RS data

Line drivers and receivers

Further information on line drivers and receivers is contained in the following books which are available from RS. 'RS232 Made Easy' (902-732) and 'Linear Interface Circuits' (903-690). See current catalogue for details.

1488 Line driver

The 1488 is a quad line driver containing 3 NAND function drivers and one inverting driver. The device meets the specification of the Electronic Industries Association standard RS232C. The 1488 is used to interface data terminals with data communications equipment.

Absolute maximum ratings

(at 25°C unless otherwise noted)

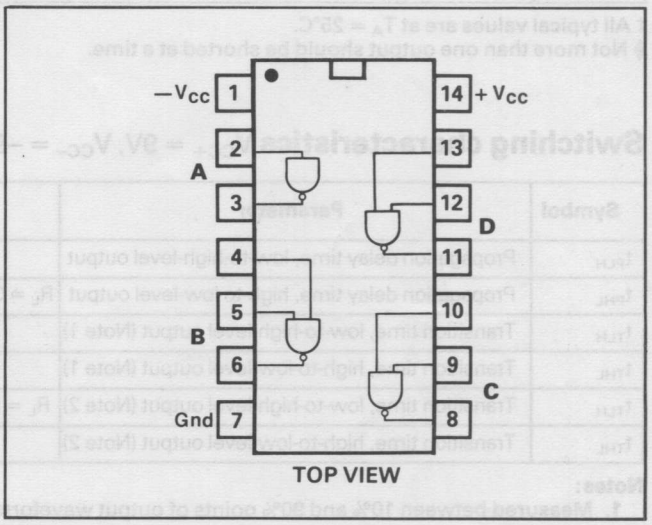
Power supply voltages:

V_{CC+}	+15V
V_{CC-}	−15V
Input voltage range (V_{IR})	−15V dc to +7.0V dc
Output signal voltage	±15V dc
Continuous total power dissipation (see note)	800mW
Operating temperature	0°C to +70°C
Storage temperature	−65°C to +150°C
Maximum lead temperature (soldering, 6 seconds)	260°C

Note:
Above 60°C ambient temperatures, derate linearly at 8.3mW/°C.

Features

- Meets specification of EIA RS232C.
- Current-limited output typically 10mA.
- Minimum power-off output impedance of 300Ω.
- Slew rate control via load capacitor.
- Input compatible with most TTL and DTL circuits.



TOP VIEW

Electrical characteristics

Electrical characteristics over operating free-air temperature range, V_{CC+} = 9V, V_{CC-} = −9V (unless otherwise noted)

Symbol	Parameter	Test Conditions		Min.	Typ.†	Max.	Unit
V_{IH}	High-level input voltage			1.9			V
V_{IL}	Low-level input voltage					0.8	V
V_{OH}	High-level output voltage	V_{IL} = 0.8V, R_L = 3kΩ	V_{CC+} = 9V, V_{CC-} = −9V	6	7		V
			V_{CC+} = 13.2V, V_{CC-} = −13.2V	9	10.5		
V_{OL}	Low-level output voltage	V_{IH} = 1.9V, R_L = 3kΩ	V_{CC+} = 9V V_{CC-} = −9V		−7	−6	V
			V_{CC+} = 13.2V, V_{CC-} = −13.2V		−10.5	−9	
I_{IH}	High-level input current	V_I = 5V				10	μA
I_{IL}	Low-level input current	V_I = 0			−1	−1.6	mA
$I_{OS(H)}$	Short-circuit output current at high level♦	V_I = 0.8V	V_O = 0	−6	−10	−12	mA
$I_{OS(L)}$	Short-circuit output current at low level♦	V_I = 1.9V,	V_O = 0	6	10	12	mA
r_o	Output resistance, power off	V_{CC+} = 0, V_O = −2V to 2V	V_{CC-} = 0,	300			Ω

Electrical characteristics

Electrical characteristics over operating free-air temperature range, $V_{CC+} = 9V$, $V_{CC-} = -9V$ (unless otherwise noted)

Symbol	Parameter	Test Conditions		Min.	Typ.†	Max.	Unit
I_{CC+}	Supply current from V_{CC+}	$V_{CC+} = 9V$, No load	All inputs at 1.9V		15	20	mA
			All inputs at 0.8V		4.5	6	
		$V_{CC+} = 12V$, No load	All inputs at 1.9V		19	25	
			All inputs at 0.8V		5.5	7	
		$V_{CC+} = 15V$, No load, $T_A = 25°C$	All inputs at 1.9V			34	
			All inputs at 0.8V			12	
I_{CC-}	Supply current from V_{CC-}	$V_{CC-} = -9V$, No load	All inputs at 1.9V		–13	–17	mA
			All inputs at 0.8V			–0.015	
		$V_{CC-} = -12V$, No load	All inputs at 1.9V		–18	–23	
			All inputs at 0.8V			–0.015	
		$V_{CC-} = -15V$, No load, $T_A = 25°C$	All inputs at 1.9V			–34	
			All inputs at 0.8V			–2.5	
P_D	Total power dissipation	$V_{CC+} = 9V$, No load	$V_{CC-} = -9V$,			333	mW
		$V_{CC+} = 12V$, No load	$V_{CC-} = -12V$,			576	

† All typical values are at $T_A = 25°C$.

♦ Not more than one output should be shorted at a time.

Switching characteristics $V_{CC+} = 9V$, $V_{CC-} = -9V$, $T_A = 25°C$

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
t_{PLH}	Propagation delay time, low-to-high-level output			220	350	ns
t_{PHL}	Propagation delay time, high-to low-level output	$R_L = 3k\Omega$, $C_L = 15pF$,		100	175	ns
t_{TLH}	Transition time, low-to-high-level output (Note 1)			55	100	ns
t_{THL}	Transition time, high-to-low-level output (Note 1)			45	75	ns
t_{TLH}	Transition time, low-to-high-level output (Note 2)	$R_L = 3k\Omega$ to $7k\Omega$, $C_L = 2500pF$		2.5		μs
t_{THL}	Transition time, high-to-low-level output (Note 2)			3.0		μs

Notes:

1. Measured between 10% and 90% points of output waveform.
2. Measured between +3V and –3V points on the output waveform (EIA RS-232C conditions).

Typical characteristics

Figure 1 **Voltage transfer**

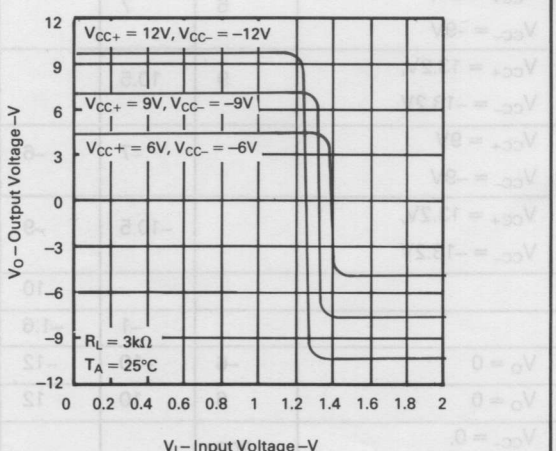


Figure 2 **Output current as a function of output voltage**

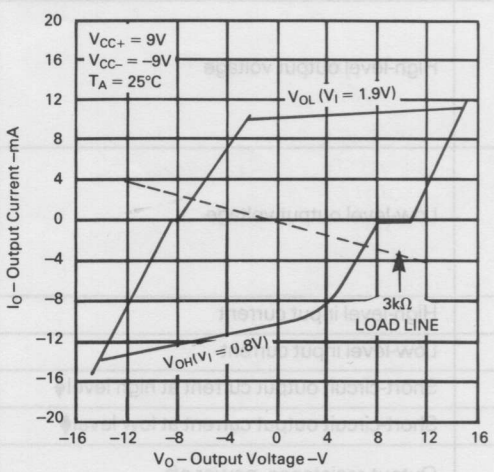
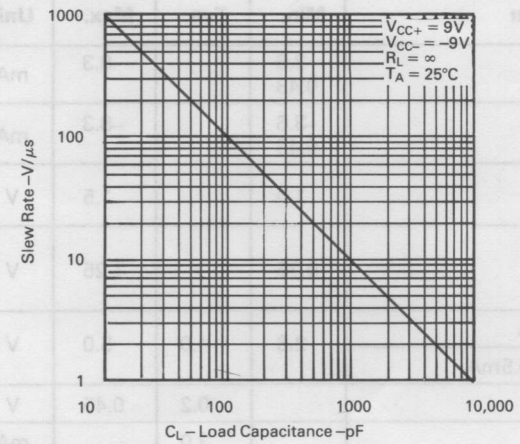
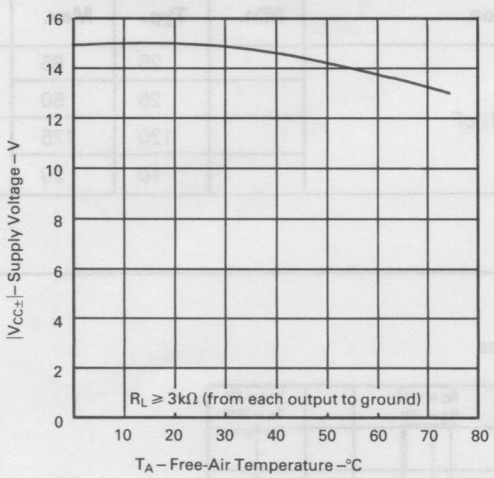


Figure 3 **Slew rate as a function of load capacities**



Thermal characteristics

Figure 4 **Maximum supply voltage as a function of free air temperature**



Typical applications

Figure 5 **Logic translator**

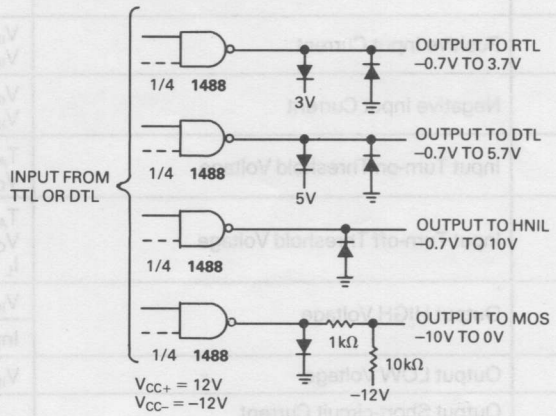
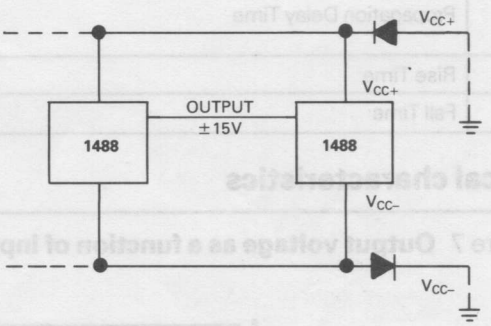


Figure 6 **Power supply protection to meet power-off fault conditions of EIA RS232C**



Diodes placed in series with the V_{CC+} and V_{CC-} leads will protect the 1488 in the fault condition where the device outputs are shorted to ± 15V and the power supplies are at low voltage and provide low-impedance paths to ground.

1489 Line receiver

The 1489 is a quadruple line receiver meeting the requirements of the EIA RS232C standards. A separate response control terminal is provided for each receiver; to shift the input voltage threshold levels via a bias voltage source and/or an external resistor, or to provide input noise filtering via an external capacitor.

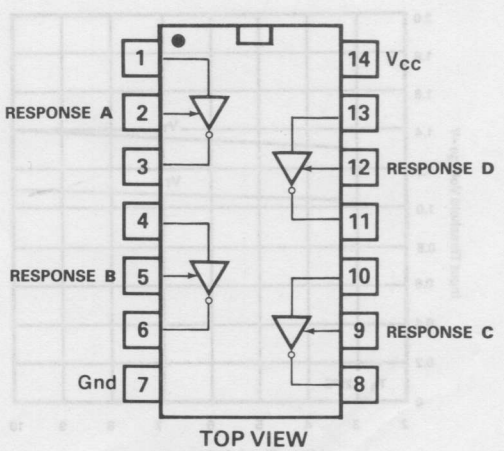
Features

- Meets requirements of EIA RS232C.
- Input resistance 3kΩ to 7kΩ.
- Input signal range ±30V.
- Internal input threshold hysteresis.
- Response control provides:
  Input threshold shifting.
  Input noise filtering.

Absolute maximum ratings

Power supply voltage	+10Vdc
Input voltage range	±30Vdc
Output load current	20mA
Continuous total power dissipation (see note)	800mW
Operating temperature	0°C to 70°C
Storage temperature	–65°C to + 175°C
Maximum lead temperature (soldering, 6 seconds)	260°C

Note:
Above 60°C ambient temperature, derate linearly at 8.3mW/°C.



DC characteristics

V_{CC} = 5.0V ± 1%, response control pin is open, T_A = 0°C to 70°C (unless otherwise noted)

Symbol	Characteristic	Condition	Min.	Typ.	Max.	Unit
I_{IH}	Positive Input Current	V_{IH} = 25V V_{IH} = 3.0V	3.6 0.43		8.3	mA
I_{IL}	Negative Input Current	V_{IL} = –25V V_{IL} = –3.0V	–3.6 –0.43		–8.3	mA
V_{IHL}	Input Turn-on Threshold Voltage	T_A = 25°C, $V_{OL} \leq$ 0.45V	1.0		1.5	V
V_{ILH}	Input Turn-off Threshold Voltage	T_A = 25°C, $V_{OH} \geq$ 2.5V, I_L = –0.5mA	0.75		1.25	V
V_{OH}	Output HIGH Voltage	V_{IH} = 0.75V, I_L = –0.5mA	2.6	4.0	5.0	V
		Input open circuit, I_L = –0.5mA				
V_{OL}	Output LOW Voltage	V_{IL} = 3.0V, I_L = 10mA		0.2	0.45	V
I_{OS}	Output Short-circuit Current			3.0		mA
I_{CC}	Power Supply Current	V_{IH} = 5.0V		20	26	mA
P_C	Power Consumption	V_{IH} = 5.0V		100	130	mW

AC characteristics V_{CC} = 5.0V ± 1%, T_A = 25°C

Symbol	Characteristic	Condition		Min.	Typ.	Max.	Unit
t_{PLH}	Propagation Delay Time	R_L = 3.9kΩ	C_L = 15pF		25	85	ns
t_{PHL}		R_L = 390Ω			25	50	
t_r	Rise Time	R_L = 3.9kΩ			120	175	ns
t_f	Fall Time	R_L = 390Ω			10	20	

Typical characteristics

Figure 7 **Output voltage as a function of input voltage**

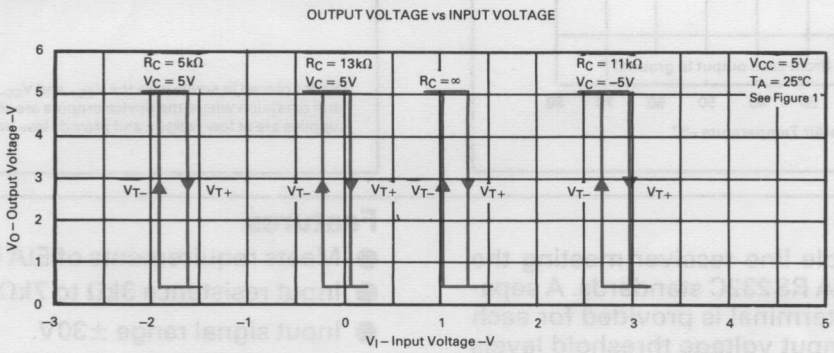


Figure 8 **Input threshold voltage as a function of supply voltage**

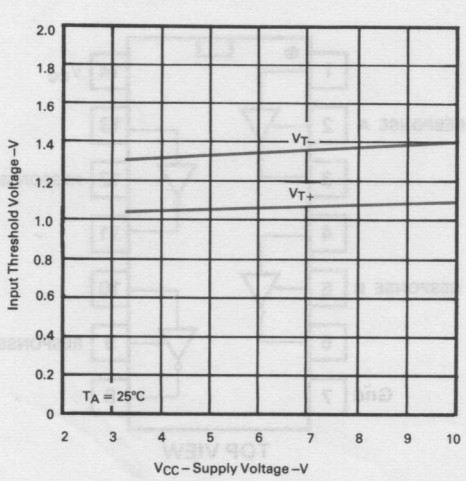


Figure 9 **Input current as a function of input voltage**

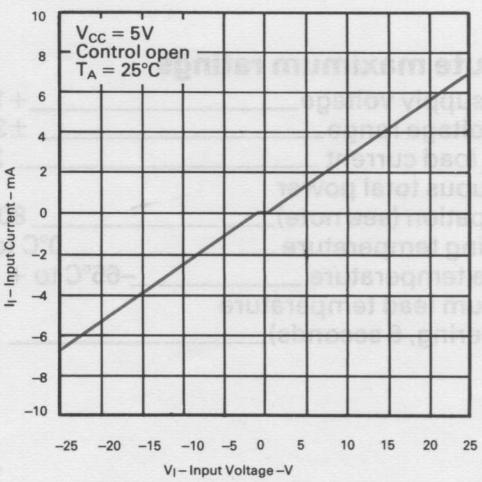
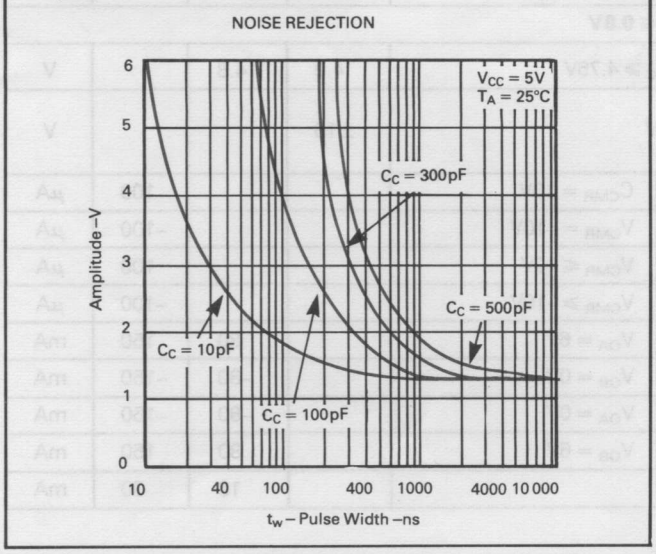
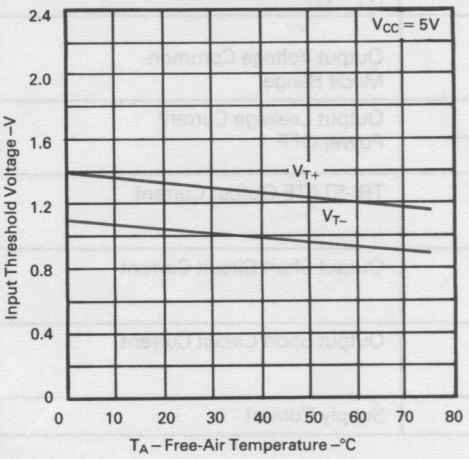


Figure 10 **Noise rejection**



Thermal characteristics

Figure 11 **Input threshold voltage as a function of free-air temperatire**



3691 Line driver

The 3691 is a low power Schottky TTL line driver meeting the requirements of EIA RS422 and RS423. The device features four buffered outputs with high source and sink current capability, plus internal short circuit protection. A mode control input provides a choice of operation either as four independent line drivers or two differential line drivers. A rise time control pin allows the use of an external capacitor to reduce rise time for suppression of near end cross talk to other receivers in the cable.

Features

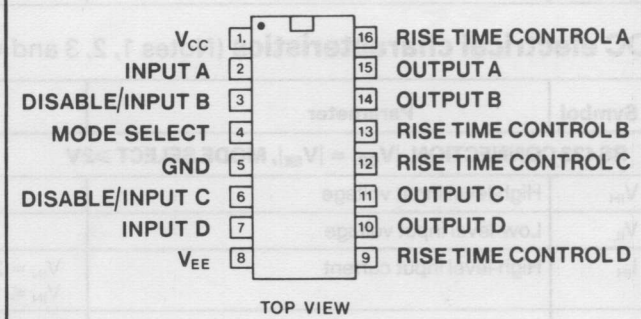
- Dual RS422 line driver with mode pin low, or quad RS423 line driver with mode pin high.
- Short circuit protection for both source and sink inputs.
- Individual rise time control for each output.
- 100Ω transmission line drive capability.
- TTL, MOS and CMOS compatible inputs.

Absolute maximum ratings

Supply voltage:

V_{CC}	7V
V_{EE}	–7V
Maximum power dissipation at 25°C (see note)	1476mW
Input voltage	15V
Output voltage (power OFF)	±15V
Storage temperature	–65°C to +150°C
Lead temperature (soldering, 10 seconds)	300°C

Note:
Above 25°C, derate linearly at 11.9mW/°C.



DC electrical characteristics (Notes 1, 2, 3 and 4)

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
RS-422 CONNECTION, V_{EE} CONNECTION TO GROUND, MODE SELECT ≤ 0.8V							
V_{IH}	High Level Input Voltage			2			V
V_{IL}	Low Level Input Voltage					0.8	V
I_{IH}	High Level Input Current	V_{IN} = 2.4V			1	40	μA
		V_{IN} ≤ 15V			10	100	μA
I_{IL}	Low Level Input Current	V_{IN} = 0.4V			–30	–200	μA
V_I	Input Clamp Voltage	I_{IN} = –12mA				–1.5	V
V_O	Differential Output Voltage	R_L = ∞	V_{IN} = 2V		3.6	6.0	V
$\overline{V_O}$	$V_{A,B}$		V_{IN} = 0.8V		–3.6	–6.0	V
V_T	Differential Output Voltage	R_L = 100Ω	V_{IN} = 2V	2	2.4		V
$\overline{V_T}$	$V_{A,B}$	V_{CC} ≥ 4.75V	V_{IN} = 0.8V	–2	–2.4		V
V_{OS}, $\overline{V_{OS}}$	Common-Mode Offset Voltage	R_L = 100Ω			2.5	3	V
$\lvert V_T\rvert - \lvert\overline{V_T}\rvert$	Difference in Differential Output Voltage	R_L = 100Ω			0.05	0.4	V
$\lvert V_{OS}\rvert - \lvert\overline{V_{OS}}\rvert$	Difference in Common-Mode Offset Voltage	R_L = 100Ω			0.05	0.4	V

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
RS-422 CONNECTION, V_{EE} CONNECTION TO GROUND, MODE SELECT ≤ 0.8V							
V_{SS}	$\|V_T - V_T\|$	$R_L = 100\Omega$, $V_{CC} \geq 4.75V$		4.0	4.8		V
V_{CMR}	Output Voltage Common-Mode Range	$V_{DISABLE} = 2.4V$		±10			V
I_{XA}	Output Leakage Current Power OFF	$V_{CC} = 0V$	$C_{CMR} = 10V$			100	μA
I_{XB}			$V_{CMR} = -10V$			-100	μA
I_{OX}	TRI-STATE Output Current	V_{CC} = Max	$V_{CMR} \leq 10V$			100	μA
			$V_{CMR} \geq -10V$			-100	μA
I_{SA}	Output Short Circuit Current	$V_{IN} = 2.4V$	$V_{OA} = 6V$		80	150	mA
			$V_{OB} = 0V$		-80	-150	mA
I_{SB}	Output Short Circuit Current	$V_{IN} = 0.4V$	$V_{OA} = 0V$		-80	-150	mA
			$V_{OB} = 6V$		80	150	mA
I_{CC}	Supply Current				18	30	mA

AC electrical characteristics $T_A = 25°C$

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
RS422 CONNECTION, V_{CC} = 5V, MODE SELECT = 0.8V						
t_r	Output rise time	$R_L = 100\Omega$, $C_L = 500pF$		120	200	ns
t_f	Output fall time	$R_L = 100\Omega$, $C_L = 500pF$		120	200	ns
t_{PDH}	Output propagation delay	$R_L = 100\Omega$, $C_L = 500pF$		120	200	ns
t_{PDL}	Output propagation delay	$R_L = 100\Omega$, $C_L = 500pF$		120	200	ns
t_{PZL}	TRI-STATE delay	$R_L = 450\Omega$, $C_L = 500pF$ $C_C = 0pF$		250	350	ns
t_{PZH}	TRI-STATE delay	$R_L = 450\Omega$, $C_L = 500pF$, $C_C = 0pF$		180	300	ns
t_{PLZ}	TRISTATE delay	$R_L = 450\Omega$, $C_L = 500pF$, $C_C = 0pF$		180	300	ns
t_{PHZ}	TRI-STATE delay	$R_L = 450\Omega$, $C_L = 500pF$, $C_C = 0pF$		250	350	ns

DC electrical characteristics (Notes 1, 2, 3 and 4)

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
RS423 CONNECTION, $\|V_{CC}\| = \|V_{EE}\|$, MODE SELECT ≥2V							
V_{IH}	High-level input voltage			2			V
V_{IL}	Low-level input voltage					0.8	V
I_{IH}	High-level input current	$V_{IN} = 2.4V$			1	40	μA
		$V_{IN} \leq 15V$			10	100	μA
I_{IL}	Low level input current	$V_{IN} = 0.4V$			-30	-200	μA
V_I	Input clamp voltage	$I_{IN} = -12mA$				-1.5	V
V_O	Output voltage	$R_L = \infty$ $V_{CC} \geq 4.75V$	$V_{IN} = 2V$	4.0	4.4	6.0	V
V_O			$V_{IN} = 0.4V$	-4.0	-4.4	-6.0	V
V_T	Output voltage	$R_L = 450\Omega$ $V_{CC} \geq 4.75V$	$V_{IN} = 2.4V$	3.6	4.1		V
V_T			$V_{IN} = 0.4V$	-3.6	-4.1		V
$\|V_T\| - \|\overline{V_T}\|$	Output unbalance	$\|V_{CC}\| = \|V_{EE}\| = 4.75V$, $R_L = 450\Omega$			0.02	0.4	V
I_X^+	Output leakage power OFF	$V_{CC} = V_{EE} = 0V$	$V_O = 6V$		2	100	μA
I_X^-	Output leakage power OFF	$V_{CC} = V_{EE} = 0V$	$V_O = -6V$		-2	-100	μA
I_S^+	Output short circuit current	$V_O = 0V$	$V_{IN} = 2.4V$		-80	-150	mA
I_S	Output short circuit current	$V_O = 0V$	$V_{IN} = 0.4V$		80	150	mA
I_{SLEW}	Slew control current				±140		μA
I_{CC}	Positive supply current	$V_{IN} = 0.4V$, $R_L = \infty$			18	30	mA
I_{EE}	Negative supply current	$V_{IN} = 0.4V$, $R_L = \infty$			-10	-22	mA

Notes:

1. Unless otherwise specified, min/max limits apply across the 0°C to +70°C range for the 3691. All typicals are given for V_{CC} = 5V and T_A = 25°C. V_{CC} and V_{EE} as listed in operating conditions.
2. All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to ground unless otherwise specified.
3. Only one output at a time should be shorted.
4. Symbols and definitions correspond to EIA RS422 and/or RS423 where applicable.

AC electrical characteristics $T_A = 25°C$

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
RS423 CONNECTION, $V_{CC} = 5V$, $V_{EE} -5V$, MODE SELECT = 2.4V						
t_r	Rise time	$R_L = 450\Omega$, $C_L = 500pF$, $C_C = 0$		120	300	ns
t_f	Fall time	$R_L = 450\Omega$, $C_L = 500pF$, $C_C = 0$		120	300	ns
t_r	Rise time	$R_L = 450\Omega$, $C_L = 500pF$, $C_C = 50pF$		3.0		μs
t_f	Fall time	$R_L = 450\Omega$, $C_L = 500pF$, $C_C = 50pF$		3.0		μs
t_{rc}	Rise time coefficient	$R_L = 450\Omega$, $C_L = 500pF$, $C_C = 50pF$		0.06		μs/pF
t_{PDH}	Output propagation delay	$R_L = 450\Omega$, $C_L = 500pF$, $C_C = 0$		180	300	ns
t_{PDL}	Output propagation delay	$R_L = 450\Omega$, $C_L = 500pF$, $C_C = 0$		180	300	ns

Typical characteristics

Figure 12 **Switching waveforms**

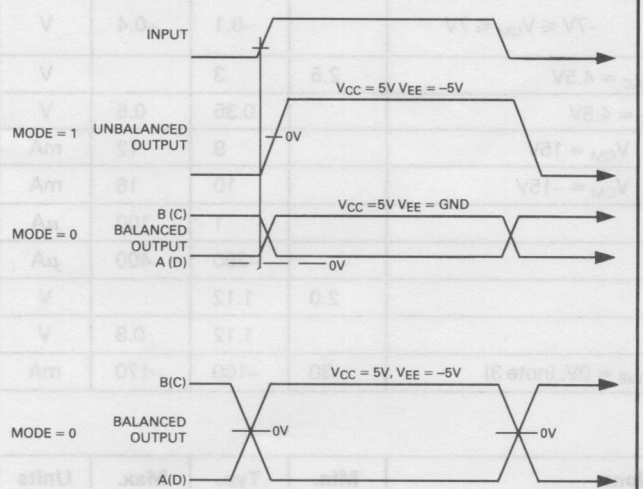
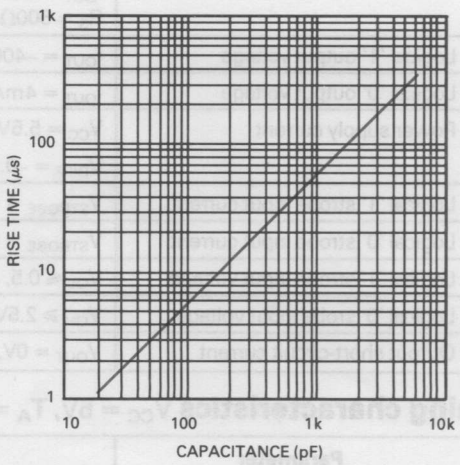


Figure 13 **Rise time as a function of external capacitor**

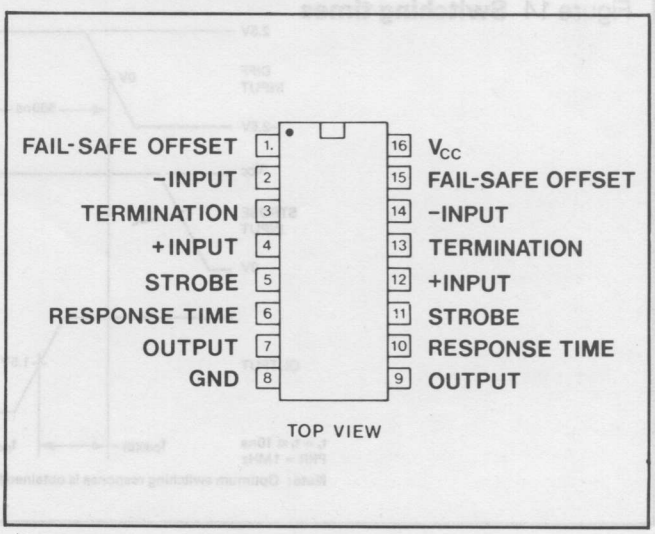


88LS120 Line receiver

The 88LS120 is a dual differential, TTL compatible, line receiver for both balanced and unbalanced data transmission. The device features hysteresis and a 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 protection, should the input be open or short circuited. Each receiver includes an optional 180Ω terminating resistor and the output gate contains a logic strobe for time discrimination.

Features

- Meets specifications of RS232C, RS422 and RS423
- Input voltage range of ±15V.
- Separate strobe input for each receiver.
- Input impedance typically 5kΩ.
- Input hysteresis 50mV.
- Separate fail-safe mode.



Absolute maximum ratings

Supply voltage	7V
Input voltage	±25V
Strobe voltage	7V
Output sink current	50mA
Maximum power dissipation at 25°C (see note)	1362mW

Note:
Above 25°C, derate linearly at 10.9mW/°C.

Electrical characteristics (Notes 1 and 2)

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Units
V_{TH}	Differential threshold voltage	$I_{OUT} = -400\mu A$, $V_{OUT} \geq 2.5V$	$-7V \leq V_{CM} \leq 7V$		0.06	0.2	V
			$-15V \leq V_{CM} \leq 15V$		0.06	0.3	V
V_{TL}	Differential threshold voltage	$I_{OUT} = 4mA$, $V_{OUT} \leq 0.5V$	$-7V \leq V_{CM} \leq 7V$		-0.08	-0.2	V
			$-15V \leq V_{CM} \leq 15V$		-0.08	-0.3	V
V_{TH}	Differential threshold voltage	$I_{OUT} = -400\mu A$, $V_{OUT} \geq 2.5V$	$-7V \leq V_{CM} \leq 7V$		0.47	0.7	V
V_{TL}	With fall safe offset = 5V	$I_{OUT} = 4mA$, $V_{OUT} \leq 0.5V$	$-7V \leq V_{CM} \leq 7V$	-0.2	-0.42		V
R_{IN}	Input resistance	$-15V \leq V_{CM} \leq 15V$, $0V \leq V_{CC} \leq 7V$		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)	$V_{CM} = 10V$	$0V \leq V_{CC} \leq 7V$		2	3.1	mA
		$V_{CM} = 0V$			0	-0.5	mA
		$V_{CM} = -10V$			-2	-3.1	mA
V_{THB}	Input balance	$I_{OUT} = -400\mu A$, $V_{OUT} \geq 2.5V$, $R_S = 500\Omega$	$-7V \leq V_{CM} \leq 7V$		-0.1	-0.4	V
		$I_{OUT} = 4mA$, $V_{OUT} \leq 0.5V$, $R_S = 500\Omega$	$-7V \leq V_{CM} \leq 7V$		-0.1	-0.4	V
V_{OH}	Logical '1' output voltage	$I_{OUT} = -400\mu A$, $V_{DIFF} = 1V$, $V_{CC} = 4.5V$		2.5	3		V
V_{OL}	Logical '0' output voltage	$I_{OUT} = 4mA$, $V_{DIFF} = -1V$, $V_{CC} = 4.5V$			0.35	0.5	V
I_{CC}	Power supply current	$V_{CC} = 5.5V$,	$V_{CM} = 15V$		9	12	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' srobe input voltage	$V_{OH} \geq 2.5V$, $I_{OUT} = -400\mu A$			1.12	0.8	V
I_{OS}	Output short-circuit current	$V_{OUT} = 0V$, $V_{CC} = 5.5V$, $V_{STROBE} = 0V$, (note 3)		-30	-100	-170	mA

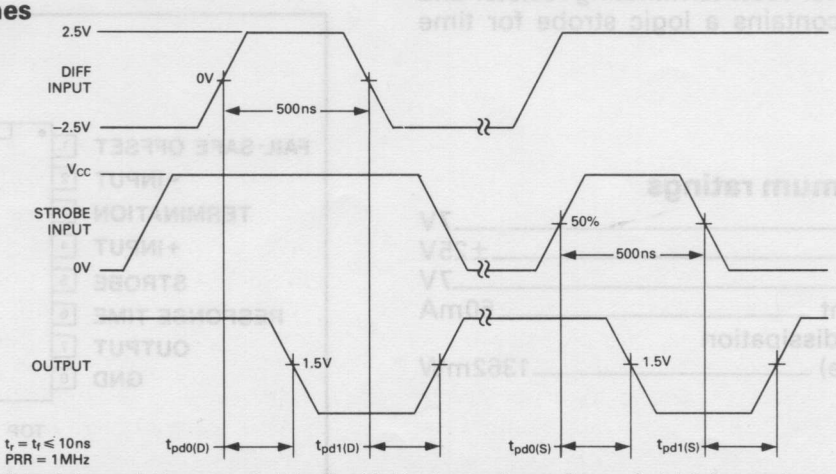
Switching characteristics $V_{CC} = 5V$, $T_A = 25°C$

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
$t_{pd0(D)}$	Differential input '0' output	Response pin open, $C_L = 15pF$, $R_L = 2k\Omega$		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

Note:

1. Unless otherwise specified min/max limits apply across the 0°C to +70°C for the 88LS120. All typical values are for $T_A = 25°C$, $V_{CC} = 5V$ and $V_{CM} = 0V$.
2. 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.
3. Only one output at a time should be shorted.

Figure 14 **Switching times**



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

Applications

Figure 15 **Balanced data transmission**

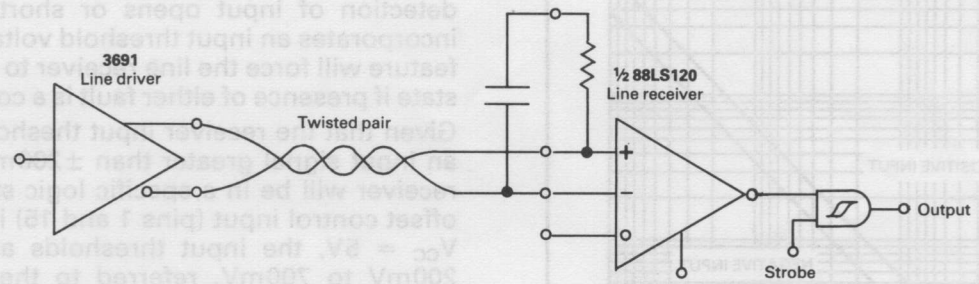
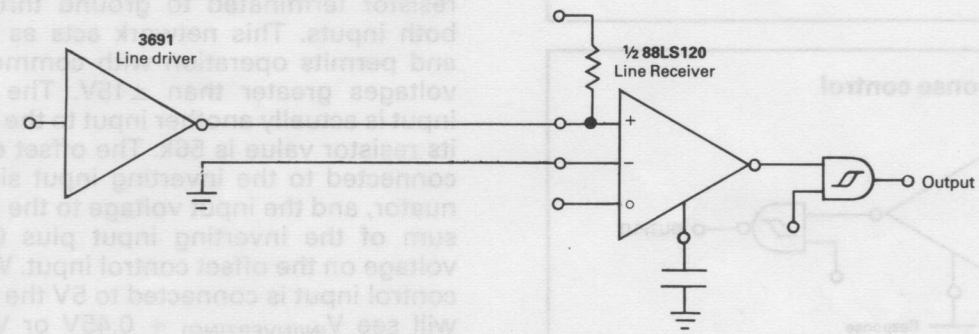
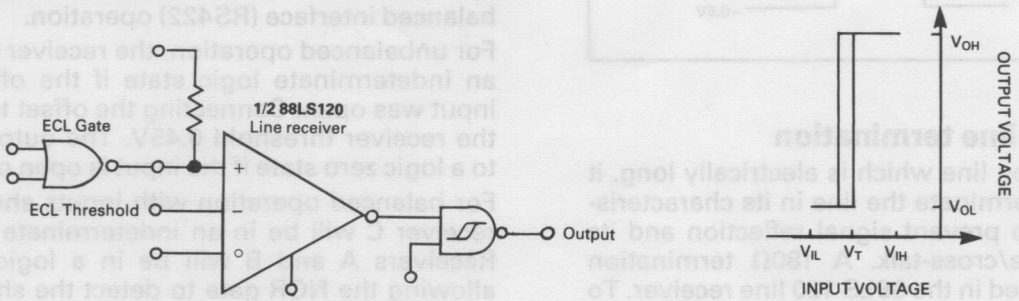


Figure 16 **Unbalanced data transmission**



The 88LS120 may be used as a level translator 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.

Figure 17 **Logic level translator**



Transmission line techniques

Response control and hysteresis

In unbalanced (RS232/RS423) 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 88LS120 by the 50mV 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 50mV can be reduced in amplitude by filtering the device input. On the 88LS120 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 versus the value of the response control capacitor is shown in Figures 18 and 19. This combination of filters followed by hysteresis will optimise performance in a worse case noise environment.

Figure 18 **Noise pulse width as a function of response control capacitor**

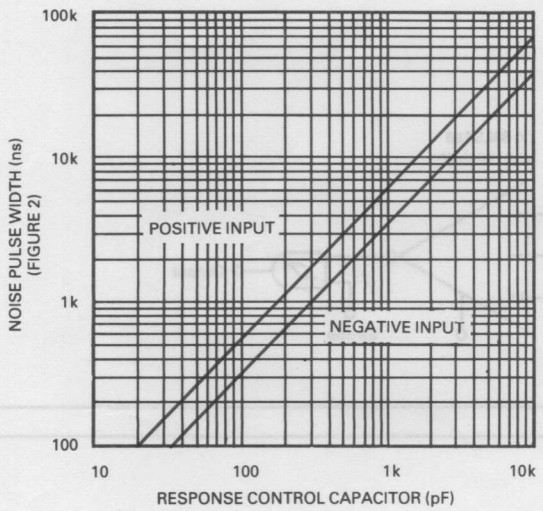
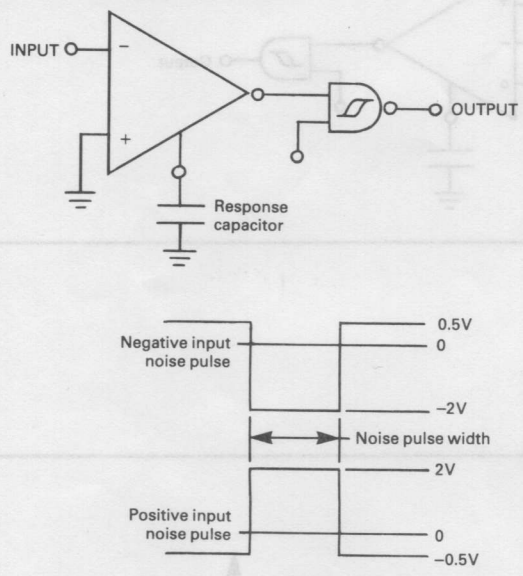


Figure 19 **Response control**



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 88LS 120 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 minimise 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 1000 feet long, (approximately 1000ns), and the termination resistor value is 180Ω, the capacitor value should be 1852pF.

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 shorts. To facilitate the detection of input opens or short, the 88LS120 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 theshold is ±200mV, an input signal greater than ±200mV ensures 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 200mV to 700mV, referred to the non-inverting input, or −200mV to −700mV, referred to the inverting input. Therefore, if the input is open or short, 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 ensure it will detect an open circuit in the presence of noise.

The offset control can be used to ensure fail-safe operation for unbalanced interface (RS423) or for balanced interface (RS422) operation.

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

For balanced operation with inputs short or open, 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 short or open 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 the 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.

Figure 20 **Unbalanced RS423 and RS232 Fail-safe**

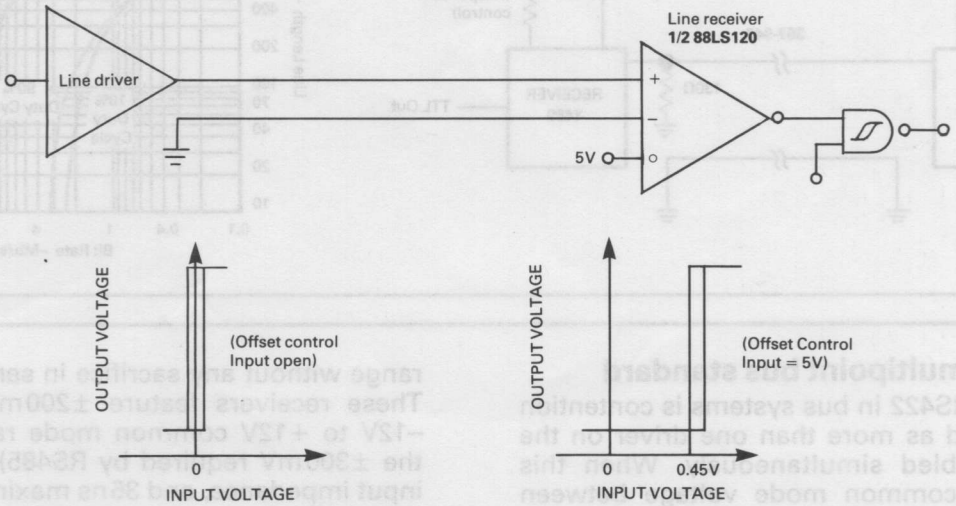
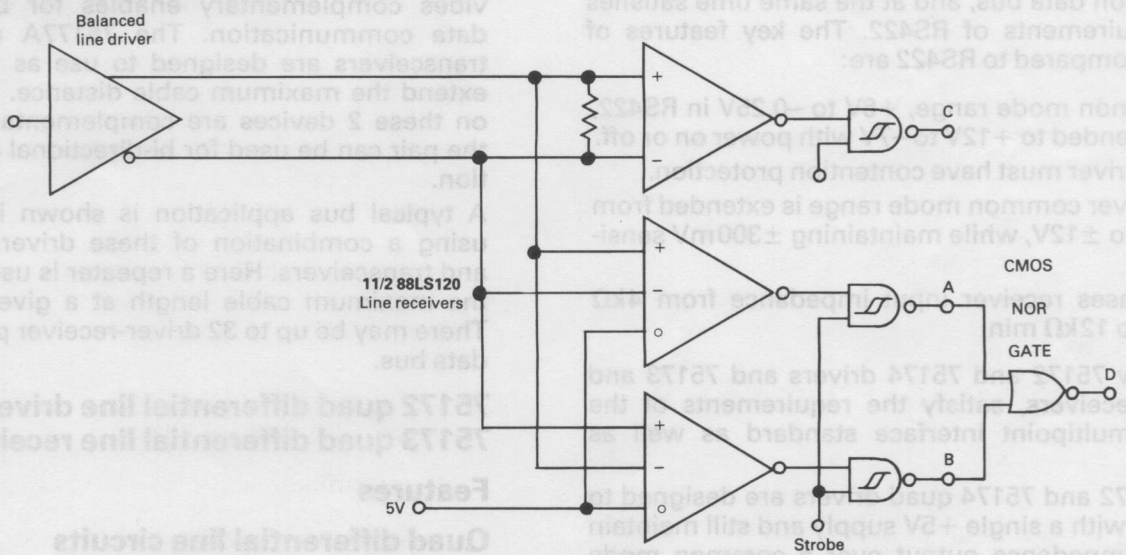
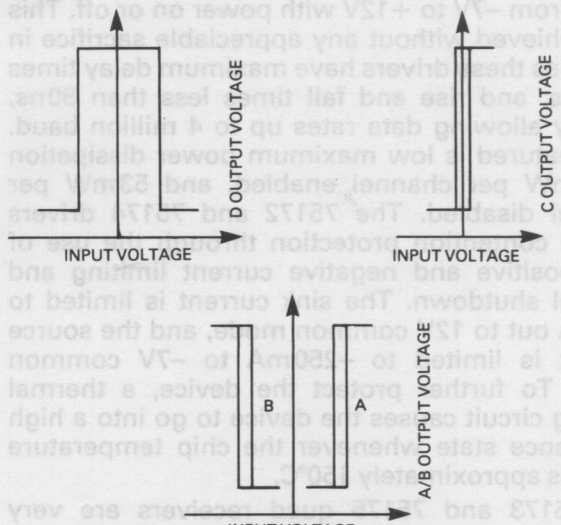


Figure 21 **Balanced RS422 Fail-safe**

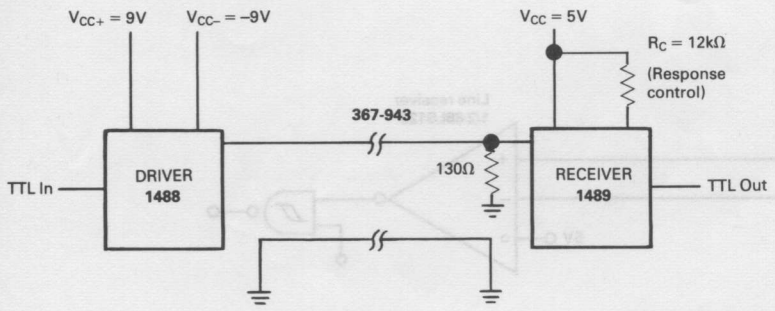


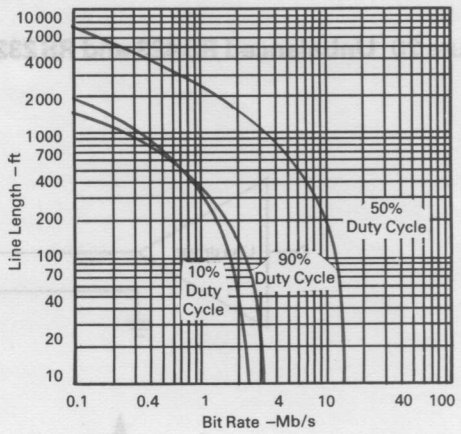


Truth table (for balanced fail-safe)

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

Figure 22 **Line length capability as a function of bit rate**





RS485: New multipoint bus standard

A limitation of RS422 in bus systems is contention which is defined as more than one driver on the bus being enabled simultaneously. When this occurs with a common mode voltage between drivers, appreciable current can result in excessive power dissipation and possible destruction of the driver. There are no constraints on the RS422 driver to protect it from destruction under these conditions. EIA has defined a new standard, RS485, patterned after RS422 and specified for multipoint interface. It allows up to 32 driver-receiver pairs on a common data bus, and at the same time satisfies the requirements of RS422. The key features of RS485 compared to RS422 are:

- Common mode range, +6V to −0.25V in RS422, is extended to +12V to −7V with power on or off.
- The driver must have contention protection.
- Receiver common mode range is extended from ±7V to ±12V, while maintaining ±300mV sensitivity.
- Increases receiver input impedance from 4kΩ min to 12kΩ min.

The new 75172 and 75174 drivers and 75173 and 75175 receivers, satisfy the requirements of the RS485 multipoint interface standard as well as RS422.

The 75172 and 75174 quad drivers are designed to operate with a single +5V supply and still maintain a high impedance output over a common mode range from −7V to +12V with power on or off. This was achieved without any appreciable sacrifice in speed, as these drivers have maximum delay times of 65ns, and rise and fall times less than 80ns, thereby allowing data rates up to 4 million baud. Also featured is low maximum power dissipation of 79mW per channel enabled, and 53mW per channel disabled. The 75172 and 75174 drivers feature contention protection through the use of both positive and negative current limiting and thermal shutdown. The sink current is limited to 500mA out to 12V common mode, and the source current is limited to −250mA to −7V common mode. To further protect the device, a thermal sensing circuit causes the device to go into a high impedance state whenever the chip temperature exceeds approximately 150°C.

The 75173 and 75175 quad receivers are very similar to existing RS422 receivers, but have higher input impedance and extended common mode range without any sacrifice in sensitivity or speed. These receivers feature ±200mV sensivity over −12V to +12V common mode range (better than the ±300mV required by RS485), 12kΩ minimum input impedance, and 35ns maximum propagation delay: 50mV hysteresis is incorporated in the receiver for increased noise margin.

In addition to the 75172, 75173, 75174 and 75175 quad drivers and receivers, the 75176A transceiver combines a single 75172 driver and 75173 receiver in an 8-pin package. This device internally connects the driver outputs to the receiver inputs, and provides complementary enables for bi-directional data communication. The 75177A and 75178A transceivers are designed to use as repeaters to extend the maximum cable distance. The enables on these 2 devices are complementary such that the pair can be used for bi-directional communication.

A typical bus application is shown in Figure 23 using a combination of these drivers, receivers, and transceivers. Here a repeater is used to extend the maximum cable length at a given data rate. There may be up to 32 driver-receiver pairs on each data bus.

75172 quad differential line driver
75173 quad differential line receiver

Features

Quad differential line circuits

- Meets EIA standards RS485, RS422A and CCITT Recommendations V.11 and X.27
- Designed for multipoint bus transmission
- Positive and negative common mode range
- Single +5V supply
- 3-state outputs
- Fast switching speeds
- Long bus lines to 1200m
- Low power requirements
- Active high and active low enables
- Pin compatible with AM26LS31 and AM26LS32.

Additional 75172 driver features

- High output impedance in 3-state or with power off over +12V to −7V common mode range
- Thermal shutdown protection
- Positive and negative current limiting
- Very low disabled power.

Additional 75173 receiver features

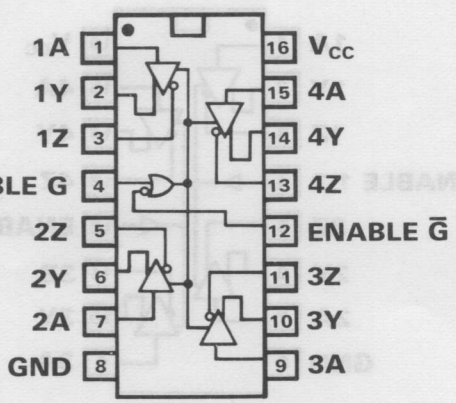
- ±200mV sensitivity over ±12V to –12V common mode range
- 12kΩ minimum input impedance
- 50mV input hysteresis.

Description

The 75172 driver and 75173 receiver designed to meet EIA standards RS485 and RS422, are optimised for balanced multipoint data bus transmission at data rates up to 4M bits and over distances up to 1200m. The high positive and negative common mode range of both the driver and receiver make the pair very suitable for party line applications in noisy environments. The 75172 driver features protection from line fault conditions and contention of multiple drivers on the line simultaneously. This is achieved through both positive and negative current limiting as well as thermal shutdown.

The 75173 receiver features input sensitivity of ±200mV over common mode range +12V to –12V, in addition to hysteresis for increased noise immunity.

75172



TOP VIEW

75172 function table

Inputs			Outputs	
A	G	$\overline{G}$	Y	Z
H	H	X	H	L
L	H	X	L	H
H	X	L	H	L
L	X	L	L	H
X	L	H	Z	Z

Absolute maximum ratings

Supply voltage, V_{CC} ——— 7V
Input voltage ——— 5.5V
Continuous total power dissipation
at 25°C ——— 1150mW
Operating free air temperature ——— 0°C to +70°C

Recommended operating conditions

	Min	Max
Supply voltage, V_{CC}	4.75V	5.25V
Common mode output voltage	–7.0V	+12.0V
High-level output current, I_{OH}		–60mA
Low-level output current, I_{OL}		60mA
Operating free air temperature, T_A	0°C	+70°C

Notes

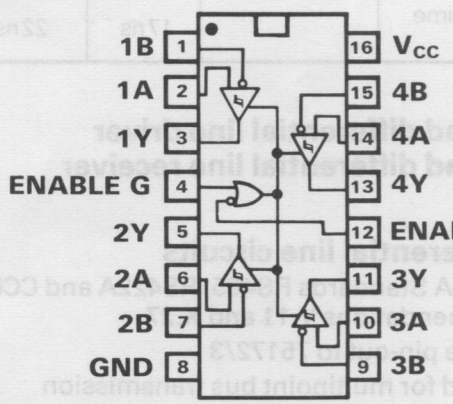
1. All voltage values are with respect to network ground terminal.
2. For operation above 25°C T_A, derate at 9.3mW°C.

75172 switching characteristics

(T_A = 25°C, V_{CC} = 5.0V)

Parameter	Conditions	Typ	Max
t_{PLH} Prop delay low to high	R_L = 27Ω	16ns	25ns
t_{PHL} Prop delay high to low	C_L = 15pF	44ns	65ns
t_{PLZ} Disable time from low		18ns	30ns
t_{PHZ} Disable time from high	I_O = ±33mA	51ns	75ns
t_{PZL} Enable time to low	C_L = 50pF	30ns	45ns
t_{PZH} Enable time to high		60ns	80ns

75173



TOP VIEW

75173 function table

Inputs			Outputs
A-B	G	$\overline{G}$	Y
≥0.2V	H	X	H
	X	L	H
≥0.2V	H	X	L
	X	L	L
X	L	H	Z

Absolute maximum ratings

Supply voltage, V_{CC} 7V
Common mode input voltage ..... ±25V
Differential input voltage ..... ±25V
Enable input voltage 7V
Continuous total power dissipation at 25°C 1150mW

Recommended operating conditions

	Min	Max
Supply voltage	4.75V	5.25V
Common mode input voltage	–12V	+12V
Differential input voltage	–12V	+12V
High-level output current I_{OH}		–400μA
Low-level output current		+16mA
Operating free air temperature, T_A	0°C	+70°C

75173 switching characteristics

(T_A = 25°C, V_{CC} = 5.0V)

Parameter	Conditions	Typ	Max
t_{PLH} Prop delay low to high	V_{ID} = –2.5V to +2.5V	20ns	35ns
t_{PHL} Prop delay high to low	C_L = 15pF	22ns	35ns
t_{PLZ} Disable time from low	C_L = 50pF	30ns	40ns
t_{PHZ} Disable time from high		21ns	30ns
t_{PZL} Enable time to low		18ns	25ns
t_{PZH} Enable time to high		17ns	22ns

75174 quad differential line driver
75175 quad differential line receiver

Features:
Quad differential line circuits

- Meets EIA Standards RS485, RS422A and CCITT. Recommendations V.11 and X.27
- Alternate pin-out to 75172/3
- Designed for multipoint bus transmission
- Positive and negative common mode range
- Single +5V supply
- 3-state outputs
- Fast switching speeds
- Long bus lines to 1200m
- Low power requirements
- Two independent active high enables, each common to 2 channels
- Pin compatible with MC3486 and MC3487.

Additional 75174 driver features

- High output impedance in 3-state or with power off over +12V to –7V common mode range
- Thermal shutdown protection
- Positive and negative current limiting
- Very low disabled power.

Additional 75175 receiver features

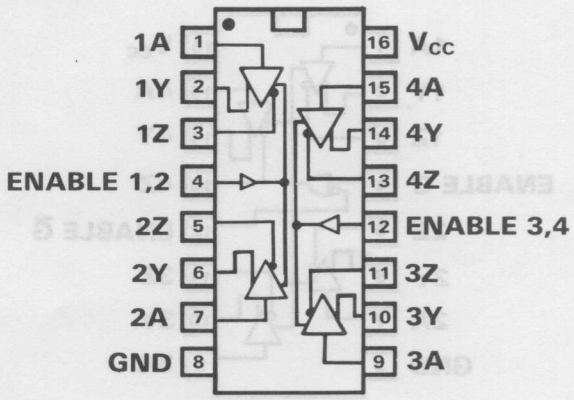
- +200mV sensitivity over +12V to –12V common mode range
- 12kΩ minimum input impedance
- 50mV input hysteresis.

Description

The 75174 driver and 75175 receiver designed to meet EIA standards RS485 and RS422, are optimised for balanced multipoint data bus transmission at data rates up to 4M bits and over distances up to 1200m. The high positive and negative common mode range of both the driver and receiver make the pair very suitable for party line applications in noisy environments. The 75174 driver features protection from line fault conditions and contention of multiple drivers on the line simultaneously. This is achieved through both positive and negative current limiting as well as thermal shutdown.

The 75175 receiver features input sensitivity of ±200mV over common mode range +12V to –12V, in addition to hysteresis for increased noise immunity.

75174



TOP VIEW

75174 function table

Inputs		Outputs	
A	E	Y	Z
H	H	H	L
L	H	L	H
X	L	Z	Z

Absolute maximum ratings

Supply voltage, V_{CC} 7V
Input voltage 5.5V
Continuous total power dissipation at 25°C 1150mW
Operating free-air temperature ..... 0°C to +70°C

Recommended operating conditions

	Min	Max
Supply voltage, V_{CC}	4.75V	5.25V
Common mode output voltage	–7.0V	+12.0V
High-level output current, I_{OH}		60mA
Low-level output current, I_{OL}		60mA
Operating free-air temperature, T_A	0°C	+70°C

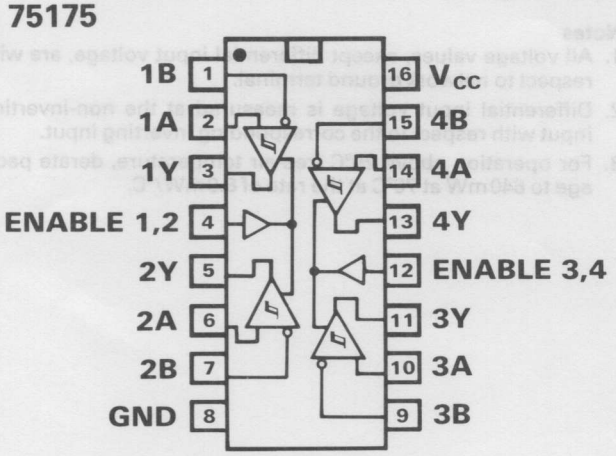
Notes
1. All voltage values are with respect to network ground terminal.
2. For operation above 25°C T_A, derate at 9.3mW/°C.

75174 switching characteristics

(T_A = 25°C, V_{CC} = 5V)

Parameter	Conditions	Typ	Max
t_{PLH} Prop delay low to high	R_L = 27Ω	16ns	25ns
t_{PHL} Prop delay high to low	C_L = 15pF	44ns	65ns
t_{PLZ} Disable time from low		18ns	30ns
t_{PHZ} Disable time from high	C_L = 50pF	51ns	75ns
t_{PZL} Enable time to low	I_O = ±33mA	30ns	45ns
t_{PZH} Enable Time to high		60ns	80ns

75175



TOP VIEW

75175 function table

Inputs		Outputs
A-B	E	Y
≥0.2V	H	H
≤0.2V	H	L
X	L	Z

Absolute maximum ratings

Supply voltage, V_{CC} ——— 7V
Common mode input voltage ——— ±25V
Differential input voltage ——— ±25V
Enable input voltage ——— 7V
Continuous total power dissipation at 25°C ——— 1150mW

Recommended operating conditions

	Min	Max
Supply voltage	4.75V	5.25V
Common mode input voltage	–12V	+12V
Differential input voltage	–12V	+12V
High-level output current, I_{OH}		–400μA
Low-level output current		+16mA
Operating free-air temperature, T_A	0°C	+70°C

75175 switching characteristics

(T_A = 25°C, V_{CC} = 5V)

Parameter	Conditions	Typ	Max
t_{PLH} Prop delay low to high	C_L = 15pF	22ns	35ns
t_{PHL} Prop delay high to low		25ns	35ns
t_{PLZ} Disable time from low		25ns	35ns
t_{PHZ} Disable time from high		25ns	35ns
t_{PZL} Enable time to low		18ns	30ns
t_{PZH} Enable time to high		13ns	30ns

75176, 75177, 75178 Differential bus transceivers/repeaters

Features:

- Meets EIA Standards RS485, RS422A and CCITT Recommendations V.11 and X.27
- Designed for Multipoint Transmission on long bus lines in noisy environments
- Bus voltage range –7V to +12V
- Driver terminal shutdown protection
- Positive and negative current limiting
- Driver output capability 60mA max
- Receiver input sensitivity ±200mV
- Receiver input impedance 12kΩ min
- Receiver input hysteresis 50mV typ
- Operates from a single 5V supply
- Low power requirements 50mA max

Description

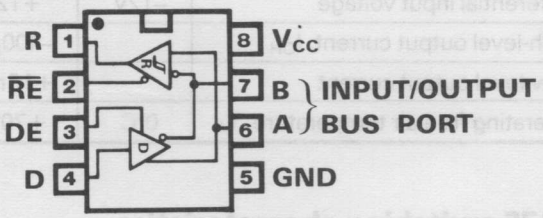
The 75176A transceiver and 75177A, 75178A repeaters are designed to meet EIA standards RS485, RS422A and CCITT recommendations V.11 and X.27, with extended positive and negative common mode range for bus applications. The 75176A transceiver is capable of transmitting and receiving data at rates up to 4M bits/second and over distances up to 1200m. If distances over 1200m are

required, the 75177A and 75178A repeaters can be used as a pair for bi-directional communication, or individually for one way communication.

With the 75176A transceiver, the $\overline{RE}$ and DE inputs can be connected together to use as a direction control input, or used individually for independent control of the driver and receiver.

The 75177A and 75178A enable inputs are complementary so that when paired and connected together, this pin serves as a direction control for bi-directional communication.

75176A



TOP VIEW

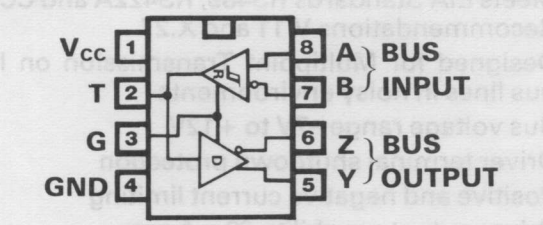
75176A transmitting

Input	Enable	Outputs
D	DE	A B
H	H	H L
L	H	L H
X	L	Z Z

75176A receiving

Differential Inputs	Enable	Output
A-B	$\overline{RE}$	R
$V_{ID} \geq 0.2V$	L	H
$-0.2V < V_{ID} < 0.2V$	L	X
$V_{ID} \leq -0.2V$	L	L
X	H	Z

75177A

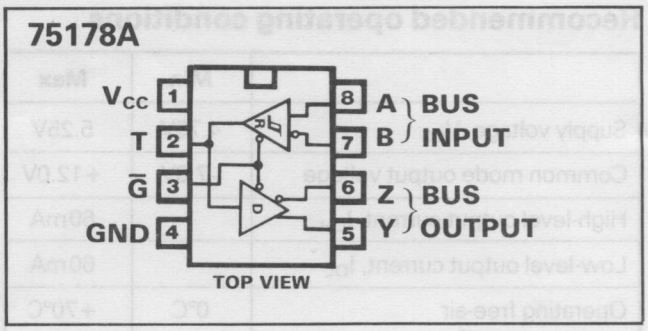


TOP VIEW

75177A

Differential Inputs	Enable	Outputs
A–B	G	T Y Z
$V_{ID} \geq 0.2V$	H	H H L
$-0.2V < V_{ID} < 0.2V$	H	X X X
$V_{ID} \leq -0.2V$	H	L L H
X	L	Z Z Z

75178A



TOP VIEW

75178A

Differential Inputs	Enable	Outputs
A–B	G	T Y Z
$V_{ID} \geq 0.2V$	L	H H L
$-0.2V < V_{ID} < 0.2V$	L	X X X
$V_{ID} \leq -0.2V$	L	L L H
X	H	Z Z Z

H = High level
L = Low level
X = Intermediate
Z = High impedance (off)

Absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC} (see Note 1) 7V
Voltage at any bus terminal ..... –10V to 15V
Differential input voltage (see Note 2) ..... ±25V
Enable input voltage 5.5V
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 3) ..... 1000 mW
Operating free-air temperature range 0°C to +70°C

Notes

1. All voltage values, except differential input voltage, are with respect to network ground terminal.
2. Differential input voltage is measured at the non-inverting input with respect to the corresponding inverting input.
3. For operation above 25°C free-air temperature, derate package to 640 mW at 70°C at the rate of 8.0 mW/°C.

Driver switching characteristics V_{CC} = 5V, T_A = 25°C

Parameter	Test conditions	Min	Typ	Max
t_{DD} Differential-output delay time	R_L = 60Ω, C_L = 15pF		40ns	60ns
t_{TD} Differential-output transition time			65ns	95ns
t_{PZH} Output enable time to high level	R_L = 110Ω, C_L = 50pF		55ns	90ns
t_{PZL} Output enable time to low level	R_L = 110Ω, C_L = 50pF		30ns	50ns
t_{PHZ} Output disable time from high level	R_L = 110Ω, C_L = 50pF		85ns	130ns
t_{PLZ} Output disable time from low level	R_L = 110Ω, C_L = 50pF		20ns	40ns

Receiver switching characteristics V_{CC} = 5V, T_A = 25°C

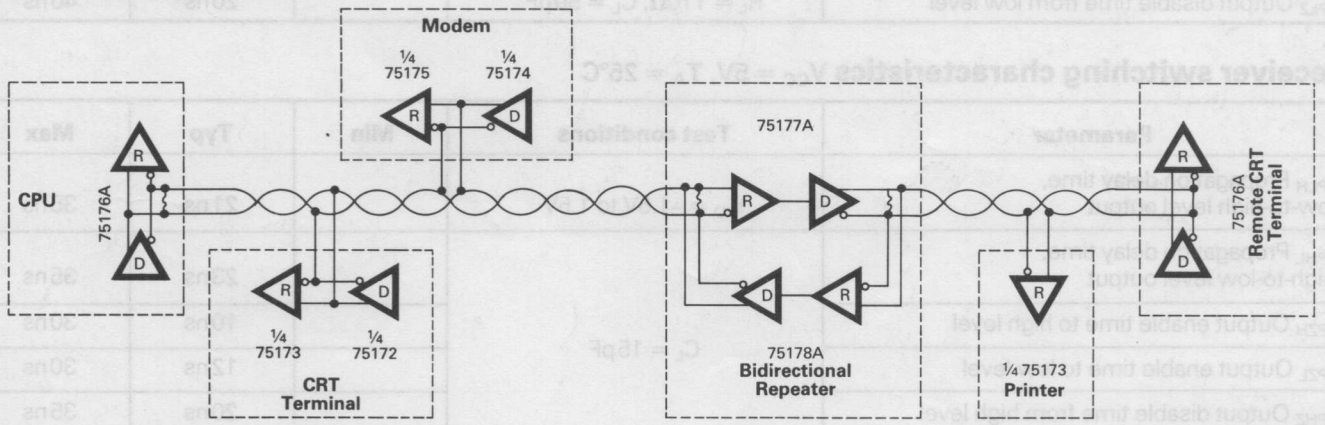
Parameter	Test conditions	Min	Typ	Max
t_{PLH} Propagation delay time, low-to-high level output	V_{ID} = –1.5V to 1.5V		21ns	35ns
t_{PHL} Propagation delay time, high-to-low level output	C_L = 15pF		23ns	35ns
t_{PZH} Output enable time to high level			10ns	30ns
t_{PZL} Output enable time to low level			12ns	30ns
t_{PHZ} Output disable time from high level			20ns	35ns
t_{PLZ} Output disable time from low level			17ns	35ns

Recommended operating conditions

		Min	Typ	Max
Supply voltage, V_{CC}		4.75V	5V	5.25V
High-level input voltage, V_{IH}		2V		
Low-level input voltage, V_{IL}				0.8V
Common-mode input voltage, V_{IC}		–7V		12V
Differential input voltage, V_{ID}				±12V
High-level output current, I_{OH}	Driver			–60mA
	Receiver			–400μA
Low-level output current, I_{OL}	Driver			60mA
	Receiver			8mA
Operating free-air temperature, T_A		0°C		+70°C

RS data

Figure 23 **RS485 schematic**



Notes:
1. 120Ω terminating resistors should be used.
2. Stub lengths (line connecting drivers, receivers, etc to the main bus twisted pair) should be kept as short as possible (less than 0.3m) to eliminate possibility of reflections.

Comparison of EIA standards

Parameter		RS232 (V28)	RS423	RS422 (V11)	RS485
Mode of operation		Single ended	Single ended	Differential	Differential
Number of drivers and receivers allowed on line		1 Driver 1 Receiver	1 Driver 10 Receivers	1 Driver 10 Receivers	32 Drivers 32 Receivers
Maximum cable length (m)		15	1200	1200	1200
Maximum data rate (bits/sec)		20k	100k	10M	10M
Maximum common mode voltage		±25V	±6V	+6V –0.25V	+12V –7V
Driver output signal		±5V min ±15V max	±3.6V min ±6.0V max	±2V min	±1.5V min
Driver load		3kΩ-7kΩ	450Ω min	100Ω	60Ω
Driver slew rate		30V/μs max	● Controlled ● Determined by cable length and data rate	NA	NA
Drive output Resistance (high Z state)	Power On	NA	NA	NA	±100μA max –7V ≤ Vcm ≤ 12V
	Power Off	300Ω	±100 μA max @ ±6V	±100μA max –0.25V ≤ Vcm ≤ 6V	±100μA max –7V ≤ Vcm ≤ 12V
Receiver input resistance		3kΩ–7kΩ	>4kΩ	>4kΩ	>12kΩ
Receiver sensitivity		±3V	±200mV	±200mV –7V ≤ Vcm ≤ 7V	±300mV –12V ≤ Vcm ≤ 12V