Multipoint RS485/RS422 Transceivers/Repeaters

Check for Samples: DS3695, DS3695T, DS3696, DS3697

FEATURES

- **Meets EIA standard RS485 for Multipoint Bus Transmission and is Compatible with RS-422**
- **15 ns Driver Propagation Delays with 2 ns Skew (Typical)**
- **Single +5V supply**
- **−7V to +12V Bus Common Mode Range Permits ±7V Ground Difference Between Devices on the Bus**
- **Thermal Shutdown Protection**
- **High Impedance to Bus with Driver in TRI-STATE or with Power Off, Over the Entire Common Mode Range Allows the Unused Devices on the Bus to be Powered Down**
- **Combined Impedance of a Driver Output and Receiver Input is Less than one RS485 Unit Load, Allowing up to 32 Transceivers on the Bus**
- **70 mV Typical Receiver Hysteresis**

DESCRIPTION

The DS3695, DS3696, and DS3697 are high speed differential TRI-STATE bus/line transceivers/repeaters designed to meet the requirements of EIA standard RS485 with extended common mode range (+12V to −7V), for multipoint data transmission.

The driver and receiver outputs feature TRI-STATE capability. The driver outputs remain in TRI-STATE over the entire common mode range of +12V to −7V. Bus faults that cause excessive power dissipation within the device trigger a thermal shutdown circuit, which forces the driver outputs into the high impedance state. The DS3696 provides an output pin TS (thermal shutdown) which reports the occurrence of the thermal shutdown of the device. This is an "open collector" pin with an internal 10 kΩ pull-up resistor. This allows the line fault outputs of several devices to be wire OR-ed.

Both AC and DC specifications are specified over the 0°C to 70°C temperature and 4.75V to 5.25V supply voltage range.

Connection and Logic Diagrams

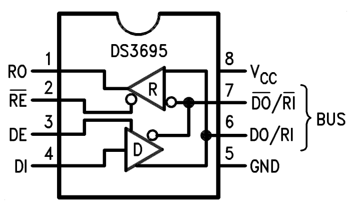


Figure 1. PDIP (Top View)
See Package Number P (R-PDIP-T8)

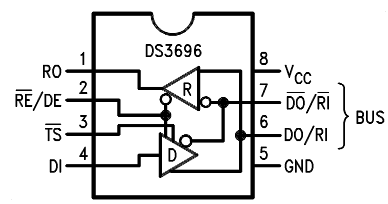


Figure 2. PDIP (Top View)
See Package Number P (R-PDIP-T8)

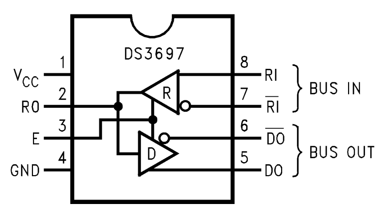


Figure 3. PDIP (Top View)
See Package Number P (R-PDIP-T8)

$\overline{\text{TS}}$ pin was $\overline{\text{LF}}$ (Line Fault) in previous data sheets and reports the occurrence of a thermal shutdown of the device.

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings [1][2]

	VALUE	UNIT
Supply Voltage, V_{CC}	7	V
Control Input Voltages	7	V
Driver Input Voltage	7	V
Driver Output Voltages	+15/−10	V
Receiver Input Voltages (DS3695, DS3696)	+15/−10	V
Receiver Common Mode Voltage (DS3697)	±25	V
Receiver Output Voltage	5.5	V
Continuous Power Dissipation @ 25°C - N Package [3]	1.07	W
Storage Temperature Range	−65 to +150	°C
Lead Temperature (Soldering, 4 sec.)	260	°C

(1) “Absolute Maximum Ratings” are those beyond which the safety of the device cannot be verified. They are not meant to imply that the device should be operated at these limits. The tables of “Electrical Characteristics” provide conditions for actual device operation.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/ Distributors for availability and specifications.
(3) All typicals are given for V_{CC} = 5V and T_A = 25°C.

Recommended Operating Conditions

		Min	Max	Units
Supply Voltage, V_{CC}		4.75	5.25	V
Bus Voltage		−7	+12	V
Operating Free Air Temp. (T_A)	Commercial	0	+70	°C
	Industrial	−40	+85	°C

Electrical Characteristics [1][2]

0°C ≤ T_A ≤ +70°C, 4.75V < V_{CC} < 5.25V unless otherwise specified

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_{OD1}	Differential Driver Output Voltage (Unloaded)	I_O = 0				5	V
V_{OD2}	Differential Driver Output Voltage (with Load)	See Figure 4	R = 50Ω; (RS-422) [3]	2			V
			R = 27Ω; (RS-485)	1.5			V
ΔV_{OD}	Change in Magnitude of Driver Differential Output Voltage for Complementary Output States	See Figure 4	R = 27Ω			0.2	V
V_{OC}	Driver Common Mode Output Voltage					3.0	V
$\Delta \lvert V_{OC} \rvert$	Change in Magnitude of Driver Common Mode Output Voltage for Complementary Output States					0.2	V
V_{IH}	Input High Voltage	DI, DE, $\overline{RE}$, E, $\overline{RE}$ /DE		2			V
V_{IL}	Input Low Voltage					0.8	V
V_{CL}	Input Clamp Voltage		I_{IN} = −18 mA			−1.5	V
I_{IL}	Input Low Current		V_{IL} = 0.4V			−200	μA
I_{IH}	Input High Current		V_{IH} = 2.4V			20	μA
I_{IN}	Input Current DO/RI, $\overline{DO}$ /$\overline{RI}$ RI, $\overline{RI}$	V_{CC} = 0V or 5.25V $\overline{RE}$ /DE or DE = 0V	V_{IN} = 12V			+1.0	mA
			V_{IN} = −7V			−0.8	mA

(1) All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to device ground unless otherwise specified.
(2) All typicals are given for V_{CC} = 5V and T_A = 25°C.
(3) All limits for which derate linearly at 11.1 mW/°C to 570 mW at 70°C is applied must be derated by 10% for DS3695T and DS3696T. Other parameters remain the same for this extended temperature range device (−40°C ≤ T_A ≤ +85°C).

Electrical Characteristics (1)(2) (continued)

0°C ≤ T_A ≤ +70°C, 4.75V < V_{CC} < 5.25V unless otherwise specified

Symbol	Parameter		Conditions		Min	Typ	Max	Units
I_{OZD}	TRI-STATE Current DS3697 & DS3698	DO, $\overline{DO}$	V_{CC} = 0V or 5.25V, E = 0V −7V < V_O < +12V				±100	μA
V_{TH}	Differential Input Threshold Voltage for Receiver		−7V ≤ V_{CM} ≤ +12V		−0.2		+0.2	V
ΔV_{TH}	Receiver Input Hysteresis		V_{CM} = 0V			70		mV
V_{OH}	Receiver Output High Voltage		I_{OH} = −400 μA		2.4			V
V_{OL}	Output Low Voltage	RO	I_{OL} = 16 mA (3)				0.5	V
		$\overline{TS}$	I_{OL} = 8 mA				0.45	V
I_{OZR}	OFF-State (High Impedance) Output Current at Receiver		V_{CC} = Max 0.4V ≤ V_O ≤ 2.4V				±20	μA
R_{IN}	Receiver Input Resistance		−7V ≤ V_{CM} ≤ +12V		12			kΩ
I_{CC}	Supply Current		No Load (3)	Driver Outputs Enabled		42	60	mA
				Driver Outputs Disabled		27	40	mA
I_{OSD}	Driver Short-Circuit Output Current		V_O = −7V (3)				−250	mA
			V_O = +12V (3)				+250	mA
I_{OSR}	Receiver Short-Circuit Output Current		V_O = 0V		−15		−85	mA

Receiver Switching Characteristics (1)(2)

0°C ≤ T_A ≤ +70°C, 4.75V < V_{CC} < 5.25V unless otherwise specified (Figure 5, Figure 6, Figure 7)

Symbol	Conditions	Min	Typ	Max	Units
t_{PLH}	C_L = 15 pF	15	25	37	ns
t_{PHL}	S1 and S2	15	25	37	ns
$\|t_{PLH}–t_{PHL}\|$	Closed	0			ns
t_{PLZ}	C_L = 15 pF, S2 Open	5	12	16	ns
t_{PHZ}	C_L = 15 pF, S1 Open	5	12	16	ns
t_{PZL}	C_L = 15 pF, S2 Open	7	15	20	ns
t_{PZH}	C_L = 15 pF, S1 Open	7	15	20	ns

(1) All typicals are given for V_{CC} = 5V and T_A = 25°C.
(2) Switching Characteristics apply for DS3695, DS3695T, DS3696, DS3697 only.

Driver Switching Characteristics

0°C ≤ T_A ≤ +70°C, 4.75V < V_{CC} < 5.25V unless otherwise specified

Symbol	Conditions	Min	Typ	Max	Units
SINGLE ENDED CHARACTERISTICS (Figure 8, Figure 9, Figure 10)					
t_{PLH}	R_LDIFF = 60Ω	9	15	22	ns
t_{PHL}	C_{L1} = C_{L2} = 100 pF	9	15	22	ns
$t_{SKEW}\|t_{PLH}–t_{PHL}\|$			2	8	ns
t_{PLZ}	C_L = 15 pF, S2 Open	7	15	30	ns
t_{PHZ}	C_L = 15 pF, S1 Open	7	15	30	ns
t_{PZL}	C_L = 100 pF, S2 Open	30	35	50	ns
t_{PZH}	C_L = 100 pF, S1 Open	30	35	50	ns
DIFFERENTIAL CHARACTERISTICS (Figure 8 Figure 11)					
t_r, t_f	R_LDIFF = 60Ω C_{L1} = C_{L2} = 100 pF	6	10	18	ns

AC Test Circuits and Switching Waveforms

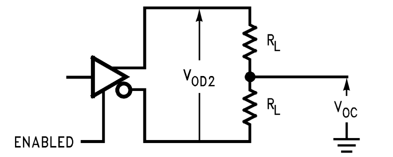


Figure 4. Driver V_{OD} and V_{OC}

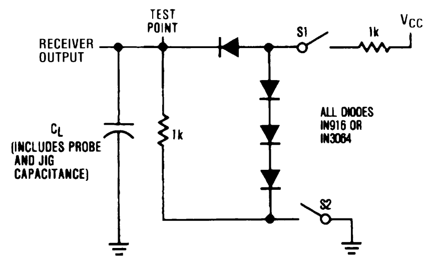
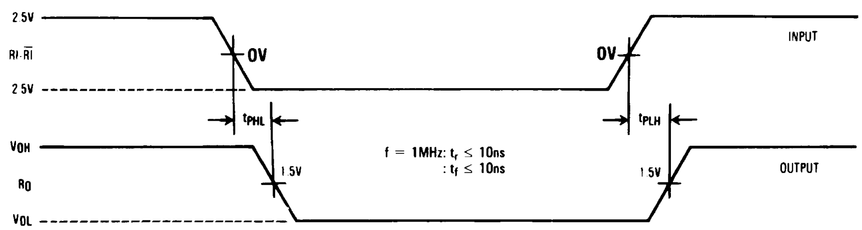


Figure 5. Receiver Propagation Delay Test Circuit



Note: Differential input voltage may be realized by grounding $\overline{RI}$ and pulsing RI between +2.5V and −2.5V.

Figure 6. Receiver Input-to-Output Propagation Delay Timing

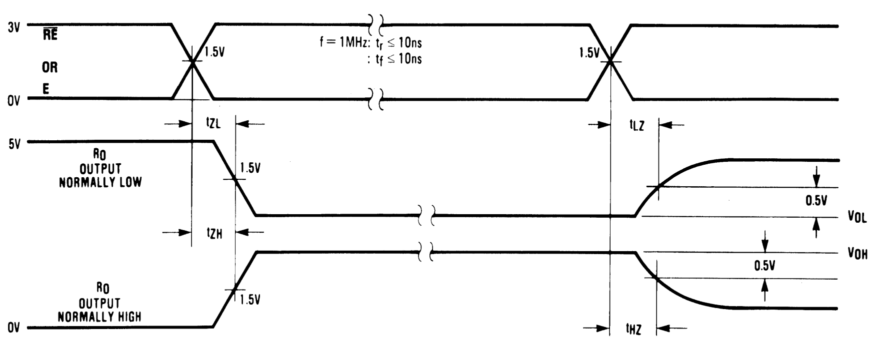
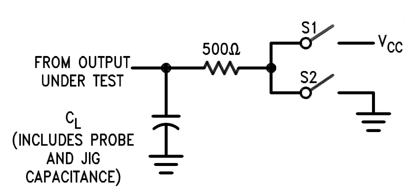


Figure 7. Receiver Enable/Disable Propagation Delay Timing



Note: Unless otherwise specified the switches are closed.

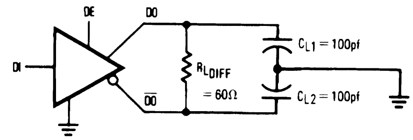
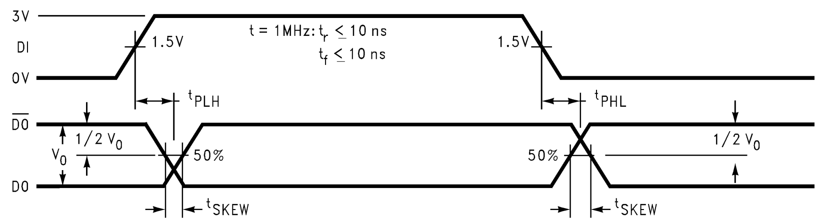


Figure 8. Driver Propagation Delay and Transition Time Test Circuits



Note: t_{PLH} and t_{PHL} are measured to the respective 50% points. t_{SKEW} is the difference between propagation delays of the complementary outputs.

Figure 9. Driver Input-to-Output Propagation Delay Timing (Single-Ended)

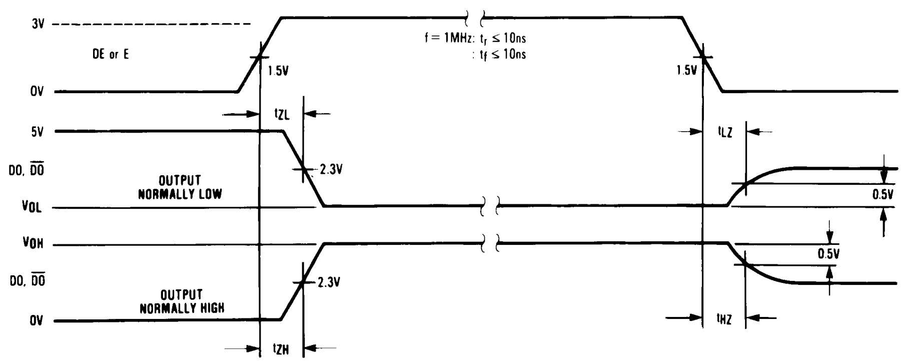


Figure 10. Driver Enable/Disable Propagation Delay Timing

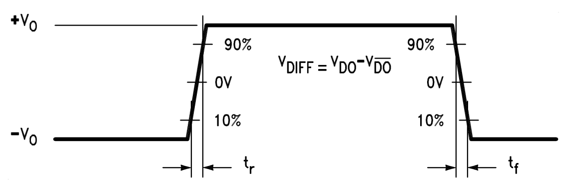


Figure 11. Driver Differential Transition Timing

Function Tables

Table 1. DS3695/DS3696 Transmitting[(1)]

Inputs			Thermal Shutdown	Outputs		
$\overline{RE}$	DE	DI		$\overline{DO}$	DO	$\overline{TS}$ * (DS3696 Only)
X	1	1	OFF	0	1	H
X	1	0	OFF	1	0	H
X	0	X	OFF	Z	Z	H
X	1	X	ON	Z	Z	L

(1) X—Don't care condition
Z—High impedance state
*$\overline{TS}$ is an "open collector" output with an on-chip 10 kΩ pull-up resistor that reports the occurrence of a thermal shutdown of the device.

Table 2. DS3695/DS3696 Receiving[(1)]

Inputs			Outputs	
$\overline{RE}$	DE	RI–$\overline{RI}$	RO	$\overline{TS}$ * (DS3696 Only)
0	0	≥ +0.2V	1	H
0	0	≤ −0.2V	0	H
1	0	X	Z	H

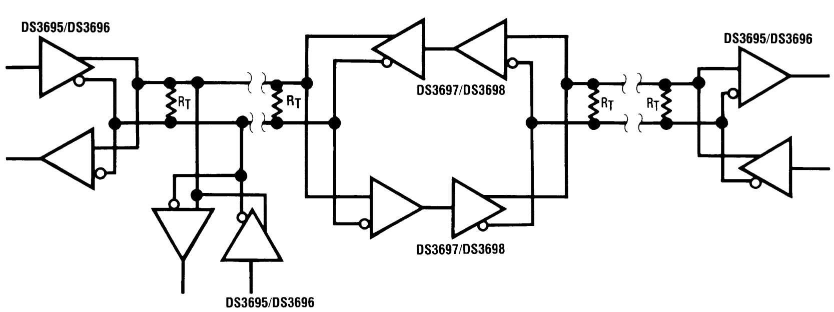
(1) X—Don't care condition
Z—High impedance state
*$\overline{TS}$ is an "open collector" output with an on-chip 10 kΩ pull-up resistor that reports the occurrence of a thermal shutdown of the device.

Table 3. DS3697[(1)]

Inputs		Thermal Shutdown	Outputs		
E	RI-$\overline{RI}$		$\overline{DO}$	DO	RO (DS3697 Only)
1	≥ +0.2V	OFF	0	1	1
1	≤ −0.2V	OFF	1	0	0
0	X	OFF	Z	Z	Z
1	≥ +0.2V	ON	Z	Z	1
1	≤ −0.2V	ON	Z	Z	0

(1) X—Don't care condition
Z—High impedance state
*$\overline{TS}$ is an "open collector" output with an on-chip 10 kΩ pull-up resistor that reports the occurrence of a thermal shutdown of the device.

Typical Application



Note: Repeater control logic not shown

Typical Performance Characteristics

Driver V_{OH} vs I_{OH} vs Temperature

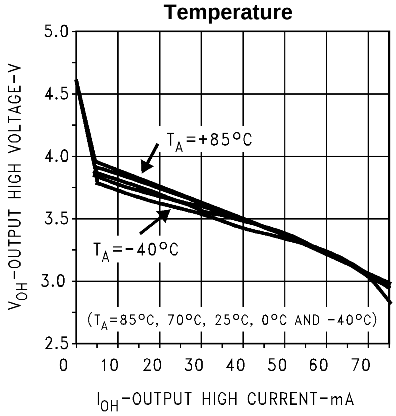


Figure 12.

Driver V_{OH} vs I_{OH} vs V_{CC}Driver V_{OH} vs I_{OH} vs V_{CC}

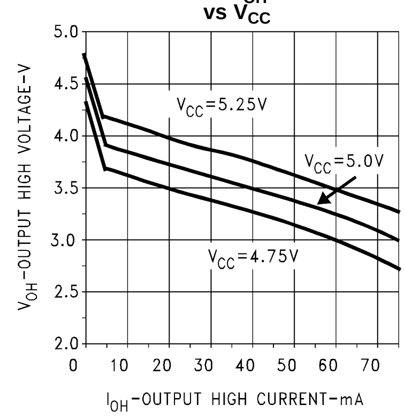


Figure 13.

Driver V_{OL} vs I_{OL} vs Temperature

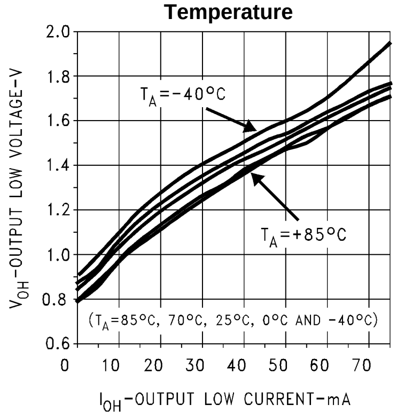


Figure 14.

Driver V_{OH} vs I_{OH} vs V_{CC}

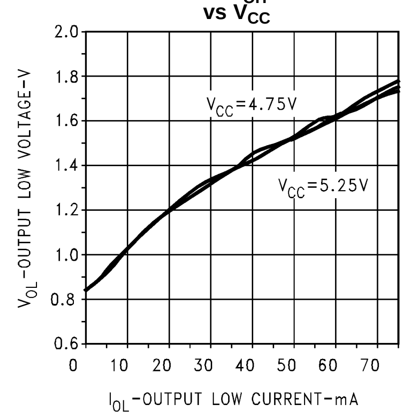


Figure 15.

Driver Differential Propagation Delay vs Temperature

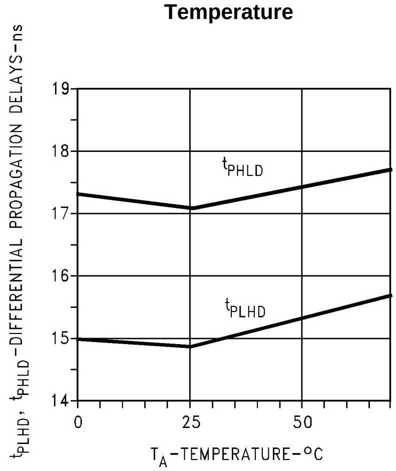


Figure 16.

Driver Differential Propagation Delay vs V_{CC}

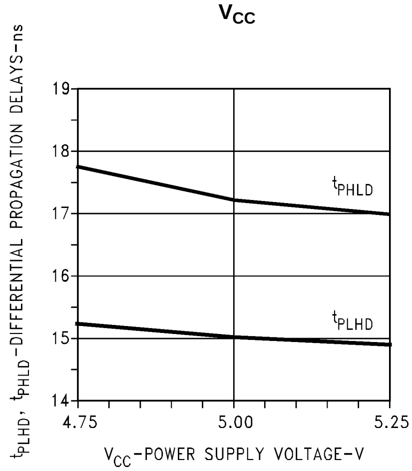


Figure 17.

Typical Performance Characteristics (continued)

Driver Single-Ended Propagation Delay vs Temperature

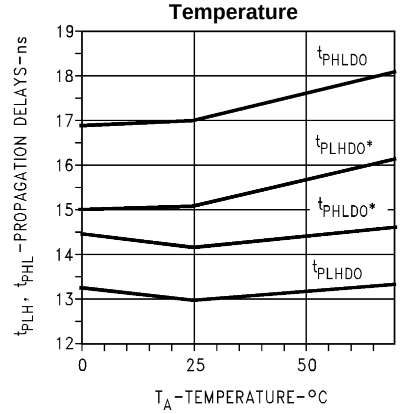


Figure 18.

Driver Single-Ended Propagation Delay vs V_{CC}

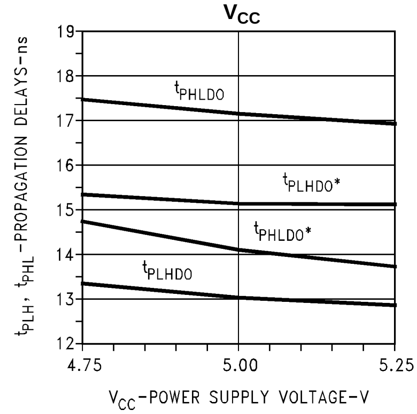


Figure 19.

Driver Transition Time vs Temperature

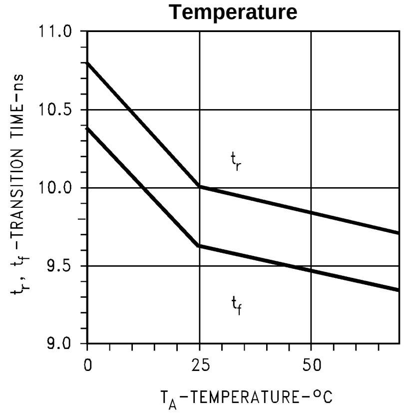


Figure 20.

Driver Transition Time vs V_{CC}

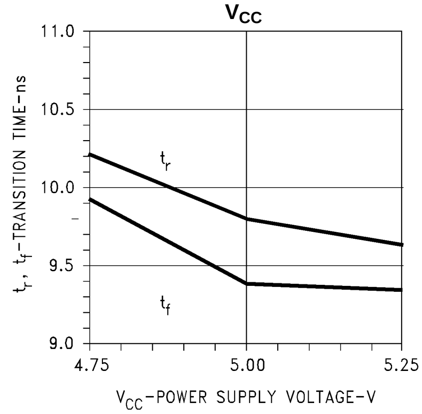


Figure 21.

Cable Length vs Data Rate

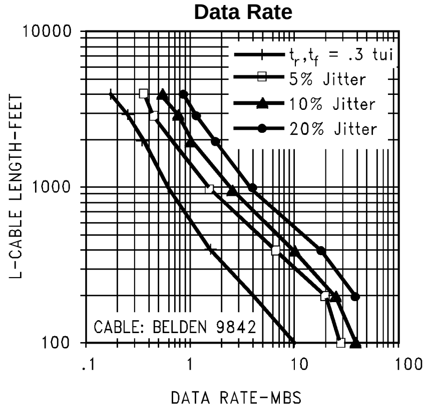


Figure 22.

Supply Current vs Temperature

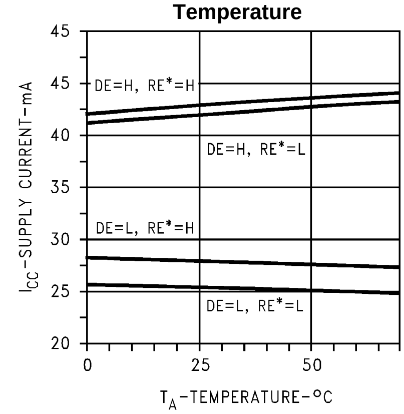


Figure 23.

Typical Performance Characteristics (continued)

Supply Current vs Power Supply Voltage

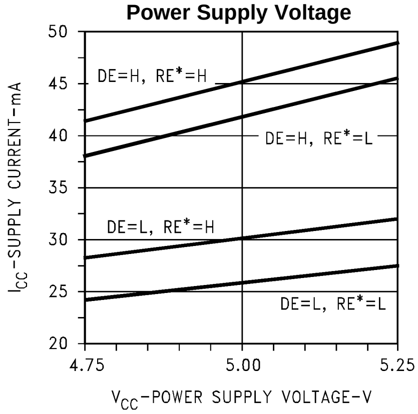


Figure 24.

Driver I_{CC} vs Switching Frequency

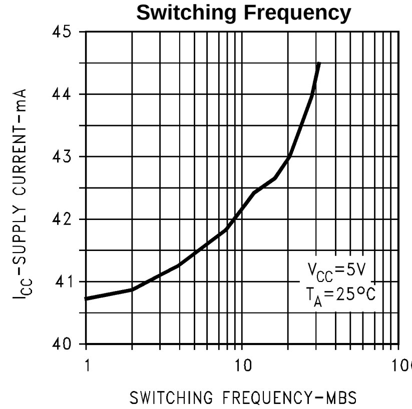


Figure 25.

Driver Short Circuit Current vs Temperature

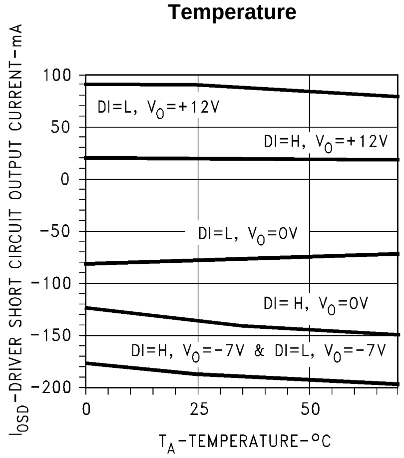


Figure 26.

Receiver V_{OH} vs I_{OH} vs Temperature

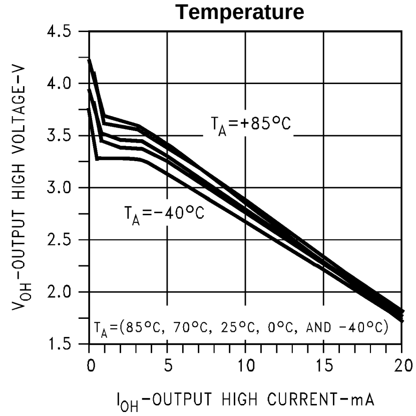


Figure 27.

Receiver V_{OH} vs I_{OH} vs V_{CC}

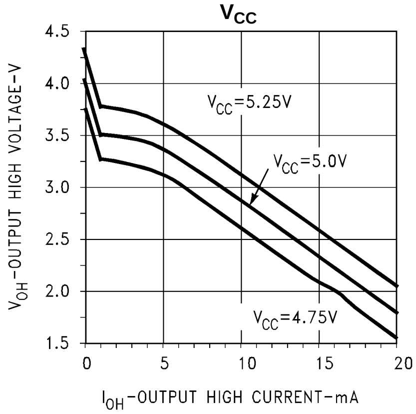


Figure 28.

Driver Short Circuit Current vs Temperature

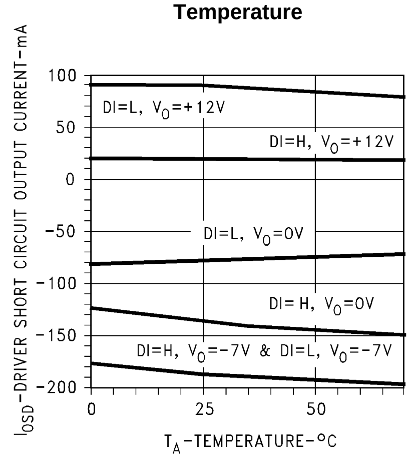


Figure 29.

Typical Performance Characteristics (continued)

Receiver V_{OH} vs I_{OH} vs Temperature

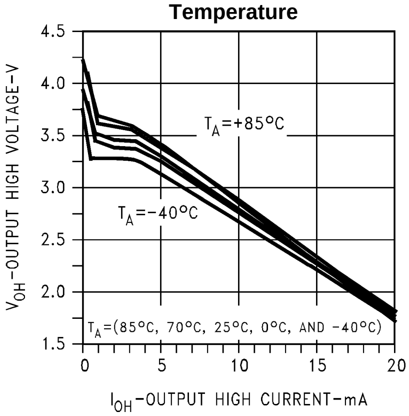


Figure 30.

Receiver V_{OH} vs I_{OH} vs V_{CC}

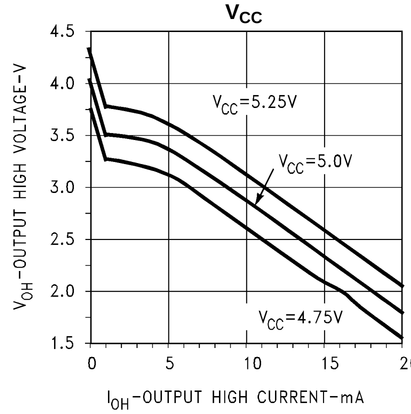


Figure 31.

Receiver V_{OL} vs I_{OL} vs Temperature

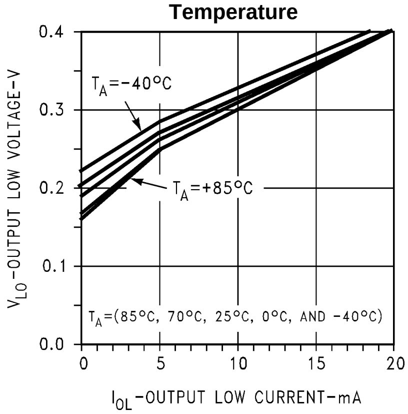


Figure 32.

Receiver V_{OL} vs I_{OL} vs V_{CC}

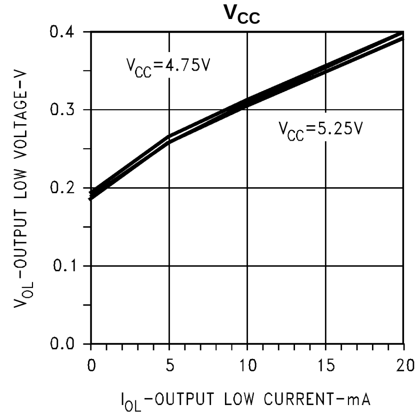


Figure 33.

Receiver Differential Propagation Delay vs Temperature

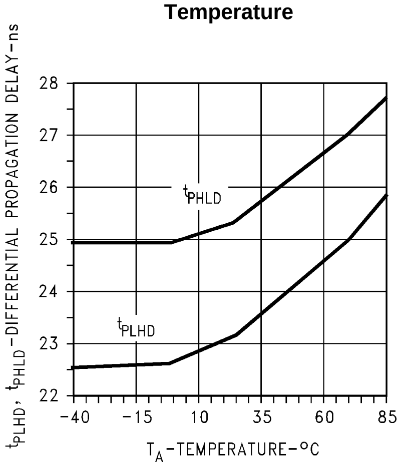


Figure 34.

Receiver Differential Propagation Delay vs V_{CC}

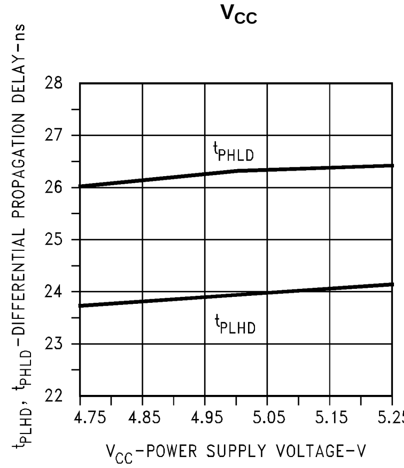


Figure 35.

Typical Performance Characteristics (continued)

Receiver Short Circuit Current vs Temperature

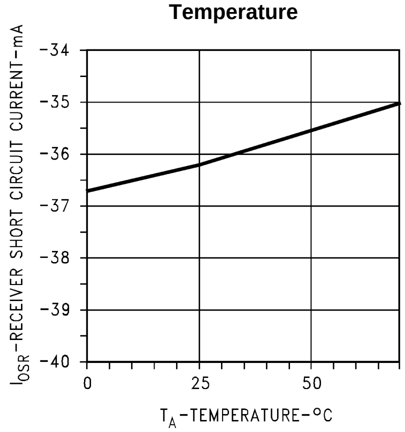


Figure 36.

Receiver Short Circuit Current vs Power Supply

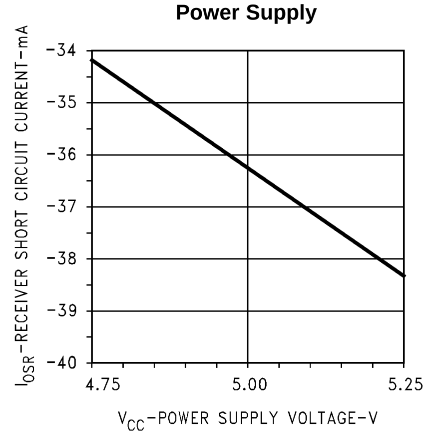


Figure 37.

Receiver Non-Inverting Input Current vs Temperature

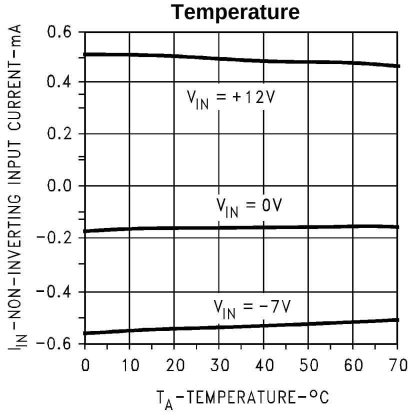


Figure 38.

Receiver Non-Inverting Input Current vs Power Supply Voltage

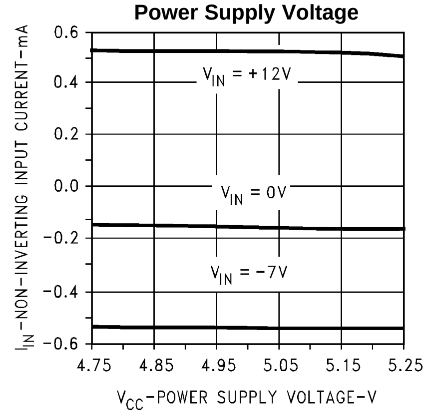


Figure 39.

Receiver Inverting Input Current vs Temperature

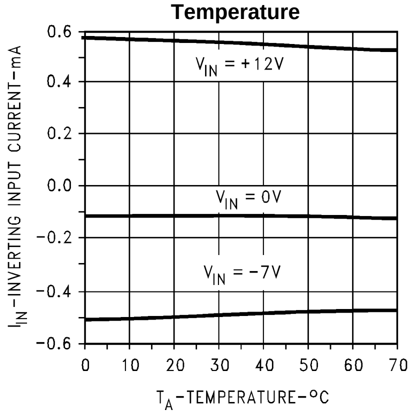


Figure 40.

Receiver Inverting Input Current vs Power Supply Voltage

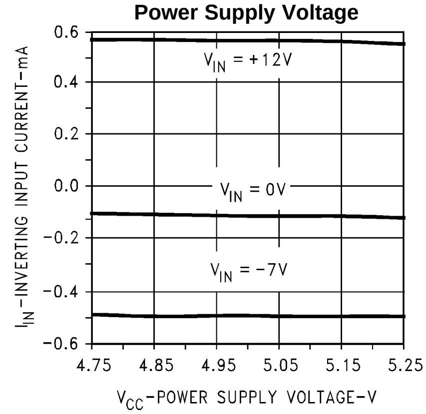


Figure 41.

Typical Performance Characteristics (continued)

Hysteresis and Differential Transition Voltage vs Temperature

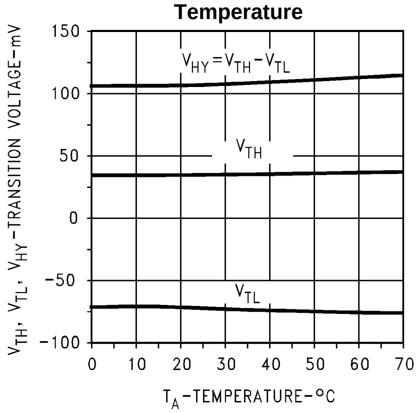


Figure 42.

Hysteresis and Differential Transition Voltage vs V_{CC}

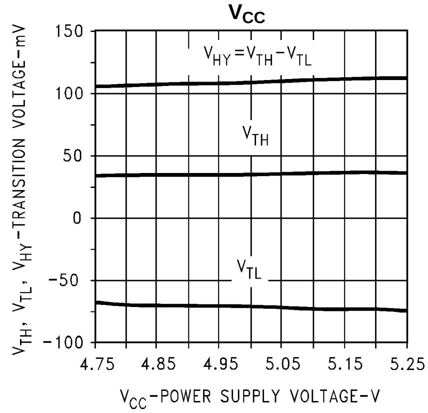


Figure 43.

REVISION HISTORY

Changes from Revision B (April 2013) to Revision C	Page
• Changed layout of National Data Sheet to TI format	11

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
DS3695N/NOPB	ACTIVE	PDIP	P	8	40	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	0 to 70	DS3695N	Samples
DS3695TN/NOPB	ACTIVE	PDIP	P	8	40	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	-40 to 85	DS 3695TN	Samples

(1) 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.

(2) 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)

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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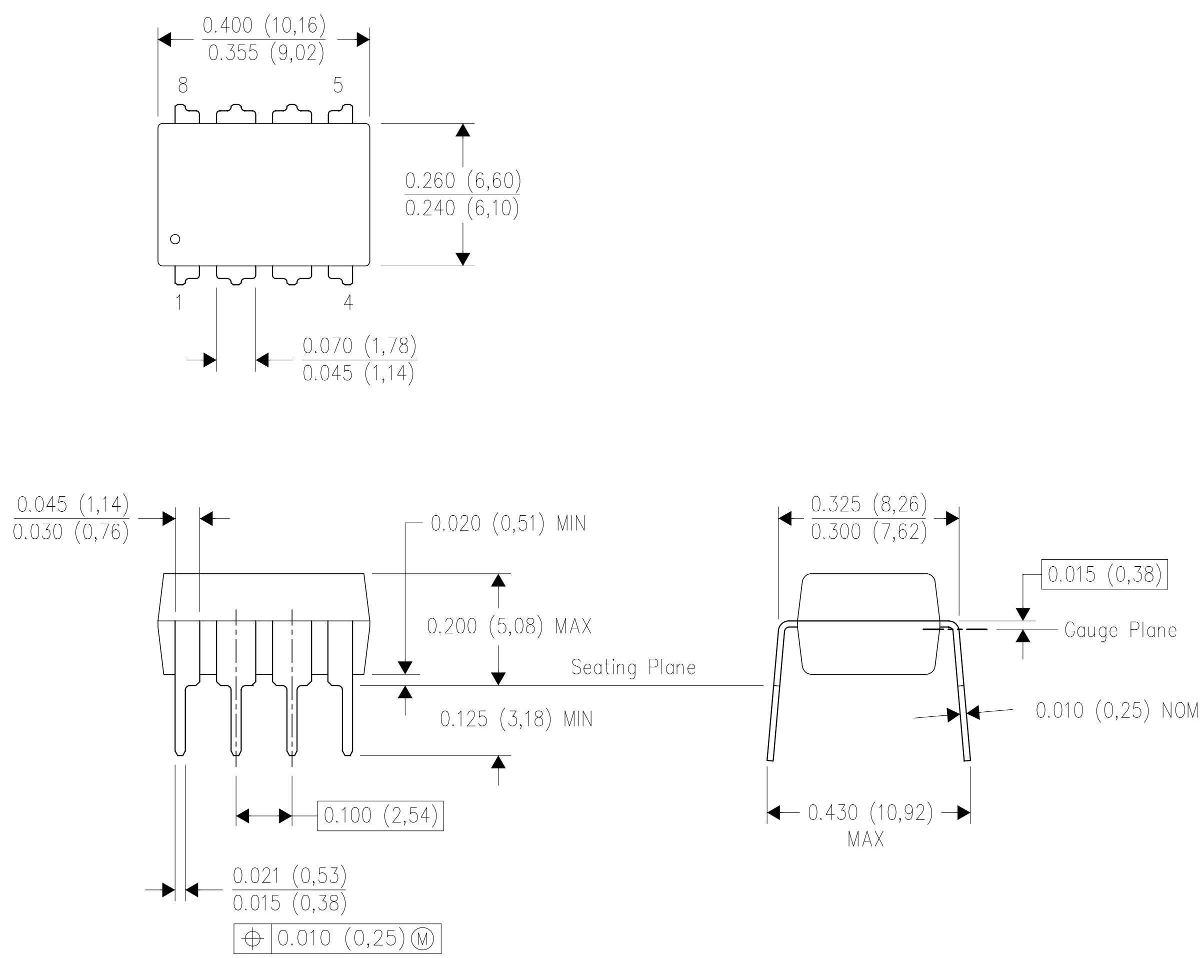
P (R–PDIP–T8) PLASTIC DUAL–IN–LINE PACKAGE



4040082/E 04/2010

NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS–001 variation BA.

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