3.3V Ultralow Power RS485 Transceiver

FEATURES

- **True RS485 from a Single 3.3V Supply**
- **Low Power: I_{CC} = 500µA Max with Driver Disabled**
- **I_{CC} = 600µA Max with Driver Enabled, No Load**
- **1µA Quiescent in Shutdown Mode**
- –7V to 12V Common Mode Range Permits ±7V Ground Difference Between Devices on the Data Line
- 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
- Up to 32 Transceivers on the Bus
- 50ns Typical Driver Propagation Delays with 10ns Skew
- Pin Compatible with the LTC485
- Available in 8-Lead DIP and SO Packages

APPLICATIONS

- Battery-Powered RS485/RS422 Applications
- Low Power RS485/RS422 Transceiver
- Level Translator

DESCRIPTION

The LTC®1480 is an ultralow power differential line transceiver which provides full RS485 compatibility while operating from a single 3.3V supply. It is designed for data transmission standard RS485 applications with extended common mode range (12V to –7V). It also meets the requirements of RS422 and features high speed operation up to 2.5Mb/s. The CMOS design offers significant power savings without sacrificing ruggedness against overload or ESD damage. Typical quiescent current is only 300µA while operating and 1µA in shutdown.

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 LTC1480 is fully specified over the commercial and extended industrial temperature range. The LTC1480 is available in 8-pin SO and DIP packages.

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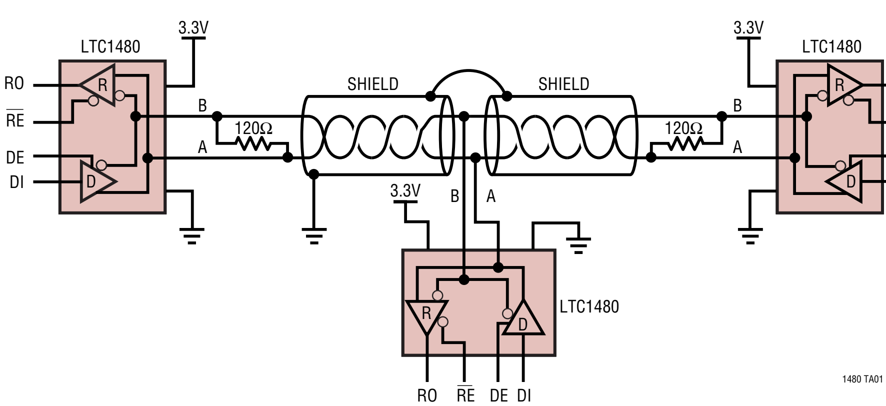
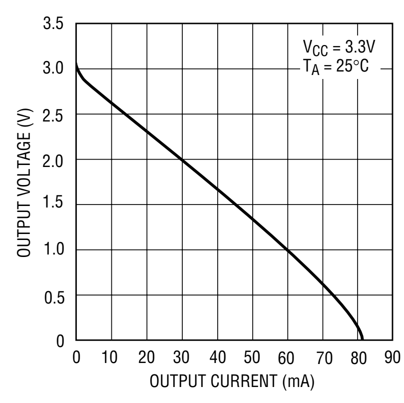
TYPICAL APPLICATION

3.3V RS485 Network



Driver Differential Output Voltage vs Output Current



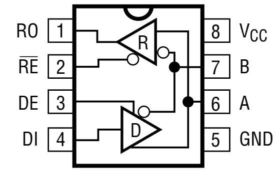
ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage (V_{CC}) 7V
Control Input Voltage .... −0.3V to V_{CC} + 0.3V
Driver Input Voltage .... −0.3V to V_{CC} + 0.3V
Driver Output Voltage .... ±14V
Receiver Input Voltage .... ±14V
Receiver Output Voltage .... −0.3V to V_{CC} + 0.3V
Operating Temperature Range
  LTC1480C .... 0°C ≤ T_A ≤ 70°C
  LTC1480I .... −40°C ≤ T_A ≤ 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 PDIP

S8 PACKAGE
8-LEAD PLASTIC SO

T_{JMAX} = 125°C, θ_{JA} = 130°C/W (N8)
T_{JMAX} = 125°C, θ_{JA} = 150°C/W (S8)

ORDER PART NUMBER	S8 PART MARKING
LTC1480CN8 LTC1480IN8 LTC1480CS8 LTC1480IS8	1480 1480I

Order Options Tape and Reel: Add #TR
Lead Free: Add #PBF   Lead Free Tape and Reel: Add #TRPBF
Lead Free Part Marking: http://www.linear.com/leadfree/

Consult LTC Marketing for parts specified with wider operating temperature ranges.

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range. V_{CC} = 3.3V (Notes 2, 3).

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OD1}	Differential Driver Output Voltage (Unloaded)	I_O = 0V	●			3.3	V
V_{OD2}	Differential Driver Output Voltage (with Load)	R = 27Ω (RS485) (Figure 1) R = 50Ω (RS422)	● ●	1.5 2.0		3.3	V 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)	●			2	V
$\Delta \lvert V_{OC} \rvert$	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	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 3.6V, V_{IN} = 12V DE = 0, V_{CC} = 0V or 3.6V, V_{IN} = −7V	● ●			1.0 −0.8	mA 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	●	2			V
V_{OL}	Receiver Output 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, Output Enabled No Load, Output Disabled	● ●		400 300	600 500	µA µA
I_{SHDN}	Supply Current in Shutdown Mode	DE = 0, $\overline{RE}$ = V_{CC}			1	10	µA

SWITCHING CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range. V_{CC} = 3.3V (Notes 2, 3).

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
I_{OSD1}	Driver Short-Circuit Current, V_{OUT} = HIGH	$-7V \le V_O \le 12V$	●	35		250	mA
I_{OSD2}	Driver Short-Circuit Current, V_{OUT} = LOW	$-7V \le V_O \le 12V$	●	35		250	mA
I_{OSR}	Receiver Short-Circuit Current	$0V \le V_O \le V_{CC}$	●	7		85	mA
t_{PLH}	Driver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF, (Figures 3, 5)	●	25	50	80	ns
t_{PHL}	Driver Input to Output		●	25	50	80	ns
t_{SKEW}	Driver Output to Output		●		10	20	ns
t_R, t_F	Driver Rise or Fall Time		●	5	15	40	ns
t_{ZH}	Driver Enable to Output HIGH	C_L = 100pF (Figures 4, 6), S2 Closed	●		70	120	ns
t_{ZL}	Driver Enable to Output LOW	C_L = 100pF (Figures 4, 6), S1 Closed	●		70	120	ns
t_{LZ}	Driver Disable Time from LOW	C_L = 15pF (Figures 4, 6), S1 Closed	●		70	120	ns
t_{HZ}	Driver Disable Time from HIGH	C_L = 15pF (Figures 4, 6), S2 Closed	●		70	120	ns
t_{PLH}	Receiver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF, (Figures 3, 7)	●	30	140	200	ns
t_{PHL}	Receiver Input to Output		●	30	140	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, 8), S1 Closed	●		50	80	ns
t_{ZH}	Receiver Enable to Output HIGH	C_{RL} = 15pF (Figures 2, 8), S2 Closed	●		50	80	ns
t_{LZ}	Receiver Disable from LOW	C_{RL} = 15pF (Figures 2, 8), S1 Closed	●		50	80	ns
t_{HZ}	Receiver Disable from HIGH	C_{RL} = 15pF (Figures 2, 8), S2 Closed	●		50	80	ns
f_{MAX}	Maximum Data Rate		●	2.5			Mbits/s
t_{SHDN}	Time to Shutdown	DE = 0, RE = ↑	●	50	200	600	ns
$t_{ZH(SHDN)}$	Driver Enable from Shutdown to Output HIGH	C_L = 100pF (Figures 4, 6), S2 Closed	●		70	120	ns
$t_{ZL(SHDN)}$	Driver Enable from Shutdown to Output LOW	C_L = 100pF (Figures 4, 6), S1 Closed	●		70	120	ns
$t_{ZH(SHDN)}$	Receiver Enable from Shutdown to Output HIGH	C_L = 15pF (Figures 2, 8), S2 Closed	●			4500	ns
$t_{ZL(SHDN)}$	Receiver Enable from Shutdown to Output LOW	C_L = 15pF (Figures 2, 8), S1 Closed	●			4500	ns

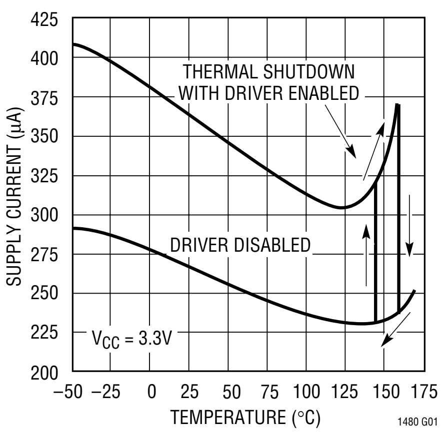
Note 1: Absolute maximum ratings are those beyond which the safety of the device cannot be guaranteed.

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.

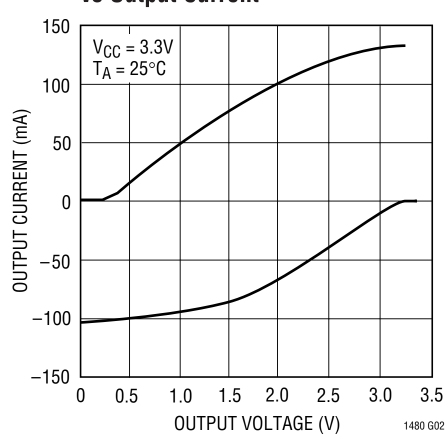
Note 3: All typicals are given for V_{CC} = 3.3V and T_A = 25°C.

TYPICAL PERFORMANCE CHARACTERISTICS

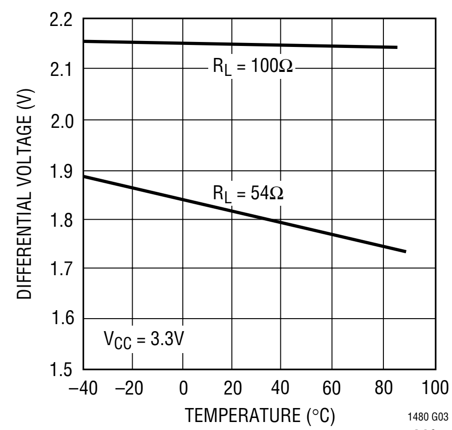
Supply Current vs Temperature



Driver Output Low/High Voltage vs Output Current

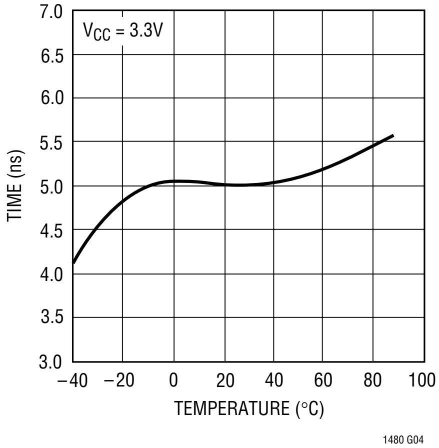


Driver Differential Output Voltage vs Temperature

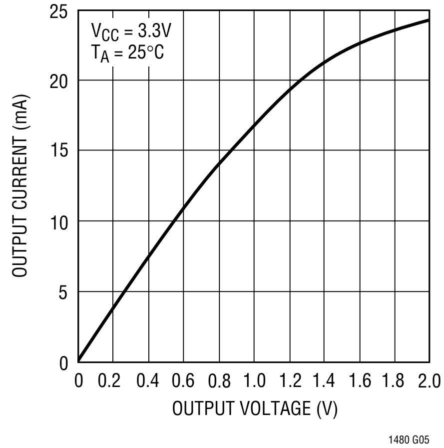


TYPICAL PERFORMANCE CHARACTERISTICS

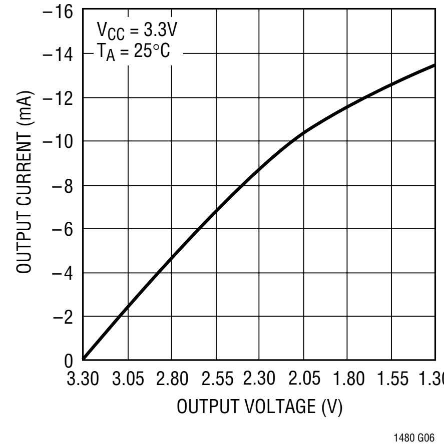
Driver Skew vs Temperature



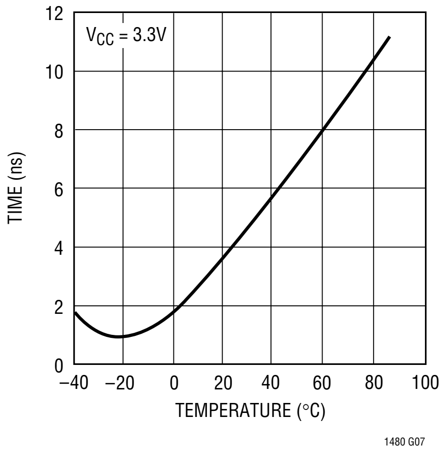
Receiver Output Low Voltage vs Output Current



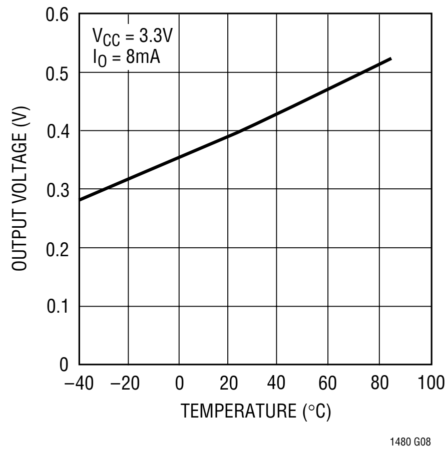
Receiver Output High Voltage vs Output Current



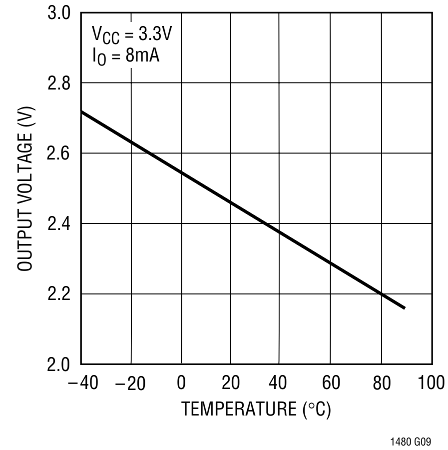
Receiver $|t_{PLH} - t_{PHL}|$ vs Temperature



Receiver Output Low Voltage vs Temperature



Receiver Output High Voltage vs Temperature



PIN FUNCTIONS

RO (Pin 1): Receiver Output. If the receiver output is enabled ($\overline{RE}$ LOW) and A > B by 200mV, then RO will be HIGH. If A < B by 200mV, then RO will be LOW.

$\overline{RE}$ (Pin 2): Receiver Output Enable. A LOW enables the receiver output, RO. A HIGH input forces the receiver output into a high impedance state.

DE (Pin 3): Driver Outputs Enable. A HIGH on DE enables the driver output. A, 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. If $\overline{RE}$ is high and DE is LOW, the part will enter a low power (1μA) shutdown state. If $\overline{RE}$ is low and DE is high, the driver outputs will be fed back to the receiver and the receive output will correspond to the driver input.

DI (Pin 4): 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.

GND (Pin 5): Ground.

A (Pin 6): Driver Output/Receiver Input.

B (Pin 7): Driver Output/Receiver Input.

V_{CC} (Pin 8): Positive Supply. 3.0V < V_{CC} < 3.6V.

FUNCTION TABLES

LTC1480 Transmitting

INPUTS			OUTPUTS	
$\overline{RE}$	DE	DI	B	A
X	1	1	0	1
X	1	0	1	0
0	0	X	Z	Z
1	0	X	Z*	Z*

*Shutdown mode

LTC1480 Receiving

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

*Shutdown mode

TEST CIRCUITS

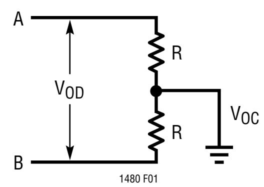


Figure 1. Driver DC Test Load

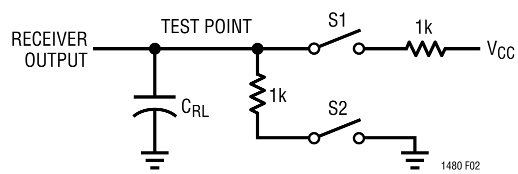


Figure 2. Receiver Timing Test Load

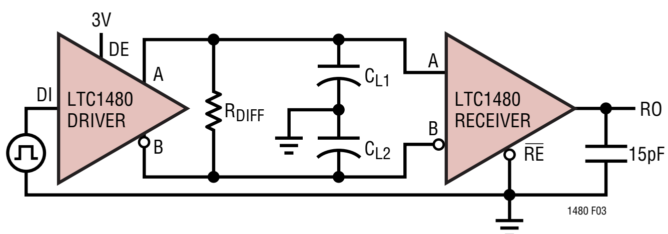


Figure 3. Driver/Receiver Timing Test Circuit

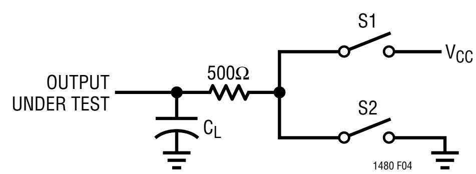


Figure 4. Driver Timing Test Load

SWITCHING TIME WAVEFORMS

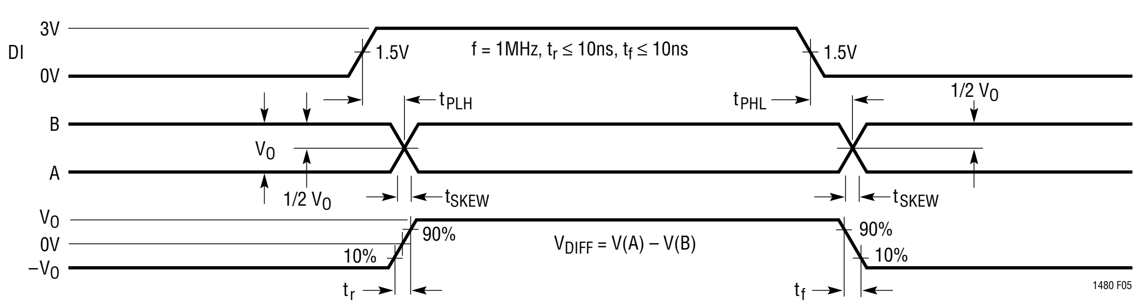


Figure 5. Driver Propagation Delays

SWITCHING TIME WAVEFORMS

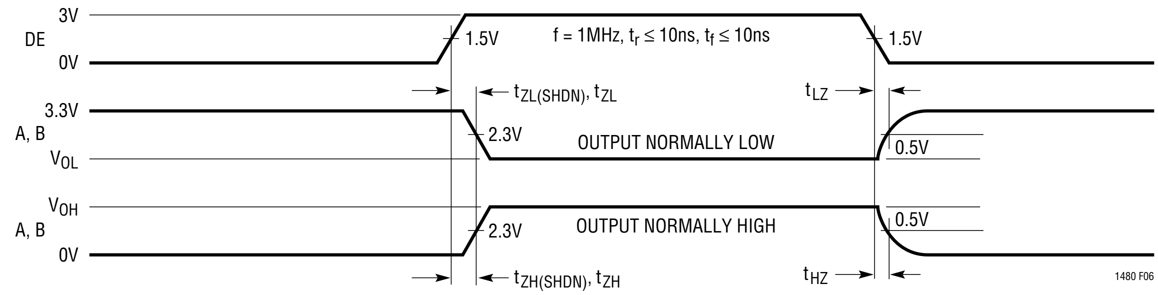


Figure 6. Driver Enable and Disable Times

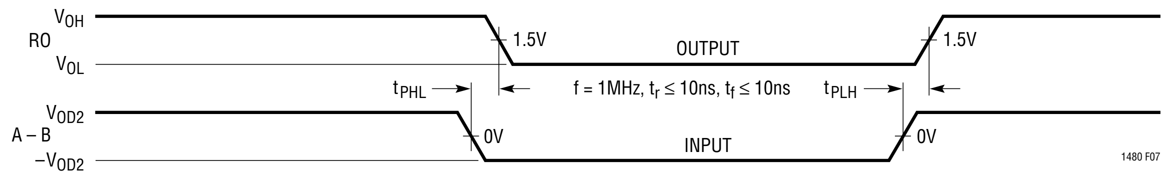


Figure 7. Receiver Propagation Delays

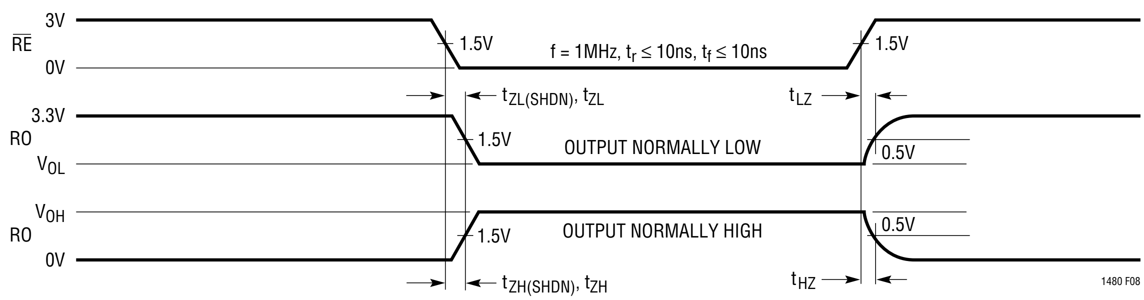


Figure 8. Receiver Enable and Disable Times

APPLICATIONS INFORMATION

CMOS Output Driver

The LTC1480 transceiver provides full RS485 compatibility while operating from a single 3.3V supply. The RS485 specification requires that a transceiver withstand common mode voltages of up to 12V or –7V at the RS485 line connections. Additionally, the transceiver must be immune to both ESD and latch-up. This rules out traditional CMOS drivers, which include parasitic diodes from their driver outputs to each supply rail (Figure 9). The LTC1480 uses a proprietary process enhancement which adds a pair of Schottky diodes to the output stage (Figure 10), preventing

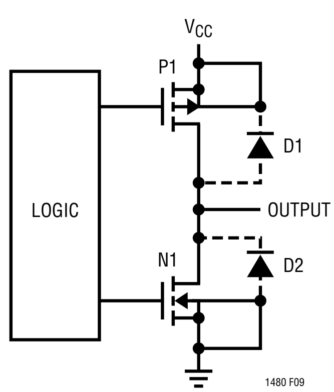


Figure 9. Conventional CMOS Output Stage

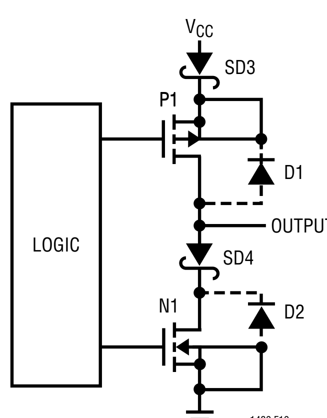


Figure 10. LTC1480 Output Stage

APPLICATIONS INFORMATION

current from flowing when the common mode voltage exceeds the supply rails. Latch-up at the output drivers is virtually eliminated and the driver is prevented from loading the line under RS485 specified fault conditions.

When two or more drivers are connected to the same transmission line, a potential condition exists whereby more than two drivers are simultaneously active. If one or more drivers is sourcing current while another driver is sinking current, excessive power dissipation may occur within either the sourcing or sinking element. This condition is defined as driver contention, since multiple drivers are competing for one transmission line. The LTC1480 provides a current limiting scheme to prevent driver contention failure. When driver contention occurs, the current drawn is limited to about 70mA preventing excessive power dissipation within the drivers.

The LTC1480 has a thermal shutdown feature which protects the part from excessive power dissipation. Under extreme fault conditions, up to 250mA can flow through the part causing rapid internal temperature rise. The thermal shutdown circuit will disable the driver outputs when the internal temperature reaches 150°C and turns them back on when the temperature cools to 130°C. This cycle will repeat as necessary until the fault condition is removed.

Receiver Inputs

The LTC1480 features an input common mode range covering the entire RS485 specified range of –7V to 12V. Differential signals of greater than ±200mV within the specified input common mode range will be converted to a TTL compatible signal at the receiver output. A small amount of input hysteresis is included to minimize the effects of noise on the line signals. If the receiver inputs are floating (unterminated) an internal pull-up of 10μA at the A input will force the receiver output to a known high state.

Low Power Operation

The LTC1480 draws very little supply current whenever the driver outputs are disabled. In shutdown mode the quiescent current is typically less than 1μA. With the receiver active and the driver outputs disabled, the LTC1480 will typically draw 300μA quiescent current. With the driver outputs enabled but unterminated, quiescent current will rise as one of the two outputs sources current into the internal receiver input resistance. With the minimum receiver input resistance of 12k and the maximum output swing of 3.3V, the quiescent current will rise by a maximum of 275μA. Typical quiescent current rise with the driver enabled is about 100μA.

The quiescent current rises significantly if the driver is enabled when it is externally terminated. With 1/2 termination load (120Ω between the driver outputs) the quiescent current will jump to at least 13mA as the drivers force a minimum of 1.5V across the termination resistance. With a fully terminated 60Ω line attached, the current will rise to greater than 25mA with the driver enabled, completely overshadowing the extra 100μA drawn by internal receiver inputs.

Shutdown Mode

Both the receiver output (RO) and the driver outputs (A, B) can be placed in three-state mode by bringing $\overline{RE}$ HIGH and DE LOW respectively. In addition, the LTC1480 will enter shutdown mode when $\overline{RE}$ is HIGH and DE is LOW.

In shutdown the LTC1480 typically draws only 1μA of supply current. In order to guarantee that the part goes into shutdown, $\overline{RE}$ must be high and DE must be LOW for at least 600ns simultaneously. If this time duration is less than 50ns the part will not enter shutdown mode.

Propagation Delay

Many digital encoding schemes are dependent upon the difference in the propagation delay times of the driver and receiver. Figure 11 shows the test circuit for the LTC1480 propagation delay.

The receiver delay times are:

$$|t_{PLH} - t_{PHL}| = 13\text{ns Typ}, V_{CC} = 3.3\text{V}$$

The driver's skew times are:

$$t_{SKEW} = 10\text{ns Typ}, V_{CC} = 3.3\text{V}$$

$$20\text{ns Max}, V_{CC} = 3.3\text{V}, T_A = -40°\text{C to } 85°\text{C}$$

LINEAR TECHNOLOGY

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