National Semiconductor

June 1998

DS16F95, DS36F95
EIA-485/EIA-422A Differential Bus Transceiver

General Description

The DS16F95/DS36F95 Differential Bus Transceiver is a monolithic integrated circuit designed for bidirectional data communication on balanced multipoint bus transmission lines. The transceiver meets both EIA-485 and EIA-422A standards.

The DS16F95/DS36F95 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. Thus, the DS16F95 and DS36F95 consume less power, and feature an extended temperature range as well as improved specifications.

The DS16F95/DS36F95 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.

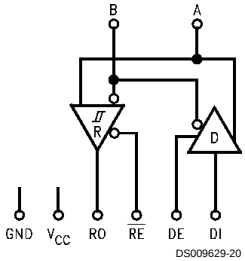
The driver is designed to accommodate loads of up to 60 mA of sink or source current and features positive and negative current limiting in addition to thermal shutdown for protection from line fault conditions.

The DS16F95/DS36F95 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

- 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
- Military temperature range available
- Qualified for MIL-STD 883C
- Standard Military Drawings (SMD) available
- Available in DIP (J), SOIC (M), LCC (E), and Flatpak (W) packages

Logic Diagram



DS009629-20

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)

TRI-STATE® is a registered trademark of National Semiconductor Corporation.

© 1998 National Semiconductor Corporation

COMMERCIAL

Absolute Maximum Ratings (Note 2)

Specifications for the 883 version of this product are listed separately on the following pages.

Storage Temperature Range	−65˚C to +175˚C
Lead Temperature	
(Soldering, 60 sec.)	300˚C
Maximum Package Power Dissipation (Note 1) at 25˚C	
'J' Package	1300 mW
'M' Package	735 mW
Supply Voltage	7.0V
Input Voltage (Bus Terminal)	+15V/−10V
Enable Input Voltage	5.5V

Recommended Operating Conditions

	Min	Typ	Max	Units
Supply Voltage (V_{CC})				
DS36F95	4.75	5.0	5.25	V
DS16F95	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)				
DS36F95	0	+25	+70	˚C
DS16F95	−55	+25	+125	˚C

Note 1: Derate 'J' package 8.7 mW/˚C above 25˚C.
Derate 'M' package 5.88 mW/˚C above 25˚C.

Driver Electrical Characteristics (Notes 3, 4)

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

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_{IH}	Input Voltage HIGH			2.0			V
V_{IL}	Input Voltage LOW					0.8	V
V_{OH}	Output Voltage HIGH	I_{OH} = −55 mA	0˚C to +70˚C	3.0			V
V_{OL}	Output Voltage LOW	I_{OL} = 55 mA	0˚C to +70˚C			2.0	V
V_{IC}	Input Clamp Voltage	I_I = −18 mA				−1.3	V
$\|V_{OD1}\|$	Differential Output Voltage	I_O = 0 mA				6.0	V
$\|V_{OD2}\|$	Differential Output Voltage	R_L = 100Ω, *Figure 1*		2.0	2.25		V
		R_L = 54Ω, *Figure 1*		1.5	2.0		
$\Delta\|V_{OD}\|$	Change in Magnitude of Differential Output Voltage (Note 5)	R_L = 54Ω or 100Ω, *Figure 1*	−40˚C to +125˚C			±0.2	V
			−55˚C to +125˚C			±0.4	
V_{OC}	Common Mode Output Voltage (Note 6)					3.0	V
$\Delta\|V_{OC}\|$	Change in Magnitude of Common Mode Output Voltage (Note 5)					±0.2	V
I_O	Output Current (Note 9) (Includes Receiver I_I)	Output Disabled	V_O = +12V			1.0	mA
			V_O = −7.0V			−0.8	
I_{IH}	Input Current HIGH	V_I = 2.4V				20	µA
I_{IL}	Input Current LOW	V_I = 0.4V				−50	µA
I_{OS}	Short Circuit Output Current (Note 10)	V_O = −7.0V				−250	mA
		V_O = 0V				−150	
		V_O = V_{CC}				150	
		V_O = +12V				250	

Driver Electrical Characteristics (Notes 3, 4) (Continued)

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			28	mA
I_{CCX}			DE = 0.8V, $\overline{RE}$ = 2V Outputs Disabled			25	

COMMERCIAL

Driver Switching Characteristics

V_{CC} = 5.0V, T_A = 25˚C

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{DD}	Differential Output Delay Time	R_L = 60Ω, *Figure 3*	8.0	15	20	ns
t_{TD}	Differential Output Transition Time		8.0	15	22	ns
t_{PLH}	Propagation Delay Time, Low-to-High Level Output	R_L = 27Ω, *Figure 4*	6.0	12	16	ns
t_{PHL}	Propagation Delay Time, High-to-Low Level Output		6.0	12	16	ns
t_{ZH}	Output Enable Time to High Level	R_L = 110Ω, *Figure 5*		25	32	ns
t_{ZL}	Output Enable Time to Low Level	R_L = 110Ω, *Figure 6*		25	32	ns
t_{HZ}	Output Disable Time from High Level	R_L = 110Ω, *Figure 5*		20	25	ns
t_{LZ}	Output Disable Time from Low Level	R_L = 110Ω, *Figure 6*		20	25	ns
t_{LZL}	Output Disable Time from Low Level with Load Resistor to GND	Load per *Figure 5* Timing per *Figure 6*		300		ns
t_{SKEW}	Skew (Pulse Width Distortion)	R_L = 60Ω, *Figure 3*		1.0	4.0	ns

Receiver Electrical Characteristics

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 7)	V_O = 0.5V, I_O = 8.0 mA		−0.2			V
$V_{T+}-V_{T-}$	Hysteresis (Note 8)	V_{CM} = 0V		35	50		mV
V_{IH}	Enable Input Voltage HIGH			2.0			V
V_{IL}	Enable Input Voltage LOW					0.8	V
V_{IC}	Enable Input Clamp Voltage	I_I = −18 mA				−1.3	V
V_{OH}	Output Voltage HIGH	V_{ID} = 200 mV, I_{OH} = −400 µA, *Figure 2*	0˚C to +70˚C	2.8			V
			−55˚C to +125˚C	2.5			
V_{OL}	Output Voltage LOW	V_{ID} = −200 mV, *Figure 2*	I_{OL} = 8.0 mA			0.45	V
			I_{OL} = 16 mA			0.50	
I_{OZ}	High Impedance State Output	V_O = 0.4V to 2.4V				±20	µA
I_I	Line Input Current (Note 9)	Other Input = 0V	V_I = +12V			1.0	mA
			V_I = −7.0V			0.8	
I_{IH}	Enable Input Current HIGH	V_{IH} = 2.7V				20	µA
I_{IL}	Enable Input Current LOW	V_{IL} = 0.4V				−50	µA
R_I	Input Resistance			14	18	22	kΩ
I_{OS}	Short Circuit Output Current	(Note 9)		−15		−85	mA

Receiver Electrical Characteristics (Continued)

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			28	mA
I_{CCX}			DE = 0.8V, $\overline{RE}$ = 2V Outputs Disabled			25	

COMMERCIAL

Receiver Switching Characteristics

V_{CC} = 5.0V, T_A = 25˚C

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{PLH}	Propagation Delay Time, Low-to-High Level Output	V_{ID} = 0V to +3.0V, C_L = 15 pF, *Figure 7*	14	19	24	ns
t_{PHL}	Propagation Delay Time, High-to-Low Level Output		14	19	24	ns
t_{ZH}	Output Enable Time to High Level	C_L = 15 pF, *Figure 8*		10	16	ns
t_{ZL}	Output Enable Time to Low Level			12	18	ns
t_{HZ}	Output Disable Time from High Level	C_L = 5.0 pF, *Figure 8*		12	20	ns
t_{LZ}	Output Disable Time from Low Level			12	18	ns
$\|t_{PLH}-t_{PHL}\|$	Pulse Width Distortion (SKEW)	*Figure 7*		1.0	4.0	ns

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: Unless otherwise specified min/max limits apply across the −55˚C to +125˚C temperature range for the DS16F95 and across the 0˚C to +70˚C range for the DS36F95. All typicals are given for V_{CC} = 5V and T_A = 25˚C.

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

Note 7: 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 8: Hysteresis is the difference between the positive-going input threshold voltage, V_T+, and the negative-going input threshold voltage, V_T-.

Note 9: Refer to TIA/EIA-485 Standard for exact conditions.

Note 10: Only one output at a time should be shorted.

Order Number:

DS16F95J, NS Package Number J08A

DS36F95J, NS Package Number J08A

DS36F95M, NS Package Number M08A

MIL-STD 883C

Absolute Maximum Ratings (Note 2)

For complete Military Product Specifications, refer to the appropriate SMD or MDS.

Storage Temperature Range	−65˚C to +175˚C
Lead Temperature	
(Soldering, 60 sec.)	300˚C
Maximum Power Dissipation (Note 11) at 25˚C	
Ceramic 'E' Package	1800 mW
Ceramic 'J' Package	1300 mW
Ceramic 'W' Package	TBD
Supply Voltage	7.0V
Input Voltage (Bus Terminal)	+15V/−10V
Enable Input Voltage	5.5V

Recommended Operating Conditions

	Min	Max	Units
Supply Voltage (V_{CC})			
DS16F95	4.50	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)			
DS16F95	−55	+125	˚C

Note 11: Above T_A = 25˚C, derate E package, J package 8.7 mW/˚C, W package 125 mW/˚C.

Driver Electrical Characteristics (Notes 3, 4)

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

Symbol	Parameter	Conditions		Min	Max	Units
V_{IH}	Input Voltage HIGH	V_{CC} = 5.5V		2.0		V
V_{IL}	Input Voltage LOW	V_{CC} = 5.5V			0.8	V
V_{OH}	Output Voltage HIGH	I_{OH} = −20 mA, V_{CC} = 4.5V		3.0		V
V_{OL}	Output Voltage LOW	I_{OL} = +20 mA, V_{CC} = 4.5V			2.0	V
V_{IC}	Input Clamp Voltage	I_I = −18 mA			−1.3	V
$\|V_{OD1}\|$	Differential Output Voltage	I_O = 0 mA, V_{IN} = 0.8V or 2V, V_{CC} = 5.5V			6.0	V
$\|V_{OD2}\|$	Differential Output Voltage	R_L = 100Ω, V_{CC} = 4.5V, *Figure 1*		2.0		V
		R_L = 54Ω, V_{CC} = 4.5V, *Figure 1*		1.5		
$\Delta\|V_{OD}\|$	Change in Magnitude of Differential Output Voltage (Note 5)	R_L = 54Ω or 100Ω, *Figure 1*, V_{CC} = 4.5V			±0.2	V
V_{OD3}	Differential Output Voltage	V_{CM} = −7V to +12V		1.0		V
V_{OC}	Common Mode Output Voltage (Note 6)	R_L = 54Ω or 100Ω			3.0	V
$\Delta\|V_{OC}\|$	Change in Magnitude of Common Mode Output Voltage (Note 5)	V_{CC} = 4.5V, R_L = 54Ω or 100Ω			±0.2	V
I_O	Output Current (Note 9) (Includes Receiver I_I)	Output Disabled	V_O = +12V		1.0	mA
		V_{CC} = 0V or 5.5V	V_O = −7.0V		−0.8	
I_{IH}	Input Current HIGH	V_I = 2.4V			20	µA
I_{IL}	Input Current LOW	V_I = 0.4V			−50	µA
I_{OS}	Short Circuit Output Current (Note 10)	V_O = −7.0V, V_{IN} = 0V or 3V			−250	mA
		V_O = 0V, V_{IN} = 0V or 3V			−150	
		V_O = V_{CC}, V_{IN} = 0V or 3V			150	
		V_O = +12V, V_{IN} = 0V or 3V			250	
I_{CC}	Supply Current (Total Package)	No Load, DE = 2V, $\overline{RE}$ = 0.8V, Inputs Open			28	mA
I_{CCX}		No Load, DE = 0.8V, $\overline{RE}$ = 2V, Inputs Open			25	

MIL-STD 883C

Driver Switching Characteristics

V_{CC} = 5.0V

Symbol	Parameter	Conditions	Min	Typ	T_A = 25˚C Max	T_A = 125˚C Max	T_A = −55˚C Max	Units
t_{DD}	Differential Output Delay Time	R_L = 60Ω, *Figure 3*	8.0	15	25	30	30	ns
t_{TD}	Differential Output Transition Time		8.0	15	25	30	30	ns
t_{PLH}	Propagation Delay Time, Low-to-High Level Output	R_L = 27Ω, *Figure 4*	6.0	12	18	25	25	ns
t_{PHL}	Propagation Delay Time, High-to-Low Level Output		6.0	12	18	25	25	ns
t_{ZH}	Output Enable Time to High Level	R_L = 110Ω, *Figure 5*		25	35	45	45	ns
t_{ZL}	Output Enable Time to Low Level	R_L = 110Ω, *Figure 6*		25	40	50	50	ns
t_{HZ}	Output Disable Time from High Level	R_L = 110Ω, *Figure 5*		20	30	40	40	ns
t_{LZ}	Output Disable Time from Low Level	R_L = 110Ω, *Figure 6*		20	30	40	40	ns
t_{LZL}	Output Disable Time from Low Level with Load Resistor to GND	Load per *Figure 5* Timing per *Figure 6*		300				ns
t_{SKEW}	Skew (Pulse Width Distortion)	R_L = 60Ω, *Figure 3*		1.0	6	12	12	ns

Receiver Electrical Characteristics

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

Symbol	Parameter	Conditions		Min	Max	Units
V_{TH}	Differential Input High Threshold Voltage	V_O = 2.5V, I_O = −0.4 mA, V_{CM} = −7V, 0V, +12V V_{CC} = 4.5V, 5.5V			0.2	V
V_{TL}	Differential Input Low Threshold Voltage (Note 7)	V_O = 0.5V, I_O = 8.0 mA, V_{CM} = −7V, 0V, +12V, V_{CC} = 4.5V, 5.5V		−0.2		V
$V_{T+}-V_{T-}$	Hysteresis (Note 8)	V_{CM} = 0V, V_{CC} = 4.5V, 5.5V		35		mV
V_{IH}	Enable Input Voltage HIGH			2.0		V
V_{IL}	Enable Input Voltage LOW				0.8	V
V_{IC}	Enable Input Clamp Voltage	I_I = −18 mA, V_{CC} = 5.5V			−1.3	V
V_{OH}	Output Voltage HIGH	V_{ID} = 200 mV, I_{OH} = −400 µA, *Figure 2*, V_{CC} = 4.5V	−55˚C to +125˚C	2.5		V
V_{OL}	Output Voltage LOW	V_{ID} = −200 mV, *Figure 2*, V_{CC} = 4.5V	I_{OL} = 8.0 mA		0.45	V
			I_{OL} = 16 mA		0.50	
I_{OZ}	High Impedance State Output	V_O = 0.4V, 2.4V			±20	µA
I_I	Line Input Current (Note 9)	Other Input = 0V V_{CC} = 5.5V or V_{CC} = 0V	V_I = +12V		1.0	mA
			V_I = −7.0V	−0.8		
I_{IH}	Enable Input Current HIGH	V_{IH} = 2.7V			20	µA
I_{IL}	Enable Input Current LOW	V_{IL} = 0.4V			−50	µA
R_I	Input Resistance			10		kΩ
I_{OS}	Short Circuit Output Current	V_{IN} = 1V, V_{OUT} = 0.0V (Note 10)		−15	−85	mA
I_{CC}	Supply Current (Total Package)	No Load, DE = 2V, $\overline{RE}$ = 0.8V, Inputs Open			28	mA
I_{CCX}		No Load, DE = 0.8V, $\overline{RE}$ = 2.0V, Inputs Open			25	

MIL-STD 883C

Receiver Switching Characteristics

V_{CC} = 5.0V

Symbol	Parameter	Conditions	Min	Typ	T_A = 25˚C Max	T_A = 125˚C Max	T_A = −55˚C Max	Units
t_{PLH}	Propagation Delay Time, Low-to-High Level Output	V_{ID} = 0V to +3.0V, C_L = 15 pF, *Figure 7*	10	19	27	38	38	ns
t_{PHL}	Propagation Delay Time, High-to-Low Level Output		10	19	27	38	38	ns
t_{ZH}	Output Enable Time to High Level	C_L = 15 pF, *Figure 8*		10	20	30	30	ns
t_{ZL}	Output Enable Time to Low Level			12	20	30	30	ns
t_{HZ}	Output Disable Time from High Level	C_L = 5.0 pF, *Figure 8*		12	20	30	30	ns
		C_L = 20.0 pF, *Figure 8* (Note 16)		12	30	40	40	ns
t_{LZ}	Output Disable Time from Low Level	C_{IL} = 50 pF, *Figure 8*		12	20	30	30	ns
$\|t_{PLH}-t_{PHL}\|$	Pulse Width Distortion (SKEW)	*Figure 7*		1.0	8	16	16	ns

Ordering Number:

DS16F95J/883, NS Package Number J08A
DS16F95E/883, NS Package Number E20A
DS16F95W/883, NS Package Number W10A

SMD Number:

DS16F95J/883 ↔ 5962-8961501PA
DS16F95W-SMD ↔ 5962-8961501HA
DS16F95E/883 ↔ 5962-89615012A

Parameter Measurement Information

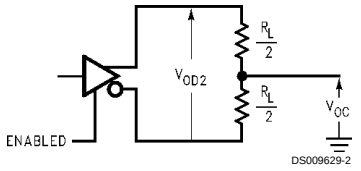


FIGURE 1. Driver V_{OD} and V_{OC} (Note 15)

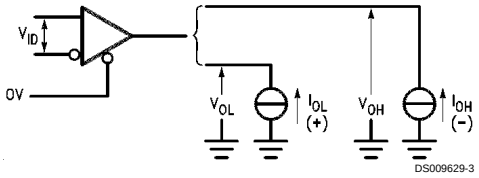
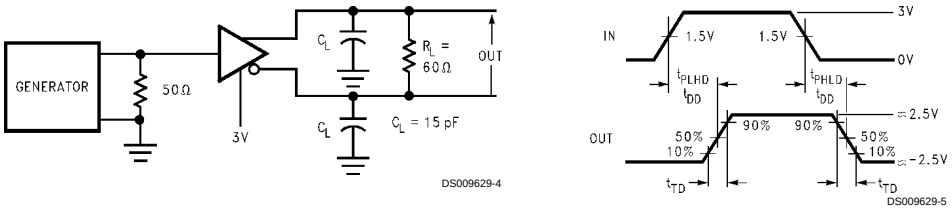


FIGURE 2. Receiver V_{OH} and V_{OL}



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

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

Parameter Measurement Information (Continued)

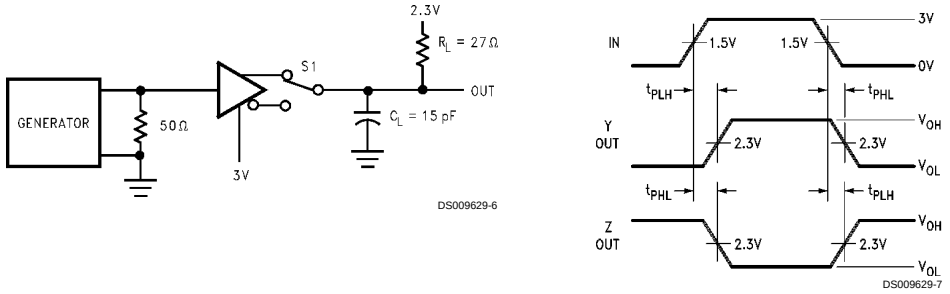


FIGURE 4. Driver Propagation Times (Notes 12, 13)

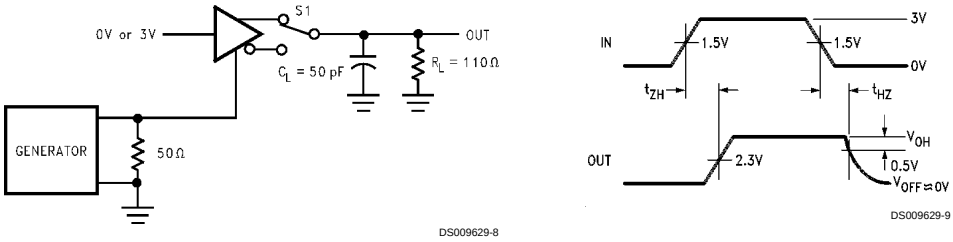


FIGURE 5. Driver Enable and Disable Times (t_{ZH}, t_{HZ}) (Notes 12, 13, 14)

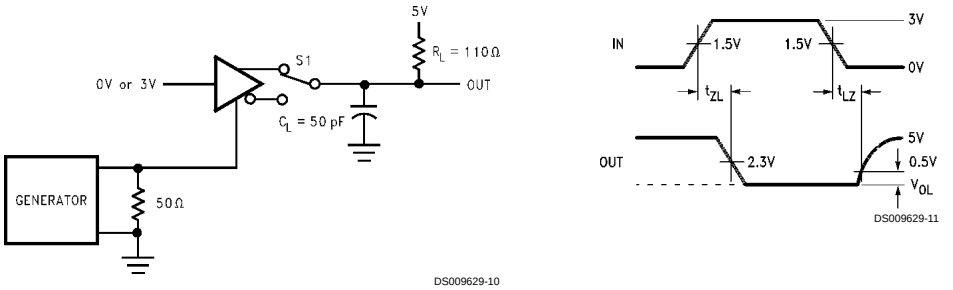


FIGURE 6. Driver Enable and Disable Times (t_{ZL}, t_{LZ}, t_{LZL}) (Notes 12, 13, 14)

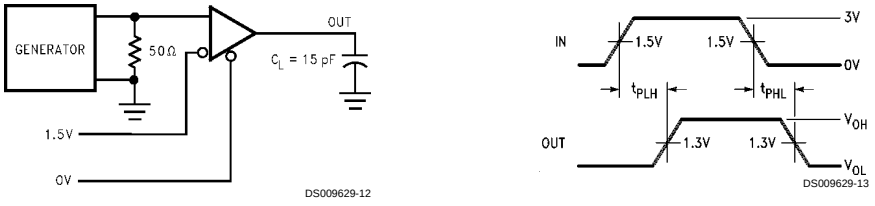


FIGURE 7. Receiver Propagation Delay Times (Notes 12, 13)

Parameter Measurement Information (Continued)

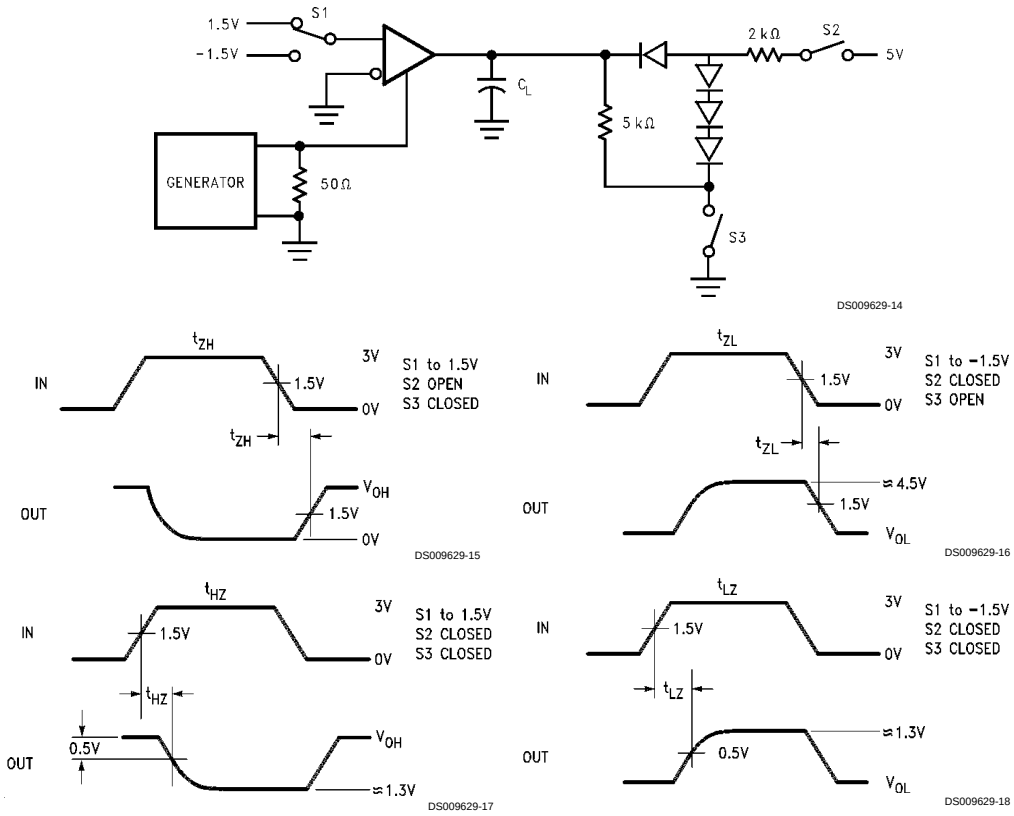


FIGURE 8. Receiver Enable and Disable Times (Notes 12, 13, 15)

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, $Z_O = 50\Omega$.

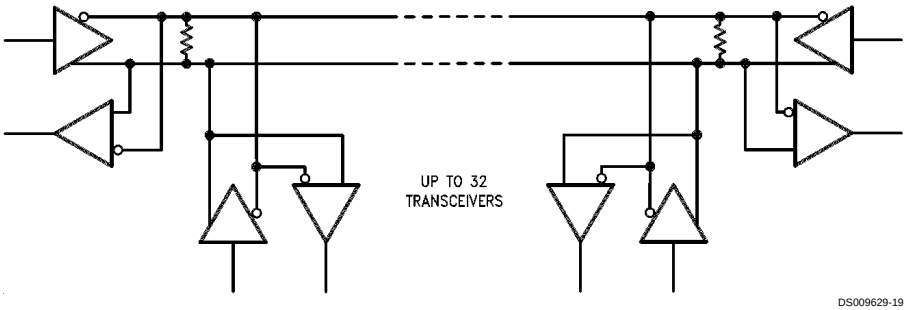
Note 13: C_L includes probe and stray capacitance.

Note 14: DS16F95/DS36F95 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.

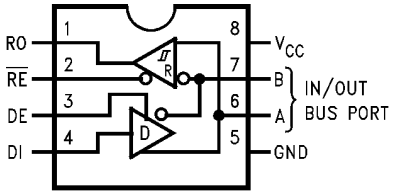
Typical Application



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.

Connection Diagrams

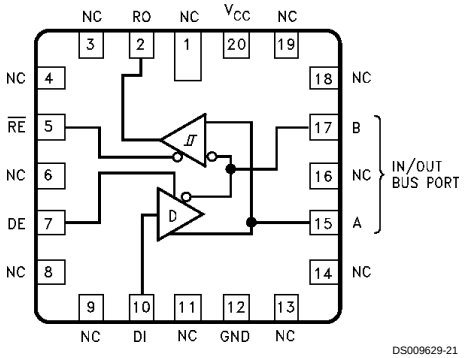
8-Lead Dual-In-Line Package or Small Outline Molded Package



DS009629-1

Order Number DS16F95, DS16F95J/883, DS36F95J, DS36F95M
See NS Package Number J08A, or M08A

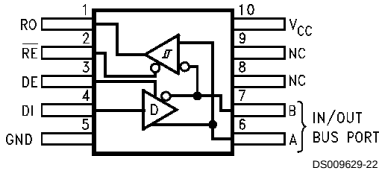
20-Lead Ceramic Leadless Chip Carrier



DS009629-21

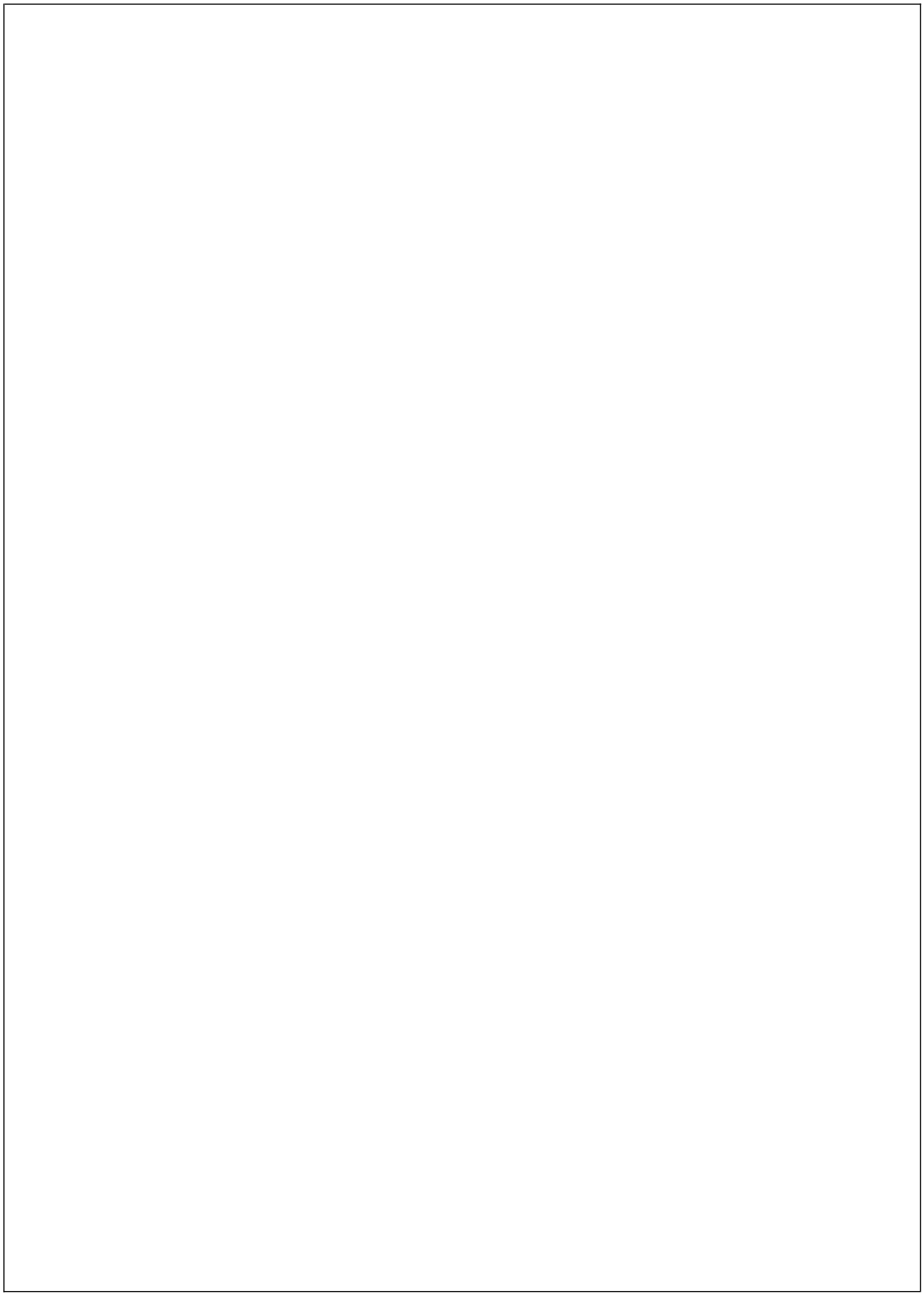
Order Number DS16F95E/883
See NS Package Number E20A

10-Lead Ceramic Flatpak

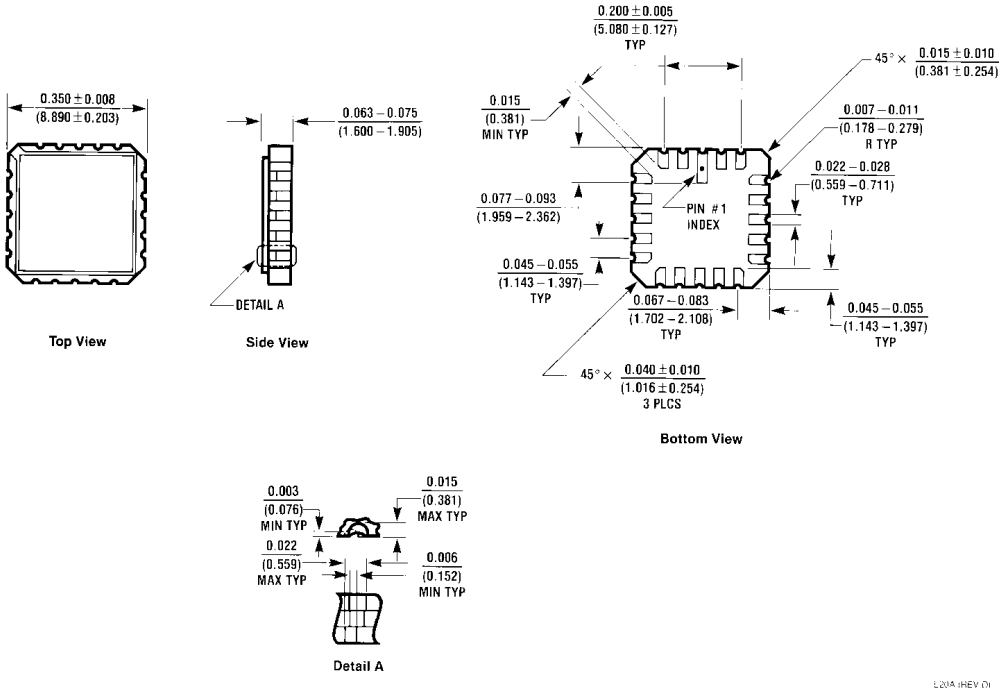


DS009629-22

Order Number DS16F95W/883
See NS Package Number W10A



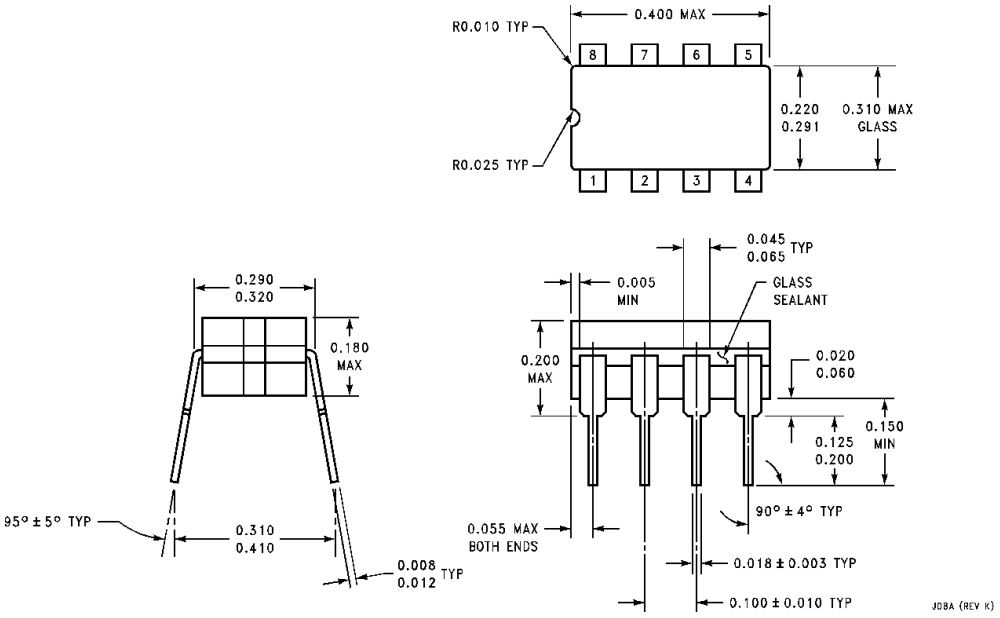
Physical Dimensions inches (millimeters) unless otherwise noted



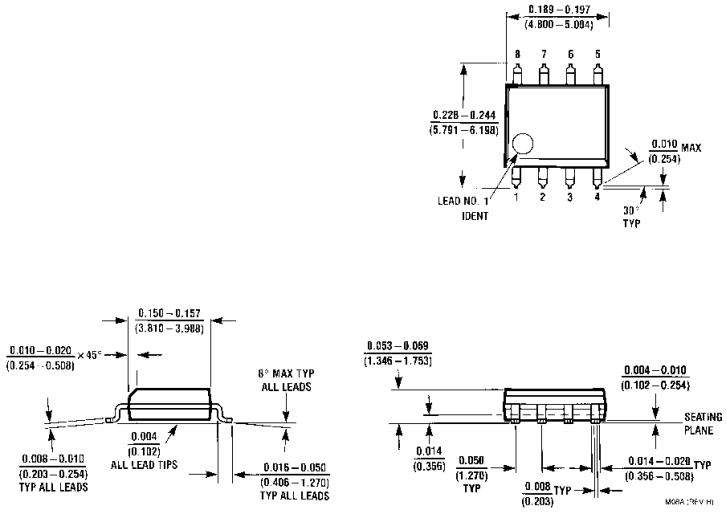
E20A (REV D)

20-Lead Ceramic Leadless Chip Carrier (E)
Order Number DS16F95E/883
NS Package Number E20A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

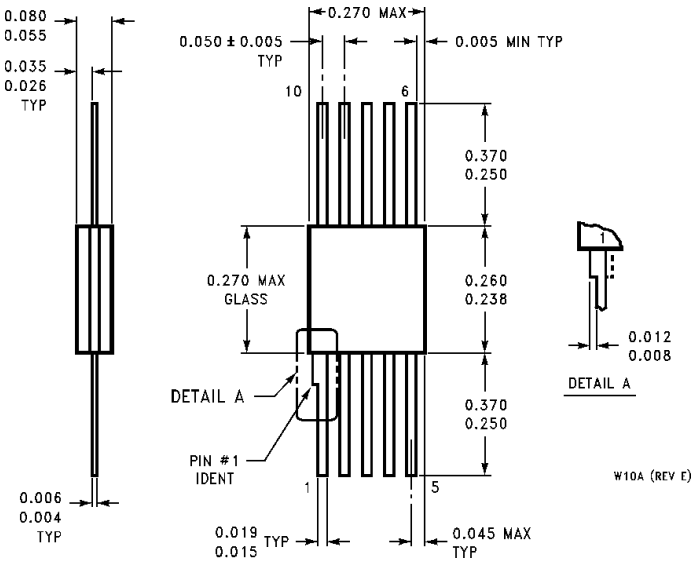


8 Narrow Lead Ceramic Dual-In-Line Package (J)
Order Number DS16F95J, DS16F95J/883 or DS36F95J
NS Package Number J08A



8-Lead (0.150" Wide) Molded Small Outline Package, JEDEC
Order Number DS36F95M
NS Package Number M08A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



10-Lead Ceramic Flatpak (W)
Order Number DS16F95W/883
NS Package Number W10A

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems 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.
2. A critical component in any component of 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.

National Semiconductor Corporation
Americas
Tel: 1-800-272-9959
Fax: 1-800-737-7018
Email: support@nsc.com

www.national.com

National Semiconductor Europe
Fax: +49 (0) 1 80-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 1 80-530 85 85
English Tel: +49 (0) 1 80-532 78 32
Français Tel: +49 (0) 1 80-532 93 58
Italiano Tel: +49 (0) 1 80-534 16 80

National Semiconductor Asia Pacific Customer Response Group
Tel: 65-2544466
Fax: 65-2504466
Email: sea.support@nsc.com

National Semiconductor Japan Ltd.
Tel: 81-3-5620-6175
Fax: 81-3-5620-6179

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.