

# DS16F95A TIA/EIA-485-A (RS-485) Extended Temperature Differential Bus Transceiver

## General Description

The DS16F95A Differential Bus Transceiver is a monolithic integrated circuit designed for bidirectional data communication on balanced multipoint bus transmission lines. The transceiver conforms to both TIA/EIA-485-A and TIA/EIA-422-B standards.

The DS16F95A offers improved performance due to the use of L-FAST bipolar technology. The L-FAST technology allows for higher speeds and lower currents by minimizing gate delay times. The DS16F95A features an extended temperature range and is offered in a rugged ceramic package.

The DS16F95A 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.

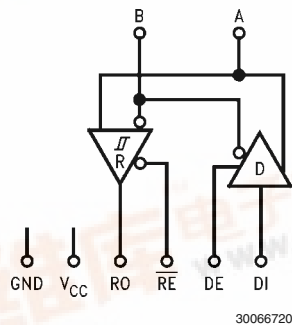
The driver is designed to accommodate loads of up to 60 mA of sink or source current and features positive and negative current limiting for protection from line fault conditions.

The device is offered in a rugged 8-lead Ceramic DIP package and is functional over the extended temperature range of  $-55^{\circ}C$  to  $+180^{\circ}C$ .

## Features

- Extended temperature range to  $+180^{\circ}C$
- Conforms to TIA/EIA-485-A
- Designed for multipoint transmission
- Wide positive and negative I/O bus voltage range
- 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 DS16F95/DS3695 and SN75176A
- Available in a 8-lead ceramic DIP package

## Logic Diagram



## 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
$0.2V > V_{ID} > -0.2V$	L	X
X	H	Z

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



**Absolute Maximum Ratings** (Note 1)

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If Military/Aerospace specified devices are required, please contact the national Semiconductor Sales office/Distributor for availability and specifications.

Storage Temperature Range (Note 10)	-65°C to +175°C
Lead Temperature (Soldering, 60 sec.)	300°C
Junction Temperature	+200°C
Maximum Package Power Dissipation Capacity (J)	1300 mW
Above 25°C, derate J package	8.7 mW/°C
Supply Voltage	7.0V
Input Voltage (Bus Terminal)	+15V/-10V
Enable Input Voltage	5.5V
ESD Ratings	(Note 11)

**Recommended Operating Conditions** (Note 10)

	Min	Typ	Max	Units
Supply Voltage ( $V_{CC}$ )	4.50	5.0	5.50	V
Voltage at Any Bus Terminal (Separately or Common Mode) ( $V_I$ or $V_{CM}$ )	-7.0		+12	V
Differential Input Voltage ( $V_{ID}$ )			±12	V
Output Current HIGH ( $I_{OH}$ )				
Driver			-60	mA
Receiver			-400	µA
Output Current LOW ( $I_{OL}$ )				
Driver			60	mA
Receiver			16	mA
Operating Temperature ( $T_A$ )	-55	+25	+180	°C

**Driver Electrical Characteristics** (Notes 2, 3)

Over recommended supply voltage and operating temperature ranges, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$V_{IH}$	Input Voltage HIGH	DI, DE	2.0			V
$V_{IL}$	Input Voltage LOW				0.8	V
$V_{IC}$	Input Clamp Voltage	$I_I = -18$ mA			-1.3	V
$I_{IH}$	Input Current HIGH	$V_I = 2.4$ V			20	µA
$I_{IL}$	Input Current Low	$V_I = 0.4$ V			-50	µA
$ V_{OD1} $	Differential Output Voltage	A-B, Figure 1 $I_O = 0$ mA, No Load		3.6	6.0	V
$ V_{OD2} $	Differential Output Voltage		2.0	2.9		V
			1.5	2.6		
$\Delta V_{OD} $	Change in Magnitude of Differential Output Voltage				±0.4	V
$V_{OC}$	Common Mode Output Voltage (Note 5)	(A+B)/2, Figure 1		2.5	3.0	V
$\Delta V_{OC} $	Change in Magnitude of Common Mode Output Voltage (Note 4)				±0.2	V
$I_O$	Output Current (Note 8) (Includes Receiver $I_I$ )	A or B, Output Disabled, DE = 0.4V	$V_O = +12$ V	0.57	1.5	mA
			$V_O = -7.0$ V	-0.43	-0.8	
$I_{OS}$	Short Circuit Output Current (Note 9)	A or B	$V_O = -7.0$ V	-157	-250	mA
			$V_O = 0$ V	-115	-150	
			$V_O = V_{CC}$	112	150	
			$V_O = +12$ V	137	250	

## Driver Switching Characteristics (Note 2)

Over recommended supply voltage and operating temperature ranges, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{DD}$	Differential Output Delay Time	$R_L = 60\Omega$ , <i>Figure 3</i>	8.0	15	45	ns
$t_{TD}$	Differential Output Transition Time		8.0	15	30	ns
$t_{ZH}$	Output Enable Time to High Level	$R_L = 110\Omega$ , <i>Figure 4</i>		25	50	ns
$t_{ZL}$	Output Enable Time to Low Level	$R_L = 110\Omega$ , <i>Figure 5</i>		25	50	ns
$t_{HZ}$	Output Disable Time from High Level	$R_L = 110\Omega$ , <i>Figure 4</i>		20	80	ns
$t_{LZ}$	Output Disable Time from Low Level	$R_L = 110\Omega$ , <i>Figure 5</i>		20	80	ns
$t_{LZL}$	Output Disable Time from Low Level with Load Resistor to GND	Load per <i>Figure 4</i> , Timing per <i>Figure 5</i>		300		ns
$t_{SKEW}$	Skew (Pulse Width Distortion)	$R_L = 60\Omega$ , <i>Figure 3</i>		1.0	12	ns

## Receiver Electrical Characteristics (Notes 2, 3)

Over recommended supply voltage and operating temperature ranges, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units	
$V_{TH}$	Differential Input High Threshold Voltage	$V_O = 2.7V$ , $I_O = -0.4$ mA			0.2	V	
$V_{TL}$	Differential Input Low Threshold Voltage (Note 6)	$V_O = 0.5V$ , $I_O = 8.0$ mA	-0.2			V	
$V_{T+}-V_{T-}$	Hysteresis (Note 7)	$V_{CM} = 0V$	35	50		mV	
$V_{IH}$	Enable Input Voltage HIGH	RE	2.0			V	
$V_{IL}$	Enable Input Voltage LOW				0.8	V	
$V_{IC}$	Enable Input Clamp Voltage		$I_I = -18$ mA		-0.8	-1.3	V
$I_{IH}$	Input Current HIGH		$V_{IH} = 2.7V$		1	20	$\mu A$
$I_{IL}$	Input Current LOW		$V_{IL} = 0.4V$		-3	-50	$\mu A$
$V_{OH}$	Output Voltage HIGH (RO)		$V_{ID} = 200$ mV, $I_{OH} = -400$ $\mu A$ , <i>Figure 2</i>	2.5	3.5		V
$V_{OL}$	Output Voltage LOW (RO)	$V_{ID} = -200$ mV, <i>Figure 2</i>		0.3	0.45	V	
		$I_{OL} = 8.0$ mA		0.4	0.50		
$I_{OS}$	Short Circuit Output Current (RO)	$V_O = 0V$ , (Note 9)	-15	-46	-85	mA	
$I_{OZ}$	High Impedance State Output (RO)	$V_O = 0.4V$ to $2.4V$		0.2	$\pm 20$	$\mu A$	
$I_I$	Line Input Current (Note 8)	A or B, Other Input = 0V	$V_I = +12V$		0.57	1.5	mA
			$V_I = -7.0V$		-0.43	-0.8	
$R_I$	Input Resistance	A or B		12	18	22	k $\Omega$

## Receiver Switching Characteristics (Note 2)

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Over recommended supply voltage and operating temperature ranges, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{PLH}$	Propagation Delay Time, Low-to-High Level Output	$V_{IN} = 0V$ to $+3.0V$ $C_L = 15$ pF, <i>Figure 6</i>	10	19	50	ns
$t_{PHL}$	Propagation Delay Time, High-to-Low Level Output		10	19	50	ns
$t_{ZH}$	Output Enable Time to High Level	$C_L = 15$ pF, <i>Figure 7</i>		10	75	ns
$t_{ZL}$	Output Enable Time to Low Level			12	75	ns
$t_{HZ}$	Output Disable Time from High Level	$C_L = 5.0$ pF, <i>Figure 7</i>		12	50	ns
$t_{LZ}$	Output Disable Time from Low Level			12	50	ns
$ t_{PLH} - t_{PHL} $	Pulse Width Distortion (SKEW)	<i>Figure 6</i>		1.0	16	ns

## Device Electrical Characteristics (Notes 2, 3)

Over recommended supply voltage and operating temperature ranges, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$I_{CC}$	Supply Current (Total Package)	No Load, All Inputs Open		21.5	28	mA
$I_{CCX}$						
				16	25	

**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  $-55^{\circ}C$  to  $+180^{\circ}C$  temperature range for the DS16F95A. All typical values are given for  $V_{CC} = 5V$  and  $T_A = 25^{\circ}C$ .

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

**Note 4:**  $\Delta I_{V_{OD}}$  and  $\Delta I_{V_{OC}}$  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 5:** In TIA/EIA-422-B and TIA/EIA-485-A Standards,  $V_{OC}$ , which is the average of the two output voltages with respect to ground, is called output offset voltage,  $V_{OS}$ .

**Note 6:** The algebraic convention, where the less positive (more negative) limit is designated minimum, is used in this data sheet for common mode input voltage and threshold voltage levels only.

**Note 7:** Hysteresis is the difference between the positive-going input threshold voltage,  $V_{T+}$ , and the negative-going input threshold voltage,  $V_{T-}$ .

**Note 8:** Refer to TIA/EIA-485-A Standard for exact conditions.

**Note 9:** Only one output at a time should be shorted. Do not exceed maximum junction temperature recommendations. This device does not include thermal shutdown protection.

**Note 10:** Lifetime expectations for continuous operation at above  $150^{\circ}C$  for more than 1000 hours should be verified with National Semiconductor Reliability Engineering. Reliability report available upon request.

**Note 11:** ESD Rating information: HBM  $>5kV$  A or B pin, all other pins  $>1kV$ . MM  $>600V$  A or B pin, all other pins  $>50V$ , CDM  $>750V$ , IEC61000-4-2 (Power On or Off)  $>2kV$  A or B pin.

## Parameter Measurement Information

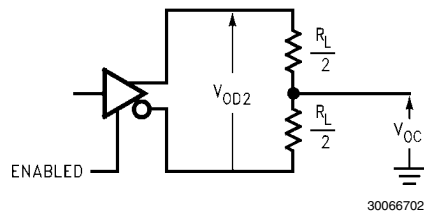


FIGURE 1. Driver  $V_{OD}$  and  $V_{OC}$  (Note 15)

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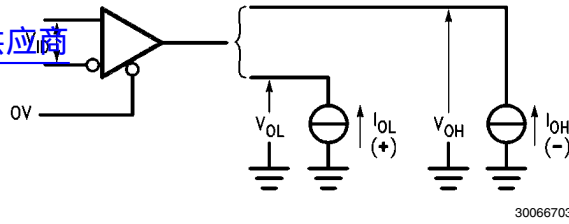
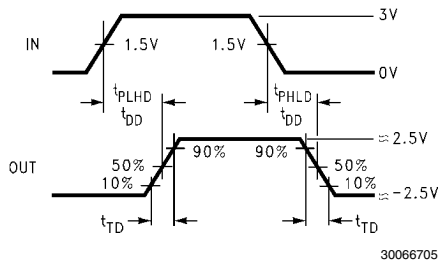
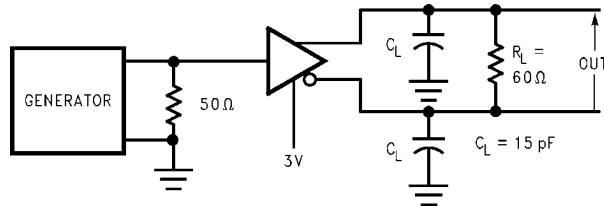


FIGURE 2. Receiver  $V_{OH}$  and  $V_{OL}$



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

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

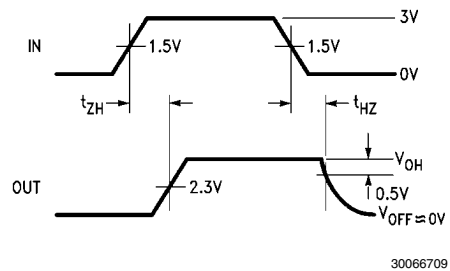
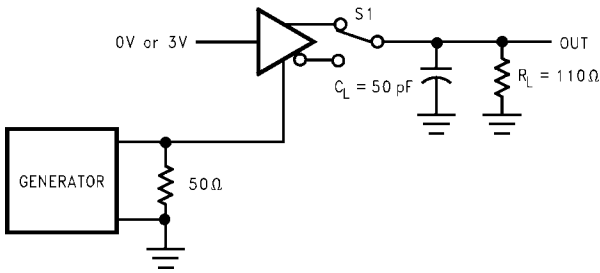


FIGURE 4. Driver Enable and Disable Times ( $t_{ZH}$ ,  $t_{HZ}$ ) (Notes 12, 13, 14)

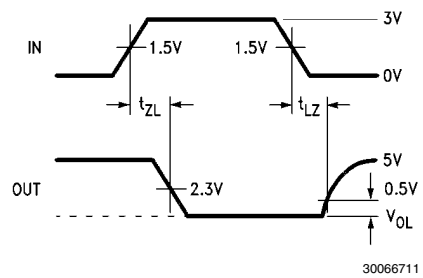
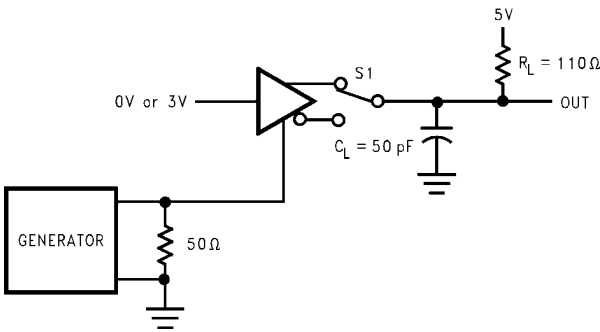
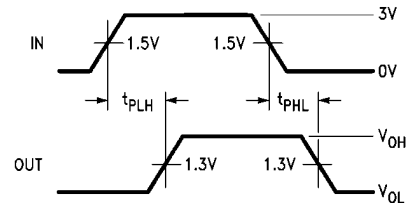
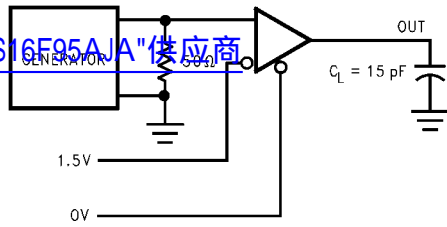
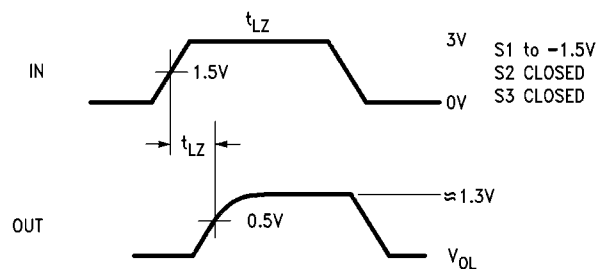
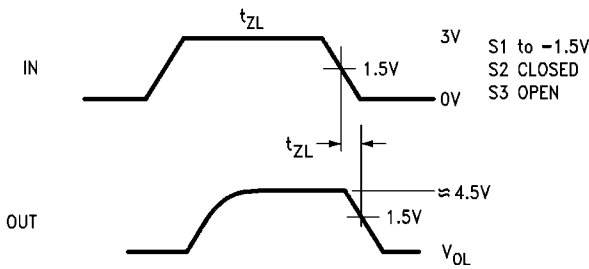
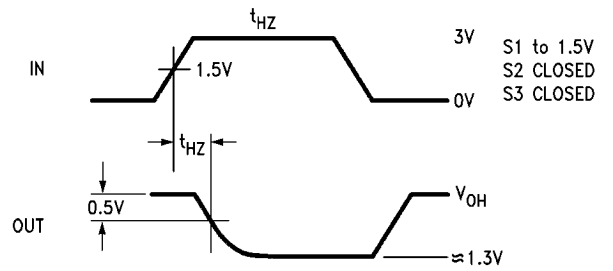
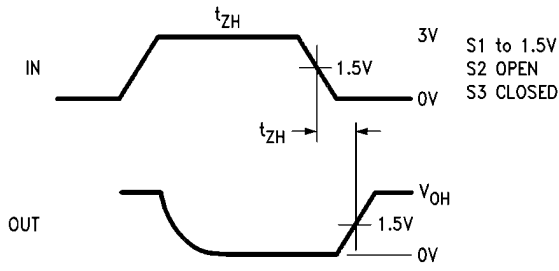
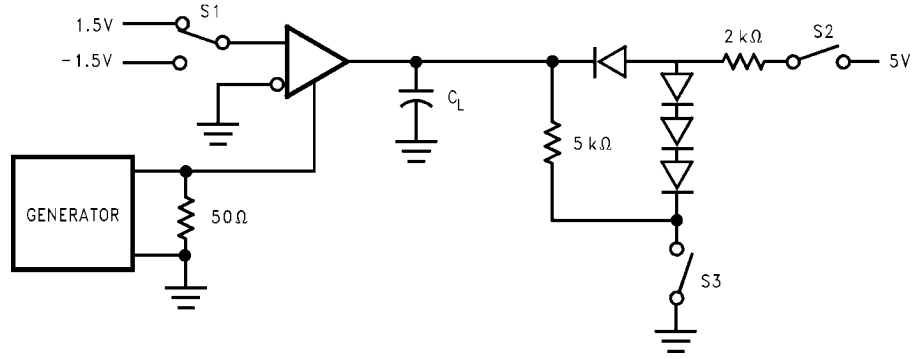


FIGURE 5. Driver Enable and Disable Times ( $t_{ZL}$ ,  $t_{LZ}$ ,  $t_{LZL}$ ) (Notes 12, 13, 14)

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**FIGURE 6. Receiver Propagation Delay Times (Notes 12, 13)**



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**FIGURE 7. Receiver Enable and Disable Times (Notes 12, 13, 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:** DS16F95A 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.

## Functional Description

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The Differential Line Driver levels shifts standard TTL/CMOS levels to a differential voltage on the bus pins (A and B) that conform to RS-485. The driver is enabled when the DE pin is High. The driver is disabled when the DE pin is Low. The DI and DE pins should be driven or tied to the desired state, do not float. The differential driver is able to source and sink up to 60mA of output current. Care should be taken that the driver is not enabled into a fault condition where the package power dissipation capacity is exceeded. The DS16F95A features driver current limiting (see  $I_{OS}$  specification) to protect from certain line faults where the amount of power is limited. This device is intended for use in rugged applications at elevated temperatures. It does not include a Thermal Shutdown feature commonly found on RS-485 transceivers.

The Differential line Receiver levels shifts the RS-485 levels to standard TTL/CMOS levels. The receiver is enabled when the  $\overline{RE}$  pin is Low. The receiver is disabled when the  $\overline{RE}$  pin is High. The  $\overline{RE}$  pin should be driven or tied to the desired state, do not float.

## Typical Application

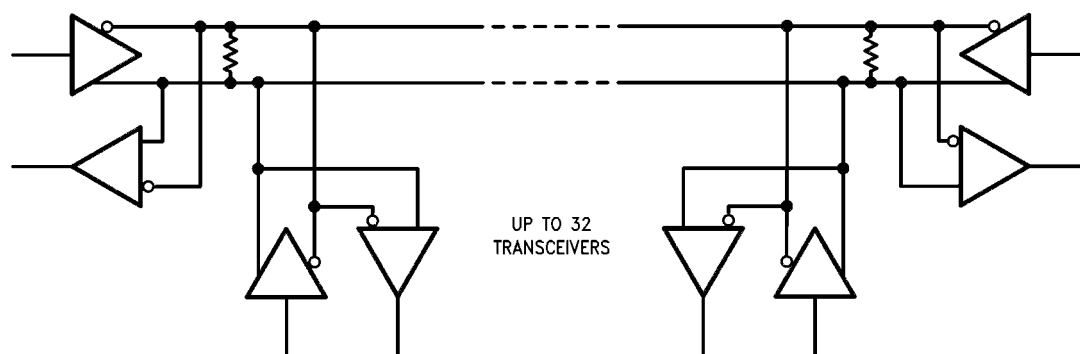
A typical application is shown below. The RS-485 network may be a simple point-to-point connection with two nodes or a more complex one with up to 32 single unit load transceivers as shown above. Stub lengths off the main line should be kept as short as possible to minimize reflections. The line is ter-

minated at both ends in its characteristic impedance (typically 100 or 120 Ohms). The RS-485 network is a bi-directional half duplex interface.

Being a multipoint bus, it is possible for all drivers to be disabled when one or more receivers are enabled. In this case, the receiver(s) is enabled when a valid differential voltage is not present and its output state is unknown. A common solution is to provide external failsafe biasing to bias the line to a known state such that the enabled receives will detect it correctly and idle with a static known state in this condition. See AN-847 for a discussion on Failsafe biasing of differential buses.

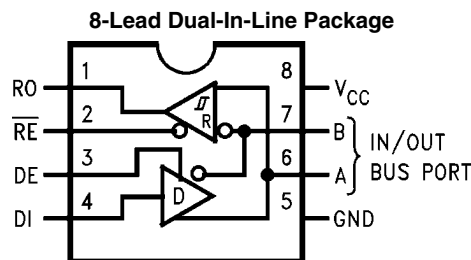
For extended temperature applications, maximum junction temperature should be calculated.  $T_{Jmax} = T_A + (\Theta_{JA})$  (Power Dissipation).  $\Theta_{JA}$  is the reciprocal of the derate term (  $1 / 8.7 \text{ mW}/^\circ\text{C}$  or  $115 \text{ }^\circ\text{C}/\text{W}$ ). Recommended maximum junction temperature for short duration operation is  $200^\circ\text{C}$ . See AN-336 for a discussion on thermal considerations.

For maximum performance, a few system / PCB recommendations are: drive the logic inputs (DI, DE,  $\overline{RE}$ ) with rail-to-rail levels. This will provide the maximum noise margins to the thresholds. A clean supply is also desirable, a  $0.1\mu\text{F}$  capacitor is recommended to be placed near the  $V_{CC}$  pin along with a bulk capacitor. The use of power and ground planes is also recommended. Stub lengths off the RS-485 interface should be minimized to limit reflections. Typical interconnect impedance is 100 Ohms.



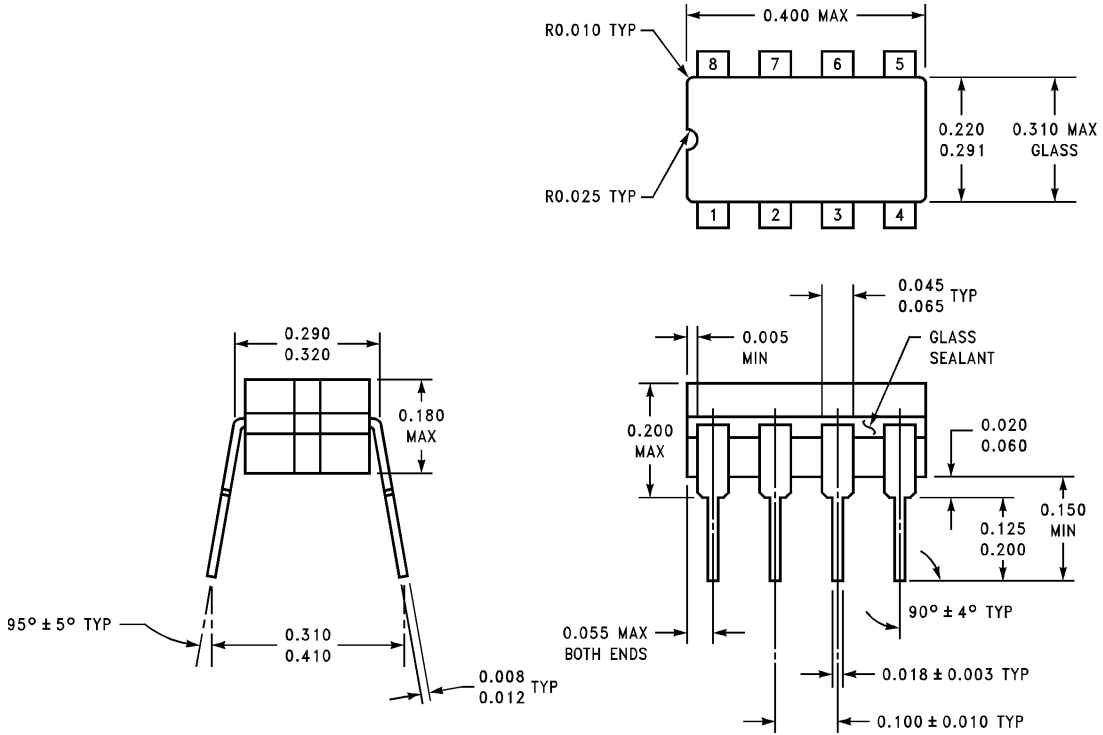
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## Connection Diagram



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**Physical Dimensions** inches (millimeters) unless otherwise noted  
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**8 Narrow Lead Ceramic Dual-In-Line Package (J)**  
**Order Number DS16F95AJA**  
**NS Package Number J08A**

J08A (REV K)

## Notes

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LED Lighting	<a href="http://www.national.com/led">www.national.com/led</a>	Feedback/Support	<a href="http://www.national.com/feedback">www.national.com/feedback</a>
Voltage Reference	<a href="http://www.national.com/vref">www.national.com/vref</a>	Design Made Easy	<a href="http://www.national.com/easy">www.national.com/easy</a>
PowerWise® Solutions	<a href="http://www.national.com/powerwise">www.national.com/powerwise</a>	Solutions	<a href="http://www.national.com/solutions">www.national.com/solutions</a>
Serial Digital Interface (SDI)	<a href="http://www.national.com/sdi">www.national.com/sdi</a>	Mil/Aero	<a href="http://www.national.com/milaero">www.national.com/milaero</a>
Temperature Sensors	<a href="http://www.national.com/tempsensors">www.national.com/tempsensors</a>	Solar Magic®	<a href="http://www.national.com/solarmagic">www.national.com/solarmagic</a>
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Life support devices or systems are devices which (a) are intended for surgical implant into the body, or (b) support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in a significant injury to the user. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system or to affect its safety or effectiveness.

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