National Semiconductor

# DS89C21
# Differential CMOS Line Driver and Receiver Pair

## General Description

The DS89C21 is a differential CMOS line driver and receiver pair, designed to meet the requirements of TIA/EIA-422-A (RS-422) electrical characteristics interface standard. The DS89C21 provides one driver and one receiver in a minimum footprint. The device is offered in an 8-pin SOIC package.

The CMOS design minimizes the supply current to 6 mA, making the device ideal for use in battery powered or power conscious applications.

The driver features a fast transition time specified at 2.2 ns, and a maximum differential skew of 2 ns making the driver ideal for use in high speed applications operating above 10 MHz.

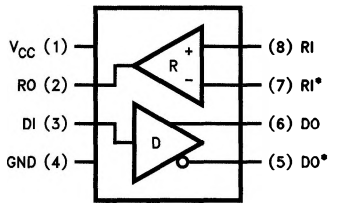
The receiver can detect signals as low as 200 mV, and also incorporates hysteresis for noise rejection. Skew is specified at 4 ns maximum.

The DS89C21 is compatible with TTL and CMOS levels (DI and RO).

## Features

- Meets TIA/EIA-422-A (RS-422) and CCITT V.11 recommendation
- LOW POWER design—15 mW typical
- Guaranteed AC parameters:
  - — Maximum driver skew 2.0 ns
  - — Maximum receiver skew 4.0 ns
- Extended temperature range −40°C to +85°C
- Available in SOIC packaging
- Operates over 20 Mbps
- Receiver OPEN input failsafe feature

## Connnection Diagram

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**Order Number DS89C21TM or DS89C21TN**
**See NS Package Number M08A or N08E**

## Truth Tables

**Driver**

| Input | Outputs | |
|---|---|---|
| **DI** | **DO** | **DO*** |
| H | H | L |
| L | L | H |

**Receiver**

| Inputs | Output |
|---|---|
| **RI–RI*** | **RO** |
| $V_{DIFF} \geq +200$ mV | H |
| $V_{DIFF} \leq -200$ mV | L |
| OPEN† | H |

†Non-terminated

## 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 ($V_{CC}$) | 7V |
| Driver Input Voltage (DI) | $-1.5V$ to $V_{CC} + 1.5V$ |
| Driver Output Voltage (DO, DO*) | $-0.5V$ to $+7V$ |
| Receiver Input Voltage—$V_{CM}$ (RI, RI*) | $\pm 14V$ |
| Differential Receiver Input Voltage—$V_{DIFF}$ (RI, RI*) | $\pm 14V$ |
| Receiver Output Voltage (RO) | $-0.5V$ to $V_{CC} + 0.5V$ |
| Receiver Output Current (RO) | $\pm 25$ mA |
| Storage Temperature Range ($T_{STG}$) | $-65°C$ to $+150°C$ |
| Lead Temperature ($T_L$) (Soldering 4 sec.) | $+260°C$ |
| Maximum Junction Temperature | 150°C |
| Maximum Package Power Dissipation @ $+25°C$ | |
| M Package | 714 mW |
| N Package | 1275 mW |
| Derate M Package | 5.7 mW/°C above $+25°C$ |
| Derate N Package | 10.2 mW/°C above $+25°C$ |

## Recommended Operating Conditions

| | Min | Max | Units |
|---|---|---|---|
| Supply Voltage ($V_{CC}$) | 4.50 | 5.50 | V |
| Operating Temperature ($T_A$) | $-40$ | $+85$ | °C |
| Input Rise or Fall Time (DI) | | 500 | ns |

## Electrical Characteristics

Over recommended supply voltage and operating temperature ranges, unless otherwise specified. (Notes 2, 3)

| Symbol | Parameter | Conditions | | Pin | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|---|
| **DRIVER CHARACTERISTICS** | | | | | | | | |
| $V_{IH}$ | Input Voltage HIGH | | | DI | 2.0 | | $V_{CC}$ | V |
| $V_{IL}$ | Input Voltage LOW | | | | GND | | 0.8 | V |
| $I_{IH}$, $I_{IL}$ | Input Current | $V_{IN} = V_{CC}$, GND, 2.0V, 0.8V | | | | 0.05 | $\pm 10$ | $\mu$A |
| $V_{CL}$ | Input Clamp Voltage | $I_{IN} = -18$ mA | | | | | $-1.5$ | V |
| $V_{OD1}$ | Unloaded Output Voltage | No Load | | DO, DO* | | 4.2 | 6.0 | V |
| $V_{OD2}$ | Differential Output Voltage | $R_L = 100\Omega$ | | | 2.0 | 3.0 | | V |
| $\Delta V_{OD2}$ | Change in Magnitude of $V_{OD2}$ for Complementary Output States | | | | | 5.0 | 400 | mV |
| $V_{OD3}$ | Differential Output Voltage | $R_L = 150\Omega$ | | | 2.1 | 3.1 | | V |
| $V_{OD4}$ | Differential Output Voltage | $R_L = 3.9$ k$\Omega$ | | | | 4.0 | 6.0 | V |
| $V_{OC}$ | Common Mode Voltage | $R_L = 100\Omega$ | | | | 2.0 | 3.0 | V |
| $\Delta V_{OC}$ | Change in Magnitude of $V_{OC}$ for Complementary Output States | | | | | 2.0 | 400 | mV |
| $I_{OSD}$ | Output Short Circuit Current | $V_{OUT} = 0V$ | | | $-30$ | $-115$ | $-150$ | mA |
| $I_{OFF}$ | Output Leakage Current | $V_{CC} = 0V$ | $V_{OUT} = +6V$ | | | 0.03 | $+100$ | $\mu$A |
| | | | $V_{OUT} = -0.25V$ | | | $-0.08$ | $-100$ | $\mu$A |

## Electrical Characteristics

Over recommended supply voltage and operating temperature ranges, unless otherwise specified. (Notes 2, 3) (Continued)

| Symbol | Parameter | Conditions | | Pin | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|---|
| **RECEIVER CHARACTERISTICS** | | | | | | | | |
| $V_{TL}$, $V_{TH}$ | Differential Thresholds | $V_{IN}$ = +7V, 0V, −7V | | RI, RI* | −200 | ±25 | +200 | mV |
| $V_{HYS}$ | Hysteresis | $V_{CM}$ = 0V | | | 20 | 50 | | mV |
| $R_{IN}$ | Input Impedance | $V_{IN}$ = −7V, +7V, Other = 0V | | | 5.0 | 9.5 | | kΩ |
| $I_{IN}$ | Input Current | Other Input = 0V, $V_{CC}$ = 5.5V and $V_{CC}$ = 0V | $V_{IN}$ = +10V | | | +1.0 | +1.5 | mA |
| | | | $V_{IN}$ = +3.0V | | 0 | +0.22 | | mA |
| | | | $V_{IN}$ = +0.5V | | | −0.04 | | mA |
| | | | $V_{IN}$ = −3V | | 0 | −0.41 | | mA |
| | | | $V_{IN}$ = −10V | | | −1.25 | −2.5 | mA |
| $V_{OH}$ | Output HIGH Voltage | $I_{OH}$ = −6 mA | $V_{DIFF}$ = +1V | RO | 3.8 | 4.9 | | V |
| | | | $V_{DIFF}$ = OPEN | | 3.8 | 4.9 | | V |
| $V_{OL}$ | Output LOW Voltage | $I_{OL}$ = +6 mA, $V_{DIFF}$ = −1V | | | | 0.08 | 0.3 | V |
| $I_{OSR}$ | Output Short Circuit Current | $V_{OUT}$ = 0V | | | −25 | −85 | −150 | mA |
| **DRIVER AND RECEIVER CHARACTERISTICS** | | | | | | | | |
| $I_{CC}$ | Supply Current | No Load | DI = $V_{CC}$ or GND | $V_{CC}$ | | 3.0 | 6 | mA |
| | | | DI = 2.4V or 0.5V | | | 3.8 | 12 | mA |

## Switching Characteristics

Over recommended supply voltage and operating temperature ranges, unless otherwise specified. (Note 3)

| Symbol | Parameter | Conditions | | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| **DIFFERENTIAL DRIVER CHARACTERISTICS** | | | | | | | |
| $t_{PLHD}$ | Propagation Delay LOW to HIGH | $R_L$ = 100Ω, $C_L$ = 50 pF | *(Figures 2, 3)* | 2 | 4.9 | 10 | ns |
| $t_{PHLD}$ | Propagation Delay HIGH to LOW | | | 2 | 4.5 | 10 | ns |
| $t_{SKD}$ | Skew, $\lvert t_{PLHD} - t_{PHLD} \rvert$ | | | | 0.4 | 2.0 | ns |
| $t_{TLH}$ | Transition Time LOW to HIGH | | *(Figures 2, 4)* | | 2.2 | 9 | ns |
| $t_{THL}$ | Transition Time HIGH to LOW | | | | 2.1 | 9 | ns |
| **RECEIVER CHARACTERISTICS** | | | | | | | |
| $t_{PLH}$ | Propagation Delay LOW to HIGH | $C_L$ = 50 pF, $V_{DIFF}$ = 2.5V, $V_{CM}$ = 0V | *(Figures 5, 6)* | 6 | 18 | 30 | ns |
| $t_{PHL}$ | Propagation Delay HIGH to LOW | | | 6 | 17.5 | 30 | ns |
| $t_{SK}$ | Skew, $\lvert t_{PLH} - t_{PHL} \rvert$ | | | | 0.5 | 4.0 | ns |
| $t_r$ | Rise Time | | *(Figure 7)* | | 2.5 | 9 | ns |
| $t_f$ | Fall Time | | | | 2.1 | 9 | ns |

**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" specify conditions for device operation.

**Note 2:** Current into device pins is defined as positive. Current out of device pins is defined as negative. All voltages are referenced to ground unless otherwise specified.

**Note 3:** All typicals are given for $V_{CC}$ = 5.0V and $T_A$ = 25°C.

**Note 4:** f = 1 MHz, $t_r$ and $t_f$ ≤ 6 ns.

**Note 5:** ESD Rating: HBM (1.5 kΩ, 100 pF) all pins ≥ 2000V.
EIAJ (0Ω, 200 pF) ≥ 250V

## Parameter Measurement Information

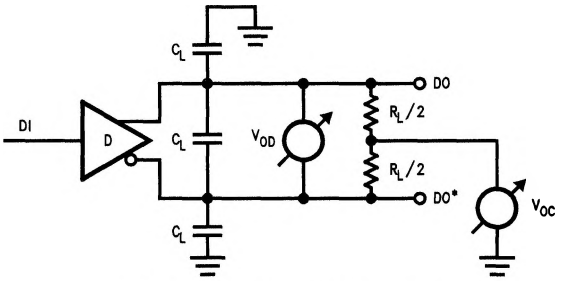


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**FIGURE 1. $V_{OD}$ and $V_{OC}$ Test Circuit**

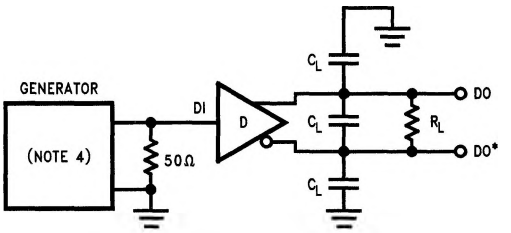


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**FIGURE 2. Driver Propagation Delay Test Circuit**

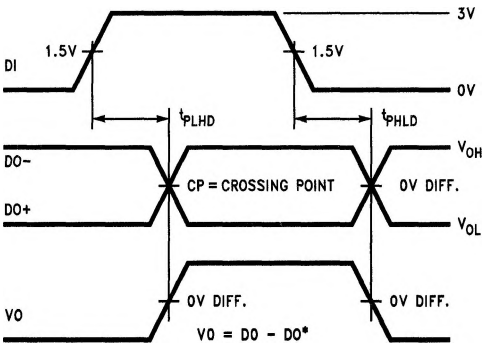


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**FIGURE 3. Driver Differential Propagation Delay Timing**

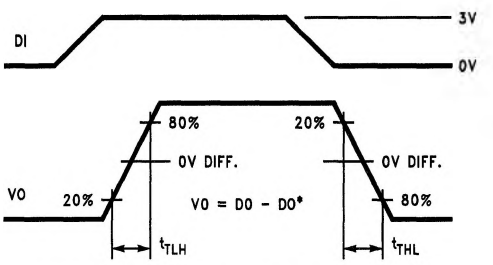


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**FIGURE 4. Driver Differential Transition Timing**

## Parameter Measurement Information (Continued)

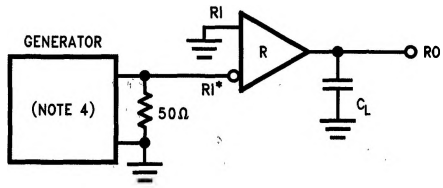


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**FIGURE 5. Receiver Propagation Delay Test Circuit**

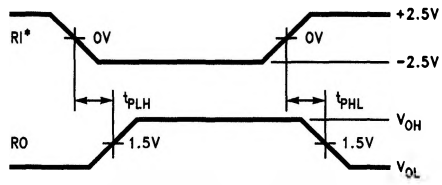


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**FIGURE 6. Receiver Propagation Delay Timing**

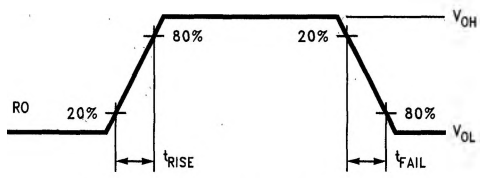


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**FIGURE 7. Receiver Rise and Fall Times**