National Semiconductor

November 11, 2008

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.

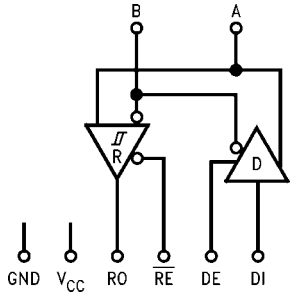
The driver is designed to accommodate loads of up to 60 mA of sink or source current and features positive and negative current limiting for protection from line fault conditions.

The device is offered in a rugged 8–lead Ceramic DIP package and is functional over the extended temperature range of -55 °C to +180 °C.

Features

- Extended temperature range to +180 °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



30066720

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)

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Absolute Maximum Ratings (Note 1)

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 = 2.4V			20	µA
I_{IL}	Input Current Low		V_I = 0.4V			-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		R_L = 100Ω	2.0	2.9		V
			R_L = 54Ω	1.5	2.6		
$\Delta\|V_{OD}\|$	Change in Magnitude of Differential Output Voltage		R_L = 54Ω or 100Ω, (Note 4)			±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 = +12V		0.57	1.5	mA
			V_O = −7.0V		-0.43	-0.8	
I_{OS}	Short Circuit Output Current (Note 9)	A or B	V_O = −7.0V		-157	-250	mA
			V_O = 0V		-115	-150	
			V_O = V_{CC}		112	150	
			V_O = +12V		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 = 60Ω, *Figure 3*	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 = 110Ω, *Figure 4*		25	50	ns
t_{ZL}	Output Enable Time to Low Level	R_L = 110Ω, *Figure 5*		25	50	ns
t_{HZ}	Output Disable Time from High Level	R_L = 110Ω, *Figure 4*		20	80	ns
t_{LZ}	Output Disable Time from Low Level	R_L = 110Ω, *Figure 5*		20	80	ns
t_{LZL}	Output Disable Time from Low Level with Load Resistor to GND	Load per *Figure 4*, Timing per *Figure 5*		300		ns
t_{SKEW}	Skew (Pulse Width Distortion)	R_L = 60Ω, *Figure 3*		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	$\overline{RE}$		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	µA
I_{IL}	Input Current LOW		V_{IL} = 0.4V		-3	-50	µA
V_{OH}	Output Voltage HIGH (RO)	V_{ID} = 200 mV, I_{OH} = −400 µA, *Figure 2*		2.5	3.5		V
V_{OL}	Output Voltage LOW (RO)	V_{ID} = −200 mV, *Figure 2*	I_{OL} = 8.0 mA		0.3	0.45	V
			I_{OL} = 16 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	±20	µA
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	DE = 0.4V	12	18	22	kΩ

Receiver Switching Characteristics (Note 2)

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, *Figure 6*	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, *Figure 7*		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, *Figure 7*		12	50	ns
t_{LZ}	Output Disable Time from Low Level			12	50	ns
$\lvert t_{PLH}-t_{PHL}\rvert$	Pulse Width Distortion (SKEW)	*Figure 6*		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	DE = 2V, $\overline{RE}$ = 0.8V Outputs Enabled		21.5	28	mA
I_{CCX}			DE = 0.8V, $\overline{RE}$ = 2V Outputs Disabled		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°C to +180°C temperature range for the DS16F95A. All typical values are given for V_{CC} = 5V and T_A = 25°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: $\Delta|V_{OD}|$ 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 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 °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

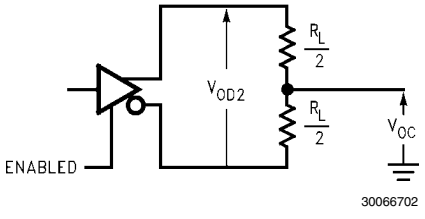


FIGURE 1. Driver V_{OD} and V_{OC} (Note 15)

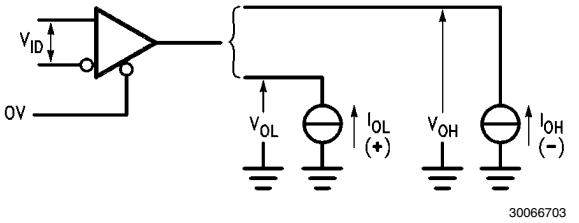
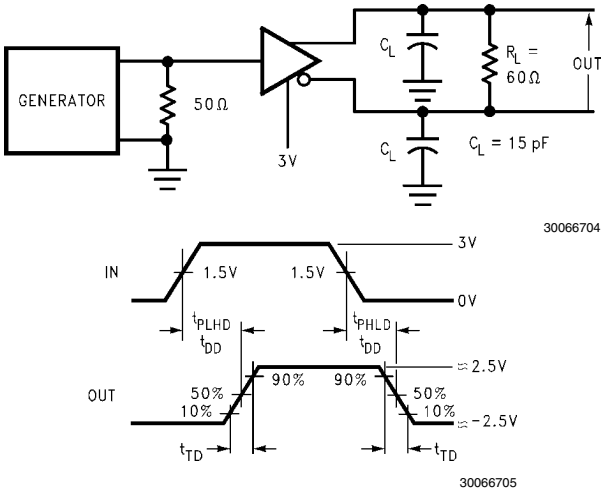


FIGURE 2. Receiver V_{OH} and V_{OL}



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

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

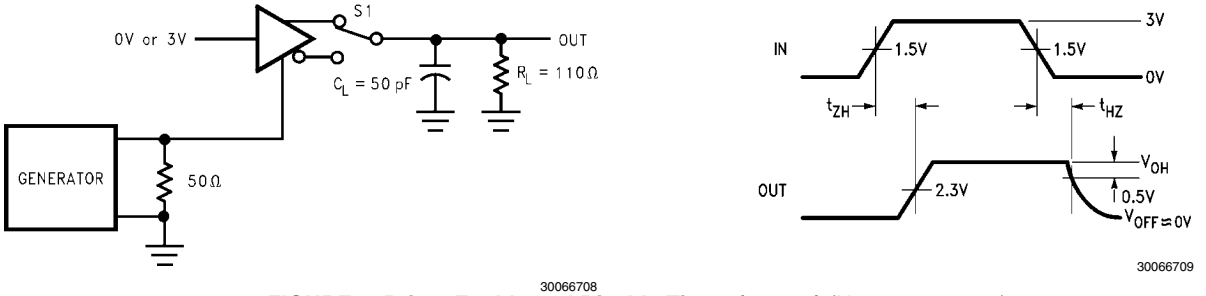


FIGURE 4. Driver Enable and Disable Times (t_{ZH}, t_{HZ}) (Notes 12, 13, 14)

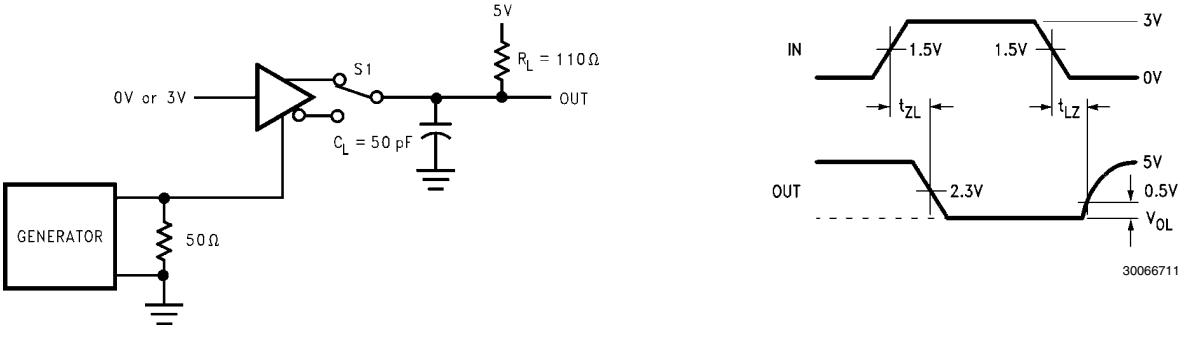


FIGURE 5. Driver Enable and Disable Times (t_{ZL}, t_{LZ}, t_{LZL}) (Notes 12, 13, 14)

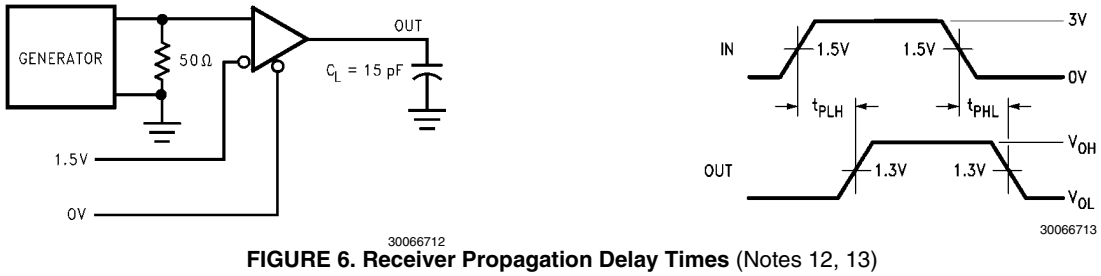
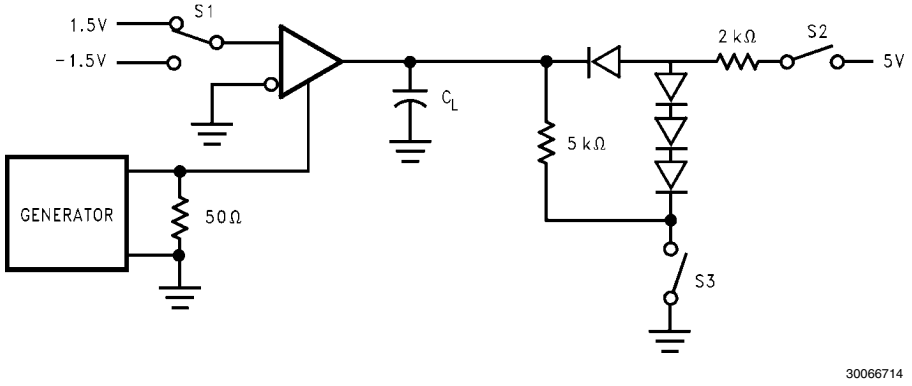


FIGURE 6. Receiver Propagation Delay Times (Notes 12, 13)



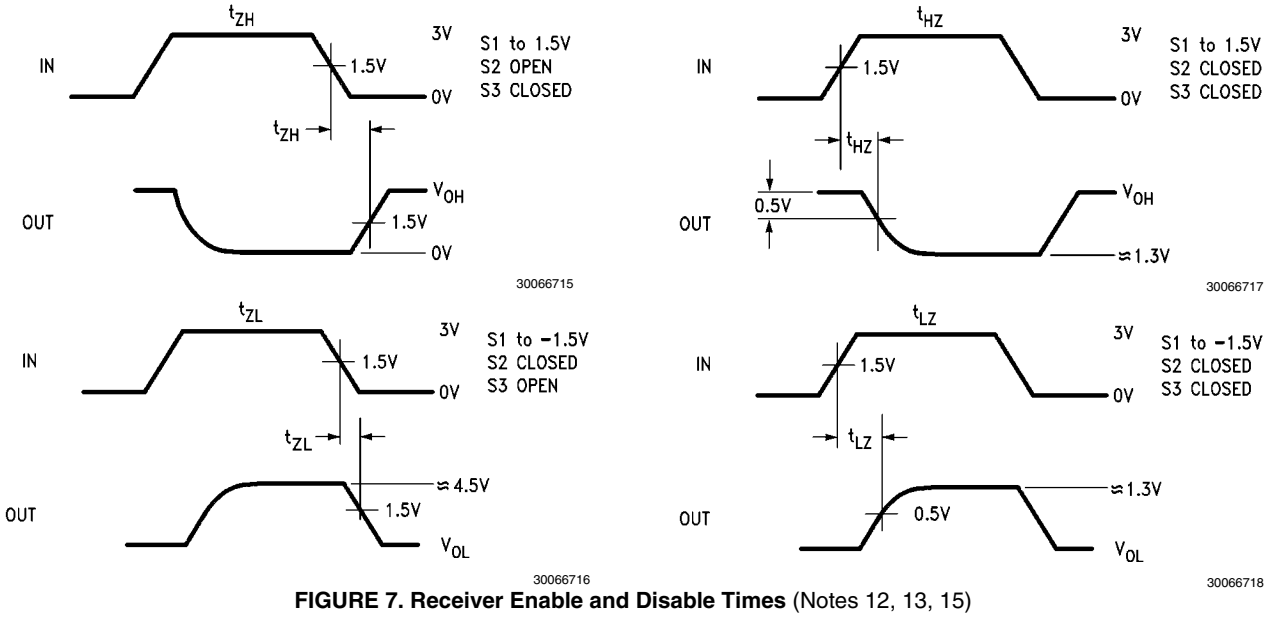


FIGURE 7. Receiver Enable and Disable Times (Notes 12, 13, 15)

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

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.

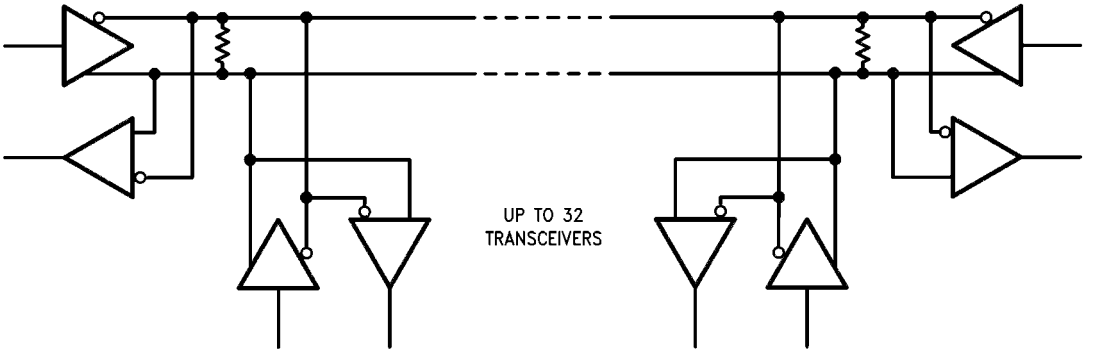
Typical Application

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 terminated 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. $T_{Jmax} = T_A + (ThetaJA)(Power\ Dissipation)$. Theta JA is the reciprocal of the derate term (1 / 8.7 mW/°C or 115 °C/W). Recommended maximum junction temperature for short duration operation is 200°C. See AN-336 for a discussion on thermal considerations.

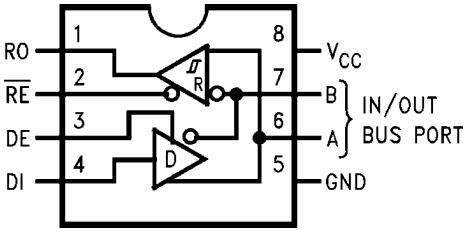
For maximum performance, a few system / PCB recommendations are: drive the logic inputs (DI, DE, $\overline{RE}$) with rail-to-rail levels. This will provide the maximum noise margins to the thresholds. A clean supply is also desirable, a 0.1µF capacitor is recommended to be placed near the V_{CC} pin 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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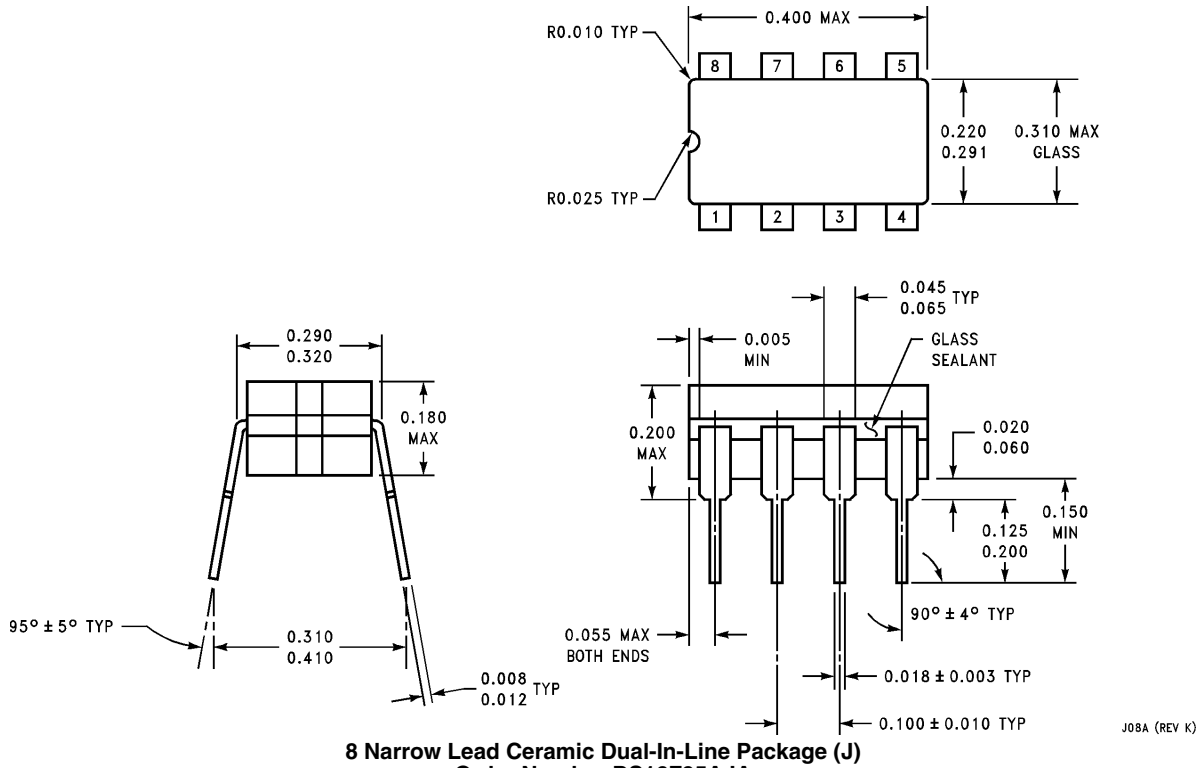
Connection Diagram

8-Lead Dual-In-Line Package



30066701

Physical Dimensions inches (millimeters) unless otherwise noted



8 Narrow Lead Ceramic Dual-In-Line Package (J)
Order Number DS16F95AJA
NS Package Number J08A

Notes

Notes

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Switching Regulators	www.national.com/switchers	Distributors	www.national.com/contacts
LDOs	www.national.com/ldo	Quality and Reliability	www.national.com/quality
LED Lighting	www.national.com/led	Feedback/Support	www.national.com/feedback
Voltage Reference	www.national.com/vref	Design Made Easy	www.national.com/easy
PowerWise® Solutions	www.national.com/powerwise	Solutions	www.national.com/solutions
Serial Digital Interface (SDI)	www.national.com/sdi	Mil/Aero	www.national.com/milaero
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