



NATL SEMICON (MEMORY)

T-75-45-05

DS1691A/DS3691

## DS1691A/DS3691 (RS-422/RS-423) Line Drivers with TRI-STATE® Outputs

### General Description

The DS1691A/DS3691 are low power Schottky TTL line drivers designed to meet the requirements of EIA standards RS-422 and RS-423. They feature 4 buffered outputs with high source and sink current capability with internal short circuit protection. A mode control input provides a choice of operation either as 4 single-ended line drivers or 2 differential line drivers. A rise time control pin allows the use of an external capacitor to slow the rise time for suppression of near end crosstalk to other receivers in the cable. Rise time capacitors are primarily intended for waveshaping output signals in the single-ended driver mode. Multipoint applications in differential mode with waveshaping capacitors is not allowed.

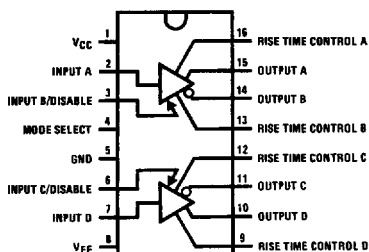
With the mode select pin low, the DS1691A/DS3691 are dual-differential line drivers with TRI-STATE outputs. They feature  $\pm 10V$  output common-mode range in TRI-STATE mode and 0V output unbalance when operated with  $\pm 5V$  supply.

### Features

- Dual RS-422 line driver with mode pin low, or quad RS-423 line driver with mode pin high
- TRI-STATE outputs in RS-422 mode
- Short circuit protection for both source and sink outputs
- Outputs will not clamp line with power off or in TRI-STATE
- 100 $\Omega$  transmission line drive capability
- Low  $I_{CC}$  and  $I_{EE}$  power consumption
  - RS-422  $I_{CC} = 9 \text{ mA/driver typ}$
  - RS-423  $I_{CC} = 4.5 \text{ mA/driver typ}$
  - $I_{EE} = 2.5 \text{ mA/driver typ}$
- Low current PNP inputs compatible with TTL, MOS and CMOS
- Pin compatible with AM26LS30

### Connection Diagram

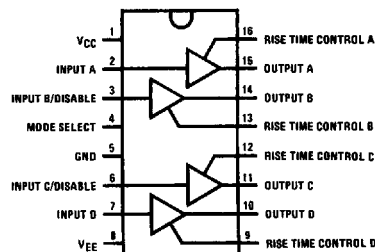
With Mode Select LOW  
(RS-422 Connection)



Top View

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With Mode Select HIGH  
(RS-423 Connection)



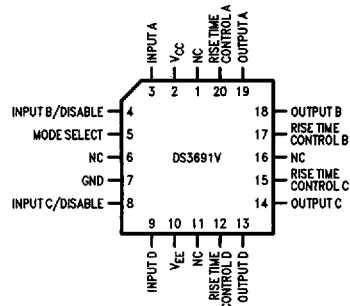
Top View

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### Truth Table

| Operation | Inputs |       |       | Outputs   |           |
|-----------|--------|-------|-------|-----------|-----------|
|           | Mode   | A (D) | B (C) | A (D)     | B (C)     |
| RS-422    | 0      | 0     | 0     | 0         | 1         |
|           | 0      | 0     | 1     | TRI-STATE | TRI-STATE |
|           | 0      | 1     | 0     | 1         | 0         |
|           | 0      | 1     | 1     | TRI-STATE | TRI-STATE |
| RS-423    | 1      | 0     | 0     | 0         | 0         |
|           | 1      | 0     | 1     | 0         | 1         |
|           | 1      | 1     | 0     | 1         | 0         |
|           | 1      | 1     | 1     | 1         | 1         |

Order Number DS1691AJ, DS3691J,  
DS3691M, DS3691N or DS3691V  
See NS Package Number J16A, M16A, N16A or V20A  
For Complete Military 883 Specifications,  
see RETS Data Sheet  
Order Number DS1691AJ/883  
See NS Package Number J16A



Top View

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**Absolute Maximum Ratings** (Note 1)

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

|                                         |                 |
|-----------------------------------------|-----------------|
| Supply Voltage                          |                 |
| V <sub>CC</sub>                         | 7V              |
| V <sub>EE</sub>                         | -7V             |
| Maximum Power Dissipation* at 25°C      |                 |
| Cavity Package                          | 1509 mW         |
| Molded DIP Package                      | 1476 mW         |
| SO Package                              | 1051 mW         |
| Input Voltage                           | 15V             |
| Output Voltage (Power OFF)              | ±15V            |
| Storage Temperature                     | -65°C to +150°C |
| Lead Temperature (Soldering, 4 seconds) | 260°C           |

\*Derate cavity package 10.1 mW/°C above 25°C; derate molded DIP package 11.9 mW/°C above 25°C. Derate SO package 8.41 mW/°C above 25°C.

**Operating Conditions**

|                               | Min   | Max   | Units |
|-------------------------------|-------|-------|-------|
| Supply Voltage                |       |       |       |
| DS1691A                       |       |       |       |
| V <sub>CC</sub>               | 4.5   | 5.5   | V     |
| V <sub>EE</sub>               | -4.5  | -5.5  | V     |
| DS3691                        |       |       |       |
| V <sub>CC</sub>               | 4.75  | 5.25  | V     |
| V <sub>EE</sub>               | -4.75 | -5.25 | V     |
| Temperature (T <sub>A</sub> ) |       |       |       |
| DS1691A                       | -55   | +125  | °C    |
| DS3691                        | 0     | +70   | °C    |

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**DC Electrical Characteristics** (Notes 2, 3, 4 and 5)

| Symbol                                                                            | Parameter                                       | Conditions                                     | Min | Typ  | Max  | Units |
|-----------------------------------------------------------------------------------|-------------------------------------------------|------------------------------------------------|-----|------|------|-------|
| <b>RS-422 CONNECTION, V<sub>EE</sub> CONNECTION TO GROUND, MODE SELECT ≤ 0.8V</b> |                                                 |                                                |     |      |      |       |
| V <sub>IH</sub>                                                                   | High Level Input Voltage                        |                                                | 2   |      |      | V     |
| V <sub>IL</sub>                                                                   | Low Level Input Voltage                         |                                                |     |      | 0.8  | V     |
| I <sub>IH</sub>                                                                   | High Level Input Current                        | V <sub>IN</sub> = 2.4V                         |     | 1    | 40   | μA    |
|                                                                                   |                                                 | V <sub>IN</sub> ≤ 15V                          |     | 10   | 100  | μA    |
| I <sub>IL</sub>                                                                   | Low Level Input Current                         | V <sub>IN</sub> = 0.4V                         |     | -30  | -200 | μA    |
| V <sub>I</sub>                                                                    | Input Clamp Voltage                             | I <sub>IN</sub> = -12 mA                       |     |      | -1.5 | V     |
| V <sub>O</sub><br>V <sub>O</sub>                                                  | Differential Output Voltage<br>V <sub>A,B</sub> | R <sub>L</sub> = ∞                             |     |      |      |       |
|                                                                                   |                                                 | V <sub>IN</sub> = 2V                           |     | 3.6  | 6.0  | V     |
|                                                                                   |                                                 | V <sub>IN</sub> = 0.8V                         |     | -3.6 | -6.0 | V     |
| V <sub>T</sub><br>V <sub>T</sub>                                                  | Differential Output Voltage<br>V <sub>A,B</sub> | R <sub>L</sub> = 100Ω                          |     |      |      |       |
|                                                                                   |                                                 | V <sub>CC</sub> ≥ 4.75V                        |     |      |      |       |
|                                                                                   |                                                 | V <sub>IN</sub> = 2V                           | 2   | 2.4  |      | V     |
|                                                                                   |                                                 | V <sub>IN</sub> = 0.8V                         | -2  | -2.4 |      | V     |
| V <sub>OS</sub> , V <sub>OS</sub>                                                 | Common-Mode Offset Voltage                      | R <sub>L</sub> = 100Ω                          |     | 2.5  | 3    | V     |
| V <sub>T</sub>   -  V <sub>T</sub>                                                | Difference in Differential Output Voltage       | R <sub>L</sub> = 100Ω                          |     | 0.05 | 0.4  | V     |
| V <sub>OS</sub>   -  V <sub>OS</sub>                                              | Difference in Common-Mode Offset Voltage        | R <sub>L</sub> = 100Ω                          |     | 0.05 | 0.4  | V     |
| V <sub>SS</sub>                                                                   | V <sub>T</sub> - V <sub>T</sub>                 | R <sub>L</sub> = 100Ω, V <sub>CC</sub> ≥ 4.75V | 4.0 | 4.8  |      | V     |
| V <sub>CMR</sub>                                                                  | Output Voltage Common-Mode Range                | V <sub>DISABLE</sub> = 2.4V                    | ±10 |      |      | V     |
| I <sub>XA</sub>                                                                   | Output Leakage Current                          | V <sub>CC</sub> = 0V                           |     |      | 100  | μA    |
| I <sub>XB</sub>                                                                   | Power OFF                                       | V <sub>CMR</sub> = 10V                         |     |      | -100 | μA    |
|                                                                                   |                                                 | V <sub>CMR</sub> = -10V                        |     |      |      | μA    |
| I <sub>OX</sub>                                                                   | TRI-STATE Output Current                        | V <sub>CC</sub> = Max                          |     |      | 100  | μA    |
|                                                                                   |                                                 | V <sub>EE</sub> = 0V and -5V                   |     |      | -100 | μA    |
| I <sub>SA</sub>                                                                   | Output Short Circuit Current                    | V <sub>IN</sub> = 0.4V                         |     | 80   | 150  | mA    |
|                                                                                   |                                                 | V <sub>OA</sub> = 6V                           |     | -80  | -150 | mA    |
|                                                                                   |                                                 | V <sub>OB</sub> = 0V                           |     |      |      | mA    |
| I <sub>SB</sub>                                                                   | Output Short Circuit Current                    | V <sub>IN</sub> = 2.4V                         |     | 80   | 150  | mA    |
|                                                                                   |                                                 | V <sub>OA</sub> = 0V                           |     | -80  | -150 | mA    |
|                                                                                   |                                                 | V <sub>OB</sub> = 6V                           |     |      |      | mA    |
| I <sub>CC</sub>                                                                   | Supply Current                                  |                                                |     | 18   | 30   | mA    |

AC Electrical Characteristics  $T_A = 25^\circ\text{C}$  (Note 5) NATL SEMICON (MEMORY)

| Symbol                                                                        | Parameter                | Conditions                                                               | Min | Typ | Max | Units |
|-------------------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------|-----|-----|-----|-------|
| <b>RS-422 CONNECTION, <math>V_{CC} = 5\text{V}</math>, MODE SELECT = 0.8V</b> |                          |                                                                          |     |     |     |       |
| $t_r$                                                                         | Output Rise Time         | $R_L = 100\Omega$ , $C_L = 500\text{pF}$ (Figure 1)                      |     | 120 | 200 | ns    |
| $t_f$                                                                         | Output Fall Time         | $R_L = 100\Omega$ , $C_L = 500\text{pF}$ (Figure 1)                      |     | 120 | 200 | ns    |
| $t_{PDH}$                                                                     | Output Propagation Delay | $R_L = 100\Omega$ , $C_L = 500\text{pF}$ (Figure 1)                      |     | 120 | 200 | ns    |
| $t_{PDL}$                                                                     | Output Propagation Delay | $R_L = 100\Omega$ , $C_L = 500\text{pF}$ (Figure 1)                      |     | 120 | 200 | ns    |
| $t_{PZL}$                                                                     | TRI-STATE Delay          | $R_L = 450\Omega$ , $C_L = 500\text{pF}$ , $C_C = 0\text{pF}$ (Figure 4) |     | 250 | 350 | ns    |
| $t_{PZH}$                                                                     | TRI-STATE Delay          | $R_L = 450\Omega$ , $C_L = 500\text{pF}$ , $C_C = 0\text{pF}$ (Figure 4) |     | 180 | 300 | ns    |
| $t_{PLZ}$                                                                     | TRI-STATE Delay          | $R_L = 450\Omega$ , $C_L = 500\text{pF}$ , $C_C = 0\text{pF}$ (Figure 4) |     | 180 | 300 | ns    |
| $t_{PHZ}$                                                                     | TRI-STATE Delay          | $R_L = 450\Omega$ , $C_L = 500\text{pF}$ , $C_C = 0\text{pF}$ (Figure 4) |     | 250 | 350 | ns    |

## DC Electrical Characteristics (Notes 2, 3, 4 and 5)

| Symbol                                                                  | Parameter                    | Conditions                                               |                        | Min  | Typ       | Max  | Units         |
|-------------------------------------------------------------------------|------------------------------|----------------------------------------------------------|------------------------|------|-----------|------|---------------|
| RS-423 CONNECTION, $ V_{CC}  =  V_{EE} $ , MODE SELECT $\geq 2\text{V}$ |                              |                                                          |                        |      |           |      |               |
| $V_{IH}$                                                                | High Level Input Voltage     |                                                          |                        | 2    |           |      | V             |
| $V_{IL}$                                                                | Low Level Input Voltage      |                                                          |                        |      |           | 0.8  | V             |
| $I_{IH}$                                                                | High Level Input Current     | $V_{IN} = 2.4\text{V}$                                   |                        |      | 1         | 40   | $\mu\text{A}$ |
|                                                                         |                              | $V_{IN} \leq 15\text{V}$                                 |                        |      | 10        | 100  | $\mu\text{A}$ |
| $I_{IL}$                                                                | Low Level Input Current      | $V_{IN} = 0.4\text{V}$                                   |                        |      | -30       | -200 | $\mu\text{A}$ |
| $V_I$                                                                   | Input Clamp Voltage          | $I_{IN} = -12\text{mA}$                                  |                        |      |           | -1.5 | V             |
| $V_O$                                                                   | Output Voltage               | $R_L = \infty$ , (Note 6)<br>$V_{CC} \geq 4.75\text{V}$  | $V_{IN} = 2\text{V}$   | 4.0  | 4.4       | 6.0  | V             |
| $\overline{V_O}$                                                        |                              |                                                          | $V_{IN} = 0.4\text{V}$ | -4.0 | -4.4      | -6.0 | V             |
| $V_T$                                                                   | Output Voltage               | $R_L = 450\Omega$<br>$V_{CC} \geq 4.75\text{V}$          | $V_{IN} = 2.4\text{V}$ | 3.6  | 4.1       |      | V             |
| $\overline{V_T}$                                                        |                              |                                                          | $V_{IN} = 0.4\text{V}$ | -3.6 | -4.1      |      | V             |
| $ V_T  -  \overline{V_T} $                                              | Output Unbalance             | $ V_{CC}  =  V_{EE}  = 4.75\text{V}$ , $R_L = 450\Omega$ |                        |      | 0.02      | 0.4  | V             |
| $I_{X^+}$                                                               | Output Leakage Power OFF     | $V_{CC} = V_{EE} = 0\text{V}$                            | $V_O = 6\text{V}$      |      | 2         | 100  | $\mu\text{A}$ |
| $I_{X^-}$                                                               | Output Leakage Power OFF     | $V_{CC} = V_{EE} = 0\text{V}$                            | $V_O = -6\text{V}$     |      | -2        | -100 | $\mu\text{A}$ |
| $I_{S^+}$                                                               | Output Short Circuit Current | $V_O = 0\text{V}$                                        | $V_{IN} = 2.4\text{V}$ |      | -80       | -150 | mA            |
| $I_{S^-}$                                                               | Output Short Circuit Current | $V_O = 0\text{V}$                                        | $V_{IN} = 0.4\text{V}$ |      | 80        | 150  | mA            |
| $I_{SLEW}$                                                              | Slew Control Current         |                                                          |                        |      | $\pm 140$ |      | $\mu\text{A}$ |
| $I_{CC}$                                                                | Positive Supply Current      | $V_{IN} = 0.4\text{V}$ , $R_L = \infty$                  |                        |      | 18        | 30   | mA            |
| $I_{EE}$                                                                | Negative Supply Current      | $V_{IN} = 0.4\text{V}$ , $R_L = \infty$                  |                        |      | -10       | -22  | mA            |

**Note 1:** "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the devices should be operated at these limits. The tables of "Electrical Characteristics" provide conditions for actual device operation.

**Note 2:** Unless otherwise specified, min/max limits apply across the  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$  temperature range for the DS1691A and across the  $0^\circ\text{C}$  to  $+70^\circ\text{C}$  range for the DS3691. All typicals are given for  $V_{CC} = 5\text{V}$  and  $T_A = 25^\circ\text{C}$ .  $V_{CC}$  and  $V_{EE}$  as listed in operating conditions.

**Note 3:** All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to ground unless otherwise specified.

**Note 4:** Only one output at a time should be shorted.

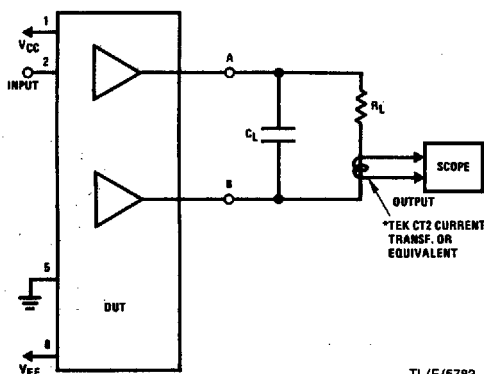
**Note 5:** Symbols and definitions correspond to EIA RS-422 and/or RS-423 where applicable.

**Note 6:** At  $-55^\circ\text{C}$ , the output voltage is  $+3.9\text{V}$  minimum and  $-3.9\text{V}$  minimum.

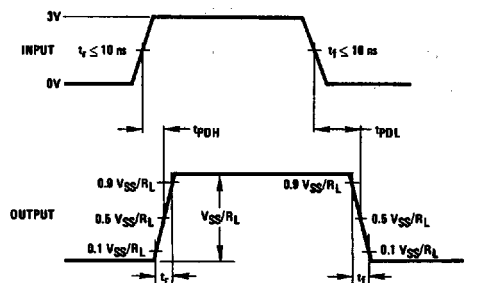
**AC Electrical Characteristics**  $T_A = 25^\circ\text{C}$  (Note 5)

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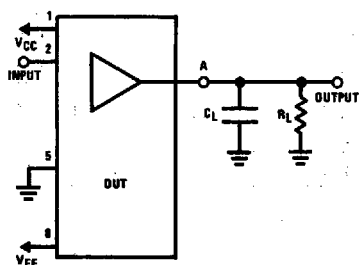
| Symbol                                                                                                          | Parameter                | Conditions                                                                | Min | Typ  | Max | Units            |
|-----------------------------------------------------------------------------------------------------------------|--------------------------|---------------------------------------------------------------------------|-----|------|-----|------------------|
| <b>RS-423 CONNECTION, <math>V_{CC} = 5\text{V}</math>, <math>V_{EE} = -5\text{V}</math>, MODE SELECT = 2.4V</b> |                          |                                                                           |     |      |     |                  |
| $t_r$                                                                                                           | Rise Time                | $R_L = 450\Omega$ , $C_L = 500\text{pF}$ , $C_C = 0$ (Figure 2)           |     | 120  | 300 | ns               |
| $t_f$                                                                                                           | Fall Time                | $R_L = 450\Omega$ , $C_L = 500\text{pF}$ , $C_C = 0$ (Figure 2)           |     | 120  | 300 | ns               |
| $t_r$                                                                                                           | Rise Time                | $R_L = 450\Omega$ , $C_L = 500\text{pF}$ , $C_C = 50\text{pF}$ (Figure 3) |     | 3.0  |     | $\mu\text{s}$    |
| $t_f$                                                                                                           | Fall Time                | $R_L = 450\Omega$ , $C_L = 500\text{pF}$ , $C_C = 50\text{pF}$ (Figure 3) |     | 3.0  |     | $\mu\text{s}$    |
| $t_{rc}$                                                                                                        | Rise Time Coefficient    | $R_L = 450\Omega$ , $C_L = 500\text{pF}$ , $C_C = 50\text{pF}$ (Figure 3) |     | 0.06 |     | $\mu\text{s/pF}$ |
| $t_{PDH}$                                                                                                       | Output Propagation Delay | $R_L = 450\Omega$ , $C_L = 500\text{pF}$ , $C_C = 0$ (Figure 2)           |     | 180  | 300 | ns               |
| $t_{PDL}$                                                                                                       | Output Propagation Delay | $R_L = 450\Omega$ , $C_L = 500\text{pF}$ , $C_C = 0$ (Figure 2)           |     | 180  | 300 | ns               |

**AC Test Circuits and Switching Time Waveforms**

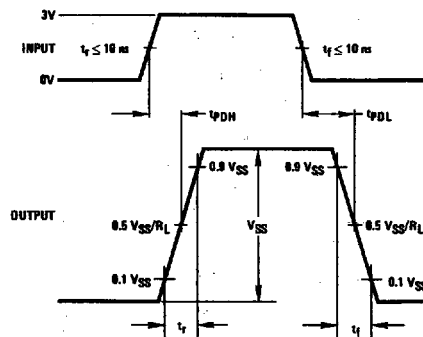
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**FIGURE 1. Differential Connection**

TL/F/5783-4

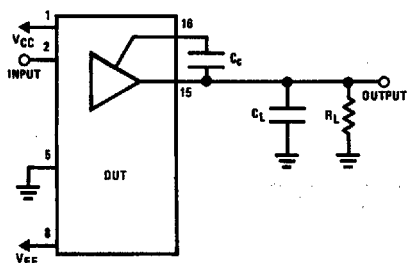


TL/F/5783-5

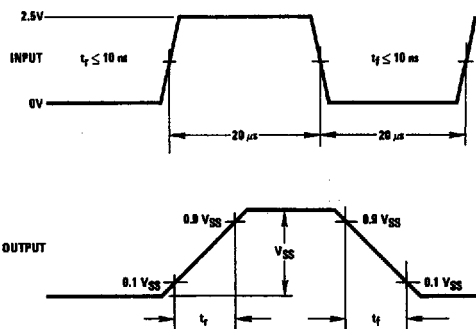
**FIGURE 2. RS-423 Connection**

TL/F/5783-6

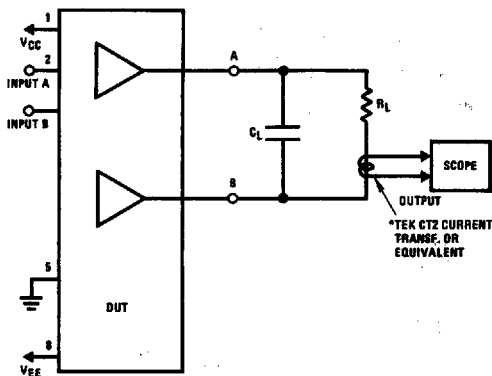
# AC Test Circuits and Switching Time Waveforms (Continued)



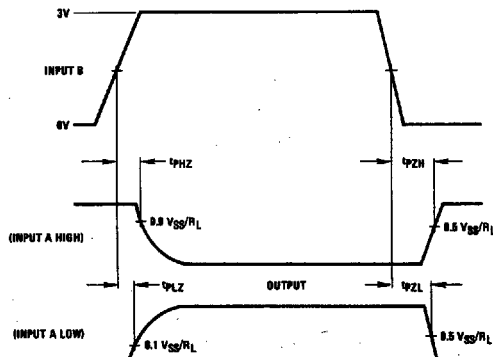
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TL/F/5783-8

**FIGURE 3. Rise Time Control for RS-423**


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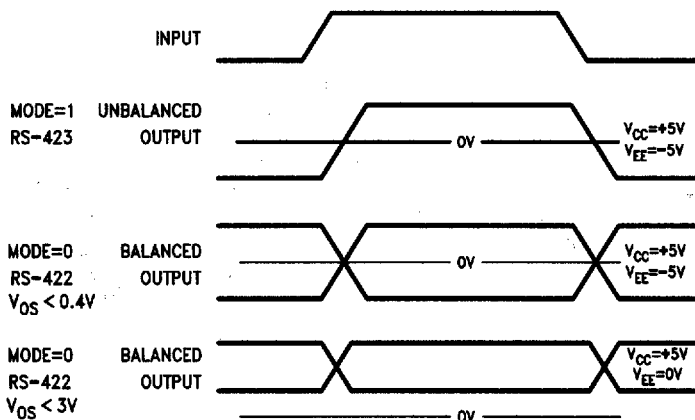


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**FIGURE 4. TRI-STATE Delays**

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## Switching Waveforms

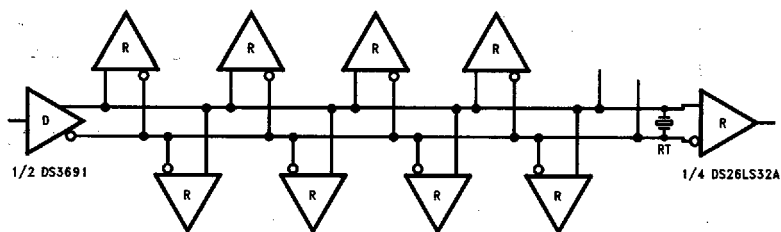

**FIGURE 5. Typical Output Voltage**

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## Typical Application Information

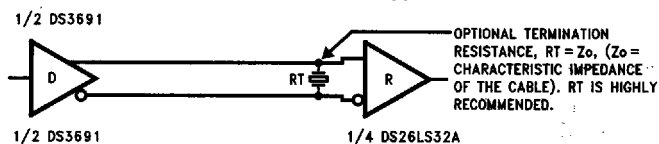
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Fully Loaded RS-422 Interface



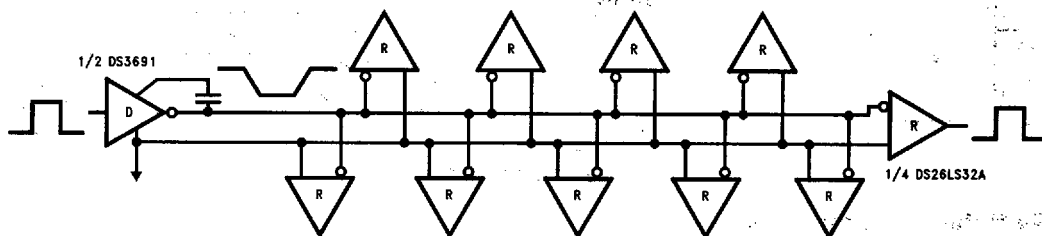
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RS-422 Point to Point Application



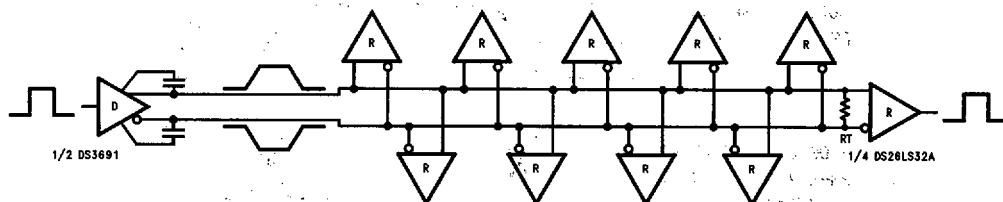
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Fully Loaded RS-423 Interface



TL/F/5783-15

Differential Application with Rise Time Control



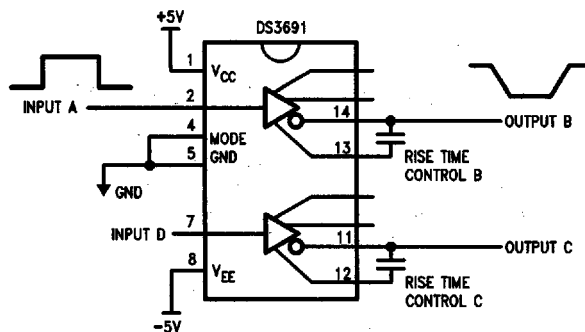
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\*Note: Controlled edge allows longer stub lengths. Multiple Drivers are NOT allowed.

# Typical Application Information (Continued)

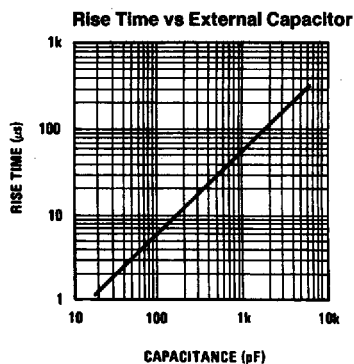
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## Dual RS-423 Inverting Driver



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## Typical Rise Time Control Characteristics (RS-423 Mode)



TL/F/5783-12