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## FEATURES

- Single Chip Provides Complete Differential Signal Interface for V.35 Port
- Drivers and Receivers Will Withstand Repeated  $\pm 10\text{kV}$  ESD Pulses
- Operates from  $\pm 5\text{V}$  Supplies
- 10Mbaud Transmission Rate
- Meets CCITT V.35 Specification
- Shutdown Mode Reduces  $I_{CC}$  to Below  $1\mu\text{A}$
- Selectable Transmitter and Receiver Configurations
- Independent Driver/Receiver Enables
- Transmitter Maintains High Impedance When Disabled, Shut Down or with Power Off
- Transmitters Are Short-Circuit Protected

## APPLICATIONS


- Modems
- Telecommunications
- Data Routers

## DESCRIPTION

The LTC<sup>®</sup>1346A is a single chip transceiver that provides the differential clock and data signals for a V.35 interface from  $\pm 5\text{V}$  supplies. Combined with an external resistor termination network and an LT<sup>®</sup>1134A RS232 transceiver for the control signals, the LTC1346A forms a complete low power DTE or DCE V.35 interface port.

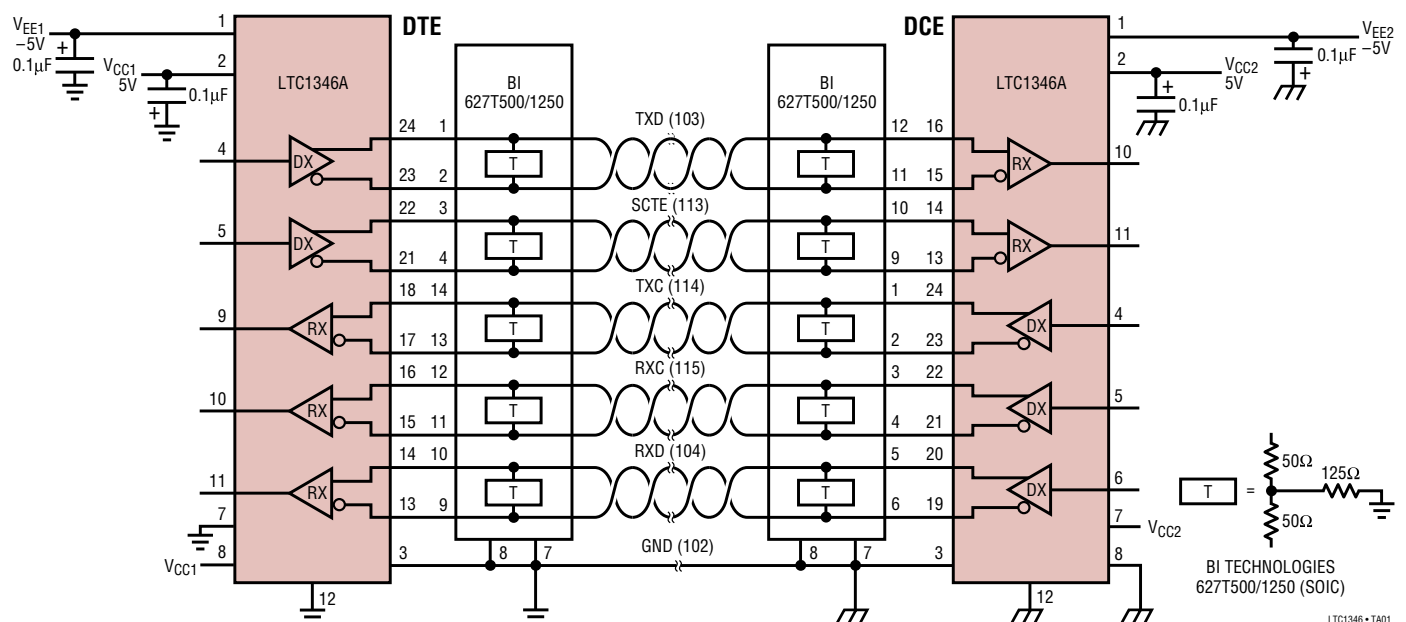
The LTC1346A features three current output differential transmitters and three differential receivers. The transceiver can be configured for DTE or DCE operation or shutdown using three Select pins. In the Shutdown mode, the supply current is reduced to below  $1\mu\text{A}$ .

The LTC1346A transceiver operates up to 10Mbaud. All transmitters feature short-circuit protection. Both the transmitter outputs and the receiver outputs can be forced into a high impedance state. The transmitter outputs and receiver inputs feature  $\pm 10\text{kV}$  ESD protection.

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## TYPICAL APPLICATION

Clock and Data Signals for V.35 Interface

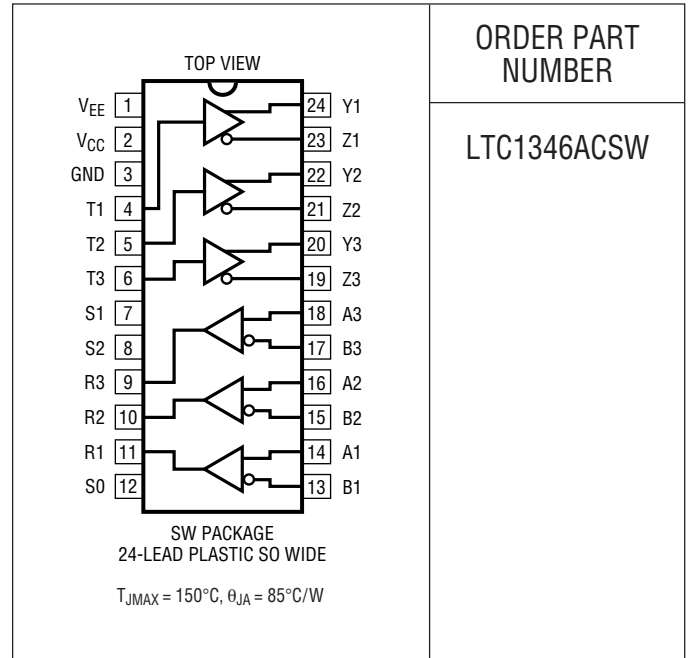


## ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage	
$V_{CC}$ .....	6.5V
$V_{EE}$ .....	-6.5V
Input Voltage	
Transmitters .....	-0.3V to ( $V_{CC} + 0.3V$ )
Receivers .....	-18V to 18V
S0, S1, S2 .....	-0.3V to ( $V_{CC} + 0.3V$ )
Output Voltage	
Transmitters .....	-18V to 18V
Receivers .....	-0.3V to ( $V_{CC} + 0.3V$ )
Short-Circuit Duration	
Transmitter Output .....	Indefinite
Receiver Output .....	Indefinite
Operating Temperature Range	
LTC1346AC .....	0°C to 70°C
Storage Temperature Range .....	-65°C to 150°C
Lead Temperature (Soldering, 10 sec) .....	300°C

## PACKAGE/ORDER INFORMATION



ORDER PART NUMBER

LTC1346ACSW





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

## DC ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range.  $V_{CC} = 5V \pm 5\%$ ,  $V_{EE} = -5V \pm 5\%$  (Note 2)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
$V_{OD}$	Transmitter Differential Output Voltage	$-4V \leq V_{OS} \leq 4V$ (Figure 1)	● 0.44	0.55	0.66	V	
$V_{OC}$	Transmitter Common Mode Output Voltage	$V_{OS} = 0V$ (Figure 1)	● -0.6	0	0.6	V	
$I_{OH}$	Transmitter Output High Current	$V_{Y,Z} = 0V$	● -12.6	-11	-9.4	mA	
$I_{OL}$	Transmitter Output Low Current	$V_{Y,Z} = 0V$	● 9.4	11	12.6	mA	
$I_{OZ}$	Transmitter Output Leakage Current	$-5V \leq V_{Y,Z} \leq 5V$ , $S1 = S2 = 0V$	●	±1	±20 ±100	μA μA	
$R_O$	Transmitter Output Impedance	$-2V \leq V_{Y,Z} \leq 2V$		100		kΩ	
$V_{TH}$	Differential Receiver Input Threshold Voltage	$-7V \leq (V_A + V_B)/2 \leq 12V$	●	25	200	mV	
$\Delta V_{TH}$	Receiver Input Hysteresis	$-7V \leq (V_A + V_B)/2 \leq 12V$		50		mV	
$I_{IN}$	Receiver Input Current (A, B)	$-7V \leq V_{A,B} \leq 12V$	●		0.7	mA	
$R_{IN}$	Receiver Input Impedance	$-7V \leq V_{A,B} \leq 12V$	●	17.5	30	kΩ	
$V_{OH}$	Receiver Output High Voltage	$I_O = 4mA$ , $V_{A,B} = 0.2V$	●	3	4.5	V	
$V_{OL}$	Receiver Output Low Voltage	$I_O = 4mA$ , $V_{A,B} = -0.2V$	●		0.2	0.4	V
$I_{OSR}$	Receiver Output Short-Circuit Current	$0V \leq V_O \leq V_{CC}$	●	7	40	85	mA
$I_{OZR}$	Receiver Three-State Output Current	$S0 = V_{CC}$ , $0V \leq V_O \leq V_{CC}$	●		±10	μA	
$V_{IH}$	Logic Input High Voltage	T, S0, S1, S2	●	2		V	
$V_{IL}$	Logic Input Low Voltage	T, S0, S1, S2	●		0.8	V	
$I_{IN}$	Logic Input Current	T, S0, S1, S2	●		±10	μA	

**AC ELECTRICAL CHARACTERISTICS** The ● denotes specifications which apply over the full operating temperature range.  $V_{CC} = 5V \pm 5\%$ ,  $V_{EE} = -5V \pm 5\%$  (Note 2)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$I_{CC}$	$V_{CC}$ Supply Current	$V_{OS} = 0V$ , $S0 = \text{Low}$ , $S1 = S2 = \text{High}$ (Figure 1)	●	40	50	mA
		No Load, $S0 = \text{Low}$ , $S1 = S2 = \text{High}$	●	6	9	mA
		Shutdown, $S0 = V_{CC}$ , $S1 = S2 = 0V$	●	0.1	100	$\mu A$
$I_{EE}$	$V_{EE}$ Supply Current	$V_{OS} = 0V$ , $S0 = \text{Low}$ , $S1 = S2 = \text{High}$ (Figure 1)	●	-40	-50	mA
		No Load, $S0 = \text{Low}$ , $S1 = S2 = \text{High}$	●	-6	-9	mA
		Shutdown, $S0 = V_{CC}$ , $S1 = S2 = 0V$	●	-0.1	-100	$\mu A$
$t_r, t_f$	Transmitter Rise or Fall Time	$V_{OS} = 0V$ (Figures 1, 3)	●	7	40	ns
$t_{PLH}$	Transmitter Input to Output 	$V_{OS} = 0V$ (Figures 1, 3)	●	25	70	ns
$t_{PHL}$	Transmitter Input to Output 	$V_{OS} = 0V$ (Figures 1, 3)	●	30	70	ns
$t_{SKEW}$	Transmitter Output to Output	$V_{OS} = 0V$ (Figures 1, 3)		5		ns
$t_{PLH}$	Receiver Input to Output 	$V_{OS} = 0V$ (Figures 1, 4)	●	50	100	ns
$t_{PHL}$	Receiver Input to Output 	$V_{OS} = 0V$ (Figures 1, 4)	●	55	100	ns
$t_{SKEW}$	Differential Receiver Skew, $ t_{PLH} - t_{PHL} $	$V_{OS} = 0V$ (Figures 1, 4)		5		ns
$t_{ZL}$	Receiver Enable to Output Low (Active Mode)	$C_L = 15pF$ , SW1 Closed (Figures 2, 5)	●	40	70	ns
	Receiver Enable to Output Low (from Shutdown, Note 3)	$C_L = 15pF$ , SW1 Closed (Figures 2, 5)		2		$\mu s$
$t_{ZH}$	Receiver Enable to Output High (Active Mode)	$C_L = 15pF$ , SW2 Closed (Figures 2, 5)	●	35	70	ns
	Receiver Enable to Output High (from Shutdown, Note 3)	$C_L = 15pF$ , SW2 Closed (Figures 2, 5)		2		$\mu s$
$t_{LZ}$	Receiver Disable from Low	$C_L = 15pF$ , SW1 Closed (Figures 2, 5)	●	30	70	ns
$t_{HZ}$	Receiver Disable from High	$C_L = 15pF$ , SW2 Closed (Figures 2, 5)	●	35	70	ns

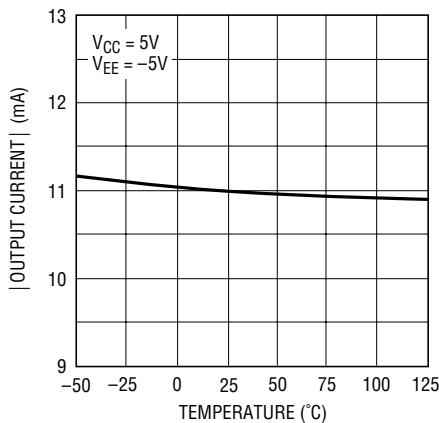
**Note 1:** The Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

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

**Note 3:** Receiver enable to output valid high or low from Shutdown is typically 2 $\mu s$ .

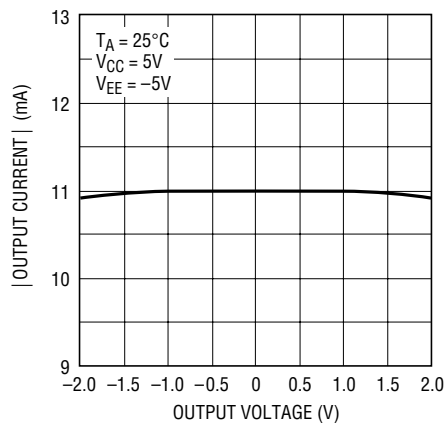
**TYPICAL PERFORMANCE CHARACTERISTICS**

Transmitter Output Current vs Temperature



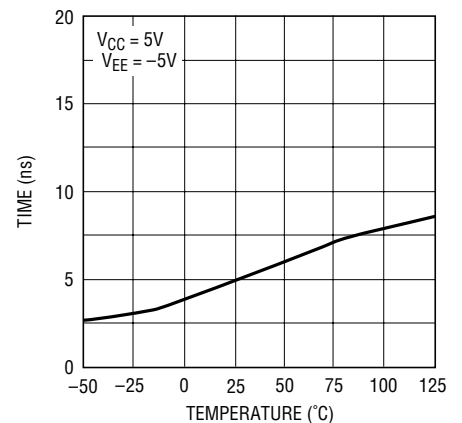
1346A G01

Transmitter Output Current vs Output Voltage



1346A G02

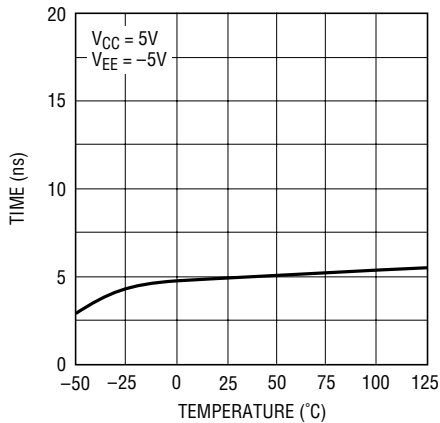
Transmitter Output Skew vs Temperature



1346A G03

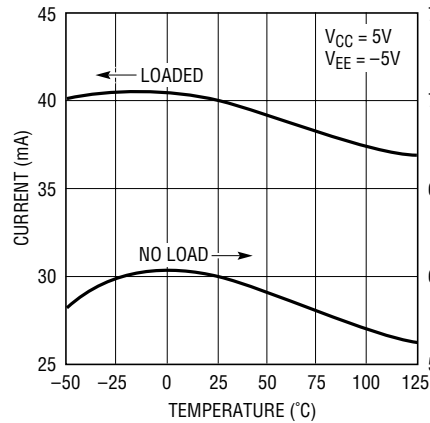
## TYPICAL PERFORMANCE CHARACTERISTICS

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



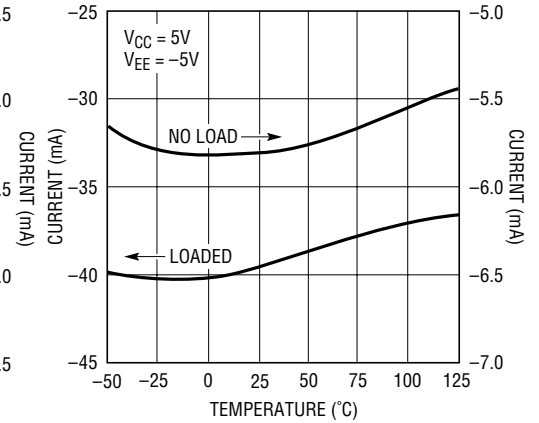
1346A G04

$I_{CC}$  Supply Current vs Temperature



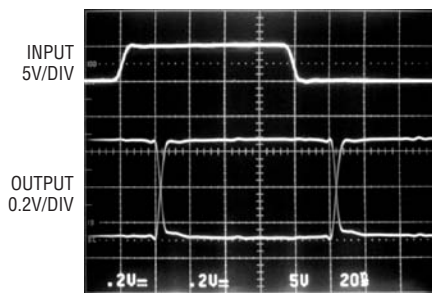
1346A G05

$I_{EE}$  Supply Current vs Temperature



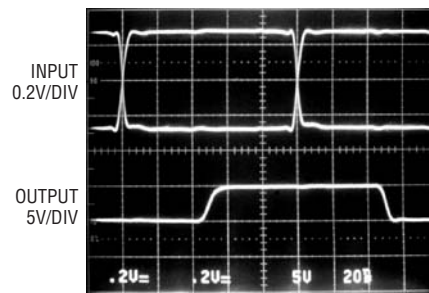
1346A G06

Transmitter Output Waveforms



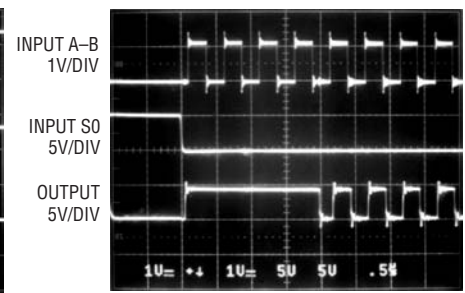
1346A G07

Receiver Output Waveforms



1346A G08

Receiver Enable from Shutdown



1346A G09

## PIN FUNCTIONS

**$V_{EE}$  (Pin 1):** Negative Supply,  $-4.75V \geq V_{EE} \geq -5.25V$

**$V_{CC}$  (Pin 2):** Positive Supply,  $4.75V \leq V_{CC} \leq 5.25V$

**GND (Pin 3):** Ground

**T1 (Pin 4):** Transmitter 1 Input, TTL Compatible

**T2 (Pin 5):** Transmitter 2 Input, TTL Compatible

**T3 (Pin 6):** Transmitter 3 Input, TTL Compatible

**S1 (Pin 7):** Select Input 1, TTL Compatible

**S2 (Pin 8):** Select Input 2, TTL Compatible

**R3 (Pin 9):** Receiver 3 Output, TTL Compatible

**R2 (Pin 10):** Receiver 2 Output, TTL Compatible

**R1 (Pin 11):** Receiver 1 Output, TTL Compatible

**S0 (Pin 12):** Select Input 0, TTL Compatible

**B1 (Pin 13):** Receiver 1 Inverting Input

**A1 (Pin 14):** Receiver 1 Noninverting Input

**B2 (Pin 15):** Receiver 2 Inverting Input

**A2 (Pin 16):** Receiver 2 Noninverting Input

**B3 (Pin 17):** Receiver 3 Inverting Input

**A3 (Pin 18):** Receiver 3 Noninverting Input

**Z3 (Pin 19):** Transmitter 3 Inverting Output

**Y3 (Pin 20):** Transmitter 3 Noninverting Output

**Z2 (Pin 21):** Transmitter 2 Inverting Output

**Y2 (Pin 22):** Transmitter 2 Noninverting Output

**Z1 (Pin 23):** Transmitter 1 Inverting Output

**Y1 (Pin 24):** Transmitter 1 Noninverting Output

# FUNCTION TABLES

**Transmitter and Receiver Configuration**

S0	S1	S2	DX ON	RX ON	Description
0	0	0	—	1, 2, 3	All RX ON, All DX OFF
1	0	0	—	—	All OFF, Shutdown
0	1	0	1, 2, 3	1, 2	DCE Mode
1	1	0	1, 2, 3	—	DCE Mode, All RX OFF
0	0	1	1, 2	1, 2, 3	DTE Mode
1	0	1	1, 2	—	DTE Mode, All RX OFF
0	1	1	1, 2, 3	1, 2, 3	All ON
1	1	1	1, 2, 3	—	All DX ON, All RX OFF

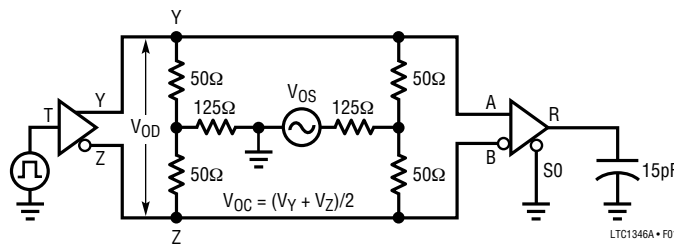
**Transmitter**

CONFIGURATION	INPUTS				OUTPUTS			
	S0	S1	S2	T	Y1 AND Y2	Z1 AND Z2	Y3	Z3
All OFF	0	0	0	X	Z	Z	Z	Z
Shutdown	1	0	0	X	Z	Z	Z	Z
DCE or All ON	X	1	X	0	0	1	0	1
DCE or All ON	X	1	X	1	1	0	1	0
DTE	X	0	1	0	0	1	Z	Z
DTE	X	0	1	1	1	0	Z	Z

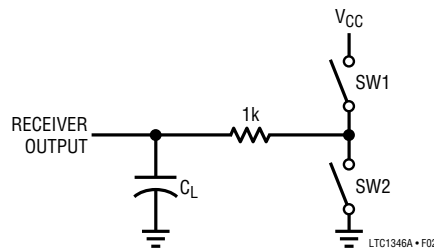
**Receiver**

CONFIGURATION	INPUTS				OUTPUTS	
	S0	S1	S2	A – B	R1 AND R2	R3
All Rx ON	0	0	0	$\leq -0.2V$	0	0
All Rx ON	0	0	0	$\geq 0.2V$	1	1
Shutdown	1	0	0	X	Z	Z
DCE	0	1	0	$\leq -0.2V$	0	Z
DCE	0	1	0	$\geq 0.2V$	1	Z
Disabled	1	1	0	X	Z	Z
DTE or All ON	0	X	1	$\leq -0.2V$	0	0
DTE or All ON	0	X	1	$\geq 0.2V$	1	1
Disabled	1	X	1	X	Z	Z

# TEST CIRCUITS



**Figure 1. V.35 Transmitter/Receiver Test Circuit**



**Figure 2. Receiver Output Enable and Disable Timing Test Load**

# SWITCHING TIME WAVEFORMS

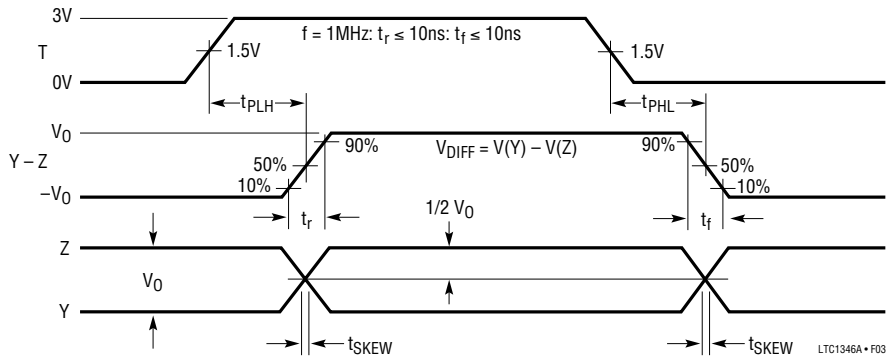


Figure 3. V.35 Transmitter Propagation Delays

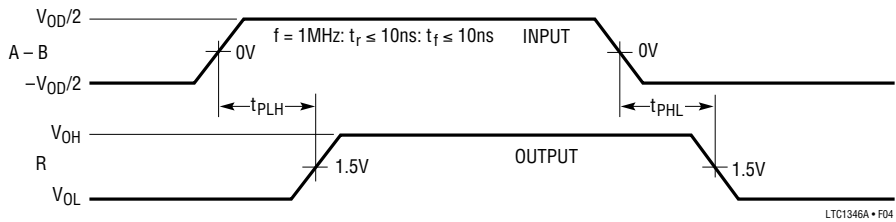


Figure 4. V.35 Receiver Propagation Delays

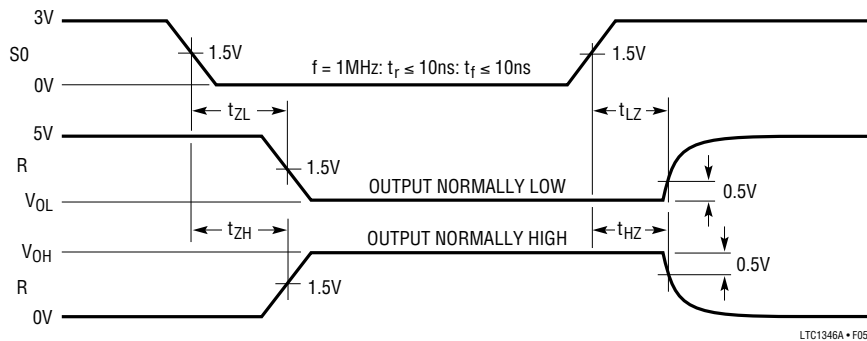


Figure 5. Receiver Enable and Disable Times

## APPLICATIONS INFORMATION

### Review of CCITT Recommendation V.35 Electrical Specifications

V.35 is a CCITT recommendation for synchronous data transmission via modems. Appendix 2 of the recommendation describes the electrical specifications which are summarized below:

1. The interface cable is a balanced twisted pair with  $80\Omega$  to  $120\Omega$  impedance.
2. The transmitter's source impedance is between  $50\Omega$  and  $150\Omega$ .
3. The transmitter's resistance between shorted terminals and ground is  $150\Omega \pm 15\Omega$ .
4. When terminated by a  $100\Omega$  resistive load, the terminal-to-terminal voltage should be  $0.55V \pm 20\%$ .
5. The transmitter's rise time should be less than 1% of the signal pulse or  $40ns$ , whichever is greater.
6. The common mode voltage at the transmitter output should not exceed  $0.6V$ .
7. The receiver impedance is  $100\Omega \pm 10\Omega$ .
8. The receiver impedance to ground is  $150\Omega \pm 15\Omega$ .
9. The transmitter or receiver should not be damaged by connection to earth ground, short-circuiting or cross connection to other lines.

10. No data errors should occur with  $\pm 2V$  common mode change at either the transmitter/receiver or  $\pm 4V$  ground potential difference between transmitter and receiver.

### Cable Termination

Each end of the cable connected to an LTC1346A must be terminated by an external Y- or  $\Delta$ -resistor network for proper operation. The Y-termination has two series connected  $50\Omega$  resistors and a  $125\Omega$  resistor connected between ground and the center tap of the two  $50\Omega$  resistors as shown in Figure 6.

The alternative  $\Delta$ -termination has a  $120\Omega$  resistor across the twisted wires and two  $300\Omega$  resistors between each wire and ground. Standard  $1/8W$ , 5% surface mount resistors can be used for the termination network. To maintain the proper differential output swing, the resistor tolerance must be 5% or better. A termination network that combines all the resistors into an SO-14 package is available from:

BI Technologies (Formerly Beckman Industrial)  
Resistor Networks  
4200 Bonita Place  
Fullerton, CA 92635  
<http://www.bitechnologies.com>  
Phone: (714) 447-2357  
FAX: (714) 447-2500  
Part #: BI Technologies 627T500/1250 (SOIC)  
899-5-500/1250 (DIP)

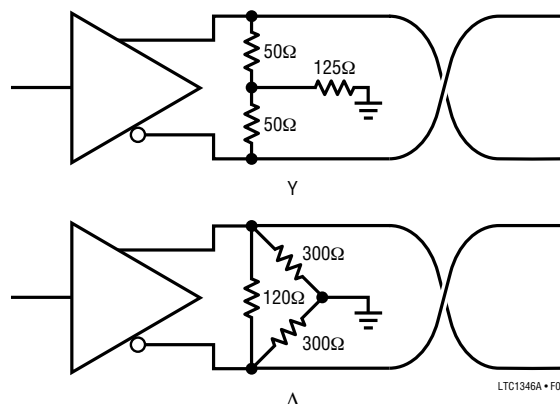


Figure 6. Y- and  $\Delta$ -Termination Networks



## APPLICATIONS INFORMATION

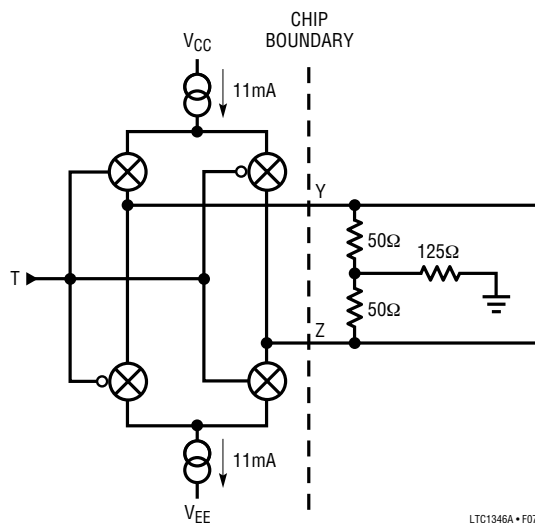


Figure 7. Simplified Transmitter Schematic

## Theory of Operation

The transmitter outputs consist of complementary switched-current sources as shown in Figure 7.

With a logic zero at the transmitter input, the inverting output Z sources 11mA and the noninverting output Y sinks 11mA. The differential transmitter output voltage is then set by the termination resistors. With two differential  $50\Omega$  resistors at each end of the cable, the voltage is set to  $(50\Omega)(11\text{mA}) = 0.55\text{V}$ . With a logic 1 at the transmitter input, output Z sinks 11mA and Y sources 11mA. The common mode voltage of Y and Z is 0V when both current sources are matched and there is no ground potential difference between the cable terminations. The transmitter current sources have a common mode range of  $\pm 2\text{V}$ , which allows for a ground difference between cable terminations of  $\pm 4\text{V}$ .

Each receiver input has a 30k resistance to ground and requires external termination to meet the V.35 input impedance specification. The receivers have an input hysteresis of 50mV to improve noise immunity.

Three Select pins, S0, S1 and S2, configure the chip as described in Function Tables. When the transmitters and

receivers are OFF, all outputs are forced into high impedance. The S0 pin can be used as receiver output enable. In Shutdown mode,  $I_{CC}$  drops to  $1\mu\text{A}$  with all transmitters and receivers OFF. When the LTC1346A is enabled from Shutdown the transmitters and receivers require  $2\mu\text{s}$  to stabilize.

## Complete V.35 Port

Figure 8 shows the schematic of a complete surface mounted,  $\pm 5\text{V}$  DTE and DCE V.35 port using only three ICs and six capacitors per port. The LTC1346A is used to transmit the clock and data signals and the LT1134A to transmit the control signals. If test signals 140, 141 and 142 are not used, the transmitter inputs should be tied to  $V_{CC}$ .

## RS422/RS485 Applications

The receivers on the LTC1346A can be used for RS422 and RS485 applications. Using the test circuit in Figure 9, the LTC1346A receivers are able to successfully extract the data stream from the common mode voltage, meeting RS422 and RS485 requirements as shown in Figures 10 and 11.

APPLICATIONS INFORMATION

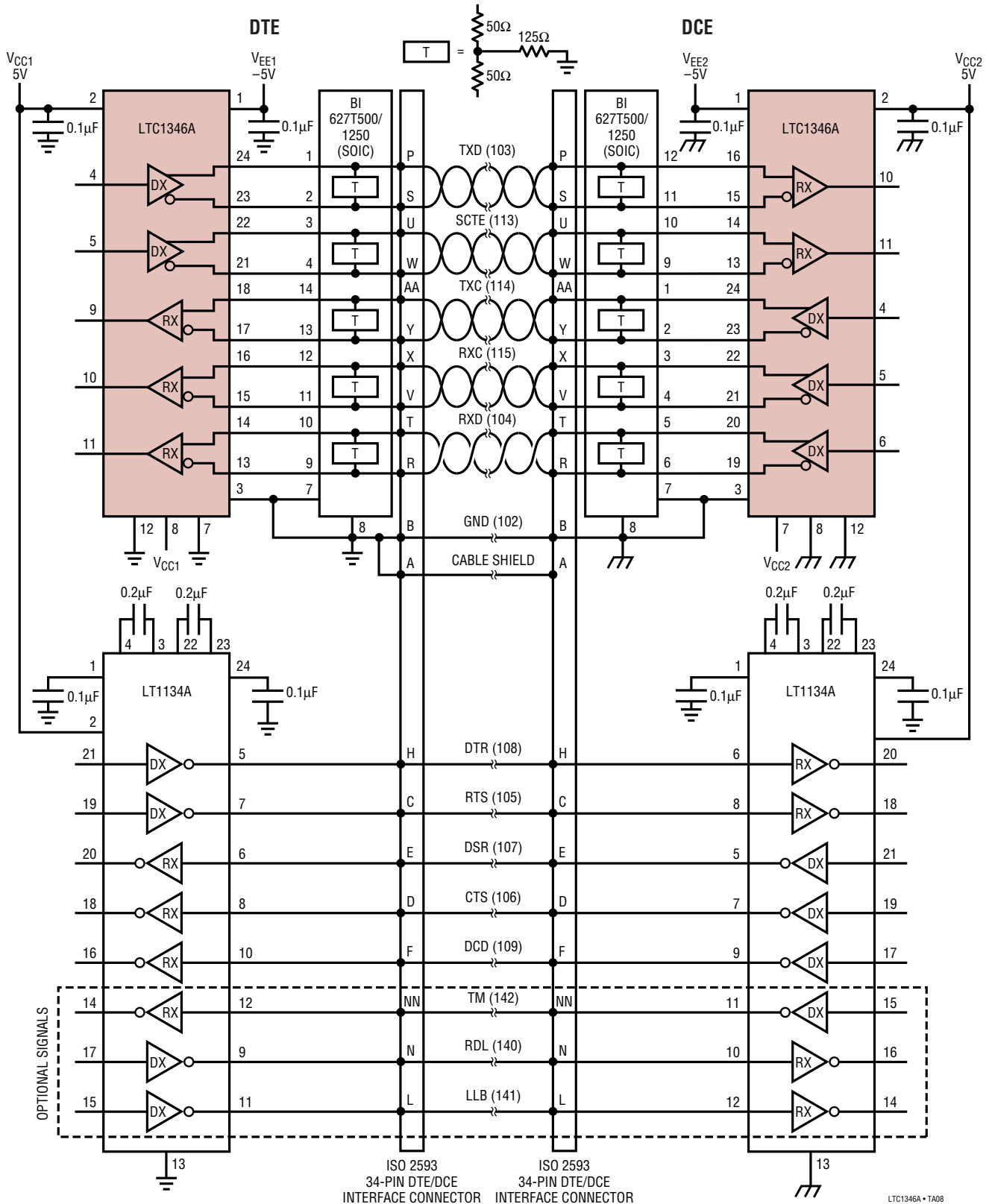


Figure 8. Complete Single ±5V .35 Interface

LTC1346A • TA08

APPLICATIONS INFORMATION

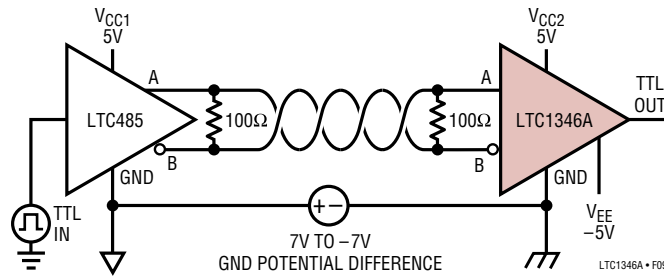


Figure 9. RS422/RS485 Receiver Interface

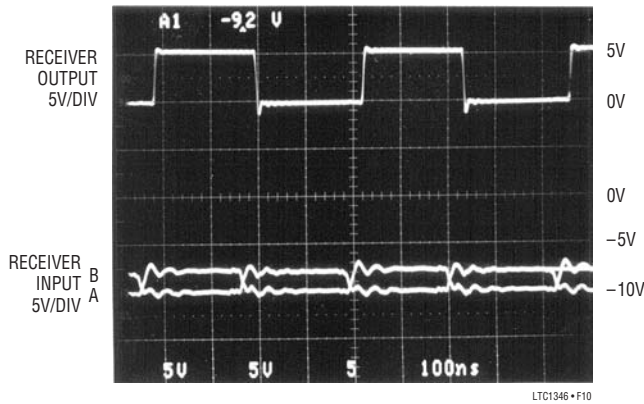


Figure 10. -7V Common Mode

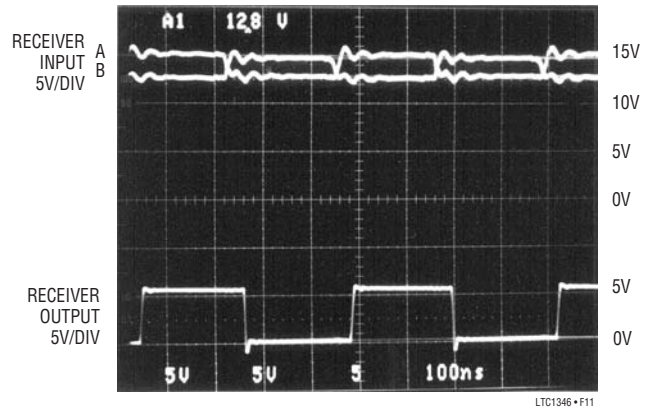


Figure 11. 12V Common Mode

Multiprotocol Application

The LTC1346A can be used in multiprotocol applications where V.35, RS232 and RS422 (used in RS530, RS449 among others) signals may appear at the same port. The LTC1346A switched current source driver is not compatible with RS232 or RS422. However, the outputs when disabled can share lines with RS232 drivers with a Shutdown feature such as the LT1030 and RS422 drivers with a disable feature such as the LTC486/LTC487 (Figure 12a).

The LTC1346A driver will not be damaged or load the shared lines when disabled. The LTC1346A receiver can receive V.35, RS232 and RS422 signals as shown in Figure 12b. The LTC1346A receiver is directly compatible with V.35 and RS422. For RS232 signal, the noninverting input of the receiver should be grounded. Because the line termination for each of the protocols is different, some form of termination switching should be included, either the connector (as shown in Figures 12a and 12b) or on the PCB.

# APPLICATIONS INFORMATION

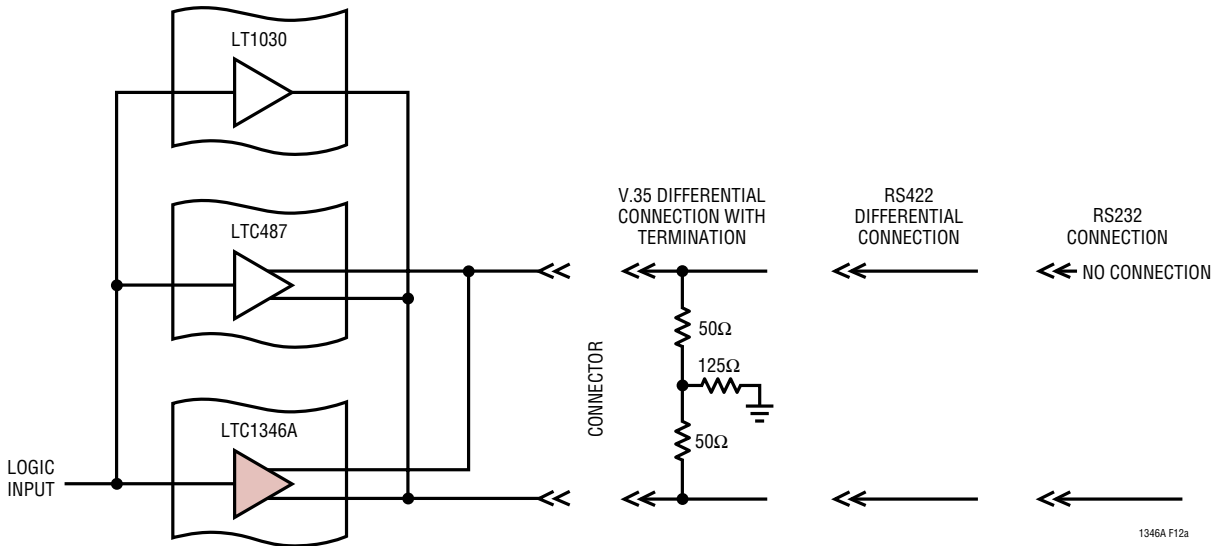


Figure 12a. Multiprotocol Transmitter

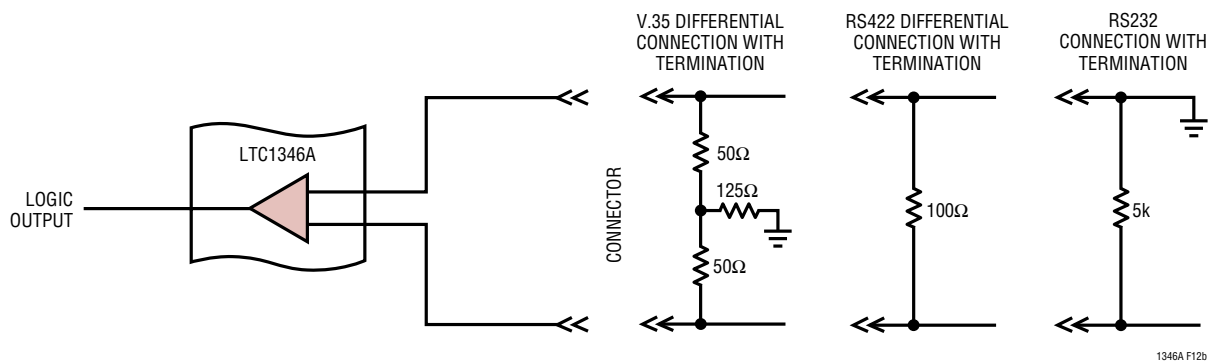


Figure 12b. Multiprotocol Receiver

