

# Overvoltage Fault Protected CAN Transceiver

December 2001

## FEATURES

- Protected from Overvoltage Line Faults to  $\pm 60V$
- ESD Protection to IEC-1000-4-2 Level 4
  - $\pm 15kV$  Air Gap Test
  - $\pm 8kV$  Contact Mode Test
- High Input Impedance Supports Up to 256 Nodes
- Controlled Slew Rates for EMI Emissions Control
- Outputs Assume a High Impedance When Off or Powered Down
- Short-Circuit Protection On All Outputs
- Thermal Shutdown Protection
- Pin Compatible with Philips PCA82C251

## APPLICATIONS

- Industrial Control Data Networks
- Automotive Systems
- HVAC Controls

## DESCRIPTION

The LT<sup>®</sup>1796 CAN transceiver provides built-in fault tolerance to survive in industrial and automotive environments. Discrete protection devices are not needed. Bus interface pins can withstand voltage faults up to  $\pm 60V$  with respect to ground with no damage to the device. Faults may occur while the transceiver is active, shut down or powered off. On-chip ESD protection withstands up to  $\pm 15kV$  air discharges and  $\pm 8kV$  contact mode discharges tested per IEC-1000-4-2. Loss of power or ground connections does not damage the IC.

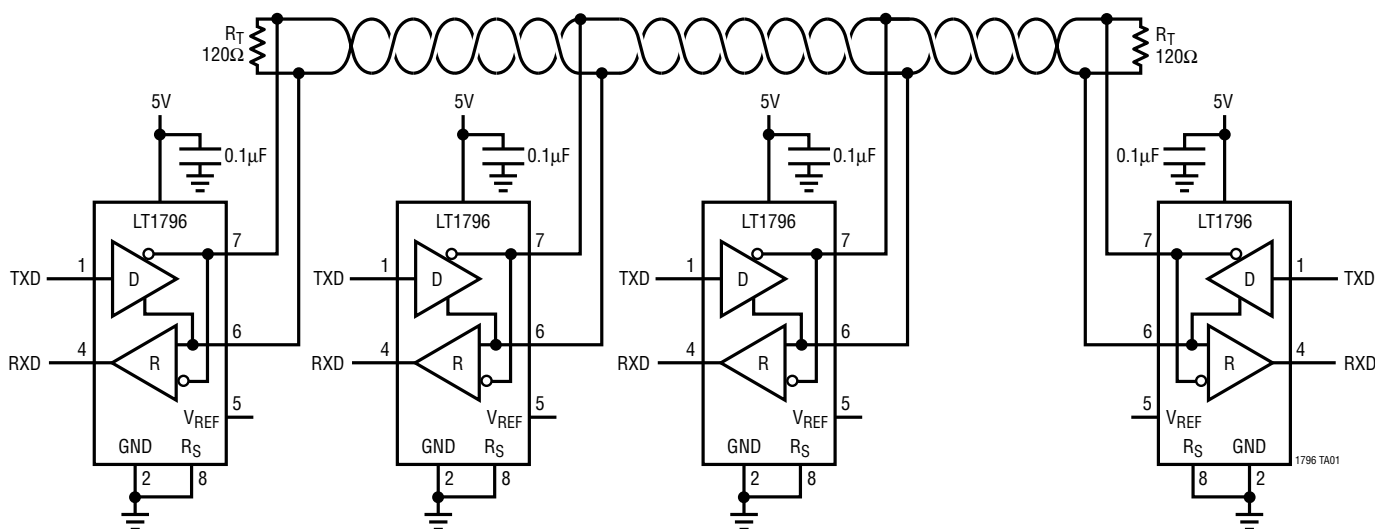
The circuit operates with data rates up to 1Mbaud. A slew control pin allows control of transmitted data pulse edges to control EMI and reflection problems on imperfectly terminated lines. High output current drive allows the use of inexpensive PVC cable with impedance as low as  $72\Omega$ . The  $100k\Omega$  input impedance allows up to 256 transceivers per data network.

The LT1796 is available in 8-lead PDIP and SO packages.

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## TYPICAL APPLICATION

Fault Protected CAN Bus Network



1796i

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

|  |                |
|--|----------------|
| Supply Voltage ( $V_{CC}$ ) .....          | 44V            |
| $R_S$ Slope Control Input Voltage .....    | -0.3V to 44V   |
| $V_{REF}$ Reference Output Pin .....       | -0.3V to 7V    |
| Driver Input Voltage .....                 | -0.3V to 44V   |
| CANH, CANL Data Line Pins .....            | -80V to 80V    |
| Receiver Output Voltages .....             | -0.3V to 7V    |
| Operating Temperature Range                |                |
| LT1796C .....                              | 0°C to 70°C    |
| LT1796I .....                              | -40°C to 85°C  |
| Storage Temperature Range .....            | -65°C to 150°C |
| Lead Temperature (Soldering, 10 sec) ..... | 300°C          |

## PACKAGE/ORDER INFORMATION

|   |  |
|---|--|
| <p>TOP VIEW</p> <p>TXD 1, GND 2, <math>V_{CC}</math> 3, RXD 4, 8 <math>R_S</math>, 7 CANH, 6 CANL, 5 <math>V_{REF}</math></p> <p>N8 PACKAGE 8-LEAD PDIP    S8 PACKAGE 8-LEAD PLASTIC SO</p> <p><math>T_{JMAX} = 150^{\circ}C, \theta_{JA} = 130^{\circ}C/W</math> (N8)<br/> <math>T_{JMAX} = 150^{\circ}C, \theta_{JA} = 150^{\circ}C/W</math> (S8)</p> | ORDER PART NUMBER                                |
|   | LT1796CN8<br>LT1796CS8<br>LT1796IN8<br>LT1796IS8 |
|   | S8 PART MARKING                                  |
|   | 1796<br>1796I                                    |

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

## DC ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^{\circ}C$ .  $V_{CC} = 4.75V$  to  $5.25V$ ,  $V_{RS} = 0V$  unless otherwise noted.

| SYMBOL     | PARAMETER                                   | CONDITIONS  | MIN    | TYP | MAX | UNITS      |
|------------|---|---|--------|-----|-----|------------|
| $V_{CANH}$ | CANH Output Voltage                         | $V_{TXD} = 0V$ , No Load                              | ● 3.8  | 4.4 | 5.0 | V          |
|            |   | $V_{TXD} = 0V$ , $R_L = 60\Omega$                     | ● 2.8  | 3.5 | 4.6 | V          |
| $V_{CANL}$ | CANL Output Voltage                         | $V_{TXD} = 0V$ , No Load                              | ● 0    | 0.5 | 0.9 | V          |
|            |   | $V_{TXD} = 0V$ , $R_L = 60\Omega$                     | ● 0    | 1.3 | 1.6 | V          |
| $V_{OD}$   | Dominant State Differential Output Voltage  | $V_{TXD} = 0V$ , No Load, $V_{CC} = 4.75V$            | ● 3.0  | 3.6 | 5.0 | V          |
|            |   | $V_{TXD} = 0V$ , $R_L = 60\Omega$ , $V_{CC} = 4.75V$  | ● 1.5  | 2.0 | 4.2 | V          |
|            |   | $V_{TXD} = 0V$ , $R_L = 36\Omega$ , $V_{CC} = 4.75V$  | ● 1.2  | 1.7 | 4.2 | V          |
| $V_{REC}$  | Recessive State Differential Output Voltage | $V_{TXD} = 5V$ , $R_L = 60\Omega$                     | ● -10  | 0   | 10  | mV         |
| $V_{CMR}$  | Recessive State Common Mode Output Voltage  | $V_{TXD} = 5V$ , No Load, $V_{CC} = 5V$               | ● 2.7  | 3   | 3.5 | V          |
| $V_{CMD}$  | Dominant State Common Mode Output Voltage   | $R_L = 60\Omega$ , $V_{CC} = 5V$                      | ● 2    | 2.5 | 3   | V          |
| $V_{IH}$   | TXD Input High Voltage                      |   | ● 2.8  |     |     | V          |
| $V_{IL}$   | TXD Input Low Voltage                       |   | ●      |     | 2   | V          |
| $I_{IN1}$  | TXD Input Current                           | $0 < V_{TXD} < V_{CC}$                                | ● -5   |     | 5   | $\mu A$    |
| $I_{SCH}$  | CANH Short-Circuit Current                  | $V_{CANH} = 0V$ , $V_{TXD} = 0V$ , $V_{CC} = 5.25V$   | ● -250 |     | -60 | mA         |
|            |   | $V_{CANH} = -36V$ , $V_{TXD} = 0V$ , $V_{CC} = 5.25V$ | ● -10  | -1  | 0   | mA         |
|            |   | $V_{CANH} = -60V$ , $V_{TXD} = 0V$ , $V_{CC} = 5.25V$ | ● -10  | -1  | 0   | mA         |
|            |   | $V_{CANH} = 60V$ , $V_{TXD} = 0V$ , $V_{CC} = 5.25V$  | ● 0    | 1   | 10  | mA         |
| $I_{SCL}$  | CANL Short-Circuit Current                  | $V_{CANL} = 5V$ , $V_{TXD} = 0V$ , $V_{CC} = 5.25V$   | ● 60   |     | 200 | mA         |
|            |   | $V_{CANL} = 36V$ , $V_{TXD} = 0V$ , $V_{CC} = 5.25V$  | ● 0    | 1   | 10  | mA         |
|            |   | $V_{CANL} = 60V$ , $V_{TXD} = 0V$ , $V_{CC} = 5.25V$  | ● 0    | 1   | 10  | mA         |
|            |   | $V_{CANL} = -60V$ , $V_{TXD} = 0V$ , $V_{CC} = 5.25V$ | ● -10  | -1  | 0   | mA         |
| $R_{IND}$  | Differential Input Resistance               | $V_{TXD} = 5V$ , $-7V < V_{CANH}$ , $V_{CANL} < 12V$  | ● 140  | 240 | 350 | k $\Omega$ |
|            | CANH, CANL Input Resistance                 | $V_{TXD} = 5V$ , $-7V < V_{CANH}$ , $V_{CANL} < 12V$  | ● 70   | 120 | 175 | k $\Omega$ |
|            | Input Fault Current (CANH, CANL)            | $V_{RS} = 5V$ , $-60V < V_{CANH}$ , $V_{CANL} < 60V$  | ● -3   |     | 3   | mA         |
|            |   | $V_{TXD} = 0V$ , $-60V < V_{CANH}$ , $V_{CANL} < 60V$ | ● -3   |     | 3   | mA         |
|            |   | $V_{CC} = 0V$ , $-60V < V_{CANH}$ , $V_{CANL} < 60V$  | ● -3   |     | 3   | mA         |

**DC ELECTRICAL CHARACTERISTICS** The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V_{CC} = 4.75\text{V}$  to  $5.25\text{V}$ ,  $V_{RS} = 0\text{V}$  unless otherwise noted.

| SYMBOL          | PARAMETER   | CONDITIONS   | MIN | TYP  | MAX  | UNITS |               |
|-----------------|---|--|-----|------|------|-------|---------------|
| $V_{TH}$        | Differential Input Threshold Voltage for Receiver | $V_{RS} = 0\text{V}, -7\text{V} < V_{CM} < 12\text{V}$                                 | ●   | 0.5  | 0.9  | V     |               |
|                 |   | $V_{RS} = 5\text{V}, -7\text{V} < V_{CM} < 12\text{V}$                                 | ●   | 0.5  | 0.9  | V     |               |
| $\Delta V_{TH}$ | Receiver Input Hysteresis                         | $-7\text{V} < V_{CM} < 12\text{V}$   |     | 70   |      | mV    |               |
| $V_{OH}$        | Receiver Output High Voltage                      | $V_{CC} = 4.75\text{V}, I_O = -400\mu\text{A}, V_{ID} = 500\text{mV}$                  | ●   | 3    | 3.6  | V     |               |
| $V_{OL}$        | Receiver Output Low Voltage                       | $V_{CC} = 4.75\text{V}, I_O = 1.6\text{mA}, V_{ID} = 900\text{mV}$                     | ●   | 0.15 | 0.4  | V     |               |
| $I_{SCR}$       | Receiver Short-Circuit Current                    | $0\text{V} < V_O < V_{CC}, V_{CC} = 5.25\text{V}$                                      | ●   | 7    | 20   | 85    | mA            |
| $V_{REF}$       | Reference Output Voltage                          | $-100\mu\text{A} < I_{REF} < 100\mu\text{A}$   | ●   | 2.25 | 2.5  | 2.7   | V             |
| $V_{REFSC}$     | Reference Output Short-Circuit Current            | $0 < V_{REF} < V_{CC}$   | ●   | -20  |      | 20    | mA            |
| $V_{RSSB}$      | $R_S$ Pin Standby Threshold                       | $V_{CC} = 5\text{V}$   | ●   | 2.5  | 2.8  | 4     | V             |
| $I_{RS}$        | $R_S$ Input Current                               | $V_{RS} = 5\text{V}, V_{CC} = 5\text{V}$   | ●   |      | 0.1  | 10    | $\mu\text{A}$ |
|                 |   | $V_{RS} = 0\text{V}, V_{CC} = 5\text{V}$   | ●   | -270 | -200 | -140  | $\mu\text{A}$ |
|                 |   | $R_S = 47\text{k}, V_{CC} = 5\text{V}$   | ●   | -90  | -60  | -40   | $\mu\text{A}$ |
| $I_{CC}$        | Supply Current                                    | Dominant<br>No Load, $V_{RS} = 0\text{V}, V_{TXD} = 0\text{V}, V_{CC} = 5.25\text{V}$  | ●   |      | 4.3  | 7     | mA            |
|                 |   | Recessive<br>No Load, $V_{RS} = 0\text{V}, V_{TXD} = 5\text{V}, V_{CC} = 5.25\text{V}$ | ●   |      | 3.8  | 7     | mA            |
|                 |   | Standby<br>No Load, $V_{RS} = 5\text{V}, V_{CC} = 5.25\text{V}$                        | ●   |      | 0.8  | 1.5   | mA            |

**SWITCHING CHARACTERISTICS** The ● denotes the specifications which apply over the full operating temperature range.  $V_{RS} = 0\text{V}$  unless otherwise noted. (Note 2)

| SYMBOL         | PARAMETER                    | CONDITIONS                          | MIN | TYP | MAX  | UNITS         |                        |
|----------------|------------------------------|-------------------------------------|-----|-----|------|---------------|------------------------|
| $t_{BIT}$      | Minimum Bit Time             | (Note 3)                            | ●   |     | 2    | $\mu\text{s}$ |                        |
| $F_{MAX}$      | Maximum Data Rate            | (Note 3)                            | ●   | 500 |      | kbps          |                        |
| $t_{TXDON}$    | Driver Input to Bus Active   | Figures 1, 2                        |     |     |      |               |                        |
|                |                              | $R_S = 0\text{k}$                   | ●   | 300 | 500  | ns            |                        |
|                |                              | $R_S = 47\text{k}$                  | ●   | 350 | 1000 | ns            |                        |
| $t_{TXDOFF}$   | Driver Input to Bus Inactive | Figures 1, 2                        |     |     |      |               |                        |
|                |                              | $R_S = 0\text{k}$                   | ●   | 500 | 1000 | ns            |                        |
|                |                              | $R_S = 47\text{k}$                  | ●   | 600 | 1500 | ns            |                        |
| $t_{LBON}$     | Loopback Delay Active        | Figures 1, 3                        | ●   | 0.6 | 1.5  | $\mu\text{s}$ |                        |
| $t_{LBOFF}$    | Loopback Delay Inactive      | Figures 1, 3                        | ●   | 1.5 | 3    | $\mu\text{s}$ |                        |
| $t_{RXDOFF}$   | Receiver Delay Off           | Figures 1, 4                        | ●   | 400 | 600  | ns            |                        |
| $t_{RXDON}$    | Receiver Delay On            | Figures 1, 4                        | ●   | 300 | 600  | ns            |                        |
| $t_{RXDOFFSB}$ | Receiver Delay Off, Standby  | $V_{RS} = 4\text{V}$ , Figures 1, 4 | ●   | 1.5 | 4    | $\mu\text{s}$ |                        |
| $t_{RXDONSB}$  | Receiver Delay On, Standby   | $V_{RS} = 4\text{V}$ , Figures 1, 4 | ●   | 1   | 4    | $\mu\text{s}$ |                        |
| $t_{WAKE}$     | Wake-Up Delay from Standby   | Figures 1, 5                        | ●   | 1   | 15   | $\mu\text{s}$ |                        |
| $SR^+$         | Positive Slew Rate           | $R_S = 0\text{k}$                   | ●   | 5   | 12   | 65            | $\text{V}/\mu\text{s}$ |
|                |                              | $R_S = 47\text{k}$                  | ●   | 2   | 4    | 30            | $\text{V}/\mu\text{s}$ |
| $SR^-$         | Negative Slew Rate           | $R_S = 0\text{k}$                   | ●   | 5   | 12   | 65            | $\text{V}/\mu\text{s}$ |
|                |                              | $R_S = 47\text{k}$                  | ●   | 2   | 4    | 10            | $\text{V}/\mu\text{s}$ |

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

**Note 2:** Unless otherwise specified, testing done at  $V_{CC} = 5\text{V}$ ,  $T_A = 25^\circ\text{C}$ .

**Note 3:** Bit time and data rate specifications are guaranteed by driver and receiver delay time measurements.

## PIN FUNCTIONS

**TXD (Pin 1):** Driver Input. Logic-level thresholds are set by  $V_{REF}$ . A logic input level higher than  $V_{REF}$  turns the driver outputs off, releasing controls of the CANH and CANL lines. A logic input less than  $V_{REF}$  turns the driver outputs on, pulling CANH high and CANL low. An open TXD input will float high, turning the driver outputs off. The TXD input pin can withstand voltages from  $-0.3V$  to  $44V$  with no damage.

**GND (Pin 2):** Ground.

**$V_{CC}$  (Pin 3):** Positive Supply Input. Normal operation is with a  $4.75V$  to  $5.25V$  supply. Operation with supplies up to  $44V$  is possible with unterminated bus lines. Operation at high voltages with normally terminated busses will result in excessive power dissipation and activation of the thermal shutdown circuit.  $V_{CC}$  should be decoupled with a  $0.1\mu F$  low ESR capacitor placed as close to the supply pin as possible.

**RXD (Pin 4):** Receiver TTL Level-Logic Output. A high level output indicates a recessive state (zero-volt differential) bus. A dominant state forces a low receiver output. The RXD output is protected from fault conditions between  $-0.3V$  to  $44V$ .

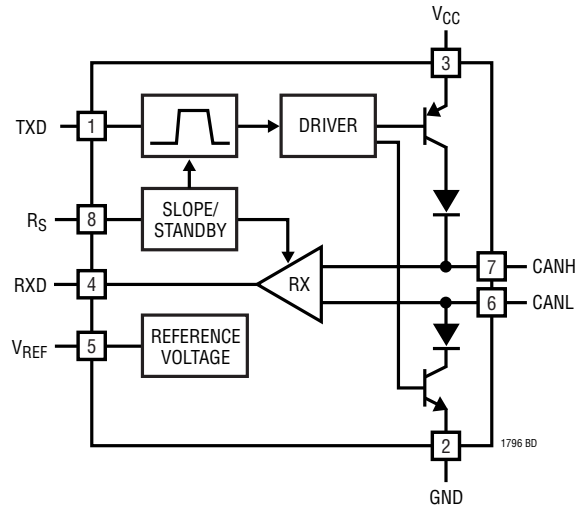
**$V_{REF}$  (Pin 5):** Reference Output. The reference voltage sets the TXD input threshold and the recessive bus common mode voltage at CANH and CANL.  $V_{REF}$  is approximately  $V_{CC}/2$  for low voltage operation. When  $V_{CC} > 7.5V$ ,  $V_{REF}$  maintains a  $3.5V$  level.

**CANL (Pin 6):** CAN Bus Low Data Line. The CANL pin is one input to the receiver and the low driver output. In the dominant state (TXD low), the driver pulls the CANL pin to within  $1V$  of GND. In the recessive state (TXD high), the driver output stays high impedance. The CANL pin is protected from voltage faults from  $-60V$  to  $60V$  in dominant, recessive, standby or powered off modes. On-chip ESD protection meets IEC-1000-4-2 levels.

**CANH (Pin 7):** CAN Bus High Data Line. The CANH pin is one input to the receiver and the high driver output. In the dominant state (TXD low), the driver pulls the CANH pin to within  $1V$  of  $V_{CC}$ . In the recessive state (TXD high), the driver output stays high impedance. The CANH pin is protected from voltage faults from  $-60V$  to  $60V$  in dominant, recessive, standby or powered off modes. On-chip ESD protection meets IEC-1000-4-2 levels.

**$R_S$  (Pin 8):** Slope Control. This pin is a multifunction control pin. When  $R_S$  is high ( $V_{RS} > 4V$ ), the circuit goes into a low power standby mode. In standby, the driver always stays in a high impedance (recessive) state. The receiver operates in a low power (slow) monitoring mode. Received data may be used to “wake-up” the system to full functionality. Full speed normal operation occurs if  $R_S$  is tied low through a resistance of less than  $3k$ . The current out of  $R_S$  will be limited to about  $500\mu A$  in the low state. Controlling the current out of  $R_S$  with a resistor greater than  $3k$  or by using a current source allows slew rate control of the data output onto CANH and CANL.

# BLOCK DIAGRAM



# TEST CIRCUIT

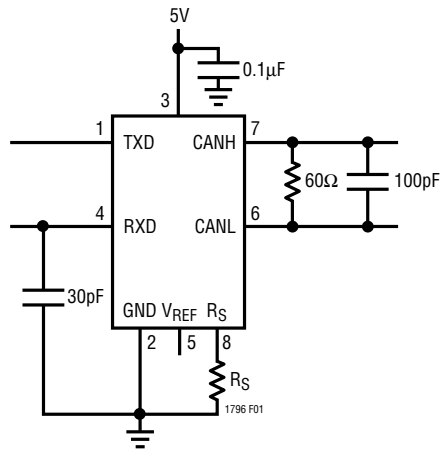


Figure 1. Switching Test Circuit

## TIMING DIAGRAMS

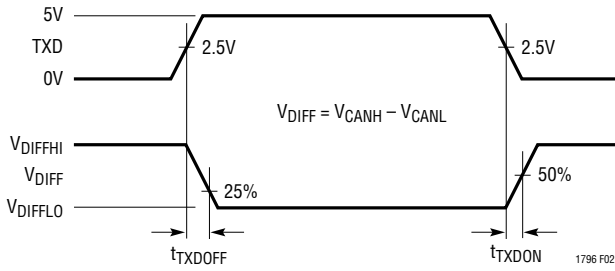


Figure 2. Driver Delay Waveforms

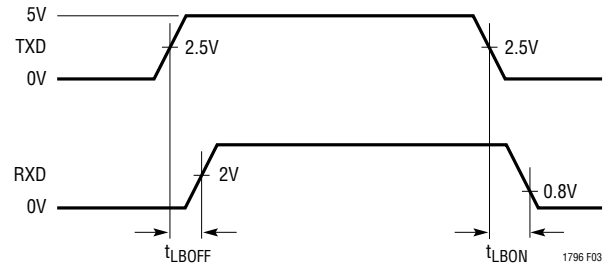


Figure 3. Loopback Delay Waveforms

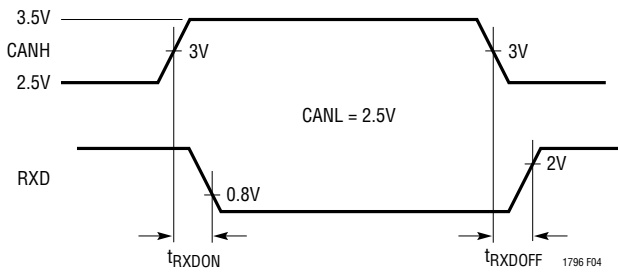


Figure 4. Receiver Delay Waveforms

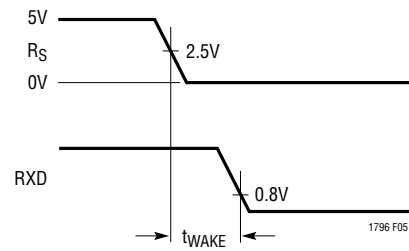


Figure 5. Wake Up from Standby Waveforms

## FUNCTION TABLES

### Driver Output

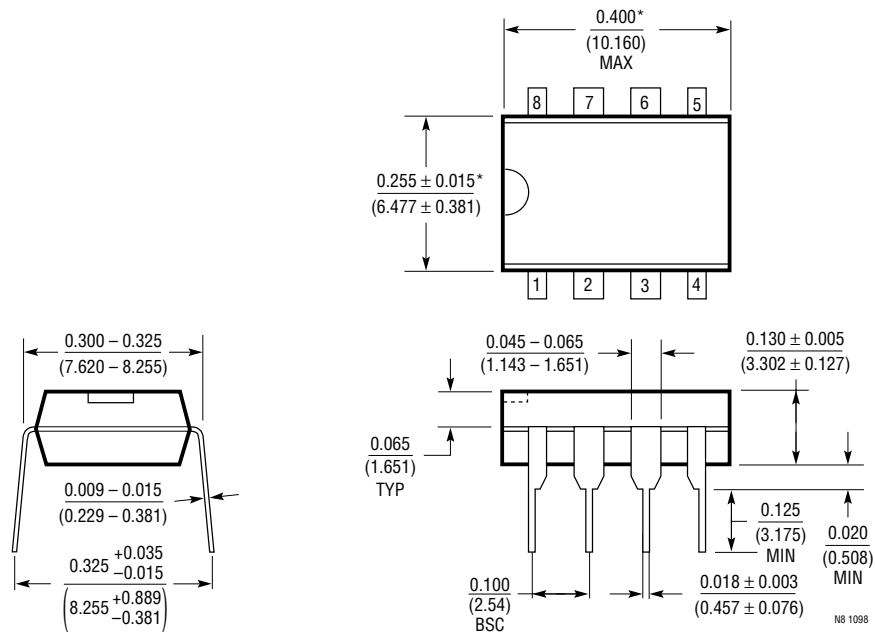
| INPUTS |               | BUS TERMINALS |      | OPERATING STATE |
|--------|---------------|---------------|------|-----------------|
| TXD    | RS            | CANH          | CANL |                 |
| 0      | $V_{RS} < 3V$ | High          | Low  | Dominant        |
| 0      | $V_{RS} > 4V$ | Hi-Z          | Hi-Z | Standby         |
| 1      | $V_{RS} < 3V$ | Hi-Z          | Hi-Z | Recessive       |
| 1      | $V_{RS} > 4V$ | Hi-Z          | Hi-Z | Standby         |

### Receiver Output

| BUS VOLTAGE<br>$V_{BUS} = V_{CANH} - V_{CANL}$ | RS  | RXD           | RESPONSE TIME |
|--|-----|---------------|---------------|
| $V_{BUS} < 0.5V$                               | <3V | High          | Fast          |
| $0.5V \leq V_{BUS} \leq 0.9V$                  | <3V | Indeterminate | Fast          |
| $V_{BUS} > 0.9V$                               | <3V | Low           | Fast          |
| $V_{BUS} < 0.5V$                               | >4V | High          | Slow          |
| $0.5V \leq V_{BUS} \leq 0.9V$                  | >4V | Indeterminate | Slow          |
| $V_{BUS} > 0.9V$                               | >4V | Low           | Slow          |

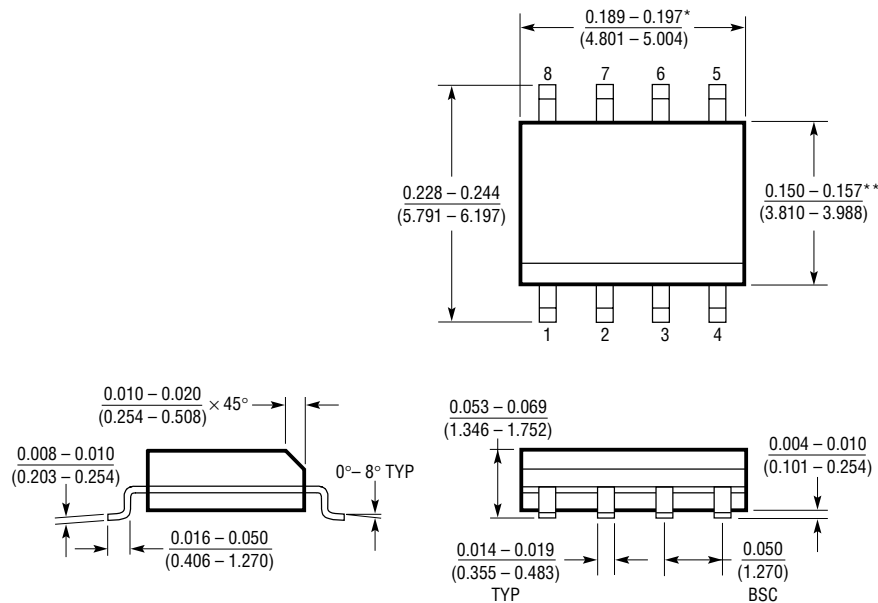
# PACKAGE DESCRIPTION

## N8 Package 8-Lead PDIP (Narrow 0.300) (LTC DWG # 05-08-1510)



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

## S8 Package 8-Lead Plastic Small Outline (Narrow 0.150) (LTC DWG # 05-08-1610)



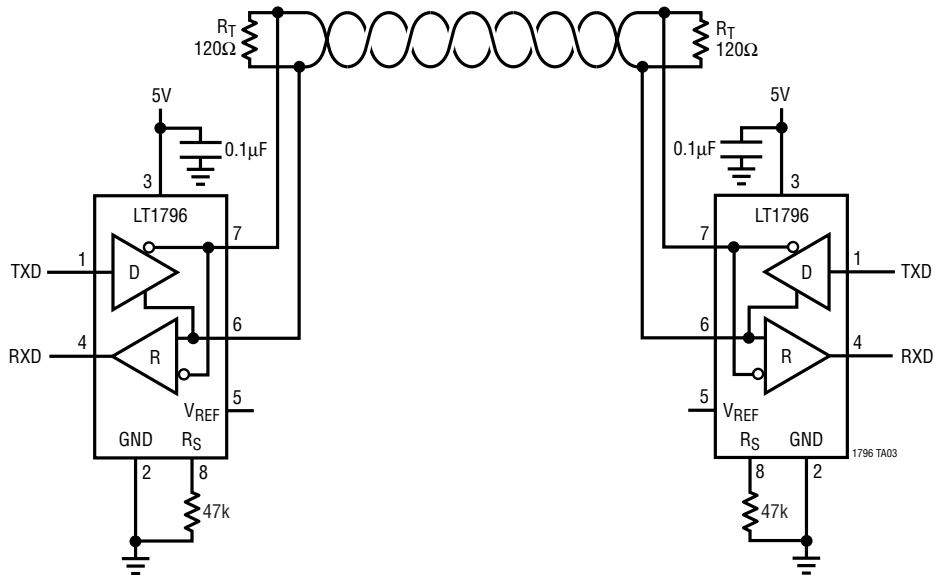
\*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

\*\*DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE

S08 1298

# TYPICAL APPLICATION

Low EMI, Slew Limited CANBUS Network



## RELATED PARTS

| PART NUMBER   | DESCRIPTION  | COMMENTS                          |
|---------------|--|-----------------------------------|
| LTC485        | Low Power RS485 Interface Transceiver                                | $I_{CC} = 300\mu A$ Typ           |
| LTC491        | Differential Driver and Receiver Pair                                | $I_{CC} = 300\mu A$ Typ           |
| LTC1483       | Ultralow Power RS485 Low EMI Transceiver                             | Controlled Driver Slew Rate       |
| LTC1485       | RS485 Differential Bus Transceiver                                   | 10Mbaud Operation                 |
| LTC1487       | Ultralow Power RS485 with Low EMI, Shutdown and High Input Impedance | Up to 256 Transceivers On the Bus |
| LT1785/LT1791 | 60V Fault-Protected RS485/RS422 Transceivers                         | 15kV ESD Protected                |