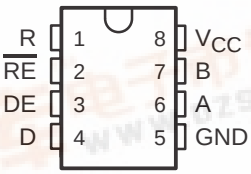
TL3695
DIFFERENTIAL BUS TRANSCEIVER

SLLS044D – NOVEMBER 1988 – REVISED DECEMBER 1999

- Bidirectional Transceiver
- Meets or Exceeds the Requirements of TIA/EIA-422-B, TIA/EIA-485-A, and ITU Recommendation V.11
- High-Speed Advanced Low-Power Schottky Circuitry
- Low Skew . . . 6 ns Max
- Designed for Multipoint Transmission on Long Bus Lines in Noisy Environments
- Low Supply-Current Requirements . . . 30 mA Max
- Wide Positive and Negative Input/Output Bus-Voltage Ranges
- Driver Output Capacity . . . ±60 mA
- Thermal-Shutdown Protection
- Driver Positive and Negative Current Limiting
- Receiver Input Impedances . . . 12 kΩ Min
- Receiver Input Sensitivity . . . ±200 mV Max
- Receiver Input Hysteresis . . . 120 mV Typ
- Fail Safe . . . High Receiver Output With Inputs Open
- Operates From a Single 5-V Supply
- Glitch-Free Power-Up and Power-Down Protection
- Interchangeable With National DS3695 and DS3695A

D OR P PACKAGE
(TOP VIEW)



description

The TL3695 differential bus transceiver is designed for bidirectional data communication on multipoint bus-transmission lines. It is designed for balanced transmission lines and meets TIA/EIA-422-B, TIA/EIA-485-A, and ITU Recommendation V.11.

The TL3695 combines a 3-state differential line driver and a differential input line receiver, both of which operate from a single 5-V power supply. The driver and receiver have active-high and active-low enables, respectively, which can be externally connected together to function as a directional control. The driver differential outputs and the receiver differential inputs are connected internally to form a differential input/output (I/O) bus port that is designed to offer minimum loading to the bus when the driver is disabled or V_{CC} = 0. This port features wide positive and negative common-mode voltage ranges, making the device suitable for party line applications.

The TL3695 is characterized for operation from 0°C to 70°C.

AVAILABLE OPTIONS

T_A	PACKAGED DEVICES	
	SMALL OUTLINE (D)	PLASTIC DIP (P)
0°C to 70°C	TL3695D	TL3695P

The D package is available taped and reeled. Add the suffix R to device type (e.g., TL3695DR).

Function Tables

DRIVER

INPUT D	ENABLE DE	OUTPUTS	
		A	B
H	H	H	L
L	H	L	H
X	L	Z	Z

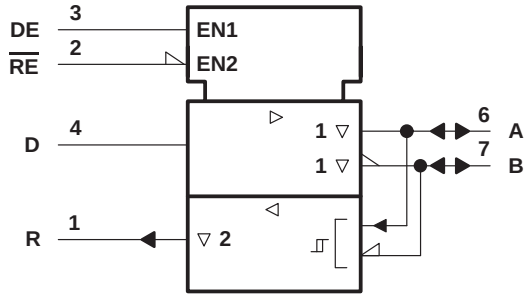
H = high level, L = low level, ? = indeterminate, X = irrelevant, Z = high impedance (off)

RECEIVER

DIFFERENTIAL INPUTS A – B	ENABLE $\overline{RE}$	OUTPUT R
$V_{ID} \geq 0.2$ V	L	H
-0.2 V $< V_{ID} < 0.2$ V	L	?
$V_{ID} \leq -0.2$ V	L	L
X	H	Z
Inputs open	L	H

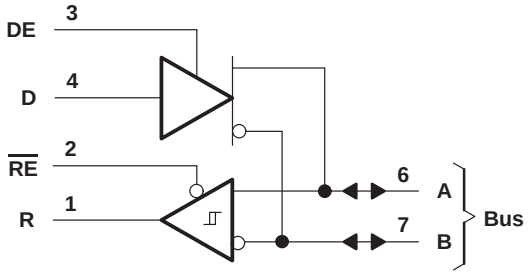
H = high level, L = low level, ? = indeterminate, X = irrelevant, Z = high impedance (off)

logic symbol†

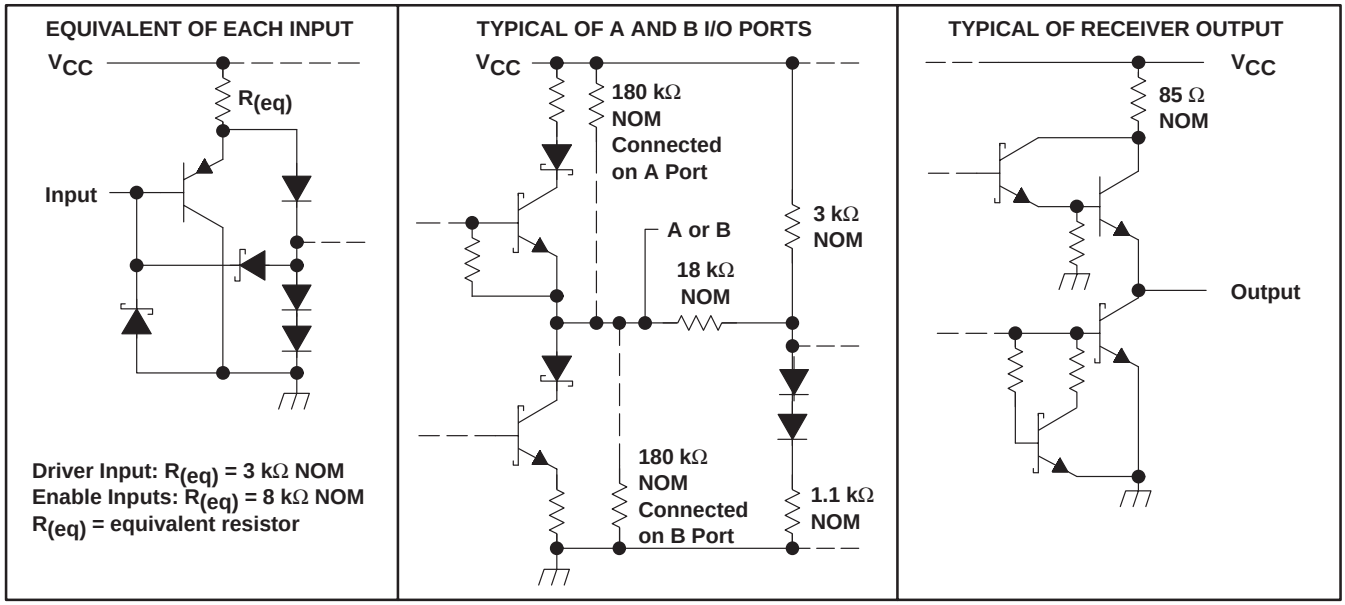


† This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.

logic diagram (positive logic)



schematic of inputs and outputs



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, V_{CC} (see Note 1) . . . . . 7 V
Voltage range at any bus terminal . . . . . –10 V to 15 V
Enable input voltage, V_I . . . . . 5.5 V
Operating free-air temperature range, T_A . . . . . 0°C to 70°C
Package thermal impedance, θ_{JA} (see Note 2): D package . . . . . 97°C/W
PW package . . . . . 85°C/W
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . . 260°C
Storage temperature range, T_{stg} . . . . . –65°C to 150°C

† 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.

NOTES: 1. All voltage values, except differential I/O bus voltage, are with respect to network ground terminal.
2. The package thermal impedance is calculated in accordance with JESD 51.

recommended operating conditions

		MIN	NOM	MAX	UNIT
Supply voltage, V_{CC}		4.75	5	5.25	V
Voltage at any bus terminal (separately or common mode), V_I or V_{IC}				12	V
				–7	
High-level Input voltage, V_{IH}	D, DE, and $\overline{RE}$	2			V
Low-level Input voltage, V_{IL}	D, DE, and $\overline{RE}$			0.8	V
Differential input voltage, V_{ID} (see Note 3)				±12	V
High-level output current, I_{OH}	Driver			– 60	mA
	Receiver			– 400	µA
Low-level output current, I_{OL}	Driver			60	mA
	Receiver			8	
Operating free-air temperature, T_A		0		70	°C

NOTE 3: Differential input/output bus voltage is measured at the noninverting terminal A with respect to the inverting terminal B.

DRIVER SECTION

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†		MIN	TYP‡	MAX	UNIT
V_{IK}	Input clamp voltage	I_I = –18 mA				–1.5	V
V_O	Output voltage	I_O = 0		0		6	V
$\|V_{OD1}\|$	Differential output voltage	I_O = 0		1.5		5	V
$\|V_{OD2}\|$	Differential output voltage	R_L = 100 Ω,	See Figure 1	1/2 V_{OD1} or 2§			V
		R_L = 54 Ω,	See Figure 1	1.5	2.5	5	V
V_{OD3}	Differential output voltage	V_{test} = –7 V to 12 V,	See Figure 2	1.5		5	V
$\Delta\|V_{OD}\|$	Change in magnitude of differential output voltage¶	R_L = 54 Ω,	See Figure 1			±0.2	V
V_{OC}	Common-mode output voltage					3	V
$\Delta\|V_{OC}\|$	Change in magnitude of common-mode output voltage¶					±0.2	V
I_O	Output current	Output disabled, See Note 4	V_O = 12 V			1	mA
			V_O = –7 V			–0.8	
I_{IH}	High-level input current	V_I = 2.4 V				20	µA
I_{IL}	Low-level input current	V_I = 0.4 V				–200	µA
I_{OS}	Short-circuit output current#	V_O = –6 V				–250	mA
		V_O = 0				–150	
		V_O = V_{CC}				250	
		V_O = 8 V				250	
I_{CC}	Supply current	No load	Outputs enabled		23	50	mA
			Outputs disabled		19	35	

† The power-off measurement in TIA/EIA-422-B applies to disabled outputs only and is not applied to combined inputs and outputs.
‡ All typical values are at V_{CC} = 5 V and T_A = 25°C.
§ The minimum V_{OD2} with a 100-Ω load is either 1/2 V_{OD1} or 2 V, whichever is greater.
¶ $\Delta|V_{OD}|$ 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.
# Duration of the short circuit should not exceed one second for this test.
NOTE 4: This applies for power on and power off. Refer to TIA/EIA-485-A for exact conditions. The TIA/EIA-422-B limit does not apply for a combined driver and receiver terminal.

switching characteristics over recommended ranges of supply voltage and operating free-air temperature

PARAMETER		TEST CONDITIONS			MIN	TYP‡	MAX	UNIT
$t_{d(OD)}$	Differential-output delay time	C_{L1} = C_{L2} = 100 pF,	R_L = 60 Ω,	See Figure 3		8	22	ns
	Skew ($\|t_{d(ODH)} - t_{d(ODL)}\|$)					1	8	ns
$t_{t(OD)}$	Differential output transition time					8	18	ns
t_{PZH}	Output enable time to high level	C_L = 100 pF,	R_L = 500 Ω,	See Figure 4			50	ns
t_{PZL}	Output enable time to low level	C_L = 100 pF,	R_L = 500 Ω,	See Figure 5			50	ns
t_{PHZ}	Output disable time from high level	C_L = 15 pF,	R_L = 500 Ω,	See Figure 4		8	30	ns
t_{PLZ}	Output disable time from low level	C_L = 15 pF,	R_L = 500 Ω,	See Figure 5		8	30	ns

‡ All typical values are at V_{CC} = 5 V and T_A = 25°C.

SYMBOL EQUIVALENTS

DATA-SHEET PARAMETER	TIA/EIA-422-B	TIA/EIA-485-A
V_O	V_{oa}, V_{ob}	V_{oa}, V_{ob}
$\|V_{OD1}\|$	V_o	V_o
$\|V_{OD2}\|$	V_t (R_L = 100 Ω)	V_t (R_L = 54 Ω)
$\|V_{OD3}\|$		V_t (test termination measurement 2)
V_{test}		V_{tst}
$\Delta\|V_{OD}\|$	$\|\|V_t\| - \|\overline{V}_t\|\|$	$\|\|V_t\| - \|\overline{V}_t\|\|$
V_{OC}	$\|V_{os}\|$	$\|V_{os}\|$
$\Delta\|V_{OC}\|$	$\|V_{os} - \overline{V}_{os}\|$	$\|V_{os} - \overline{V}_{os}\|$
I_{OS}	$\|I_{sa}\|$, $\|I_{sb}\|$	
I_O	$\|I_{xa}\|$, $\|I_{xb}\|$	I_{ia}, I_{ib}

RECEIVER SECTION

electrical characteristics over recommended ranges of common-mode input voltage, supply voltage, and operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP†	MAX	UNIT
V_{IT+}	Positive-going input threshold voltage	V_O = 2.7 V, I_O = –0.4 mA				0.2	V
V_{IT-}	Negative-going input threshold voltage	V_O = 0.5 V, I_O = 8 mA		–0.2‡			V
V_{hys}	Hysteresis voltage (V_{IT+}–V_{IT-})	V_{OC} = 0			70		mV
V_{IK}	Enable-input clamp voltage	I_I = –18 mA				–1.5	V
V_{OH}	High-level output voltage	V_{ID} = 200 mV or inputs open, I_{OH} = –400 μA, See Figure 6		2.4			V
V_{OL}	Low-level output voltage	V_{ID} = –200 mV, See Figure 6	I_{OL} = 16 mA			0.5	V
			I_{OL} = 8 mA			0.45	
I_{OZ}	High-impedance-state output current	V_O = 0.4 V to 2.4 V				±20	μA
I_I	Line input current	Other input = 0, See Note 5	V_I = 12 V			1	mA
			V_I = –7 V			–0.8	
I_{IH}	High-level enable-input current	V_{IH} = 2.7 V				20	μA
I_{IL}	Low-level enable-input current	V_{IL} = 0.4 V				–100	μA
r_I	Input resistance			12			kΩ
I_{OS}	Short-circuit output current§	V_O = 0		–15		–85	mA
I_{CC}	Supply current	No load	Outputs enabled		23	50	mA
			Outputs disabled		19	35	

† All typical values are at V_{CC} = 5 V and T_A = 25°C.
‡ The algebraic convention, in which 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.
§ Duration of the short circuit should not exceed one second for this test.
NOTE 5: This applies for power on and power off. Refer to TIA/EIA-485-A for exact conditions.

switching characteristics over recommended ranges of supply voltage and operating free-air temperature range, C_L = 15 pF

PARAMETER		TEST CONDITIONS	MIN	TYP†	MAX	UNIT
t_{PLH}	Propagation delay time, low- to high-level output	V_{ID} = –1.5 V to 1.5 V, See Figure 7		14	37	ns
t_{PHL}	Propagation delay time, high- to low-level output			14	37	ns
t_{PZH}	Output enable time to high level	See Figure 8		7	20	ns
t_{PZL}	Output enable time to low level			7	20	ns
t_{PHZ}	Output disable time from high level	See Figure 8		7	16	ns
t_{PLZ}	Output disable time from low level			8	16	ns

† All typical values are at V_{CC} = 5 V and T_A = 25°C.

PARAMETER MEASUREMENT INFORMATION

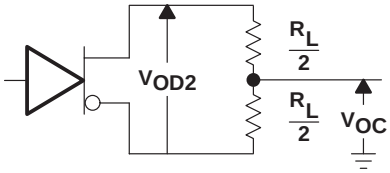


Figure 1. Driver V_{OD} and V_{OC}

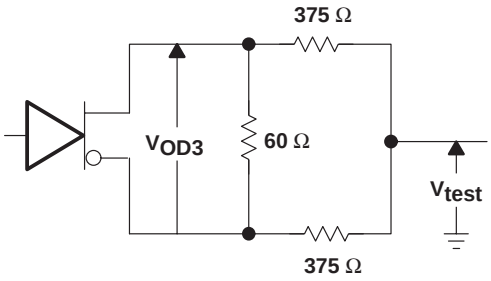
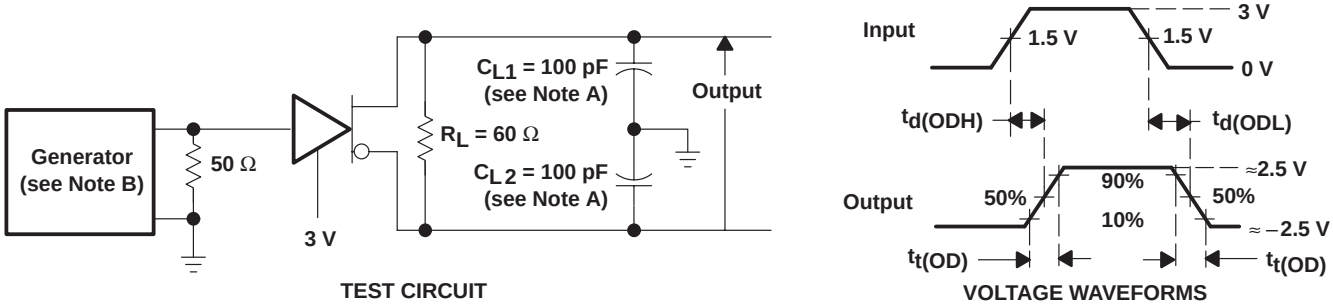


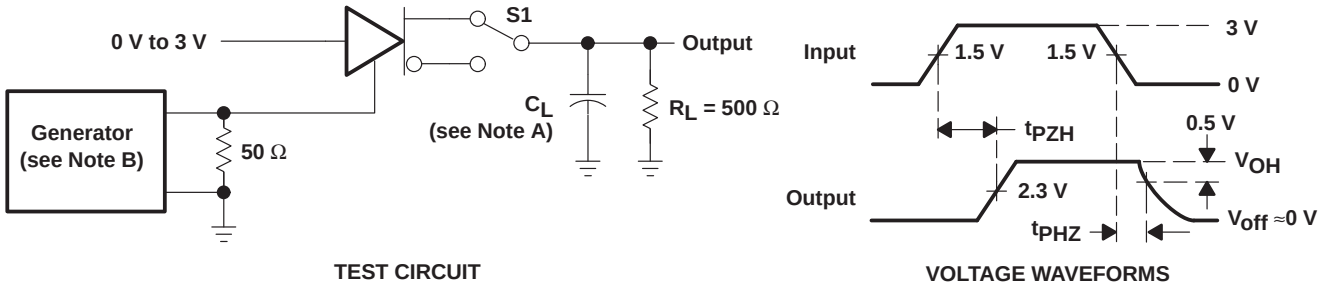
Figure 2. Driver V_{OD3}



NOTES: A. C_L includes probe and jig capacitance.
B. The input pulse is supplied by a generator having the following characteristics: PRR ≤ 1 MHz, 50% duty cycle, t_r ≤ 6 ns, t_f ≤ 6 ns, Z_O = 50 Ω.

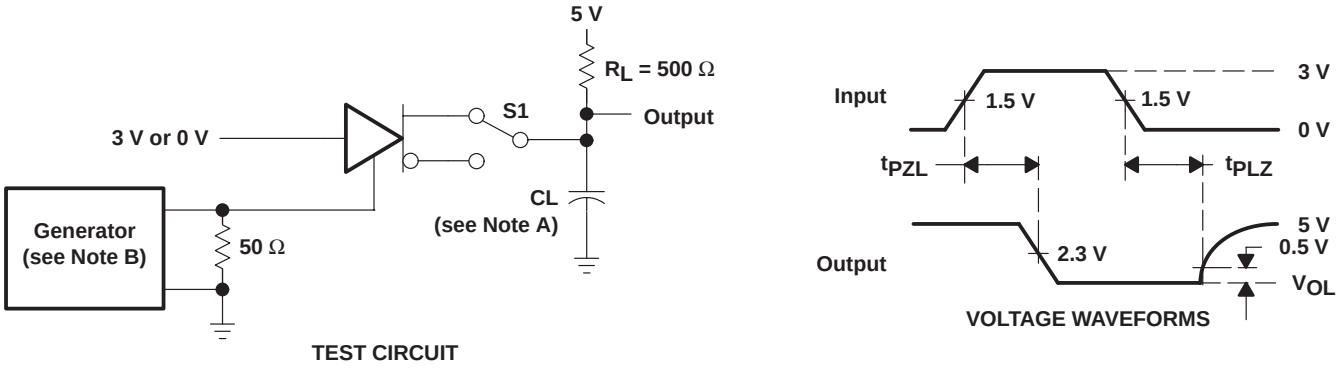
Figure 3. Driver Differential-Output Test Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION



NOTES: A. C_L includes probe and jig capacitance.
B. The input pulse is supplied by a generator having the following characteristics: PRR ≤ 1 MHz, 50% duty cycle, t_r ≤ 10 ns, t_f ≤ 10 ns, Z_O = 50 Ω.

Figure 4. Driver Test Circuit and Voltage Waveforms



NOTES: A. C_L includes probe and jig capacitance.
B. The input pulse is supplied by a generator having the following characteristics: PRR ≤ 1 MHz, 50% duty cycle, t_r ≤ 10 ns, t_f ≤ 10 ns, Z_O = 50 Ω..

Figure 5. Driver Test Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION

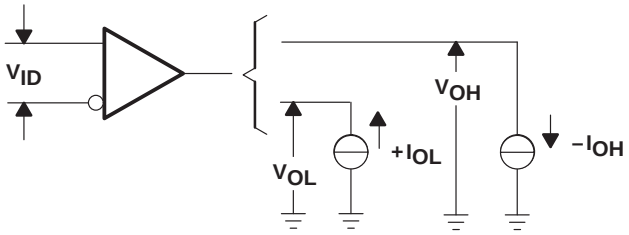
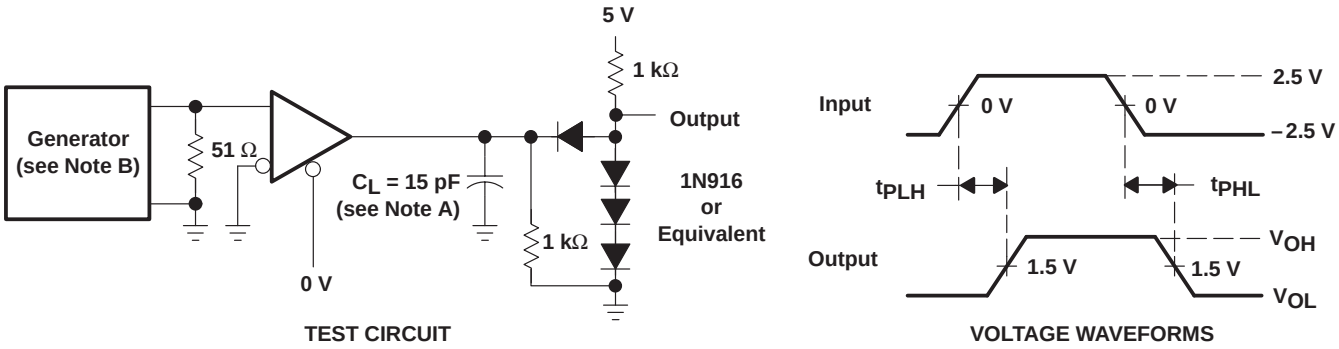


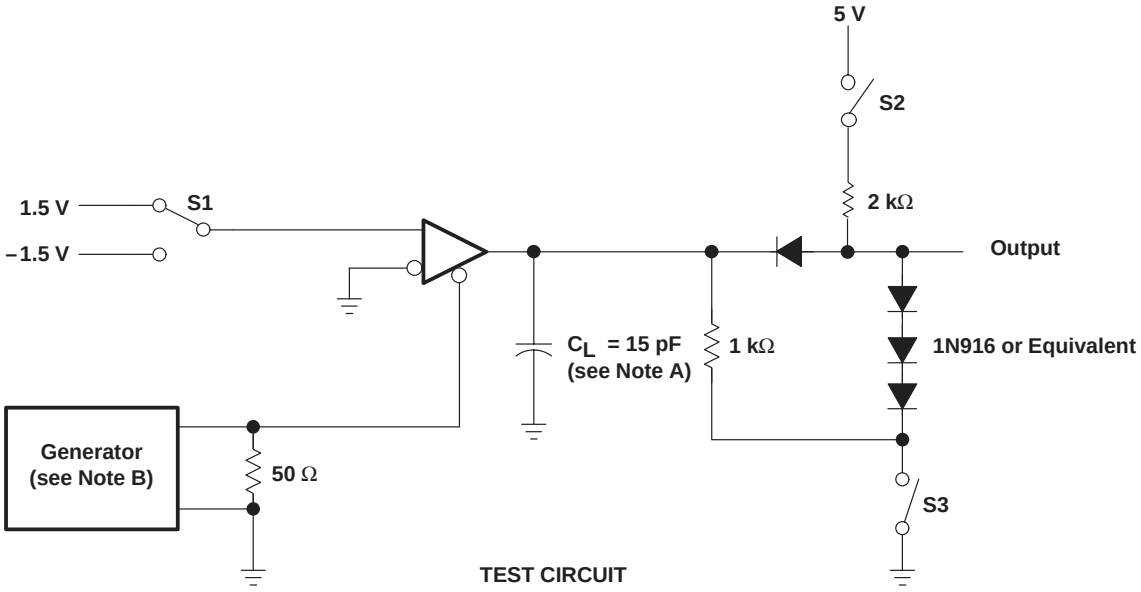
Figure 6. Receiver V_{OH} and V_{OL}



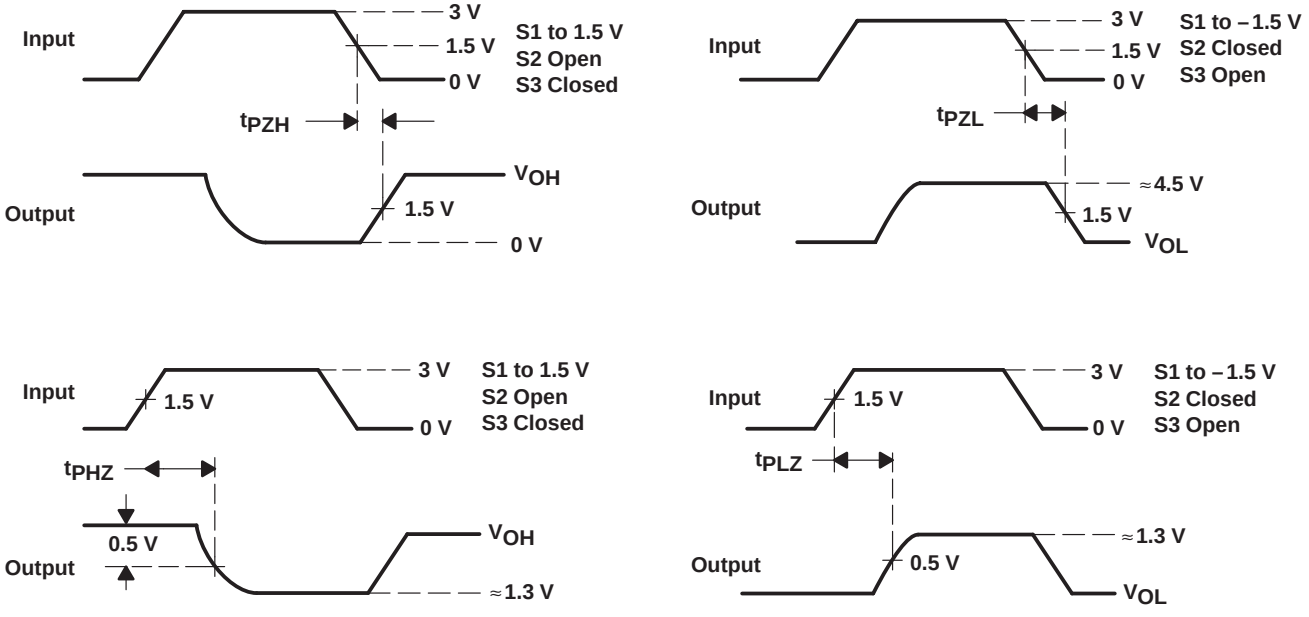
NOTES: A. C_L includes probe and jig capacitance.
B. The input pulse is supplied by a generator having the following characteristics: PRR ≤ 1 MHz, 50% duty cycle, t_r ≤ 10 ns, t_f ≤ 10 ns, Z_O = 50 Ω.

Figure 7. Receiver Test Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

NOTES: A. C_L includes probe and jig capacitance.
B. The input pulse is supplied by a generator having the following characteristics: PRR ≤ 1 MHz, 50% duty cycle, t_r ≤ 10 ns, t_f ≤ 10 ns, Z_O = 50 Ω.

Figure 8. Receiver Test Circuit and Voltage Waveforms

TYPICAL CHARACTERISTICS†

DRIVER
HIGH-LEVEL OUTPUT VOLTAGE
vs
HIGH-LEVEL OUTPUT CURRENT

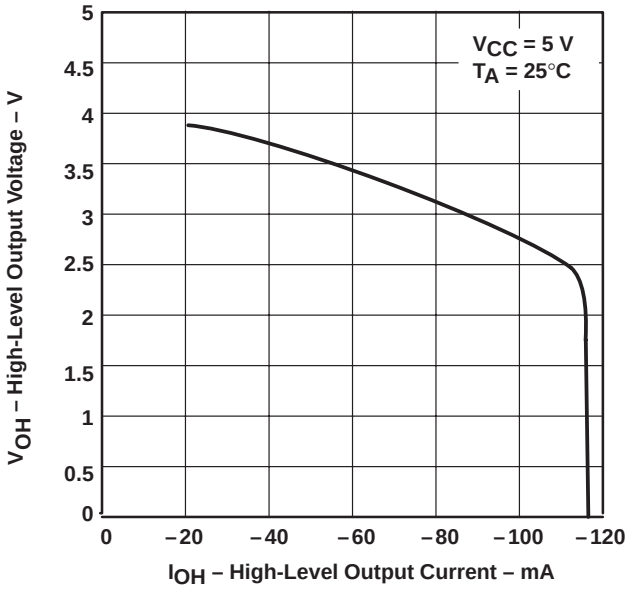


Figure 9

DRIVER
LOW-LEVEL OUTPUT VOLTAGE
vs
LOW-LEVEL OUTPUT CURRENT

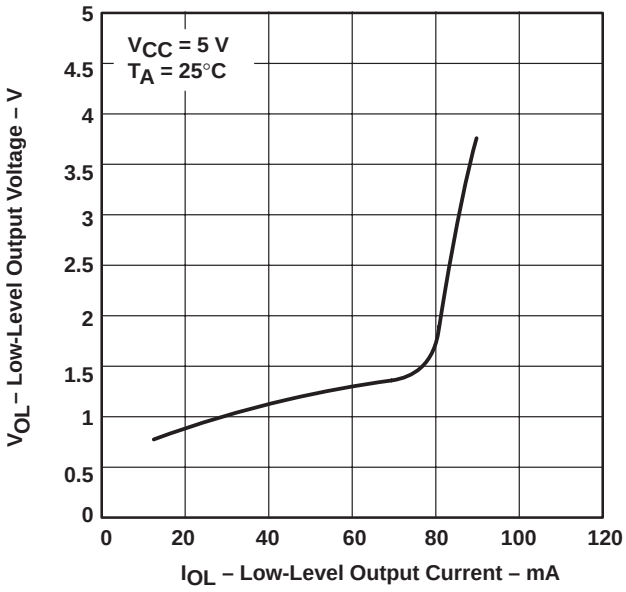


Figure 10

DRIVER
DIFFERENTIAL OUTPUT VOLTAGE
vs
OUTPUT CURRENT

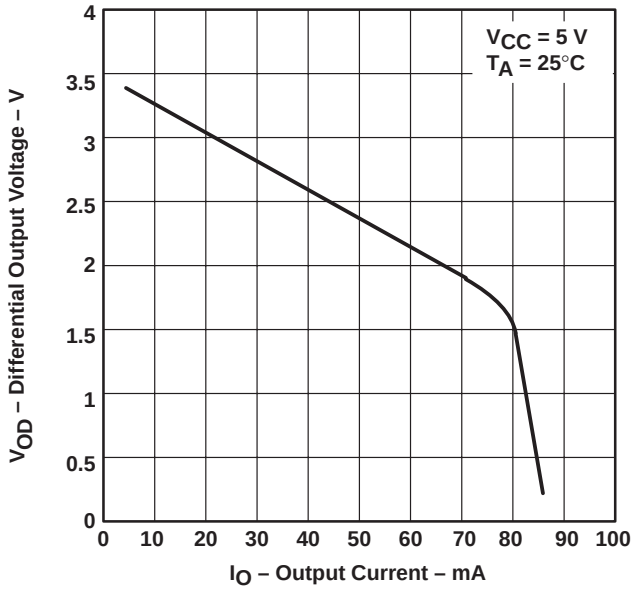


Figure 11

† Operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied.

TYPICAL CHARACTERISTICS†

RECEIVER
HIGH-LEVEL OUTPUT VOLTAGE
vs
HIGH-LEVEL OUTPUT CURRENT

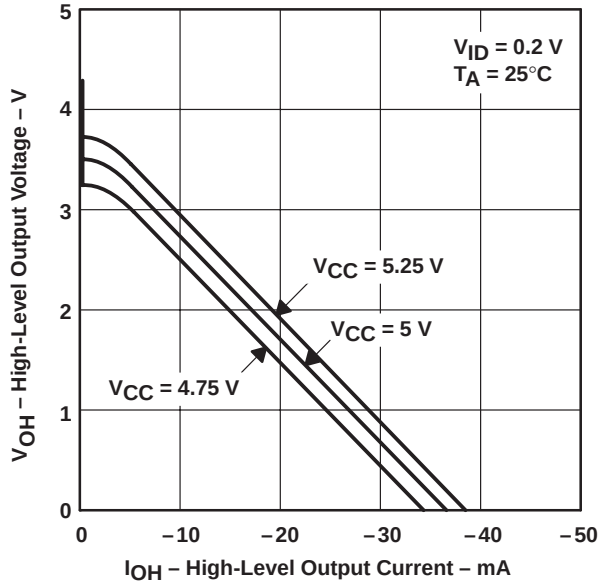


Figure 12

RECEIVER
HIGH-LEVEL OUTPUT VOLTAGE
vs
FREE-AIR TEMPERATURE

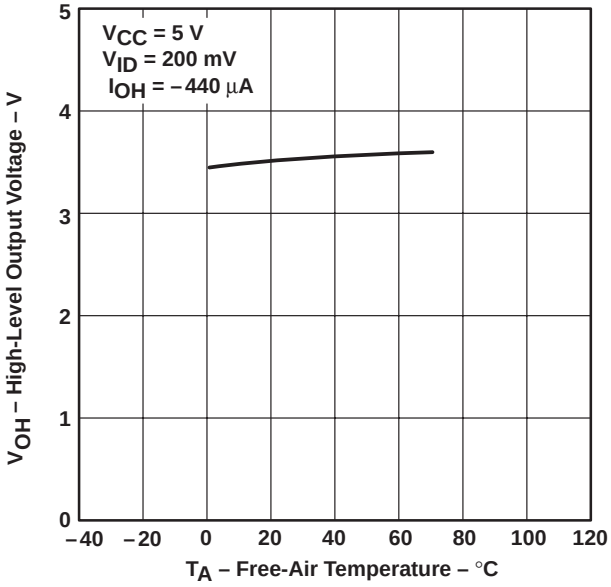


Figure 13

RECEIVER
LOW-LEVEL OUTPUT VOLTAGE
vs
LOW-LEVEL OUTPUT CURRENT

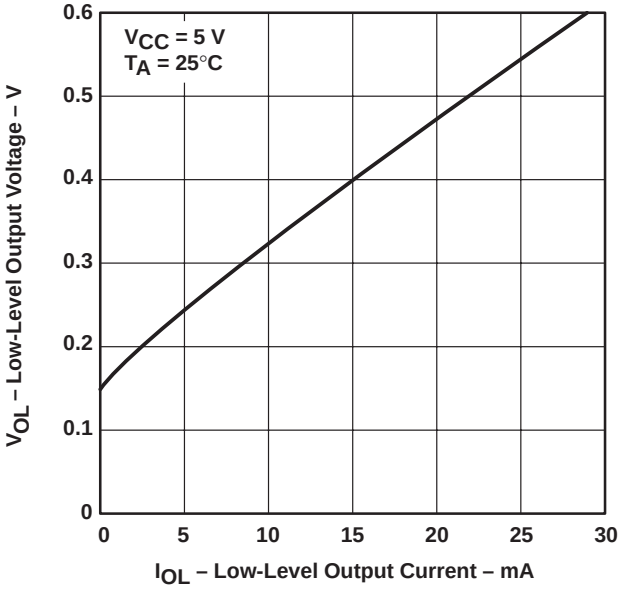


Figure 14

RECEIVER
LOW-LEVEL OUTPUT VOLTAGE
vs
FREE-AIR TEMPERATURE

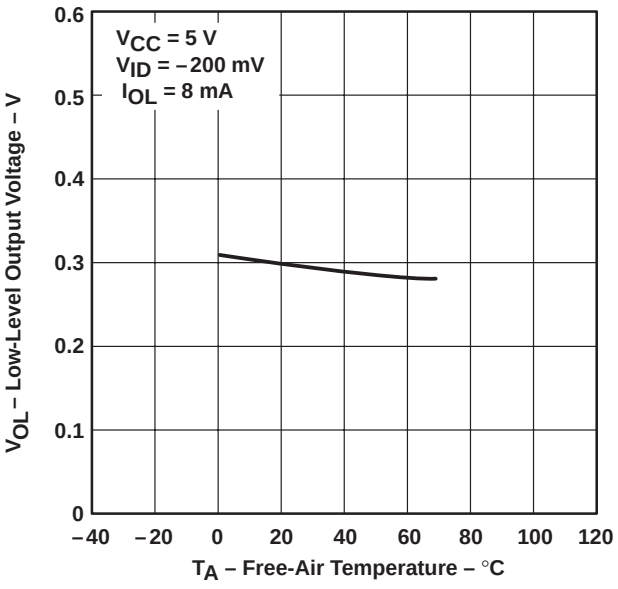


Figure 15

† Operation of the device at these or any other conditions beyond those indicated under ‘‘recommended operating conditions” is not implied.

TYPICAL CHARACTERISTICS†

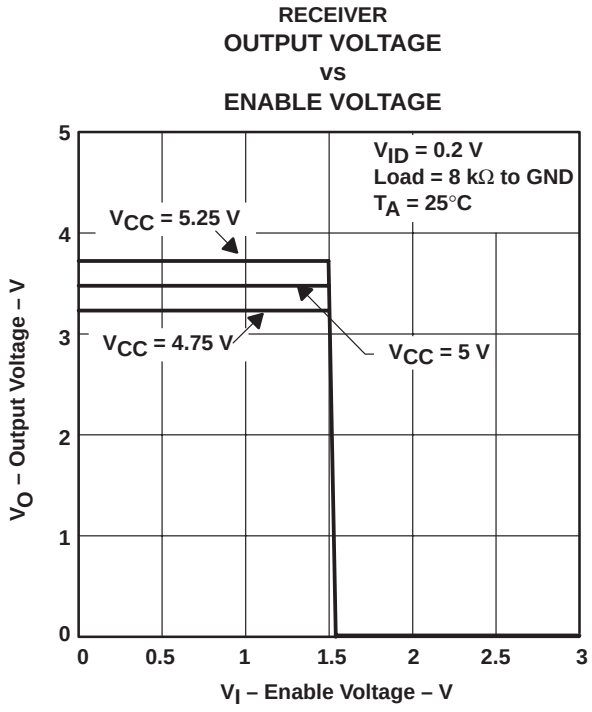


Figure 16

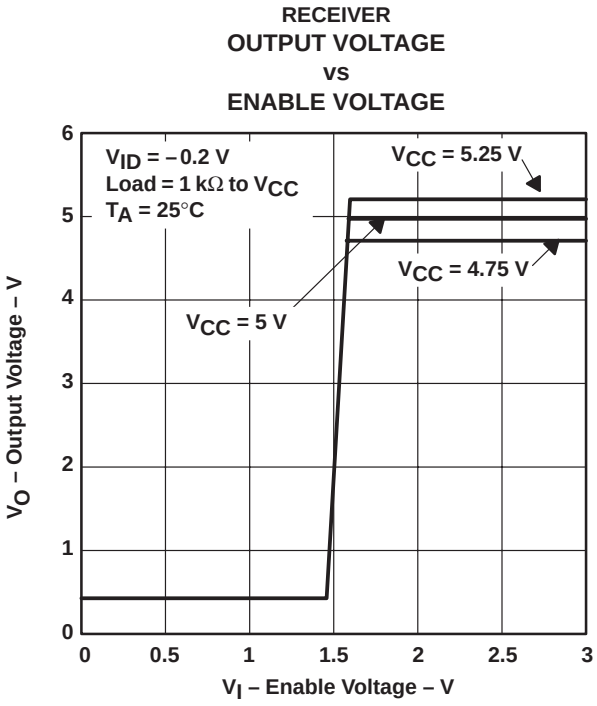
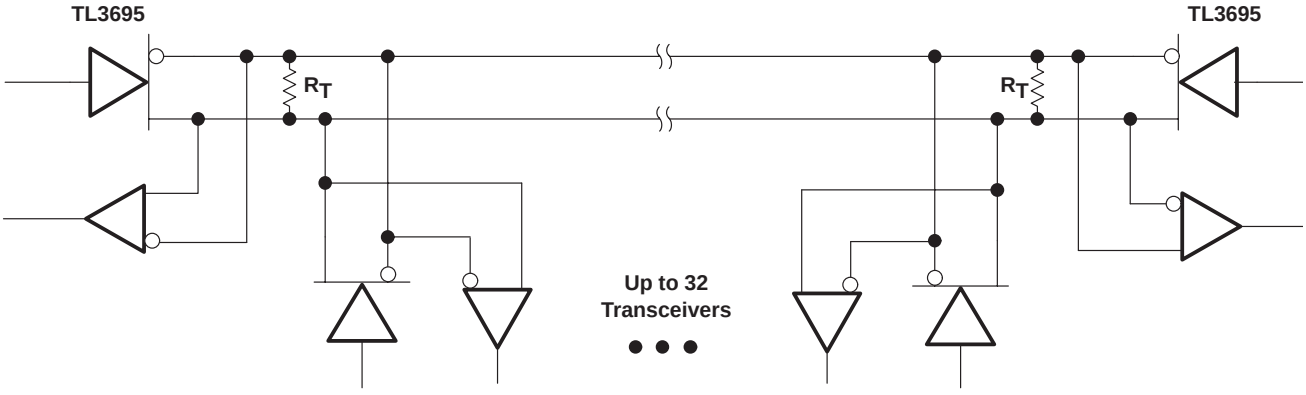


Figure 17

† Operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied.

APPLICATION INFORMATION



NOTE A: The line should be terminated at both ends in its characteristic impedance ($R_T = Z_O$). Stub lengths off the main line should be kept as short as possible.

Figure 18. Typical Application Circuit

IMPORTANT NOTICE

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgement, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

CERTAIN APPLICATIONS USING SEMICONDUCTOR PRODUCTS MAY INVOLVE POTENTIAL RISKS OF DEATH, PERSONAL INJURY, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE ("CRITICAL APPLICATIONS"). TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS. INCLUSION OF TI PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE FULLY AT THE CUSTOMER'S RISK.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI's publication of information regarding any third party's products or services does not constitute TI's approval, warranty or endorsement thereof.