# DS16F95QML

***DS16F95QML EIA-485/EIA-422A Differential Bus Transceiver***

Literature Number: SNOSAN0A

National Semiconductor

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# DS16F95QML

# EIA-485/EIA-422A Differential Bus Transceiver

## General Description

The DS16F95 Differential Bus Transceiver is a monolithic integrated circuit designed for bidirectional data communication on balanced multipoint bus transmission lines. The transceiver meets EIA standard RS-485 as well as RS-422A.

The DS16F95 offers improved performance due to the use of state-of-the-art L-FAST bipolar technology. The L-FAST technology allows for higher speeds and lower currents by utilizing extremely short gate delay times. Thus, the DS16F95QML features lower power, extended temperature range and improved specifications.

The DS16F95 combines a TRI-STATE® differential line driver and a differential input line receiver, both of which operate from a single 5.0V power supply. The driver and receiver have an active Enable that can be externally connected to function as a direction control. The driver differential outputs and the receiver differential inputs are internally connected to form differential input/output (I/O) bus ports that are designed to offer minimum loading to the bus whenever the driver is disabled or when $V_{CC}$ = 0V. These ports feature wide positive and negative common mode voltage ranges, making the device suitable for multipoint applications in noisy environments.

The driver is designed to accommodate loads of up to 60 mA of sink or source current and features positive and negative current limiting in addition to thermal shutdown for protection from line fault conditions.

The DS16F95 can be used in transmission line applications employing the DS96F172 and the DS96F174 quad differential line drivers and the DS96F173 and DS96F175 quad differential line receivers.

## Features

- Radiation guaranteed 300 krad(Si)
- Meets EIA-485 and EIA-422A
- Meets SCSI-1 (5 MHZ) specifications
- Designed for multipoint transmission
- Wide positive and negative input/output bus voltage ranges
- Thermal shutdown protection
- Driver positive and negative current-limiting
- High impedance receiver input
- Receiver input hysteresis of 50 mV typical
- Operates from single 5.0V supply
- Reduced power consumption
- Pin compatible with DS3695 and SN75176A

## Ordering Information

| NS Part Number | SMD Part Number | NS Package Number | Package Description |
|---|---|---|---|
| DS16F95E/883 | 5962–89615012A | E20A | 20LD LCC |
| DS16F95J/883 | 5962–8961501PA | J08A | 8LD CERDIP |
| DS16F95W/883 | | W10A | 10LD CERPACK |
| DS16F95WFQMLV | 5962F8961501VHA<br>300 krad(Si) | W10A | 10LD CERPACK |
| DS16F95 MDR | | (*Note 1*) | Bare Die |
| DS16F95 MDS | | (*Note 1*) | Bare Die |

**Note 1: FOR ADDITIONAL DIE INFORMATION, PLEASE VISIT THE HI REL WEB SITE AT: www.national.com/analog/space/level_die**

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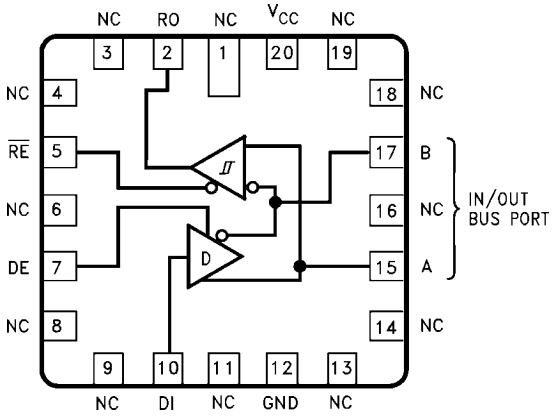
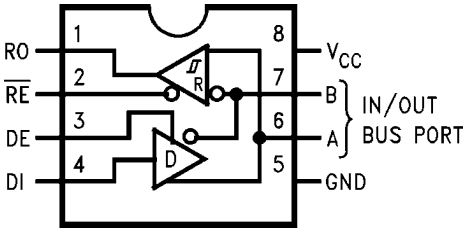
## Connection Diagrams

**20-Lead Ceramic Leadless Chip Carrier**



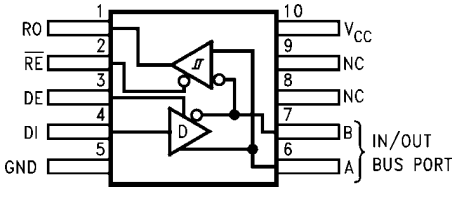

**See NS Package Number E20A**

**8-Lead Dual-In-Line Package**



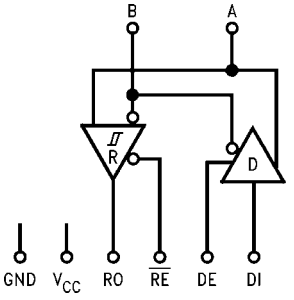

**See NS Package Number J08A**

**10-Lead Flatpak Package**




**See NS Package Number W10A**

## Logic Diagram

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## Function Tables

**Driver**

| Driver Input | Enable | Outputs | |
|---|---|---|---|
| **DI** | **DE** | **A** | **B** |
| H | H | H | L |
| L | H | L | H |
| X | L | Z | Z |

**Receiver**

| Differential Inputs | Enable | Output |
|---|---|---|
| **A–B** | **$\overline{RE}$** | **RO** |
| $V_{ID} \geq 0.2V$ | L | H |
| $V_{ID} \leq -0.2V$ | L | L |
| X | H | Z |

H = High Level
L = Low Level
X = Immaterial
Z = High Impedance (Off)

## Absolute Maximum Ratings (*Note 2*)

| | |
|---|---|
| Storage Temperature Range | -65°C ≤ $T_A$ ≤ +175°C |
| Lead Temperature | |
| (Soldering, 60 sec.) | 300°C |
| Maximum Power Dissipation at 25°C (*Note 3*) | |
| LCC 'E' Package | 1800 mW |
| Cerdip 'J' Package | 1274 mW |
| Cerpack 'W' Package | 725 mW |
| Supply Voltage | 7.0V |
| Input Voltage (Bus Terminal) | +15V/−10V |
| Enable Input Voltage | 5.5V |
| Junction Temperature (TJ) | +175°C |
| Thermal Resistance | |
| $\theta_{JA}$ | |
| LCC 'E' Package | 83°C/W @ 0.5W |
| Cerdip 'J' Package | 118°C/W @ 1.0W |
| Cerpack 'W' Package | 207°C/W @ 0.5W |
| $\theta_{JC}$ | |
| LCC 'E' Package | 17°C/W |
| Cerdip 'J' Package | 14°C/W |
| Cerpack 'W' Package | 18°C/W |
| ESD Tolerance (*Note 4*) | 500V |

## Recommended Operating Conditions

| | |
|---|---|
| Supply Voltage ($V_{CC}$) | 4.50 to 5.50V |
| Voltage at Any Bus Terminal (Separately or Common Mode) ($V_I$ or $V_{CM}$) | -7.0V to +12V |
| Differential Input Voltage ($V_{ID}$) | -7.0V to ±12V |
| Output Current HIGH ($I_{OH}$) | |
| Driver | -60mA |
| Receiver | -400µA |
| Output Current LOW ($I_{OL}$) | |
| Driver | 60mA |
| Receiver | 16mA |
| Operating Temperature ($T_A$) | -55°C to +125°C |

## Quality Conformance Inspection

MIL-STD-883, Method 5005 - Group A

| Subgroup | Description | Temp (°C) |
|---|---|---|
| 1 | Static tests at | +25 |
| 2 | Static tests at | +125 |
| 3 | Static tests at | -55 |
| 4 | Dynamic tests at | +25 |
| 5 | Dynamic tests at | +125 |
| 6 | Dynamic tests at | -55 |
| 7 | Functional tests at | +25 |
| 8A | Functional tests at | +125 |
| 8B | Functional tests at | -55 |
| 9 | Switching tests at | +25 |
| 10 | Switching tests at | +125 |
| 11 | Switching tests at | -55 |

## DC - Driver Electrical Characteristics (*Note 11*)

The following conditions apply to all parameters, unless otherwise specified. $V_{CC}$ = 5.5V

| Symbol | Parameter | Conditions | Notes | Min | Max | Unit | Sub-group |
|---|---|---|---|---|---|---|---|
| VOD1 | Differential Vout | $V_{CC}$ = 5.5V, $I_O$ = 0A, $V_{IN}$ = .8V | | | 6 | V | 1, 2, 3 |
| | | $V_{CC}$ = 5.5V, $I_O$ = 0A, $V_{IN}$ = 2V | | | 6 | V | 1, 2, 3 |
| VOD2 | Differential Vout *Figure 1* | $V_{CC}$ = 4.5V, $R_L$ = 100Ω | | 2 | | V | 1, 2, 3 |
| | | $V_{CC}$ = 4.5V, $R_L$ = 54Ω | | 1.5 | | V | 1, 2, 3 |
| $\Delta V_{OD}$ | Change In Differential Vout | $V_{CC}$ = 4.5V, $R_L$ = 100Ω | (*Note 5*) | -200 | 200 | mV | 1, 2, 3 |
| | | $V_{CC}$ = 4.5V, $R_L$ = 54Ω | | -200 | 200 | mV | 1, 2, 3 |
| $\Delta V_{OC}$ | Change In Common Mode Vout | $V_{CC}$ = 4.5V, $R_L$ = 100Ω | (*Note 5*) | -200 | 200 | mV | 1, 2, 3 |
| | | $V_{CC}$ = 4.5V, $R_L$ = 54Ω | | -200 | 200 | mV | 1, 2, 3 |
| $V_{OC}$ | Common Mode Vout | $R_L$ = 100Ω | | | 3 | V | 1, 2, 3 |
| | | $R_L$ = 54Ω | | | 3 | V | 1, 2, 3 |
| $I_{IH}$ | Logical "1" Input Current | $V_I$ = 2.4V | | | 20 | uA | 1, 2, 3 |
| $I_O$ | Output Current | Output Disable, $V_O$ = 12V | | | 1 | mA | 1, 2, 3 |
| | | Output Disable, $V_O$ = -7V | (*Note 6*) | -0.8 | | mA | 1, 2, 3 |
| | | $V_{CC}$ = 0, Output Disable, $V_O$ = 12V | | | 1 | mA | 1, 2, 3 |
| | | $V_{CC}$ = 0, Output Disable, $V_O$ = -7V | (*Note 6*) | -0.8 | | mA | 1, 2, 3 |
| $I_{OS}$ | Output Short Circuit | $V_{IN}$ = 3V, $V_{OUT}$ = $V_{CC}$ | | | 150 | mA | 1, 2, 3 |
| | | $V_{IN}$ = 3V, $V_{OUT}$ = -7V | (*Note 6*) | -250 | | mA | 1, 2, 3 |
| | | $V_{IN}$ = 3V, $V_{OUT}$ = 0V | (*Note 6*) | -150 | | mA | 1, 2, 3 |
| | | $V_{IN}$ = 3V, $V_{OUT}$ = 12V | | | 250 | mA | 1, 2, 3 |
| | | $V_{IN}$ = 0V, $V_{OUT}$ = 12V | | | 250 | mA | 1, 2, 3 |
| | | $V_{IN}$ = 0V, $V_{OUT}$ = $V_{CC}$ | | | 150 | mA | 1, 2, 3 |
| | | $V_{IN}$ = 0V, $V_{OUT}$ = -7V | (*Note 6*) | -250 | | mA | 1, 2, 3 |
| | | $V_{IN}$ = 0V, $V_{OUT}$ = 0V | (*Note 6*) | -150 | | mA | 1, 2, 3 |
| $V_{OH}$ | Logical "1" Output Voltage | $V_{CC}$ = 4.5V, $I_O$ = -20mA | | 3 | | V | 1, 2, 3 |
| $V_{OL}$ | Logical "0" Output Voltage | $V_{CC}$ = 4.5V, $I_O$ = 20mA | | | 2 | V | 1, 2, 3 |
| VOD3 | Differential Vout | $V_{CM}$ = -7V to 12V | | 1 | | V | 1, 2, 3 |

## DC - Receiver Electrical Characteristics (*Note 11*)

The following conditions apply to all parameters, unless otherwise specified. $V_{CC}$ = 5.5V

| Symbol | Parameter | Conditions | Notes | Min | Max | Unit | Sub-group |
|---|---|---|---|---|---|---|---|
| $V_{OH}$ | Logical "1" Output Voltage ***Figure 2*** | $V_{CC}$ = 4.5V, $V_{LD}$ = 200mV, $I_{OH}$ = -400uA | | 2.5 | | V | 1, 2, 3 |
| $V_{OL}$ | Logical "0" Output Voltage ***Figure 2*** | $V_{CC}$ = 4.5V, $V_{LD}$ = -200mV, $I_{OL}$ = 8mA | | | .45 | V | 1, 2, 3 |
| | | $V_{CC}$ = 4.5V, $V_{LD}$ = -200mV, $I_{OL}$ = 16mA | | | .5 | V | 1, 2, 3 |
| $I_I$ | Line Input Current | Untested Input = 0V, $V_I$ = 12V | | | 1 | mA | 1, 2, 3 |
| | | Untested Input = 0V, $V_I$ = -7V | (*Note 6*) | -.8 | | mA | 1, 2, 3 |
| | | $V_{CC}$ = 0V, Untested Input = 0V, $V_I$ = 12V | (*Note 6*) | | 1 | mA | 1, 2, 3 |
| | | $V_{CC}$ = 0V, Untested Input = 0V, $V_I$ = -7V | | -.8 | | mA | 1, 2, 3 |
| $I_{IH}$ | Logical "1" Input Current | $V_I$ = 2.7V (Receiver) | | | 20 | uA | 1, 2, 3 |
| $R_{IN}$ | Input Resistance | Untested Input = 0V, $V_I$ = 12V | (*Note 7*) | 10 | | KΩ | 1, 2, 3 |
| | | Untested Input = 0V, $V_I$ = -7V | (*Note 7*) | 10 | | KΩ | 1, 2, 3 |
| | | $V_{CC}$ = 0V, Untested Input = 0V, $V_I$ = 12V | (*Note 7*) | 10 | | KΩ | 1, 2, 3 |
| | | $V_{CC}$ = 0V, Untested Input = 0V, $V_I$ = -7V | (*Note 7*) | 10 | | KΩ | 1, 2, 3 |
| $I_{OZ}$ | High Impedance State | $V_I$ = .4V | | -20 | 20 | uA | 1, 2, 3 |
| | | $V_I$ = 2.4V | | -20 | 20 | uA | 1, 2, 3 |
| $I_{OS}$ | Output Short Circuit | $V_{IN}$ = 1V, $V_{OUT}$ = 0V | | -85 | -15 | mA | 1, 2, 3 |
| $V_{TH}$ | Differential Input High Threshold | $V_{CC}$ = 4.5V, $V_O$ = 2.5V, $V_{CM}$ = 12V & 0V & -7V, $I_O$ = -.4mA | | | .2 | V | 1, 2, 3 |
| | | $V_{CC}$ = 5.5V, Vo = 2.5V, $V_{CM}$ = 12V & 0V & -7V, $I_O$ = -.4mA | | | .2 | V | 1, 2, 3 |
| $V_T1$ | Differential Input Low Threshold | $V_{CC}$ = 4.5V, $V_O$ = .5V, $V_{CM}$ = 12V & 0V & -7V, $I_O$ = 8mA | | -.2 | | V | 1, 2, 3 |
| | | $V_{CC}$ = 5.5V, $V_O$ = .5V, $V_{CM}$ = 12V & 0V & -7V, $I_O$ = 8mA | | -.2 | | V | 1, 2, 3 |
| $V_{TH}$+ - ($V_{TH}$-) | Hyteresis | $V_{CC}$ = 4.5V, $V_{CM}$ = 0V | | 35 | | mV | 1, 2, 3 |
| | | $V_{CC}$ = 5.5V, $V_{CM}$ = 0V | | 35 | | mV | 1, 2, 3 |

## DC - Both Driver and Receiver Electrical Characteristics (*Note 11*)

The following conditions apply to all parameters, unless otherwise specified. $V_{CC}$ = 5.5V

| Symbol | Parameter | Conditions | Notes | Min | Max | Unit | Sub-group |
|---|---|---|---|---|---|---|---|
| $I_{CC}$ | Supply Current $I_{CC}$ Both Disable | $\overline{RE}$ = 2V, $\overline{DE}$ = .8V | | | 25 | mA | 1, 2, 3 |
| $I_{CC}$ | Supply Current $I_{CC}$ Both Enable | $\overline{RE}$ =.8V, $\overline{DE}$ = 2V | | | 28 | mA | 1, 2, 3 |
| $V_{IC}$ | Input Clamp Volt | $I_I$ = -18mA | | -1.3 | | V | 1, 2, 3 |
| $V_{IH}$ | Logical "1" Input Voltage | | | 2 | | V | 1, 2, 3 |
| $V_{IL}$ | Logical "0" Input Voltage | | | | .8 | V | 1, 2, 3 |
| $V_{IH}$ | Logical "1" Enable Input Voltage | | | 2 | | V | 1, 2, 3 |
| $V_{IL}$ | Logical "0" Enable Input Voltage | | | | .8 | V | 1, 2, 3 |
| $I_{IL}$ | Logical "0" Input Current | $V_I$ = .4V | (*Note 6*) | -50 | | uA | 1, 2, 3 |

## AC - Driver Electrical Characteristics (*Note 11*)

The following conditions apply to all parameters, unless otherwise specified.

$V_{CC}$ = 5V, PRR = 1MH$_Z$, $T_R \leq T_F \leq$ 6nS, 50% duty cycle, AMP = 3V, $VL_O$, $Z_{OUT}$ = 50Ω

| Symbol | Parameter | Conditions | Notes | Min | Max | Unit | Sub-group |
|---|---|---|---|---|---|---|---|
| $t_{DD}$ | Differential Output Delay Time ***Figure 3*** | $R_L$ = 60Ω | (*Note 10*) | 8 | 25 | nS | 9 |
| | | | (*Note 10*) | 8 | 30 | nS | 10, 11 |
| $t_{TD}$ | Differential Output Transition Time ***Figure 3*** | $R_L$ = 60Ω | (*Note 9*) | 8 | 25 | nS | 9 |
| | | | (*Note 10*) | 8 | 30 | nS | 10, 11 |
| $t_{PLH}$ | Propagation Delay Time Low to High ***Figure 4*** | $R_L$ = 27Ω | | 6 | 18 | nS | 9 |
| | | | | 6 | 25 | nS | 10, 11 |
| $t_{PHL}$ | Propagation Delay Time high to Low ***Figure 4*** | $R_L$ = 27Ω | | 6 | 18 | nS | 9 |
| | | | | 6 | 25 | nS | 10, 11 |
| $t_{PZH}$ | Output Enable Time to H ***Figure 5*** | $R_L$ = 110Ω | | | 35 | nS | 9 |
| | | | | | 45 | nS | 10, 11 |
| $t_{PZL}$ | Output Enable Time to L ***Figure 6*** | $R_L$ = 110Ω | | | 40 | nS | 9 |
| | | | | | 50 | nS | 10, 11 |
| $t_{PHZ}$ | Output Disable Time to H ***Figure 5*** | RL = 110Ω | | | 30 | nS | 9 |
| | | | | | 40 | nS | 10, 11 |
| $t_{PLZ}$ | Output Disable Time to L ***Figure 6*** | $R_L$ = 110Ω | | | 30 | nS | 9 |
| | | | | | 40 | nS | 10, 11 |
| $T_{SKEW}$ | Differential Output Skew Time ***Figure 3*** | | | | 6 | nS | 9 |
| | | | | | 12 | nS | 10, 11 |

## AC - Receiver Electrical Characteristics (*Note 11*)

The following conditions apply to all parameters, unless otherwise specified.

$V_{CC}$ = 5V, PRR = 1MH$_Z$, $T_R \leq T_F \leq$ 6nS, 50% duty cycle, AMP = 3V, $VL_O$, $Z_{OUT}$ = 50Ω

| Symbol | Parameter | Conditions | Notes | Min | Max | Unit | Sub-group |
|---|---|---|---|---|---|---|---|
| $t_{PLH}$ | Propagation Delay Time Low to High ***Figure 7*** | $C_L$ = 15pF | | 10 | 27 | nS | 9 |
| | | | | 10 | 38 | nS | 10, 11 |
| $t_{PHL}$ | Propagation Delay Time High to Low ***Figure 7*** | $C_L$ = 15pF | | 10 | 27 | nS | 9 |
| | | | | 10 | 38 | nS | 10, 11 |
| $t_{PZH}$ | Output Enable Time to H ***Figure 8*** | $C_L$ = 15pF | | | 20 | nS | 9 |
| | | | | | 30 | nS | 10, 11 |
| $t_{PZL}$ | Output Enable Time to L ***Figure 8*** | $C_L$ = 15pF | | | 20 | nS | 9 |
| | | | | | 30 | nS | 10, 11 |
| $\|t_{PLH} - t_{PHL}\|$ | Output to Output Delay Time ***Figure 7*** | | | | 8 | nS | 9 |
| | | | | | 16 | nS | 10, 11 |
| $t_{PHZ}$ | Output Disable Time From H ***Figure 8*** | $C_L$ = 20pF | (*Note 8*) (*Note 16*) | | 30 | nS | 9 |
| | | | (*Note 8*) | | 40 | nS | 10, 11 |
| | | $C_L$ = 5pF | (*Note 8*) | | 20 | nS | 9 |
| | | | | | 30 | nS | 10, 11 |
| $t_{PLZ}$ | Output Disable Time From L ***Figure 8*** | $C_L$ = 5pF | | | 20 | nS | 9 |
| | | | | | 30 | nS | 10, 11 |

**Note 2:** "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 3:** Above $T_A$ = 25°C, derate E package 12.1mW°C, J package 8.5 mW/°C, W & WG package 4.8mW/°C.

**Note 4:** Human body model, 1.5kΩ in series with 100pF

**Note 5:** $\Delta|V_{OD}|$ 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.

**Note 6:** Negative sign of the limits indicates the direction of the current flow only.

**Note 7:** $R_{IN}$ is guaranteed by testing "Line Input Current" (II).

**Note 8:** Testing at 20pF assures conformance to spec at 5pF.

**Note 9:** tTD = Non-inverting output rise time + inverting output fall time / 2, Non-inverting output fall time + inverting output rise time / 2.

**Note 10:** Rise time 20% to 80%, Fall time 80% to 20%.

**Note 11:** Pre and post irradiation limits are identical to those listed under A C and DC electrical characteristics. These parts may be dose rate sensitive in a space environment and demonstrate enhanced low dose rate effect. Radiation end point limits for the noted parameters are guaranteed only for the conditions as specified in MIL-STD 883, Method 1019, condition A.

## Parameter Measurement Information

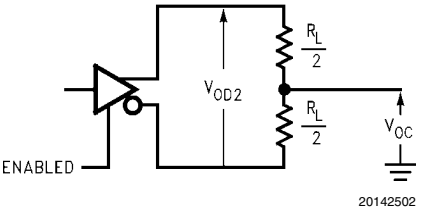



**FIGURE 1. Driver $V_{OD}$ and $V_{OC}$** (*Note 15*)

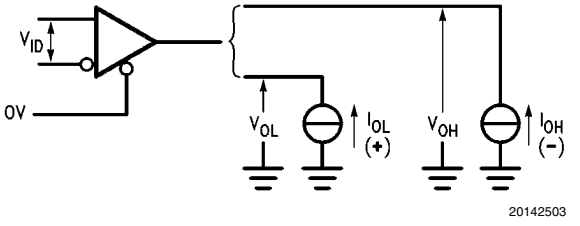
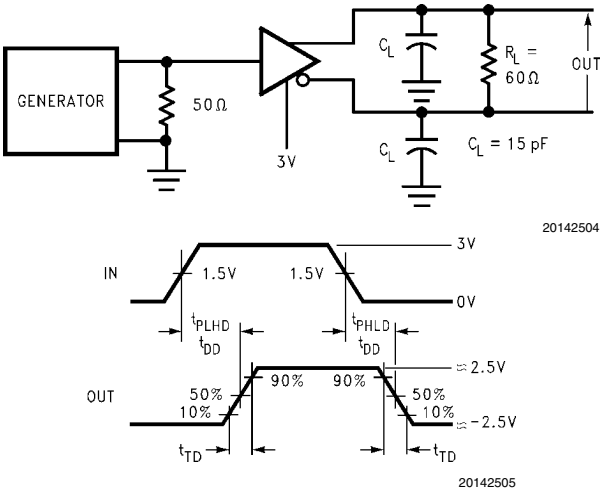
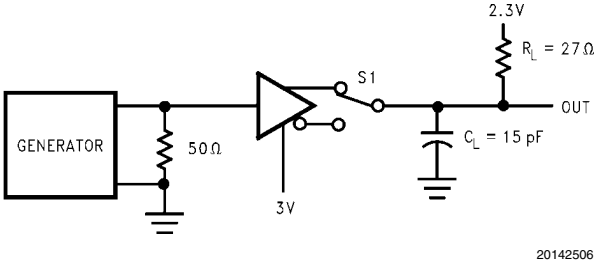



**FIGURE 2. Receiver $V_{OH}$ and $V_{OL}$**




$t_{SKEW} = |t_{PLHD} - t_{PHLD}|$

**FIGURE 3. Driver Differential Output Delay and Transition Times** (*Note 12*, *Note 14*)



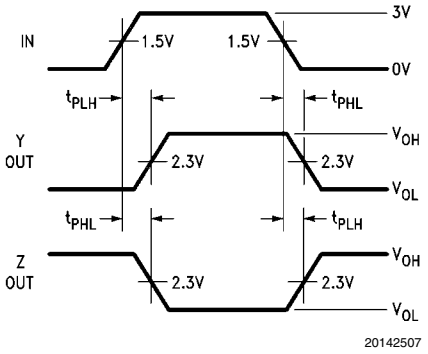



**FIGURE 4. Driver Propagation Times** (*Note 12*, *Note 13*)

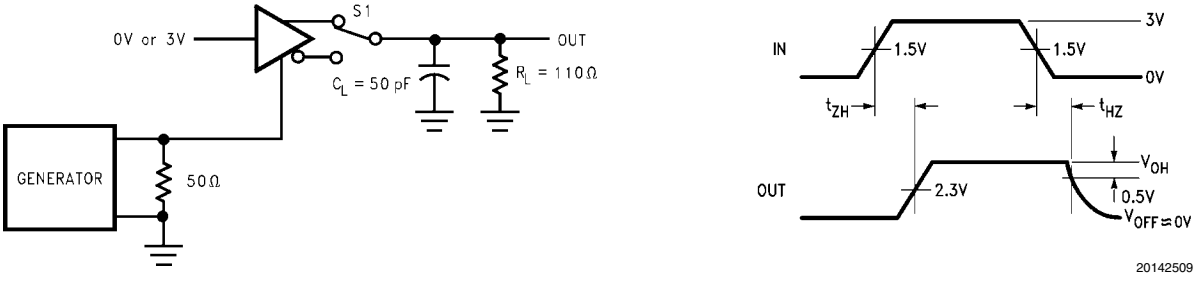



**FIGURE 5. Driver Enable and Disable Times ($t_{ZH}$, $t_{HZ}$)** (*Note 12*, *Note 13*, *Note 14*)

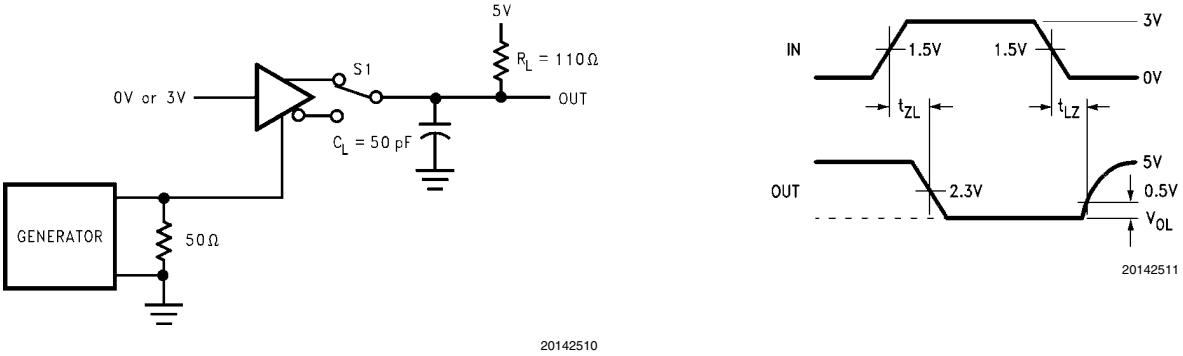



**FIGURE 6. Driver Enable and Disable Times ($t_{ZL}$, $t_{LZ}$)** (*Note 12*, *Note 13*, *Note 14*)

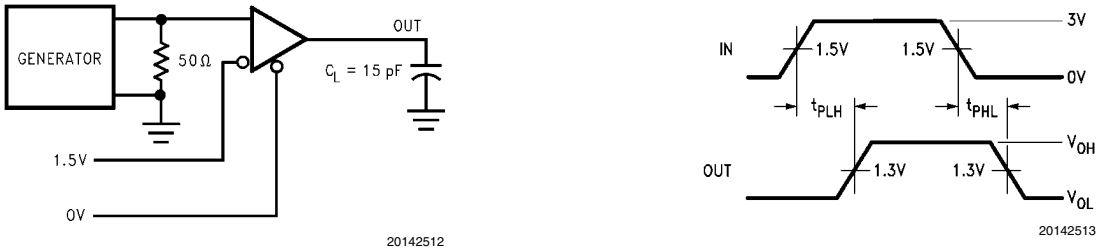



**FIGURE 7. Receiver Propagation Delay Times** (*Note 12*, *Note 13*)

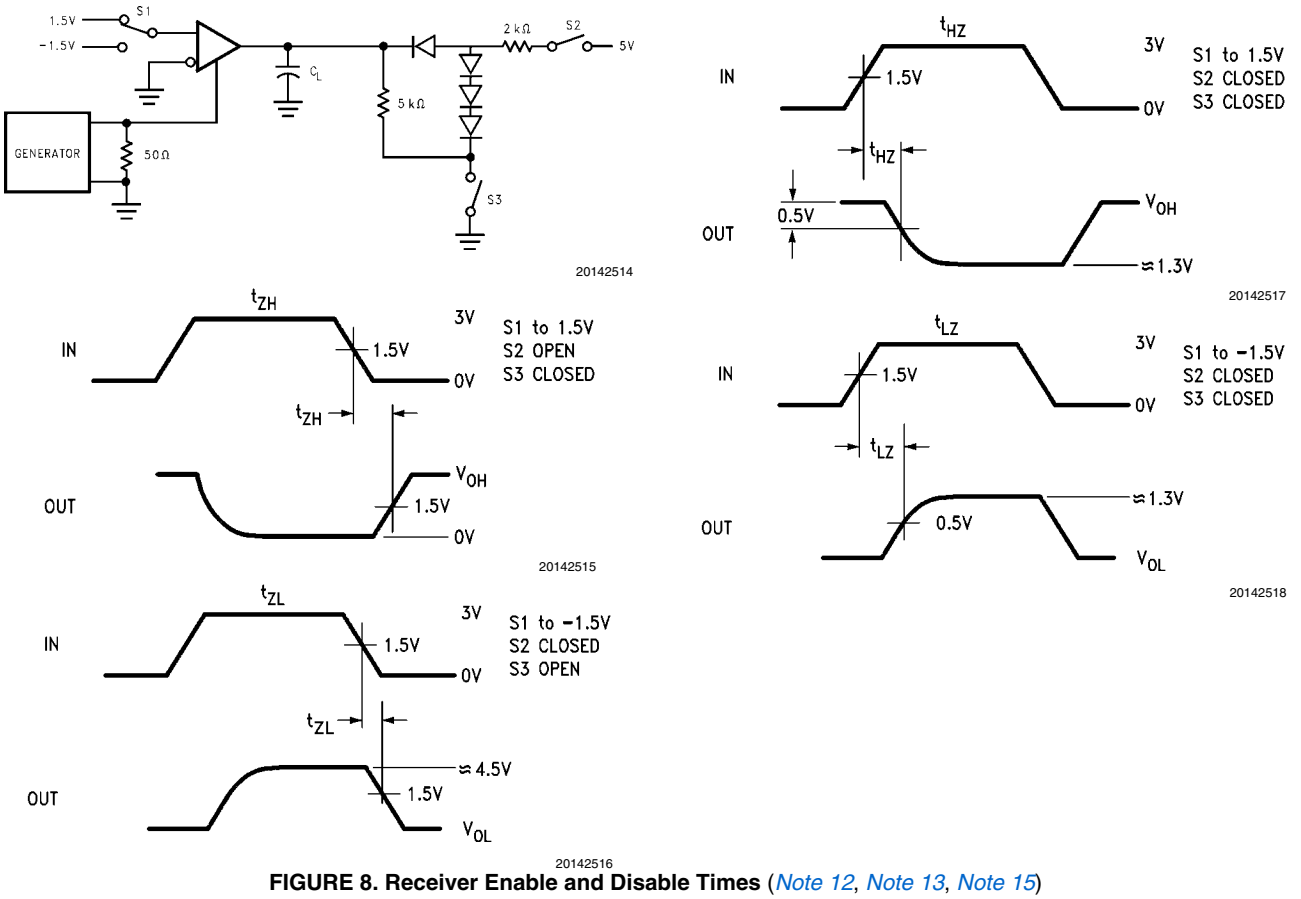



**FIGURE 8. Receiver Enable and Disable Times** (*Note 12*, *Note 13*, *Note 15*)

**Note 12:** The input pulse is supplied by a generator having the following characteristics: PRR = 1.0 MHz, 50% duty cycle, $t_r \leq 6.0$ ns, $t_f \leq 6.0$ ns, $Z_O = 50\Omega$.

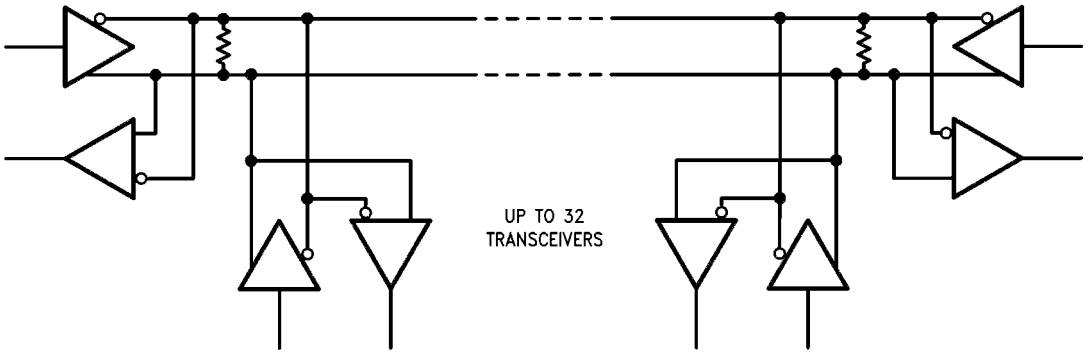
**Note 13:** $C_L$ includes probe and stray capacitance.

**Note 14:** DS16F95 Driver enable is Active-High.

**Note 15:** All diodes are 1N916 or equivalent.

**Note 16:** Testing at 20 pF assures conformance to 5 pF specification.

## Typical Application



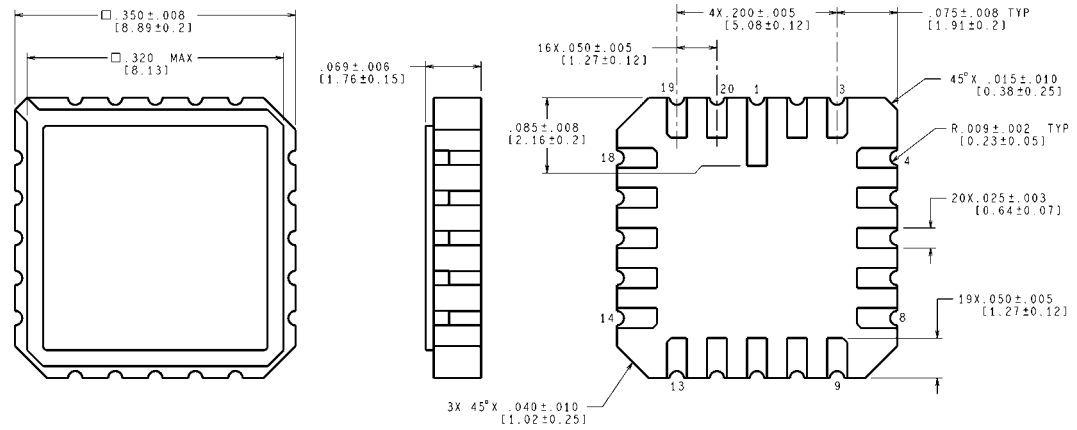

20142519

The line should be terminated at both ends in its characteristic impedance, typically 120Ω.
Stub lengths off the main line should be kept as short as possible.

## Revision History

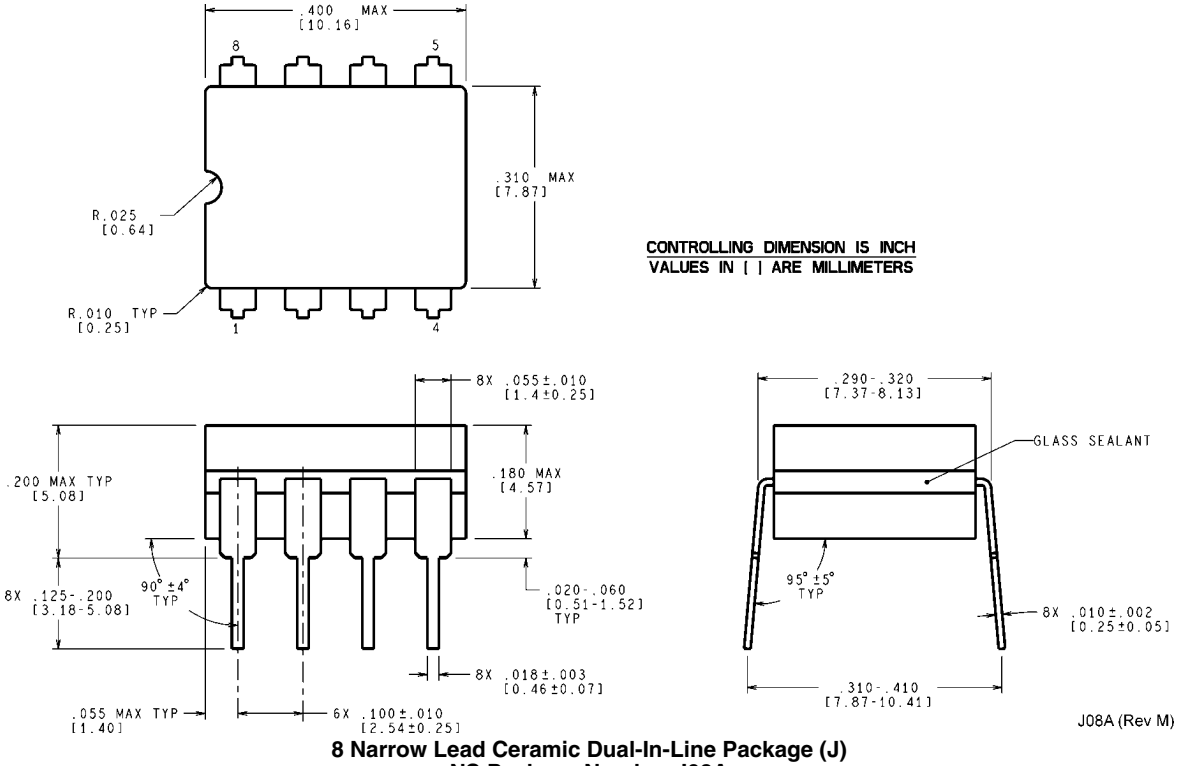
| Date Released | Revision | Section | Changes |
|---|---|---|---|
| 9/23/2005 | A | New Release, Corporate format | 1 MDS data sheet converted into Corporate data sheet format. MDS data sheet MNDS16F95-X-RH, Rev. 0A1 will be Archived. |
| 10/26/2010 | B | Features, Ordering Table, Connection Diagrams W pkg, Absolute Ratings, Electricals - DC Receiver $V_T1$, AC Driver conditions, Physical Dimensions Mkt drawing | Update with current device information and format. Correction to rad info., Code K NSID's removed, removed reference to WG pkg, typo correction to conditions, Removed WG pkg drawing. Revision A will be Archived |
| | | | |
| | | | |

## Physical Dimensions inches (millimeters) unless otherwise noted



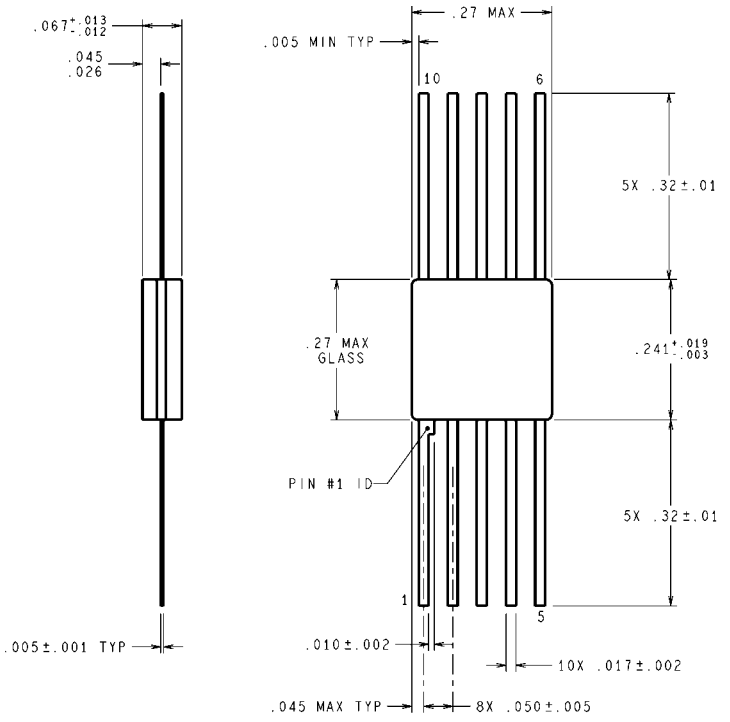

E20A (Rev F)

**20-Lead Ceramic Leadless Chip Carrier (E)**
**NS Package Number E20A**




J08A (Rev M)

**8 Narrow Lead Ceramic Dual-In-Line Package (J)**
**NS Package Number J08A**




DIMENSIONS ARE IN INCHES

W10A (Rev H)

**10-Lead Ceramic Flatpak (W)**
**NS Package Number W10A**

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