Low Power 5V RS232 Dual Driver/Receiver with 0.1μF Capacitors

FEATURES

- ESD Protection over ±**10kV**
- Uses Small Capacitors: 0.1μF
- 120kBaud Operation for R_L = 3k, C_L = 2500pF
- 250kBaud Operation for R_L = 3k, C_L = 1000pF
- Outputs Withstand ±30V Without Damage
- CMOS Comparable Low Power: 40mW
- Operates from a Single 5V Supply
- Rugged Bipolar Design
- Outputs Assume a High Impedance State When Off or Powered Down
- Meets All RS232 Specifications
- Available With or Without Shutdown
- Absolutely No Latch-up
- Available in SO Package

APPLICATIONS

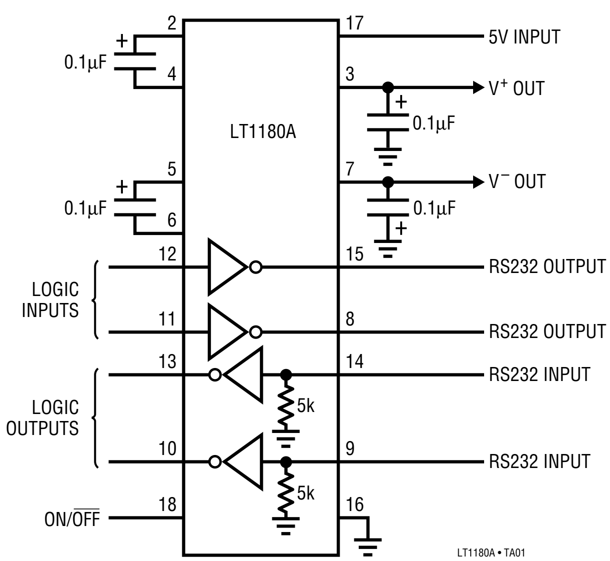
- Portable Computers
- Battery-Powered Systems
- Power Supply Generator
- Terminals
- Modems

DESCRIPTION

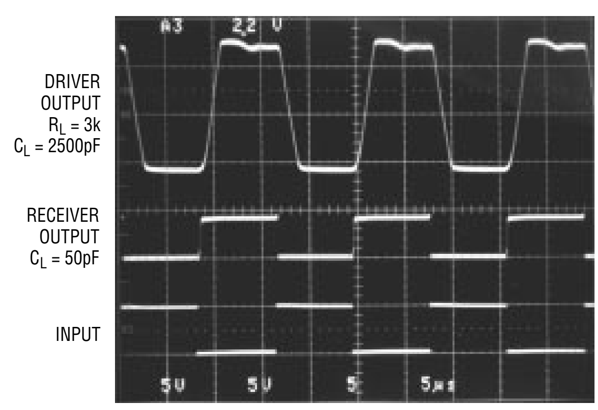
The LT1180A/LT1181A are dual RS232 driver/receiver pairs with integral charge pump to generate RS232 voltage levels from a single 5V supply. These circuits feature rugged bipolar design to provide operating fault tolerance and ESD protection unmatched by competing CMOS designs. Using only 0.1μF external capacitors, these circuits consume only 40mW of power, and can operate to 120k baud even while driving heavy capacitive loads. New ESD structures on the chip allow the LT1180A/LT1181A to survive multiple ±10kV strikes, eliminating the need for costly TransZorbs® on the RS232 line pins. The LT1180A/LT1181A are fully compliant with EIA RS232 standards. Driver outputs are protected from overload, and can be shorted to ground or up to ±30V without damage. During SHUTDOWN or power-off conditions, driver and receiver outputs are in a high impedance state, allowing line sharing.

The LT1181A is available in 16-pin DIP and SO packages. The LT1180A is supplied in 18-pin DIP and SO packages for applications which require SHUTDOWN.

TYPICAL APPLICATION



Output Waveforms

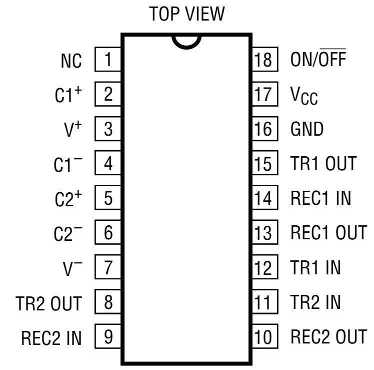


ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{CC}) 6V
V^+ 13.2V
V^- .... −13.2V
Input Voltage
  Driver .... V^- to V^+
  Receiver .... −30V to 30V
  ON/$\overline{OFF}$ .... −0.3V to 12V
Output Voltage
  Driver .... V^+ – 30V to V^- + 30V
  Receiver .... −0.3V to V_{CC} + 0.3V

Short-Circuit Duration
  V^+ .... 30 sec
  V^- .... 30 sec
  Driver Output .... Indefinite
  Receiver Output .... Indefinite
Operating Temperature Range
  LT1180AI/LT1181AI .... −40°C to 85°C
  LT1180AC/LT1181AC .... 0°C to 70°C
Storage Temperature Range .... −65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

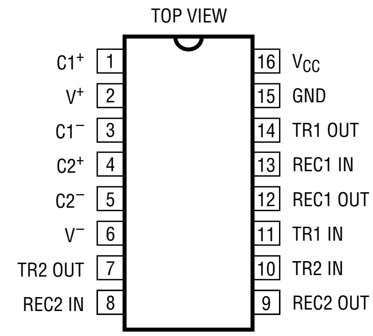
PACKAGE/ORDER INFORMATION



N PACKAGE 18-LEAD PLASTIC DIP — S PACKAGE 18-LEAD PLASTIC SOL

T_{JMAX} = 125°C, θ_{JA} = 80°C/W, θ_{JC} = 36°C/W (N)
T_{JMAX} = 125°C, θ_{JA} = 90°C/W, θ_{JC} = 26°C/W (S)

ORDER PART NUMBER: LT1180AIN, LT1180ACN, LT1180ACS



N PACKAGE 16-LEAD PLASTIC DIP — S PACKAGE 16-LEAD PLASTIC SOL

T_{JMAX} = 125°C, θ_{JA} = 90°C/W, θ_{JC} = 46°C/W (N)
T_{JMAX} = 125°C, θ_{JA} = 95°C/W, θ_{JC} = 27°C/W (S)

ORDER PART NUMBER: LT1181AIN, LT1181ACN, LT1181ACS

Consult factory for Military grade parts.

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
Power Supply Generator							
V^+ Output					7.9		V
V^- Output					−7.0		V
Supply Current (V_{CC})	(Note 3), T_A = 25°C				9	13	mA
			●			16	mA
Supply Current When OFF (V_{CC})	SHUTDOWN (Note 4) LT1180A Only		●		1	10	µA
Supply Rise Time	C1 = C2 = C3 = C4 = 0.1µF				0.2		ms
SHUTDOWN to Turn-On	LT1180A Only				0.2		ms
ON/$\overline{OFF}$ Pin Thresholds	Input Low Level (Device SHUTDOWN)		●	0.8	1.2		V
	Input High Level (Device Enabled)		●		1.6	2.4	V
ON/$\overline{OFF}$ Pin Current	0V ≤ $V_{ON/\overline{OFF}}$ ≤ 5V		●	−15		80	µA
Oscillator Frequency					130		kHz
Driver							
Output Voltage Swing	Load = 3k to GND	Positive	●	5.0	7.5		V
		Negative	●		−6.3	−5.0	V
Logic Input Voltage Level	Input Low Level (V_{OUT} = High)		●		1.4	0.8	V
	Input High Level (V_{OUT} = Low)		●	2.0	1.4		V

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Logic Input Current	$0.8V \le V_{IN} \le 2.0V$	●		5	20	μA
Output Short-Circuit Current	$V_{OUT} = 0V$		±9	17		mA
Output Leakage Current	SHUTDOWN $V_{OUT} = \pm 30V$ (Note 4)	●		10	100	μA
Date Rate	$R_L = 3k$, $C_L = 2500pF$ $R_L = 3k$, $C_L = 1000pF$		120 250			kBaud kBaud
Slew Rate	$R_L = 3k$, $C_L = 51pF$ $R_L = 3k$, $C_L = 2500pF$		 4	15 7	30	V/μs V/μs
Propagation Delay	Output Transition t_{HL} High-to-Low (Note 5) Output Transition t_{LH} Low-to-High			0.6 0.5	1.3 1.3	μs μs
Receiver						
Input Voltage Thresholds	Input Low Threshold (V_{OUT} = High) Input High Threshold (V_{OUT} = Low)		0.8	1.3 1.7	 2.4	V V
Hysteresis		●	0.1	0.4	1.0	V
Input Resistance	$V_{IN} = \pm 10V$		3	5	7	kΩ
Output Leakage Current	SHUTDOWN (Note 4) $0 \le V_{OUT} \le V_{CC}$	●		1	10	μA
Output Voltage	Output Low, $I_{OUT} = -1.6mA$ Output High, $I_{OUT} = 160\mu A$ ($V_{CC} = 5V$)	● ●	 3.5	0.2 4.2	0.4	V V
Output Short-Circuit Current	Sinking Current, $V_{OUT} = V_{CC}$ Sourcing Current, $V_{OUT} = 0V$		 10	−20 20	−10	mA mA
Propagation Delay	Output Transition t_{HL} High-to-Low (Note 6) Output Transition t_{LH} Low-to-High			250 350	600 600	ns ns

The ● denotes specifications which apply over the operating temperature range ($0°C \le T_A \le 70°C$ for commercial grade, and $-40°C \le T_A \le 85°C$ for industrial grade.

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: Testing done at $V_{CC} = 5V$ and $V_{ON/\overline{OFF}} = 3V$, unless otherwise specified.

Note 3: Supply current is measured as the average over several charge pump cycles. $C^+ = C^- = C1 = C2 = 0.1\mu F$. All outputs are open, with all driver inputs tied high.

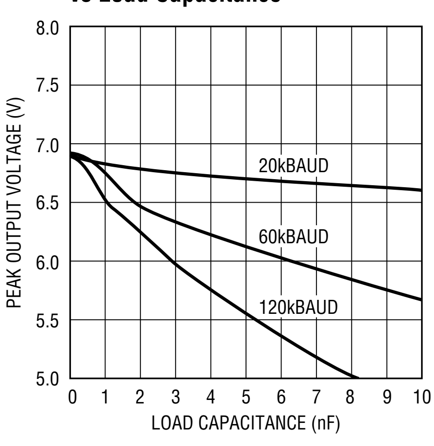
Note 4: Supply current measurements in SHUTDOWN are performed with $V_{ON/\overline{OFF}} \le 0.1V$.

Note 5: For driver delay measurements, $R_L = 3k$ and $C_L = 51pF$. Trigger points are set between the driver's input logic threshold and the output transition to the zero crossing ($t_{HL} = 1.4V$ to 0V and $t_{LH} = 1.4V$ to 0V).

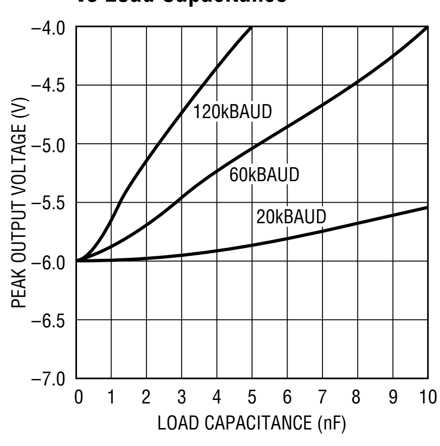
Note 6: For receiver delay measurements, $C_L = 51pF$. Trigger points are set between the receiver's input logic threshold and the output transition to standard TTL/CMOS logic threshold ($t_{HL} = 1.3V$ to 2.4V and $t_{LH} = 1.7V$ to 0.8V).

TYPICAL PERFORMANCE CHARACTERISTICS

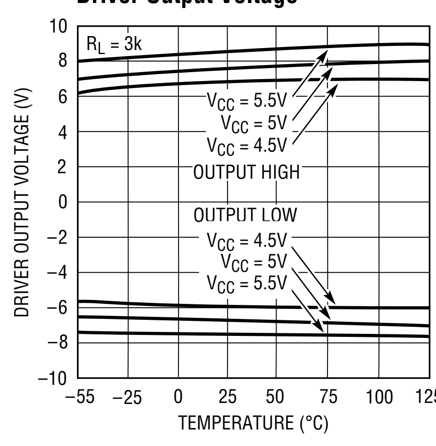
Driver Maximum Output Voltage vs Load Capacitance



Driver Minimum Output Voltage vs Load Capacitance

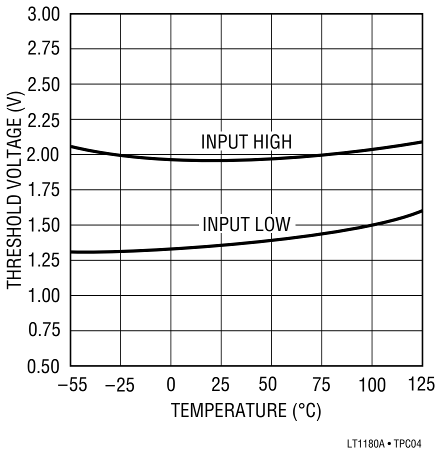


Driver Output Voltage

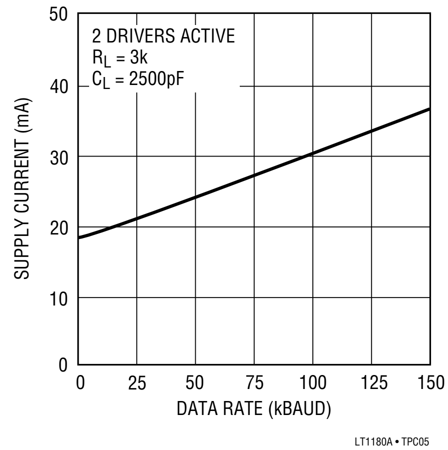


TYPICAL PERFORMANCE CHARACTERISTICS

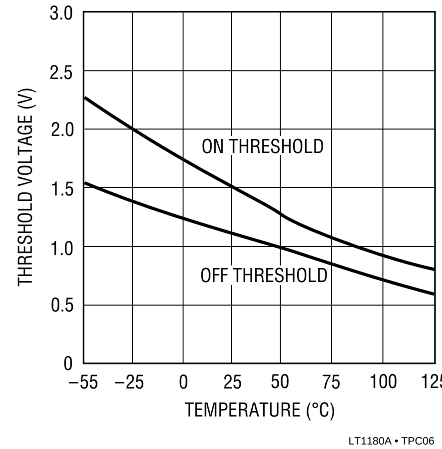
Receiver Input Thresholds



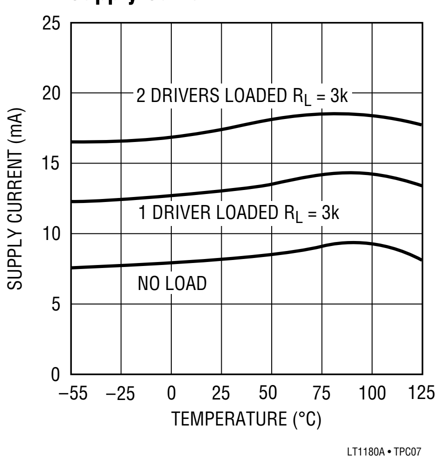
Supply Current vs Data Rate



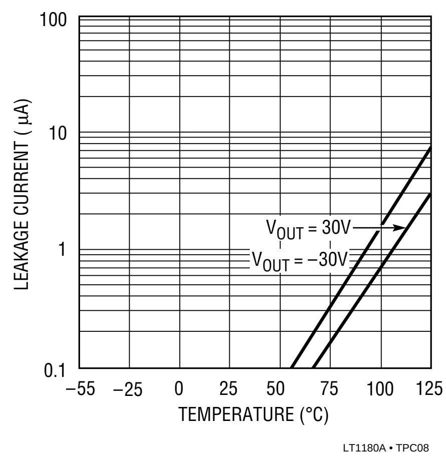
ON/$\overline{\text{OFF}}$ Thresholds



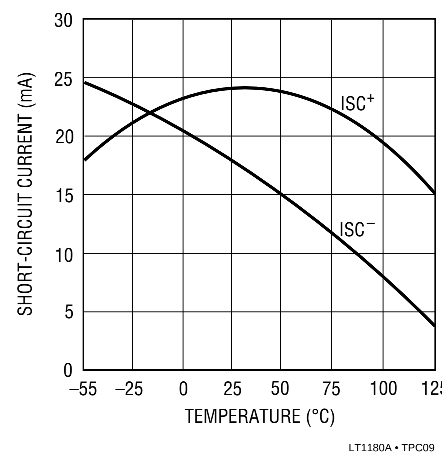
Supply Current



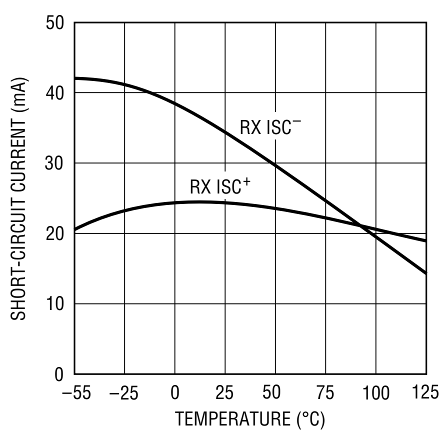
Driver Leakage in Shutdown



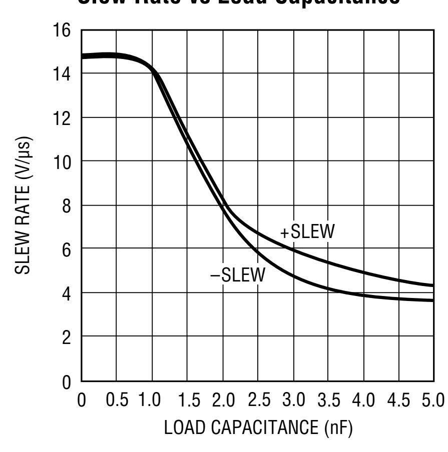
Driver Short-Circuit Current



Receiver Short-Circuit Current

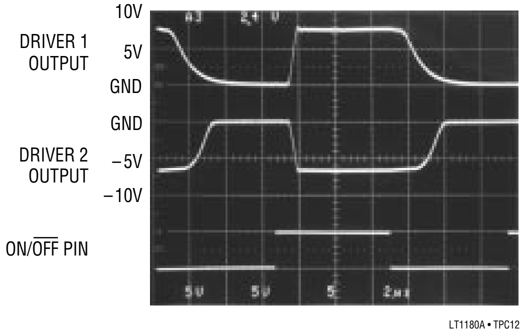


Slew Rate vs Load Capacitance

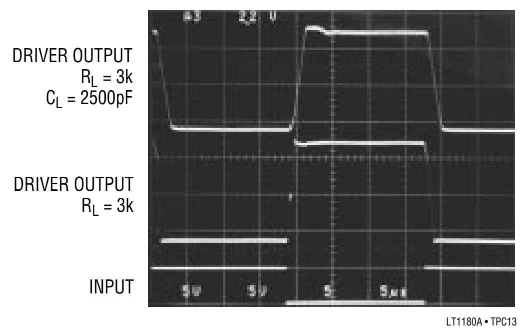


TYPICAL PERFORMANCE CHARACTERISTICS

Shutdown to Driver Outputs



Driver Output Waveforms



PIN FUNCTIONS

V_{CC}: 5V Input Supply Pin. This pin should be decoupled with a 0.1µF ceramic capacitor close to the package pin. Insufficient supply bypassing can result in low output drive levels and erratic charge pump operation.

GND: Ground Pin.

ON/$\overline{\text{OFF}}$: A TTL/CMOS Compatible Operating Mode Control. A logic low puts the LT1180A in SHUTDOWN mode. Supply current drops to zero and both driver and receiver outputs assume a high impedance state. A logic high fully enables the device.

V^+: Positive Supply Output (RS232 Drivers). $V^+ \approx 2V_{CC} - 1.5V$. This pin requires an external charge storage capacitor $C \geq 0.1\mu F$, tied to ground or V_{CC}. Larger value capacitors may be used to reduce supply ripple. With multiple transceivers, the V^+ and V^- pins may be paralleled into common capacitors.

V^-: Negative Supply Output (RS232 Drivers). $V^- \approx -(2V_{CC} - 2.5V)$. This pin requires an external charge storage capacitor $C \geq 0.1\mu F$. Larger value capacitors may be used to reduce supply ripple. With multiple transceivers, the V^+ and V^- pins may be paralleled into common capacitors.

TR1 IN, TR2 IN: RS232 Driver Input Pins. These inputs are TTL/CMOS compatible. Inputs should not be allowed to float. Tie unused inputs to V_{CC}.

TR1 OUT, TR2 OUT: Driver Outputs at RS232 Voltage Levels. Driver output swing meets RS232 levels for loads up to 3k. Slew rates are controlled for lightly loaded lines. Output current capability is sufficient for load conditions up to 2500pF. Outputs are in a high impedance state when in SHUTDOWN mode, V_{CC} = 0V, or when the driver disable pin is active. Outputs are fully short-circuit protected from $V^- + 30V$ to $V^+ - 30V$. Applying higher voltages will not damage the device if the overdrive is moderately current limited. Short circuits on one output can load the power supply generator and may disrupt the signal levels of the other outputs. The driver outputs are protected against ESD to ±10kV for human body model discharges.

REC1 IN, REC2 IN: Receiver Inputs. These pins accept RS232 level signals (±30V) into a protected 5k terminating resistor. The receiver inputs are protected against ESD to ±10kV for human body model discharges. Each receiver provides 0.4V of hysteresis for noise immunity. Open receiver inputs assume a logic low state.

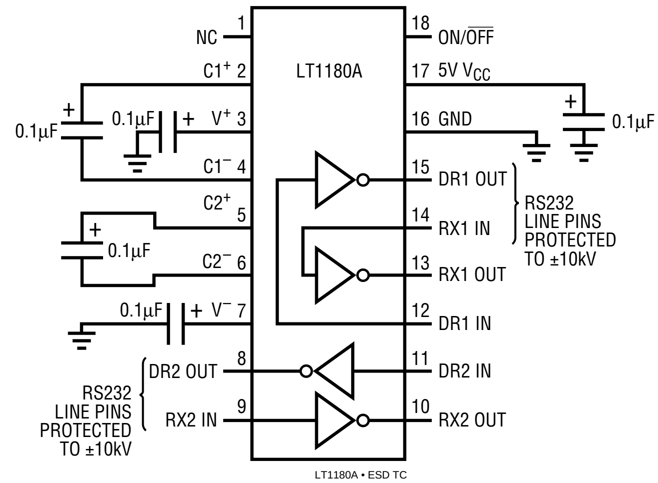
REC1 OUT, REC2 OUT: Receiver outputs with TTL/CMOS Voltage Levels. Outputs are in a high impedance state when in SHUTDOWN mode to allow data line sharing. Outputs are fully short-circuit protected to ground or V_{CC} with the power ON, OFF or in the SHUTDOWN mode.

$C1^+$, $C1^-$, $C2^+$, $C2^-$: Commutating Capacitor Inputs. These pins require two external capacitors $C \geq 0.1\mu F$: one from $C1^+$ to $C1^-$ and another from $C2^+$ to $C2^-$. C1 should be deleted if a separate 12V supply is available and connected to pin $C1^+$. Similarly, C2 should be deleted if a separate −12V supply is connected to pin V^-.

ESD PROTECTION

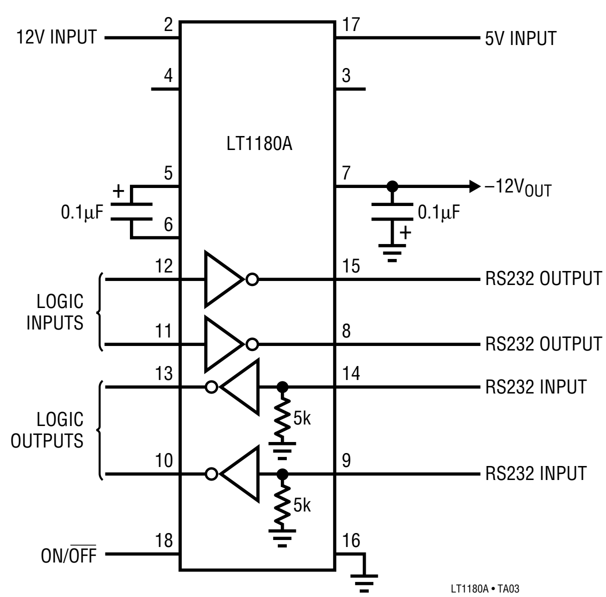
The RS232 line inputs of the LT1180A/LT1181A have on-chip protection from ESD transients up to ±10kV. The protection structures act to divert the static discharge safely to system ground. In order for the ESD protection to function effectively, the power supply and ground pins of the circuit must be connected to ground through low impedances. The power supply decoupling capacitors and charge pump storage capacitors provide this low impedance in normal application of the circuit. The only constraint is that low ESR capacitors must be used for bypassing and charge storage. ESD testing must be done with pins V_{CC}, V_L, V^+, V^-, and GND shorted to ground or connected with low ESR capacitors.

ESD Test Circuit



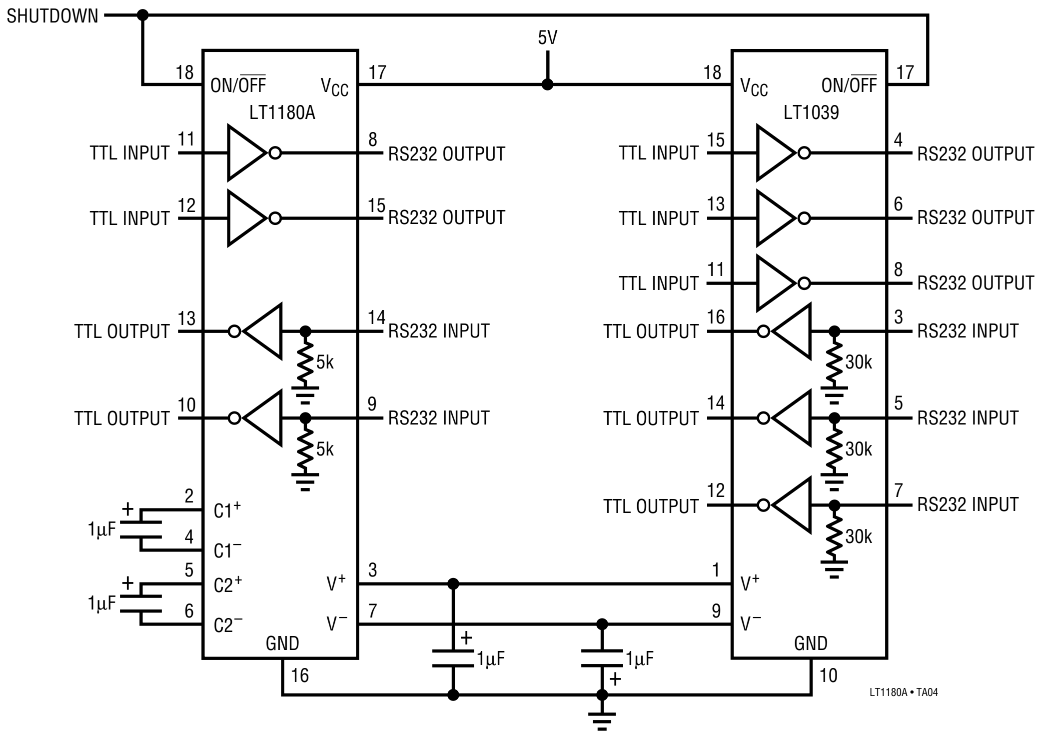
TYPICAL APPLICATIONS

Operation Using 5V and 12V Power Supplies



TYPICAL APPLICATIONS

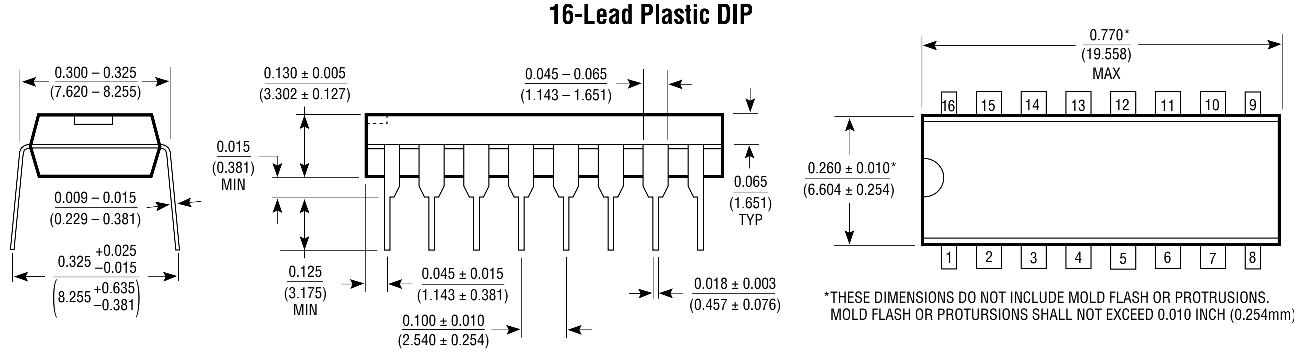
Supporting an LT1039 (Triple Driver/Receiver)



PACKAGE DESCRIPTION

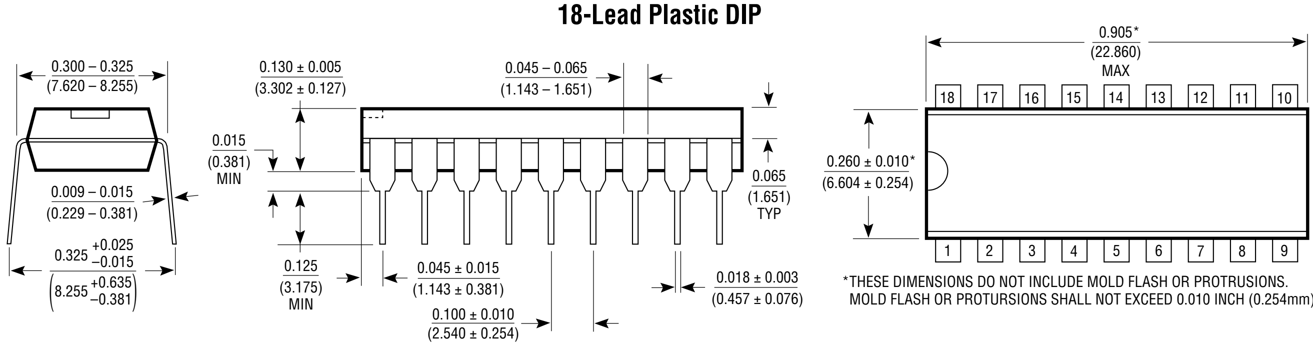
Dimensions in inches (millimeters) unless otherwise noted.

N Package
16-Lead Plastic DIP



*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTURSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm).

N Package
18-Lead Plastic DIP

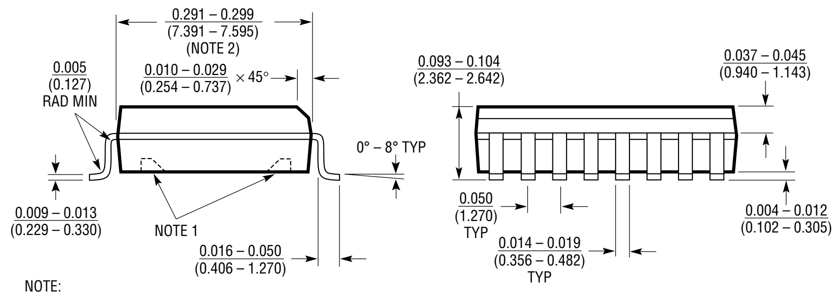


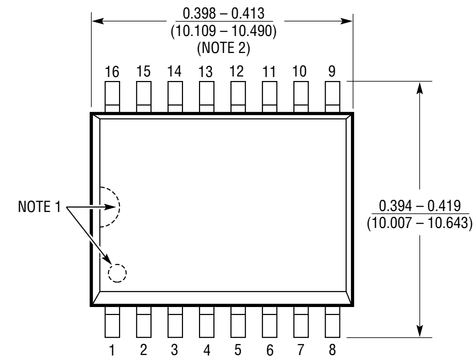
*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTURSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm).

PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

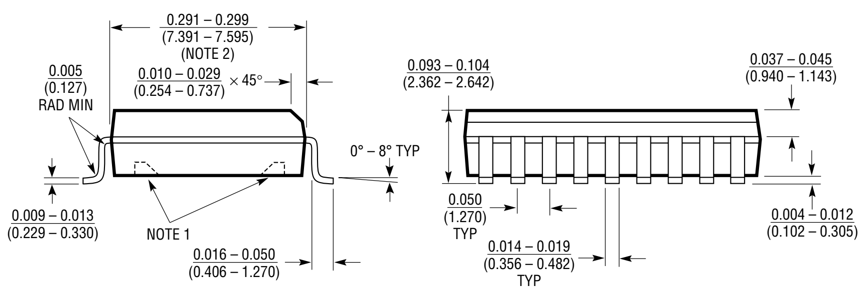
S Package
16-Lead SOL

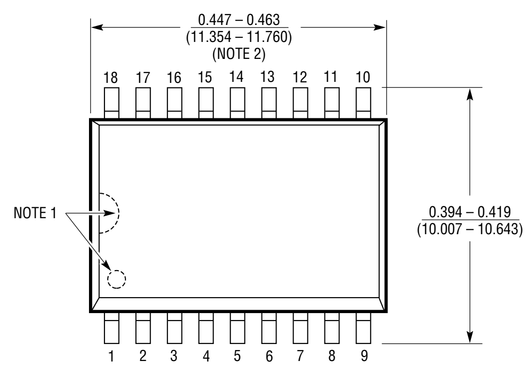




NOTE:
1. PIN 1 IDENT, NOTCH ON TOP AND CAVITIES ON THE BOTTOM OF PACKAGES ARE THE MANUFACTURING OPTIONS. THE PART MAY BE SUPPLIED WITH OR WITHOUT ANY OF THE OPTIONS.
2. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.006 INCH (0.15mm).

S Package
18-Lead SOL





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(408) 432-1900 • FAX: (408) 434-0507 • TELEX: 499-3977
LT/GP 0694 2K REV A • PRINTED IN USA

Low Power RS485 Interface Transceiver

FEATURES

- Low Power: I_{CC} = 300μA Typ
- Designed for RS485 Interface Applications
- Single 5V supply
- –7V to 12V Bus Common-Mode Range Permits ±7V Ground Difference Between Devices on the Bus
- Thermal Shutdown Protection
- Power-Up/Down Glitch-Free Driver Outputs Permit Live Insertion or Removal of Transceiver
- Driver Maintains High Impedance in Three-State or with the Power Off
- Combined Impedance of a Driver Output and Receiver Allows Up to 32 Transceivers on the Bus
- 70mV Typical Input Hysteresis
- 30ns Typical Driver Propagation Delays with 5ns Skew
- Pin Compatible with the SN75176A, DS75176A and μA96176

APPLICATIONS

- Low Power RS485/RS422 Transceiver
- Level Translator

DESCRIPTION

The LTC485 is a low power differential bus/line transceiver designed for multipoint data transmission standard RS485 applications with extended common-mode range (12V to –7V). It also meets the requirements of RS422.

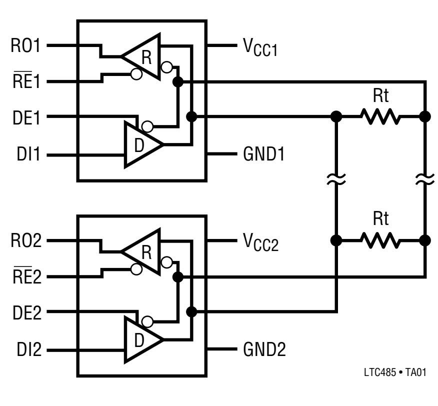
The CMOS design offers significant power savings over its bipolar counterpart without sacrificing ruggedness against overload of ESD damage.

The driver and receiver feature three-state outputs, with the driver outputs maintaining high impedance over the entire common-mode range. Excessive power dissipation caused by bus contention or faults is prevented by a thermal shutdown circuit which forces the driver outputs into a high impedance state.

The receiver has a fail-safe feature which guarantees a high output state when the inputs are left open.

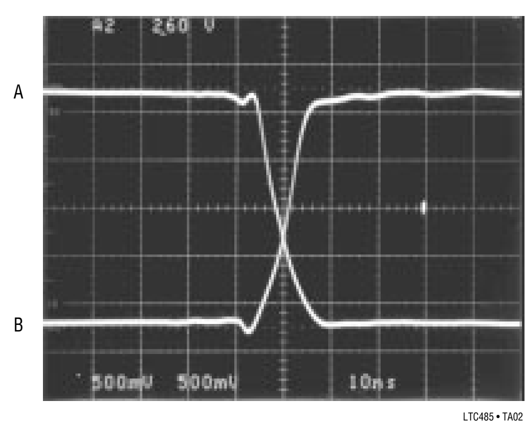
The LTC485 is fully specified over the commercial and extended industrial temperature range.

TYPICAL APPLICATION



LTC485 • TA01

Driver Outputs



LTC485 • TA02

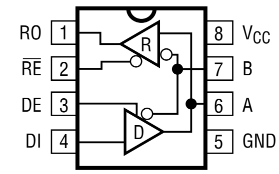
ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage 12V
Control Input Voltages .... −0.5V to V_{CC} + 0.5V
Driver Input Voltage .... −0.5V to V_{CC} + 0.5V
Driver Output Voltage .... ±14V
Receiver Input Voltage.. ±14V
Receiver Output Voltages .... −0.5V to V_{CC} + 0.5V
Operating Temperature Range
  LTC485I .... −40°C ≤ T_A ≤ 85°C
  LTC485C.. 0°C ≤ T_A ≤ 70°C
  LTC485M................................. −55°C ≤ T_A ≤ 125°C
Lead Temperature (Soldering, 10 sec)................. 300°C

PACKAGE/ORDER INFORMATION

TOP VIEW



J8 PACKAGE 8-LEAD CERAMIC DIP
N8 PACKAGE 8-LEAD PLASTIC DIP
S8 PACKAGE 8-LEAD PLASTIC SOIC

T_{JMAX} = 155°C, θ_{JA} = 100°C/ W (J)
T_{JMAX} = 100°C, θ_{JA} = 130°C/ W (N)
T_{JMAX} = 100°C, θ_{JA} = 170°C/ W (S)

ORDER PART NUMBER
LTC485CJ8
LTC485CN8
LTC485CS8
LTC485IN8
LTC485IS8
LTC485MJ8
S8 PART MARKING
485
485I

ELECTRICAL CHARACTERISTICS

V_{CC} = 5V ±5%, unless otherwise noted. (Notes 2 and 3)

SYMBOL	PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
V_{OD1}	Differential Driver Output Voltage (Unloaded)	I_O = 0		●			5	V
V_{OD2}	Differential Driver Output Voltage (with Load)	R = 50Ω (RS422)		●	2			V
		R = 27Ω (RS485), Figure 1		●	1.5		5	V
ΔV_{OD}	Change in Magnitude of Driver DifferentialOutput Voltage for Complementary States	R = 27Ω or R = 50Ω, Figure 1		●			0.2	V
V_{OC}	Driver Common-Mode Output Voltage	R = 27Ω or R = 50Ω, Figure 1		●			3	V
$\Delta \lvert V_{OC} \rvert$	Change in Magnitude of Driver Common-Mode Output Voltage for Complementary States	R = 27Ω or R = 50Ω, Figure 1		●			0.2	V
V_{IH}	Input High Voltage	DE, DI, $\overline{RE}$		●	2			V
V_{IL}	Input Low Voltage	DE, DI, $\overline{RE}$		●			0.8	V
I_{IN1}	Input Current	DE, DI, $\overline{RE}$		●			±2	μA
I_{IN2}	Input Current (A, B)	DE = 0, V_{CC} = 0V or 5.25V	V_{IN} = 12V	●			±1	mA
			V_{IN} = −7V	●			−0.8	mA
V_{TH}	Differential Input Threshold Voltage for Receiver	−7V ≤ V_{CM} ≤ 12V		●	−0.2		0.2	V
ΔV_{TH}	Receiver Input Hysteresis	V_{CM} = 0V		●		70		mV
V_{OH}	Receiver Output High Voltage	I_O = −4mA, V_{ID} = 200mV		●	3.5			V
V_{OL}	Receiver Outpu Low Voltage	I_O = 4mA, V_{ID} = −200mV		●			0.4	V
I_{OZR}	Three-State (High Impedance) Output Current at Receiver	V_{CC} = Max, 0.4V ≤ V_O ≤ 2.4V		●			±1	μA
R_{IN}	Receiver Input Resistance	−7V ≤ V_{CM} ≤ 12V		●	12			kΩ
I_{CC}	Supply Current	No Load, Pins 2, 3, 4 = 0V or 5V	Outputs Enabled	●		500	900	μA
			Outputs Disabled	●		300	500	μA
I_{OSD1}	Driver Short-Circuit Current, V_{OUT} = HIGH	V_O = −7V		●	35	100	250	mA
I_{OSD2}	Driver Short-Circuit Current, V_{OUT} = LOW	V_O = 10V		●	35	100	250	mA
I_{OSR}	Receiver Short-Circuit Current	0V ≤ V_O ≤ V_{CC}		●	7		85	mA

SWITCHING CHARACTERISTICS V_{CC} = 5V ±5%, unless otherwise noted. (Notes 2 and 3)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
t_{PLH}	Driver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF, (Figures 3 and 5)	●	10	30	50	ns
t_{PHL}	Driver Input to Output		●	10	30	50	ns
t_{SKEW}	Driver Output to Output		●		5	10	ns
t_r, t_f	Driver Rise or Fall Time		●	3	15	25	ns
t_{ZH}	Driver Enable to Output High	C_L = 100pF (Figures 4 and 6) S2 Closed	●		40	70	ns
t_{ZL}	Driver Enable to Output Low	C_L = 100pF (Figures 4 and 6) S1 Closed	●		40	70	ns
t_{LZ}	Driver Disable Time from Low	C_L = 15pF (Figures 4 and 6) S1 Closed	●		40	70	ns
t_{HZ}	Driver Disable Time from High	C_L = 15pF (Figures 4 and 6) S2 Closed	●		40	70	ns
t_{PLH}	Receiver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF, (Figures 3 and 7)	●	30	90	200	ns
t_{PHL}			●	30	90	200	ns
t_{SKD}	$\lvert t_{PLH} - t_{PHL} \rvert$ Differential Receiver Skew		●		13		ns
t_{ZL}	Receiver Enable to Output Low	C_{RL} = 15pF (Figures 2 and 8) S1 Closed	●		20	50	ns
t_{ZH}	Receiver Enable to Output High	C_{RL} = 15pF (Figures 2 and 8) S2 Closed	●		20	50	ns
t_{LZ}	Receiver Disable from Low	C_{RL} = 15pF (Figures 2 and 8) S1 Closed	●		20	50	ns
t_{HZ}	Receiver Disable from High	C_{RL} = 15pF (Figures 2 and 8) S2 Closed	●		20	50	ns

The ● denotes specifications which apply over the full operating temperature range.

Note 1: Absolute maximum ratings are those beyond which the safety of the device cannot be guaranteed.

Note 2: All currents into device pins are positive; all currents out ot device pins are negative. All voltages are referenced to device ground unless otherwise specified.

Note 3: All typicals are given for V_{CC} = 5V and T_A = 25°C.

Note 4: The LTC485 is guaranteed by design to be functional over a supply voltage range of 5V ±10%. Data sheet parameters are guaranteed over the tested supply voltage range of 5V ±5%.

TEST CIRCUITS

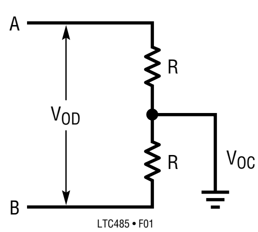


Figure 1. Driver DC Test Load

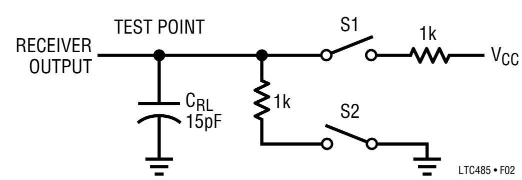


Figure 2. Receiver Timing Test Load

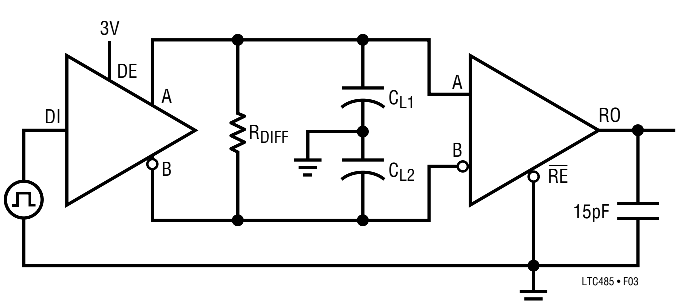


Figure 3. Driver/Receiver Timing Test Circuit

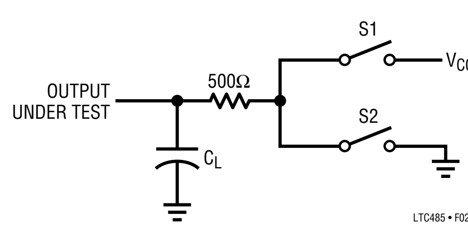


Figure 4. Driver Timing Test Load #2

SWITCHING TIME WAVEFORMS

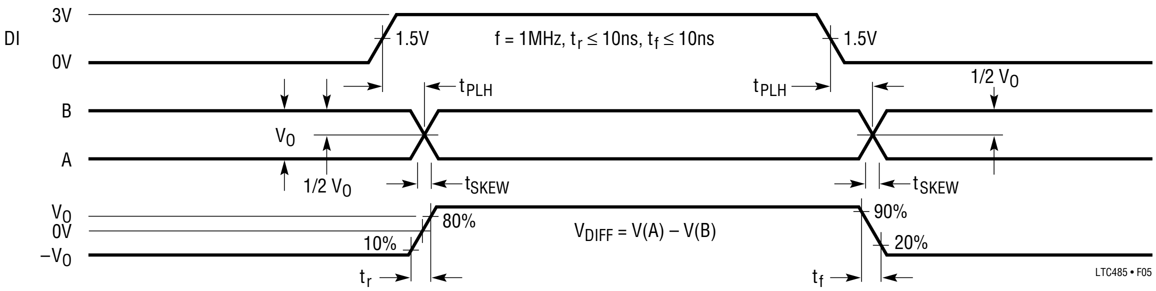


Figure 5. Driver Propagation Delays

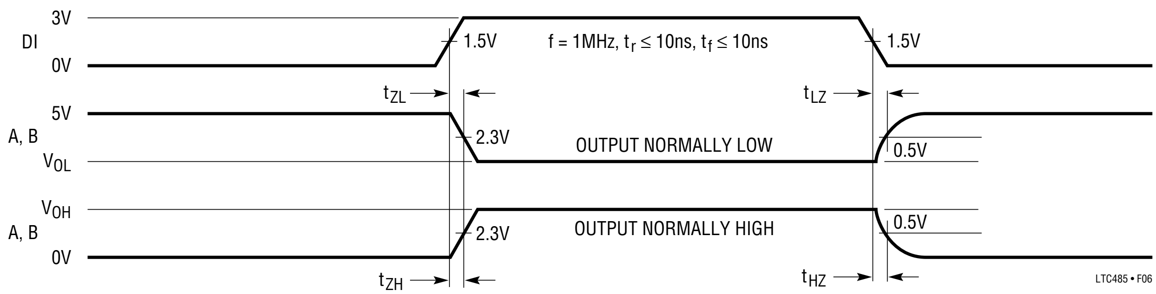


Figure 6. Driver Enable and Disable Times

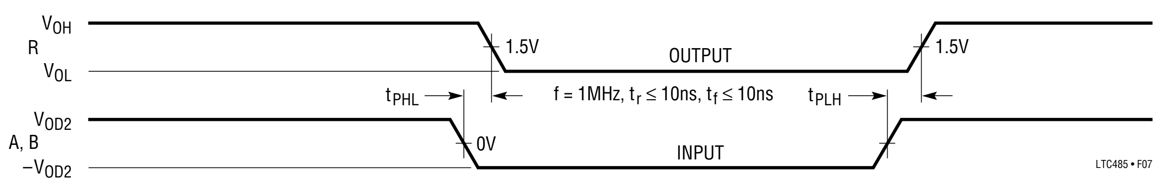


Figure 7. Receiver Propagation Delays

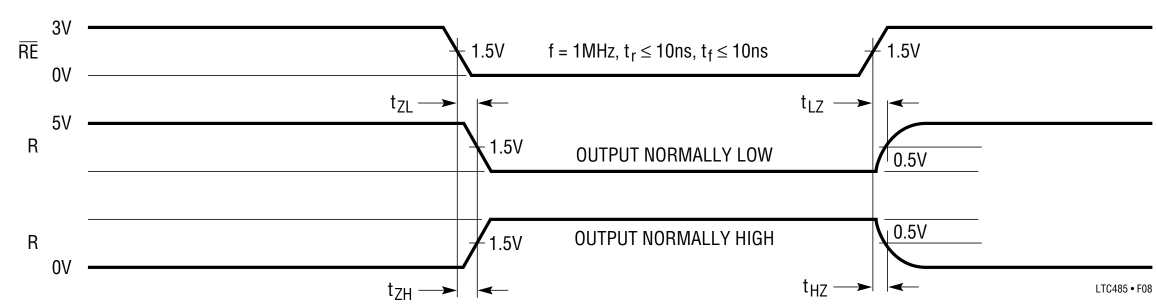


Figure 8. Receiver Enable and Disable Times

FUNCTION TABLES

LTC485 Transmitting

INPUTS			LINE CONDITION	OUTPUTS	
$\overline{RE}$	DE	DI		B	A
X	1	1	No Fault	0	1
X	1	0	No Fault	1	0
X	0	X	X	Z	Z
X	1	X	Fault	Z	Z

LTC485 Receiving

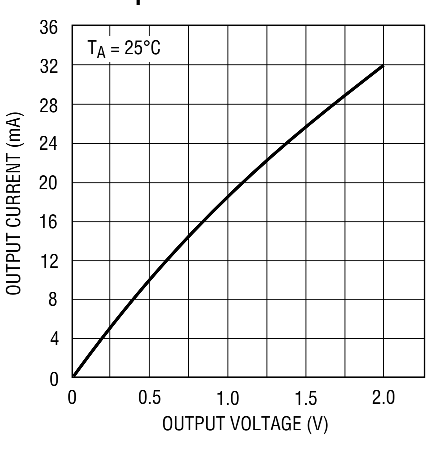
INPUTS			OUTPUTS
$\overline{RE}$	DE	A – B	R
0	0	≥0.2V	1
0	0	≤–0.2V	0
0	0	Inputs Open	1
1	0	X	Z

PIN FUNCTIONS

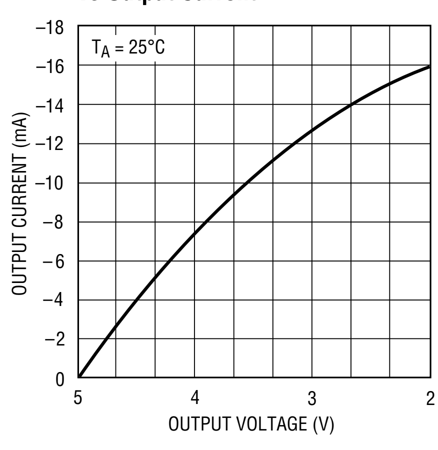
PIN #	NAME	DESCRIPTION
1	RO	Receiver Output. If the receiver output is enabled ($\overline{RE}$ low), then if A > B by 200mV, RO will be high. If A < B by 200mV, then RO will be low.
2	$\overline{RE}$	Receiver Output Enable. A low enables the receiver output, RO. A high input forces the receiver output into a high impedance state.
3	DE	Driver Outputs Enable. A high on DE enables the driver output. A and B, and the chip will function as a line driver. A low input will force the driver outputs into a high impedance state and the chip will function as a line receiver.
4	DI	Driver Input. If the driver outputs are enabled (DE high), then a low on DI forces the outputs A low and B high. A high on DI with the driver outputs enabled will force A high and B low.
5	GND	Ground Connection.
6	A	Driver Output/Receiver Input.
7	B	Driver Output/Receiver Input.
8	V_{CC}	Positive Supply; $4.75 < V_{CC} < 5.25$

TYPICAL PERFORMANCE CHARACTERISTICS

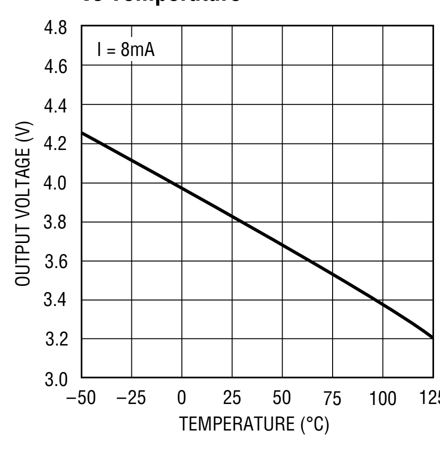
Receiver Output Low Voltage vs Output Current



Receiver Output High Voltage vs Output Current

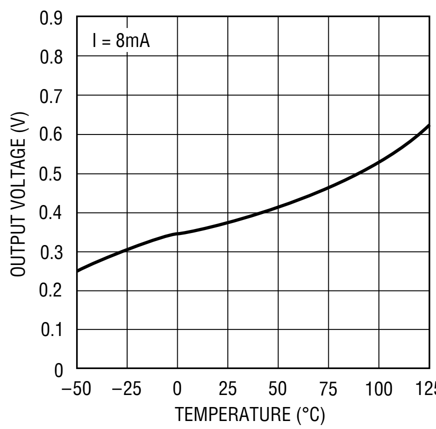


Receiver Output High Voltage vs Temperature



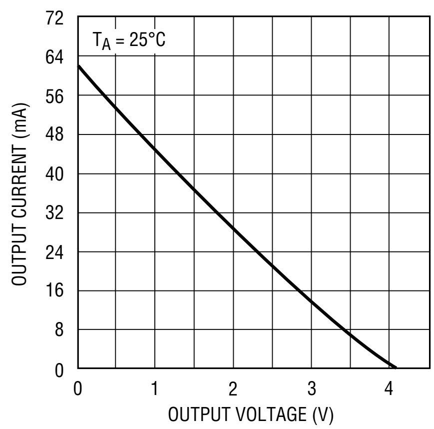
TYPICAL PERFORMANCE CHARACTERISTICS

Receiver Output Low Voltage vs Temperature



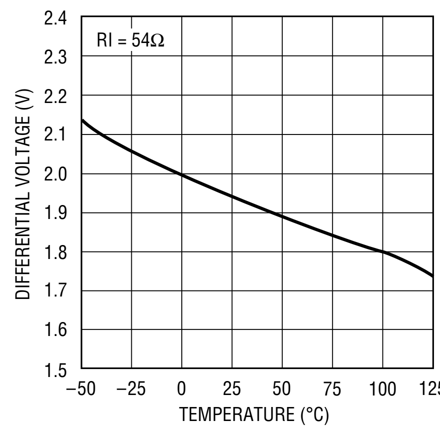
LTC485 • TPC03

Driver Differential Output Voltage vs Output Current



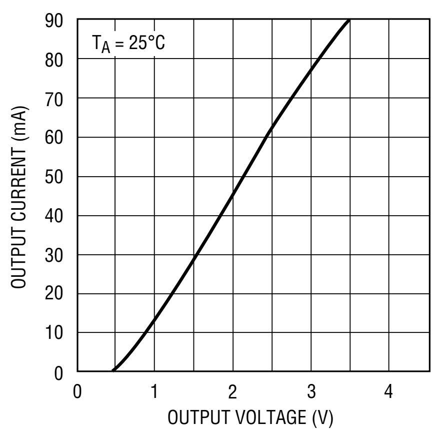
LTC485 • TPC05

Driver Differential Output Voltage vs Temperature



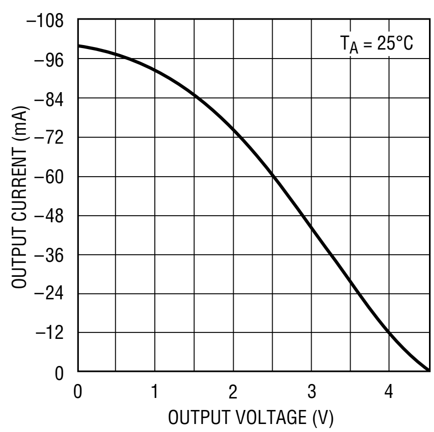
LTC485 • TPC06

Driver Output Low Voltage vs Output Current



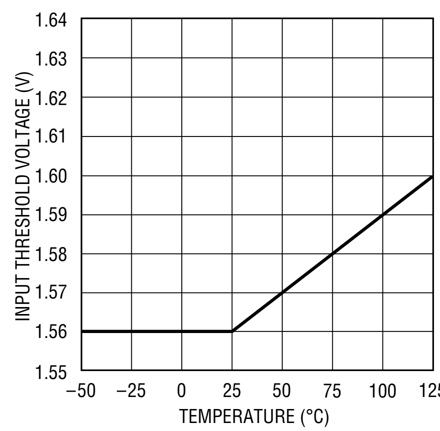
LTC485 • TPC07

Driver Output High Voltage vs Output Current



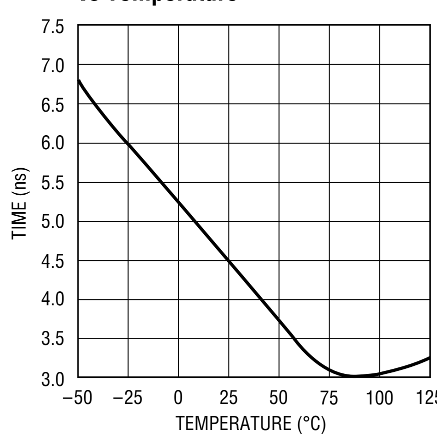
LTC485 • TPC08

TTL Input Threshold vs Temperature



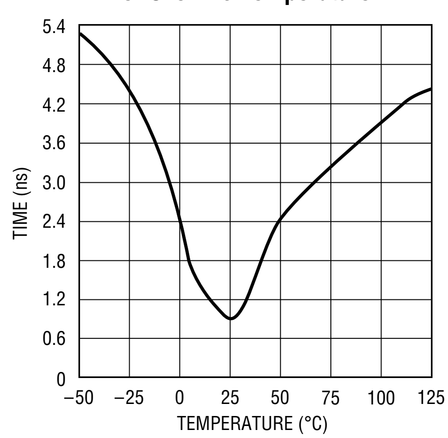
LTC485 • TPC09

Receiver $|t_{PLH} – t_{PHL}|$ vs Temperature



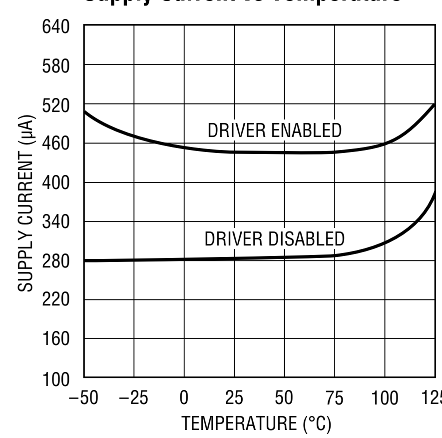
LTC485 • TPC10

Driver Skew vs Temperature



LTC485 • TPC11

Supply Current vs Temperature



LTC485 • TPC12

APPLICATIONS INFORMATION

Basic Theory of Operation

Previous RS485 transceivers have been designed using bipolar technology because the common-mode range of the device must extend beyond the supplies and the device must be immune to ESD damage and latchup. Unfortunately, the bipolar devices draw a large amount of supply current, which is unacceptable for the numerous applications that require low power consumption. The LTC485 is the first CMOS RS485/RS422 transceiver which features ultra-low power consumption without sacrificing ESD and latchup immunity.

The LTC485 uses a proprietary driver output stage, which allows a common-mode range that extends beyond the power supplies while virtually eliminating latchup and providing excellent ESD protection. Figure 9 shows the LTC485 output stage while Figure 10 shows a conventional CMOS output stage.

When the conventional CMOS output stage of Figure 10 enters a high impedance state, both the P-channel (P1) and the N-channel (N1) are turned off. If the output is then driven above V_{CC} or below ground, the P + /N-well diode (D1) or the N + /P-substrate diode (D2) respectively will turn on and clamp the output to the supply. Thus, the output stage is no longer in a high impedance state and is not able to meet the RS485 common-mode range requirement. In addition, the large amount of current flowing through either diode will induce the well known CMOS latchup condition, which could destroy the device.

The LTC485 output stage of Figure 9 eliminates these problems by adding two Schottky diodes, SD3 and SD4. The Schottky diodes are fabricated by a proprietary modification to the standard N-well CMOS process. When the output stage is operating normally, the Schottky diodes are forward biased and have a small voltage drop across them. When the output is in the high impedance state and is driven above V_{CC} or below ground, the parasitic diodes D1 or D2 still turn on, but SD3 or SD4 will reverse bias and prevent current from flowing into the N-well or the substrate. Thus, the high impedance state is maintained even with the output voltage beyond the supplies. With no minority carrier current flowing into the N-well or substrate, latchup is virtually eliminated under power-up or power-down conditions.

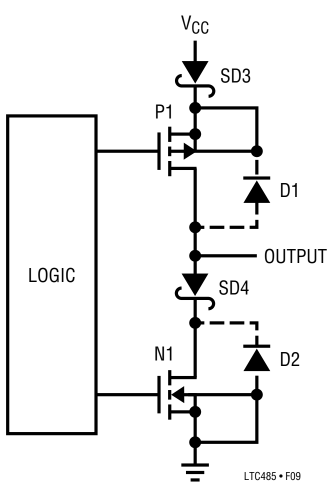


Figure 9. LTC485 Output Stage

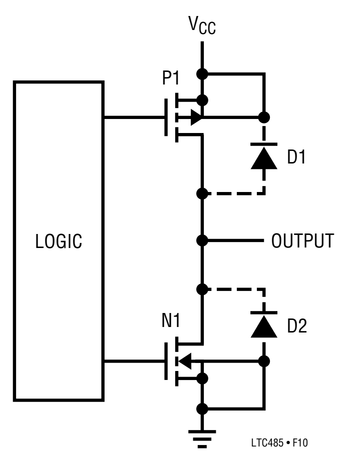


Figure 10. Conventional CMOS Output Stage

APPLICATIONS INFORMATION

The LTC485 output stage will maintain a high impedance state until the breakdown of the N-channel or P-channel is reached when going positive or negative respectively. The output will be clamped to either V_{CC} or ground by a Zener voltage plus a Schottky diode drop, but this voltage is way beyond the RS485 operating range. This clamp protects the MOS gates from ESD voltages well over 2000V. Because the ESD injected current in the N-well or substrate consists of majority carriers, latchup is prevented by careful layout techniques.

Propagation Delay

Many digital encoding schemes are dependent upon the difference in the propagation delay times of the driver and the receiver. Using the test circuit of Figure 13, Figures 11 and 12 show the typical LTC485 receiver propagation delay.

The receiver delay times are:

$$|t_{PLH} - t_{PHL}| = 9\text{ns Typ, } V_{CC} = 5\text{V}$$

The driver skew times are:

Skew = 5ns Typ, V_{CC} = 5V

10ns Max, V_{CC} = 5V, T_A = –40°C to 85°C

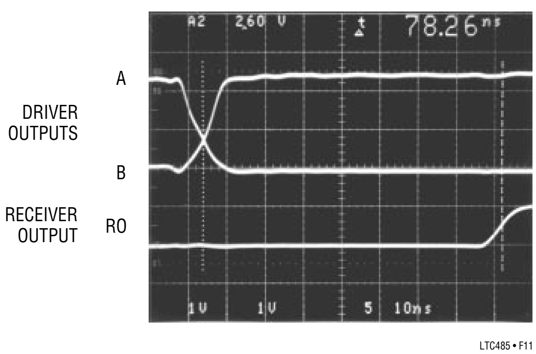


Figure 11. Receiver t_{PHL}

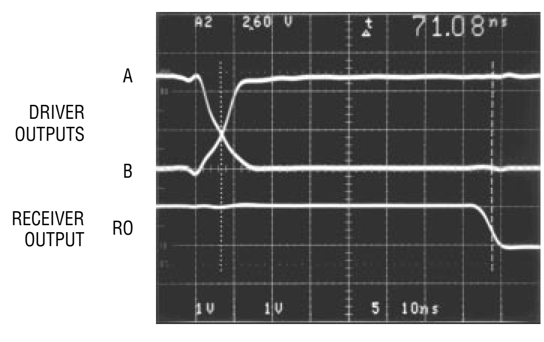


Figure 12. Receiver t_{PLH}

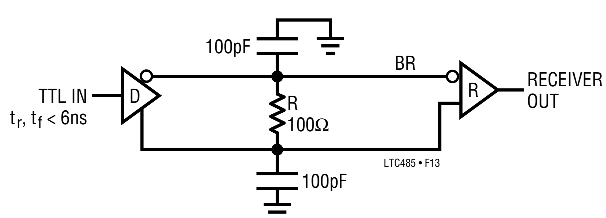


Figure 13. Receiver Propagation Delay Test Circuit

APPLICATIONS INFORMATION

LTC485 Line Length vs Data Rate

The maximum line length allowable for the RS422/RS485 standard is 4000 feet.

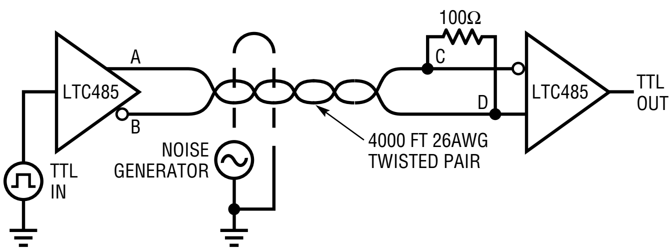


Figure 14. Line Length Test Circuit

Using the test circuit in Figure 14, Figures 15 and 16 show that with ~20V_{P-P} common-mode noise injected on the line, The LTC485 is able to reconstruct the data stream at the end of 4000 feet of twisted pair wire.

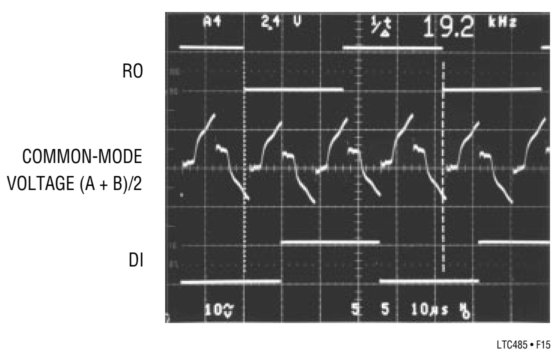


Figure 15. System Common-Mode Voltage at 19.2kHz

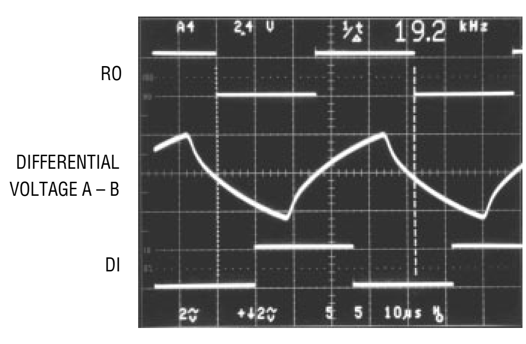


Figure 16. System Differential Voltage at 19.2kHz

Figures 17 and 18 show that the LTC485 is able to comfortably drive 4000 feet of wire at 110kHz.

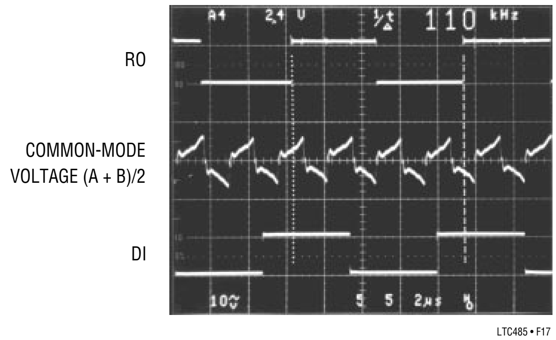


Figure 17. System Common-Mode Voltage at 110kHz

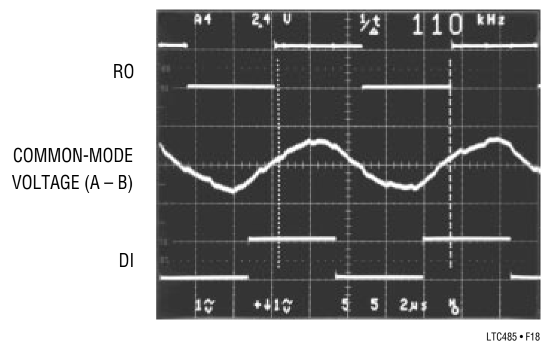


Figure 18. System Differential Voltage at 110kHz

When specifying line length vs maximum data rate the curve in Figure 19 should be used:

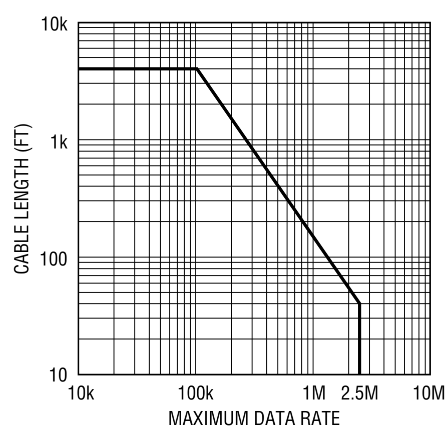
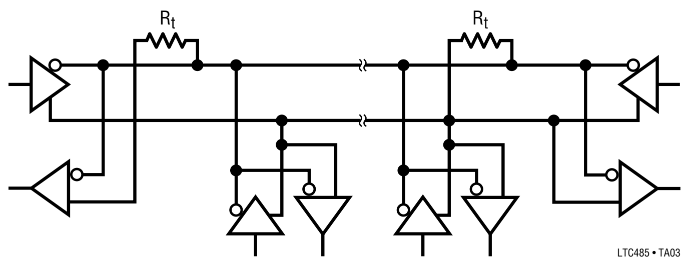


Figure 19. Cable Length vs Maximum Data Rate

TYPICAL APPLICATIONS

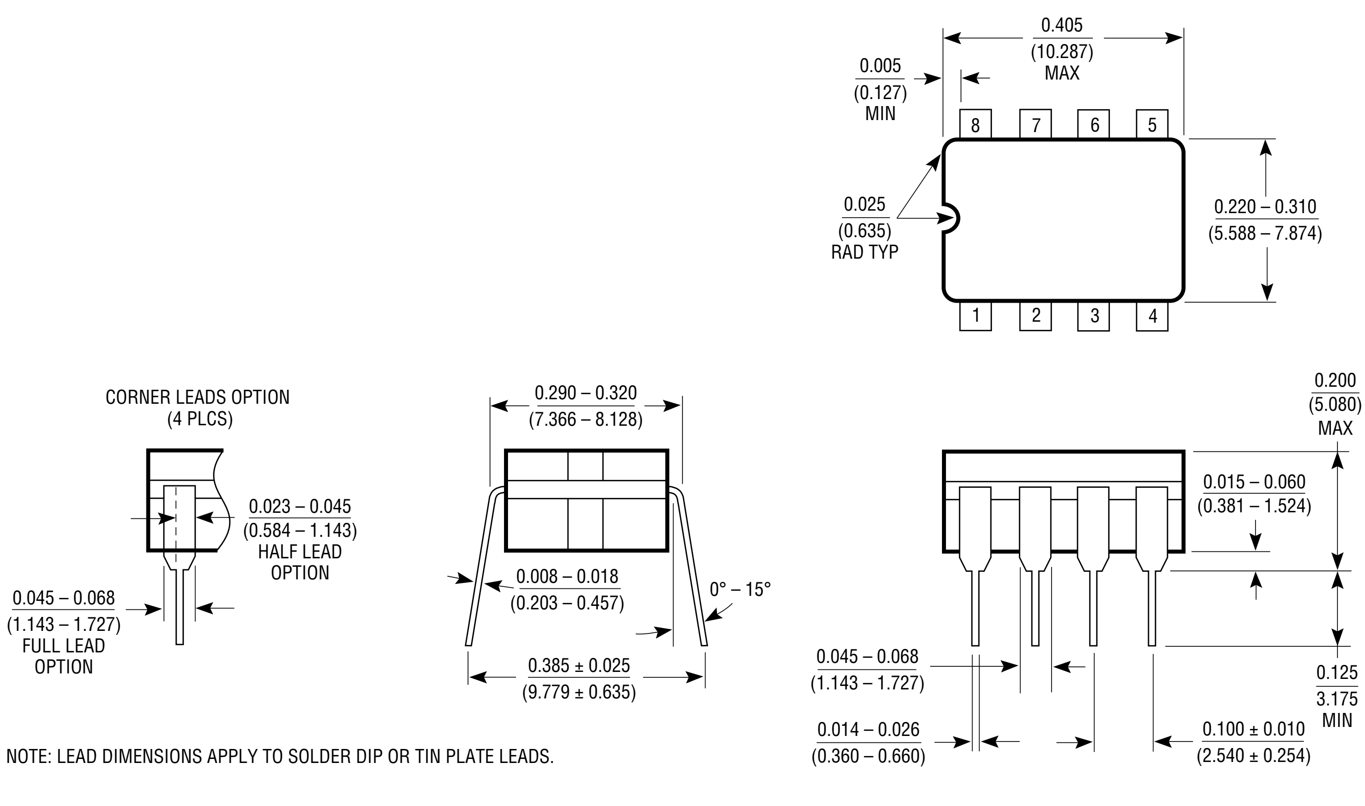
Typical RS485 Network



PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

J8 Package
8-Lead Ceramic DIP

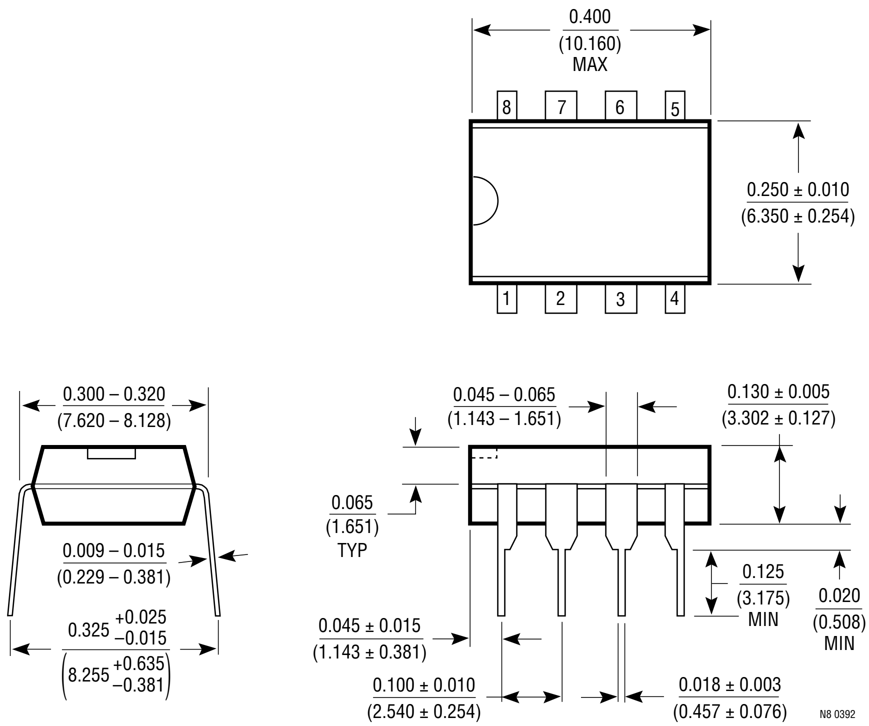


NOTE: LEAD DIMENSIONS APPLY TO SOLDER DIP OR TIN PLATE LEADS.

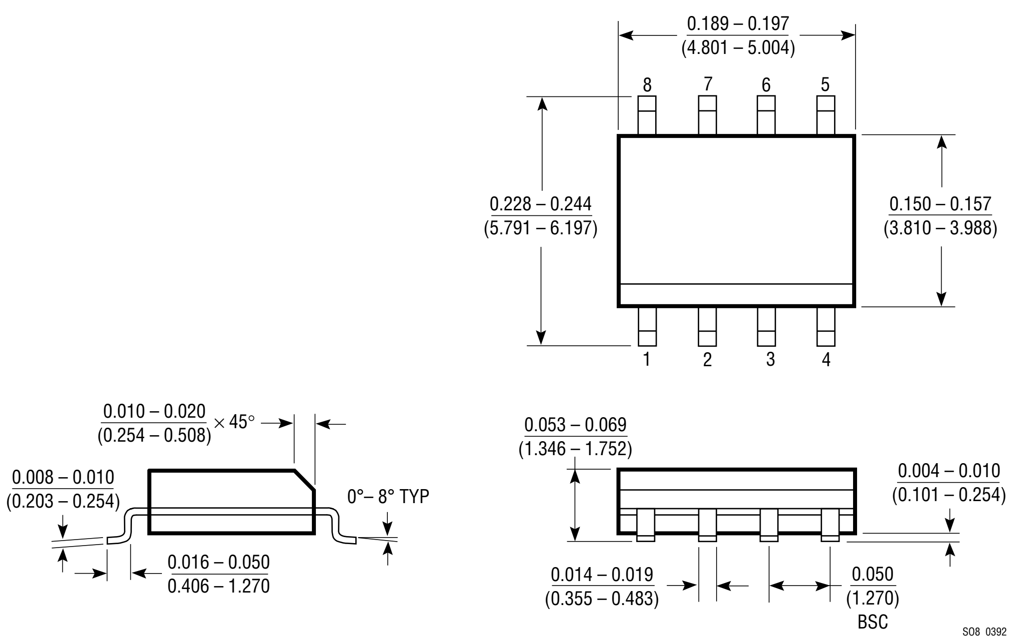
PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

N8 Package
8-Lead Plastic DIP



S8 Package
8-Lead Plastic SOIC



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Differential Driver and Receiver Pair

FEATURES

- Low Power: I_{CC} = 300µA Typical
- Designed for RS485 or RS422 Applications
- Single 5V Supply
- –7V to 12V Bus Common-Mode Range Permits ±7V Ground Difference Between Devices on the Bus
- Thermal Shutdown Protection
- Power-Up/Down Glitch-Free Driver Outputs Permit Live Insertion or Removal of Package
- Driver Maintains High Impedance with the Power Off
- Combined Impedance of a Driver Output and Receiver Allows up to 32 Transceivers on the Bus
- 70mV Typical Input Hysteresis
- 28ns Typical Driver Propagation Delays with 5ns Skew
- Pin Compatible with the SN75179

APPLICATIONS

- Low Power RS485/RS422 Transceiver
- Level Translator

DESCRIPTION

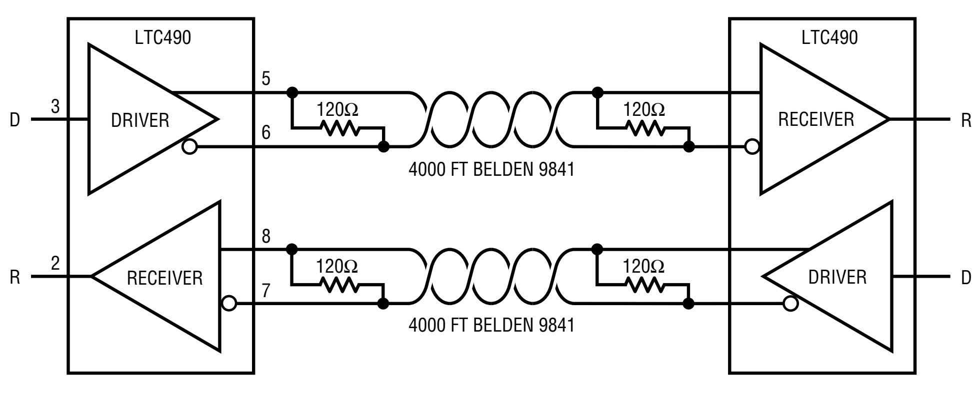
The LTC490 is a low power differential bus/line transceiver designed for multipoint data transmission standard RS485 applications with extended common-mode range (12V to –7V). It also meets the requirements of RS422.

The CMOS design offers significant power savings over its bipolar counterpart without sacrificing ruggedness against overload or ESD damage.

Excessive power dissipation caused by bus contention or faults is prevented by a thermal shutdown circuit which forces the driver outputs into a high impedance state. The receiver has a fail safe feature which guarantees a high output state when the inputs are left open.

Both AC and DC specifications are guaranteed from 0°C to 70°C and 4.75V to 5.25V supply voltage range.

TYPICAL APPLICATION



LTC490 • TA01

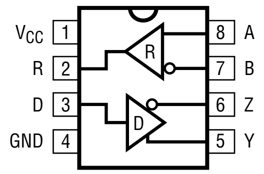
ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage (V_{CC}) 12V
Driver Input Currents .... −25mA to 25mA
Driver Input Voltages .... −0.5V to V_{CC} +0.5V
Driver Output Voltages .... ±14V
Receiver Input Voltages .... ±14V
Receiver Output Voltages .... −0.5V to V_{CC} +0.5V
Operating Temperature Range
  LTC490C .... 0°C to 70°C
  LTC490I .... −40°C to 85°C
Storage Temperature Range .... −65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PACKAGE/ORDER INFORMATION

TOP VIEW



N8 PACKAGE
8-LEAD PLASTIC DIP
S8 PACKAGE
8-LEAD PLASTIC SOIC

T_{JMAX} = 125°C, θ_{JA} = 100°C/W (N8)
T_{JMAX} = 150°C, θ_{JA} = 150°C/W (S8)

ORDER PART NUMBER
LTC490CN8 LTC490CS8 LTC490IN8 LTC490IS8
S8 PART MARKING
490 490I

Consult factory for Military grade parts.

DC ELECTRICAL CHARACTERISTICS

V_{CC} = 5V ±5%

SYMBOL	PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
V_{OD1}	Differential Driver Output Voltage (Unloaded)	I_O = 0		●			5	V
V_{OD2}	Differential Driver Output Voltage (with Load)	R = 50Ω (RS422)		●	2			V
		R = 27Ω (RS485) (Figure 1)		●	1.5		5	V
ΔV_{OD}	Change in Magnitude of Driver Differential Output Voltage for Complementary Output States	R = 27Ω or R = 50Ω (Figure 1)		●			0.2	V
V_{OC}	Driver Common-Mode Output Voltage	R = 27Ω or R = 50Ω (Figure 1)		●			3	V
$\Delta \vert V_{OC} \vert$	Change in Magnitude of Driver Common Mode Output Voltage for Complementary Output States	R = 27Ω or R = 50Ω (Figure 1)		●			0.2	V
V_{IH}	Input High Voltage (D)			●	2.0			V
V_{IL}	Input Low Voltage (D)			●			0.8	V
I_{IN1}	Input Current (D)			●			±2	µA
I_{IN2}	Input Current (A, B)	V_{CC} = 0V or 5.25V	V_{IN} = 12V	●			1	mA
			V_{IN} = −7V	●			−0.8	mA
V_{TH}	Differential Input Threshold Voltage for Receiver	$-7V \le V_{CM} \le 12V$		●	−0.2		0.2	V
ΔV_{TH}	Receiver Input Hysteresis	V_{CM} = 0V		●		70		mV
V_{OH}	Receiver Output High Voltage	I_O = −4mA, V_{ID} = 0.2V		●	3.5			V
V_{OL}	Receiver Output Low Voltage	I_O = 4mA, V_{ID} = −0.2V		●			0.4	V
I_{OZR}	Three-State Output Current at Receiver	V_{CC} = Max $0.4V \le V_O \le 2.4V$		●			±1	µA
I_{CC}	Supply Current	No Load; D = GND or V_{CC}		●		300	500	µA
R_{IN}	Receiver Input Resistance	$-7V \le V_O \le 12V$		●	12			kΩ
I_{OSD1}	Driver Short-Circuit Current, V_{OUT} = High	V_O = – 7V		●		100	250	mA
I_{OSD2}	Driver Short-Circuit Current, V_{OUT} = Low	V_O = 12V		●		100	250	mA
I_{OSR}	Receiver Short-Circuit Current	$0V \le V_O \le V_{CC}$		●	7		85	mA
I_{OZ}	Driver Three-State Output Current	V_O = −7V to 12V		●		±2	±200	µA

SWITCHING CHARACTERISTICS

V_{CC} = 5V ±5%

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
t_{PLH}	Driver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2, 3)	●	10	30	50	ns
t_{PHL}	Driver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2, 3)	●	10	30	50	ns
t_{SKEW}	Driver Output to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2, 3)	●		5		ns
t_r, t_f	Driver Rise or Fall Time	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2, 3)	●	5	5	25	ns
t_{PLH}	Receiver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2, 4)	●	40	70	150	ns
t_{PHL}	Receiver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2, 4)	●	40	70	150	ns
t_{SKD}	$\lvert t_{PLH} - t_{PHL} \rvert$ Differential Receiver Skew	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2, 4)	●		13		ns

The ● denotes specifications which apply over the full operating temperature range.

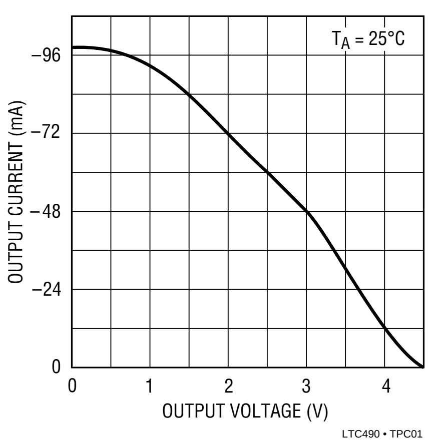
Note 1: Absolute maximum ratings are those beyond which the safety of the device cannot be guaranteed.

Note 2: All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to device ground unless otherwise specified.

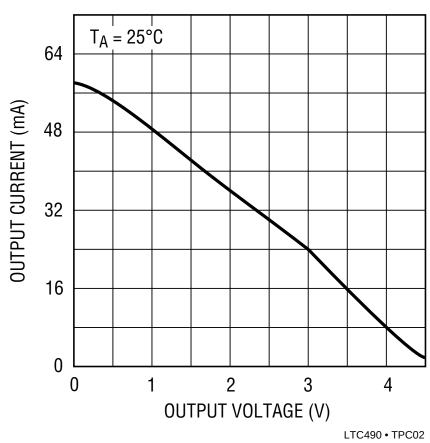
Note 3: All typicals are given for V_{CC} = 5V and Temperature = 25°C.

TYPICAL PERFORMANCE CHARACTERISTICS

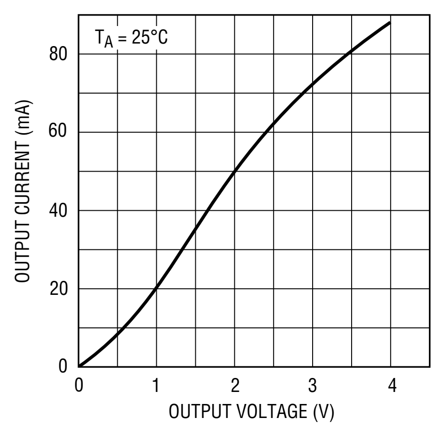
Driver Output High Voltage vs Output Current



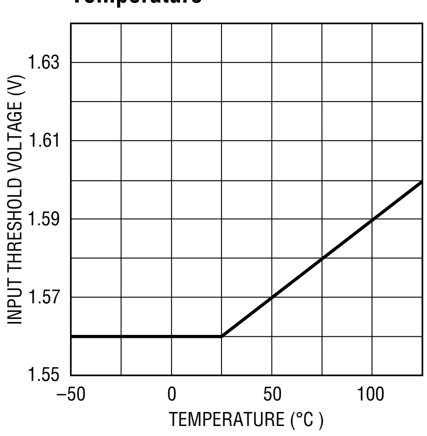
Driver Differential Output Voltage vs Output Current



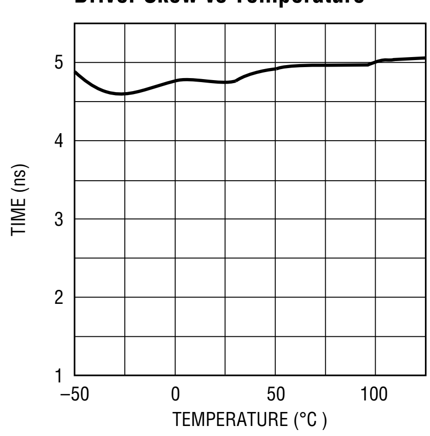
Driver Output Low Voltage vs Output Current



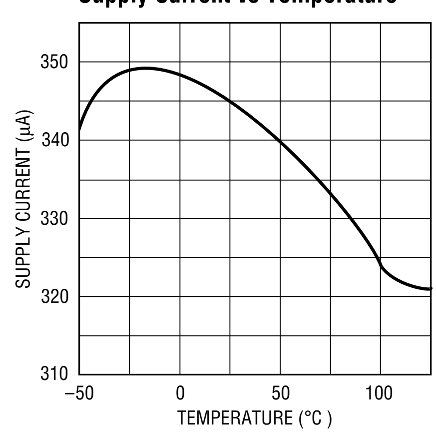
TTL Input Threshold vs Temperature



Driver Skew vs Temperature

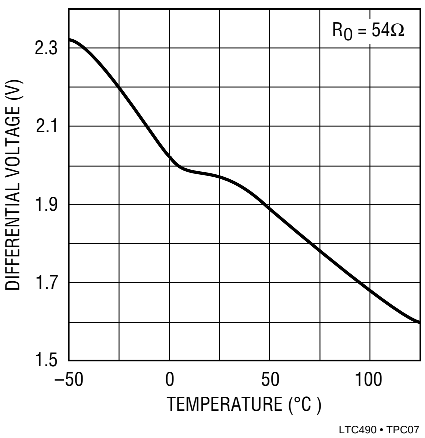


Supply Current vs Temperature

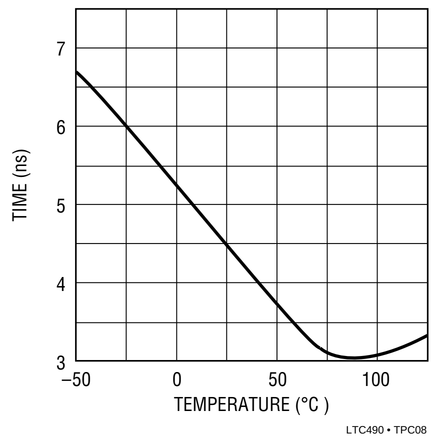


TYPICAL PERFORMANCE CHARACTERISTICS

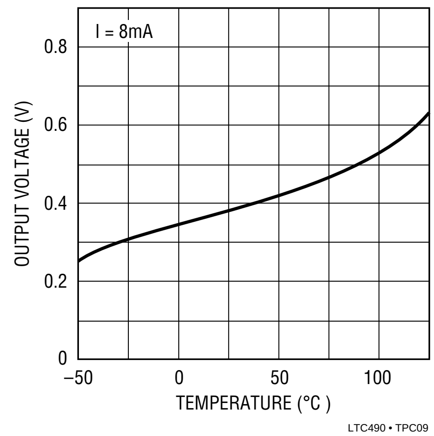
Driver Differential Output Voltage vs Temperature



Receiver |t_{PLH}-t_{PHL}| vs Temperature



Receiver Output Low Voltage vs Temperature



PIN FUNCTIONS

V_{CC} (Pin 1): Positive Supply; 4.75V ≤ V_{CC} ≤ 5.25V.

R (Pin 2): Receiver Output. If A > B by 200mV, R will be high. If A < B by 200mV, then R will be low.

D (Pin 3): Driver Input. A low on D forces the driver outputs A low and B high. A high on D will force A high and B low.

GND (Pin 4): Ground Connection.

Y (Pin 5): Driver Output.

Z (Pin 6): Driver Output.

B (Pin 7): Receiver Input.

A (Pin 8): Receiver Input.

TEST CIRCUITS

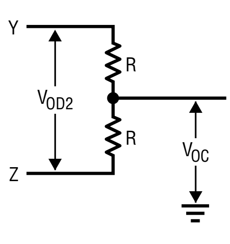


Figure 1. Driver DC Test Load

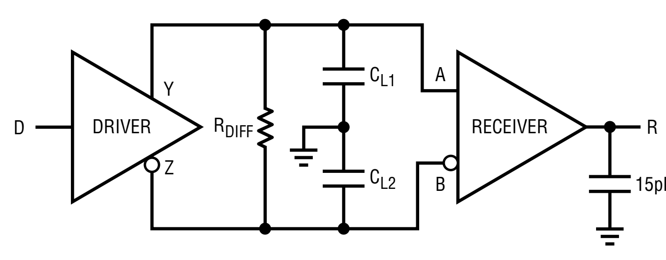


Figure 2. Driver/Receiver Timing Test Circuit

SWITCHING TIME WAVEFORMS

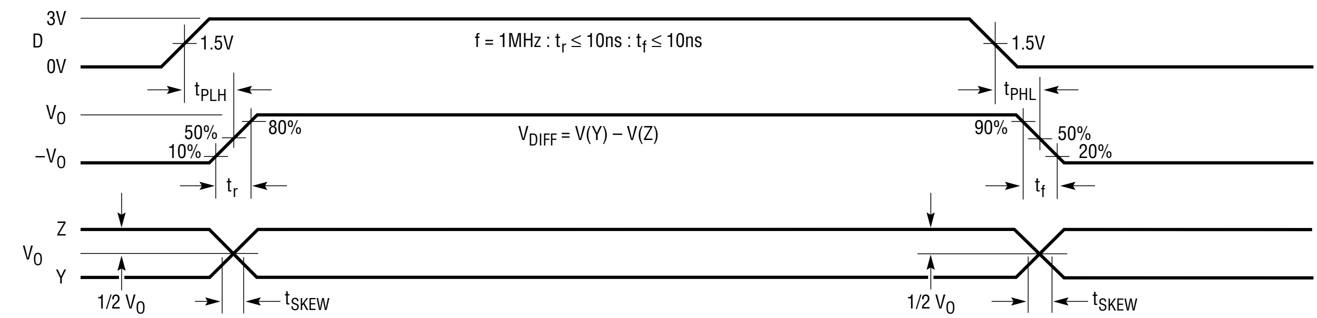


Figure 3. Driver Propagation Delays

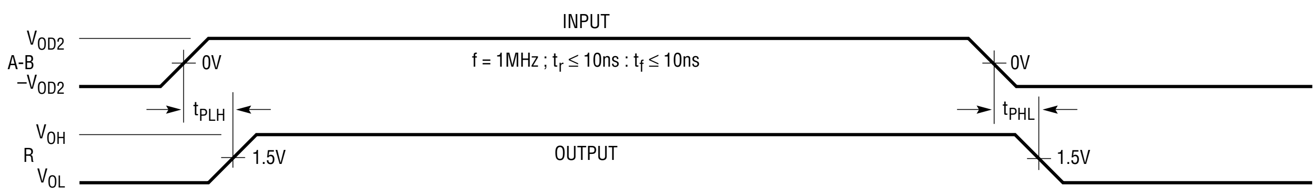


Figure 4. Receiver Propagation Delays

APPLICATIONS INFORMATION

Typical Application

A typical connection of the LTC490 is shown in Figure 5. Two twisted-pair wires connect two driver/receiver pairs for full duplex data transmission. Note that the driver and receiver outputs are always enabled. If the outputs must be disabled, use the LTC491.

There are no restrictions on where the chips are connected, and it isn't necessary to have the chips connected at the ends of the wire. However, the wires must be terminated only at the ends with a resistor equal to their characteristic impedance, typically 120Ω. Because only

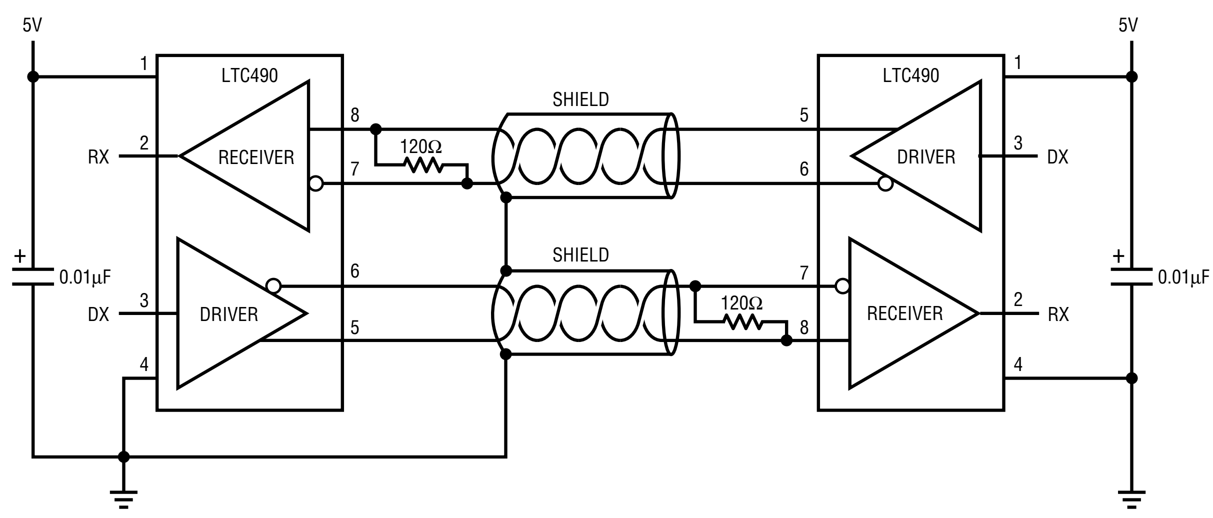


Figure 5. Typical Connection

APPLICATIONS INFORMATION

one driver can be connected on the bus, the cable can be terminated only at the receiving end. The optional shields around the twisted pair help reduce unwanted noise, and are connected to GND at one end.

The LTC490 can also be used as a line repeater as shown in Figure 6. If the cable length is longer than 4000 feet, the LTC490 is inserted in the middle of the cable with the receiver output connected back to the driver input.

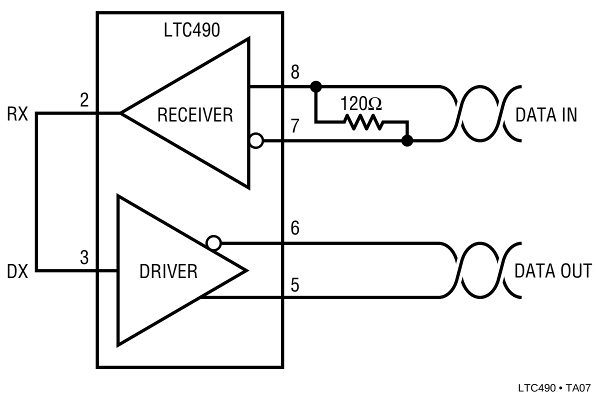


Figure 6. Line Repeater

Thermal Shutdown

The LTC490 has a thermal shutdown feature which protects the part from excessive power dissipation. If the outputs of the driver are accidently shorted to a power supply or low impedance, source, up to 250mA can flow through the part. The thermal shutdown circuit disables the driver outputs when the internal temperature reaches 150°C and turns them back on when the temperature cools to 130°C. If the outputs of two or more LTC490 drivers are shorted directly, the driver outputs can not supply enough current to activate the thermal shutdown. Thus, the thermal shutdown circuit will not prevent contention faults when two drivers are active on the bus at the same time.

Cables and Data Rate

The transmission line of choice for RS485 applications is a twisted pair. There are coaxial cables (twinaxial) made for this purpose that contain straight pairs, but these are less flexible, more bulky, and more costly than twisted pairs. Many cable manufacturers offer a broad range of 120Ω cables designed for RS485 applications.

Losses in a transmission line are a complex combination of DC conductor loss, AC losses (skin effect), leakage and AC losses in the dielectric. In good polyethylene cables such as the Belden 9841, the conductor losses and dielectric losses are of the same order of magnitude, leading to relatively low overall loss (Figure 7).

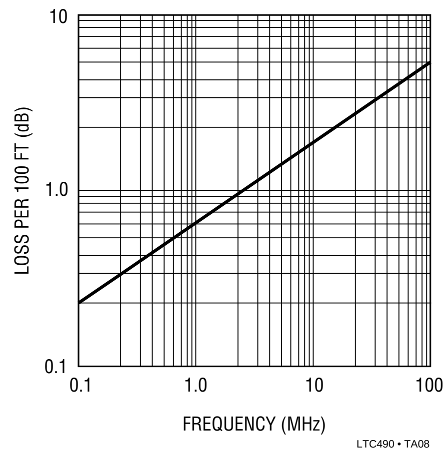


Figure 7. Attenuation vs Frequency for Belden 9841

When using low loss cables, Figure 8 can be used as a guideline for choosing the maximum line length for a given data rate. With lower quality PVC cables, the dielectric loss factor can be 1000 times worse. PVC twisted pairs have terrible losses at high data rates (>100kbs), and greatly reduce the maximum cable length. At low data rates however, they are acceptable and much more economical.

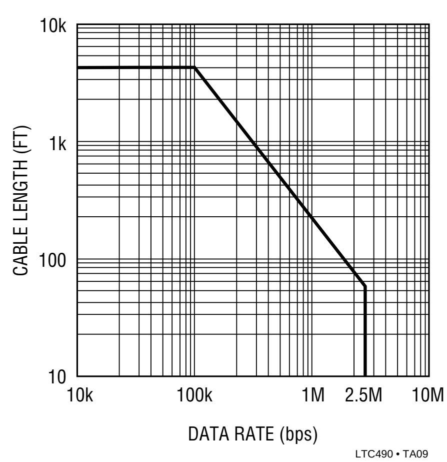


Figure 8. RS485 Cable Length Specification. Applies for 24 Gauge, Polyethylene Dielectric Twisted Pair.

APPLICATIONS INFORMATION

Cable Termination

The proper termination of the cable is very important. If the cable is not terminated with its characteristic impedance, distorted waveforms will result. In severe cases, distorted (false) data and nulls will occur.

A quick look at the output of the driver will tell how well the cable is terminated. It is best to look at a driver connected to the end of the cable, since this eliminates the possibility of getting reflections from two directions. Simply look at the driver output while transmitting square wave data. If the cable is terminated properly, the waveform will look like a square wave (Figure 9). If the cable is loaded excessively (47Ω), the signal initially sees the surge impedance of the cable and jumps to an initial amplitude. The signal travels down the cable and is reflected back out of phase because of the mistermination. When the reflected signal returns to the driver, the amplitude will be lowered. The width of the pedestal is equal to twice the electrical length of the cable (about 1.5ns/foot). If the cable is lightly loaded (470Ω), the signal reflects in phase and increases the amplitude at the driver output. An input frequency of 30kHz is adequate for tests out to 4000 feet of cable.

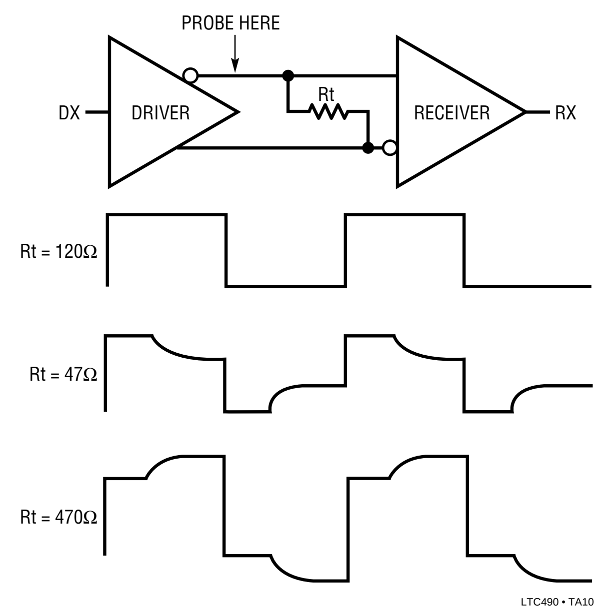


Figure 9. Termination Effects

AC Cable Termination

Cable termination resistors are necessary to prevent unwanted reflections, but they consume power. The typical differential output voltage of the driver is 2V when the cable is terminated with two 120Ω resistors, causing 33mA of DC current to flow in the cable when no data is being sent. This DC current is about 60 times greater than the supply current of the LTC490. One way to eliminate the unwanted current is by AC coupling the termination resistors as shown in Figure 10.

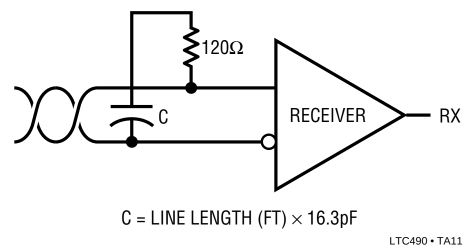


Figure 10. AC Coupled Termination

The coupling capacitor must allow high frequency energy to flow to the termination, but block DC and low frequencies. The dividing line between high and low frequency depends on the length of the cable. The coupling capacitor must pass frequencies above the point where the line represents an electrical one-tenth wavelength. The value of the coupling capacitor should therefore be set at 16.3pF per foot of cable length for 120Ω cables.

With the coupling capacitors in place, power is consumed only on the signal edges, and not when the driver output is idling at a 1 or 0 state. A 100nF capacitor is adequate for lines up to 4000 feet in length. Be aware that the power savings start to decrease once the data rate surpasses $1/(120\Omega \times C)$.

Fault Protection

All of LTC's RS485 products are protected against ESD transients up to 2kV using the human body model (100pF, 1.5kΩ). However, some applications need more protection. The best protection method is to connect a bidirectional TransZorb® from each line side pin to ground (Figure 11). A TransZorb® is a silicon transient voltage

TransZorb® is a registered trademark of General Instruments, GSI

APPLICATIONS INFORMATION

suppressor that has exceptional surge handling capabilities, fast response time, and low series resistance. They are available from General Instruments, GSI and come in a variety of breakdown voltages and prices. Be sure to pick a breakdown voltage higher than the common- mode voltage required for your application (typically 12V). Also, don't forget to check how much the added parasitic capacitance will load down the bus.

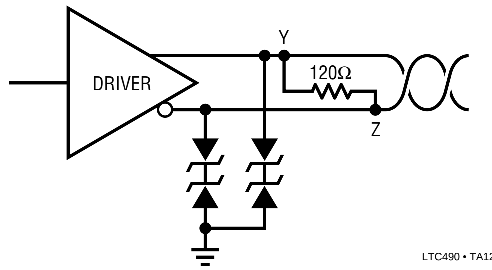
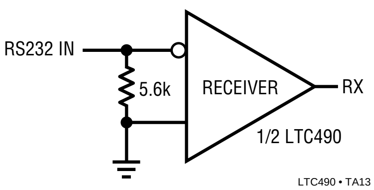


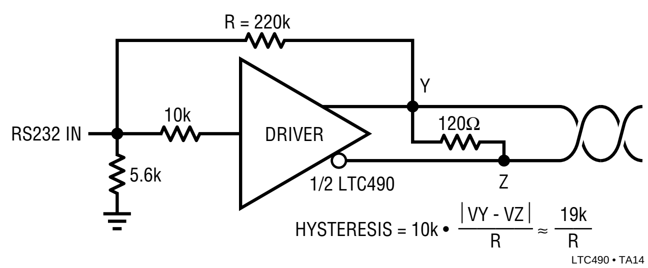
Figure 11. ESD Protection with TransZorbs®

TYPICAL APPLICATIONS

RS232 Receiver

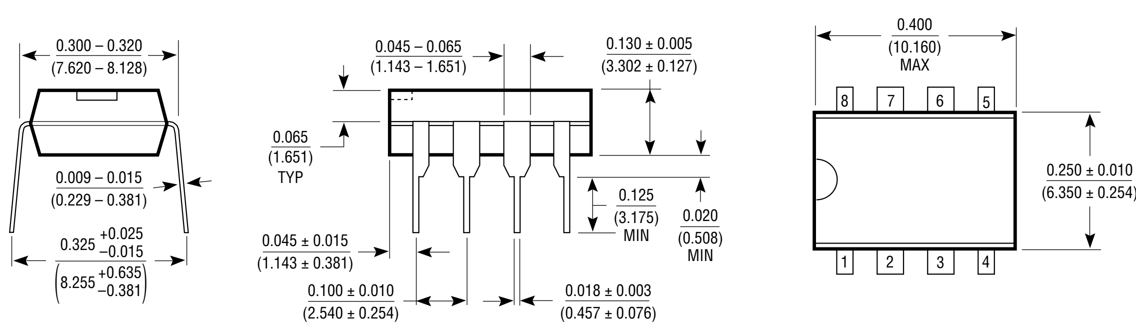


RS232 to RS485 Level Transistor with Hysteresis

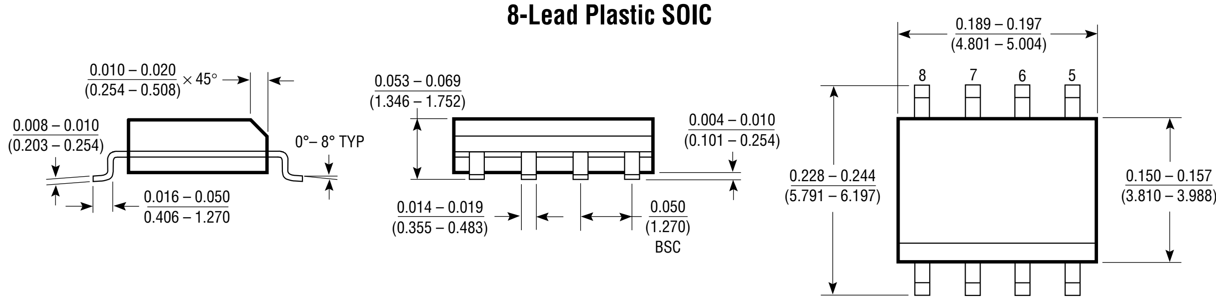


PACKAGE DESCRIPTION **Dimensions in inches (millimeters) unless otherwise noted.**

N8 Package
8-Lead Plastic DIP



S8 Package
8-Lead Plastic SOIC



Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7487
(408) 432-1900 • FAX: (408) 434-0507 • TELEX: 499-3977
BA/LT/GP 0893 5K REV A • PRINTED IN USA

Differential Driver and Receiver Pair

FEATURES

- Low Power: I_{CC} = 300µA Typical
- Designed for RS485 or RS422 Applications
- Single +5V Supply
- –7V to +12V Bus Common Mode Range Permits ±7V Ground Difference Between Devices on the Bus
- Thermal Shutdown Protection
- Power-Up/Down Glitch-Free Driver Outputs Permit Live Insertion or Removal of Package
- Driver Maintains High Impedance in Three-State or with the Power Off
- Combined Impedance of a Driver Output and Receiver Allows up to 32 Transceivers on the Bus
- 70mV Typical Input Hysteresis
- 28ns Typical Driver Propagation Delays with 5ns Skew
- Pin Compatible with the SN75180

APPLICATIONS

- Low Power RS485/RS422 Transceiver
- Level Translator

DESCRIPTION

The LTC491 is a low power differential bus/line transceiver designed for multipoint data transmission standard RS485 applications with extended common mode range (+12V to –7V). It also meets the requirements of RS422.

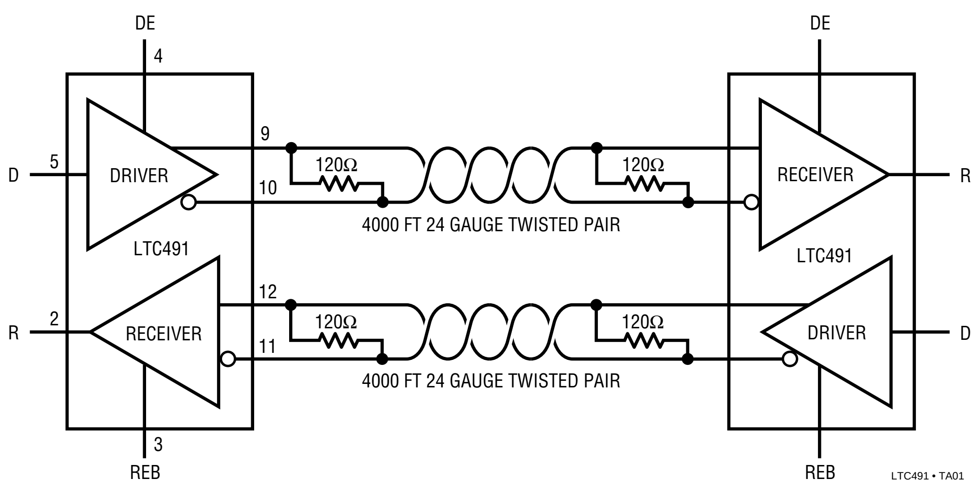
The CMOS design offers significant power savings over its bipolar counterpart without sacrificing ruggedness against overload or ESD damage.

The driver and receiver feature three-state outputs, with the driver outputs maintaining high impedance over the entire common mode range. Excessive power dissipation caused by bus contention or faults is prevented by a thermal shutdown circuit which forces the driver outputs into a high impedance state.

The receiver has a fail safe feature which guarantees a high output state when the inputs are left open.

Both AC and DC specifications are guaranteed from 0°C to 70°C and 4.75V to 5.25V supply voltage range.

TYPICAL APPLICATION

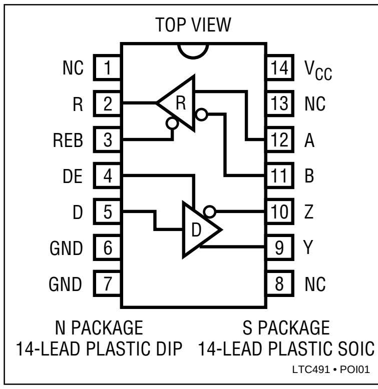


ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage (V_{CC}) 12V
Control Input Voltages .... –0.5V to V_{CC} +0.5V
Control Input Currents .... –50mA to 50mA
Driver Input Voltages .... –0.5V to V_{CC} +0.5V
Driver Input Currents .... –25mA to 25mA
Driver Output Voltages .... ±14V
Receiver Input Voltages .... ±14V
Receiver Output Voltages .... –0.5V to V_{CC} +0.5V
Operating Temperature Range
  LTC491C .... 0°C to 70°C
  LTC491I .... –40°C to 85°C
Storage Temperature Range .... –65°C to 150°C
Lead Temperature (Soldering, 10 sec.) .... 300°C

PACKAGE/ORDER INFORMATION



ORDER PART NUMBER
LTC491CN
LTC491CS
LTC491IN
LTC491IS

Consult factory for Military grade parts.

DC ELECTRICAL CHARACTERISTICS

V_{CC} = 5V ±5%

SYMBOL	PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
V_{OD1}	Differential Driver Output Voltage (Unloaded)	$I_O = 0$		●			5	V
V_{OD2}	Differential Driver Output Voltage (With load)	R = 50Ω; (RS422)		●	2			V
		R = 27Ω; (RS485) (Figure 1)		●	1.5		5	V
ΔV_{OD}	Change in Magnitude of Driver Differential Output Voltage for Complementary Output States	R = 27Ω or R = 50Ω (Figure 1)		●			0.2	V
V_{OC}	Driver Common Mode Output Voltage			●			3	V
$\Delta \vert V_{OC} \vert$	Change in Magnitude of Driver Common Mode Output Voltage for Complementary Output States			●			0.2	V
V_{IH}	Input High Voltage	D, DE, REB		●	2.0			V
V_{IL}	Input Low Voltage			●			0.8	V
I_{IN1}	Input Current			●			±2	μA
I_{IN2}	Input Current (A, B)	V_{CC} = 0V or 5.25V	V_{IN} = 12V	●			1.0	mA
			V_{IN} = –7V	●			–0.8	mA
V_{TH}	Differential Input Threshold Voltage for Receiver	$-7V \le V_{CM} \le 12V$		●	–0.2		0.2	V
ΔV_{TH}	Receiver Input Hysteresis	V_{CM} = 0V		●	70			mV
V_{OH}	Receiver Output High Voltage	I_O = –4mA, V_{ID} = 0.2V		●	3.5			V
V_{OL}	Receiver Output Low Voltage	I_O = 4mA, V_{ID} = –0.2V		●			0.4	V
I_{OZR}	Three-State Output Current at Receiver	V_{CC} = Max $0.4V \le V_O \le 2.4V$		●			±1	μA
I_{CC}	Supply Current	No Load; D = GND,	Outputs Enabled	●		300	500	μA
		or V_{CC}	Outputs Disabled	●		300	500	μA
R_{IN}	Receiver Input Resistance	$-7V \le V_{CM} \le 12V$		●	12			kΩ
I_{OSD1}	Driver Short Circuit Current, V_{OUT} = High	V_O = –7V		●		100	250	mA
I_{OSD2}	Driver Short Circuit Current, V_{OUT} = Low	V_O = 12V		●		100	250	mA
I_{OSR}	Receiver Short Circuit Current	$0V \le V_O \le V_{CC}$		●	7		85	mA
I_{OZ}	Driver Three-State Output Current	V_O = –7V to 12V		●		±2	±200	μA

SWITCHING CHARACTERISTICS

V_{CC} = 5V ±5%

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
t_{PLH}	Driver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2, 5)	●	10	30	50	ns
t_{PHL}	Driver Input to Output		●	10	30	50	ns
t_{SKEW}	Driver Output to Output		●		5		ns
t_r, t_f	Driver Rise or Fall Time		●	5	15	25	ns
t_{ZH}	Driver Enable to Output High	C_L = 100pF (Figures 4, 6) S2 Closed	●		40	70	ns
t_{ZL}	Driver Enable to Output Low	C_L = 100pF (Figures 4, 6) S1 Closed	●		40	70	ns
t_{LZ}	Driver Disable Time From Low	C_L = 15pF (Figures 4, 6) S1 Closed	●		40	70	ns
t_{HZ}	Driver Disable Time From High	C_L = 15pF (Figures 4, 6) S2 Closed	●		40	70	ns
t_{PLH}	Receiver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2, 7)	●	40	70	150	ns
t_{PHL}	Receiver Input to Output		●	40	70	150	ns
t_{SKD}	$\lvert t_{PLH} - t_{PHL} \rvert$ Differential Receiver Skew		●		13		ns
t_{ZL}	Receiver Enable to Output Low	C_L = 15pF (Figures 3, 8) S1 Closed	●		20	50	ns
t_{ZH}	Receiver Enable to Output High	C_L = 15pF (Figures 3, 8) S2 Closed	●		20	50	ns
t_{LZ}	Receiver Disable From Low	C_L = 15pF (Figures 3, 8) S1 Closed	●		20	50	ns
t_{HZ}	Receiver Disable From High	C_L = 15pF (Figures 3, 8) S2 Closed	●		20	50	ns

The ● denotes specifications which apply over the full operating temperature range.

Note 1: "Absolute Maximum Ratings" are those beyond which the safety of the device cannot be guaranteed.

Note 2: All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to device ground unless otherwise specified.

Note 3: All typicals are given for V_{CC} = 5V and Temperature = 25°C.

PIN FUNCTIONS

NC (Pin 1): Not Connected.

R (Pin 2): Receiver output. If the receiver output is enabled (REB low), then if A > B by 200mV, R will be high. If A < B by 200mV, then R will be low.

REB (Pin 3): Receiver output enable. A low enables the receiver output, R. A high input forces the receiver output into a high impedance state.

DE (Pin 4): Driver output enable. A high on DE enables the driver outputs, A and B. A low input forces the driver outputs into a high impedance state.

D (Pin 5): Driver input. If the driver outputs are enabled (DE high), then A low on D forces the driver outputs A low and B high. A high on D will force A high and B low.

GND (Pin 6): Ground Connection.

GND (Pin 7): Ground Connection.

NC (Pin 8): Not Connected.

Y (Pin 9): Driver output.

Z (Pin 10): Driver output.

B (Pin 11): Receiver input.

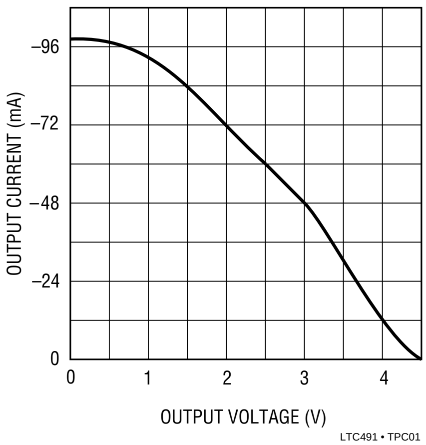
A (Pin 12): Receiver input.

NC (Pin 13): Not Connected.

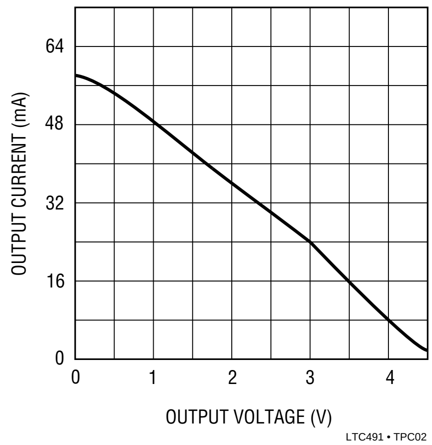
V_{CC} (Pin 14): Positive supply; 4.75V ≤ V_{CC} ≤ 5.25V.

TYPICAL PERFORMANCE CHARACTERISTICS

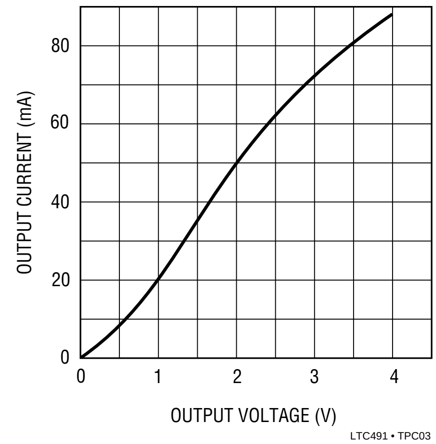
Driver Output High Voltage vs Output Current T_A = 25°C



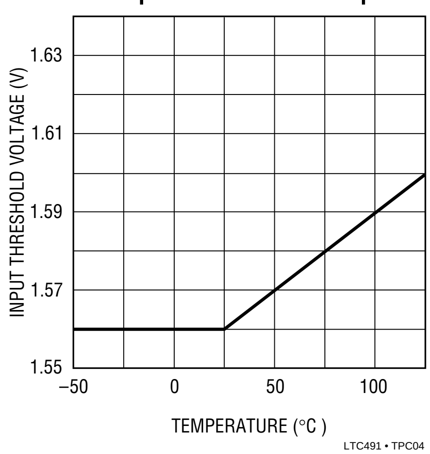
Driver Differential Output Voltage vs Output Current T_A = 25°C



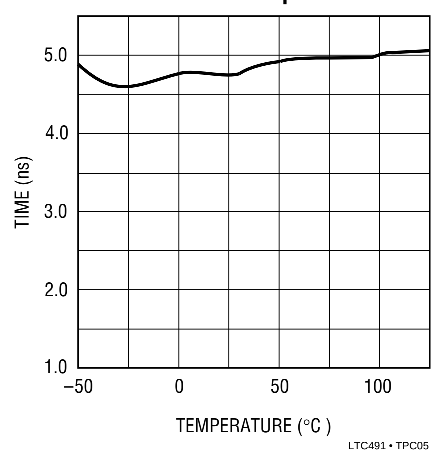
Driver Output Low Voltage vs Output Current T_A = 25°C



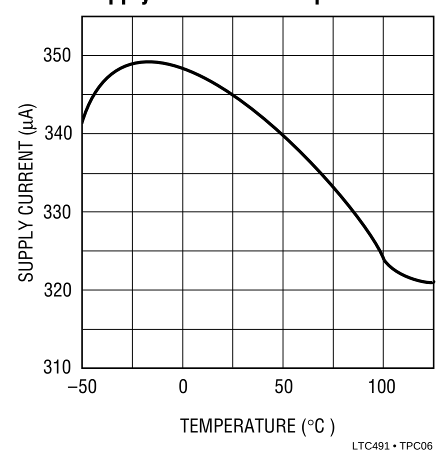
TTL Input Threshold vs Temperature



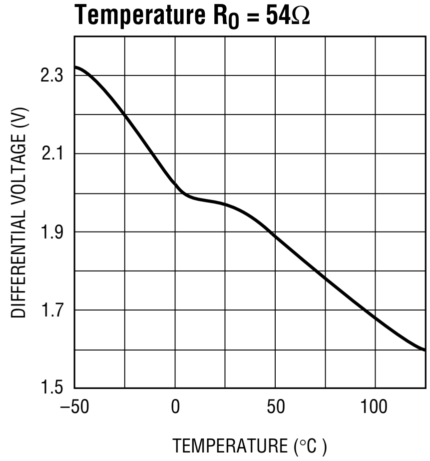
Driver Skew vs Temperature



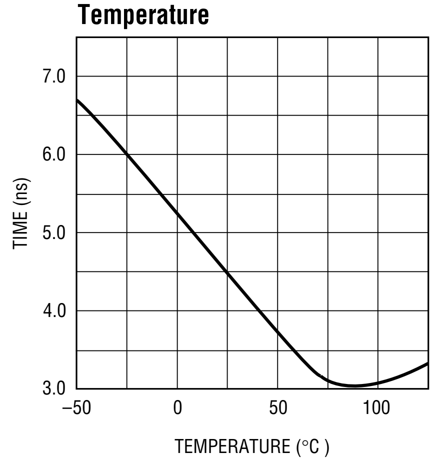
Supply Current vs Temperature



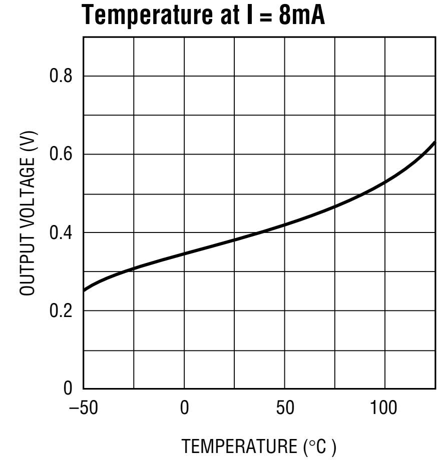
Driver Differential Output Voltage vs Temperature R_O = 54Ω



Receiver |t_{PLH} t_{PHL}| vs Temperature



Receiver Output Low Voltage vs Temperature at I = 8mA



TEST CIRCUITS

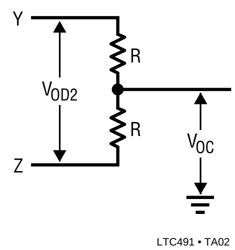


Figure 1. Driver DC Test Load

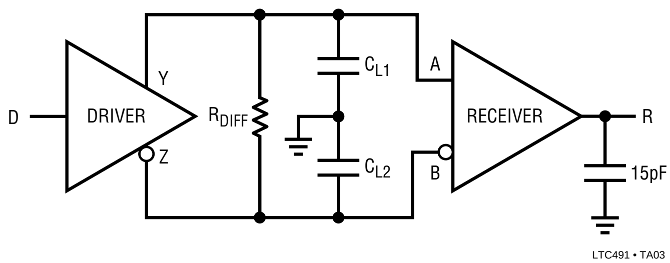


Figure 2. Driver/Receiver Timing Test Circuit

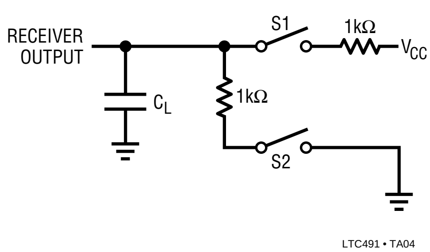


Figure 3. Receiver Timing Test Load

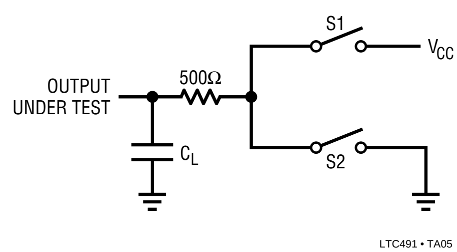


Figure 4. Driver Timing Test Load

SWITCHING TIME WAVEFORMS

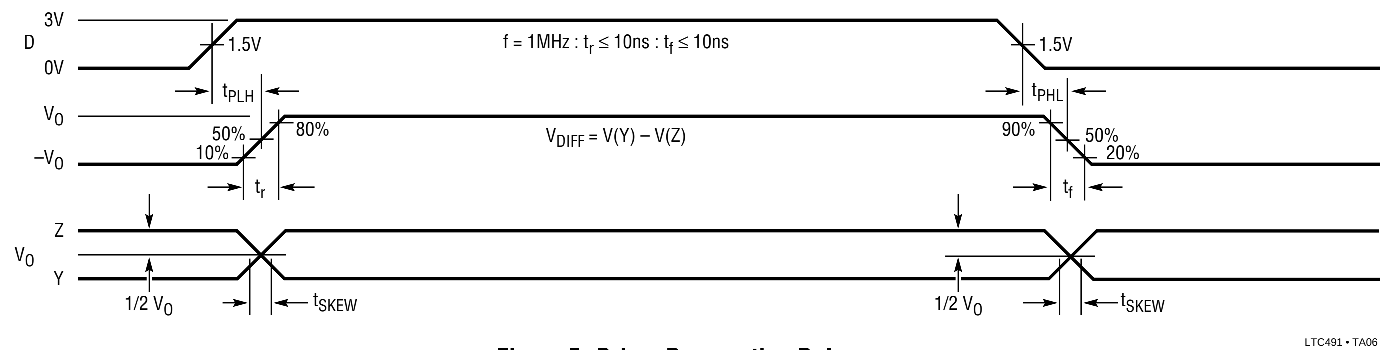


Figure 5. Driver Propagation Delays

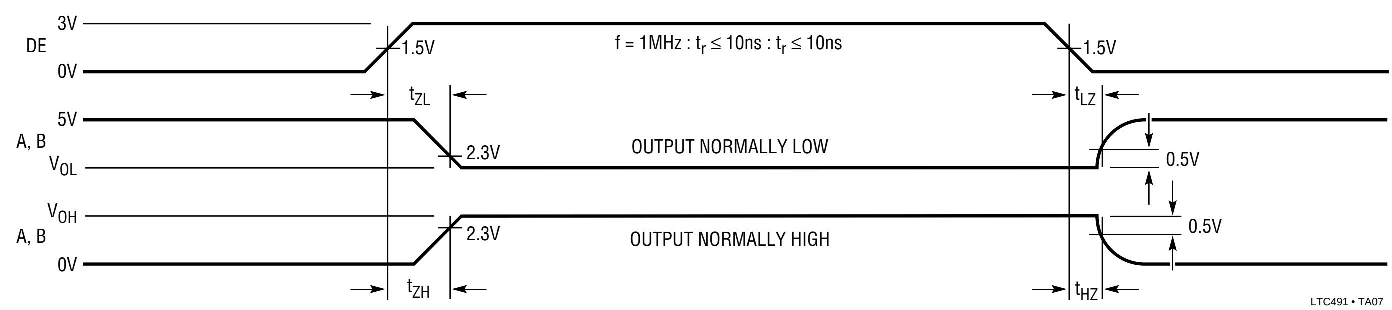


Figure 6. Driver Enable and Disable Times

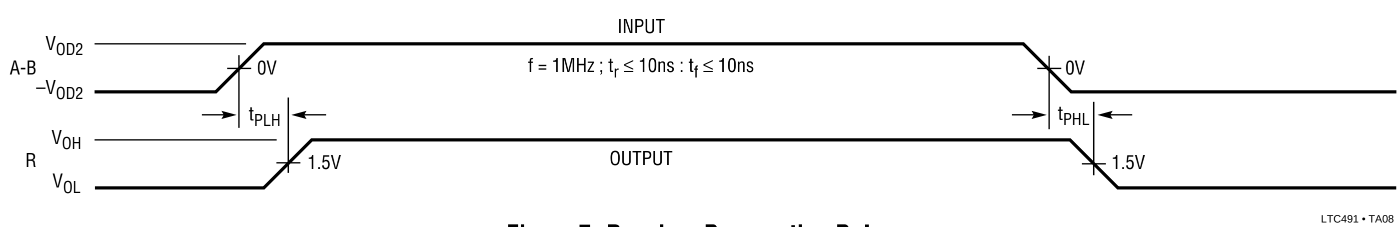


Figure 7. Receiver Propagation Delays

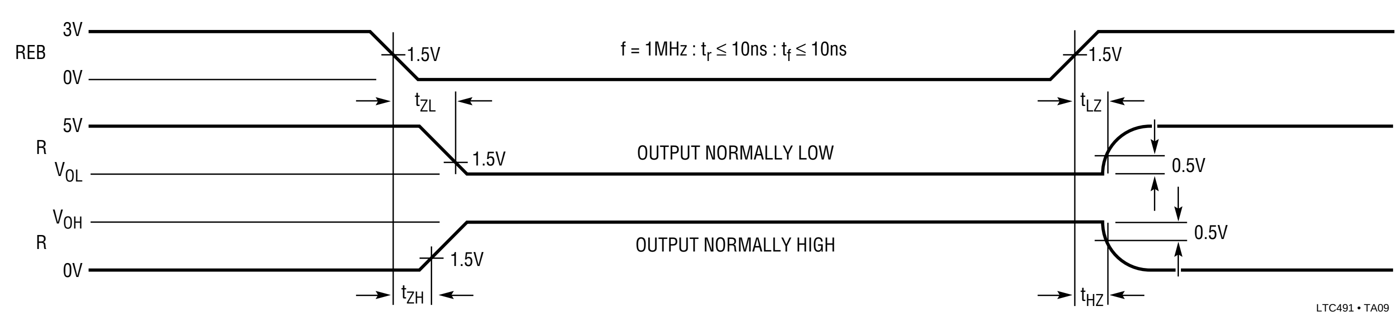


Figure 8. Receiver Enable and Disable Times

APPLICATIONS INFORMATION

Typical Application

A typical connection of the LTC491 is shown in Figure 9. Two twisted pair wires connect up to 32 driver/receiver pairs for full duplex data transmission. There are no restrictions on where the chips are connected to the wires, and it isn't necessary to have the chips connected at the ends. However, the wires must be terminated only at the ends with a resistor equal to their characteristic impedance, typically 120Ω. The input impedance of a receiver is typically 20kΩ to GND, or 0.6 unit RS-485 load, so in practice 50 to 60 transceivers can be connected to the same wires. The optional shields around the twisted pair help reduce unwanted noise, and are connected to GND at one end.

The LTC491 can also be used as a line repeater as shown in Figure 10. If the cable length is longer than 4000 feet, the LTC491 is inserted in the middle of the cable with the receiver output connected back to the driver input.

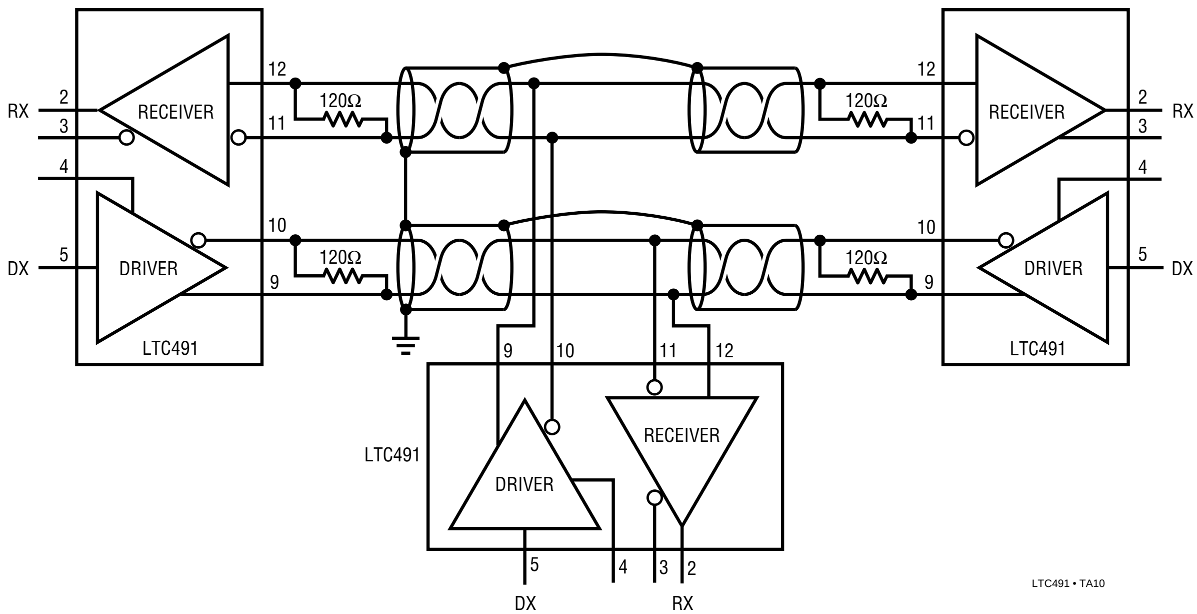


Figure 9. Typical Connection

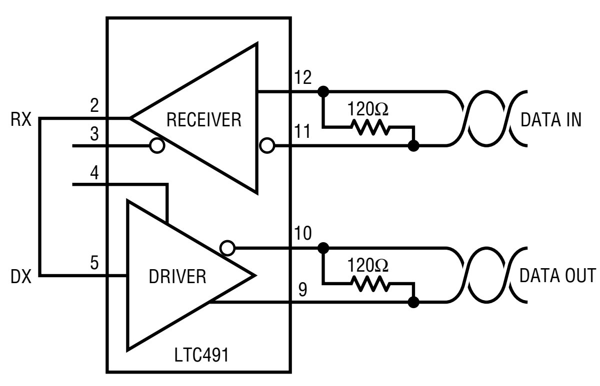


Figure 10. Line Repeater

APPLICATIONS INFORMATION

Thermal Shutdown

The LTC491 has a thermal shutdown feature which protects the part from excessive power dissipation. If the outputs of the driver are accidently shorted to a power supply or low impedance source, up to 250mA can flow through the part. The thermal shutdown circuit disables the driver outputs when the internal temperature reaches 150°C and turns them back on when the temperature cools to 130°C. If the outputs of two or more LTC491 drivers are shorted directly, the driver outputs can not supply enough current to activate the thermal shutdown. Thus, the thermal shutdown circuit will not prevent contention faults when two drivers are active on the bus at the same time.

Cables and Data Rate

The transmission line of choice for RS485 applications is a twisted pair. There are coaxial cables (twinaxial) made for this purpose that contain straight pairs, but these are less flexible, more bulky, and more costly than twisted pairs. Many cable manufacturers offer a broad range of 120Ω cables designed for RS485 applications.

Losses in a transmission line are a complex combination of DC conductor loss, AC losses (skin effect), leakage and AC losses in the dielectric. In good polyethylene cables such as the Belden 9841, the conductor losses and dielectric losses are of the same order of magnitude, leading to relatively low over all loss (Figure 11).

When using low loss cables, Figure 12 can be used as a guideline for choosing the maximum line length for a given data rate. With lower quality PVC cables, the dielectric loss factor can be 1000 times worse. PVC twisted pairs have terrible losses at high data rates (>100kBs), and greatly reduce the maximum cable length. At low data rates however, they are acceptable and much more economical.

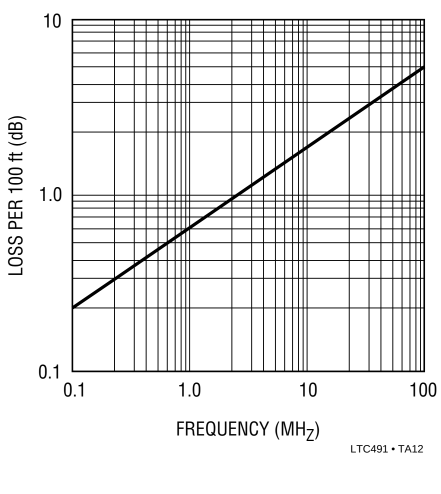


Figure 11. Attenuation vs Frequency for Belden 9481

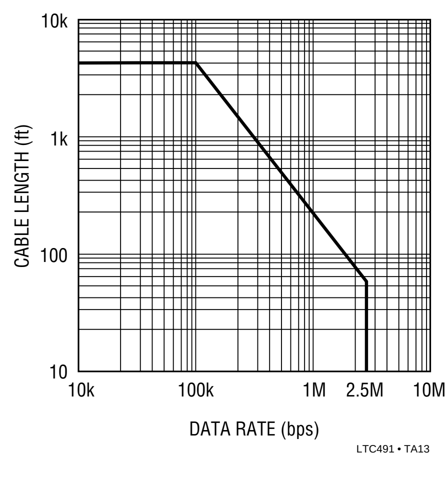


Figure 12. Cable Length vs Data Rate

APPLICATIONS INFORMATION

Cable Termination

The proper termination of the cable is very important. If the cable is not terminated with it's characteristic impedance, distorted waveforms will result. In severe cases, distorted (false) data and nulls will occur. A quick look at the output of the driver will tell how well the cable is terminated. It is best to look at a driver connected to the end of the cable, since this eliminates the possibility of getting reflections from two directions. Simply look at the driver output while transmitting square wave data. If the cable is terminated properly, the waveform will look like a square wave (Figure 13).

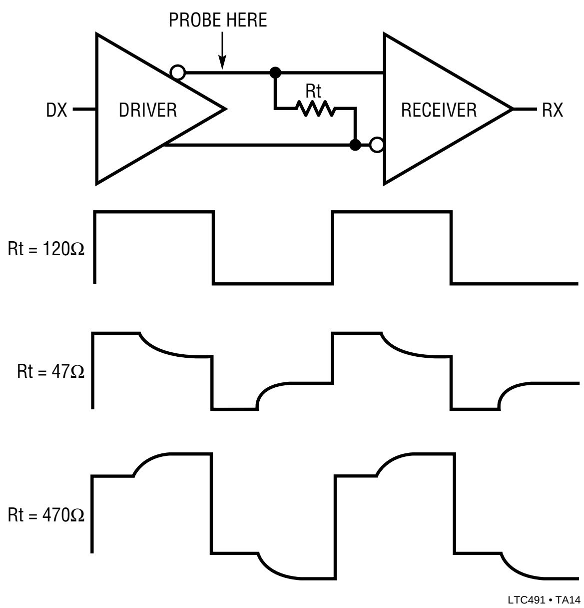


Figure 13. Termination Effects

If the cable is loaded excessively (47Ω), the signal initially sees the surge impedance of the cable and jumps to an initial amplitude. The signal travels down the cable and is reflected back out of phase because of the mistermination. When the reflected signal returns to the driver, the amplitude will be lowered. The width of the pedestal is equal to twice the electrical length of the cable (about 1.5ns/foot).

If the cable is lightly loaded (470Ω), the signal reflects in phase and increases the amplitude at the driver output. An input frequency of 30kHz is adequate for tests out to 4000 feet of cable.

AC Cable Termination

Cable termination resistors are necessary to prevent unwanted reflections, but they consume power. The typical differential output voltage of the driver is 2V when the cable is terminated with two 120Ω resistors, causing 33mA of DC current to flow in the cable when no data is being sent. This DC current is about 60 times greater than the supply current of the LTC491. One way to eliminate the unwanted current is by AC coupling the termination resistors as shown in Figure 14.

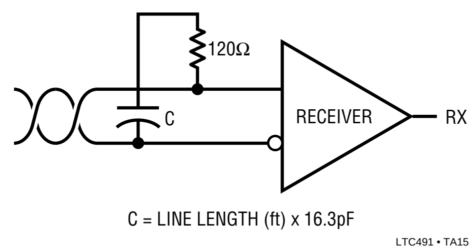


Figure 14. AC Coupled Termination

The coupling capacitor must allow high-frequency energy to flow to the termination, but block DC and low frequencies. The dividing line between high and low frequency depends on the length of the cable. The coupling capacitor must pass frequencies above the point where the line represents an electrical one-tenth wavelength. The value of the coupling capacitor should therefore be set at 16.3pF per foot of cable length for 120Ω cables. With the coupling capacitors in place, power is consumed only on the signal edges, and not when the driver output is idling at a 1 or 0 state. A 100nF capacitor is adequate for lines up to 4000 feet in length. Be aware that the power savings start to decrease once the data rate surpasses $1/(120\Omega \times C)$.

APPLICATIONS INFORMATION

Receiver Open-Circuit Fail-Safe

Some data encoding schemes require that the output of the receiver maintains a known state (usually a logic 1) when the data is finished transmitting and all drivers on the line are forced into three-state. The receiver of the LTC491 has a fail-safe feature which guarantees the output to be in a logic 1 state when the receiver inputs are left floating (open-circuit). However, when the cable is terminated with 120Ω, the differential inputs to the receiver are shorted together, not left floating. Because the receiver has about 70mV of hysteresis, the receiver output will maintain the last data bit received.

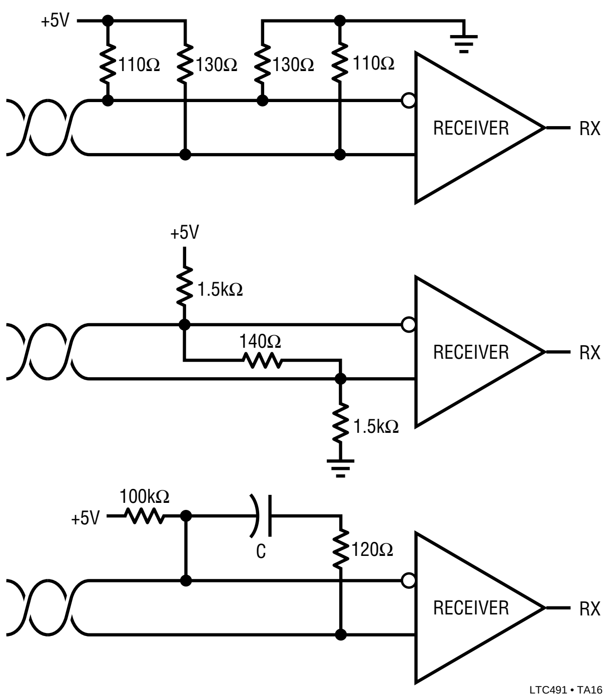


Figure 15. Forcing "0" When All Drivers are Off

The termination resistors are used to generate a DC bias which forces the receiver output to a known state, in this case a logic 0. The first method consumes about 208mW and the second about 8mW. The lowest power solution is to use an AC termination with a pull-up resistor. Simply swap the receiver inputs for data protocols ending in logic 1.

Fault Protection

All of LTC's RS485 products are protected against ESD transients up to 2kV using the human body model (100pF, 1.5kΩ). However, some applications need more protection. The best protection method is to connect a bidirectional TransZorb from each line side pin to ground (Figure 16).

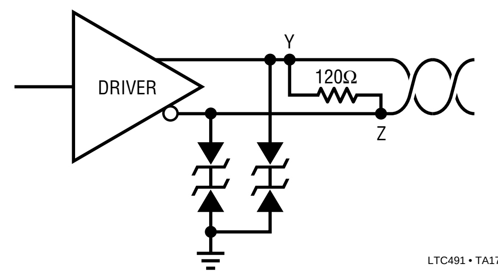
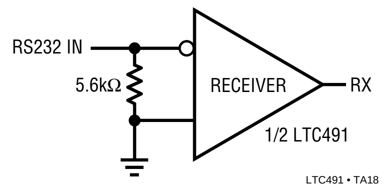


Figure 16. ESD Protection with TransZorbs

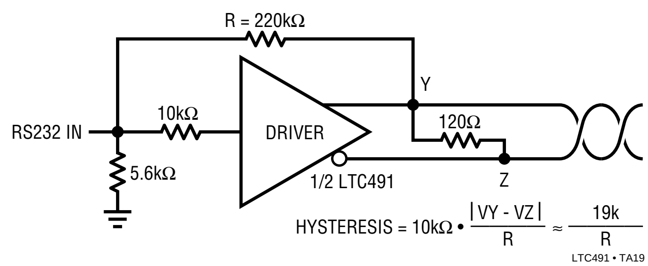
A TransZorb is a silicon transient voltage suppressor that has exceptional surge handling capabilities, fast response time, and low series resistance. They are available from General Semiconductor Industries and come in a variety of breakdown voltages and prices. Be sure to pick a breakdown voltage higher than the common mode voltage required for your application (typically 12V). Also, don't forget to check how much the added parasitic capacitance will load down the bus.

TYPICAL APPLICATIONS

RS232 Receiver

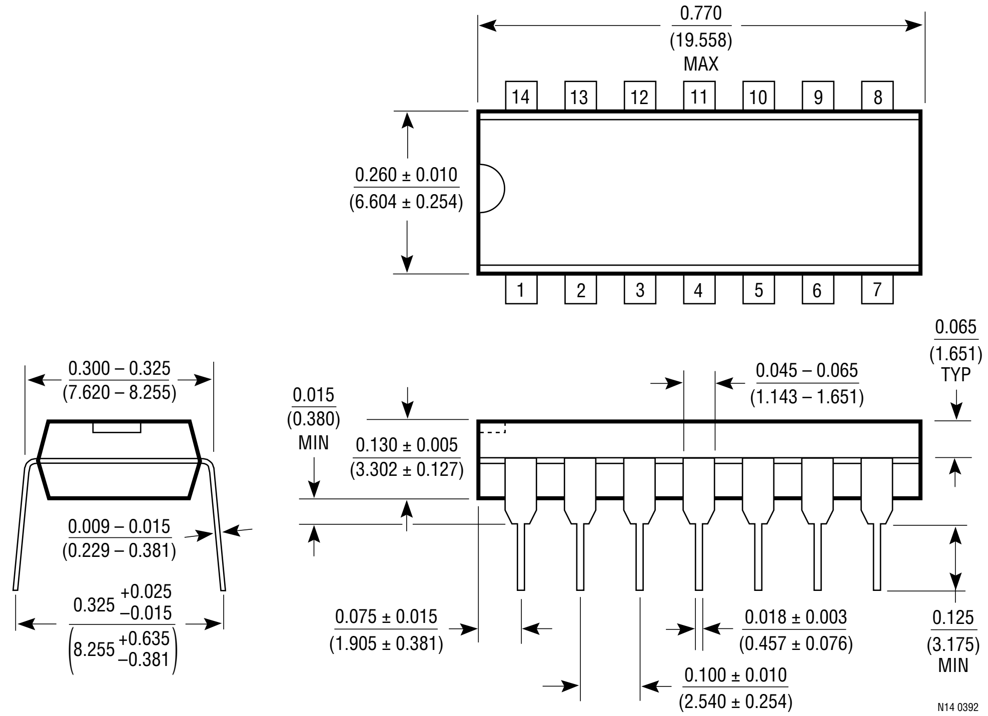


RS232 to RS485 Level Transistor with Hysteresis



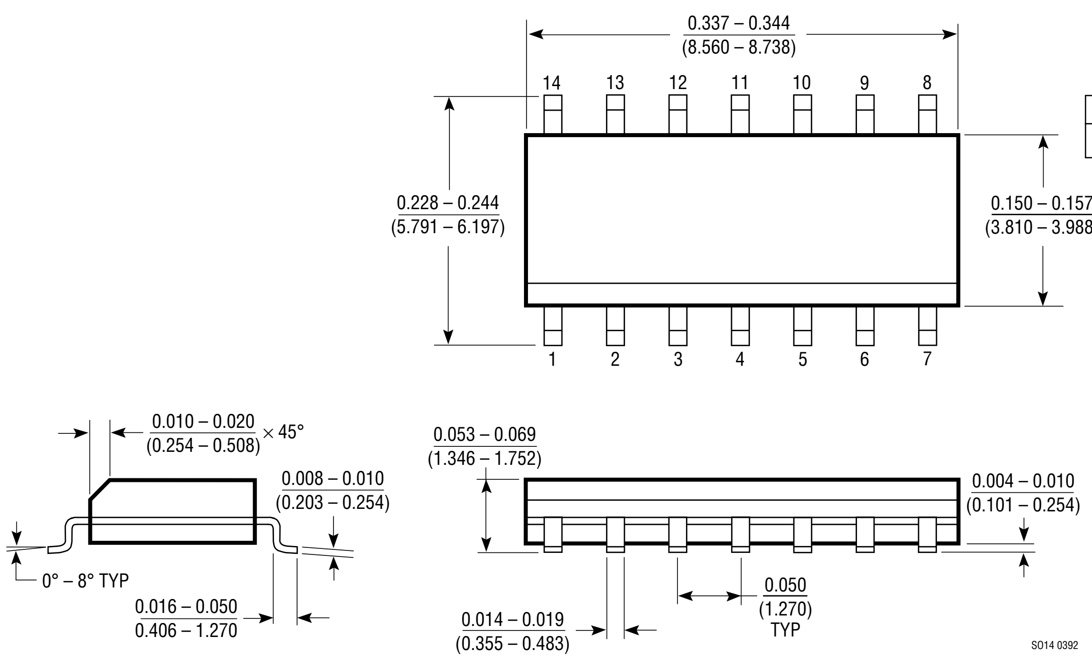
PACKAGE DESCRIPTION Dimensions in inches (millimeters) unless otherwise noted.

N Package
14-Lead Plastic DIP



$T_{J\,MAX}$	θ_{JA}
100°C	90°C/W

S Package
14-Lead Plastic SOIC



$T_{J\,MAX}$	θ_{JA}
100°C	110°C/W

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