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## TYPICAL CHARACTERISTICS

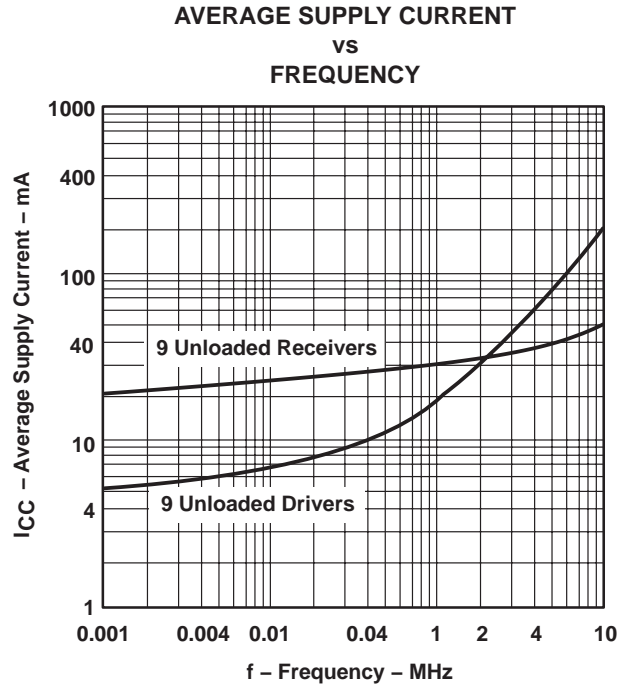


Figure 7

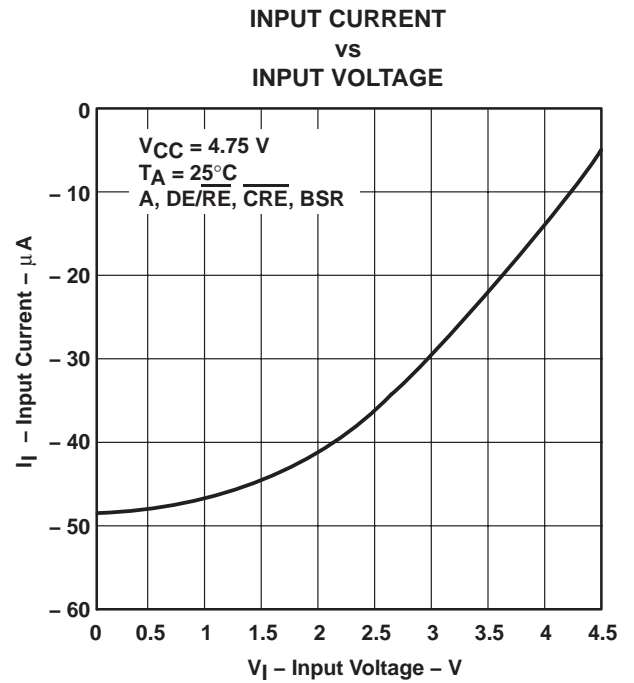


Figure 8

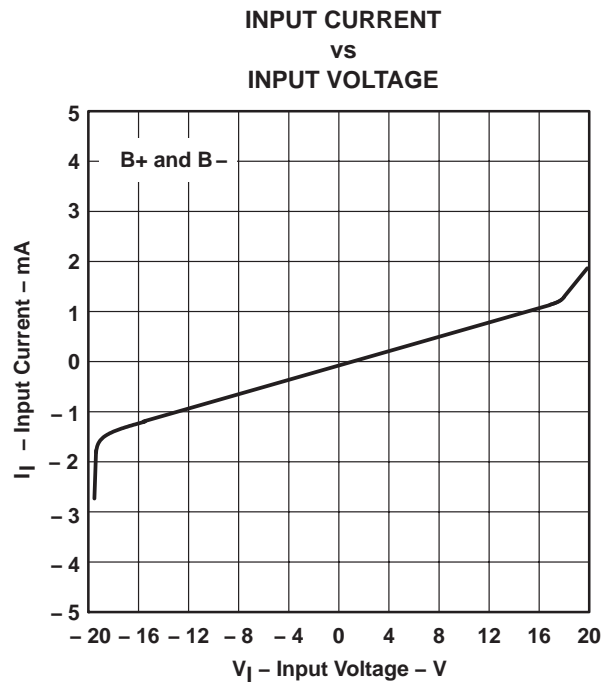


Figure 9

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### TYPICAL CHARACTERISTICS

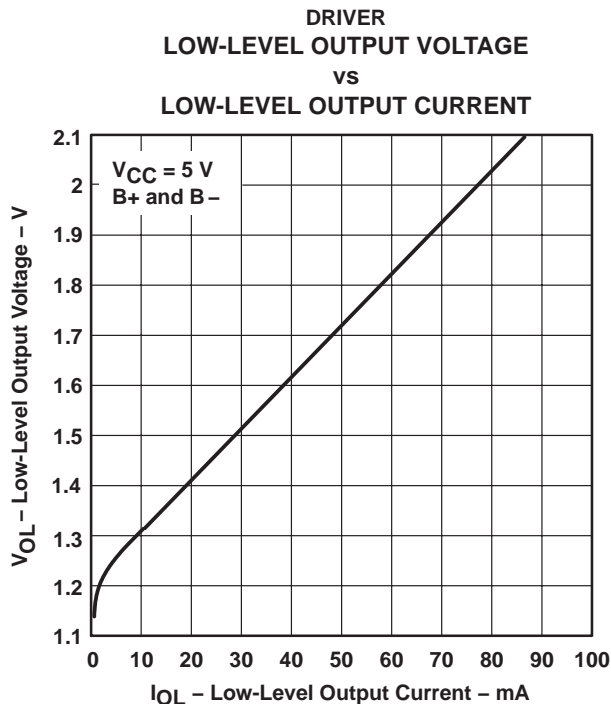


Figure 10

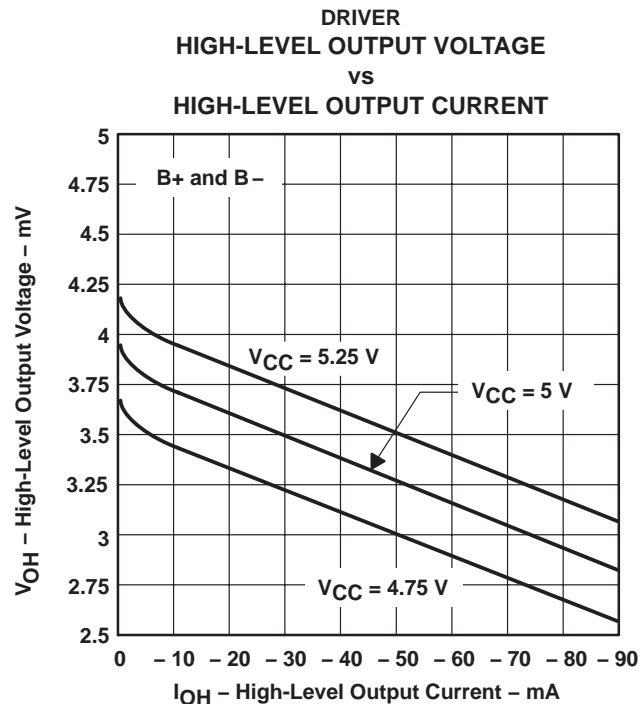


Figure 11

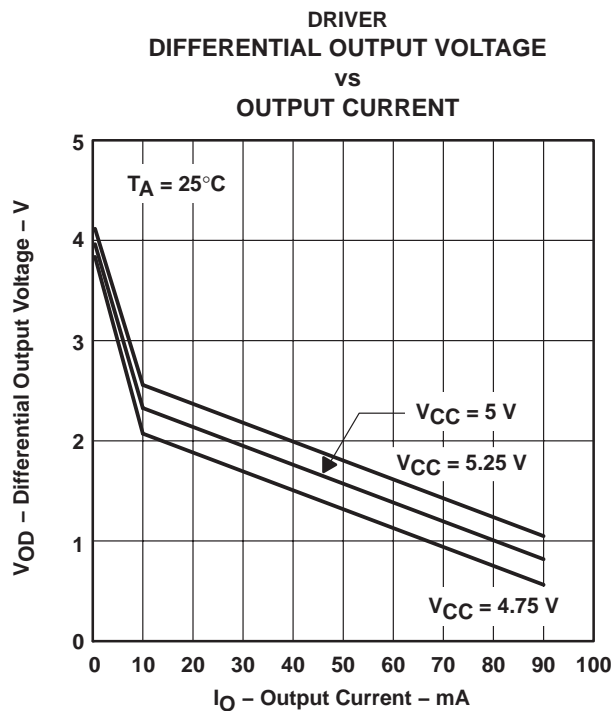


Figure 12

TYPICAL CHARACTERISTICS

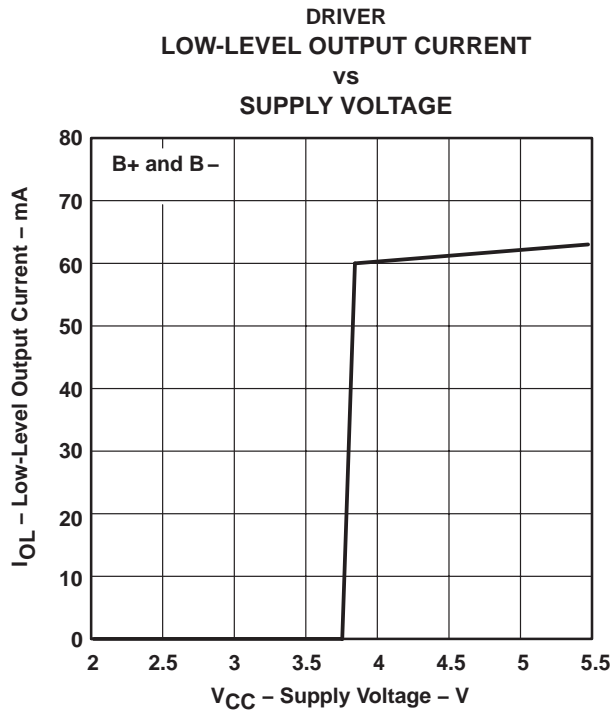


Figure 13

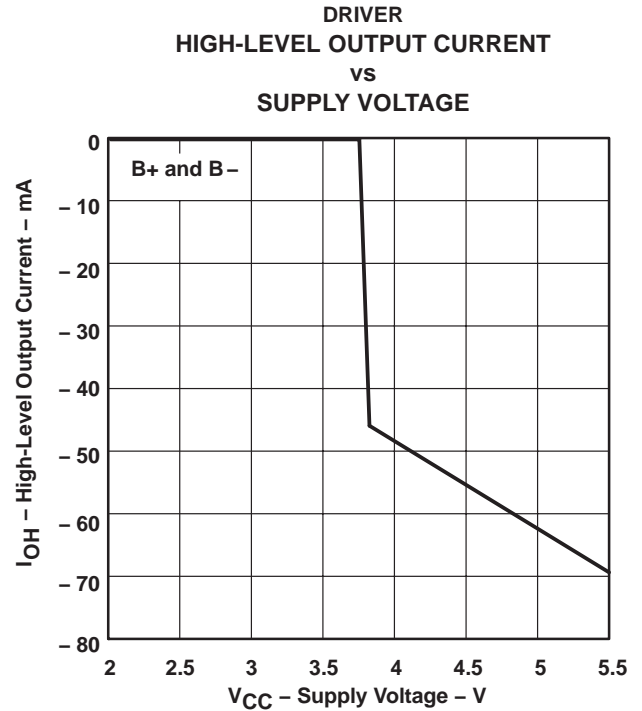


Figure 14

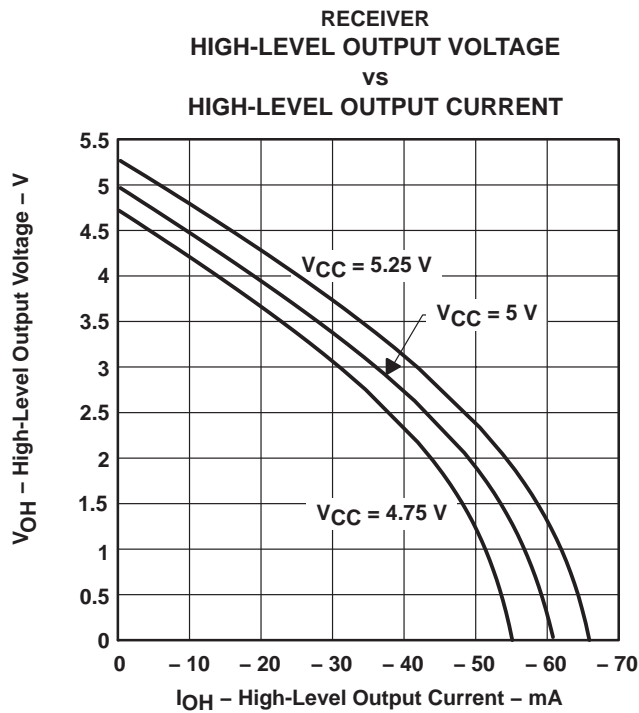


Figure 15

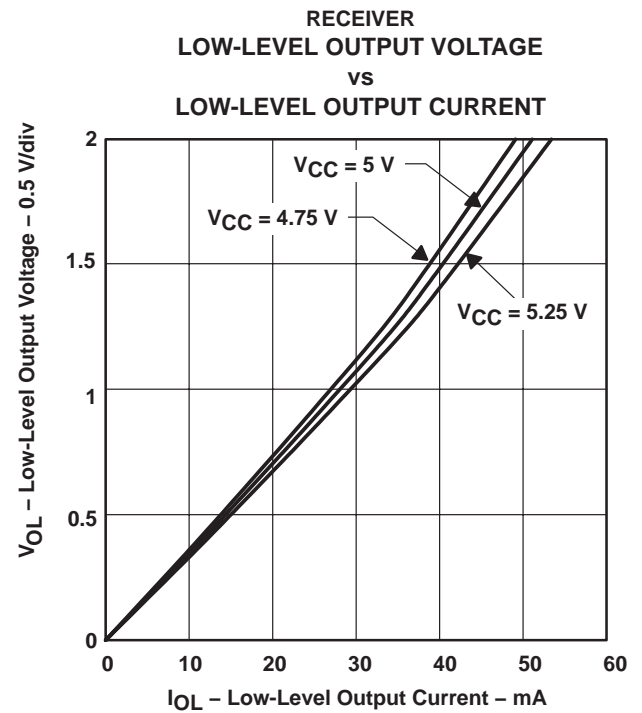


Figure 16

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### TYPICAL CHARACTERISTICS

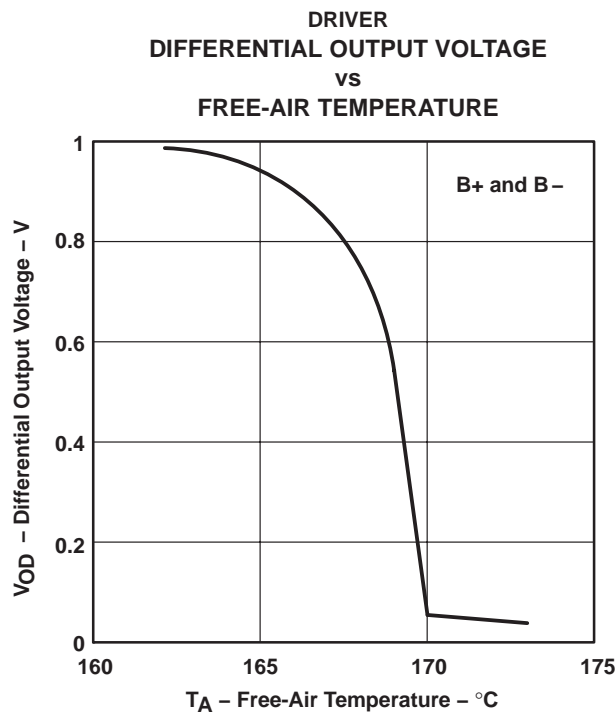


Figure 17

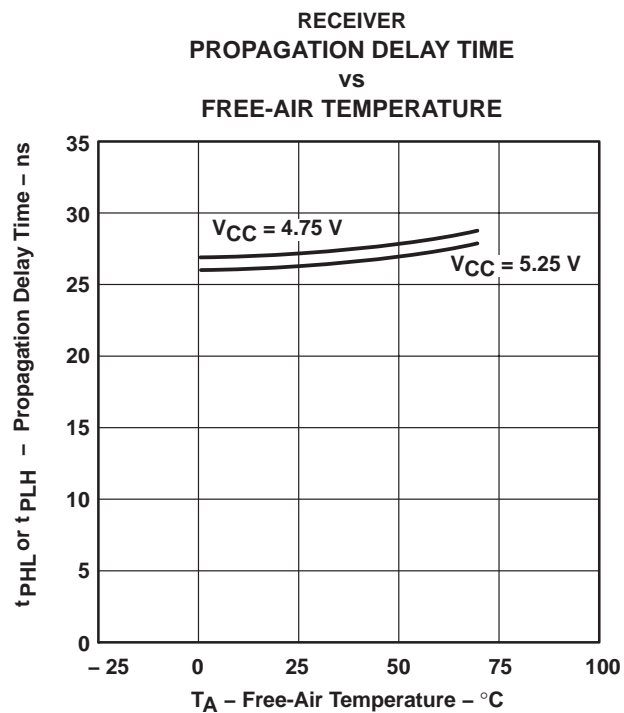


Figure 18

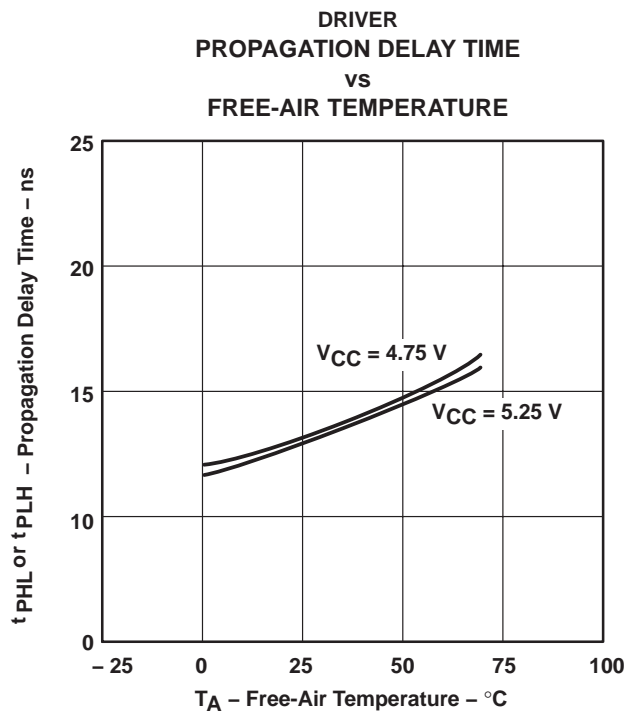


Figure 19

## APPLICATION INFORMATION

**Table 1. Typical Signal and Terminal Assignments**

SIGNAL	TERMINAL	SCSI DATA	SCSI CONTROL	IPI DATA	IPI CONTROL
CDE0	54	DIFFSENSE	DIFFSENSE	V <sub>CC</sub>	V <sub>CC</sub>
CDE1	55	GND	GND	XMTA, XMTB	GND
CDE2	56	GND	GND	XMTA, XMTB	SLAVE/MASTER
BSR	2	GND	GND	GND, BSR	GND
$\overline{\text{CRE}}$	3	GND	GND	GND	V <sub>CC</sub>
1A	4	DB0, DB8	ATN	AD7, BD7	NOT USED
1DE/ $\overline{\text{RE}}$	5	DBE0, DBE8	INIT EN	GND	GND
2A	6	DB1, DB9	BSY	AD6, BD6	NOT USED
2DE/ $\overline{\text{RE}}$	7	DBE1, DBE9	BSY EN	GND	GND
3A	8	DB2, DB10	ACK	AD5, BD5	SYNC IN
3DE/ $\overline{\text{RE}}$	9	DBE2, DBE10	INIT EN	GND	GND
4A	10	DB3, DB11	RST	AD4, BD4	SLAVE IN
4DE/ $\overline{\text{RE}}$	11	DBE3, DBE11	GND	GND	GND
5A	19	DB4, DB12	MSG	AD3, BD3	NOT USED
5DE/ $\overline{\text{RE}}$	20	DBE4, DBE12	TARG EN	GND	GND
6A	21	DB5, DB13	SEL	AD2, BD2	SYNC OUT
6DE/ $\overline{\text{RE}}$	22	DBE5, DBE13	SEL EN	GND	GND
7A	23	DB6, DB14	C/D	AD1, BD1	MASTER OUT
7DE/ $\overline{\text{RE}}$	24	DBE6, DBE14	TARG EN	GND	GND
8A	25	DB7, DB15	REQ	AD0, BD0	SELECT OUT
8DE/ $\overline{\text{RE}}$	26	DBE7, DBE15	TARG EN	GND	GND
9A	27	DBP0, DBP1	I/O	AP, BP	ATTENTION IN
9DE/ $\overline{\text{RE}}$	28	DBPE0, DBPE1	TARG EN	XMTA, XMTB	V <sub>CC</sub>

**ABBREVIATIONS:**

DBn, data bit n, where n = (0,1, . . . ,15)  
 DBEn, data bit n enable, where n = (0,1, . . . ,15)  
 DBP0, parity bit for data bits 0 through 7 or IPI bus A  
 DBPE0, parity bit enable for P0  
 DBP1, parity bit for data bits 8 through 15 or IPI bus B  
 DBPE1, parity bit enable for P1  
 ADn or BDn, IPI Bus A – Bit n (ADn) or Bus B – Bit n (BDn), where n = (0,1, . . . ,7)  
 AP or BP, IPI parity bit for bus A or bus B  
 XMTA or XMTB, transmit enable for IPI bus A or B  
 BSR, bit significant response  
 INIT EN, common enable for SCSI initiator mode  
 TARG EN, common enable for SCSI target mode

**NOTE:** Signal inputs are shown as active high. If only active-low inputs are available, logic inversion is accomplished by reversing the B+ and B– connector terminal assignments.



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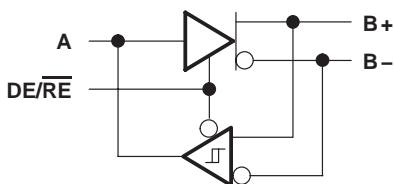
## Function Tables



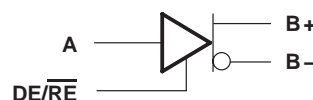
INPUTS		OUTPUT A
B + †	B - †	
L	H	L
H	L	H



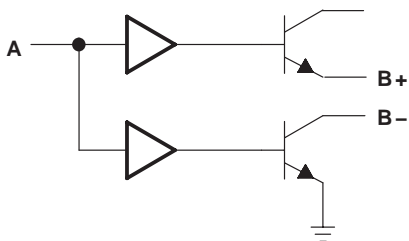
INPUT A	OUTPUTS	
	B+	B-
L	L	H
H	H	L



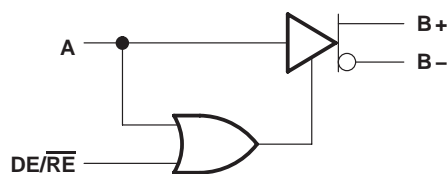
INPUTS				OUTPUTS		
DE/RE	A	B+†	B-†	A	B+	B-
L	-	L	H	L	-	-
L	-	H	L	H	-	-
H	L	-	-	-	L	H
H	H	-	-	-	H	L



INPUTS		OUTPUTS	
DE/RE	A	B+	B-
L	L	Z	Z
L	H	Z	Z
H	L	L	H
H	H	H	L



INPUT A	OUTPUTS	
	B+	B-
L	Z	Z
H	H	L

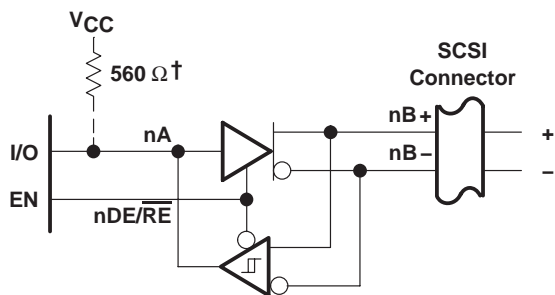


INPUTS		OUTPUTS	
DE/RE	A	B+	B-
L	L	Z	Z
L	H	H	L
H	L	L	H
H	H	H	L

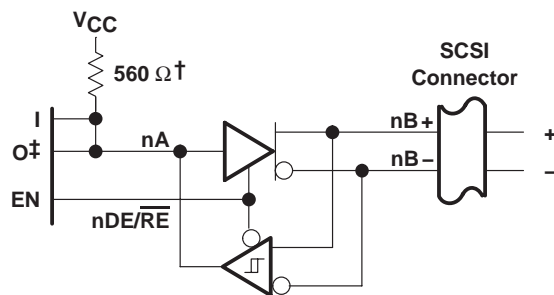
† An H in this column represents a voltage 200 mV higher than the other bus input. An L represents a voltage 200 mV lower than the other bus input. Any voltage less than 200 mV results in an indeterminate receiver output.



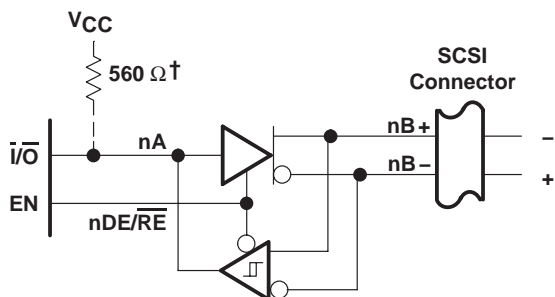
# APPLICATION INFORMATION



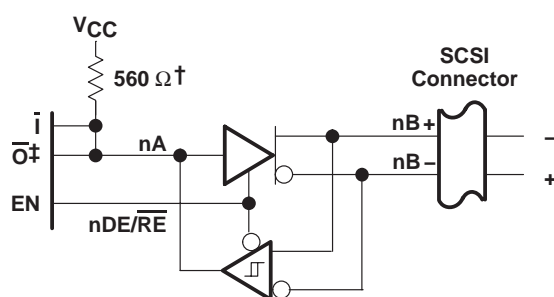
(a) ACTIVE-HIGH BIDIRECTIONAL I/O WITH SEPARATE ENABLE



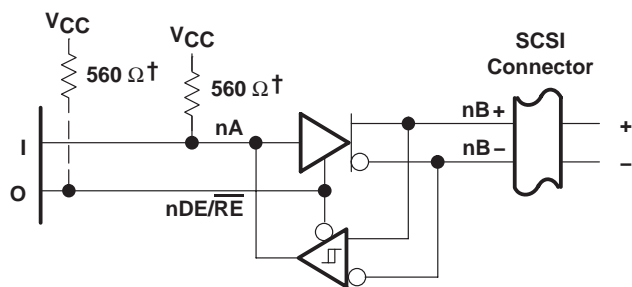
(d) SEPARATE ACTIVE-HIGH INPUT, OUTPUT, AND ENABLE



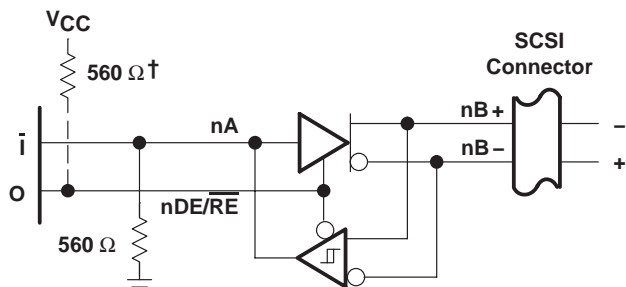
(b) ACTIVE-LOW BIDIRECTIONAL I/O WITH SEPARATE ENABLE



(e) SEPARATE ACTIVE-LOW INPUT AND OUTPUT AND ACTIVE-HIGH ENABLE



(c) WIRED-OR DRIVER AND ACTIVE-HIGH INPUT



(f) WIRED-OR DRIVER AND ACTIVE-LOW INPUT

† If 0, is open drain

‡ Must be open-drain or 3-state output

NOTE: The BSR, CRE, A, and DE/RE inputs have internal pullups. CDE0, CDE1, and CDE2 have internal pulldowns.

Figure 20. Typical SCSI Transceiver Connections

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#### channel logic configurations with control input logic

The following logic diagrams show the positive-logic representation for all combinations of control inputs. The control inputs are from MSB to LSB; BSR, CDE0, CDE1, CDE2, and  $\overline{\text{CRE}}$ , and are shown below the diagrams. Channel 1 is at the top and channel 9 is at the bottom of the logic diagrams.

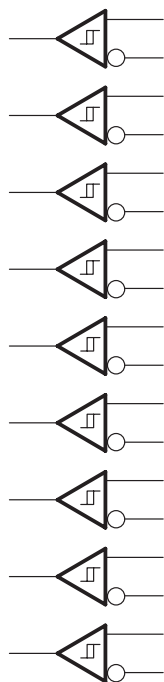


Figure 21. 00000

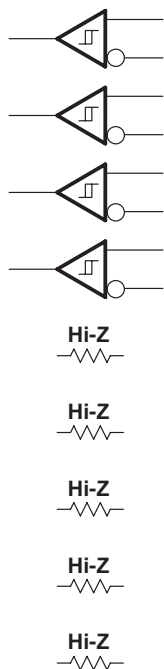


Figure 22. 00001

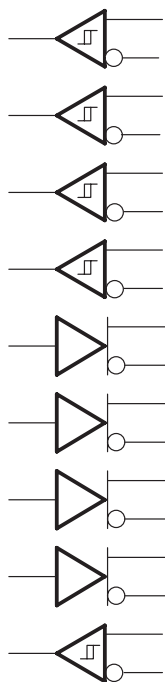


Figure 23. 00010

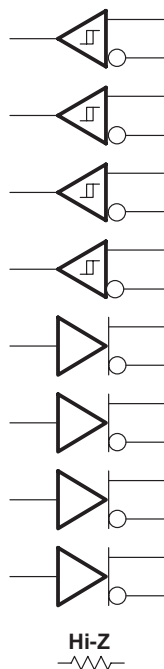


Figure 24. 00011

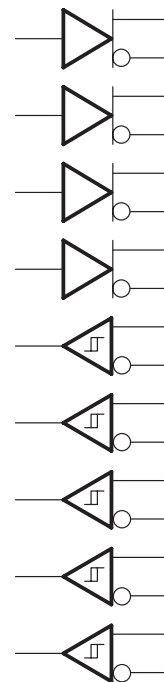
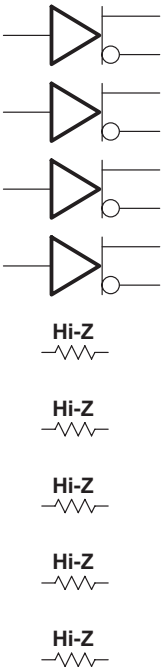
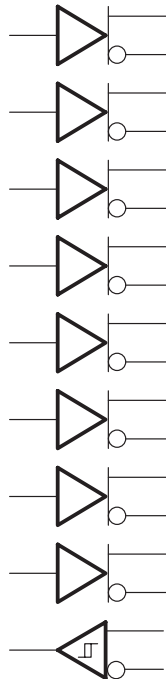


Figure 25. 00100

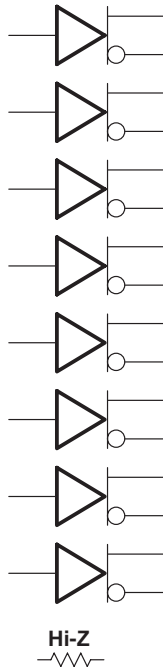
### APPLICATION INFORMATION



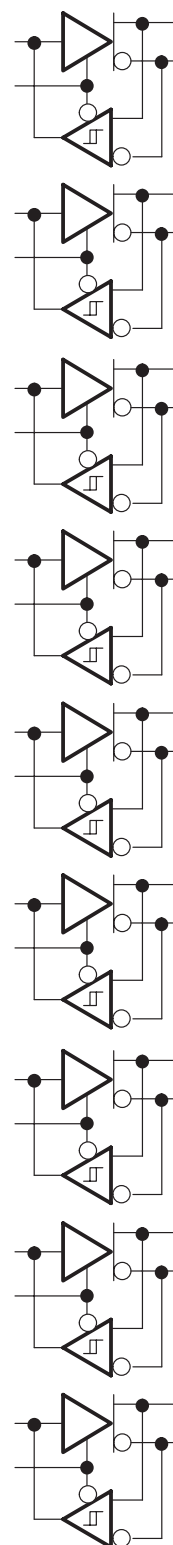
**Figure 26. 00101**



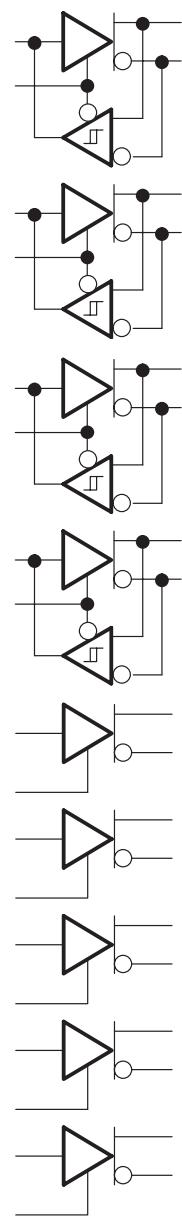
**Figure 27. 00110**



**Figure 28. 00111**



**Figure 29. 01000**



**Figure 30. 01001**

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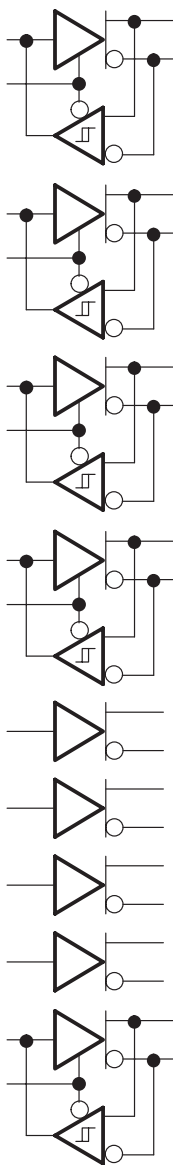


Figure 31. 01010

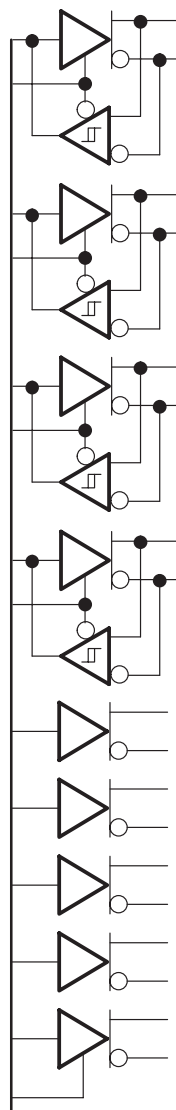


Figure 32. 01011

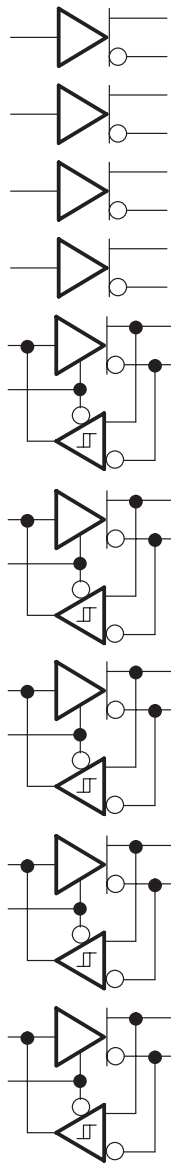


Figure 33. 01100

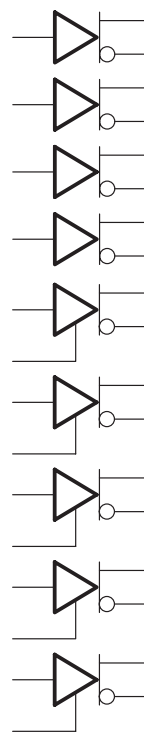


Figure 34. 01101

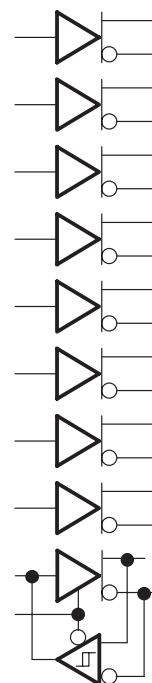
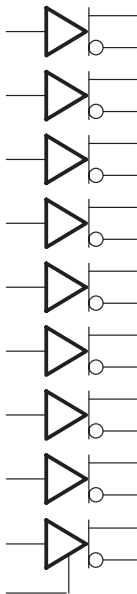
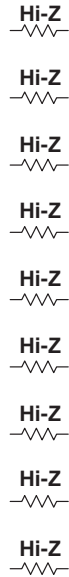


Figure 35. 01110

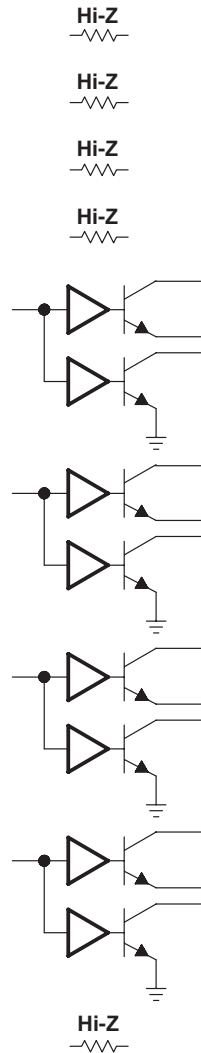
### APPLICATION INFORMATION



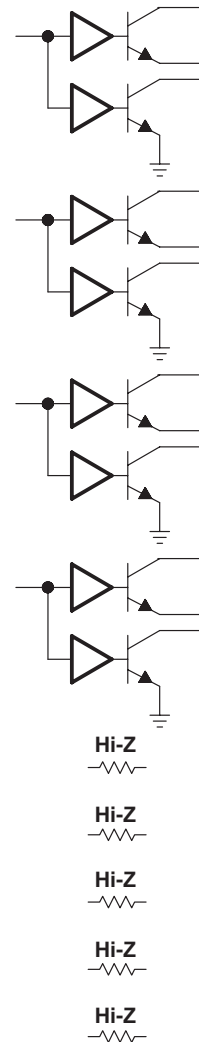
**Figure 36. 01111**



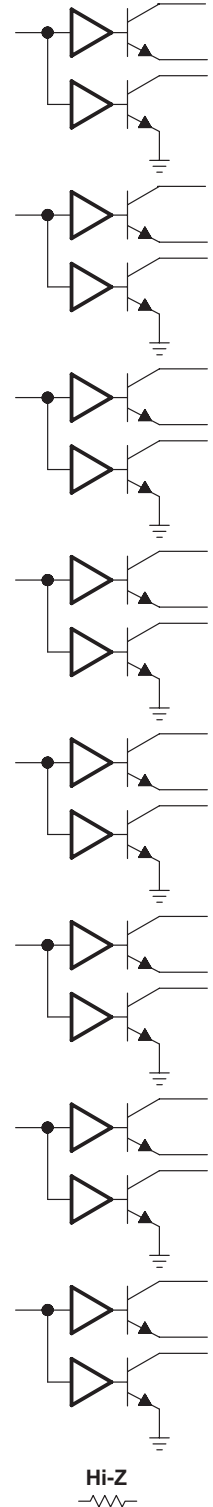
**Figure 37. 10000 and 10001**



**Figure 38. 10010 and 10011**



**Figure 39. 10100 and 10101**



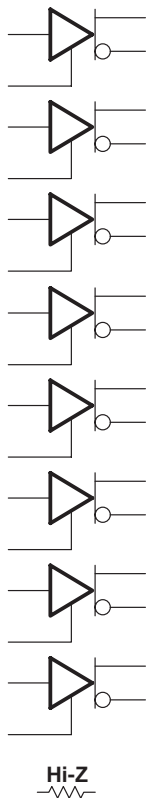
**Figure 40. 10110 and 10111**

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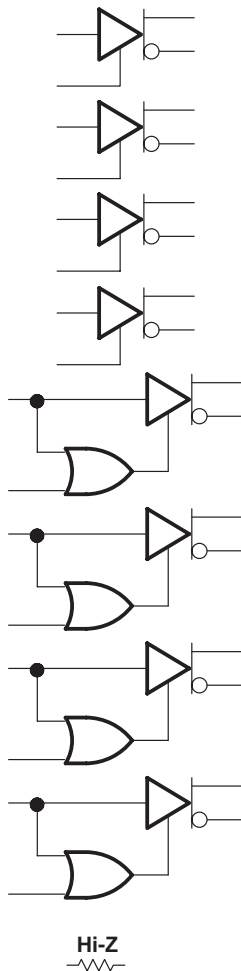
## 9-CHANNEL DIFFERENTIAL TRANSCIEVER

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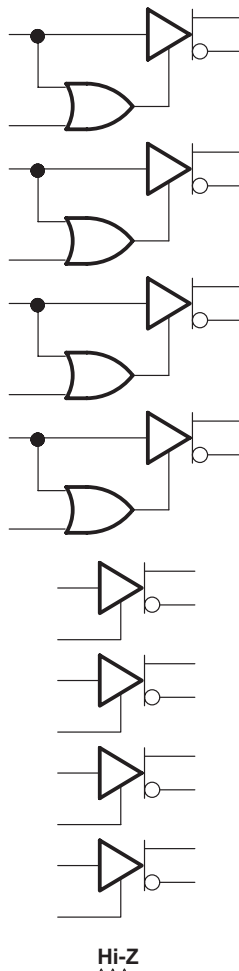
### APPLICATION INFORMATION



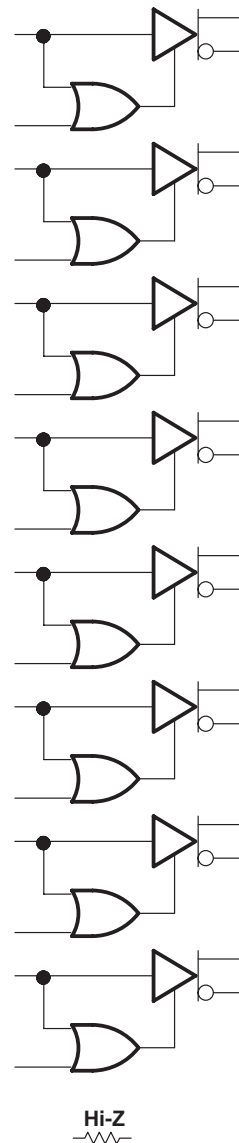
**Figure 41. 11000 and 11001**



**Figure 42. 11010 and 11011**



**Figure 43. 11100 and 11101**



**Figure 44. 11110 and 11111**

## PACKAGING INFORMATION

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
SN75LBC976DLR	OBSOLETE	SSOP	DL	56		TBD	Call TI	Call TI

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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- Military: [SN55LBC976](#)

NOTE: Qualified Version Definitions:

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