September 1999

National Semiconductor

DS78LS120
Dual Differential Line Receiver (Noise Filtering and Fail-Safe)

General Description

The DS78LS120 is a high performance, dual differential, TTL compatible line receiver for both balanced and unbalanced digital data transmission. The inputs are compatible with EIA, Federal and MIL standards.

The line receiver will discriminate a ±200 mV input signal over a common-mode range of ±10V and a ±300 mV signal over a range of ±15V.

Circuit features include hysteresis and response control for applications where controlled rise and fall times and/or high frequency noise rejection are desirable. Threshold offset control is provided for fail-safe detection, should the input be open or short. Each receiver includes an optional 180Ω terminating resistor and the output gate contains a logic strobe for time discrimination. The DS78LS120 is specified over a −55˚C to +125˚C temperature range.

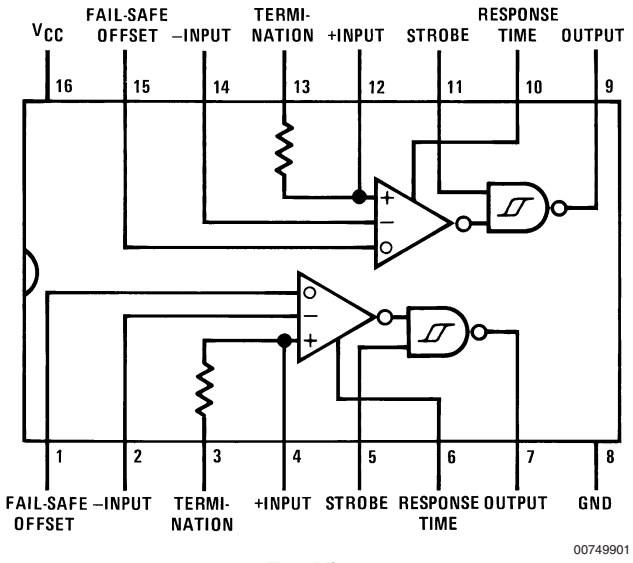
Input specifications meet or exceed those of the popular DS7820 line receiver.

Features

- Meets EIA standards RS232-C, RS422 and RS423, Federal Standards 1020, 1030 and MIL-188-114
- Input voltage range of ±15V (differential or common-mode)
- Separate strobe input for each receiver
- 5k typical input impedance
- Optional 180Ω termination resistor
- 50mV input hysteresis
- 200mV input threshold
- Separate fail-safe mode

Connection Diagram

Dual-In-Line-Package



Top View
see RETS Data Sheet.
Order Number DS78LS120J/883 or DS78LS120W/883
See NS Package Number J16A or W16A

Absolute Maximum Ratings (Note 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Supply Voltage	7V
Input Voltage	±25V
Strobe Voltage	7V
Output Sink Current	50 mA
Storage Temperature Range	−65˚C to +150˚C
Maximum Power Dissipation at 25˚C (Note 1)	1433 mV
Lead Temperature (Soldering, 4 sec)	260˚C

Operating Conditions

	Min	Max	Units
Supply Voltage (V_{CC})	4.5	5.5	V
Temperature (T_A)	−55	+125	˚C
Common-Mode Voltage (V_{CM})	−15	+15	V

Electrical Characteristics (Notes 3, 4)

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_{TH}	Differential Threshold Voltage	I_{OUT} = −400 µA, $V_{OUT} \geq$ 2.5V	−7V ≤ V_{CM} ≤ 7V		0.06	0.2	V
			−15 ≤ V_{CM} ≤15V		0.06	0.3	V
V_{TL}	Differential Threshold Voltage	I_{OUT} = 4 mA, $V_{OUT} \leq$ 0.5V	−7V ≤ V_{CM} ≤7V		−0.08	−0.2	V
			−15V ≤ V_{CM} ≤ 15V		−0.08	−0.3	V
V_{TH}	Differential Threshold Voltage	I_{OUT} = −400 µA, $V_{OUT} \geq$ 2.5V	−7V ≤ V_{CM} ≤ 7V		0.47	0.7	V
V_{TL}	with Fail-Safe Offset = 5V	I_{OUT} = 4 mA, $V_{OUT} \leq$ 0.5V	−7V ≤ V_{CM} ≤ 7V	−0.2	−0.42		V
R_{IN}	Input Resistance	−15V ≤ V_{CM} ≤ 15V, 0V ≤ V_{CC} ≤ 7V		4	5		kΩ
R_T	Line Termination Resistance	T_A = 25˚C		100	180	300	Ω
R_O	Offset Control Resistance	T_A = 25˚C		42	56	70	kΩ
I_{IND}	Data Input Current (Unterminated)	V_{CM} = 10V	0V ≤ V_{CC} ≤ 7V		2	3.1	mA
		V_{CM} = 0V			0	−0.5	mA
		V_{CM} = −10V			−2	−3.1	mA
V_{THB}	Input Balance (Note 6)	I_{OUT} = −400 µA, $V_{OUT} \geq$ 2.5V, R_S = 500Ω	−7V ≤ V_{CM} 7V		0.1	0.4	V
		I_{OUT} = 4 mA, $V_{OUT} \leq$ 0.5V, R_S = 500Ω	−7V ≤ V_{CM} ≤ 7V		−0.1	−0.4	V
V_{OH}	Logical “1” Output Voltage	I_{OUT} = −400 µA, V_{DIFF} = 1V, V_{CC} = 4.5V		2.5	3		V
V_{OL}	Logical “0” Output Voltage	I_{OUT} = 4 mA, V_{DIFF} = −1V, V_{CC} = 4.5V			0.35	0.5	V
I_{CC}	Power Supply Current	V_{CC} = 5.5V	V_{CM} = 15V		10	16	mA
		V_{DIFF} = −0.5V, (Both Receivers)	V_{CM} = −15V		10	16	mA
$I_{IN\ (1)}$	Logical “1” Strobe Input Current	V_{STROBE} = 5.5V, V_{DIFF} = 3V			1	100	µA
$I_{IN\ (0)}$	Logical “0” Strobe Input Current	V_{STROBE} = 0V, V_{DIFF} = −3V			−290	−400	µA
V_{IH}	Logical “1” Strobe Input Voltage	$V_{OL} \leq$ 0.5, I_{OUT} = 4mA		2.0	1.12		V
V_{IL}	Logical “0” Strobe Input Voltage	$V_{OH} \geq$ 2.5V, I_{OUT}, = −400 µA			1.12	0.8	V
I_{OS}	Output Short-Circuit Current	V_{OUT} = 0V, V_{CC} = 5.5V, V_{STROBE} = 0V,(Note 5)		−30	−100	−170	mA

Note 1: Derate cavity package 9.6 mW/˚C above 25˚C.

Note 2: “Absolute Maximum Ratings” are those values beyond which the safety of the device cannot be guaranteed. Except for “Operating Temperature Range” they are not meant to imply that the devices should be operated at these limits. The table of “Electrical Characteristics” provides 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 DS78LS120. All typical values are for T_A = 25˚C, V_{CC} = 5V and V_{CM} = 0V.

Note 4: All currents into device pins shown as positive, out of device pins as negative, all voltages referenced to ground unless otherwise noted. All values shown as max or min on absolute value basis.

Note 5: Only one output at a time should be shorted.

Note 6: Refer to EIA-RS422 for exact conditions.

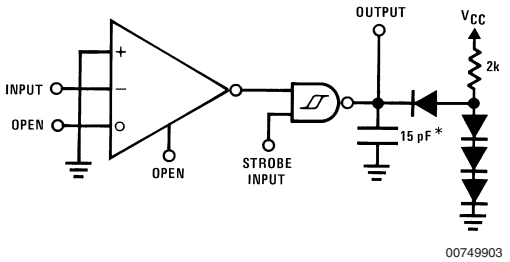
Switching Characteristics

V_{CC} = 5V, T_A = 25˚C

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{pd0(D)}$	Differential Input to "0" Output	Response Pin Open, C_L = 15 pF, R_L = 2 kΩ		38	60	ns
$t_{pd1(D)}$	Differential Input to "1" Output			38	60	ns
$t_{pd0(S)}$	Strobe Input to "0" Output			16	25	ns
$t_{pd1(S)}$	Strobe Input to "1" Output			12	25	ns

AC Test Circuit and Switching Time Waveforms

Differential and Strobe Input Signal



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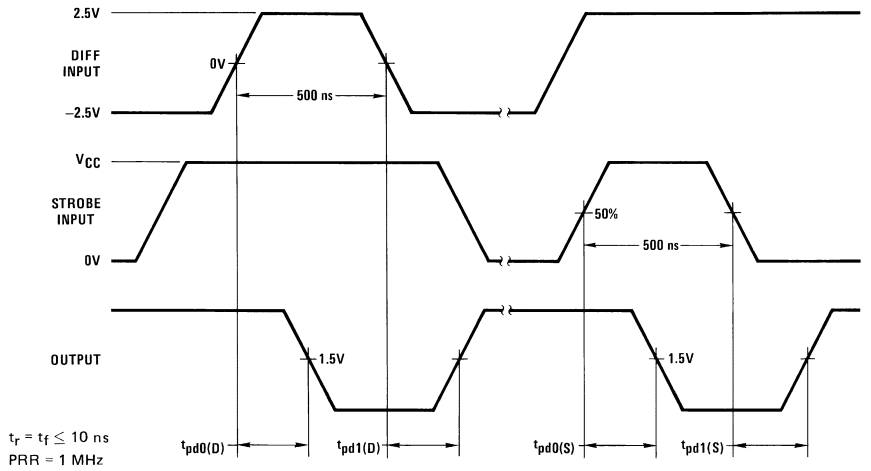
Includes probe and test fixture capacitance



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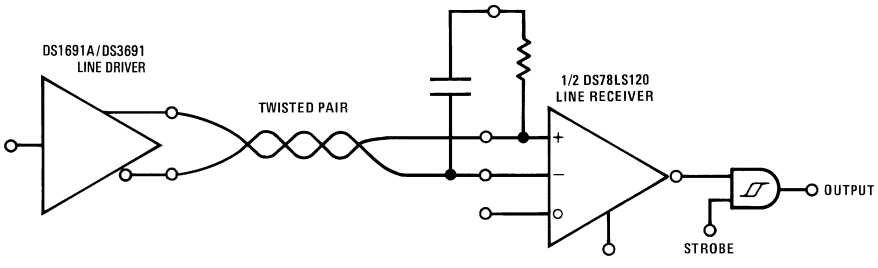
Note: Optimum switching response is obtained by minimizing stray capacitance on Response Control pin (no external connection).

Application Hints

Balanced Data Transmission



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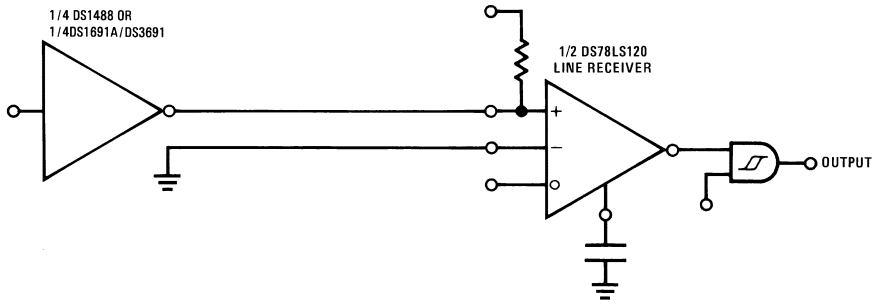
Application Hints (Continued)

Unbalanced Data Transmission



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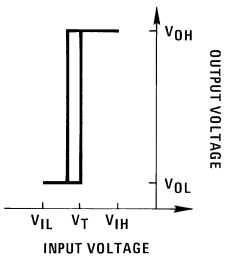

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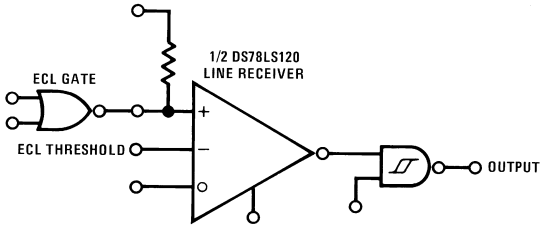
Logic Level Translator



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The DS78LS120 may be used as a level translator to interface between ±12V MOS, ECL, TTL and CMOS. To configure, bias either input to a voltage equal to ½ the voltage of the input signal, and the other input to the driving gate.

LINE DRIVERS

Line drivers which will interface with the DS78LS120 are listed below.

Balanced Drivers

DS26LS31: Quad RS-422 Line Driver, Dual CMOS

DS7830, DS8830: Dual TTL

DS7831, DS8831: Dual TRI-STATE TTL

DS7832, DS8832: Dual TRI-STATE TTL

DS1691A, DS3691: Quad RS-423/Dual RS-422 TTL

DS1692, DS3692: Quad RS-423/Dual TRI-STATE RS-422 TTL

DS3487: Quad TRI-STATE RS-422

Unbalanced Drivers

DS1488: Quad RS-232

DS75150: Dual RS-232

RESPONSE CONTROL AND HYSTERESIS

In unbalanced (RS-232/RS-423) applications it is recommended that the rise time and fall time of the line driver be controlled to reduce cross-talk. Elimination of switching noise is accomplished in the DS78LS120 by the 50 mV of hysteresis incorporated in the output gate. This eliminates the oscillations which may appear in a line receiver due to the input signal slowly varying about the threshold level for extended periods of time.

High frequency noise which is superimposed on the input signal which may exceed 50 mV can be reduced in amplitude by filtering the device input. On the DS78LS120, a high impedance response control pin in the input amplifier is available to filter the input signal without affecting the termination impedance of the transmission line. Noise pulse width rejection vs the value of the response control capacitor is shown in *Figure 1* and *Figure 2*. This combination of filters followed by hysteresis will optimize performance in a worse case noise environment.

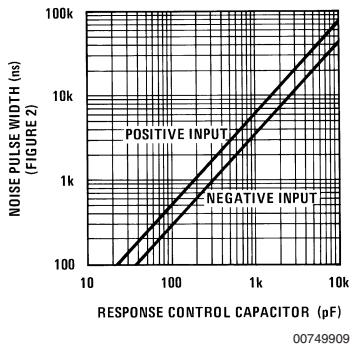

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FIGURE 1. Noise Pulse Width vs Response Control Capacitor

Application Hints (Continued)

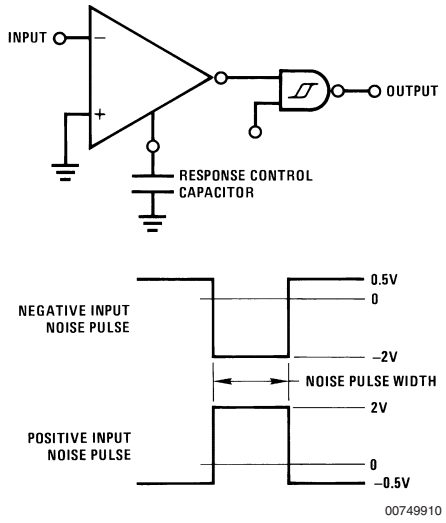


FIGURE 2.

TRANSMISSION LINE TERMINATION

On a transmission line which is electrically long, it is advisable to terminate the line in its characteristic impedance to prevent signal reflection and its associated noise/cross-talk. A 180Ω termination resistor is provided in the DS78LS120 line receiver. To use the termination resistor, connect pins 2 and 3 together and pins 13 and 14 together. The 180Ω resistor provides a good compromise between line reflections, power dissipation in the driver, and IR drop in the transmission line. If power dissipation and IR drop are still a concern, a capacitor may be connected in series with the resistor to minimize power loss.

The value of the capacitor is recommended to be the line length (time) divided by 3 times the resistor value. Example: if the transmission line is 1,000 feet long, (approximately 1000 ns), and the termination resistor value is 180Ω, the capacitor value should be 1852 pF. For additional application details, refer to application notes AN-22 and AN-108.

FAIL-SAFE OPERATION

Communication systems require elements of a system to detect the presence of signals in the transmission lines, and it is desirable to have the system shut-down in a fail-safe mode if the transmission line is open or shorted. To facilitate the detection of input opens or shorts, the DS78LS120 incorporates an input threshold voltage offset. This feature will force the line receiver to a specific logic state if presence of either fault is a condition.

Given that the receiver input threshold is ±200 mV, an input signal greater than ±200 mV insures the receiver will be in a specific logic state. When the offset control input (pins 1 and 15) is connected to V_{CC} = 5V, the input thresholds are offset from 200 mV to 700 mV, referred to the non-inverting input, or −200 mV to −700 mV, referred to the inverting input. Therefore, if the input is open or shorted, the input will be greater than the input threshold and the receiver will remain in a specified logic state.

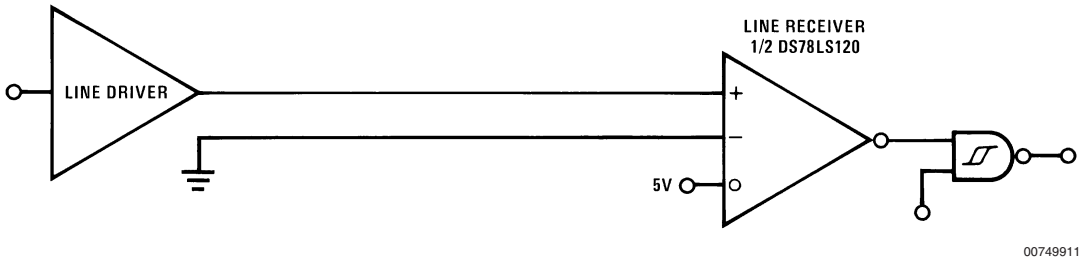
The input circuit of the receiver consists of a 5k resistor terminated to ground through 120Ω on both inputs. This network acts as an attenuator, and permits operation with common-mode input voltages greater than ±15V. The offset control input is actually another input to the attenuator, but its resistor value is 56k. The offset control input is connected to the inverting input side of the attenuator, and the input voltage to the amplifier is the sum of the inverting input plus 0.09 times the voltage on the offset control input. When the offset control input is connected to 5V the input amplifier will see $V_{IN(INVERTING)}$ +0.45V or $V_{IN(INVERTING)}$ +0.9V when the control input is connected to 10V. The offset control input will not significantly affect the differential performance of the receiver over its common-mode operating range, and will not change the input impedance balance of the receiver.

It is recommended that the receiver be terminated (500Ω or less) to insure it will detect an open circuit in the presence of noise.

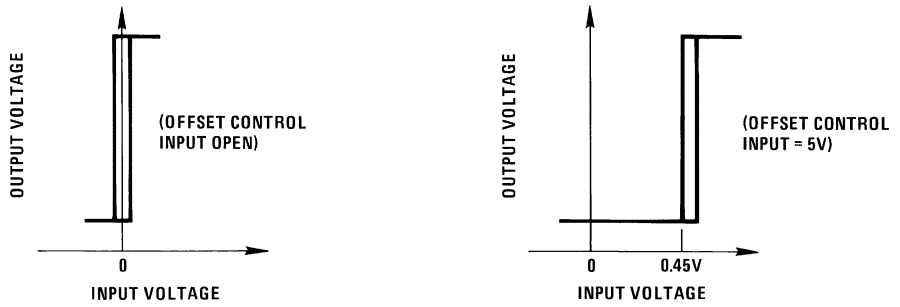
The offset control can be used to insure fail-safe operation for unbalanced interface (RS-423) or for balanced interface (RS-422) operation.

For unbalanced operation, the receiver would be in an indeterminate logic state if the offset control input was open. Connecting the fail-safe offset pin to 5V, offsets the receiver threshold to 0.45V. The output is forced to a logic zero state if the input is open or shorted.

Unbalanced RS-423 and RS-232 Fail-Safe



Application Hints (Continued)



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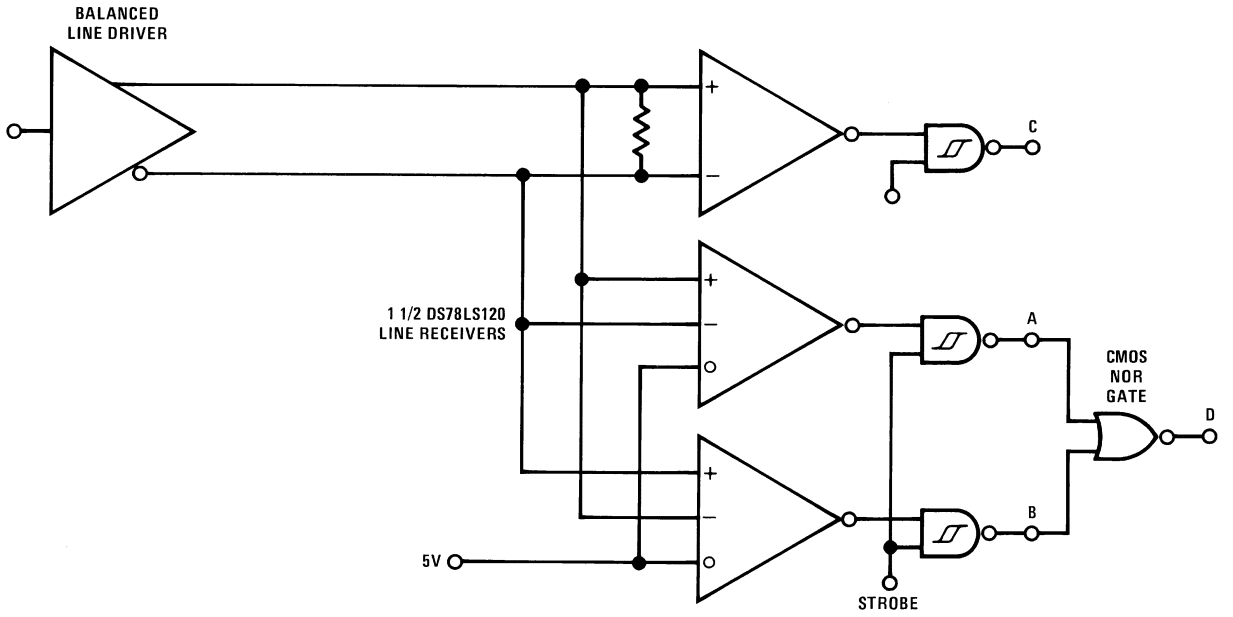
Balanced RS-422 Fail-Safe



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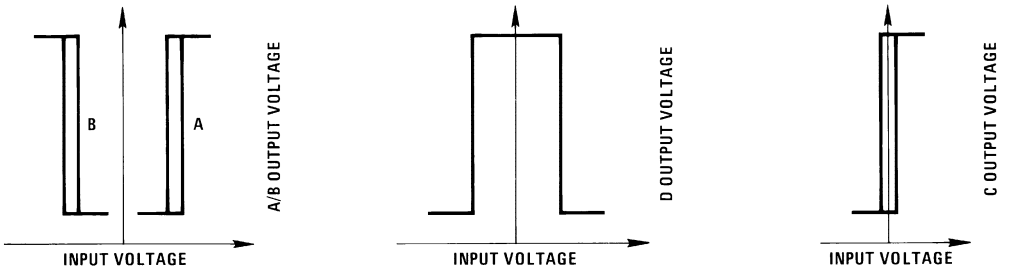

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For balanced operation with inputs open or shorted, receiver C will be in an indeterminate logic state. Receivers A and B will be in a logic zero state allowing the NOR gate to detect the open or short condition. The strobe will disable receivers A and B and may therefore be used to sample the fail-safe detector. Another method of fail-safe detection consists of filtering the output of NOR gate D so it would not indicate a fault condition when receiver inputs pass through the threshold region, generating an output transient.

In a communications system, only the control signals are required to detect input fault conditions. Advantages of a balanced data transmission system over an unbalanced transmission system are:

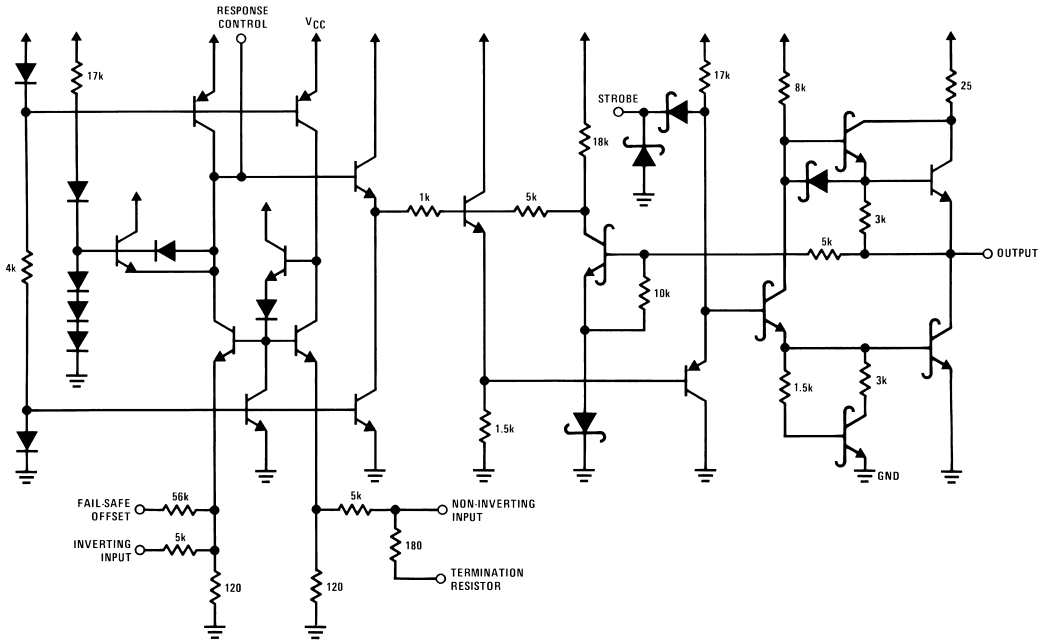
1. High noise immunity
2. High data ratio
3. Long line lengths

Truth Table

(For Balanced Fail-Safe)

Input	Strobe	A-Out	B-Out	C-Out	D-Out
0	1	0	1	0	0
1	1	1	0	1	0
X	1	0	0	X	1
0	0	1	1	0	0
1	0	1	1	0	0
X	0	1	1	0	0

Schematic Diagram



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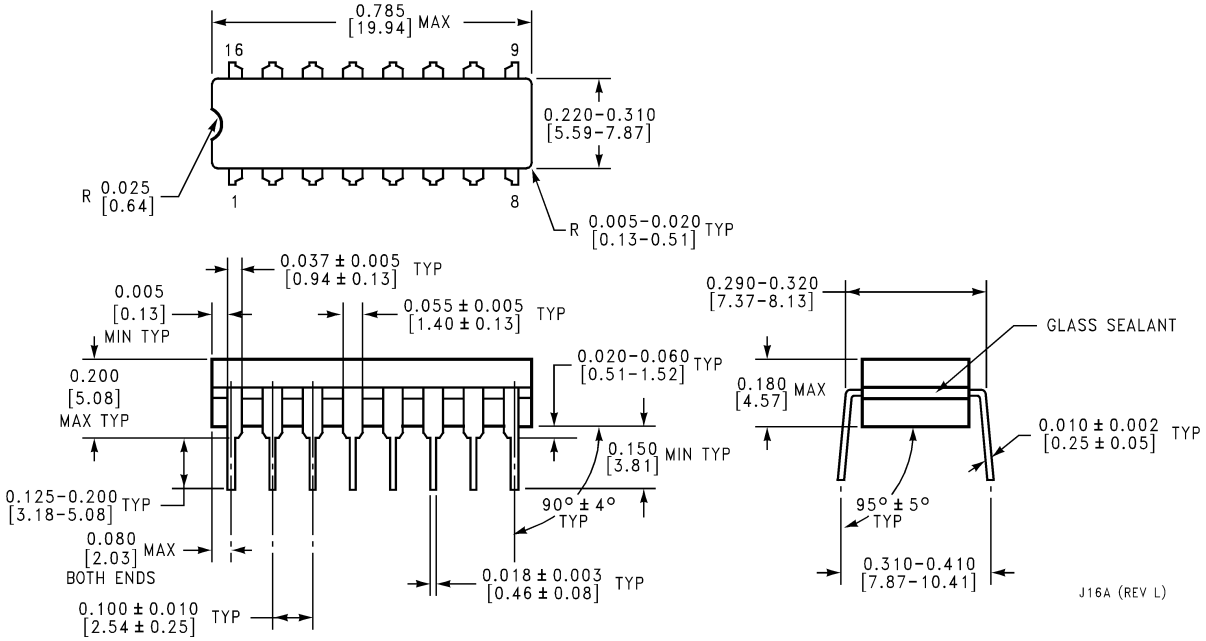
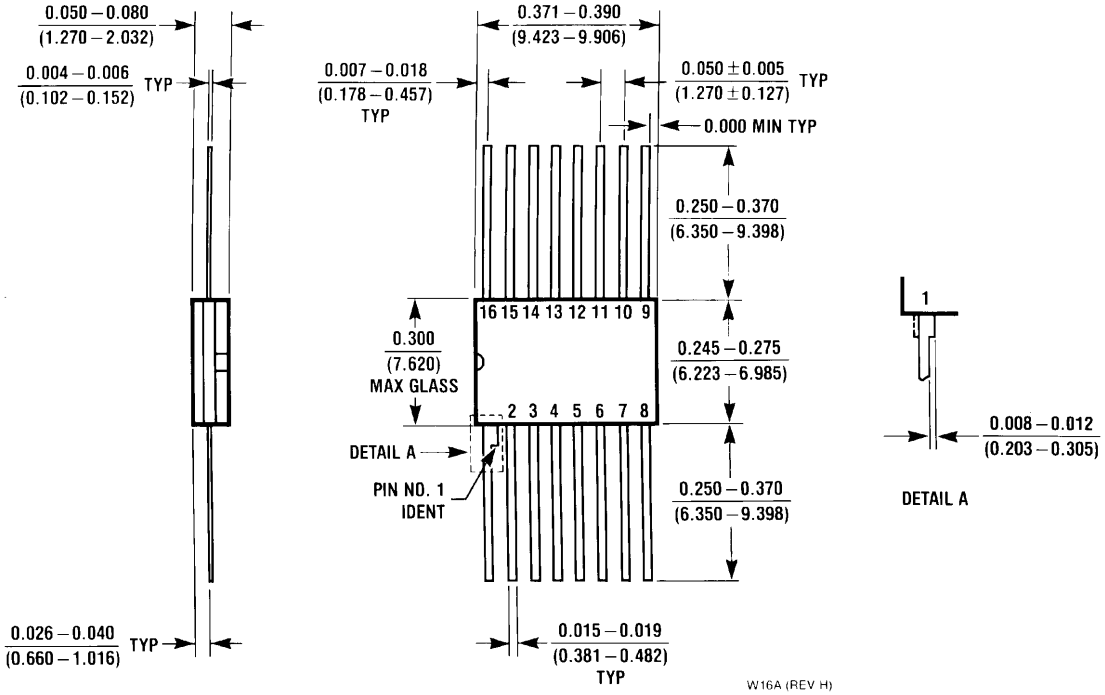
Physical Dimensions inches (millimeters) unless otherwise noted



Ceramic Dual-In-Line Package (J)
Order Number DS78LS120J/883
NS Package Number J16A



Ceramic Dual-In-Line Package (W)
Order Number DS78LS120W/883
NS Package Number W16A

Notes

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