

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

Check for Samples: [DS16F95A](#)

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 CDIP Package

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.

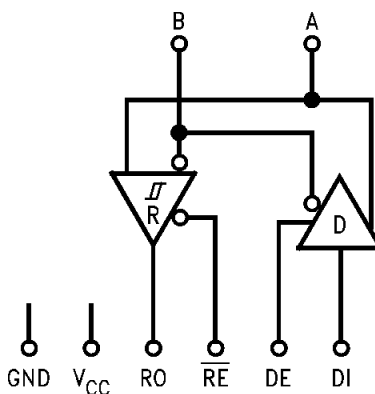
The DS16F95A offers improved performance due to the use of L-FAST bipolar technology. The L-FAST technology allows for higher speeds and lower currents by minimizing gate delay times. The DS16F95A features an extended temperature range and is offered in a rugged ceramic package.

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 CDIP package and is functional over the extended temperature range of -55 °C to +180 °C.

LOGIC DIAGRAM



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

FUNCTION TABLES

Table 1. DRIVER

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

Table 2. 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



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings⁽¹⁾⁽²⁾

Storage Temperature Range ⁽³⁾	-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	See ⁽⁴⁾

- (1) "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be verified. 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.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales office/Distributor for availability and specifications.
- (3) Lifetime expectations for continuous operation at above 150 °C for more than 1000 hours should be verified with Texas Instruments Reliability Engineering. Reliability report available upon request.
- (4) 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.

Recommended Operating Conditions⁽¹⁾

		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	μ A
Output Current LOW (I_{OL})	Driver			60	mA
	Receiver			2	mA
Operating Temperature (T_A)		-55	+25	+180	°C

- (1) Lifetime expectations for continuous operation at above 150 °C for more than 1000 hours should be verified with Texas Instruments Reliability Engineering. Reliability report available upon request.

Driver Electrical Characteristics⁽¹⁾⁽²⁾

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

Parameter		Test 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		V
Δ V _{OD}	Change in Magnitude of Differential Output Voltage		R _L = 54Ω or 100Ω, See ⁽³⁾			±0.4	V
V _{OC}	Common Mode Output Voltage ⁽⁴⁾	(A+B)/2, Figure 1			2.5	3.0	V
Δ V _{OC}	Change in Magnitude of Common Mode Output Voltage ⁽³⁾					±0.2	V
I _O	Output Current ⁽⁵⁾ (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 ⁽⁶⁾	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	

- (1) 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.
- (2) 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.
- (3) Δ|V_{OD}| and Δ|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.
- (4) 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}.
- (5) Refer to TIA/EIA-485-A Standard for exact conditions.
- (6) Only one output at a time should be shorted. Do not exceed maximum junction temperature recommendations. This device does not include thermal shutdown protection.

Driver Switching Characteristics⁽¹⁾

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

Parameter		Test 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 _{SKREW}	Skew (Pulse Width Distortion)	R _L = 60Ω, Figure 3			1.0	12	ns

- (1) 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.

Receiver Electrical Characteristics⁽¹⁾⁽²⁾

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

Parameter		Test Conditions		Min	Typ	Max	Units		
V_{TH}	Differential Input High Threshold Voltage	$V_O = 2.7V, I_O = -0.4\text{ mA}$				0.2	V		
V_{TL}	Differential Input Low Threshold Voltage ⁽³⁾	$V_O = 0.5V, I_O = 2.0\text{ mA}$		-0.2			V		
$V_{T+}-V_{T-}$	Hysteresis ⁽⁴⁾	$V_{CM} = 0V$		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			$I_I = -18\text{ mA}$			-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)	$V_{ID} = 200\text{ mV}, I_{OH} = -400\text{ }\mu\text{A}$, Figure 2		2.5	3.5		V		
V_{OL}	Output Voltage LOW (RO)	$V_{ID} = -200\text{ mV}, I_{OL} = 2.0\text{ mA}$, Figure 2			0.3	0.45	V		
I_{OS}	Short Circuit Output Current (RO)	$V_O = 0V$, (Note 9)		-15	-46	-85	mA		
I_{OZ}	High Impedance State Output (RO)	$V_O = 0.4V\text{ to }2.4V$			0.2	± 20	μA		
I_I	Line Input Current ⁽⁵⁾	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	k Ω

- (1) Unless otherwise specified min/max limits apply across the -55°C to $+180^\circ\text{C}$ temperature range for the DS16F95A. All typical values are given for $V_{CC} = 5V$ and $T_A = 25^\circ\text{C}$.
- (2) 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.
- (3) 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.
- (4) Hysteresis is the difference between the positive-going input threshold voltage, V_{T+} , and the negative-going input threshold voltage, V_{T-} .
- (5) Refer to TIA/EIA-485-A Standard for exact conditions.

Receiver Switching Characteristics⁽¹⁾

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

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

- (1) Unless otherwise specified min/max limits apply across the -55°C to $+180^\circ\text{C}$ temperature range for the DS16F95A. All typical values are given for $V_{CC} = 5V$ and $T_A = 25^\circ\text{C}$.

Device Electrical Characteristics⁽¹⁾⁽²⁾

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

Parameter		Test 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	

- (1) 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 $T_A = 25^\circ C$.
- (2) 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.

Parameter Measurement Information

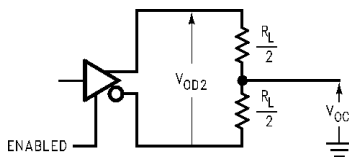


Figure 1. Driver V_{OD} and V_{OC} ⁽³⁾

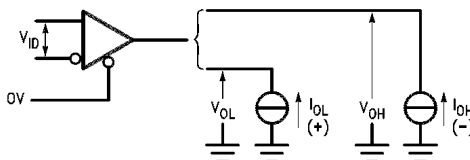
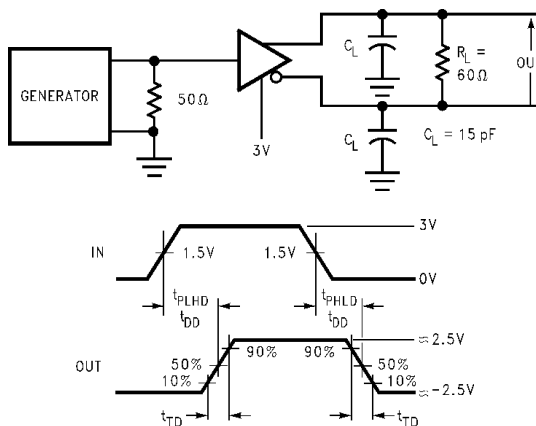


Figure 2. Receiver V_{OH} and V_{OL}



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

Figure 3. Driver Differential Output Delay and Transition Times⁽⁴⁾⁽⁵⁾

- (3) All diodes are 1N916 or equivalent.
- (4) 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, $Z_0 = 50\Omega$.
- (5) DS16F95A Driver enable is Active-High.

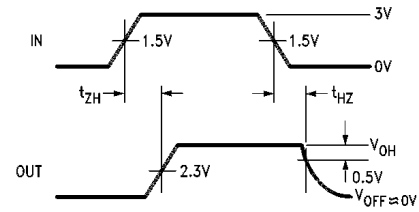
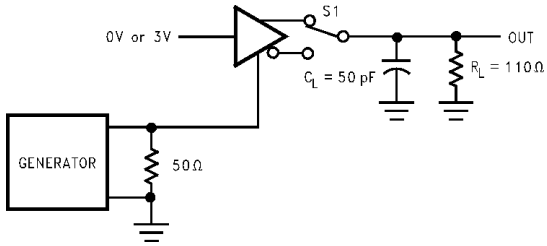


Figure 4. Driver Enable and Disable Times (t_{ZH} , t_{HZ})⁽⁶⁾⁽⁷⁾⁽⁸⁾

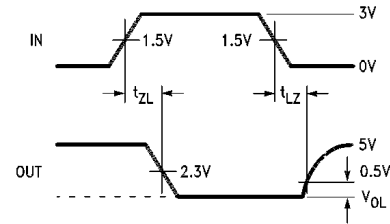
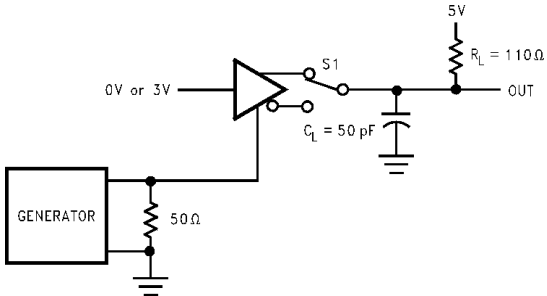


Figure 5. Driver Enable and Disable Times (t_{ZL} , t_{LZ} , t_{LZL})⁽⁶⁾⁽⁷⁾⁽⁸⁾

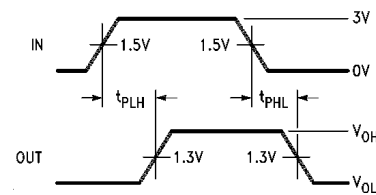
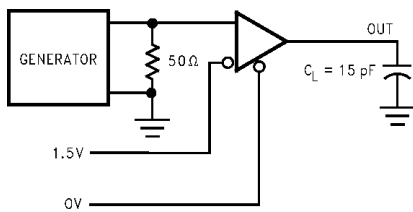


Figure 6. Receiver Propagation Delay Times⁽⁶⁾⁽⁷⁾

- (6) 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, $Z_O = 50\Omega$.
- (7) C_L includes probe and stray capacitance.
- (8) DS16F95A Driver enable is Active-High.

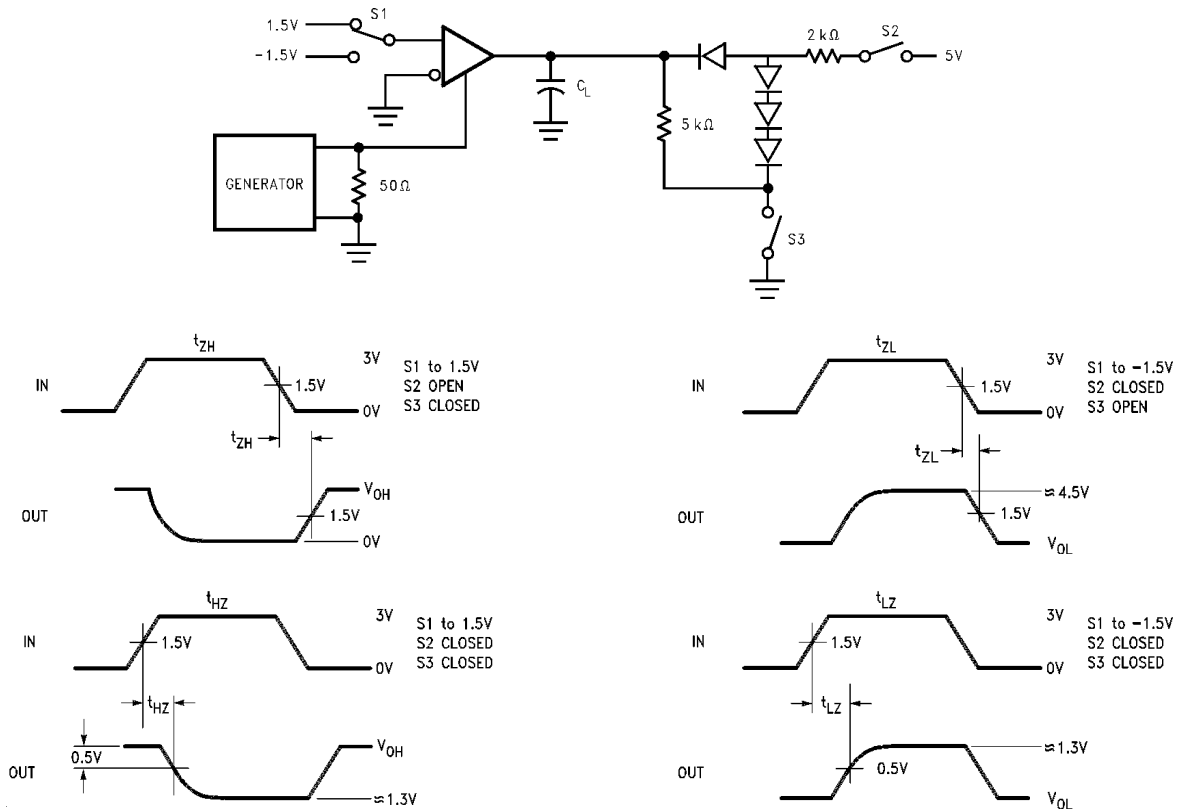


Figure 7. Receiver Enable and Disable Times⁽⁹⁾⁽¹⁰⁾⁽¹¹⁾

(9) 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, $Z_O = 50\Omega$.

(10) C_L includes probe and stray capacitance.

(11) All diodes are 1N916 or equivalent.

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 RE pin is Low. The receiver is disabled when the RE pin is High. The RE pin should be driven or tied to the desired state, do not float.

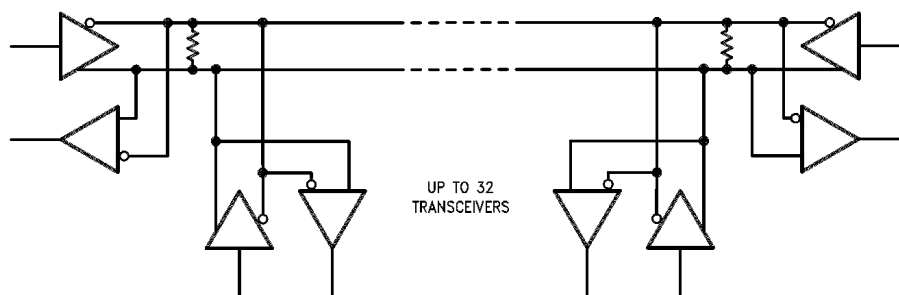
Typical Application

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.

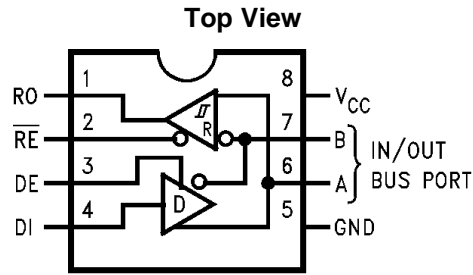
Being a multipoint bus, it is possible for all drivers to be disabled when one or more receivers are enabled. In this case, the receiver(s) is enabled when a valid differential voltage is not present and its output state is unknown. A common solution is to provide external failsafe biasing to bias the 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 (Literature Number [SNLA031](#)) for a discussion on Failsafe biasing of differential buses.

For extended temperature applications, maximum junction temperature should be calculated. $T_{Jmax} = T_A + (\Theta_{JA})(\text{Power Dissipation})$. Θ_{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°C . See AN-336 (Literature Number [SNVA509](#)) for a discussion on thermal considerations.

For maximum performance, a few system / PCB recommendations are: drive the logic inputs (DI, DE, $\overline{\text{RE}}$) 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.



Connection Diagram



**Figure 8. 8-Lead CDIP Package
See Package Number NAB0008A**

REVISION HISTORY

Changes from Revision A (April 2013) to Revision B	Page
• Changed layout of National Data Sheet to TI format	9

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
DS16F95AJA	LIFEBUY	CDIP	NAB	8	40	TBD	Call TI	Call TI	0 to 0	DS16F95AJA	

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

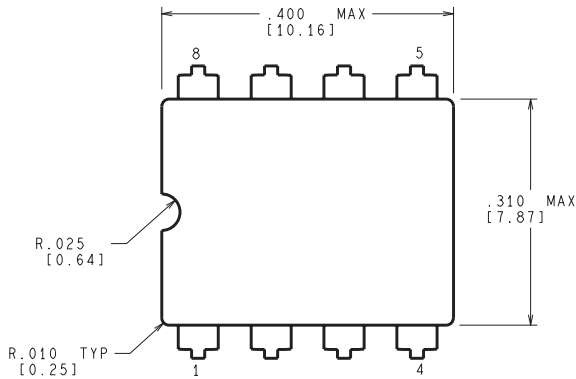
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

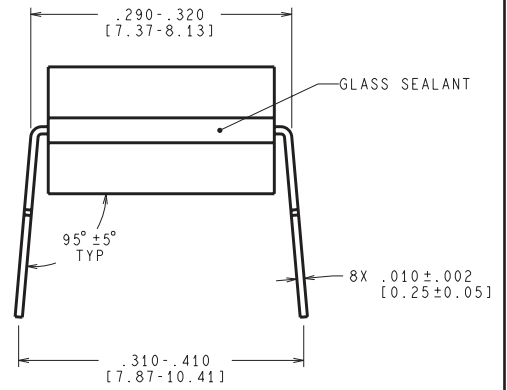
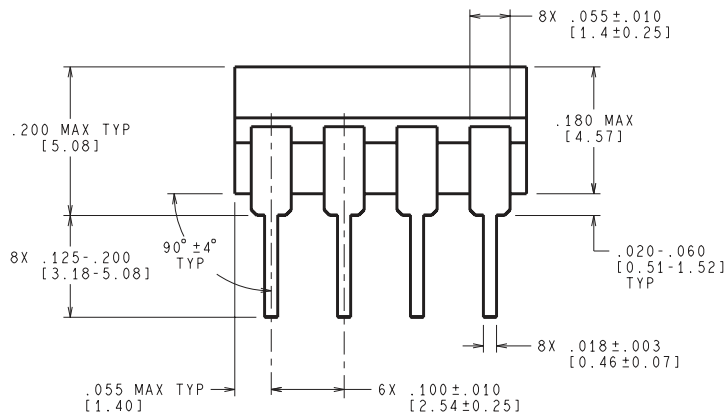
Important Information and Disclaimer:The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

NAB0008A



CONTROLLING DIMENSION IS INCH
VALUES IN [] ARE MILLIMETERS



J08A (Rev M)

IMPORTANT NOTICE

Texas Instruments Incorporated (TI) reserves the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete.

TI's published terms of sale for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>) apply to the sale of packaged integrated circuit products that TI has qualified and released to market. Additional terms may apply to the use or sale of other types of TI products and services.

Reproduction of significant portions of TI information in TI data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such reproduced documentation. Information of third parties may be subject to additional restrictions. Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyers and others who are developing systems that incorporate TI products (collectively, "Designers") understand and agree that Designers remain responsible for using their independent analysis, evaluation and judgment in designing their applications and that Designers have full and exclusive responsibility to assure the safety of Designers' applications and compliance of their applications (and of all TI products used in or for Designers' applications) with all applicable regulations, laws and other applicable requirements. Designer represents that, with respect to their applications, Designer has all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. Designer agrees that prior to using or distributing any applications that include TI products, Designer will thoroughly test such applications and the functionality of such TI products as used in such applications.

TI's provision of technical, application or other design advice, quality characterization, reliability data or other services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using TI Resources in any way, Designer (individually or, if Designer is acting on behalf of a company, Designer's company) agrees to use any particular TI Resource solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

Designer is authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS. TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY DESIGNER AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

Unless TI has explicitly designated an individual product as meeting the requirements of a particular industry standard (e.g., ISO/TS 16949 and ISO 26262), TI is not responsible for any failure to meet such industry standard requirements.

Where TI specifically promotes products as facilitating functional safety or as compliant with industry functional safety standards, such products are intended to help enable customers to design and create their own applications that meet applicable functional safety standards and requirements. Using products in an application does not by itself establish any safety features in the application. Designers must ensure compliance with safety-related requirements and standards applicable to their applications. Designer may not use any TI products in life-critical medical equipment unless authorized officers of the parties have executed a special contract specifically governing such use. Life-critical medical equipment is medical equipment where failure of such equipment would cause serious bodily injury or death (e.g., life support, pacemakers, defibrillators, heart pumps, neurostimulators, and implantables). Such equipment includes, without limitation, all medical devices identified by the U.S. Food and Drug Administration as Class III devices and equivalent classifications outside the U.S.

TI may expressly designate certain products as completing a particular qualification (e.g., Q100, Military Grade, or Enhanced Product). Designers agree that it has the necessary expertise to select the product with the appropriate qualification designation for their applications and that proper product selection is at Designers' own risk. Designers are solely responsible for compliance with all legal and regulatory requirements in connection with such selection.

Designer will fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of Designer's non-compliance with the terms and provisions of this Notice.