National Semiconductor

T-75-45-05

DS3695/DS3695T/DS3696/DS3696T/DS3697/DS3698 Multipoint RS485/RS422 Transceivers/Repeaters

General Description

The DS3695, DS3696, DS3697 and DS3698 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. In addition they meet the requirements of RS422.

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 and DS3698 provide an output pin which reports the occurrence of a line fault causing 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.

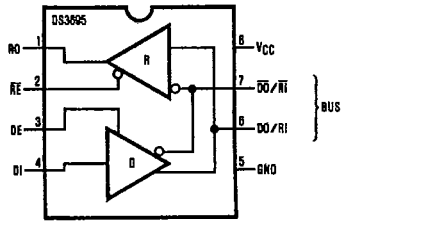
The receiver incorporates a fail safe feature which guarantees a high output state when the inputs are left open.

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

Features

- Meets EIA standard RS485 for multipoint bus transmission and RS422
- 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
- Power-up/down glitch-free driver outputs permit live insertion or removal of transceivers
- 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

Connection and Logic Diagrams



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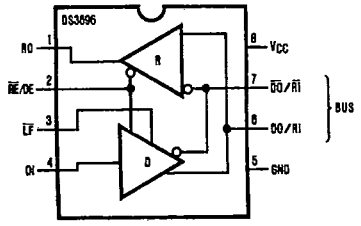
Top View



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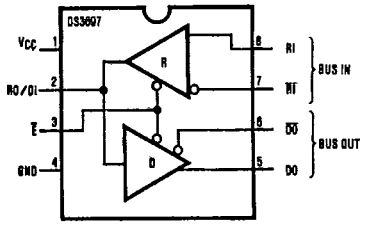
Top View



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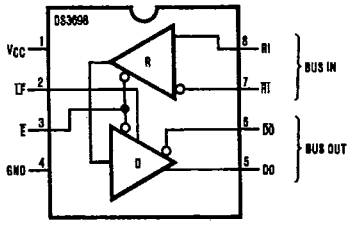
Top View



TL/F/5272-4

Top View

Molded Dual-In-Line Package (N)
Order Number DS3695J, DS3696J, DS3697J, DS3698J, DS3695M, DS3696M, DS3695N, DS3696N, DS3697N, DS3698N, DS3695TN, DS3696TN, DS3695TJ or DS3696TJ
See NS Package Number J08A, M08A or N08E

Absolute Maximum Ratings (Note 1)

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

Supply Voltage, V_{CC}	7V
Control Input Voltages	7V
Driver Input Voltage	7V
Driver Output Voltages	+15V/−10V
Receiver Input Voltages (DS3695, DS3696)	+15V/−10V
Receiver Common Mode Voltage (DS3697, DS3698)	±25V
Receiver Output Voltage	5.5V
Continuous Power Dissipation @ 25°C	
N Package	1.07W (Note 4)
M Package	630 mW (Note 5)
Storage Temp. Range	−65°C to +150°C
Lead Temp. (Soldering 4 seconds)	260°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 $0°C \le T_A \le 70°C$, $4.75V < V_{CC} < 5.25V$ unless otherwise specified (Notes 2 & 3)

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)		*(Figure 1)*	R = 50Ω; (RS-422) (Note 6)	2			V
				R = 27Ω; (RS-485)	1.5			V
ΔV_{OD}	Change in Magnitude of Driver Differential Output Voltage For Complementary Output States		*(Figure 1)*	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			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 DE/E = 0V	$V_{IN} = 12V$			+1.0	mA
				$V_{IN} = -7V$			−0.8	mA
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		$-7V \le V_{CM} \le +12V$		−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 (Note 6)				0.5	V
		$\overline{LF}$	$I_{OL} = 8$ mA				0.45	V
I_{OZR}	OFF-State (High Impedance) Output Current at Receiver		$V_{CC} = Max$ $0.4V \le V_O \le 2.4V$				±20	μA
R_{IN}	Receiver Input Resistance		$-7V \le V_{CM} \le +12V$		12			kΩ
I_{CC}	Supply Current		No Load (Note 6)	Driver Outputs Enabled		42	60	mA
				Driver Outputs Disabled		27	40	mA

1

T-75-45-05

Electrical Characteristics

$0°C \le T_A \le 70°C$, $4.75V < V_{CC} < 5.25V$ unless otherwise specified (Notes 2 & 3) (Continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
I_{OSD}	Driver Short-Circuit Output Current	$V_O = -7V$ (Note 6)			−250	mA
		$V_O = 0V$ (Note 6)			−150	mA
		$V_O = +12V$ (Note 6)			+250	mA
I_{OSR}	Receiver Short-Circuit Output Current	$V_O = 0V$	−15		−85	mA

Note 1: "Absolute maximum ratings" are those beyond which the safety of the device cannot be guaranteed. 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.

Note 2: 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.

Note 3: All typicals are given for $V_{CC} = 5V$ and $T_A = 25°C$.

Note 4: Derate linearly at 11.1 mW/°C to 570 mW at 70°C.

Note 5: Derate linearly at 6.5 mW/°C to 337 mW at 70°C.

Note 6: All limits for which Note 6 is applied must be derated by 10% for DS3695T and DS3696T. Other parameters remain the same for these extended temperature range devices ($-40°C \le T_A \le +85°C$).

Receiver Switching Characteristics (*Figures 1, 2* and *3*)

Symbol	Conditions	Min	Typ	Max	Units
t_{PLH}	$C_L = 15$ pF, S1 and S2 Closed	15	25	37	ns
t_{PHL}		15	25	37	ns
$\lvert t_{PLH} - t_{PHL} \rvert$		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

Driver Switching Characteristics (*Figures 4, 5* and *6*)

Symbol	Conditions	Min	Typ	Max	Units
SINGLE ENDED CHARACTERISTICS					
t_{PLH}	$R_{L_{DIFF}} = 60\Omega$, $C_{L1} = C_{L2} = 100$ pF	9	15	22	ns
t_{PHL}		9	15	22	ns
$t_{SKEW} \lvert t_{PLH} - t_{PHL} \rvert$		0	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 Switching Characteristics (Note 7, *Figure 7*)

Symbol	Conditions	Min	Typ	Max	Units
t_r, t_f	$R_{L_{DIFF}} = 60\Omega$, $C_{L1} = C_{L2} = 100$ pF	6	10	18	ns
t_{PLHD}					ns
t_{PHLD}					ns
$\lvert t_{PLHD} - t_{PHLD} \rvert$					ns

Note 7: Differential Delays are defined as calculated results from single ended rise and fall time measurements. This approach in establishing AC performance specifications has been taken due to limitations of available Automatic Test Equipment (ATE).

The calculated ATE results assume a linear transition between measurement points and are a result of the following equations:

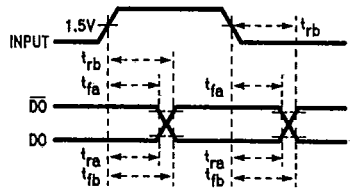
$$Tcr = \frac{(Tfb \times Trb) - (Tra \times Tfa)}{Trb - Tra - Tfa + Tfb}$$

Where: Tcr = Crossing Point

Tra, Trb, Tfa and Tfb are time measurements with respect to the input.

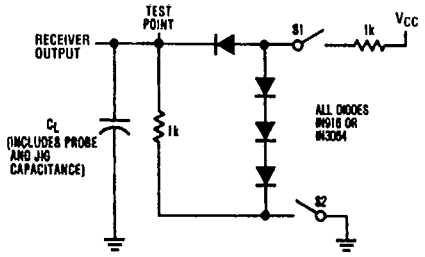
See figure following page.

Switching Time Waveforms



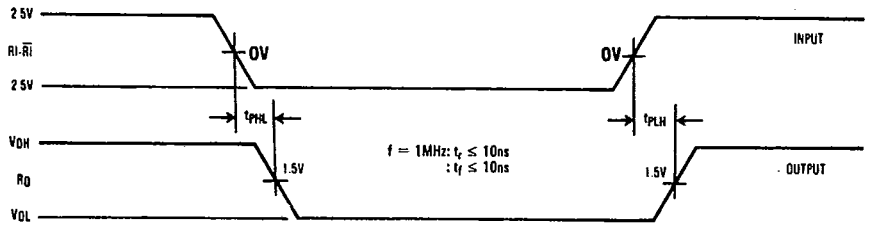
TL/F/5272–5

AC Test Circuits and Switching Waveforms



TL/F/5272–6

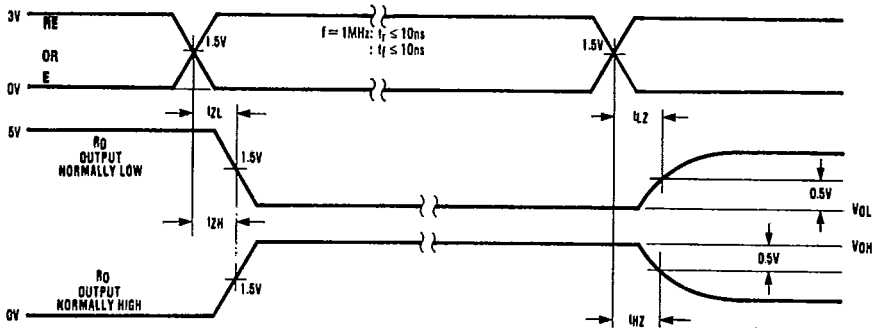
FIGURE 1. Receiver Propagation Delay Test Circuit



TL/F/5272–7

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

FIGURE 2. Receiver Input-to-Output Propagation Delay Timing



TL/F/5272–8

FIGURE 3. Receiver Enable/Disable Propagation Delay Timing

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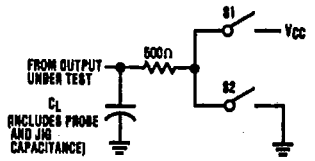
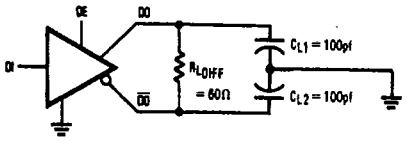
AC Test Circuits and Switching Waveforms (Continued)



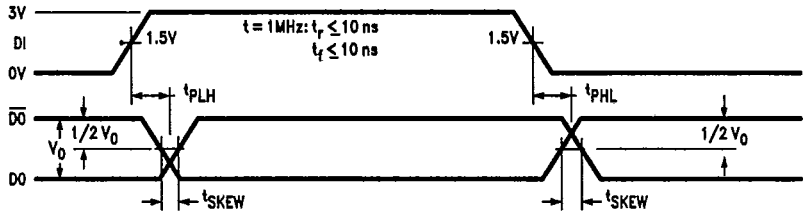
Note: Unless otherwise specified the switches are closed.

TL/F/5272-9



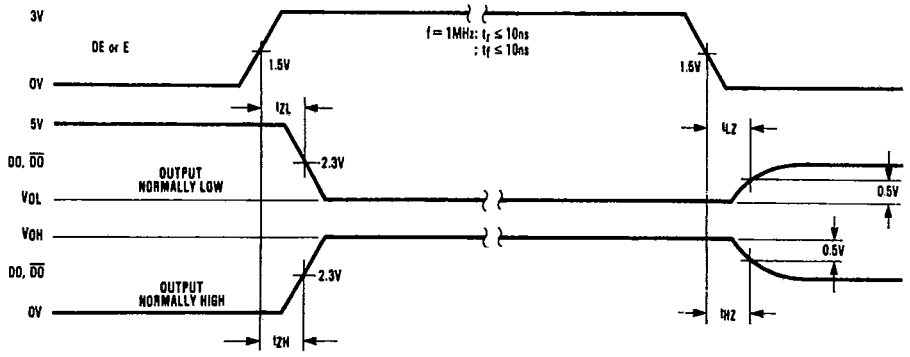
TL/F/5272-10

FIGURE 4. Driver Propagation Delay Test Circuits



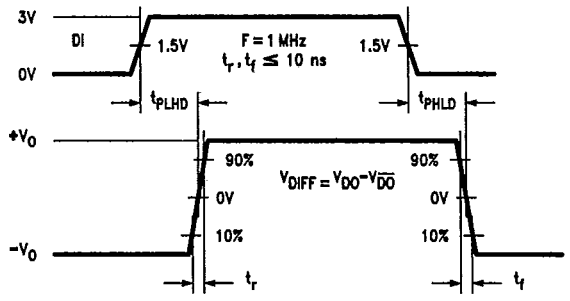
TL/F/5272-11

FIGURE 5. Driver Input-to-Output Propagation Delay Timing (Single-Ended)



TL/F/5272-12

FIGURE 6. Driver Enable/Disable Propagation Delay Timing

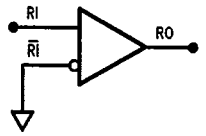


TL/F/5272-13

FIGURE 7. Driver Differential Input-to-Output Propagation Delay and Differential Transition Timing

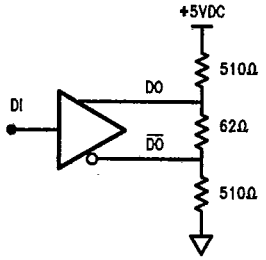
DS3695/DS3696 Channel Distortion (Note 8, *Figures 8, 9*)

Symbol	Parameter	Conditons	Max	Units
t_{PRR}	The difference of any two input to output propagation delays between any two receivers.	$\Delta T_A \leq 25°C$ $\Delta V_{CC} \leq 200$ mV $(4.75V \leq V_{CC} \leq 5.25V)$	9	ns
t_{PDD}	The difference of any two differential input to output propagation delays between any two drivers.	Measured between any two parts on the same interface channel.	6	ns



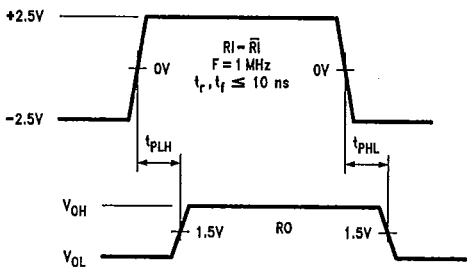
TL/F/5272–14

25 MBS Receiver Propagation Delay Test Circuit



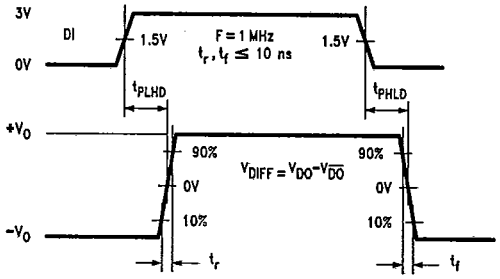
TL/F/5272–15

25 MBS Driver Propagation Delay Test Circuit



TL/F/5272–16

FIGURE 8. 25 MBS Receiver Propagation Delay Timing



TL/F/5272–17

FIGURE 9. 25 MBS Driver Propagation Delay Timing

Note 8: Specified to meet the 25 Mbyte Intelligent Peripheral Interface (IPI) requirements.

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Function Tables

T-75-45-05

DS3695/DS3696 Transmitting

Inputs			Line Condition	Outputs		
$\overline{RE}$	DE	DI		$\overline{DO}$	DO	$\overline{LF}$* (DS3696 Only)
X	1	1	No Fault	0	1	H
X	1	0	No Fault	1	0	H
X	0	X	X	Z	Z	H
X	1	X	Fault	Z	Z	L

DS3695/DS3696 Receiving

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

DS3697/DS3698

Inputs		Line Condition	Outputs			
E	RI–$\overline{RI}$		$\overline{DO}$	DO	RO/DI (DS3697 Only)	$\overline{LF}$* (DS3698 Only)
1	≥ +0.2V	No Fault	0	1	1	H
1	≤ −0.2V	No Fault	1	0	0	H
1	Open**	No Fault	0	1	1	H
0	X	X	Z	Z	Z	H
1	≥ +0.2V	Fault	Z	Z	1	L
1	≤ −0.2V	Fault	Z	Z	0	L

X — Don't care condition

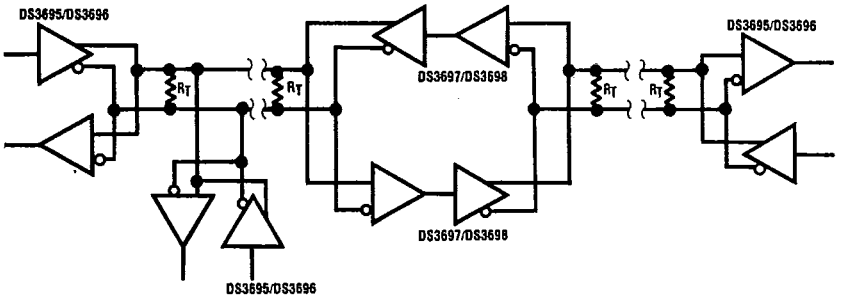
Z — High impedance state

Fault — Improper line conditions causing excessive power dissipation in the driver, such as shorts or bus contention situations

*$\overline{LF}$ is an "open collector" output with an on-chip 10 kΩ pull-up resistor

** This is a fail safe condition

Typical Application



TL/F/5272–18