

## FEATURES

- **UL Rated Isolated RS485: 2500V<sub>RMS</sub>**  
**UL Recognized**  **File #E151738**
- **Eliminates Ground Loops**
- **250kBd Maximum Data Rate**
- **Self-Powered with 420kHz Converter**
- Half- or Full-Duplex
- Fail-Safe Output High for Open or Shorted Receiver Inputs
- Short-Circuit Current Limit
- Slow Slew Rate Control
- 68k $\Omega$  Input Impedance Allows Up to 128 Nodes
- Thermal Shutdown
- 8kV ESD Protection On Driver Outputs and Receiver Inputs
- Available in 28-Lead SW Package

## APPLICATIONS

- Isolated RS485 Receiver/Driver
- RS485 with Large Common Mode Voltage
- Breaking RS485 Ground Loops
- Multiple Unterminated Line Taps

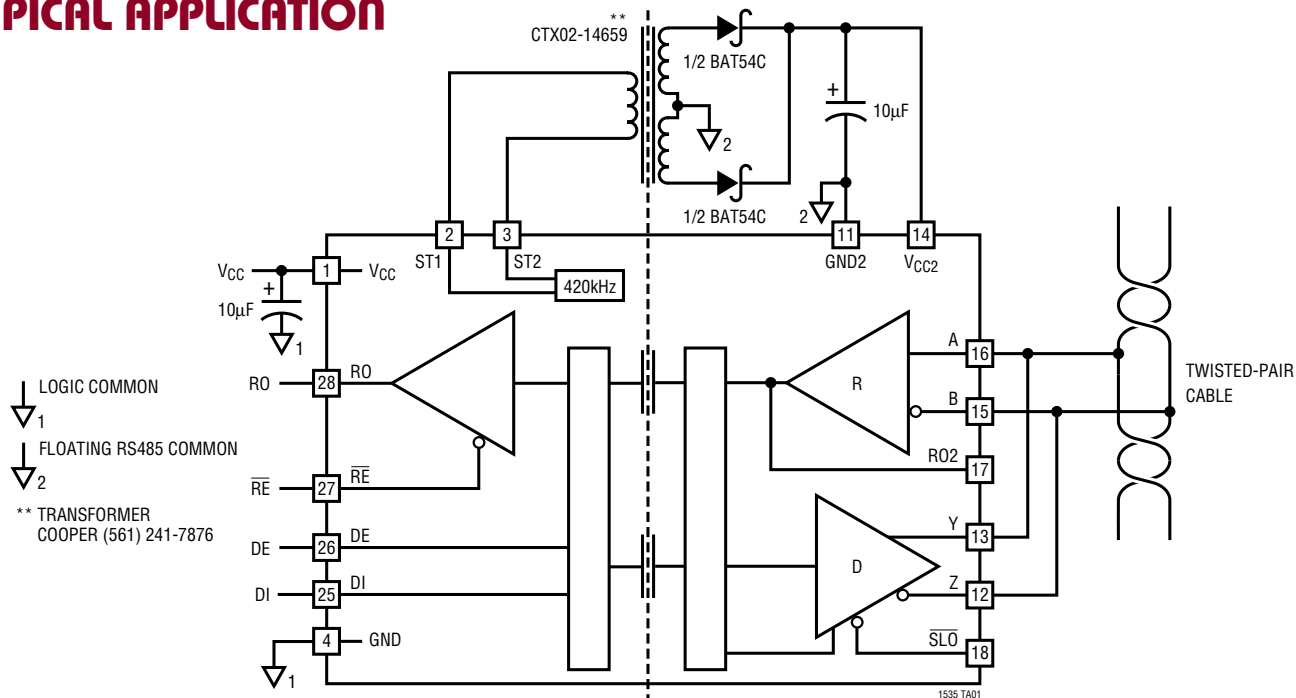
## DESCRIPTION

The LTC<sup>®</sup>1535 is an isolated RS485 full-duplex differential line transceiver. Isolated RS485 is ideal for systems where the ground loop is broken to allow for much larger common mode voltage ranges. An internal capacitive isolation barrier provides 2500V<sub>RMS</sub> of isolation between the line transceiver and the logic level interface. The powered side contains a 420kHz push-pull converter to power the isolated RS485 transceiver. Internal full-duplex communication occurs through the capacitive isolation barrier. The transceiver meets RS485 and RS422 requirements.

The driver and receiver feature three-state outputs, with the driver maintaining high impedance over the entire common mode range. The drivers have short-circuit current limits in both directions and a slow slew rate select to minimize EMI or reflections. The 68k $\Omega$  receiver input allows up to 128 node connections. A fail-safe feature defaults to a high output state when the receiver inputs are open or shorted.

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## TYPICAL APPLICATION



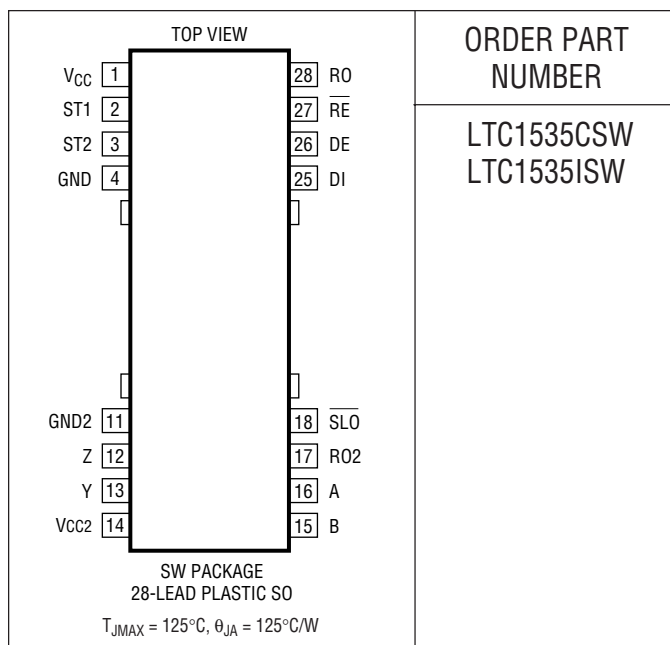
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## ABSOLUTE MAXIMUM RATINGS

(Note 1)

|                                                          |                                          |
|----------------------------------------------------------|------------------------------------------|
| $V_{CC}$ to GND .....                                    | 6V                                       |
| $V_{CC2}$ to GND2 .....                                  | 8V                                       |
| Control Input Voltage to GND .....                       | $-0.3V$ to $(V_{CC} + 0.3V)$             |
| Driver Input Voltage to GND .....                        | $-0.3V$ to $(V_{CC} + 0.3V)$             |
| Driver Output Voltage<br>(Driver Disabled) to GND2 ..... | $(V_{CC2} - 13V)$ to 13V                 |
| Driver Output Voltage<br>(Driver Enabled) to GND2 .....  | $(V_{CC2} - 13V)$ to 10V                 |
| Receiver Input Voltage to GND2 .....                     | $\pm 14V$                                |
| Receiver Output Voltage .....                            | $-0.3V$ to $(V_{CC} + 0.3V)$             |
| Operating Temperature Range                              |                                          |
| LTC1535C .....                                           | $0^{\circ}C \leq T_A \leq 70^{\circ}C$   |
| LTC1535I .....                                           | $-40^{\circ}C \leq T_A \leq 85^{\circ}C$ |
| Storage Temperature Range .....                          | $-65^{\circ}C$ to $150^{\circ}C$         |
| Lead Temperature (Soldering, 10 sec) .....               | $300^{\circ}C$                           |

## PACKAGE/ORDER INFORMATION

ORDER PART  
NUMBERLTC1535CSW  
LTC1535ISW

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, otherwise specifications are at  $T_A = 25^{\circ}C$ .  $V_{CC} = 5V$ ,  $V_{CC2} = 5V$  unless otherwise noted.

| SYMBOL            | PARAMETER                                                                         | CONDITIONS                                                                                             |        | MIN                                                         | TYP        | MAX           | UNITS    |          |          |
|-------------------|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|--------|-------------------------------------------------------------|------------|---------------|----------|----------|----------|
| V <sub>CC</sub>   | V <sub>CC</sub> Supply Range                                                      |                                                                                                        | ●      | 4.5                                                         |            | 5.5           | V        |          |          |
| V <sub>CC2</sub>  | V <sub>CC2</sub> Supply Range                                                     |                                                                                                        | ●      | 4.5                                                         |            | 7.5           | V        |          |          |
| I <sub>CC</sub>   | V <sub>CC</sub> Supply Current                                                    | Transformer Not Driven (Note 10)                                                                       | ●      |                                                             | 13         | 28            | mA       |          |          |
| I <sub>CC2</sub>  | V <sub>CC2</sub> Supply Current                                                   | R = 27Ω, Figure 2<br>No Load                                                                           | ●<br>● |                                                             | 63<br>7    | 73<br>12      | mA<br>mA |          |          |
| V <sub>OD1</sub>  | Differential Driver Output                                                        | No Load                                                                                                | ●      |                                                             |            | 5             | V        |          |          |
| V <sub>OD2</sub>  | Differential Driver Output                                                        | R = 50Ω (RS422) (Note 2), V <sub>CC2</sub> = 4.5V<br>R = 27Ω(RS485), Figure 2, V <sub>CC2</sub> = 4.5V | ●<br>● | 2<br>1.5                                                    | 2          |               | V<br>V   |          |          |
| V <sub>OC</sub>   | Driver Output Common Mode Voltage                                                 | DC Level, R = 50Ω, Figure 2                                                                            | ●      | 2.0                                                         | 2.5        | 3.0           | V        |          |          |
| I <sub>OSD1</sub> | Driver Short-Circuit Current<br>V <sub>OUT</sub> = HIGH<br>V <sub>OUT</sub> = LOW | Driver Enabled (DE = 1)<br>−7V ≤ V <sub>CM</sub> ≤ 10V<br>−7V ≤ V <sub>CM</sub> ≤ 10V                  | ●<br>● | 60<br>60                                                    | 100<br>100 | 150<br>150    | mA<br>mA |          |          |
| V <sub>IH</sub>   | Logic Input High Voltage                                                          | DE, DI, RE<br>SLO                                                                                      | ●<br>● | 2<br>4                                                      | 1.7<br>2.2 |               | V<br>V   |          |          |
| V <sub>IL</sub>   | Logic Input Low Voltage                                                           | DE, DI, RE<br>SLO                                                                                      | ●<br>● |                                                             | 1.7<br>1.8 | 0.8<br>1      | V<br>V   |          |          |
| I <sub>IN</sub>   | Input Current (A, B)                                                              | (Note 3)                                                                                               |        | V <sub>IN</sub> = 12V<br>V <sub>IN</sub> = −7V              | ●<br>●     | 0.25<br>−0.20 | mA<br>mA |          |          |
| V <sub>TH</sub>   | Receiver Input Threshold                                                          | −7V ≤ V <sub>CM</sub> ≤ 12V, (Note 4)                                                                  |        | ●                                                           | −200       | −90           | −10      | mV       |          |
| ΔV <sub>TH</sub>  | Receiver Input Hysteresis                                                         | −7V ≤ V <sub>CM</sub> ≤ 12V                                                                            |        | 0°C ≤ T <sub>A</sub> ≤ 0°C<br>−40°C ≤ T <sub>A</sub> ≤ 85°C | ●<br>●     | 10<br>5       | 30<br>30 | 70<br>70 | mV<br>mV |
| R <sub>IIN</sub>  | Receiver Input Impedance                                                          |                                                                                                        | ●      | 50                                                          | 68         | 100           |          | kΩ       |          |

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**ELECTRICAL CHARACTERISTICS**

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V_{CC} = 5\text{V}$ ,  $V_{CC2} = 5\text{V}$  unless otherwise noted.

| SYMBOL    | PARAMETER                           | CONDITIONS                                       | MIN          | TYP  | MAX  | UNITS                  |
|-----------|-------------------------------------|--------------------------------------------------|--------------|------|------|------------------------|
| $V_{IOC}$ | Receiver Input Open Circuit Voltage |                                                  |              | 3.4  |      | V                      |
| $V_{OH}$  | RO Output High Voltage              | $I_{RO} = -4\text{mA}$ , $V_{CC} = 4.5\text{V}$  | ● 3.7        | 4.0  |      | V                      |
| $V_{OL}$  | RO Output Low Voltage               | $I_{RO} = 4\text{mA}$ , $V_{CC} = 4.5\text{V}$   | ●            | 0.4  | 0.8  | V                      |
| $I_{OZ}$  | Driver Output Leakage               | Driver Disabled ( $DE = 0$ )                     |              | 1    |      | $\mu\text{A}$          |
| $V_{OH2}$ | RO2 Output High Voltage             | $I_{RO2} = -4\text{mA}$ , $V_{CC} = 4.5\text{V}$ | ● 3.7        | 3.9  |      | V                      |
| $V_{OL2}$ | RO2 Output Low Voltage              | $I_{RO2} = 4\text{mA}$ , $V_{CC} = 4.5\text{V}$  | ●            | 0.4  | 0.8  | V                      |
| $f_{SW}$  | DC Converter Frequency              |                                                  | ● 290        | 420  | 590  | kHz                    |
| $R_{SWH}$ | DC Converter Impedance High         |                                                  | ●            | 4    | 6    | $\Omega$               |
| $R_{SWL}$ | DC Converter Impedance Low          |                                                  | ●            | 2.5  | 5    | $\Omega$               |
| $I_{REL}$ | $\overline{RE}$ Output Low Current  | $\overline{RE}$ Sink Current, Fault = 0          | ● -40        | -50  | -80  | $\mu\text{A}$          |
| $I_{REH}$ | $\overline{RE}$ Output High Current | $\overline{RE}$ Source Current, Fault = 1        | ● 80         | 100  | 130  | $\mu\text{A}$          |
| $V_{UVL}$ | Undervoltage Low Threshold          | $\overline{RE}$ Fault = 1, (Note 5)              | ● 3.70       | 4.00 | 4.25 | V                      |
| $V_{UVH}$ | Undervoltage High Threshold         | $\overline{RE}$ Fault = 0, (Note 5)              | ● 4.05       | 4.20 | 4.40 | V                      |
| $V_{ISO}$ | Isolation Voltage                   | 1 Minute, (Note 6)<br>1 Second                   | 2500<br>3000 |      |      | $V_{RMS}$<br>$V_{RMS}$ |

**SWITCHING CHARACTERISTICS**

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V_{CC} = 5\text{V}$ ,  $V_{CC2} = 5\text{V}$ ,  $R = 27\Omega$  (RS485) unless otherwise noted.

| SYMBOL        | PARAMETER                  | CONDITIONS                                                                                                                 | MIN        | TYP         | MAX         | UNITS    |
|---------------|----------------------------|----------------------------------------------------------------------------------------------------------------------------|------------|-------------|-------------|----------|
| $t_{SJ}$      | Data Sample Jitter         | Figure 8, (Note 7)                                                                                                         | ●          | 250         | 285         | ns       |
| $f_{MAX}$     | Max Baud Rate              | Jitter = 10% Max, $\overline{SLO} = 1$ , (Note 8)                                                                          | ● 250      | 410         |             | kBd      |
| $t_{PLH}$     | Driver Input to Output     | $DE = 1$ , $\overline{SLO} = 1$ , Figure 4, Figure 6<br>$DE = 1$ , $\overline{SLO} = 0$ , Figure 4, Figure 6               | ●<br>●     | 600<br>1300 | 855<br>1560 | ns<br>ns |
| $t_{PHL}$     | Driver Input to Output     | $DE = 1$ , $\overline{SLO} = 1$ , Figure 4, Figure 6<br>$DE = 1$ , $\overline{SLO} = 0$ , Figure 4, Figure 6               | ●<br>●     | 600<br>1300 | 855<br>1560 | ns<br>ns |
| $t_r$ , $t_f$ | Driver Rise or Fall Time   | $DE = 1$ , $\overline{SLO} = 1$ , Figure 4, Figure 6<br>$DE = 1$ , $\overline{SLO} = 0$ , $V_{CC} = V_{CC2} = 4.5\text{V}$ | ●<br>● 150 | 20<br>500   | 100<br>1000 | ns<br>ns |
| $t_{ZH}$      | Driver Enable to Output    | $DI = 1$ , $\overline{SLO} = 1$ , Figure 5, Figure 7                                                                       | ●          | 1000        | 1400        | ns       |
| $t_{ZL}$      | Driver Enable to Output    | $DI = 0$ , $\overline{SLO} = 1$ , Figure 5, Figure 7                                                                       | ●          | 1000        | 1400        | ns       |
| $t_{LZ}$      | Driver Disable to Output   | $DI = 0$ , $\overline{SLO} = 1$ , Figure 5, Figure 7                                                                       | ●          | 700         | 1300        | ns       |
| $t_{HZ}$      | Driver Disable to Output   | $DI = 1$ , $\overline{SLO} = 1$ , Figure 5, Figure 7                                                                       | ●          | 700         | 1300        | ns       |
| $t_{PLH}$     | Receiver Input to RO       | $\overline{RE} = 0$ , Figure 3, Figure 8                                                                                   | ●          | 600         | 855         | ns       |
| $t_{PHL}$     | Receiver Input to RO       | $\overline{RE} = 0$ , Figure 3, Figure 8                                                                                   | ●          | 600         | 855         | ns       |
| $t_{PLH}$     | Receiver Input to RO2      | $\overline{RE} = 0$ , Figure 3, Figure 8                                                                                   |            | 30          |             | ns       |
| $t_{PHL}$     | Receiver Input to RO2      | $\overline{RE} = 0$ , Figure 3, Figure 8                                                                                   |            | 30          |             | ns       |
| $t_r$ , $t_f$ | Receiver Rise or Fall Time | $\overline{RE} = 0$ , Figure 3, Figure 8                                                                                   |            | 20          |             | ns       |
| $t_{LZ}$      | Receiver Disable to Output | Figure 3, Figure 9                                                                                                         |            | 30          |             | ns       |
| $t_{HZ}$      | Receiver Disable to Output | Figure 3, Figure 9                                                                                                         |            | 30          |             | ns       |
| $t_{START}$   | Initial Start-Up Time      | (Note 9)                                                                                                                   |            | 1200        |             | ns       |
| $t_{TOF}$     | Data Time-Out Fault        | (Note 9)                                                                                                                   |            | 1200        |             | ns       |
|               | ST1, ST2 Duty Cycle        | $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$<br>$-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$                     | ●<br>●     |             | 56<br>57    | %<br>%   |

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## ELECTRICAL CHARACTERISTICS

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

**Note 2:** RS422 50Ω specification based on RS485 27Ω test.

**Note 3:**  $I_{IN}$  is tested at  $V_{CC2} = 5V$ , guaranteed by design from  $GND2 \leq V_{CC2} \leq 5.25V$ .

**Note 4:** Input fault conditions on the RS485 receiver are detected with a fixed receiver offset. The offset is such that an input short or open will result in a high data output.

**Note 5:** The low voltage detect faults when  $V_{CC2}$  or  $V_{CC}$  drops below  $V_{UVL}$  and reenables when greater than  $V_{UVH}$ . The fault can be monitored through the weak driver output on RE.

**Note 6:** Value derived from 1 second test.

**Note 7:** The input signals are internally sampled and encoded. The internal sample rate determines the data output jitter since the internal sampling is asynchronous with respect to the external data. Nominally, a 4MHz internal sample rate gives 250ns of sampling uncertainty in the input signals.

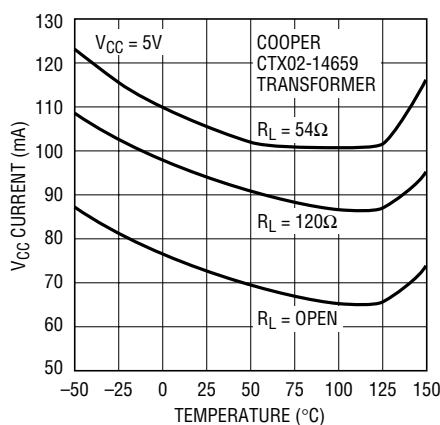
**Note 8:** The maximum baud rate is 250kBd with 10% sampling jitter. Lower baud rates have lower jitter.

**Note 9:** Start-up time is the time for communication to recover after a fault condition. Data time-out is the time a fault is indicated on RE after data communication has stopped.

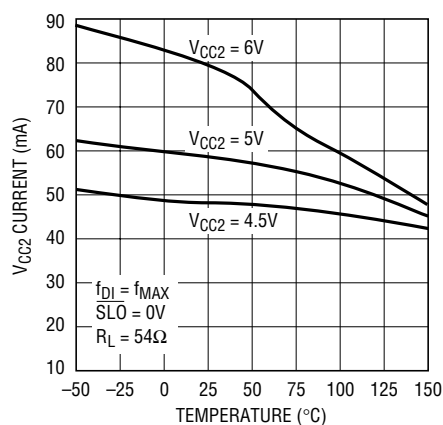
**Note 10:**  $I_{CC}$  measured with no load, ST1 and ST2 floating.

## TYPICAL PERFORMANCE CHARACTERISTICS

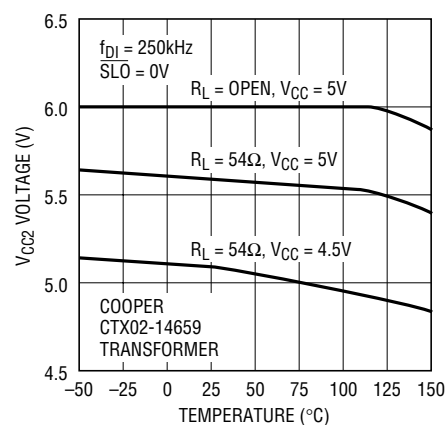
**$V_{CC}$  Supply Current vs Temperature**



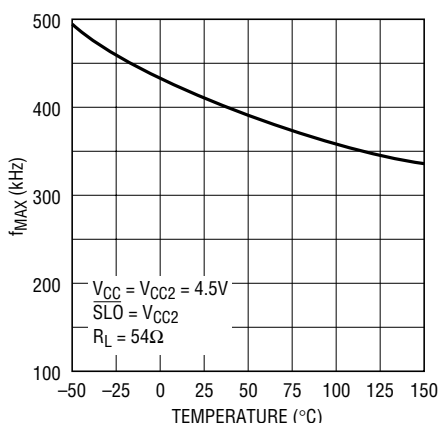
**$V_{CC2}$  Supply Current vs Temperature**



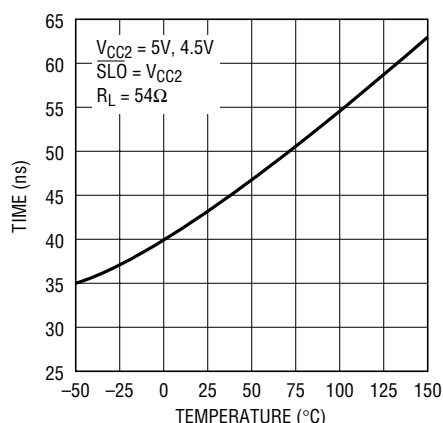
**$V_{CC2}$  Supply Voltage vs Temperature**



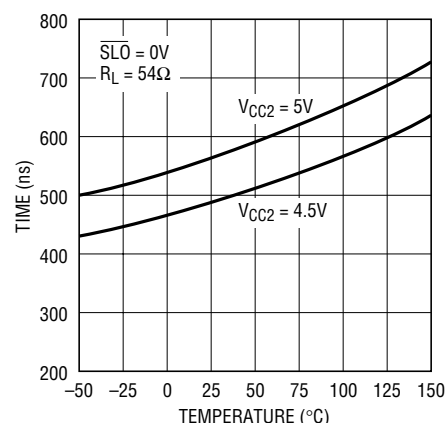
**Maximum Baud Rate vs Temperature**



**Driver Differential Output Rise/Fall Time vs Temperature**

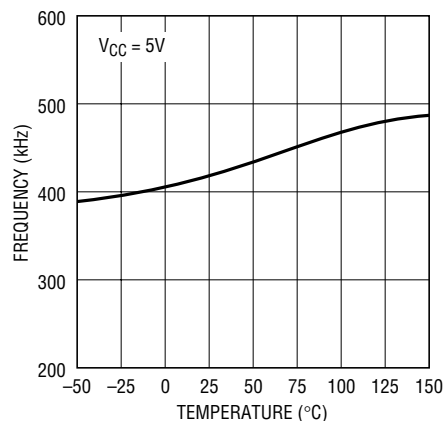


**Driver Differential Output Rise/Fall Time vs Temperature**



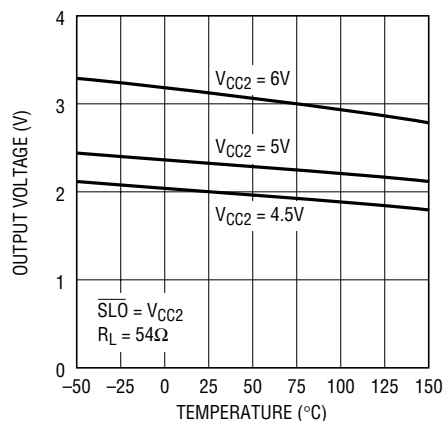
## TYPICAL PERFORMANCE CHARACTERISTICS

Switcher Frequency vs Temperature



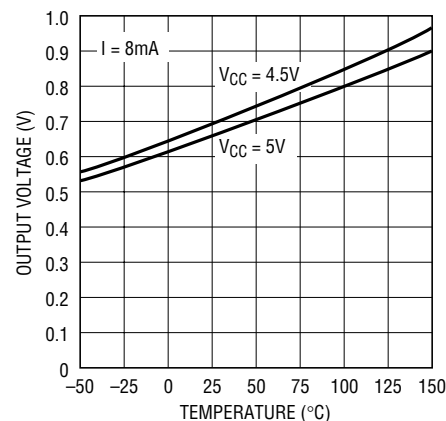
1535 G07

Driver Differential Output Voltage vs Temperature



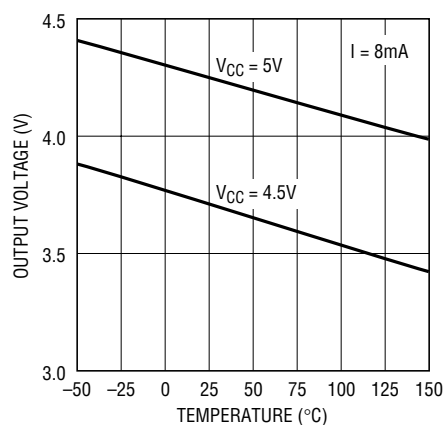
1535 G08

Receiver Output Low Voltage vs Temperature



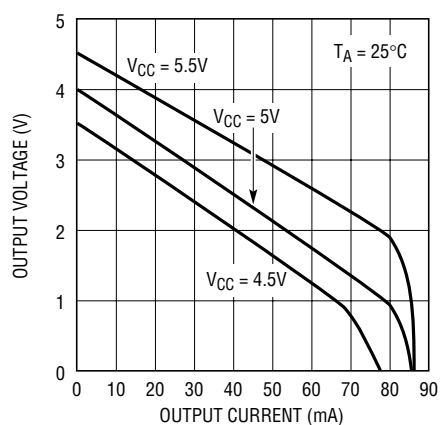
1535 G09

Receiver Output High Voltage vs Temperature



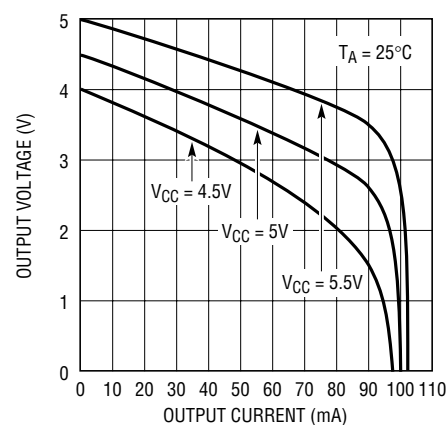
1535 G10

Driver Differential Output Voltage vs Output Current



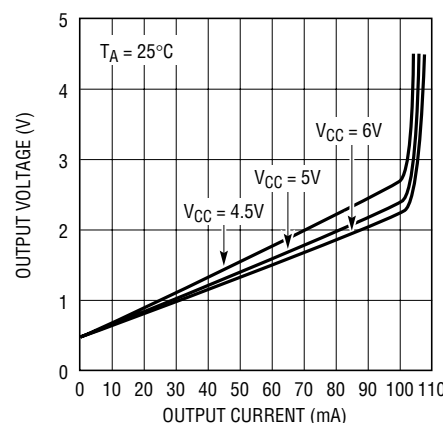
1535 G11

Driver Output High Voltage vs Output Current

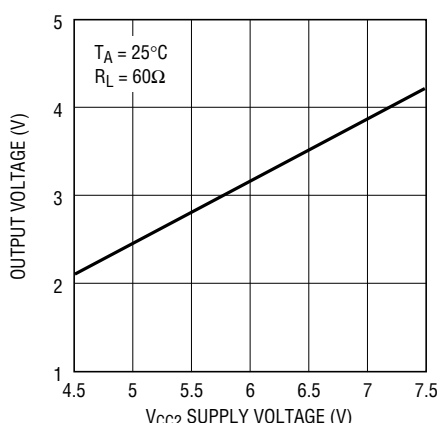


1535 G12

Driver Output Low Voltage vs Output Current

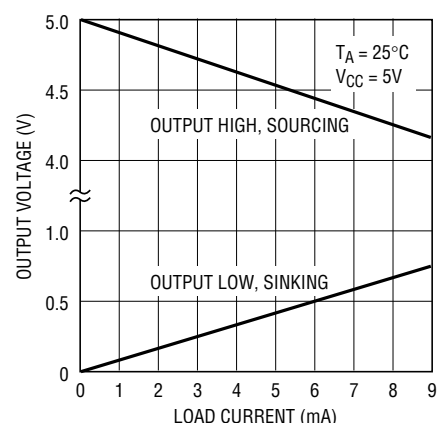


1535 G13

Driver Differential Output Voltage vs  $V_{CC2}$  Supply Voltage

1535 G14

Receiver Output Voltage vs Load Current



1535 G15

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## PIN FUNCTIONS

### POWER SIDE

**V<sub>CC</sub> (Pin 1):** 5V Supply. Bypass to GND with 10 $\mu$ F capacitor.

**ST1 (Pin 2):** DC Converter Output 1 to DC Transformer.

**ST2 (Pin 3):** DC Converter Output 2 to DC Transformer.

**GND (Pin 4):** Ground.

**DI (Pin 25):** Transmit Data TTL Input to the Isolated Side RS485 Driver. Do not float.

**DE (Pin 26):** Transmit Enable TTL Input to the Isolated Side RS485 Driver. A high level enables the driver. Do not float.

**RE (Pin 27):** Receive Data Output Enable TTL Input. A low level enables the receiver. This pin also provides a fault output signal. (See Figure 11.)

**RO (Pin 28):** Receive Data TTL Output.

### ISOLATED SIDE

**GND2 (Pin 11):** Isolated Side Power Ground.

**Z (Pin 12):** Differential Driver Inverting Output.

**Y (Pin 13):** Differential Driver Noninverting Output.

**V<sub>CC2</sub> (Pin 14):** 5V to 7.5V Supply from DC Transformer. Bypass to GND2 with 10 $\mu$ F capacitor.

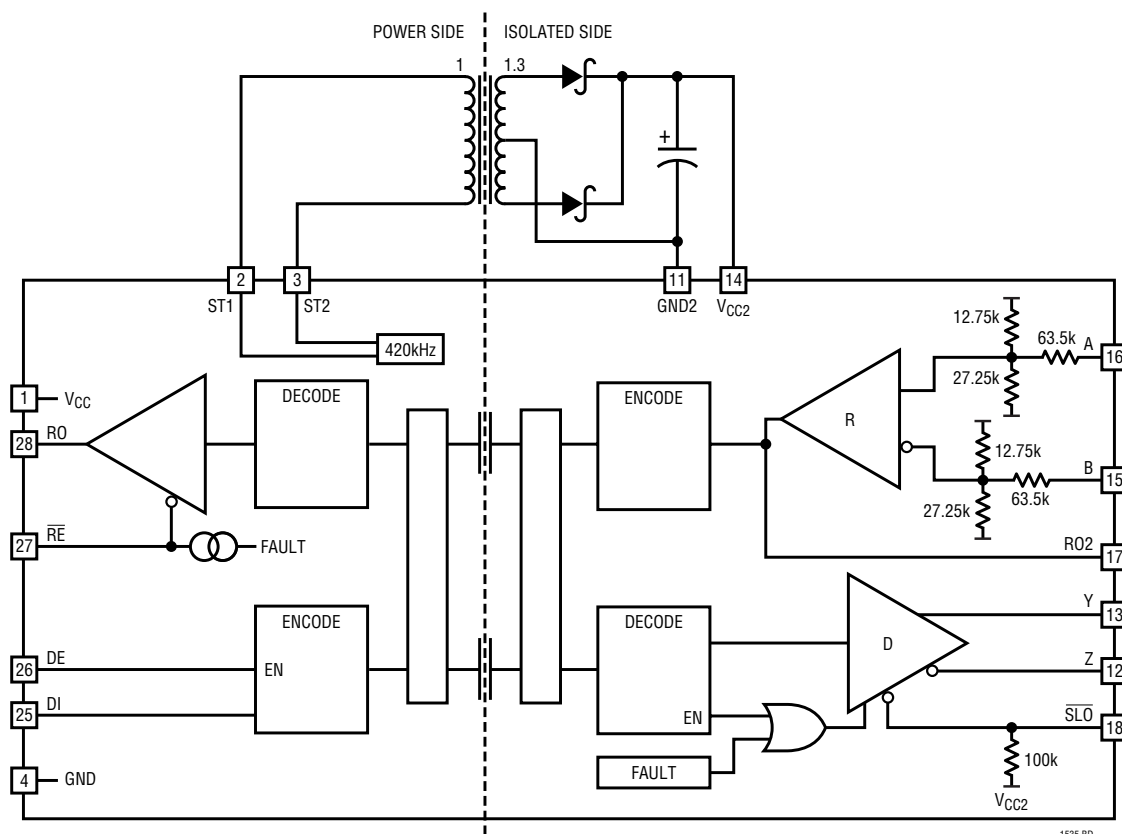
**B (Pin 15):** Differential Receiver Inverting Input.

**A (Pin 16):** Differential Receiver Noninverting Input.

**RO2 (Pin 17):** Isolated Side Receiver TTL Output. This output is always enabled and is unaffected by RE.

**SLO (Pin 18):** Slow Slew Rate Control of RS485 Driver. A low level forces the driver outputs into slow slew rate mode.

## BLOCK DIAGRAM



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## SWITCHING TIME WAVEFORMS

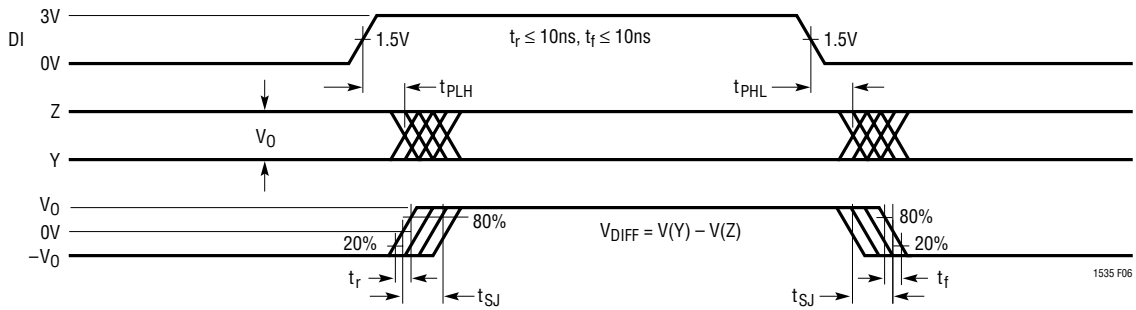


Figure 6. Driver Propagation Delays

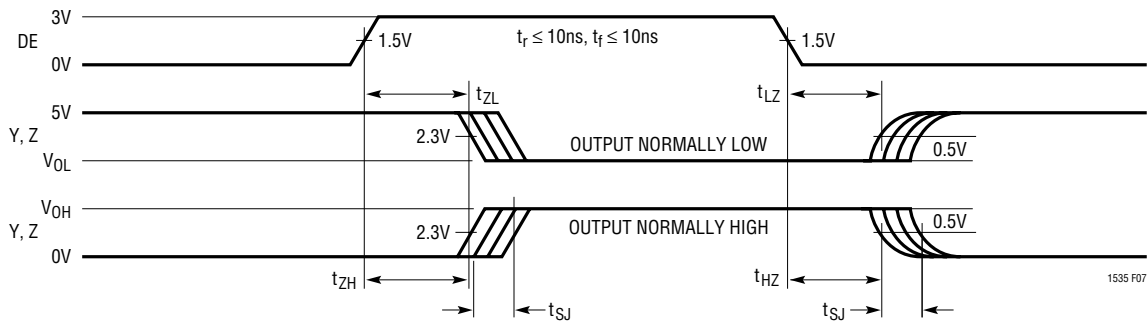


Figure 7. Driver Enable and Disable Times

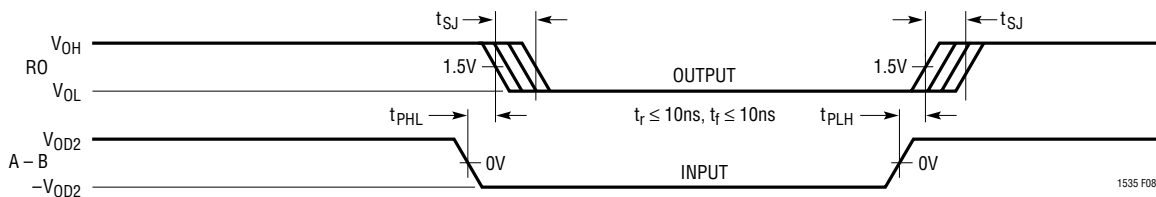


Figure 8. Receiver Propagation Delays

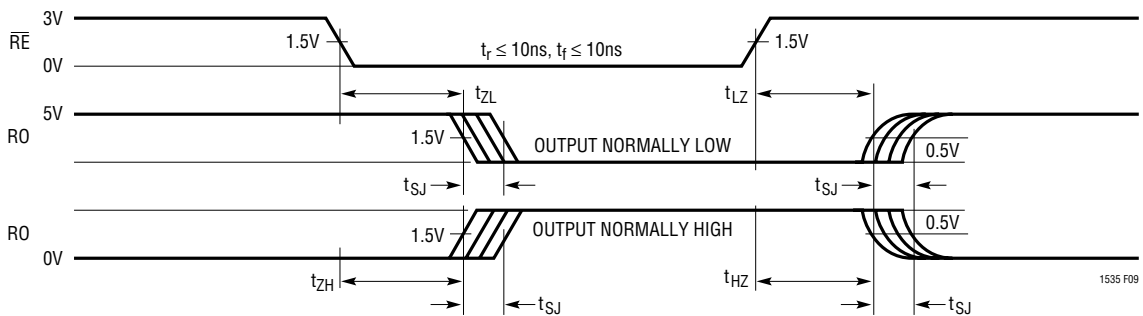


Figure 9. Receiver Enable and Disable Times

## APPLICATIONS INFORMATION

### Isolation Barrier and Sampled Communication

The LTC1535 uses the SW-28 isolated lead frame package to provide capacitive isolation barrier between the logic interface and the RS485 driver/receiver pair. The barrier provides  $2500V_{RMS}$  of isolation. Communication between the two sides uses the isolation capacitors in a multiplexed way to communicate full-duplex data across this barrier (see Figure 20 and Block Diagram). The data is sampled and encoded before transmitting across the isolation barrier, which will add sampling jitter and delay to the signals (see Figures 13 and 14). The sampling jitter is approximately 250ns with a nominal delay of 600ns. At 250kBd rate, this represents 6.2% total jitter. The nominal DE signal to the driver output delay is  $875ns \pm 125ns$ , which is longer due to the encoding. Communication start-up time is approximately  $1\mu s$  to  $2\mu s$ . A time-out fault will occur if communication from the isolated side fails. Faults can be monitored on the  $\overline{RE}$  pin.

The maximum baud rate can be determined by connecting in self-oscillation mode as shown in Figure 1. In this configuration, with  $\overline{SLO} = V_{CC2}$ , the oscillation frequency is set by the internal sample rate. With  $\overline{SLO} = 0V$ , the frequency is reduced by the slower output rise and fall times.

### Push-Pull DC/DC Converter

The powered side contains a full-bridge open-loop driver, optimized for use with a single primary and center-tapped secondary transformer. Figure 10 shows the DC/DC converter in a configuration that can deliver up to 100mA of current to the isolated side using a Cooper CTX02-14659 transformer.

Because the DC/DC converter is open-loop, care in choosing low impedance parts is important for good regulation. Care must also be taken to not exceed the  $V_{CC2}$  recommended maximum voltage of 7.5V when there is very light loading. The isolated side contains a low voltage detect circuit to ensure that communication across the barrier will only occur when there is sufficient isolated supply voltage. If the output of the DC/DC converter is overloaded, the supply voltage will trip the low voltage detection at 4.2V. For higher voltage stand-off, the Cooper CTX02-14608 transformer may be used.

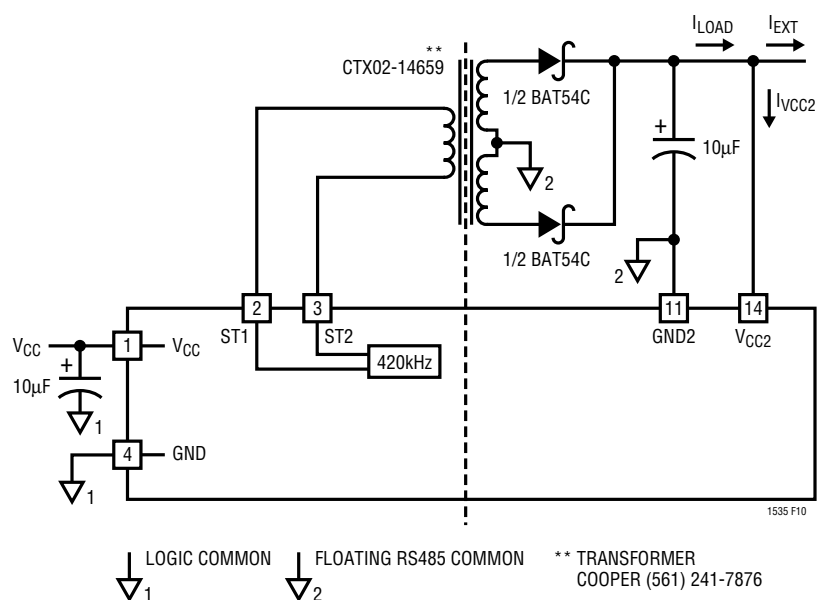
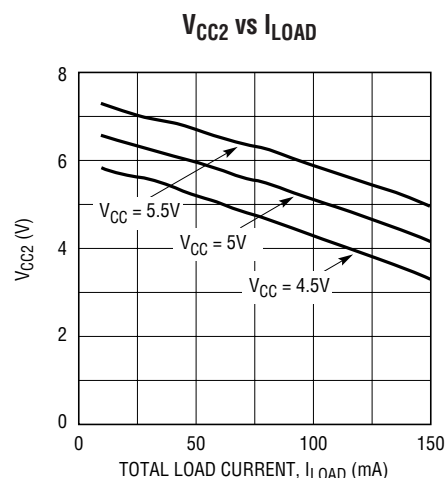


Figure 10



1535 F10a

## APPLICATIONS INFORMATION

### Driver Output and Slow Slew Rate Control

The LTC1535 uses a proprietary driver output stage that allows a common mode voltage range that extends beyond the power supplies. Thus, the high impedance state is maintained over the full RS485 common mode range. The output stage provides 100mA of short-circuit current limiting in both the positive and negative directions. Thus, even under short-circuit conditions, the supply voltage from the open-loop DC converter will remain high enough for proper communication across the isolation barrier. The driver output will be disabled in the event of a thermal shutdown and a fault condition will be indicated through the  $\overline{RE}$  weak output.

The CMOS level  $\overline{SLO}$  pin selects slow or fast slew rates on the RS485 driver output (see Figures 15, 16, 17, 18 for typical waveforms). The  $\overline{SLO}$  input has an internal 100k pull-up resistor. When  $\overline{SLO}$  is low, the driver outputs are slew rate limited to reduce high frequency edges. Left open or tied high,  $\overline{SLO}$  defaults to fast edges. The part draws more current during slow slew rate edges.

### Monitoring Faults on $\overline{RE}$

The  $\overline{RE}$  pin can be used to monitor the following fault conditions: low supply voltages, thermal shutdown or a time-out fault when there is no data communication across the barrier. During a fault, the receiver output, RO, defaults to a high state (see Table 2). Open circuit or short-circuit conditions on the twisted pair do not cause a fault indication. However, the RS485 receiver defaults to a high output state when the receiver input is open or short-circuited.

The  $\overline{RE}$  pin has a weak current drive output mode for indicating fault conditions. This fault state can be polled using a bidirectional microcontroller I/O line or by using the circuit in Figure 11, where the control to  $\overline{RE}$  is three-stated and the fault condition read back from the  $\overline{RE}$  pin. The weak drive has 100 $\mu$ A pull-up current to indicate a fault and 50 $\mu$ A pull-down current for no fault. This allows the  $\overline{RE}$  pin to be polled without disabling  $\overline{RE}$  on nonfault conditions.

Both sides contain a low voltage detect circuit. A voltage less than 4.2V on the isolated side disables communication.

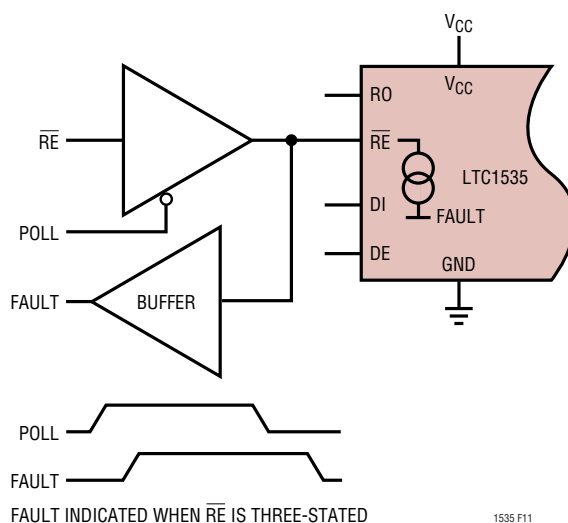


Figure 11. Detecting Fault Conditions

## APPLICATIONS INFORMATION

Table 1. List of Transformers Designed for LTC1535

| MANUFACTURER             | PART NUMBER     | DC ISOLATION VOLTAGE (1 Second) | PHONE NUMBER                         |
|--------------------------|-----------------|---------------------------------|--------------------------------------|
| Cooper                   | CTX02-14659     | 500V                            | (561) 241-7876                       |
| Cooper                   | CTX02-14608     | 3.75kVAC                        | (561) 241-7876                       |
| Epcos AG (Germany) (USA) | B78304-A1477-A3 | 500V                            | (0 89) 636-2 80 00<br>(800) 888-7724 |
| Midcom                   | 31160R          | 1.25kV                          | (605) 886-4385                       |
| Pulse FEE (France)       | P1597           | 500V                            | (33) 3 84 35 04 04                   |
| Sumida (Japan)           | S-167-5779      | 100V                            | 03-3667-3320                         |
| Transpower               | TTI7780-SM      | 500V                            | (775) 852-0140                       |

Table 2. Fault Mode Behavior

| FUNCTION (PINS)                         |                                   | $V_{CC} > V_{UVH}$<br>$V_{CC2} > V_{UVH}$ | $V_{CC} < V_{UVL}$<br>$V_{CC2} > V_{UVH}$ | $V_{CC} > V_{UVH}$<br>$V_{CC2} < V_{UVL}$ | $V_{CC} < V_{UVL}$<br>$V_{CC2} > V_{UVL}$ | THERMAL SHUTDOWN |
|-----------------------------------------|-----------------------------------|-------------------------------------------|-------------------------------------------|-------------------------------------------|-------------------------------------------|------------------|
| DC/DC Converter (2, 3)                  |                                   | On                                        | On                                        | On                                        | On                                        | Off              |
| RO (28)                                 | $\overline{RE} = 0V$              | Active                                    | Forced High                               | Forced High                               | Forced High                               | Forced High      |
|                                         | $\overline{RE} = V_{CC}$          | Hi-Z                                      | Hi-Z                                      | Hi-Z                                      | Hi-Z                                      | Hi-Z             |
|                                         | $\overline{RE} = \text{Floating}$ | Active                                    | Hi-Z                                      | Hi-Z                                      | Hi-Z                                      | Hi-Z             |
| R02 (17)                                |                                   | Active                                    | Active                                    | Active                                    | Active                                    | Active           |
| Driver Outputs Y and Z (13,12)          |                                   | Active                                    | Hi-Z                                      | Hi-Z                                      | Hi-Z                                      | Hi-Z             |
| Communication Across Isolation Barrier  |                                   | Active                                    | Disabled                                  | Disabled                                  | Disabled                                  | Disabled         |
| Fault Indicator on $\overline{RE}$ (27) |                                   | Low                                       | High                                      | High                                      | High                                      | High             |

Table 3. Driver Function Table

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

Note: Z = high impedance, X = don't care

Table 4. Receiver Function Table

| INPUTS          |    |                    | OUTPUTS |     |
|-----------------|----|--------------------|---------|-----|
| $\overline{RE}$ | DE | A-B                | R0      | R02 |
| 0               | X  | $\geq V_{TH(MAX)}$ | 1       | 1   |
| 0               | X  | $\leq V_{TH(MIN)}$ | 0       | 0   |
| 0               | X  | Inputs Open        | 1       | 1   |
| 0               | X  | Inputs Shorted     | 1       | 1   |
| 1               | X  | $\geq V_{TH(MAX)}$ | Z       | 1   |
| 1               | X  | $\leq V_{TH(MIN)}$ | Z       | 0   |
| 1               | X  | Inputs Open        | Z       | 1   |
| 1               | X  | Inputs Shorted     | Z       | 1   |

Note: Z = high impedance, X = don't care

## APPLICATIONS INFORMATION

### High Voltage Considerations

The LTC1535 eliminates ground loops on data communication lines. However, such isolation can bring potentially dangerous voltages onto the circuit board. An example would be accidental faulting to 117V AC at some point on the cable which is then conducted to the PC board. Figure 12 shows how to detect and warn the user or installer that a voltage fault condition exists on the twisted pair or its shield. A small (3.2mm) glow lamp is connected between GND2 (the isolated ground) and the equipment's safety "earth" ground. If a potential of more than 75V AC is present on the twisted pair or shield, B1 will light, indicating a wiring fault. Resistors R3 and R4 are used to ballast the current in B1. Two resistors are necessary because they can only stand off 200V each, as well as for power dissipation. As shown, the circuit can withstand a direct fault to a 440V 3 $\phi$  system.

Other problems introduced by floating the twisted pair include the collection of static charge on the twisted pair, its shield and the attached circuitry. Resistors R1 and R2

provide a path to shunt static charge safely to ground. Again, two resistors are necessary to withstand high voltage faults. Electrostatic spikes, electromagnetically induced transients and radio frequency pickup are shunted by addition capacitor C1.

### Receiver Inputs Fail-Safe

The LTC1535 features an input common mode range covering the entire RS485 specified range of -7V to 12V. Differential signals of greater than  $\pm 200\text{mV}$  within the specified input common mode range will be converted to TTL compatible signals at the receiver outputs, RO and RO2. A small amount of input hysteresis is included to minimize the effects of noise on the line signals. If the receiver inputs are floating or shorted, a designed-in receiver offset guarantees a fail-safe logic high at the receiver outputs. If a fail-safe logic low is desired, connect as shown in Figure 19.

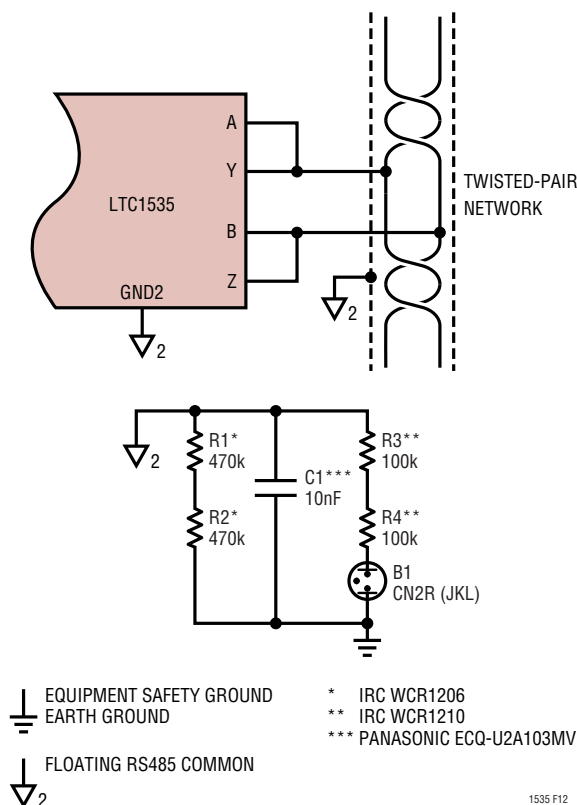


Figure 12. Detecting Wiring Faults

## APPLICATIONS INFORMATION

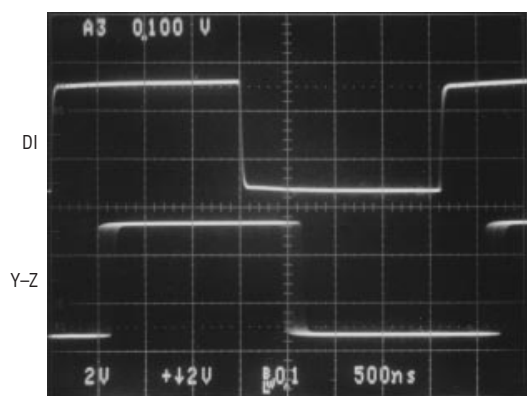


Figure 13. Driver Propagation Delay with Sample Jitter.  $SLO = V_{CC2}$

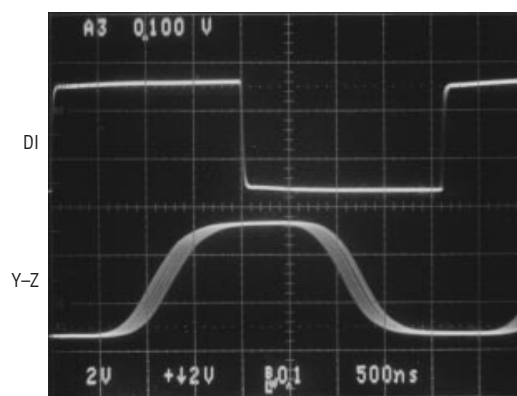


Figure 14. Driver Propagation Delay with Sample Jitter.  $SLO = 0V$

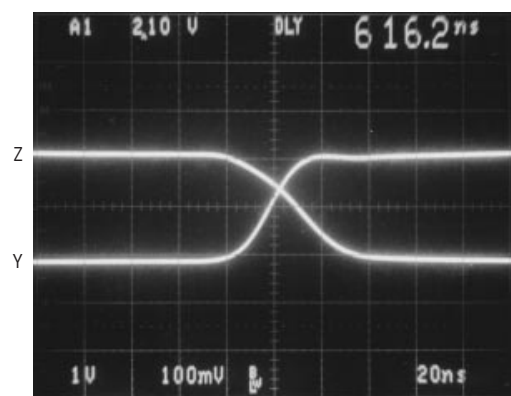


Figure 15. Driver Output.  
 $R = 27\Omega$ ,  $V_{CC2} = 5V$ ,  $SLO = V_{CC2}$

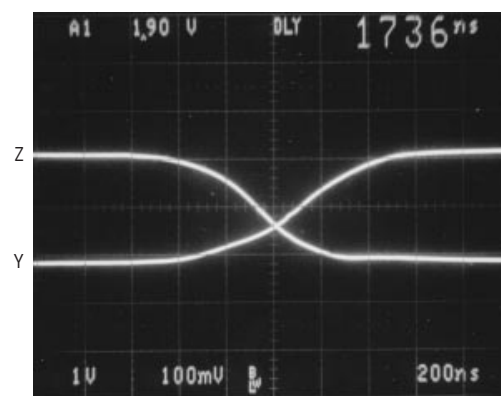


Figure 16. Driver Output.  
 $R = 27\Omega$ ,  $V_{CC2} = 5V$ ,  $SLO = 0V$

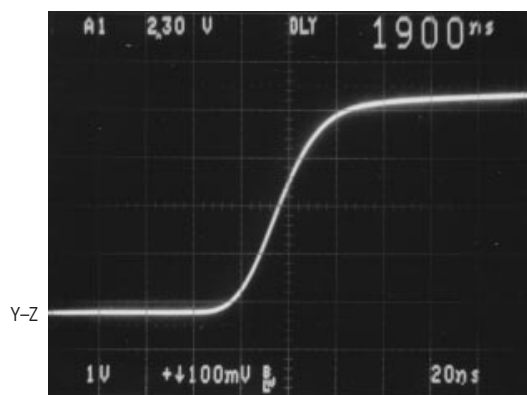


Figure 17. Driver Differential Output.  
 $R = 27\Omega$ ,  $V_{CC2} = 5V$ ,  $SLO = V_{CC2}$

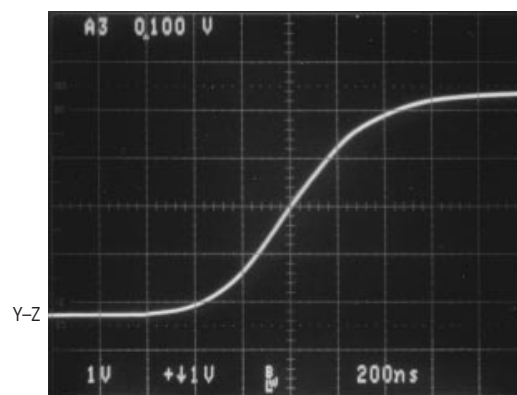


Figure 18. Driver Differential Output.  
 $R = 27\Omega$ ,  $V_{CC2} = 5V$ ,  $SLO = 0V$

TYPICAL APPLICATIONS

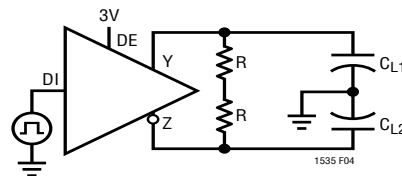


Figure 19. Fail-Safe Logic “0”

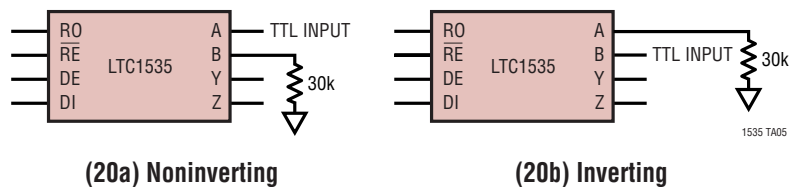
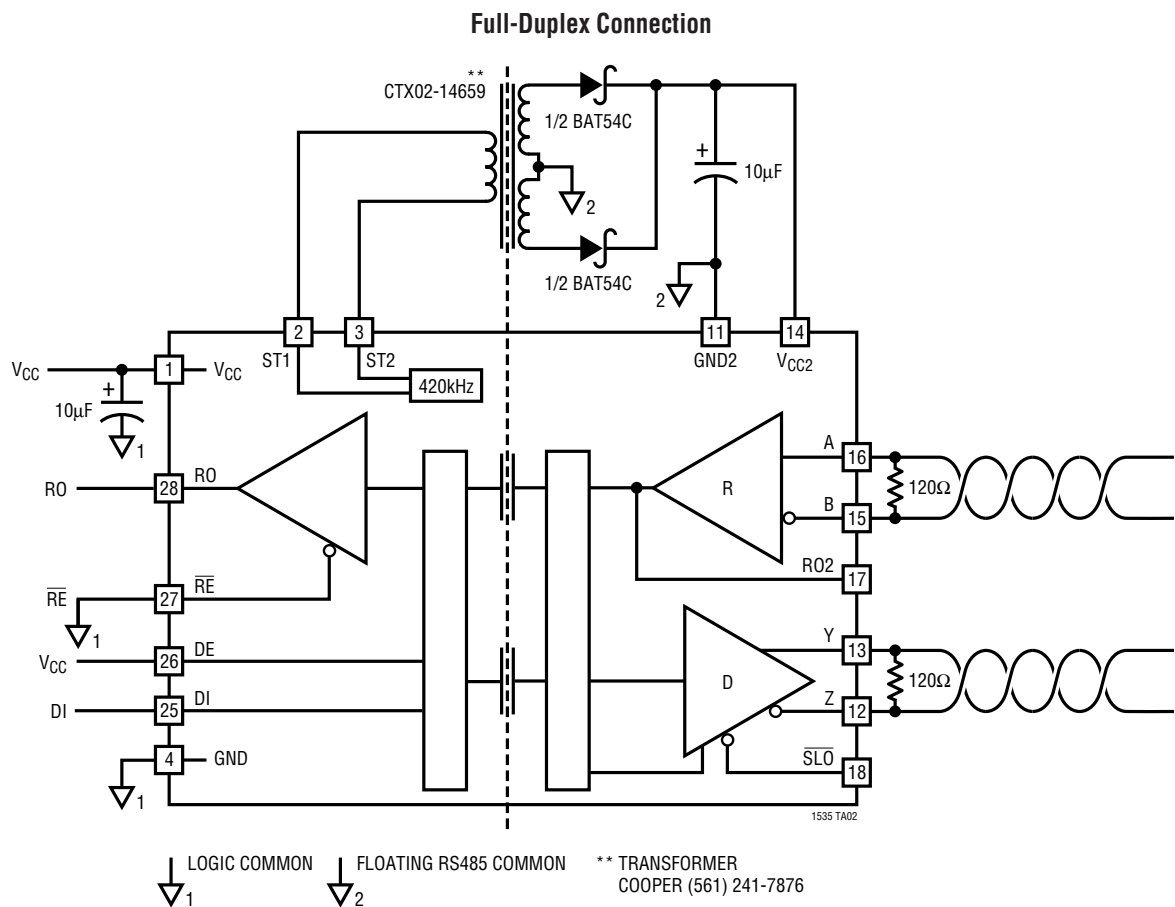
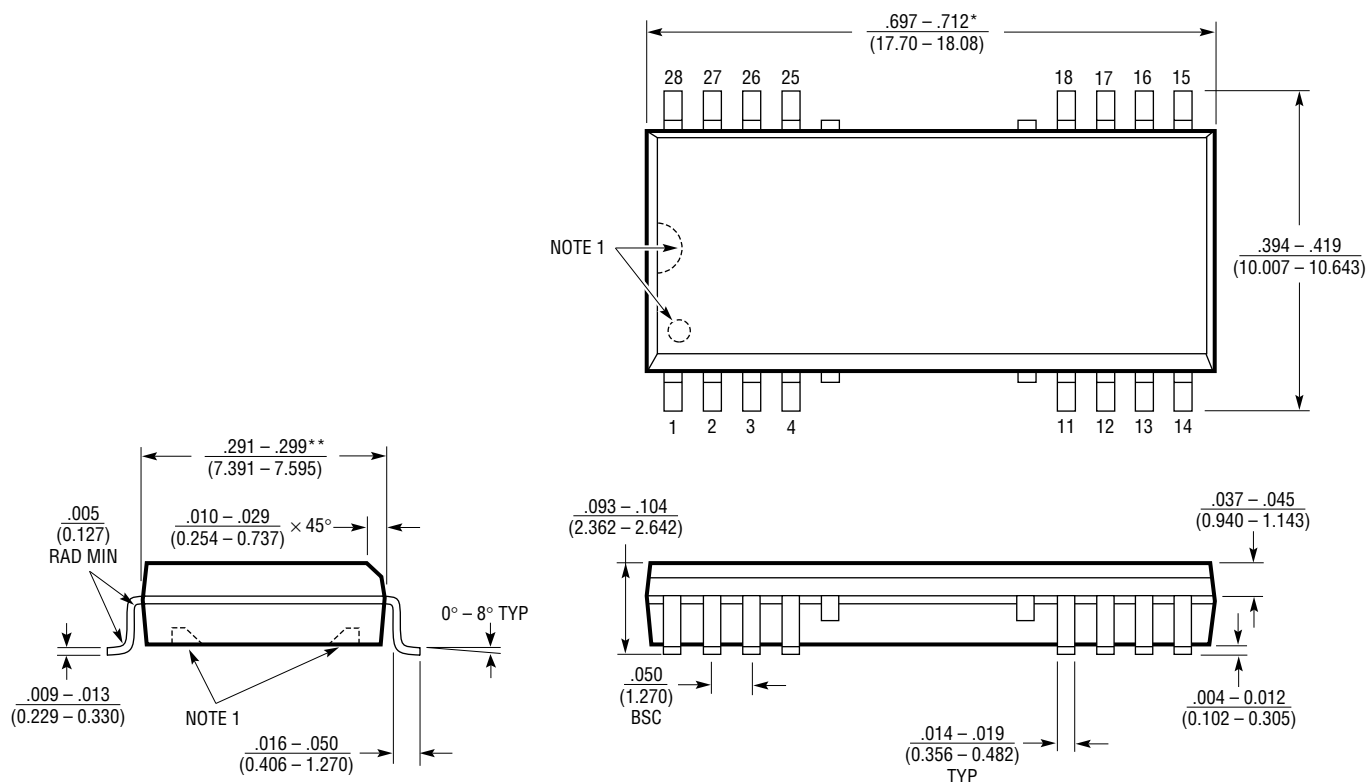


Figure 20. Configuring Receiver for TTL Level Input. Y and Z Outputs Are TTL Compatible with No Modification



# PACKAGE DESCRIPTION

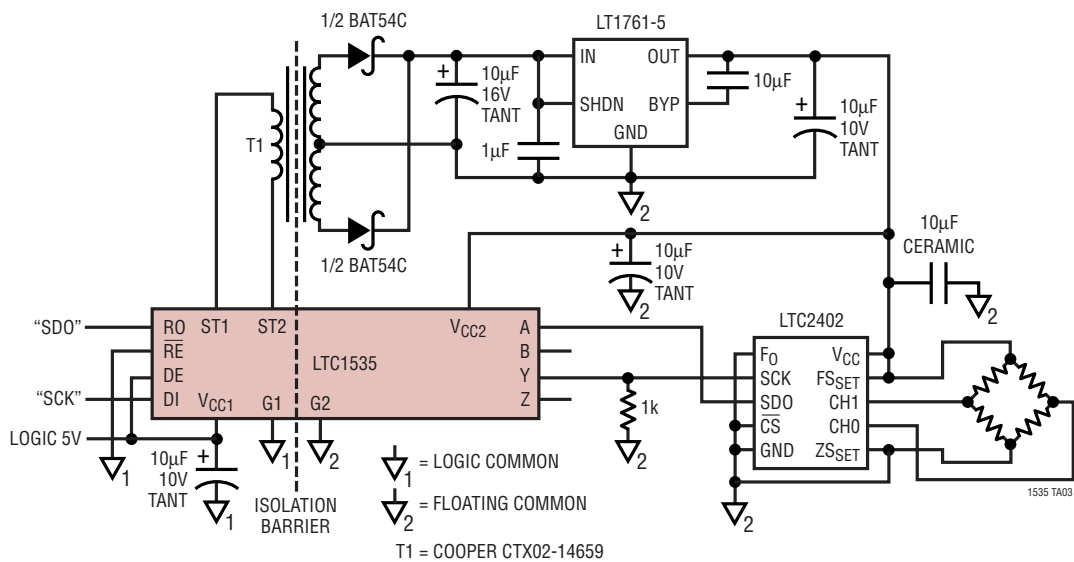
## SW Package 28-Lead Plastic Small Outline Isolation Barrier (Wide .300 Inch) (Reference LTC DWG # 05-08-1690)



SW28 (ISO) 0502

TYPICAL APPLICATION

Complete, Isolated 24-Bit Data Acquisition System



RELATED PARTS

| PART NUMBER   | DESCRIPTION                                              | COMMENTS                                                |
|---------------|----------------------------------------------------------|---------------------------------------------------------|
| LT1424-5      | Isolated Flyback Switching Regulator                     | ±5% Accurate with No Optoisolator Required              |
| LTC1485       | High Speed RS485 Transceiver                             | 10Mbps, Pin Compatible with LTC485                      |
| LTC1531       | Self-Powered Isolated Comparator                         | 2.5V Isolated Reference, 3000V <sub>RMS</sub> Isolation |
| LT1785/LT1791 | ±60V Fault Protected RS485 Transceiver, Half/Full-Duplex | ±15kV ESD Protection, Industry Standard Pinout          |
| LTC1690       | Full-Duplex RS485 Transceiver                            | ±15kV ESD Protection, Fail-Safe Receiver                |