# RS232/RS485 Multiprotocol Transceivers with Integrated Termination

## FEATURES

- **One RS485 and Two RS232 Transceivers**
- **3V to 5.5V Supply Voltage**
- **20Mbps RS485 and 500kbps RS232**
- **Automatic Selection of Integrated RS485 (120Ω) and RS232 (5kΩ)Termination Resistors**
- **Half-/Full-Duplex RS485 Switching**
- **High ESD: ±26kV (LTC2870), ±16kV (LTC2871)**
- Logic Loopback Mode
- 1.7V to 5.5V Logic Interface
- Supports Up to 256 RS485 Nodes
- RS485 Receiver Failsafe Eliminates UART Lockup
- Available in 28-Pin 4mm × 5mm QFN and TSSOP (LTC2870), and 38-Pin 5mm × 7mm QFN and TSSOP (LTC2871)

## APPLICATIONS

- Flexible RS232/RS485/RS422 Interface
- Software Selectable Multiprotocol Interface Ports
- Point-of-Sale Terminals
- Cable Repeaters
- Protocol Translators

## DESCRIPTION

The LTC®2870/LTC2871 are robust pin-configurable multiprotocol transceivers, supporting RS232, RS485, and RS422 protocols, operating on a single 3V to 5.5V supply. The LTC2870 can be configured as two RS232 single-ended transceivers or one RS485 differential transceiver on shared I/O lines. The LTC2871 offers independent control of two RS232 transceivers and one RS485 transceiver, each on dedicated I/O lines.

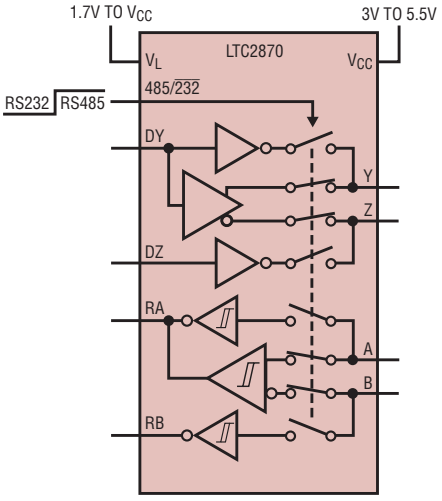
Pin-controlled integrated termination resistors allow for easy interface reconfiguration, eliminating external resistors and control relays. Half-duplex switches allow four-wire and two-wire RS485 configurations. Loopback mode steers the driver inputs to the receiver outputs for diagnostic self-test.The RS485 receivers support up to 256 nodes per bus, and feature full failsafe operation for floating, shorted or terminated inputs.

An integrated DC/DC boost converter uses a small inductor and one capacitor, eliminating the need for multiple supplies for driving RS232 levels.

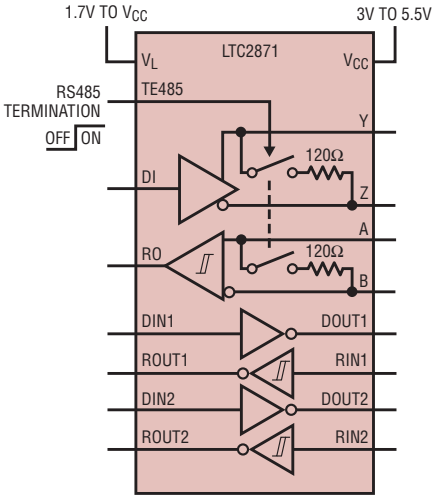


## TYPICAL APPLICATIONS

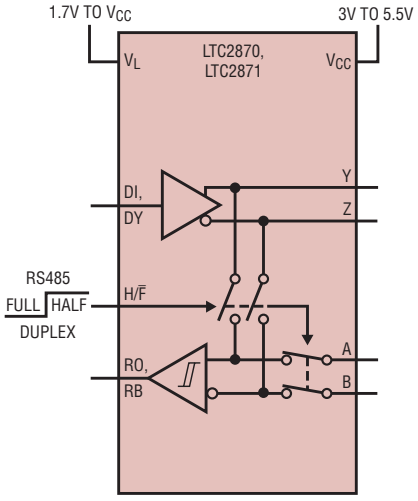
**Protocol Switching with Automatic Termination Selection**




**Simultaneous Protocols and RS485 Termination Switching**




**RS485 Duplex Switching**



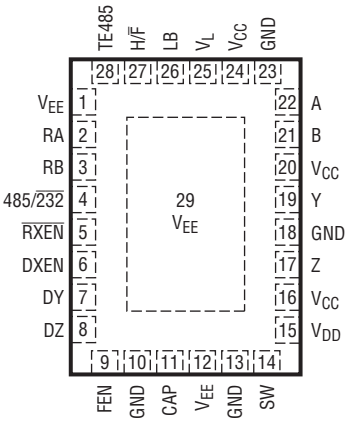
## ABSOLUTE MAXIMUM RATINGS (Notes 1 and 2)

Input Supplies
$V_{CC}$, $V_L$ ..... –0.3V to 7V
Generated Supplies
$V_{DD}$ ..... $V_{CC}$ – 0.3V to 7.5V
$V_{EE}$ ..... 0.3V to –7.5V
$V_{DD} – V_{EE}$ ..... 15V
SW ..... –0.3V to ($V_{DD}$ + 0.3V)
CAP ..... 0.3V to ($V_{EE}$ – 0.3V)
A, B, Y, Z, RIN1, RIN2, DOUT1, DOUT2 ..... –15V to 15V
DI, DZ, DY, $\overline{RXEN}$, DXEN, LB, H/$\overline{F}$, TE485, $\overline{RX485}$, DX485, $\overline{RX232}$, DX232, DIN1, DIN2, 485/$\overline{232}$, $\overline{CH2}$ ..... –0.3V to 7V
FEN, RA, RB, RO, ROUT1, ROUT2 ... –0.3V to ($V_L$ + 0.3V)
Differential Enabled Terminator Voltage (A-B or Y-Z) ..... ±6V
Operating Temperature
LTC2870C/LTC2871C ..... 0°C to 70°C
LTC2870I/LTC2871I ..... –40°C to 85°C
Storage Temperature Range ..... –65°C to 125°C
Lead Temperature (Soldering, 10 sec)
FE package ..... 300°C

## PIN CONFIGURATION

LTC2870

TOP VIEW

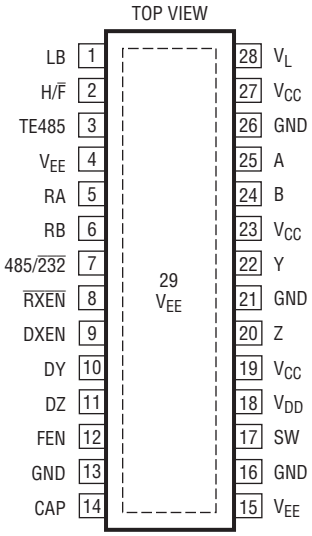



UFD PACKAGE
28-LEAD (4mm × 5mm) PLASTIC QFN

$T_{JMAX}$ = 125°C, $\theta_{JA}$ = 43°C/W
EXPOSED PAD (PIN 29) IS $V_{EE}$,
MUST BE SOLDERED TO PCB

LTC2870

TOP VIEW

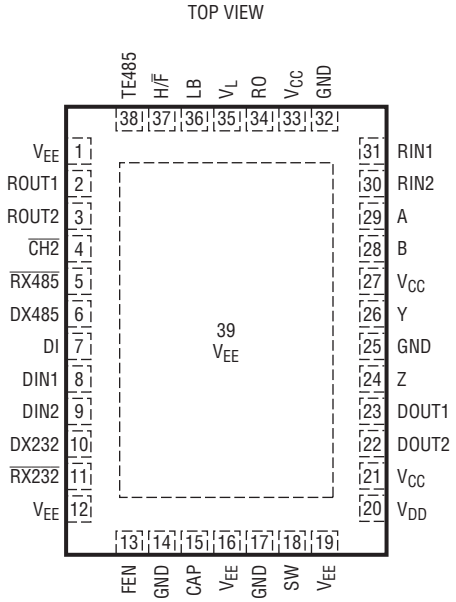



FE PACKAGE
28-LEAD PLASTIC TSSOP

$T_{JMAX}$ = 125°C, $\theta_{JA}$ = 25°C/W
EXPOSED PAD (PIN 29) IS $V_{EE}$,
MUST BE SOLDERED TO PCB

# PIN CONFIGURATIONS

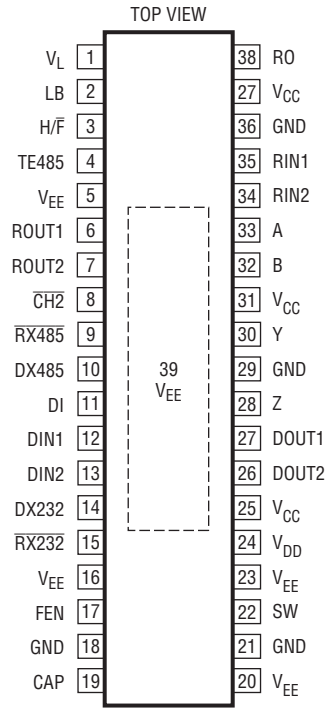
LTC2871




UHF PACKAGE
38-LEAD (5mm × 7mm) PLASTIC QFN

$T_{JMAX}$ = 125°C, $\theta_{JA}$ = 34°C/W
EXPOSED PAD (PIN 39) IS $V_{EE}$,
MUST BE SOLDERED TO PCB

LTC2871




FE PACKAGE
38-LEAD PLASTIC SSOP

$T_{JMAX}$ = 125°C, $\theta_{JA}$ = 29°C/W
EXPOSED PAD (PIN 39) IS $V_{EE}$,
MUST BE SOLDERED TO PCB

# ORDER INFORMATION

| LEAD FREE FINISH | TAPE AND REEL | PART MARKING | PACKAGE DESCRIPTION | TEMPERATURE RANGE |
|---|---|---|---|---|
| LTC2870CFE#PBF<br>LTC2870IFE#PBF | LTC2870CFE#TRPBF<br>LTC2870IFE#TRPBF | LTC2870FE<br>LTC2870FE | 28-Lead Plastic TSSOP<br>28-Lead Plastic TSSOP | 0°C to 70°C<br>–40°C to 85°C |
| LTC2870CUFD#PBF<br>LTC2870IUFD#PBF | LTC2870CUFD#TRPBF<br>LTC2870IUFD#TRPBF | 2870<br>2870 | 28-Lead (4mm × 5mm) Plastic QFN<br>28-Lead (4mm × 5mm) Plastic QFN | 0°C to 70°C<br>–40°C to 85°C |
| LTC2871CFE#PBF<br>LTC2871IFE#PBF | LTC2871CFE#TRPBF<br>LTC2871IFE#TRPBF | LTC2871FE<br>LTC2871FE | 38-Lead Plastic TSSOP<br>38-Lead Plastic TSSOP | 0°C to 70°C<br>–40°C to 85°C |
| LTC2871CUHF#PBF<br>LTC2871IUHF#PBF | LTC2871CUHF#TRPBF<br>LTC2871IUHF#TRPBF | 2871<br>2871 | 38-Lead (5mm × 7mm) Plastic QFN<br>38-Lead (5mm × 7mm) Plastic QFN | 0°C to 70°C<br>–40°C to 85°C |

Consult LTC Marketing for parts specified with wider operating temperature ranges.
Consult LTC Marketing for information on non-standard lead based finish parts.

For more information on lead free part marking, go to: http://www.linear.com/leadfree/
For more information on tape and reel specifications, go to: http://www.linear.com/tapeandreel/

# PRODUCT SELECTION GUIDE

| PART NUMBER | CONFIGURABLE TRANSCEIVER COMBINATIONS (RS485 + RS232) | PACKAGES |
|---|---|---|
| LTC2870 | (0 + 0), (1 + 0), (0 + 2) | 28-Lead QFN, 28-Lead TSSOP |
| LTC2871 | (0 + 0), (1 + 0), (1 + 1), (1 + 2), (0 + 1), (0 + 2) | 38-Lead QFN, 38-Lead TSSOP |

## ELECTRICAL CHARACTERISTICS

**The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A$ = 25°C. $V_{CC}$ = $V_L$ = 3.3V, TE485 = 0V, LB = 0V unless otherwise noted.**

| SYMBOL | PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **Power Supply** | | | | | | | |
| $V_{CC}$ | Supply Voltage Operating Range | | | 3 | | 5.5 | V |
| $V_L$ | Logic Supply Voltage Operating Range | $V_L \le V_{CC}$ | | 1.7 | | $V_{CC}$ | V |
| | $V_{CC}$ Supply Current in Shutdown Mode | $\overline{RXEN}$ = $V_L$, DXEN = TE485 = FEN = 0V, (LTC2870)<br>DX485 = DX232 = TE485 = FEN = H/$\overline{F}$ = 0V,<br>$\overline{RX485}$ = $\overline{RX232}$ = $V_L$ (LTC2871) | ● | | 8 | 60 | µA |
| | $V_{CC}$ Supply Current in Transceiver Mode (Outputs Unloaded) (Note 3) | 485/$\overline{232}$ = DXEN = $V_L$, $\overline{RXEN}$ = 0V,<br>DY/DZ = 0V or $V_L$ (LTC2870) | | | 3.3 | | mA |
| | $V_L$ Supply Current in Transceiver Mode (Outputs Unloaded) | DX485 = DX232 = $V_L$, $\overline{RX485}$ = $\overline{RX232}$ = 0V,<br>DI/DIN1/DIN2 = 0V or $V_L$ (LTC2871) | ● | | 0 | 5 | µA |
| **RS485 Driver** | | | | | | | |
| $\lvert V_{OD} \rvert$ | Differential Output Voltage | $R_L$ = ∞, $V_{CC}$ = 3V (Figure 1)<br>$R_L$ = 27Ω, $V_{CC}$ = 3V (Figure 1)<br>$R_L$ = 50Ω, $V_{CC}$ = 3.13V (Figure 1) | ●<br>●<br>● | 1.5<br>1.5<br>2 | | 6<br>$V_{CC}$<br>$V_{CC}$ | V<br>V<br>V |
| $\Delta\lvert V_{OD} \rvert$ | Difference in Magnitude of Differential Output Voltage for Complementary Output States | $R_L$ = 27Ω, $V_{CC}$ = 3V (Figure 1)<br>$R_L$ = 50Ω, $V_{CC}$ = 3.13V (Figure 1) | ●<br>● | | | 0.2<br>0.2 | V<br>V |
| $V_{OC}$ | Common Mode Output Voltage | $R_L$ = 27Ω or 50Ω (Figure 1) | ● | | | 3 | V |
| $\Delta\lvert V_{OC} \rvert$ | Difference in Magnitude of Common Mode Output Voltage for Complementary Output States | $R_L$ = 27Ω or 50Ω (Figure 1) | ● | | | 0.2 | V |
| $I_{OZD485}$ | Three-State (High Impedance) Output Current | $V_{OUT}$ = 12V or –7V, $V_{CC}$ = 0V or 3.3V (Figure 2) | ● | –100 | | 125 | µA |
| $I_{OSD485}$ | Maximum Short-Circuit Current | –7V ≤ $V_{OUT}$ ≤ 12V (Figure 2) | ● | –250 | | 250 | mA |
| **RS485 Receiver** | | | | | | | |
| $I_{IN485}$ | Input Current | $V_{IN}$ = 12V or –7V, $V_{CC}$ = 0V or 3.3V (Figure 3) (Note 5) | ● | –100 | | 125 | µA |
| $R_{IN485}$ | Input Resistance | $V_{IN}$ = 12V or –7V, $V_{CC}$ = 0V or 3.3V (Figure 3) (Note 5) | ● | 96 | 125 | | kΩ |
| | Differential Input Signal Threshold Voltage (A-B) | –7V ≤ (A or B) ≤ 12V (Note 5) | ● | | | ±200 | mV |
| | Input Hysteresis | B = 0V (Notes 3, 5) | | | 130 | | mV |
| | Differential Input Failsafe Threshold Voltage | –7V ≤ (A or B) ≤ 12V (Note 5) | ● | –200 | –50 | 0 | mV |
| | Input DC Failsafe Hysteresis | B = 0V (Note 5) | | | 25 | | mV |
| $V_{OL}$ | Output Low Voltage | Output Low, I(RA, RO) = 3mA (Sinking), 3V ≤ $V_L$ ≤ 5.5V | ● | | | 0.4 | V |
| | | Output Low, I(RA, RO) = 1mA (Sinking), 1.7V ≤ $V_L$ < 3V | ● | | | 0.4 | V |
| $V_{OH}$ | Output High Voltage | Output High, I(RA, RO) = –3mA (Sourcing), 3V ≤ $V_L$ ≤ 5.5V | ● | $V_L$ – 0.4 | | | V |
| | | Output High, I(RA, RO) = –1mA (Sourcing), 1.7V ≤ $V_L$ < 3V | ● | $V_L$ – 0.4 | | | V |
| | Three-State (High Impedance) Output Current | 0V ≤ (RA, RO), ≤$V_L$, $V_L$ = 5.5V | ● | | 0 | ±5 | µA |
| | Short-Circuit Output Current | 0V ≤ (RA, RO), ≤$V_L$, $V_L$ = 5.5V | ● | | | ±125 | mA |

## ELECTRICAL CHARACTERISTICS

**The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A$ = 25°C. $V_{CC}$ = $V_L$ = 3.3V, TE485 = 0V, LB = 0V unless otherwise noted.**

| SYMBOL | PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| $R_{TERM}$ | Terminating Resistor | TE485 = $V_L$, A – B = 2V, B = –7V, 0V, 10V (Figure 8) (Note 5) | ● | 108 | 120 | 156 | Ω |
| **RS232 Driver** | | | | | | | |
| $V_{OLD}$ | Output Low Voltage | $R_L$ = 3kΩ; $V_{EE}$ ≤ –5.9V | ● | –5 | –5.7 | –7.5 | V |
| $V_{OHD}$ | Output High Voltage | $R_L$ = 3kΩ; $V_{DD}$ ≥ 6.5V | ● | 5 | 6.2 | 7.5 | V |
| | Three-State (High Impedance) Output Current | Y or Z (LTC2870) = ±15V<br>RS232 Receiver Enabled<br>DOUT1 or DOUT2 (LTC2871) = ±15V | ●<br><br>● | | | ±156<br><br>±10 | µA<br><br>µA |
| | Output Short-Circuit Current | Driver Output = 0V | ● | | ±35 | ±90 | mA |
| **RS232 Receiver** | | | | | | | |
| | Input Threshold Voltage | | ● | 0.6 | 1.5 | 2.5 | V |
| | Input Hysteresis | | ● | 0.1 | 0.4 | 1.0 | V |
| | Output Low Voltage | I(RA, RB, ROUT1, ROUT2) = 1mA (Sinking)<br>1.7V ≤ $V_L$ ≤ 5.5V | ● | | | 0.4 | V |
| | Output High Voltage | I(RA, RB, ROUT1, ROUT2) = –1mA (Sourcing)<br>1.7V ≤ $V_L$ ≤ 5.5V | ● | $V_L$ – 0.4 | | | V |
| | Input Resistance | –15V ≤ (A, B, RIN1, RIN2) ≤ 15V,<br>RS232 Receiver Enabled | ● | 3 | 5 | 7 | kΩ |
| | Three-State (High Impedance) Output Current | 0V ≤ (RA, RB, ROUT1, ROUT2) ≤ $V_L$ | ● | | 0 | ±5 | µA |
| | Output Short-Circuit Current | $V_L$ = 5.5V<br>0V ≤ (RA, RB, ROUT1, ROUT2) ≤ $V_L$ | ● | | ±25 | ±50 | mA |
| **Logic Inputs** | | | | | | | |
| | Threshold Voltage | | ● | 0.4 | | 0.75 • $V_L$ | V |
| | Input Current | | ● | | 0 | ±5 | µA |
| **Power Supply Generator** | | | | | | | |
| $V_{DD}$ | Regulated $V_{DD}$ Output Voltage | RS232 Drivers Enabled, Outputs Loaded with $R_L$ = 3kΩ to GND, DIN1/DY = $V_L$, DIN2/DZ = 0V (Note 3) | | | 7 | | V |
| $V_{EE}$ | Regulated $V_{EE}$ Output Voltage | | | | –6.3 | | V |
| **ESD** | | | | | | | |
| | LTC2870 Interface Pins (A, B, Y, Z) | Human Body Model to GND or $V_{CC}$, Powered or Unpowered (Note 7) | | | ±26 | | kV |
| | LTC2871 Interface Pins (A, B, Y, Z, RIN1, RIN2, DOUT1, DOUT2) | | | | ±16 | | kV |
| | All Other Pins | Human Body Model (Note 7) | | | ±4 | | kV |

## ELECTRICAL CHARACTERISTICS

**The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A$ = 25°C. $V_{CC}$ = $V_L$ = 3.3V, TE485 = 0V, LB = 0V unless otherwise noted. $V_L \le V_{CC}$.**

| SYMBOL | PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **RS485 AC Characteristics** | | | | | | | |
| | Maximum Data Rate | (Note 3) | ● | 20 | | | Mbps |
| $t_{PLHD485}$ $t_{PHLD485}$ | Driver Propagation Delay | $R_{DIFF}$ = 54Ω, $C_L$ = 100pF (Figure 4) | ● | | 20 | 70 | ns |
| | Driver Propagation Delay Difference $\lvert t_{PLHD485} - t_{PHLD485} \rvert$ | $R_{DIFF}$ = 54Ω, $C_L$ = 100pF (Figure 4) | ● | | 1 | 6 | ns |
| $t_{SKEWD485}$ | Driver Skew (Y to Z) | $R_{DIFF}$ = 54Ω, $C_L$ = 100pF (Figure 4) | ● | | 1 | ±6 | ns |
| $t_{RD485}$, $t_{FD485}$ | Driver Rise or Fall Time | $R_{DIFF}$ = 54Ω, $C_L$ = 100pF (Figure 4) | ● | | | 15 | ns |
| $t_{ZLD485}$, $t_{ZHD485}$, $t_{LZD485}$, $t_{HZD485}$ | Driver Output Enable or Disable Time | FEN = $V_L$, $R_L$ = 500Ω, $C_L$ = 50pF (Figure 5) | ● | | | 120 | ns |
| $t_{ZHSD485}$, $t_{ZLSD485}$ | Driver Enable from Shutdown | $R_L$ = 500Ω, $C_L$ = 50pF (Figure 5) | ● | | | 8 | µs |
| $t_{PLHR485}$, $t_{PHLR485}$ | Receiver Input to Output | $C_L$ = 15pF, $V_{CM}$ = 1.5V, \|A – B\| = 1.5V (Figure 6) (Note 5) | ● | | 65 | 85 | ns |
| $t_{SKEWR485}$ | Differential Receiver Skew $\lvert t_{PLHR485} - t_{PHLR485} \rvert$ | $C_L$ = 15pF (Figure 6) | ● | | 1 | 6 | ns |
| $t_{RR485}$, $t_{FR485}$ | Receiver Output Rise or Fall Time | $C_L$ = 15pF (Figure 6) | ● | | 3 | 15 | ns |
| $t_{ZLR485}$, $t_{ZHR485}$, $t_{LZR485}$, $t_{HZR485}$ | Receiver Output Enable or Disable Time | FEN = $V_L$, $R_L$ = 1kΩ, $C_L$ = 15pF (Figure 7) | ● | | | 50 | ns |
| $t_{RTEN485}$, $t_{RTZ485}$ | Termination Enable or Disable Time | FEN = $V_L$, $V_B$ = 0V, $V_{AB}$ = 2V (Figure 8) (Note 5) | ● | | | 100 | µs |
| **RS232 AC Characteristics** | | | | | | | |
| | Maximum Data Rate | $R_L$ = 3kΩ, $C_L$ = 2500pF<br>$R_L$ = 3kΩ, $C_L$ = 500pF<br>(Note 3) | ●<br>● | 100<br>500 | | | kbps<br>kbps |
| | Driver Slew Rate (Figure 9) | $R_L$ = 3kΩ, $C_L$ = 2500pF<br>$R_L$ = 3kΩ, $C_L$ = 50pF | ●<br>● | 4 | | <br>30 | V/µs<br>V/µs |
| $t_{PHLD232}$, $t_{PLHD232}$ | Driver Propagation Delay | $R_L$ = 3kΩ, $C_L$ = 50pF (Figure 9) | ● | | 1 | 2 | µs |
| $t_{SKEWD232}$ | Driver Skew | $R_L$ = 3kΩ, $C_L$ = 50pF (Figure 9) | | | 50 | | ns |
| $t_{ZLD232}$, $t_{ZHD232}$, $t_{LZD232}$, $t_{HZD232}$ | Driver Output Enable or Disable Time | FEN = $V_L$, $R_L$ = 3kΩ, $C_L$ = 50pF (Figure 10) | ● | | 0.4 | 2 | µs |
| $t_{PHLR232}$, $t_{PLHR232}$ | Receiver Propagation Delay | $C_L$ = 150pF (Figure 11) | ● | | 60 | 200 | ns |
| $t_{SKEWR232}$ | Receiver Skew | $C_L$ = 150pF (Figure 11) | | | 25 | | ns |
| $t_{RR232}$, $t_{FR232}$ | Receiver Rise or Fall Time | $C_L$ = 150pF (Figure 11) | ● | | 60 | 200 | ns |
| $t_{ZLR232}$, $t_{ZHR232}$, $t_{LZR232}$, $t_{HZR232}$ | Receiver Output Enable or Disable Time | FEN = $V_L$, $R_L$ = 1kΩ, $C_L$ = 150pF (Figure 12) | ● | | 0.7 | 2 | µs |
| **Power Supply Generator** | | | | | | | |
| | $V_{DD}$/$V_{EE}$ Supply Rise Time | FEN = ⎍, (Notes 3 and 4) | ● | | 0.2 | 2 | ms |

**Note 1:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

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

**Note 3:** Guaranteed by other measured parameters and not tested directly.

**Note 4:** Time from FEN ⎍ until $V_{DD} \ge 5V$ and $V_{EE} \le -5V$. External components as shown in the Typical Application section.

**Note 5:** Condition applies to A, B for H/$\overline{F}$ = 0V, and Y, Z for H/$\overline{F}$ = $V_L$.

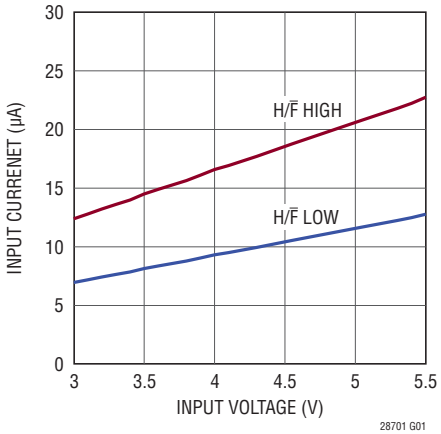
**Note 6:** This IC includes overtemperature protection that is intended to protect the device during momentary overload conditions. Overtemperature protection activates at a junction temperature exceeding 150°C. Continuous operation above the specified maximum operating junction temperature may result in device degradation or failure.

**Note 7:** Guaranteed by design and not subject to production test.

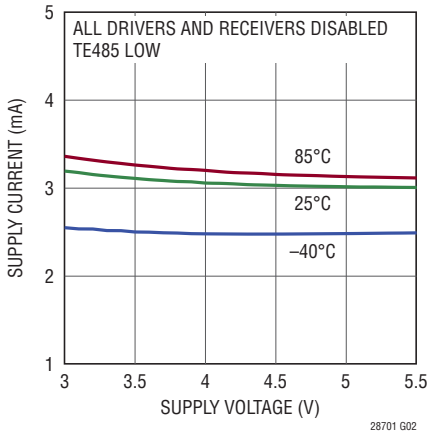
## TYPICAL PERFORMANCE CHARACTERISTICS

$T_A$ = 25°C, $V_{CC}$ = $V_L$ = 3.3V, unless otherwise noted.

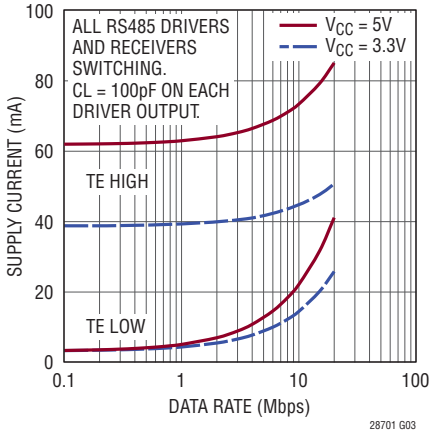
### $V_{CC}$ Supply Current vs Supply Voltage in Shutdown Mode



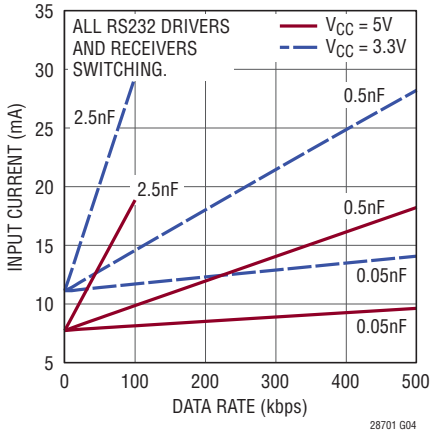

### $V_{CC}$ Supply Current vs Supply Voltage in Fast Enable Mode



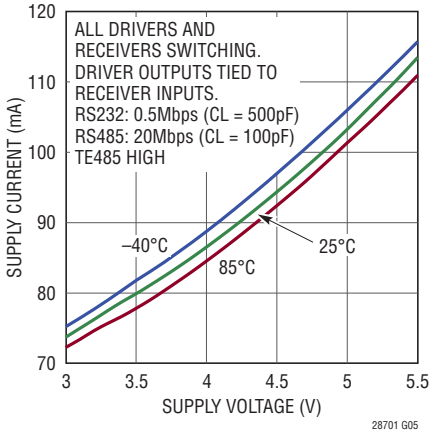

### $V_{CC}$ Supply Current vs RS485 Data Rate



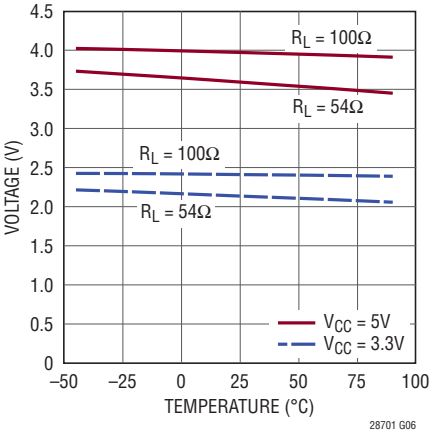

### $V_{CC}$ Supply Current vs RS232 Data Rate



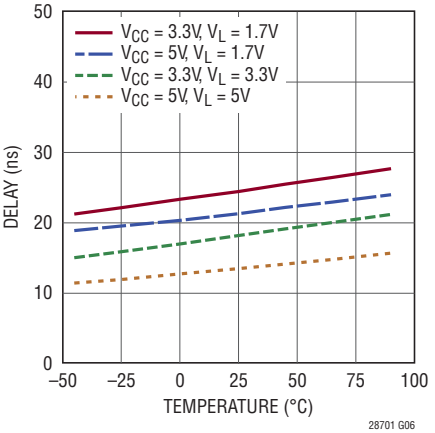

### $V_{CC}$ Supply Current vs Supply Voltage, All Transceivers at Max Rate (LTC2871)



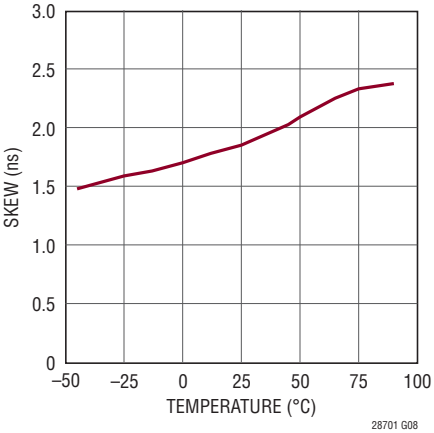

### RS485 Driver Differential Output Voltage vs Temperature



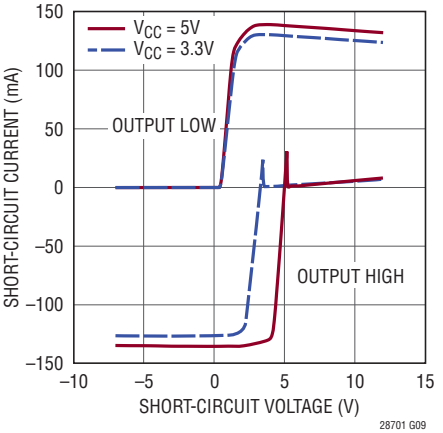

### RS485 Driver Propagation Delay vs Temperature




### RS485 Driver Skew vs Temperature



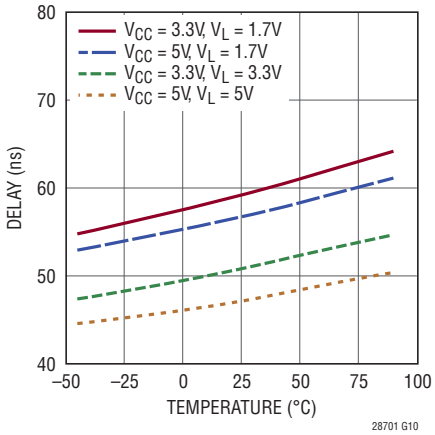

### RS485 Driver Short-Circuit Current vs Short-Circuit Voltage



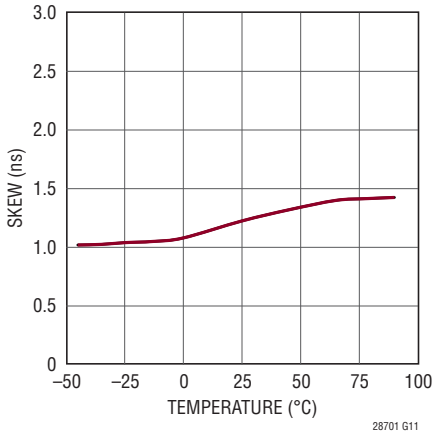
## TYPICAL PERFORMANCE CHARACTERISTICS

$T_A$ = 25°C, $V_{CC}$ = $V_L$ = 3.3V, unless otherwise noted.

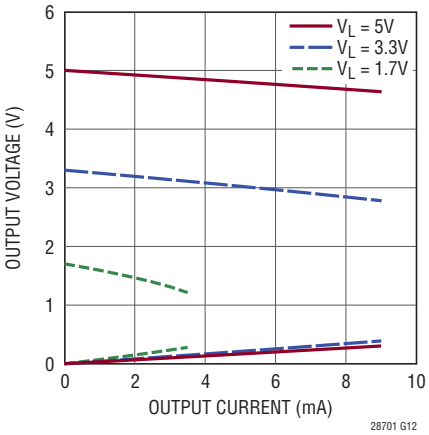
### RS485 Receiver Propagation Delay vs Temperature



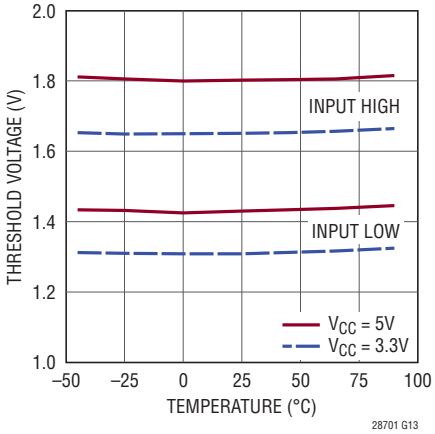

### RS485 Receiver Skew vs Temperature



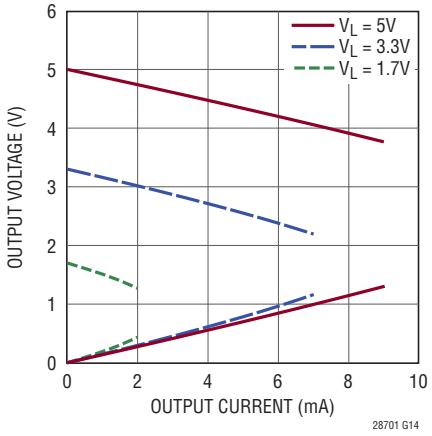

### RS485 Receiver Output Voltage vs Load Current



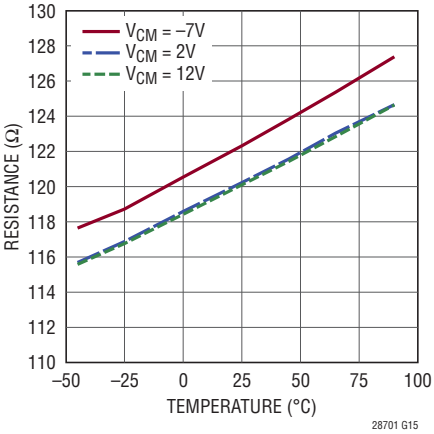

### RS232 Receiver Input Threshold vs Temperature



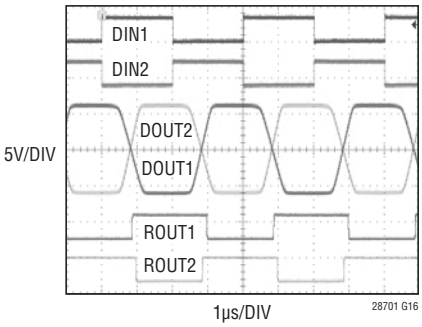

### RS232 Receiver Output Voltage vs Load Current




### RS485 Termination Resistance vs Temperature

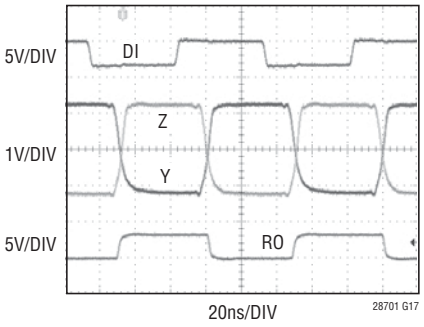



### RS232 Operation at 500kbps



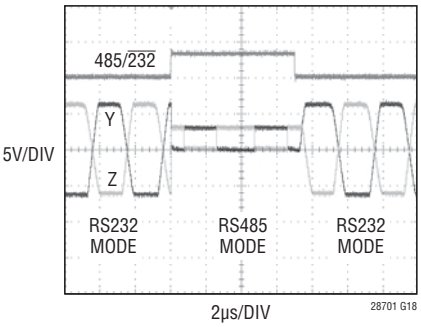

WRAPPING DATA
DOUT LOADS: 5kΩ + 50pF

### RS485 Operation at 20Mbps




H/F̄ HIGH
Y, Z LOADS: 120Ω (DIFF) + 50pF

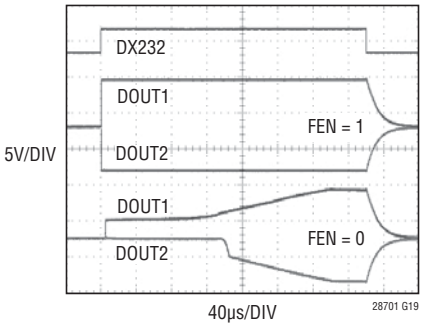
### LTC2870 Drivers Changing Modes



## TYPICAL PERFORMANCE CHARACTERISTICS

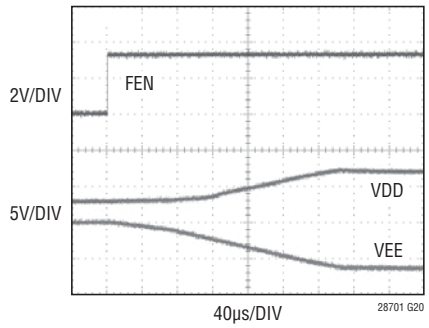
$T_A$ = 25°C, $V_{CC}$ = $V_L$ = 3.3V, unless otherwise noted.

**RS232 Driver Outputs Enabling and Disabling**

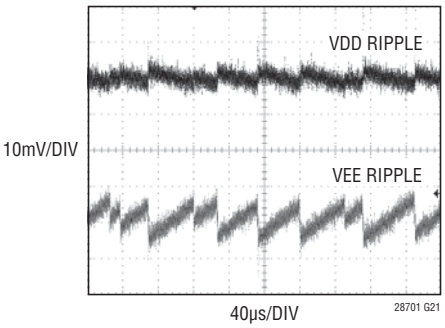



TOP CURVES: FAST ENABLE ↔ DX232
BOTTOM CURVES: SHUTDOWN ↔ DX232

**$V_{DD}$ and $V_{EE}$ Powering Up**




**$V_{DD}$ and $V_{EE}$ Ripple**




FAST ENABLE MODE,
ALL DRIVERS AND RECEIVERS DISABLED.

## PIN FUNCTIONS

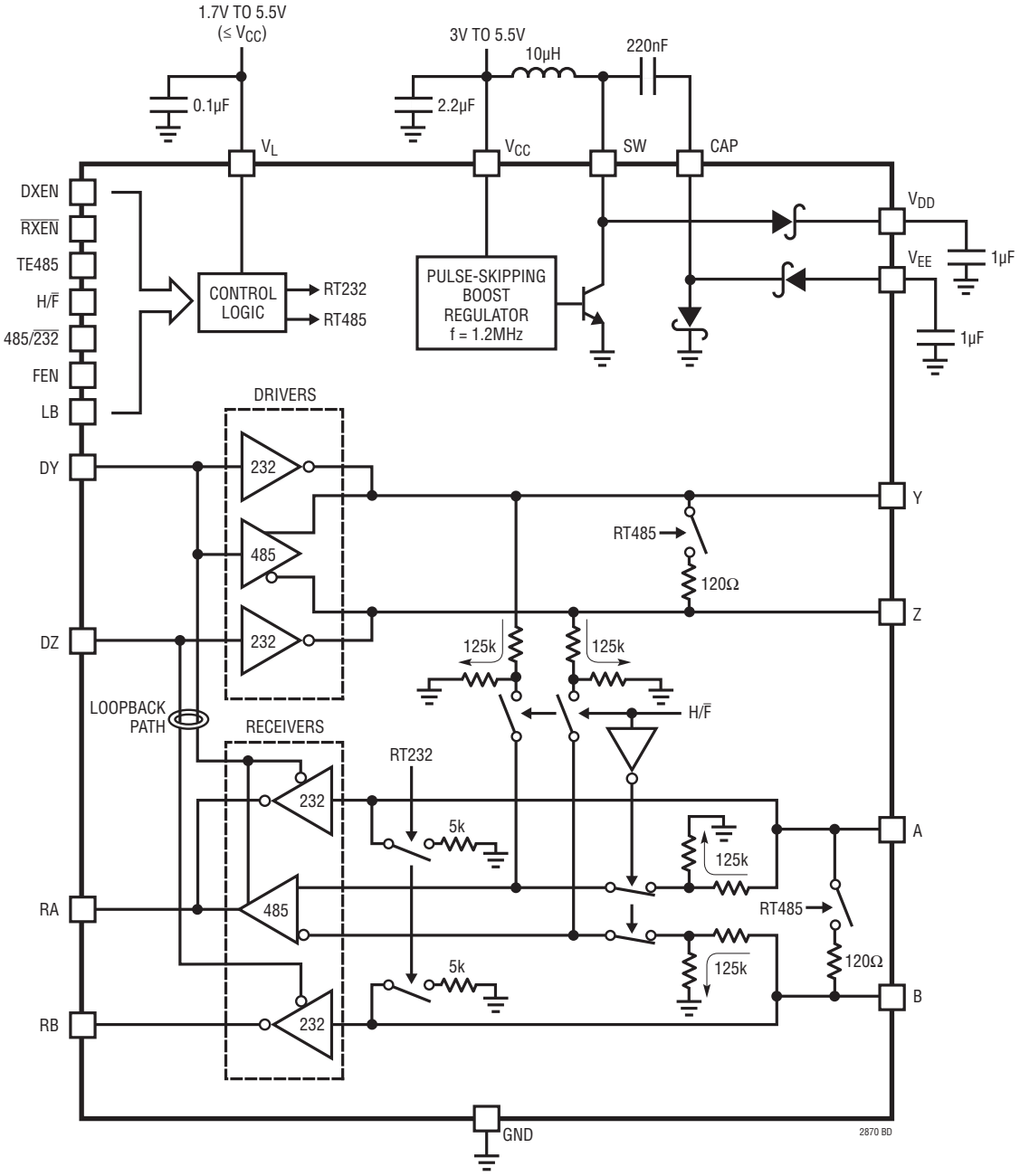
| PIN NAME | LTC2870 QFN | LTC2870 TSSOP | LTC2871 QFN | LTC2871 TSSOP | DESCRIPTION |
|---|---|---|---|---|---|
| $V_{CC}$ | 16, 20, 24 | 19, 23, 27 | 21, 27, 33 | 25, 31, 37 | Input Supply (3V to 5.5V). Tie all three pins together and connect a 2.2µF or larger capacitor between $V_{CC}$ (adjacent to $V_{DD}$) and GND. |
| $V_L$ | 25 | 28 | 35 | 1 | Logic Supply (1.7V to 5.5V) for the receiver outputs, driver inputs, and control inputs. Bypass this pin to GND with a 0.1µF capacitor if not tied tot $V_{CC}$. Keep $V_L \leq V_{CC}$ for proper operation. However, $V_L > V_{CC}$ will not damage the device, provided that absolute maximum limits are respected. |
| $V_{DD}$ | 15 | 18 | 20 | 24 | Generated Positive Supply Voltage for RS232 Driver (+7V). Connect 1µF capacitor between $V_{DD}$ and GND. |
| $V_{EE}$ | 1, 12, 29 | 4, 15, 29 | 1, 12, 16, 19, 39 | 5, 16, 20, 23, 39 | Generated Negative Supply Voltage for RS232 Driver (–6.3V). Tie all pins together and connect 1µF capacitor between $V_{EE}$ (adjacent to the CAP pin) and GND. |
| GND | 10, 13, 18, 23 | 13, 16, 21, 26 | 14, 17, 25, 32 | 18, 21, 29, 36 | Ground. Tie all four pins together. |
| CAP | 11 | 14 | 15 | 19 | Charge Pump Capacitor for Generated Negative Supply Voltage. Connect a 220nF capacitor between CAP and SW. |
| SW | 14 | 17 | 18 | 22 | Switch Pin. Connect 10µH inductor between SW and $V_{CC}$. |
| A | 22 | 25 | 29 | 33 | RS485 Positive Receiver Input (Full-Duplex Mode) or RS232 Receiver Input 1 (LTC2870). |
| B | 21 | 24 | 28 | 32 | RS485 Negative Receiver Input (Full-Duplex Mode) or RS232 Receiver Input 2 (LTC2870). |
| RA | 2 | 5 | | | RS485 Differential Receiver Output or RS232 Receiver Output 1. |
| RB | 3 | 6 | | | RS232 Receiver Output 2. |
| RO | | | 34 | 38 | RS485 Differential Receiver Output. |
| RIN1 | | | 31 | 35 | RS232 Receiver Input 1. |
| RIN2 | | | 30 | 34 | RS232 Receiver Input 2. |
| ROUT1 | | | 2 | 6 | RS232 Receiver Output 1. |
| ROUT2 | | | 3 | 7 | RS232 Receiver Output 2. |
| DIN1 | | | 8 | 12 | RS232 Driver Input 1. |
| DIN2 | | | 9 | 13 | RS232 Driver Input 2. |

## PIN FUNCTIONS

| PIN NAME | LTC2870 QFN | LTC2870 TSSOP | LTC2871 QFN | LTC2871 TSSOP | DESCRIPTION |
|---|---|---|---|---|---|
| DOUT1 | | | 23 | 27 | RS232 Driver Output 1. |
| DOUT2 | | | 22 | 26 | RS232 Driver Output 2. |
| DI | | | 7 | 11 | RS485 Driver Input. |
| DY | 7 | 10 | | | RS485 Driver Input or RS232 Driver Input 1. |
| DZ | 8 | 11 | | | RS232 Driver Input 2. |
| Y | 19 | 22 | 26 | 30 | RS485 Positive Driver Output. RS232 Driver Output 1 (LTC2870).<br>RS485 Positive Receiver Input (LTC2870 or LTC2871 in Half-Duplex Mode). |
| Z | 17 | 20 | 24 | 28 | RS485 Negative Driver Output or RS232 Driver Output 2 (LTC2870).<br>RS485 Negative Receiver Input (LTC2870 or LTC2871 in Half-Duplex Mode). |
| 485/$\overline{232}$ | 4 | 7 | | | Interface Select Input. A logic low enables RS232 mode and a high enables RS485 mode. The mode determines which transceiver inputs and outputs are accessible at the LTC2870 pins as well as which is controlled by the driver and receiver enable pins. |
| $\overline{RXEN}$ | 5 | 8 | | | Receiver Enable. A logic high disables RS232 and RS485 receivers leaving receiver outputs Hi-Z. A logic low enables the RS232 or RS485 receivers, depending on the state of the interface select input 485/$\overline{232}$ . |
| DXEN | 6 | 9 | | | Driver Enable. A logic low disables the RS232 and RS485 drivers leaving the driver output in a Hi-Z state. A logic high enables the RS232 or RS485 drivers, depending on the state of the interface select input 485/$\overline{232}$. |
| $\overline{RX232}$ | | | 11 | 15 | RS232 Receiver Enable. A logic high disables the RS232 receivers and input termination resistors leaving the RS232 receiver outputs in a Hi-Z state. A logic low enables the RS232 receivers and resistors, subject to the state of the $\overline{CH2}$ pin. |
| $\overline{RX485}$ | | | 5 | 9 | RS485 Receiver Enable. A logic high disables the RS485 receiver leaving the RS485 receiver output in a Hi-Z state. A logic low enables the RS485 receiver and resistors, subject to the state of the $\overline{CH2}$ pin. |
| DX232 | | | 10 | 14 | RS232 Driver Enable. A logic low disables the RS232 drivers leaving the RS232 driver outputs in a Hi-Z state. A logic high enables the RS232 drivers. |
| DX485 | | | 6 | 10 | RS485 Driver Enable. A logic low disables the RS485 driver leaving the RS485 driver output in a Hi-Z state. A logic high enables the RS485 driver. |
| H/$\overline{F}$ | 27 | 2 | 37 | 3 | RS485 Half-Duplex Select Input. A logic low is used for full-duplex operation where pins A and B are the receiver inputs and pins Y and Z are the driver outputs. A logic high is used for half-duplex operation where pins Y and Z are both the receiver inputs and driver outputs and pins A and B do not serve as the receiver inputs. The impedance on A and B and state of differential termination between A and B is independent of the state of H/$\overline{F}$. The H/$\overline{F}$ pin has no effect on RS232 operation. |
| TE485 | 28 | 3 | 38 | 4 | RS485 Termination Enable. A logic high enables a 120Ω resistor between pins A and B and also between pins Y and Z. A logic low opens the resistors, leaving A/B and Y/Z unterminated. The LTC2870 termination resistors are never enabled in RS232 mode. |
| FEN | 9 | 12 | 13 | 17 | Fast Enable. A logic high enables fast enable mode. In fast enable mode the integrated DC/DC converter is active independent of the state of driver, receiver, and termination enable pins allowing faster circuit enable times than are otherwise possible. A logic low disables fast enable mode leaving the state of the DC/DC converter dependent on the state of driver, receiver, and termination enable control inputs. The DC/DC converter powers down only when FEN is low and all drivers, receivers, and terminators are disabled (refer to Table 1). |
| LB | 26 | 1 | 36 | 2 | Loopback Enable. A logic high enables logic loopback diagnostic mode, internally routing the driver input logic levels to the receiver output pins. This applies to both RS232 channels as well as the RS485 driver/receiver. The targeted receiver must be enabled for the loopback signal to be available on its output. A logic low disables loopback mode. In Loopback mode, signals are not inverted from driver inputs to receiver outputs. |
| $\overline{CH2}$ | | | 4 | 8 | RS232 Channel 2 Disable. A logic high disables RS232 receiver 2 and RS232 driver 2 independent of the state of $\overline{RX232}$ and DX232 pins. In this state, the disabled driver output becomes Hi-Z and the 5kΩ load resistor on the disabled receiver input is opened. A logic low allows both RS232 transceiver channels to be enabled or disabled together based on the $\overline{RX232}$ and DX232 pins. |

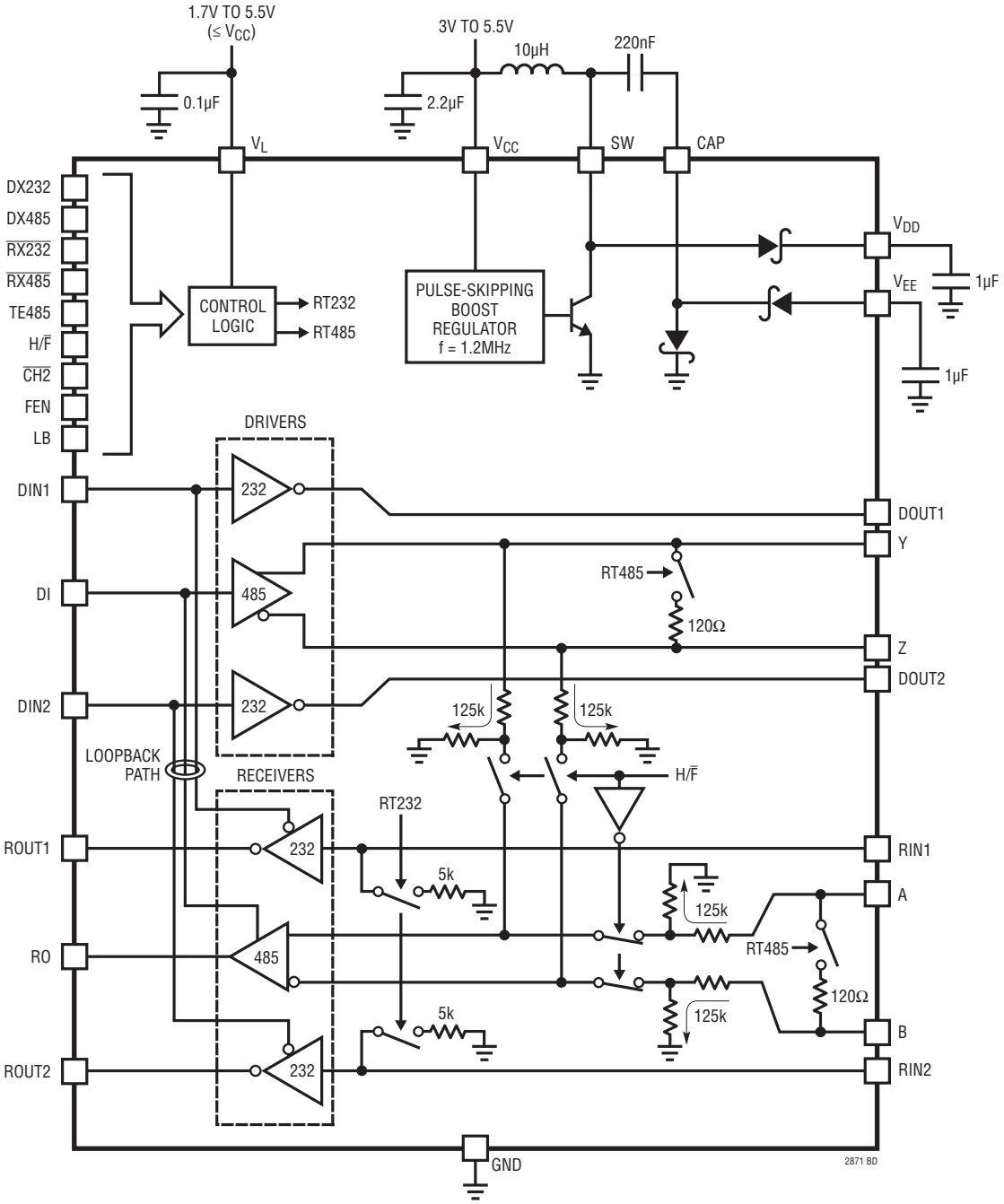
## BLOCK DIAGRAM

**LTC2870**



## BLOCK DIAGRAM

**LTC2871**



## TEST CIRCUITS

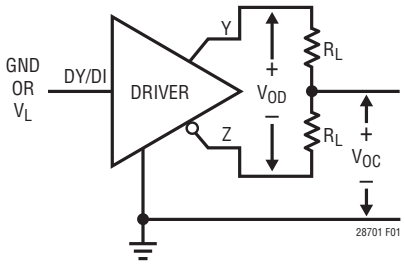



Figure 1. RS485 Driver DC Characteristics

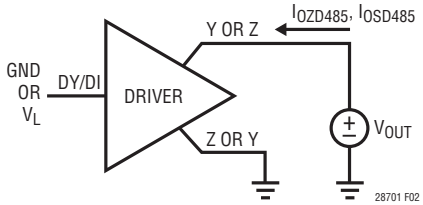



Figure 2. RS485 Driver Output Current

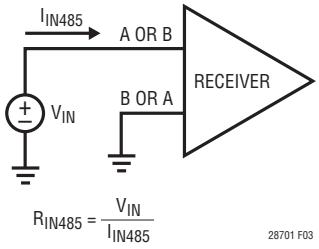



Figure 3. RS485 Receiver Input Current and Resistance (Note 5)

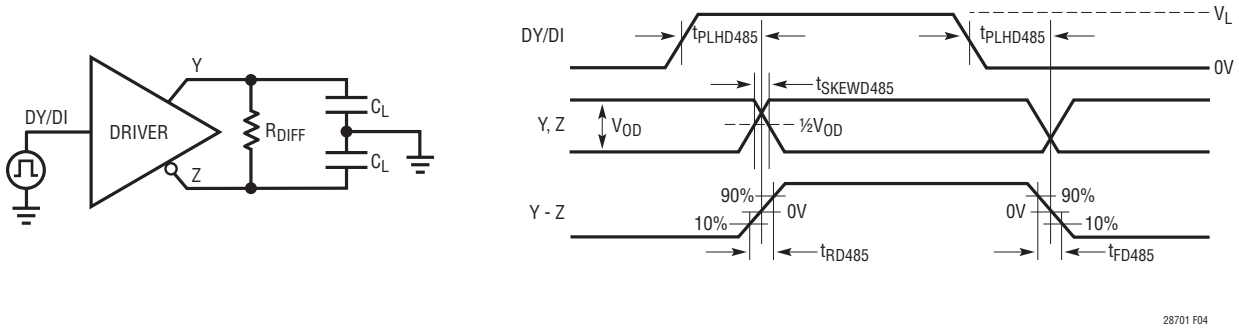



Figure 4. RS485 Driver Timing Measurement

## TEST CIRCUITS

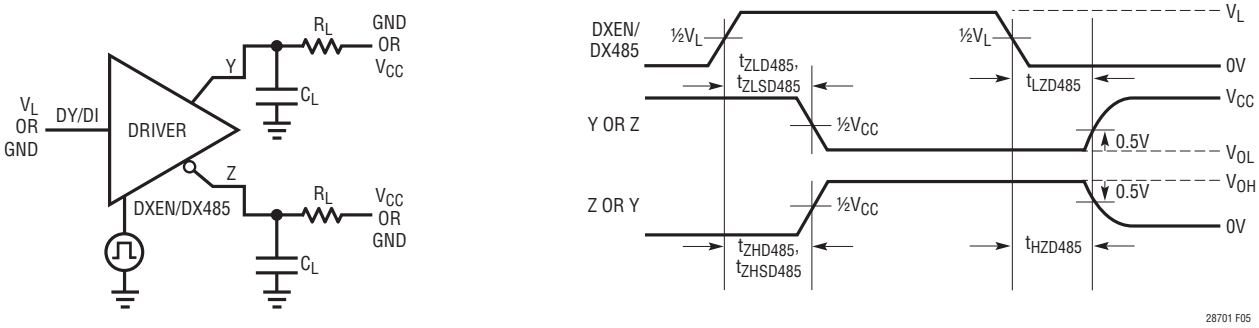



**Figure 5. RS485 Driver Enable and Disable Timing Measurements**

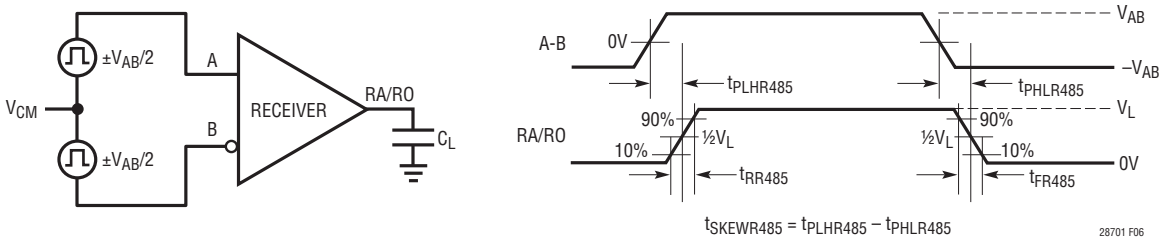



**Figure 6. RS485 Receiver Propagation Delay Measurements (Note 5)**

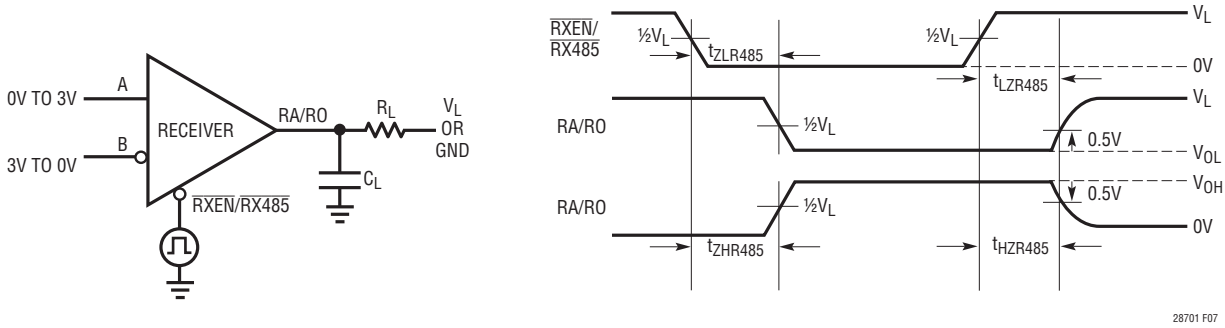



**Figure 7. RS485 Receiver Enable and Disable Timing Measurements (Note 5)**

## TEST CIRCUITS

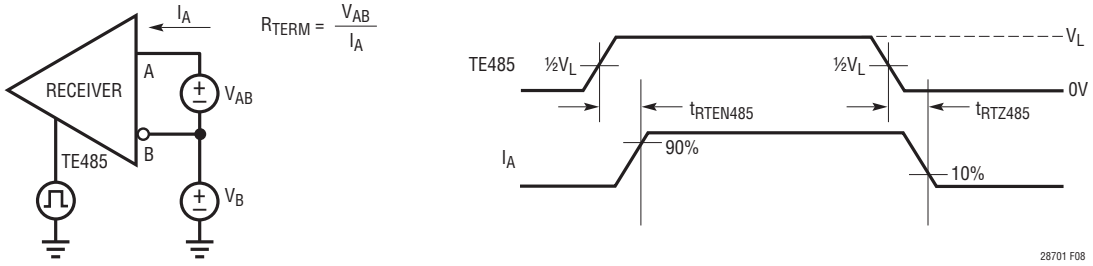



**Figure 8. RS485 Termination Resistance and Timing Measurements (Note 5)**

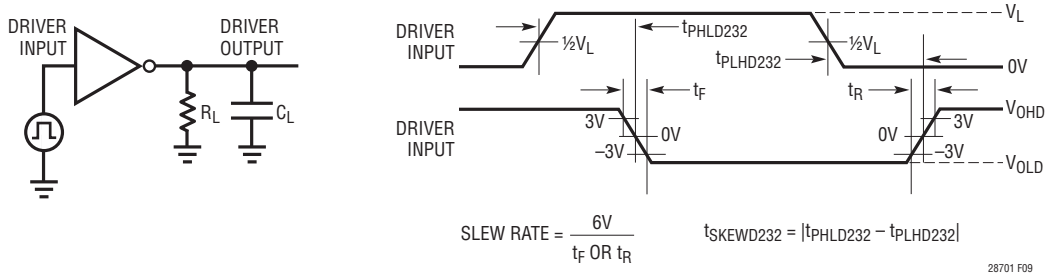



**Figure 9. RS232 Driver Timing and Slew Rate Measurements**

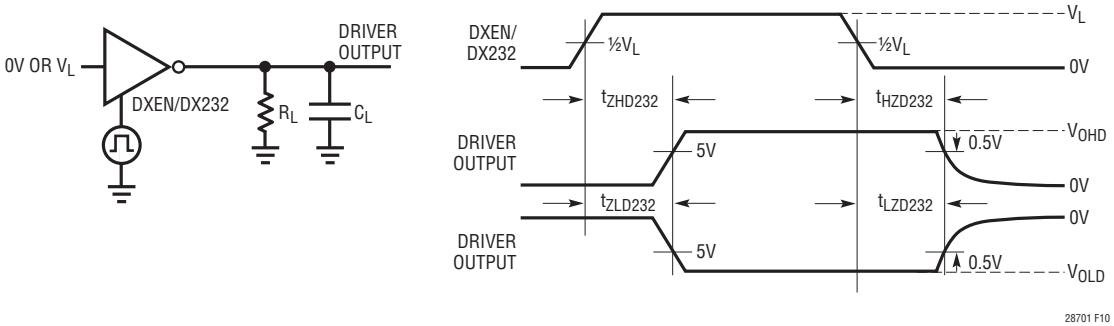



**Figure 10. RS232 Driver Enable and Disable Times**

## TEST CIRCUITS

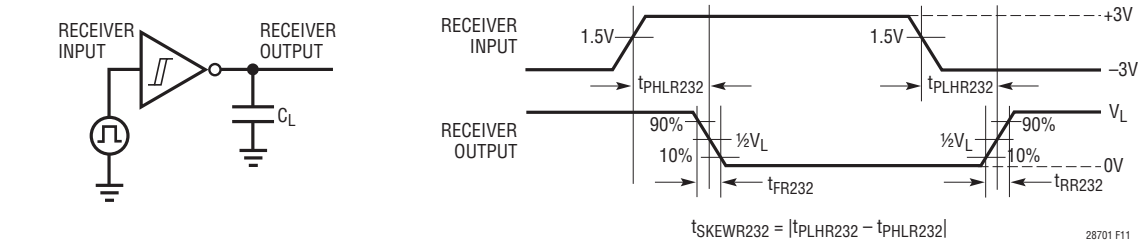



**Figure 11. RS232 Receiver Timing Measurements**

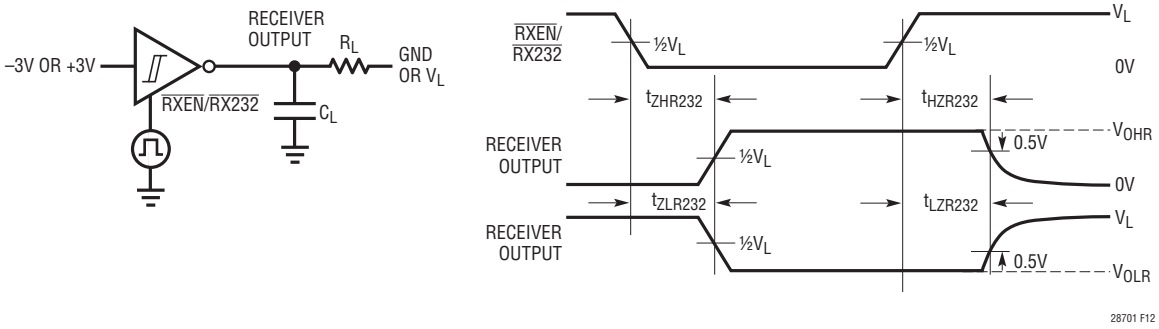



**Figure 12. RS232 Receiver Enable and Disable Times**

# FUNCTION TABLES

**Table 1. LTC2870 Mode Selection Table**

| FEN | 485/$\overline{232}$ | $\overline{RXEN}$ | DXEN | TE485 | H/$\overline{F}$ | LB | DC/DC CONVERTER | MODE AND COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 0 | X | 1 | 0 | 0 | X | X | OFF | Low Power Shutdown: All Main Functions Off |
| 0 | 0 | 1 | 0 | X | X | X | OFF | Low Power Shutdown: All Main Functions Off |
| 1 | X | 1 | 0 | 0 | X | X | ON | Fast-Enable: DC/DC Converter On Only |
| X | 0 | X | 1 | X | X | 0 | ON | RS232 Drivers On |
| X | 0 | 0 | X | X | X | 0 | ON | RS232 Receivers On |
| X | 1 | X | 1 | X | X | 0 | ON | RS485 Driver On |
| X | 1 | 0 | X | X | X | 0 | ON | RS485 Receiver On |
| X | 1 | X | X | 1 | X | X | ON | RS485 Driver and Receiver 120Ω Termination Enabled |
| X | 1 | X | X | X | 0 | 0 | X | RS485 Full-Duplex Mode |
| X | 1 | X | X | X | 1 | 0 | X | RS485 Half-Duplex Mode |
| X | 1 | 0 | X | X | X | 1 | ON | RS485 Loopback Mode |
| X | 0 | 0 | X | X | X | 1 | ON | RS232 Loopback Mode |

**Table 2. LTC2871 Mode Selection Table ($\overline{CH2}$ = 0)**

| FEN | $\overline{RX232}$ | DX232 | $\overline{RX485}$ | DX485 | TE485 | H/$\overline{F}$ | LB | DC/DC CONVERTER | MODE AND COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 0 | 1 | 0 | 0 | X | X | OFF | Low Power Shutdown: All Main Functions Off |
| 1 | 1 | 0 | 1 | 0 | 0 | X | X | ON | Fast-Enable: DC/DC Converter On Only |
| X | X | 1 | X | X | X | X | 0 | ON | RS232 Drivers On |
| X | 0 | X | X | X | X | X | 0 | ON | RS232 Receivers On |
| X | X | X | X | 1 | X | X | 0 | ON | RS485 Driver On |
| X | X | X | 0 | X | X | X | 0 | ON | RS485 Receiver On |
| X | X | X | X | X | X | 0 | 0 | X | RS485 Full-Duplex Mode |
| X | X | X | X | X | X | 1 | 0 | X | RS485 Half-Duplex Mode |
| X | X | X | 0 | X | X | X | 1 | ON | RS485 Loopback Mode |
| X | 0 | X | X | X | X | X | 1 | ON | RS232 Loopback Mode |

**Table 3. RS232 Receiver Mode (485/$\overline{232}$ = 0 for LTC2870, $\overline{CH2}$ = 0 for LTC2871)**

| $\overline{RX232}$ OR $\overline{RXEN}$ | RECEIVER INPUTS (A, B, RIN1, RIN2) | CONDITIONS | RECEIVER OUTPUTS (RA, RB, ROUT1, ROUT2) | LTC2870 RECEIVER INPUTS (A, B) | LTC2871 RECEIVER INPUTS (RIN1, RIN2) |
|---|---|---|---|---|---|
| 1 | X | No Fault | Hi-Z | 125kΩ | Hi-Z |
| 0 | 0 | No Fault | 1 | 5kΩ | 5kΩ |
| 0 | 1 | No Fault | 0 | 5kΩ | 5kΩ |
| 0 | X | Thermal Fault | Hi-Z | 5kΩ | 5kΩ |

**Table 4. RS232 Driver Mode (485/$\overline{232}$ = 0 for LTC2870, $\overline{CH2}$ = 0 for LTC2871)**

| DX232 OR DXEN | DRIVER INPUTS (DY, DZ, DIN1, DIN2) | CONDITIONS | LTC2870 DRIVER OUTPUTS (Y, Z) | LTC2871 DRIVER OUTPUTS (DOUT1, DOUT2) |
|---|---|---|---|---|
| 0 | X | No Fault | 125kΩ | Hi-Z |
| 1 | 0 | No Fault | 1 | 1 |
| 1 | 1 | No Fault | 0 | 0 |
| X | X | Thermal Fault | 125kΩ | Hi-Z |

# FUNCTION TABLES

**Table 5. LTC2871 $\overline{CH2}$ CONTROL**

| | | | RS232 RECEIVER INPUTS | | RS232 DRIVER OUTPUTS | | |
|---|---|---|---|---|---|---|---|
| $\overline{CH2}$ | DX232 | $\overline{RX232}$ | RIN1 | RIN2 | DOUT1 | DOUT2 | COMMENTS |
| X | 0 | 1 | Hi-Z | Hi-Z | Hi-Z | Hi-Z | Both Drivers and Receivers Disabled |
| 0 | 0 | 0 | 5kΩ | 5kΩ | Hi-Z | Hi-Z | Both Receivers Enabled, Both Drivers Disabled |
| 0 | 1 | 1 | Hi-Z | Hi-Z | Driven | Driven | Both Receivers Disabled, Both Drivers Enabled |
| 0 | 1 | 0 | 5kΩ | 5kΩ | Driven | Driven | Both Receivers and Drivers Enabled |
| 1 | 0 | 0 | 5kΩ | Hi-Z | Hi-Z | Hi-Z | Channel 2 Drivers and Receivers Disabled |
| 1 | 1 | 1 | Hi-Z | Hi-Z | Driven | Hi-Z | Channel 2 Drivers and Receivers Disabled |
| 1 | 1 | 0 | 5kΩ | Hi-Z | Driven | Hi-Z | Channel 2 Drivers and Receivers Disabled |

**Table 6. RS485 Driver Mode (TE485 = 0)**

| DX485 OR DXEN | DI | CONDITIONS | Y | Z |
|---|---|---|---|---|
| 0 | X | No Fault | 125kΩ | 125kΩ |
| 1 | 0 | No Fault | 0 | 1 |
| 1 | 1 | No Fault | 1 | 0 |
| X | X | Thermal Fault | 125kΩ | 125kΩ |

**Table 7. RS485 Receiver Mode (LB = 0)**

| $\overline{RXEN}$ OR $\overline{RX485}$ | A - B (NOTE 5) | CONDITIONS | RA, RO |
|---|---|---|---|
| 1 | X | No Fault | Hi-Z |
| 0 | < –200mV | No Fault | 0 |
| 0 | > 200mV | No Fault | 1 |
| 0 | Inputs Open or Shorted Together (DC) | Failsafe | 1 |
| X | X | Thermal Fault | Hi-Z |

**Table 8. RS485 Termination (485/$\overline{232}$ = 1 for LTC2870)**

| TE485 | H/$\overline{F}$, LB | CONDITIONS | R (A TO B) | R (Y TO Z) |
|---|---|---|---|---|
| 0 | X | No Fault | Hi-Z | Hi-Z |
| 1 | X | No Fault | 120Ω | 120Ω |
| X | X | Thermal Fault | Hi-Z | Hi-Z |

**Table 9. RS485 Duplex Control (485/$\overline{232}$ = 1 for LTC2870)**

| H/$\overline{F}$ | RS485 DRIVER OUTPUTS | RS485 RECEIVER INPUTS |
|---|---|---|
| 0 | Y, Z | A, B |
| 1 | Y, Z | Y, Z |

**Table 10. LTC2870 Loopback Functions**

| LB | $\overline{RXEN}$ | MODE |
|---|---|---|
| 0 | X | Not Loopback |
| X | 1 | Not Loopback |
| 1 | 0 | Loopback (RA = DY, RB = DZ) |

**Table 11. LTC2871 Loopback Functions**

| LB | $\overline{RX232}$ | $\overline{RX485}$ | MODE |
|---|---|---|---|
| 0 | X | X | Not Loopback |
| X | 1 | 1 | Not Loopback |
| 1 | 0 | 1 | Loopback RS232 (ROUT1 = DIN1, ROUT2 = DIN2) |
| 1 | 1 | 0 | Loopback RS485 (RO = DI) |
| 1 | 0 | 0 | Loopback All (ROUT1 = DIN1, ROUT2 = DIN2, RO = DI) |

# APPLICATIONS INFORMATION

## Overview

The LTC2870 and LTC2871 are flexible multiprotocol transceivers supporting RS485/RS422 and RS232 protocols. These parts can be powered from a single 3V to 5.5V supply with optional logic interface supply as low as 1.7V. An integrated DC/DC converter provides the positive and negative supply rails needed for RS232 operation. Automatically selected integrated termination resistors for both RS232 and RS485 protocols are included, eliminating the need for external components and switching relays. Both parts include loopback control for self-test and debug as well as logically-switchable half- and full-duplex control of the RS485 bus interface.

The LTC2870 offers a single port that can be configured as either two RS232 receivers and drivers or one RS485/RS422 receiver and driver depending on the state of the 485/$\overline{232}$ pin. Control inputs DXEN and $\overline{RXEN}$ provide independent control of driver and receiver operation for either RS232 or RS485 transceivers, depending on the selected operating protocol.

The LTC2871 separates the RS232 and RS485 transceivers into independent I/Os allowing simultaneous operation of two RS232 transceivers and one RS485 transceiver. Independent control over driver and receiver mode for each protocol is provided with logic inputs DX232, $\overline{RX232}$, DX485, $\overline{RX485}$. Single channel RS232 operation is possible via the $\overline{CH2}$ control pin. The disabled channel maintains a Hi-Z state on the receiver input and driver output, allowing these lines to be shared with other transceivers.

Both parts feature rugged operation with ESD ratings of ±26kV (LTC2870) and ±16kV (LTC2871) HBM on the RS232 and RS485 receiver inputs and driver outputs, both unpowered and powered. All other pins offer protection exceeding ±4kV.

## DC/DC Converter

The on-chip DC/DC converter operates from the $V_{CC}$ input, generating a 7V $V_{DD}$ supply and a charge pumped –6.3V $V_{EE}$ supply, as shown in Figure 13. $V_{DD}$ and $V_{EE}$ power the output stage of the RS232 drivers and are regulated to levels that guarantee greater than ±5V output swing.

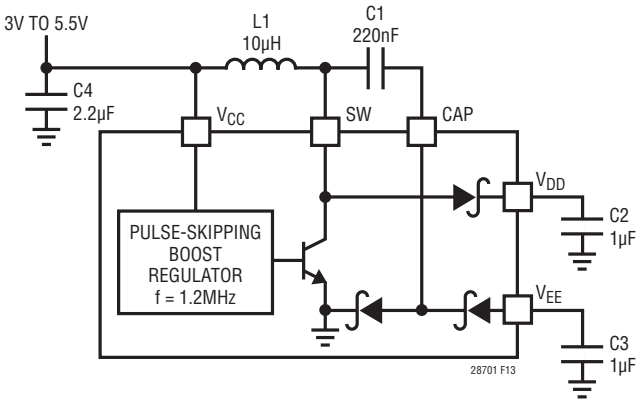



**Figure 13. DC/DC Converter**

The DC/DC converter requires a 10µH inductor (L1) and a bypass capacitor (C4) of 2.2µF. The charge pump capacitor (C1) is 220nF and the storage capacitors (C2 and C3) are 1µF. Larger storage capacitors up to 4.7µF may be used if C1 and C4 are scaled proportionately. Locate C1–C4 close to their associated pins.

Up to two LTC2870 or LTC2871 devices can be powered from one of the devices; see Figure 48 in the Typical Applications section.

## Inductor Selection

A 10µH inductor with a saturation current ($I_{SAT}$) rating of at least 220mA and a DCR (copper wire resistance) of less than 1.3Ω is required. Some small inductors meeting these requirements are listed in Table 12.

**Table 12. Recommended Inductors**

| PART NUMBER | $I_{SAT}$ (mA) | MAX DCR (Ω) | SIZE(mm) | MANUFACTURER |
|---|---|---|---|---|
| LBC2016T100K<br>CBC2016T100M | 245<br>380 | 1.07<br>1.07 | 2 × 1.6 × 1.6<br>2 × 1.6 × 1.6 | Taiyo Yuden<br>www.t-yuden.com |
| FSLB2520-100K | 220 | 1.1 | 2.5 × 2 × 1.6 | Toko<br>www.tokoam.com |

## Capacitor Selection

The small size of ceramic capacitors makes them ideal for the LTC2870 and LTC2871. Use X5R or X7R dielectric types; their ESR is low and they retain their capacitance over relatively wide voltage and temperature ranges. Use a voltage rating of at least 10V.

## APPLICATIONS INFORMATION

### Inrush Current and Supply Overshoot Precaution

In certain applications fast supply slew rates are generated when power is connected. If the $V_{CC}$ voltage is greater than 4.5V and its rise time is faster than 10µs, the pins $V_{DD}$ and SW can exceed their absolute maximum values during start-up. When supply voltage is applied to $V_{CC}$, the voltage difference between $V_{CC}$ and $V_{DD}$ generates inrush current flowing through inductor L1 and capacitors C1 and C2. The peak inrush current must not exceed 2A. To avoid this condition, add a 1Ω resistor as shown in Figure 14. This precaution is not relevant for supply voltages below 4.5V or rise times longer than 10µs.

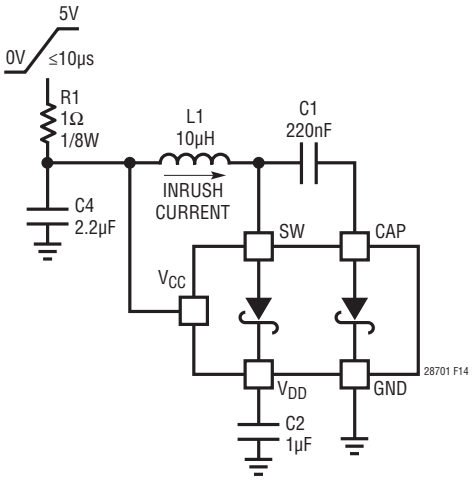



**Figure 14. Supply Current Overshoot Protection for Input Supplies of 4.5V of Higher**

### $V_L$ Logic Supply and Logic Pins

A separate logic supply pin $V_L$ allows the LTC2870 and LTC2871 to interface with any logic signal from 1.7V to 5.5V. All logic I/Os use $V_L$ as their high supply. For proper operation, $V_L$ should not be greater than $V_{CC}$. During power-up, if $V_L$ is higher than $V_{CC}$, the device will not be damaged, but behavior of the device is not guaranteed. If $V_L$ is not connected to $V_{CC}$, bypass $V_L$ with a 0.1µF capacitor to GND.

RS232 and RS485 driver outputs are undriven and the RS485 termination resistors are disabled when $V_L$ or $V_{CC}$ is grounded or $V_{CC}$ is disconnected.

Although all logic input pins reference $V_L$ as their high supply, they can be driven up to 7V, independent of $V_L$ and $V_{CC}$, with the exception of FEN, which must not exceed $V_L$ by more than 1V for proper operation. Logic input pins do not have internal biasing devices to pull them up or down. They must be driven high or low to establish valid logic levels; do not float.

### RS485 Driver

The RS485 driver provides full RS485/RS422 compatibility. When enabled, if DI is high, Y – Z is positive. With the driver disabled the Y and Z output resistance is greater than 96kΩ (typically 125kΩ) to ground over the entire common mode range of –7V to +12V. This resistance is equivalent to the input resistance on these lines when the driver is configured in half-duplex mode and Y and Z act as the RS485 receiver inputs.

### Driver Overvoltage and Overcurrent Protection

The RS232 and RS485 driver outputs are protected from short circuits to any voltage within the absolute maximum range ±15V. The maximum current in this condition is 90mA for the RS232 driver and 250mA for the RS485 driver.

If the RS485 driver output is shorted to a voltage greater than $V_{CC}$, when it is active, positive current of up to 100mA may flow from the driver output back to $V_{CC}$. If the system power supply or loading cannot sink this excess current, clamp $V_{CC}$ to GND with a Zener diode (e.g., 5.6V, 1W, 1N4734) to prevent an overvoltage condition on $V_{CC}$.

## APPLICATIONS INFORMATION

All devices also feature thermal shutdown protection that disables the drivers, receivers, and RS485 terminators in case of excessive power dissipation (see Note 6).

### RS485 Balanced Receiver with Full Failsafe Operation

The LTC2870 and LTC2871 receivers use a window comparator with two voltage thresholds centered around zero for low pulse width distortion. As illustrated in Figure 15, for a differential signal approaching from a negative direction, the threshold is typically +65mV. When approaching from the positive direction, the threshold is typically –65mV. Each of these thresholds has about 25mV of hysteresis (not shown in the figure). The state of RO reflects the polarity of A–B in full-duplex mode or Y–Z in half-duplex mode.

This windowing around 0V preserves pulse width and duty cycle for small input signals with heavily slewed edges, typical of what might be seen at the end of a very long cable. This performance is highlighted in Figure 16, where a signal is driven through 4000 feet of CAT5e cable at 3Mbps. Even though the differential signal peaks at just over ±100mV and is heavily slewed, the output maintains a nearly perfect signal with almost no duty cycle distortion.

An additional benefit of the window comparator architecture is excellent noise immunity due to the wide effective differential hysteresis (or 'AC' hysteresis) of about 130mV for normal signals transitioning through the window region in less than approximately 2µs. Increasingly slower signals will have increasingly less effective hysteresis, limited by the DC failsafe value of about 25mV.

The LTC2870 and LTC2871 provide full failsafe operation that guarantees the receiver output will be a logic high state when the inputs are shorted, left open, or terminated but not driven, for more than about 2µs. The delay allows normal data signals to transition through the threshold region without being interpreted as a failsafe condition.

### RS485 Biasing Resistors Not Required

RS485 networks are often biased with a resistive divider to generate a differential voltage of ≥200mV on the data lines, which establishes a logic high state when all the transmitters on the network are disabled. The values of the biasing resistors depend on the number and type of transceivers on the line and the number and value of terminating resistors. Therefore the values of the biasing resistors must be customized to each specific network installation, and may change if nodes are added to or removed from the network.

The internal failsafe feature of the LTC2870 and LTC2871 eliminates the need for external biasing resistors. The LTC2870 and LTC2871 transceivers will operate correctly on unbiased, biased or underbiased networks.

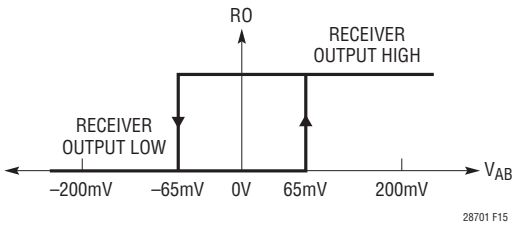



**Figure 15. RS485 Receiver Input Threshold Characteristics**

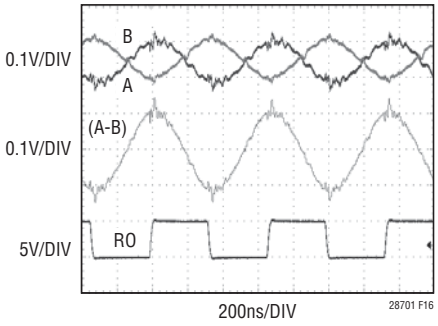



**Figure 16. A 3Mbps Signal Driven Down 4000ft of CAT 5e Cable. Top Traces: Received Signals After Transmission Through Cable; Middle Trace: Math Showing Differences of Top Two Signals; Bottom Trace: Receiver Output**

## APPLICATIONS INFORMATION

### Receiver Outputs

The RS232 and RS485 receiver outputs are internally driven high (to $V_L$) or low (to GND) with no external pull-up needed. When the receivers are disabled the output pin becomes Hi-Z with leakage of less than ±5µA for voltages within the $V_L$ supply range.

### RS485 Receiver Input Resistance

The RS485 receiver input resistance from A or B to GND (Y or Z to GND in half-duplex mode with driver disabled) is greater than 96kΩ (typically 125kΩ) when the integrated termination is disabled. This permits up to a total of 256 receivers per system without exceeding the RS485 receiver loading specification. The input resistance of the receiver is unaffected by enabling/disabling the receiver or whether the part is in half-duplex, full-duplex, loopback mode, or even unpowered. The equivalent input resistance looking into the RS485 receiver pins is shown in Figure 17.

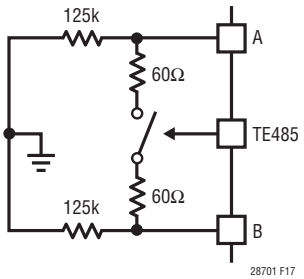



**Figure 17: Equivalent RS485 Receiver Input Resistance Into A and B (Note 5)**

### Selectable RS485 Termination

Proper cable termination is important for good signal fidelity. When the cable is not terminated with its characteristic impedance, reflections cause waveform distortion.

The LTC2870 and LTC2871 offer integrated switchable 120Ω termination resistors between the differential receiver inputs and also between the differential driver outputs. This provides the advantage of being able to easily change, through logic control, the proper line termination for correct operation when configuring transceiver networks. Termination should be enabled on transceivers positioned at both ends of the network bus. Termination on the driver nodes is important for cases where the driver is disabled but there is communication on the connecting bus from another node. Differential termination resistors are never enabled in RS232 mode on the LTC2870.

When the TE485 pin is high, the termination resistors are enabled and the differential resistance from A to B and Y to Z is 120Ω. The resistance is maintained over the entire RS485 common mode range of –7V to 12V as shown in Figure 18.

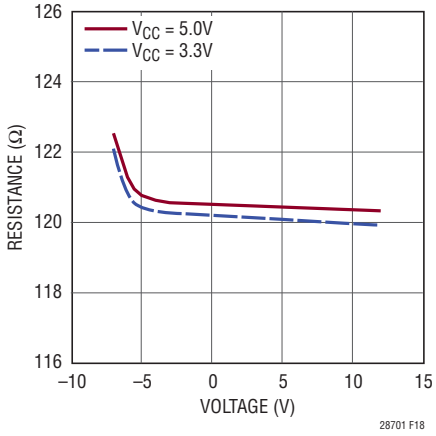



**Figure 18. Typical Resistance of the Enabled RS485 Terminator vs Common Mode Voltage on A /B**

### RS485 Half- and Full-Duplex Control

The LTC2870 and LTC2871 are equipped with a control to switch between half- and full-duplex operation. With the H/$\overline{F}$ pin set to a logic low, the A and B pins serve as the differential receiver inputs. With the H/$\overline{F}$ pin set to a logic high, the Y and Z pins serve as the differential inputs. In either configuration, the RS485 driver outputs are always on Y and Z. The impedance looking into the A and B pins is not affected by H/$\overline{F}$ control, including the differential termination resistance. The H/$\overline{F}$ control does not affect RS232 operation.

## APPLICATIONS INFORMATION

### Logic Loopback

A loopback mode connects the driver inputs to the receiver outputs (non-inverting) for self test. This applies to both RS232 and RS485 transceivers. Loopback mode is entered when the LB pin is high and the relevant receiver is enabled.

In loopback mode, the drivers function normally. They can be disabled with outputs in a Hi-Z state or left enabled to allow loopback testing in normal operation. Loopback works in half- or full-duplex mode and does not affect the termination resistors.

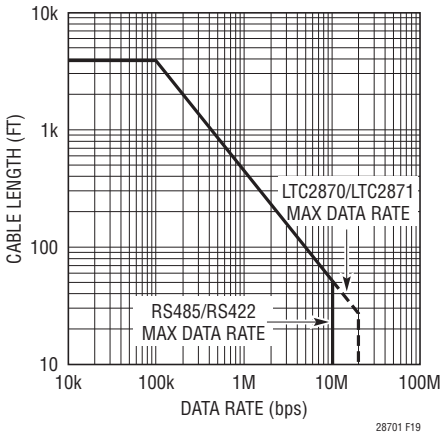



**Figure 19. Cable Length vs Data Rate (RS485/RS422 Standard Shown in Vertical Solid Line)**

### RS485 Cable Length vs Data Rate

For a given data rate, the maximum transmission distance is bounded by the cable properties. A typical curve of cable length vs data rate compliant with the RS485/RS422 standards is shown in Figure 19. Three regions of this curve reflect different performance limiting factors in data transmission. In the flat region of the curve, maximum distance is determined by resistive losses in the cable. The downward sloping region represents limits in distance and data rate due to AC losses in the cable. The solid vertical line represents the specified maximum data rate in the RS485/RS422 standards. The dashed lines at 20Mbps show the maximum data rates of the LTC2870 and LTC2871.

### Layout Considerations

All $V_{CC}$ pins must be connected together on the PC board with very low impedance traces or with a dedicated plane. A 2.2µF or larger decoupling capacitor (C4 in Figure 13) must be placed less than 0.7cm away from the $V_{CC}$ pin that is adjacent to the $V_{DD}$ pin.

0.1µF capacitors to GND can be added on the $V_{CC}$ pins adjacent to the B and $V_L$ pins if the connection to the 2.2µF decoupling capacitor is not direct or if the trace is very narrow. All GND pins must be connected together and all $V_{EE}$ pins must be connected together, including the exposed pad on the bottom of the package. The bypass capacitor at $V_{EE}$, C3, should be positioned closest to the $V_{EE}$ pin that is adjacent to the CAP pin, with no more than 1cm of total trace length between the $V_{EE}$ and GND pins.

Place the charge pump capacitor, C1, directly adjacent to the SW and CAP pins, with no more than one centimeter of total trace length to maintain low inductance. Close placement of the inductor, L1, is of secondary importance compared to the placement of C1 but should include no more than two centimeters of total trace length.

The PC board traces connected to high speed signals A/B and Y/Z should be symmetrical and as short as possible to minimize capacitive imbalance and maintain good differential signal integrity. To minimize capacitive loading effects, the differential signals should be separated by more than the width of a trace.

Route outputs away from sensitive inputs to reduce feedback effects that might cause noise, jitter, or even oscillations. For example, do not route DI or A/B near the driver or receiver outputs.

## TYPICAL APPLICATIONS

**$V_{CC}$ = 3V to 5.5V, $V_L$ = 1.7V to $V_{CC}$. Logic input pins not shown are tied to a valid logic state.**

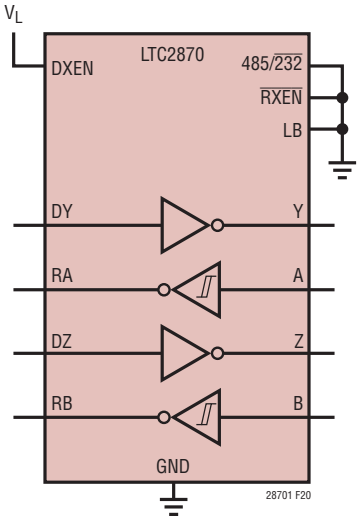



Figure 20. LTC2870 in RS232 Mode

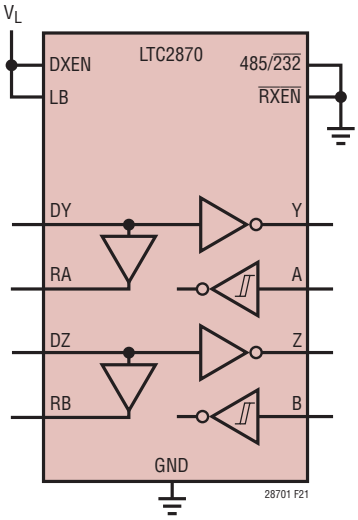



Figure 21. LTC2870 in RS232 Mode with Loopback

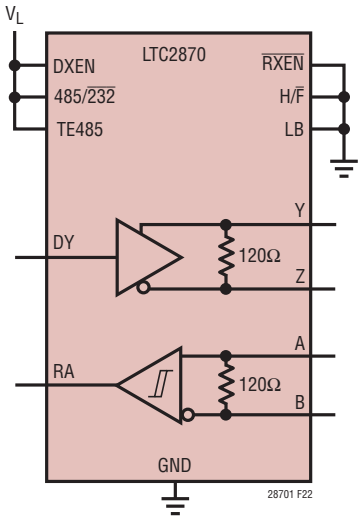



Figure 22. LTC2870 in RS485 Mode, Terminated

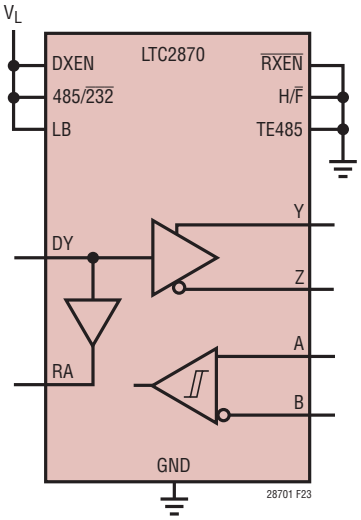



Figure 23. LTC2870 in RS485 Mode in Loopback

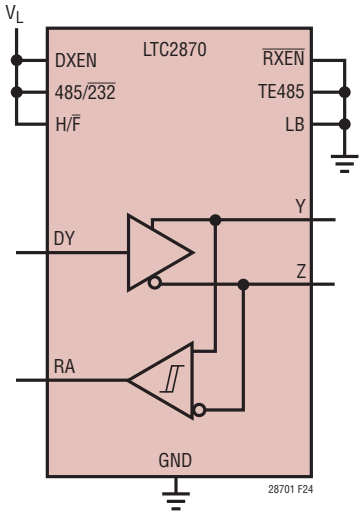



Figure 24. LTC2870 in RS485 Mode Half-Duplex

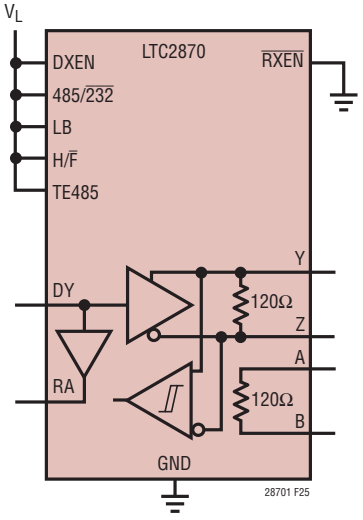



Figure 25. LTC2870 in RS485 Mode, Half-Duplex, with Loopback and Terminated

## TYPICAL APPLICATIONS

**$V_{CC}$ = 3V to 5.5V, $V_L$ = 1.7V to $V_{CC}$. Logic input pins not shown are tied to a valid logic state.**

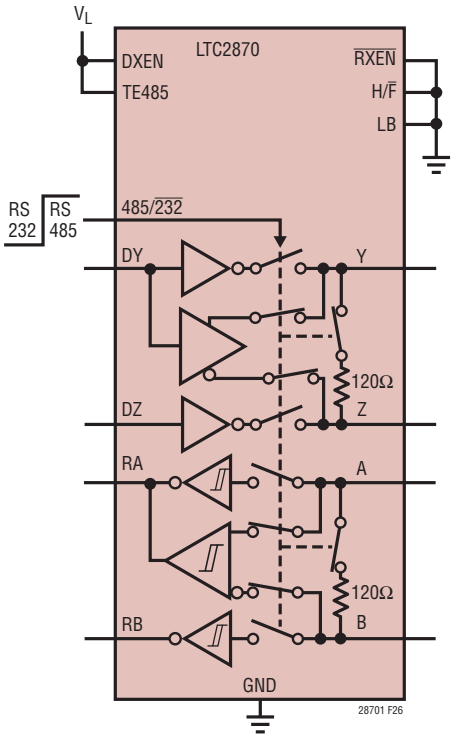



Figure 26. LTC2870 Protocol Switching

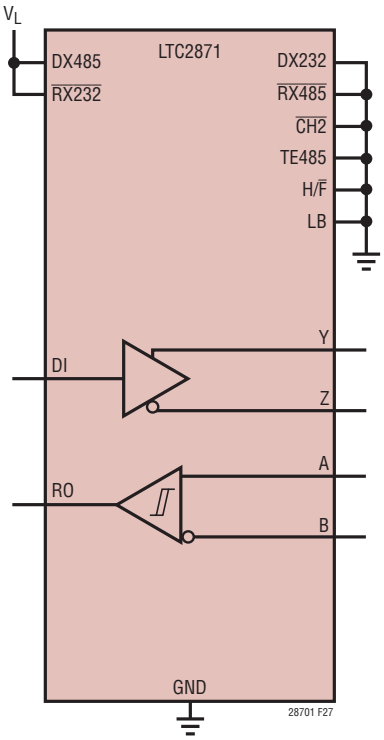



Figure 27. LTC2871 in RS485 Mode

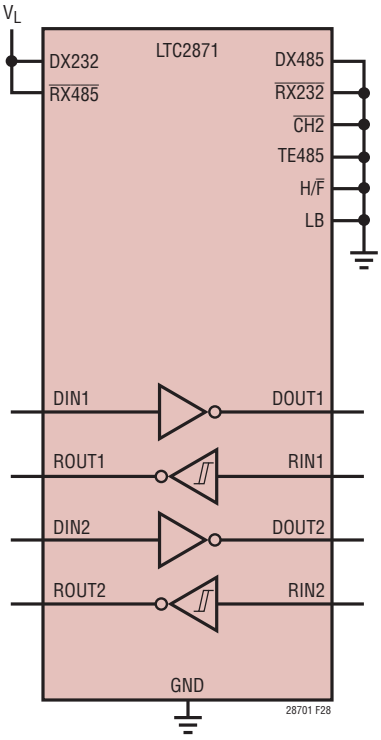



Figure 28. LTC2871 in RS232 Mode

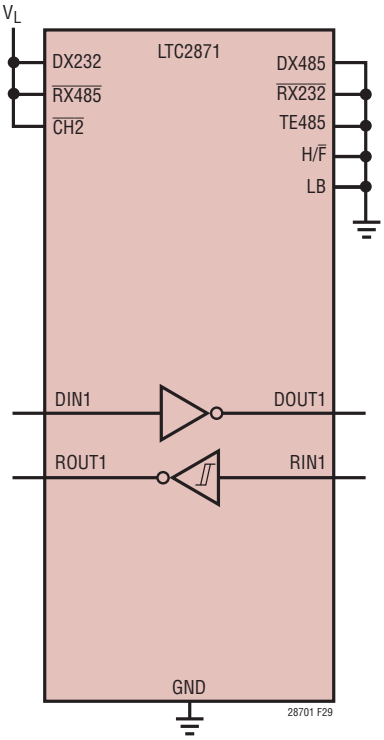



Figure 29. LTC2871 Single RS232 Channel Active

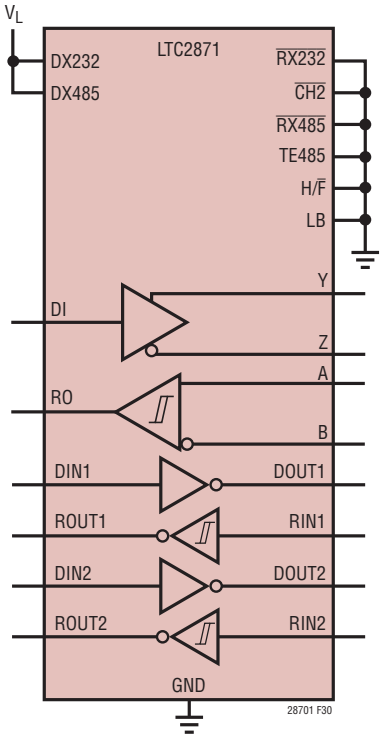



Figure 30. LTC2871 in RS485 and RS232 Mode

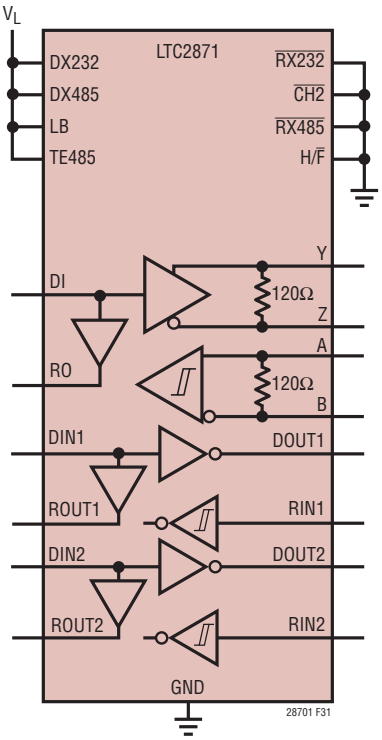



Figure 31. LTC2871 in RS485 and RS232 Mode with Loopback and RS485 Termination

## TYPICAL APPLICATIONS

**$V_{CC}$ = 3V to 5.5V, $V_L$ = 1.7V to $V_{CC}$. Logic input pins not shown are tied to a valid logic state.**

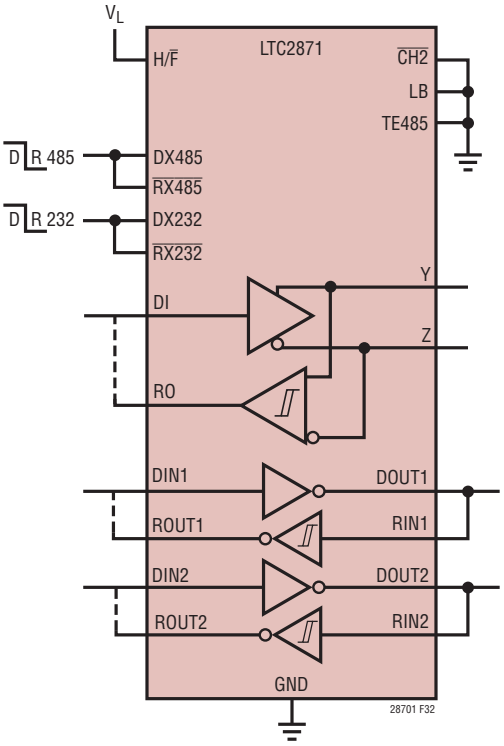



**Figure 32. LTC2871 in RS485 and RS232 Mode, Both Half-Duplex**

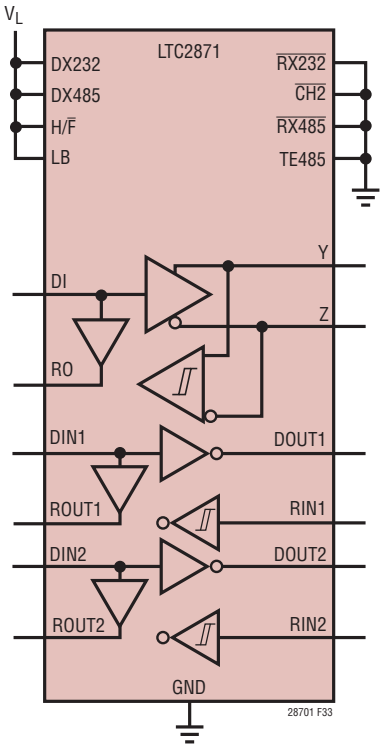



**Figure 33. LTC2871 in RS485 and RS232 Mode, RS485 Half-Duplex, Loopback**

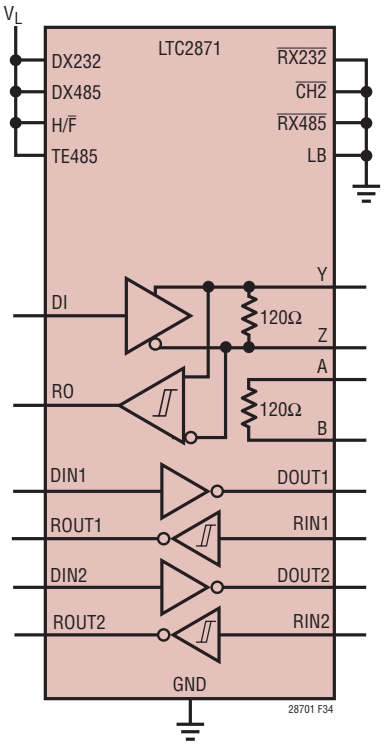



**Figure 34. LTC2871 in RS485 and RS232 Mode, RS485 Half-Duplex, Terminated**

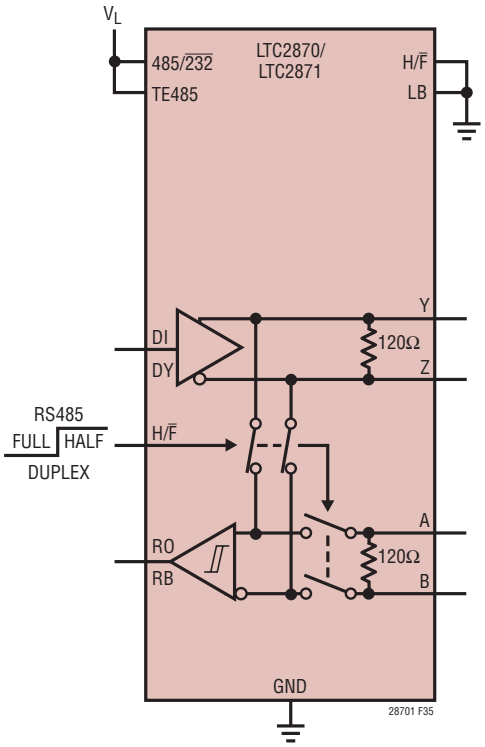



**Figure 35. RS485 Duplex Switching**

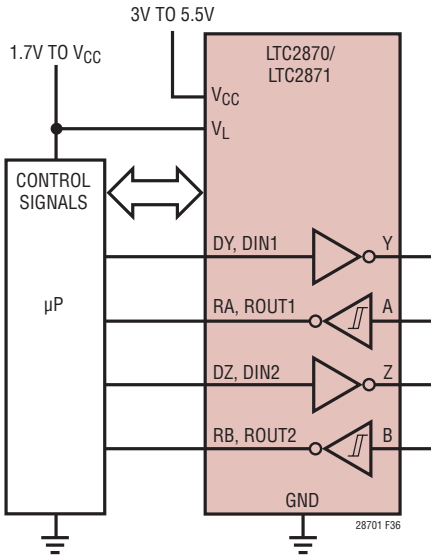



**Figure 36. Microprocessor Interface**

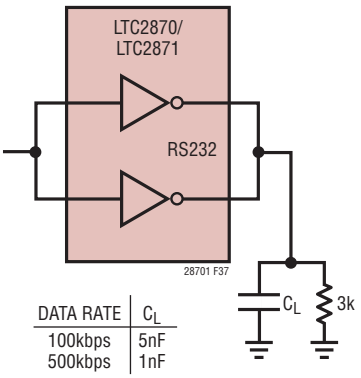



**Figure 37. Driving Larger RS232 Loads**

## TYPICAL APPLICATIONS

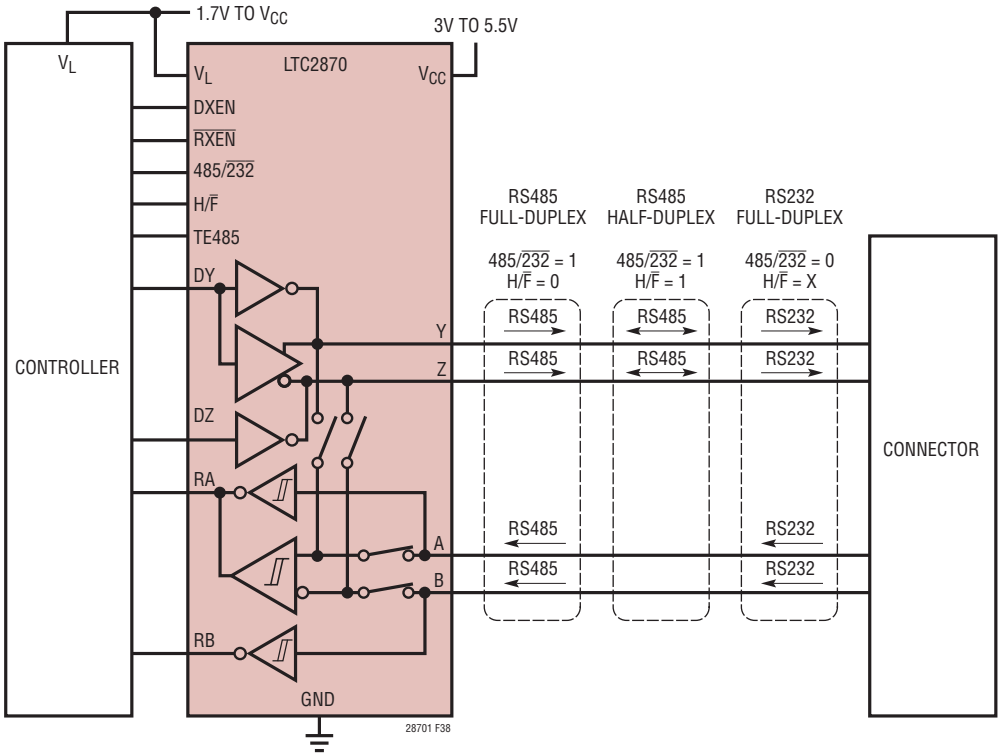



**Figure 38. LTC2870: Making Use of Shared I/O for Various Communication Configurations**

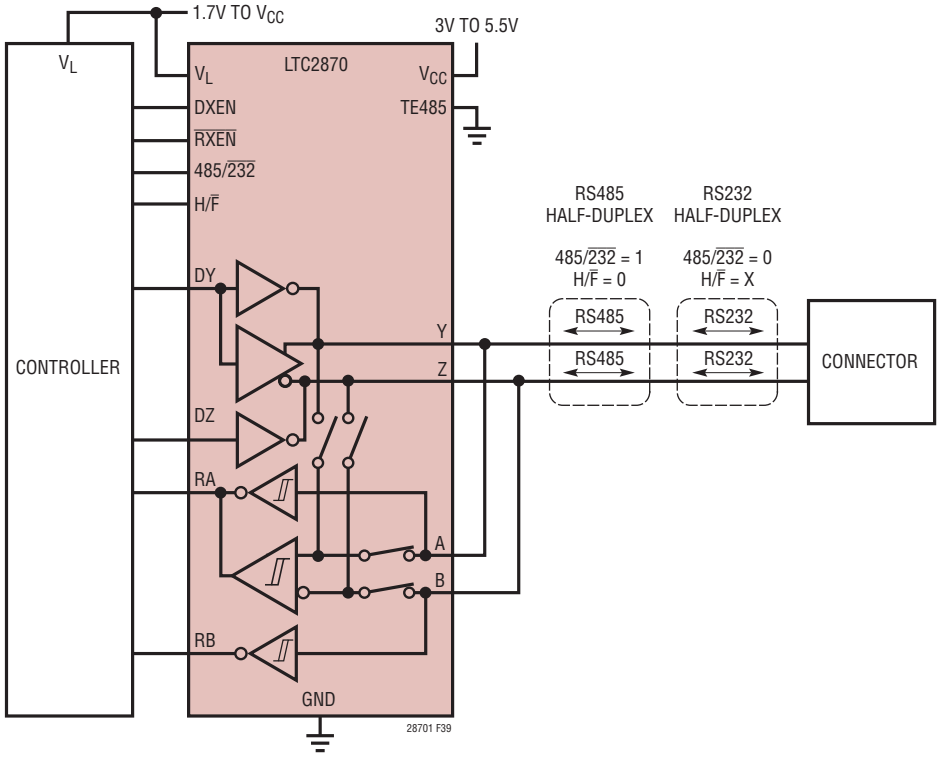



**Figure 39. LTC2870: Using External Connections for Half-Duplex RS232 or RS485 Operation**

## TYPICAL APPLICATIONS

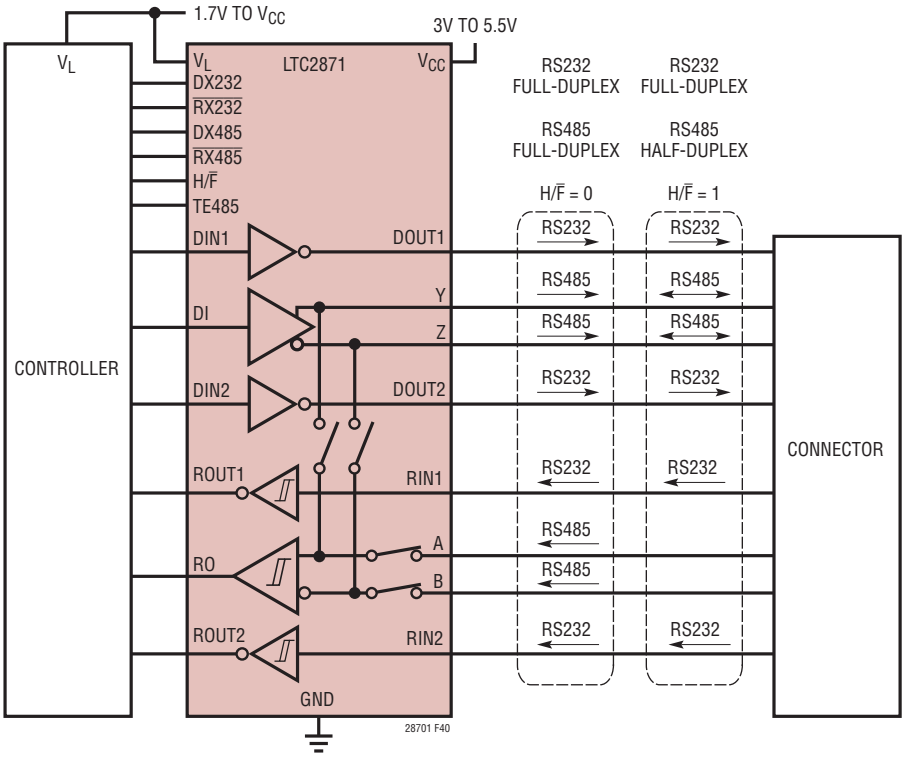



**Figure 40. LTC2871: Various Communication Configurations**

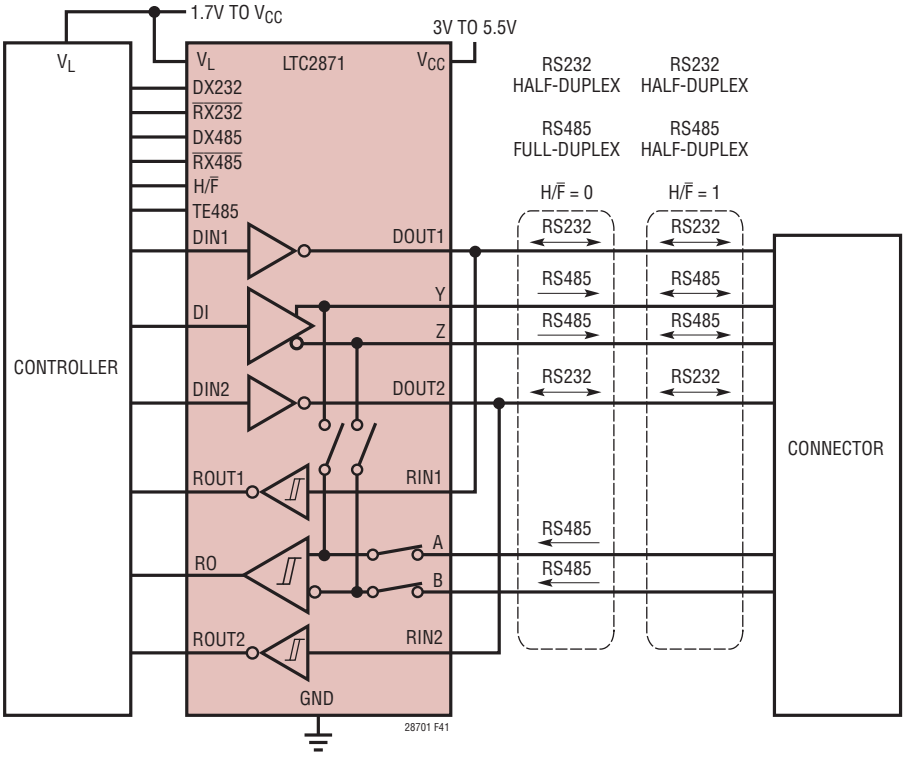



**Figure 41. LTC2871: More Communication Configurations Using External Connections**

## TYPICAL APPLICATIONS

**$V_{CC}$ = 3V to 5.5V, $V_L$ = 1.7V to $V_{CC}$. Logic input pins not shown are tied to a valid logic state.**

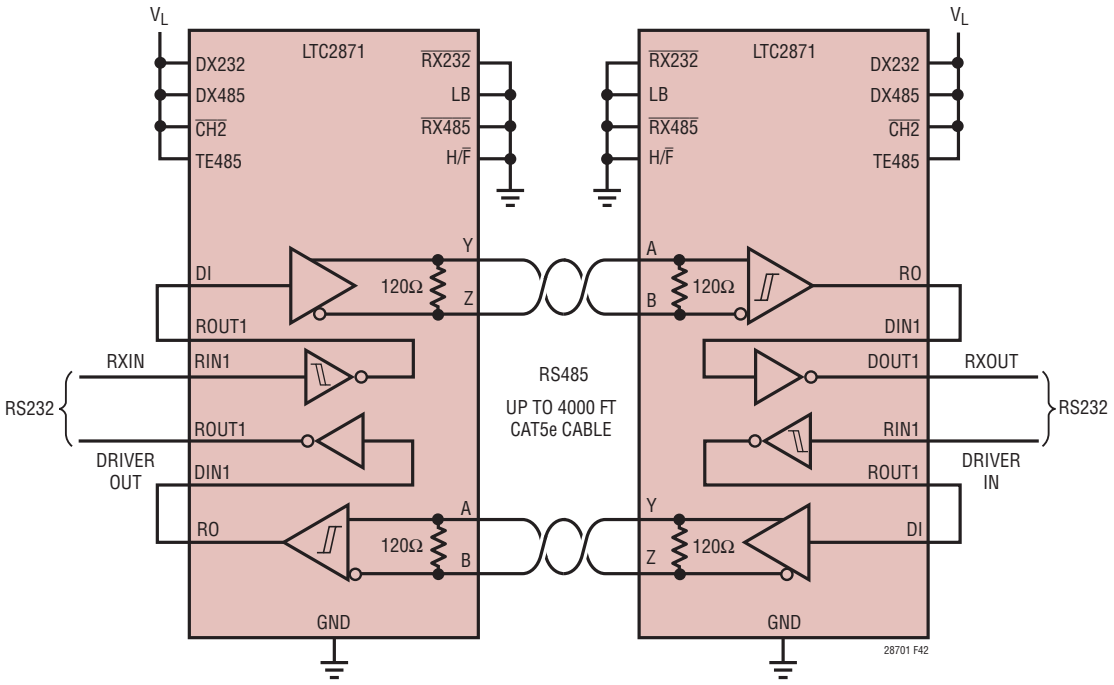



**Figure 42. RS232 Extension Cord Using RS232 to RS485 Conversion**

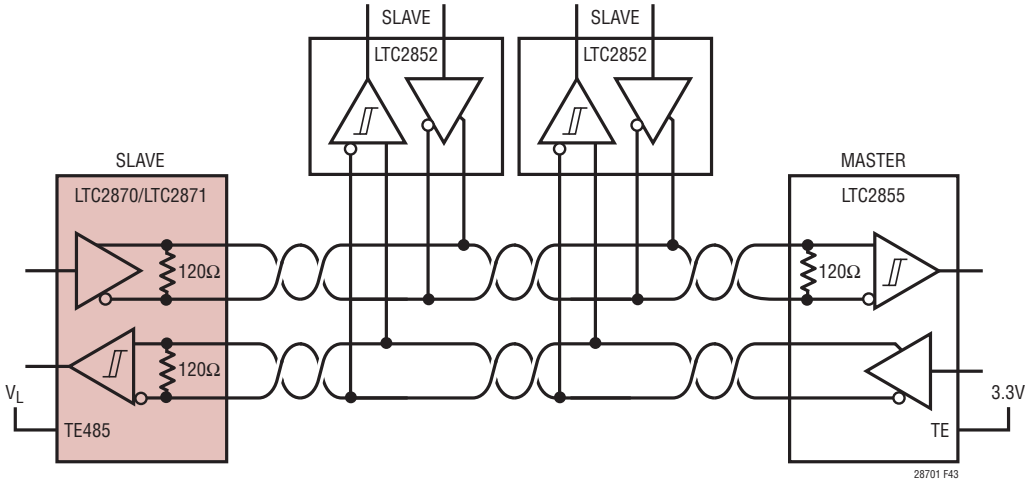



**Figure 43. RS485 Full-Duplex Network**

## TYPICAL APPLICATIONS

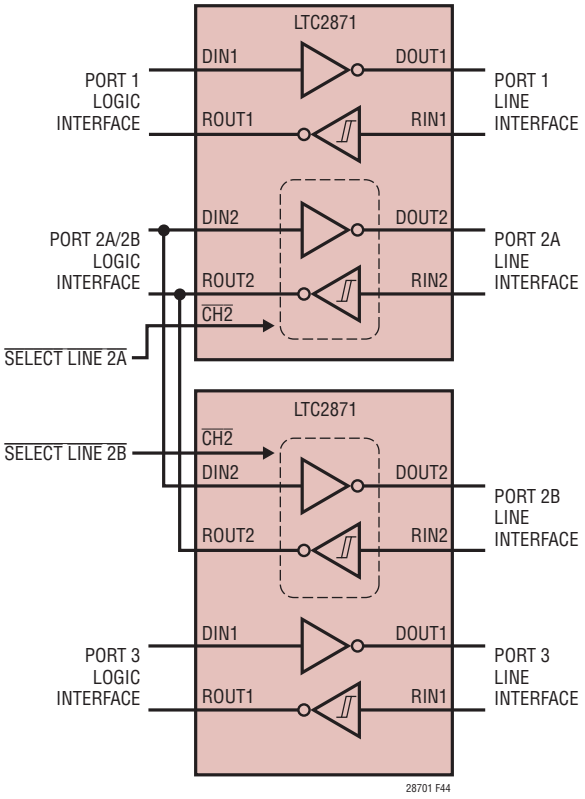



**Figure 44. RS232 Triple Transceiver with Selectable Line Interface**

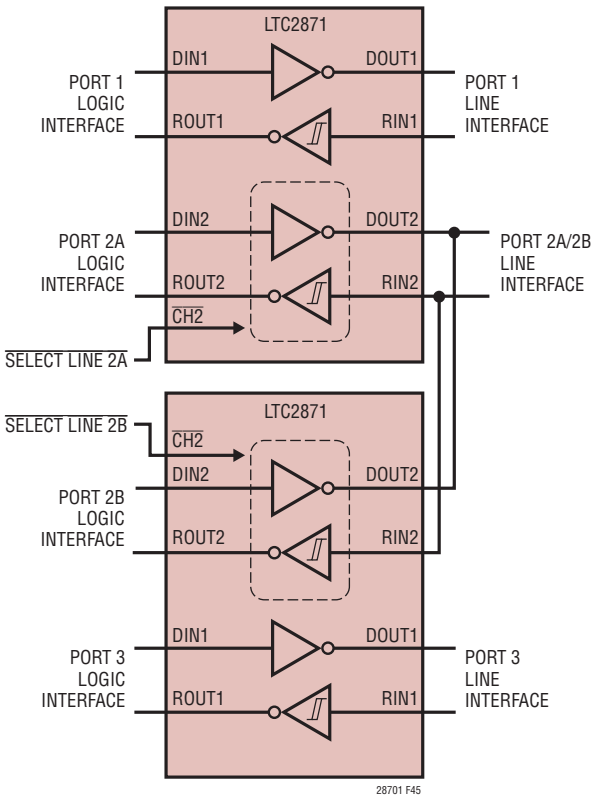



**Figure 45. RS232 Triple Transceiver with Selectable Logic Interface**

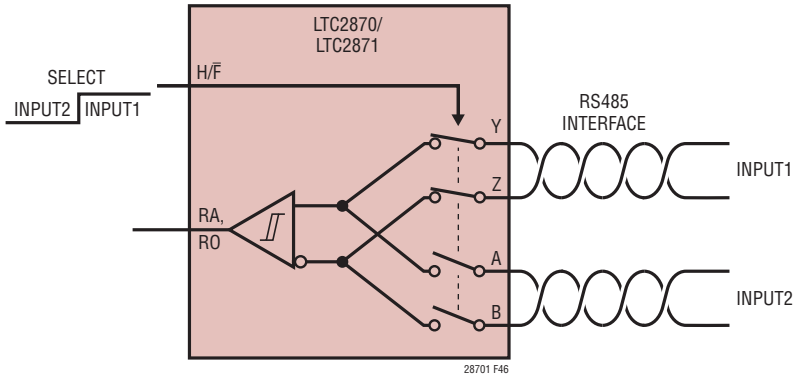



**Figure 46. RS485 Receiver with Multiplexed Inputs**

## TYPICAL APPLICATIONS

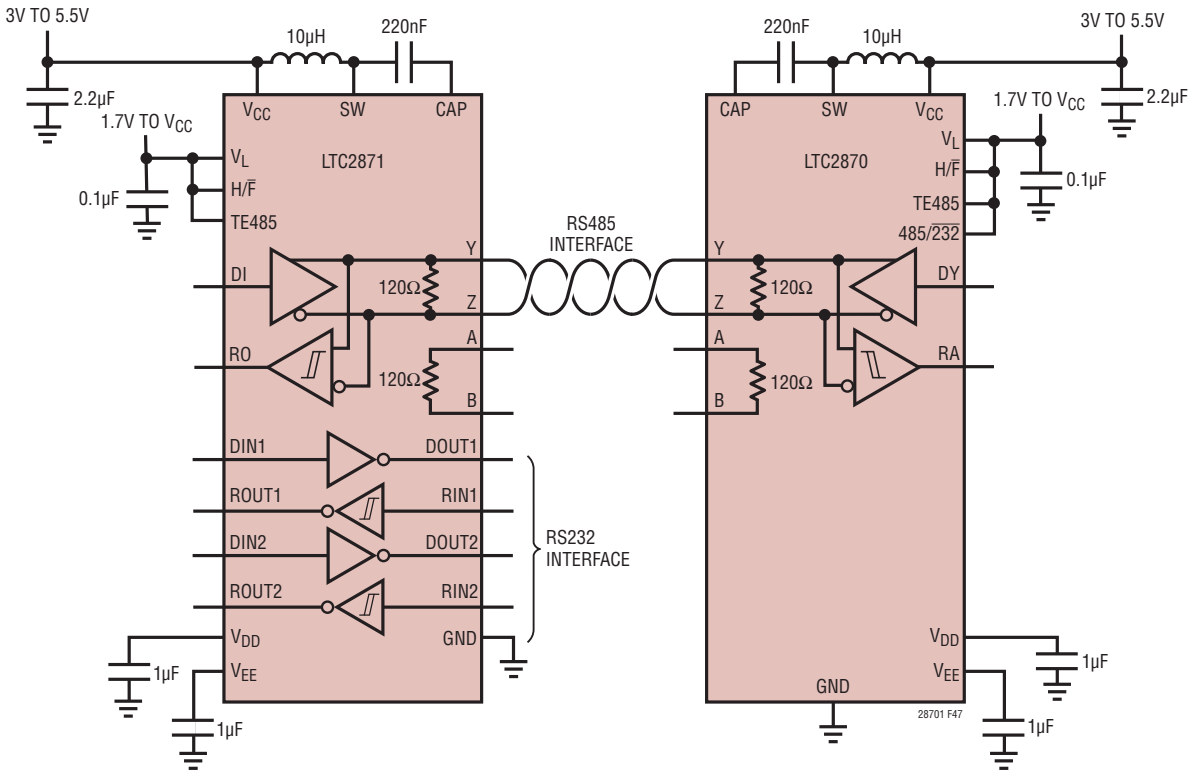
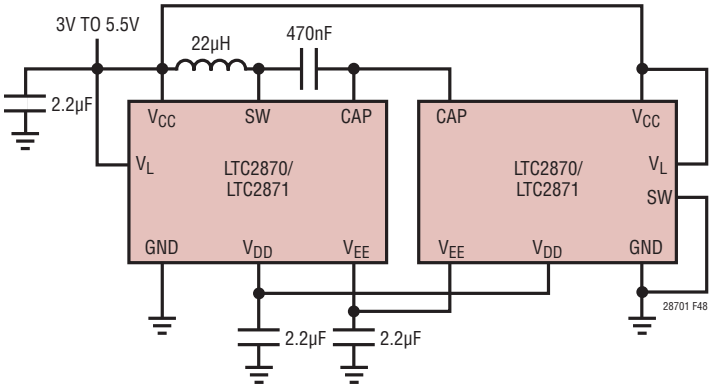



**Figure 47. Typical Supply Connections with External Components Shown**



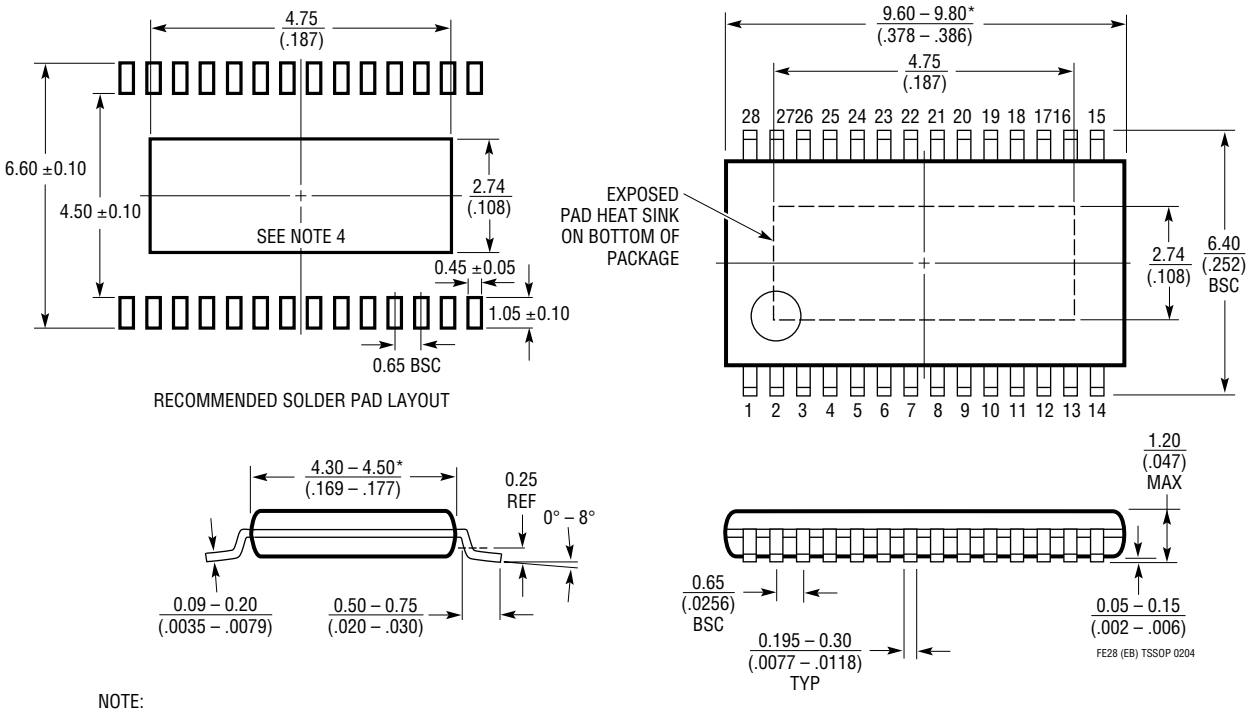

INDUCTOR: TAIYO YUDEN CBC2518T220M,
MURATA LQH32CN220K53

**Figure 48. Running Two LTC2870 or LTC2871 Devices from One Shared Power Source**

# PACKAGE DESCRIPTION

**FE Package**
**28-Lead Plastic TSSOP (4.4mm)**
(Reference LTC DWG # 05-08-1663)

**Exposed Pad Variation EB**



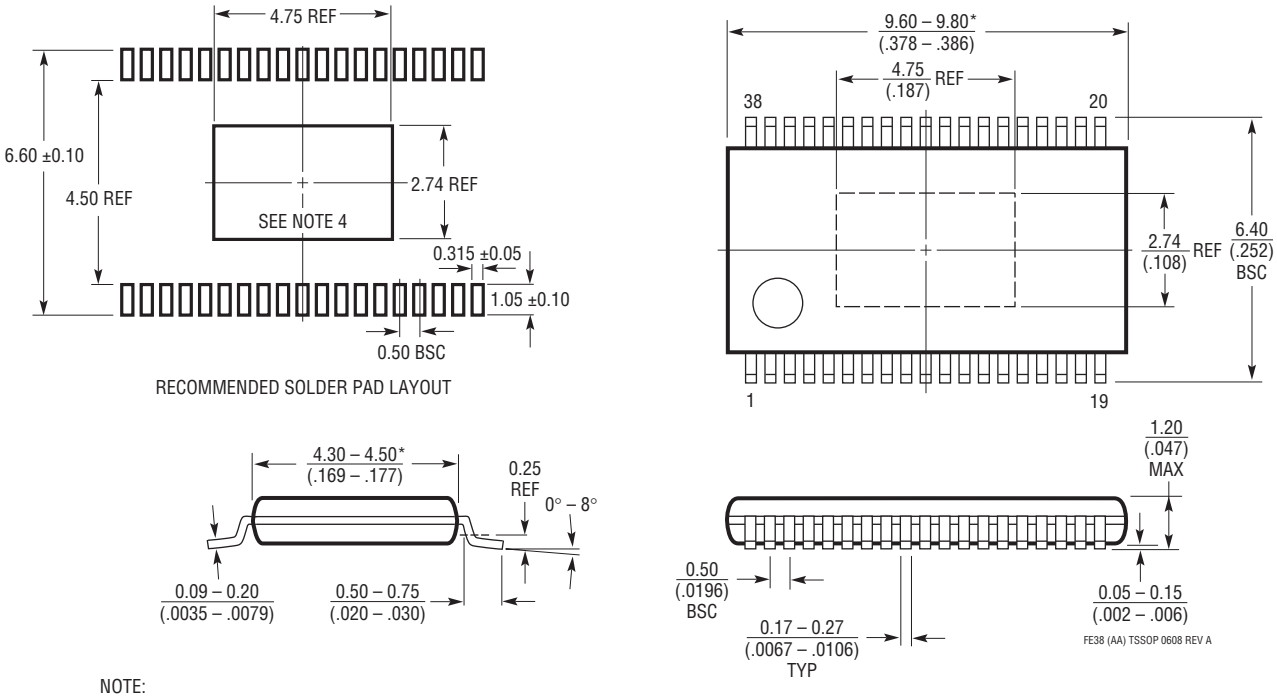

NOTE:
1. CONTROLLING DIMENSION: MILLIMETERS
2. DIMENSIONS ARE IN MILLIMETERS (INCHES)
3. DRAWING NOT TO SCALE
4. RECOMMENDED MINIMUM PCB METAL SIZE FOR EXPOSED PAD ATTACHMENT

*DIMENSIONS DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.150mm (.006") PER SIDE

# PACKAGE DESCRIPTION

**FE Package**
**38-Lead Plastic TSSOP (4.4mm)**
(Reference LTC DWG # 05-08-1772 Rev A)

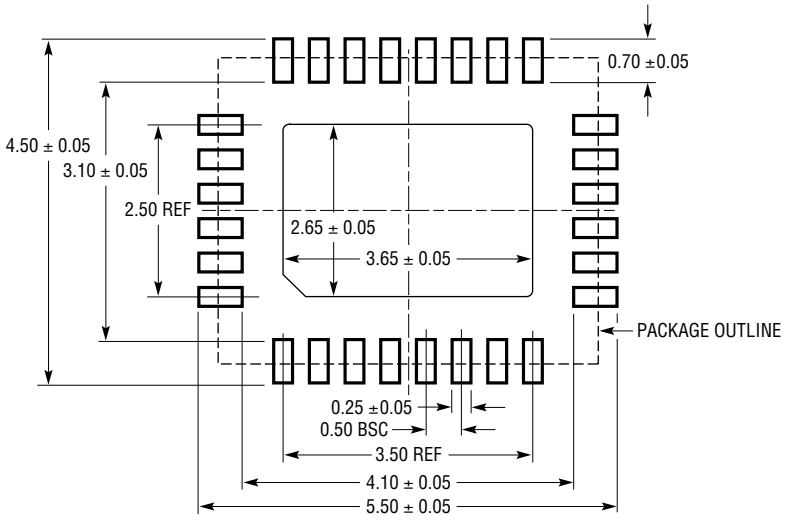
**Exposed Pad Variation AA**



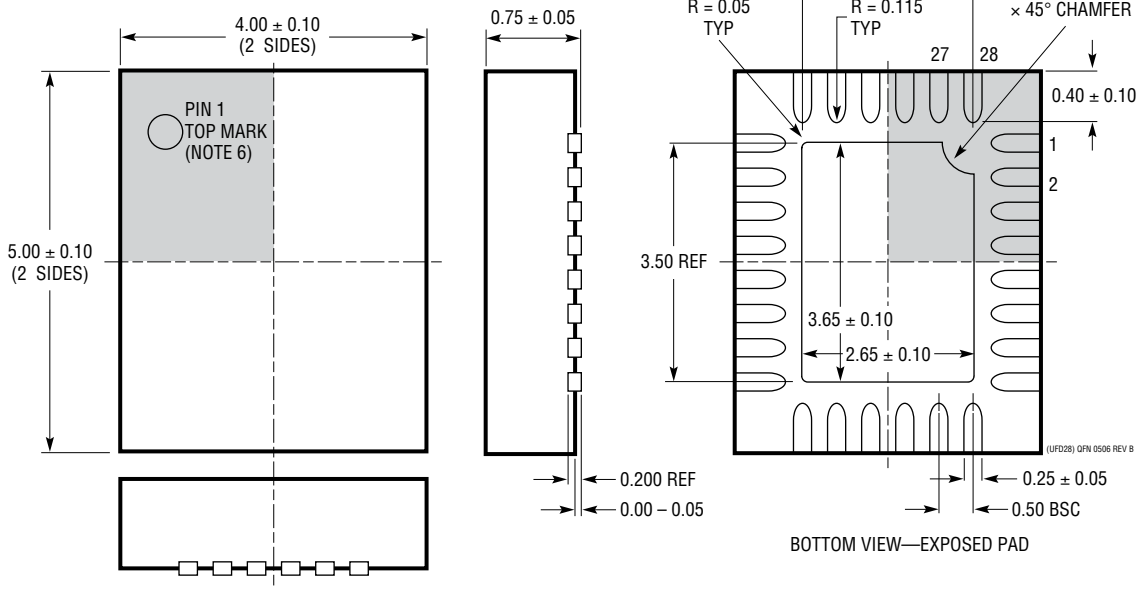

NOTE:
1. CONTROLLING DIMENSION: MILLIMETERS
2. DIMENSIONS ARE IN MILLIMETERS (INCHES)
3. DRAWING NOT TO SCALE
4. RECOMMENDED MINIMUM PCB METAL SIZE FOR EXPOSED PAD ATTACHMENT
*DIMENSIONS DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.150mm (.006") PER SIDE

# PACKAGE DESCRIPTION

**UFD Package**
**28-Lead Plastic QFN (4mm × 5mm)**
(Reference LTC DWG # 05-08-1712 Rev B)




RECOMMENDED SOLDER PAD PITCH AND DIMENSIONS
APPLY SOLDER MASK TO AREAS THAT ARE NOT SOLDERED

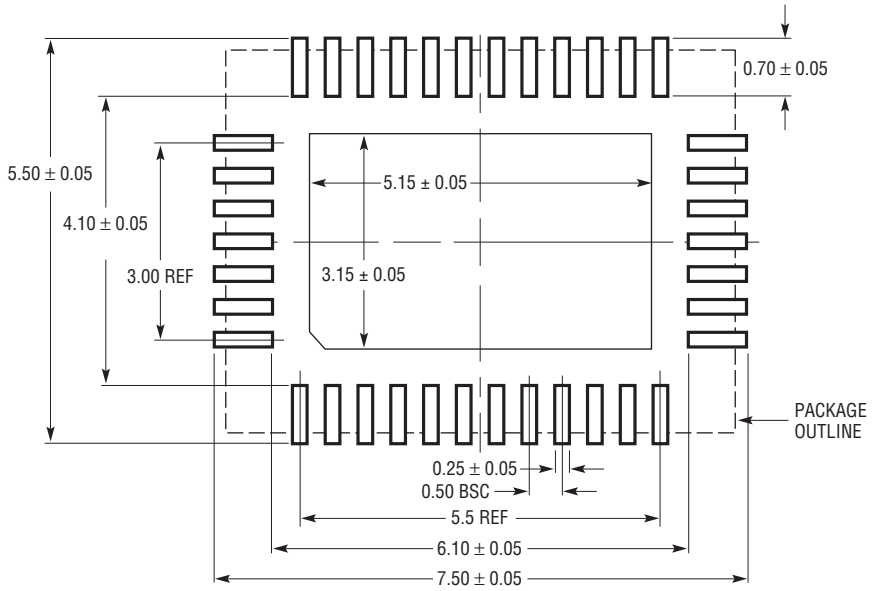



BOTTOM VIEW—EXPOSED PAD

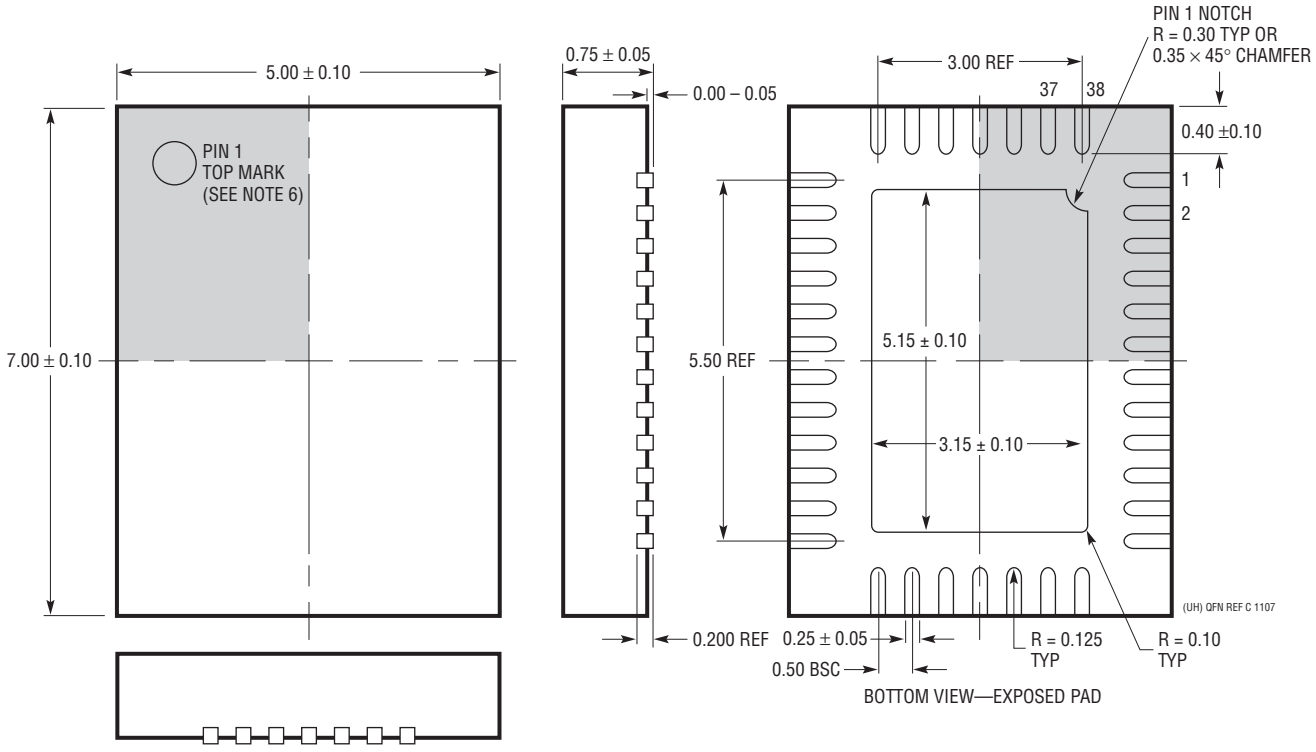
NOTE:
1. DRAWING PROPOSED TO BE MADE A JEDEC PACKAGE OUTLINE MO-220 VARIATION (WXXX-X).
2. DRAWING NOT TO SCALE
3. ALL DIMENSIONS ARE IN MILLIMETERS
4. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.15mm ON ANY SIDE
5. EXPOSED PAD SHALL BE SOLDER PLATED
6. SHADED AREA IS ONLY A REFERENCE FOR PIN 1 LOCATION ON THE TOP AND BOTTOM OF PACKAGE

# PACKAGE DESCRIPTION

**UHF Package**
**38-Lead Plastic QFN (5mm × 7mm)**
(Reference LTC DWG # 05-08-1701 Rev C)



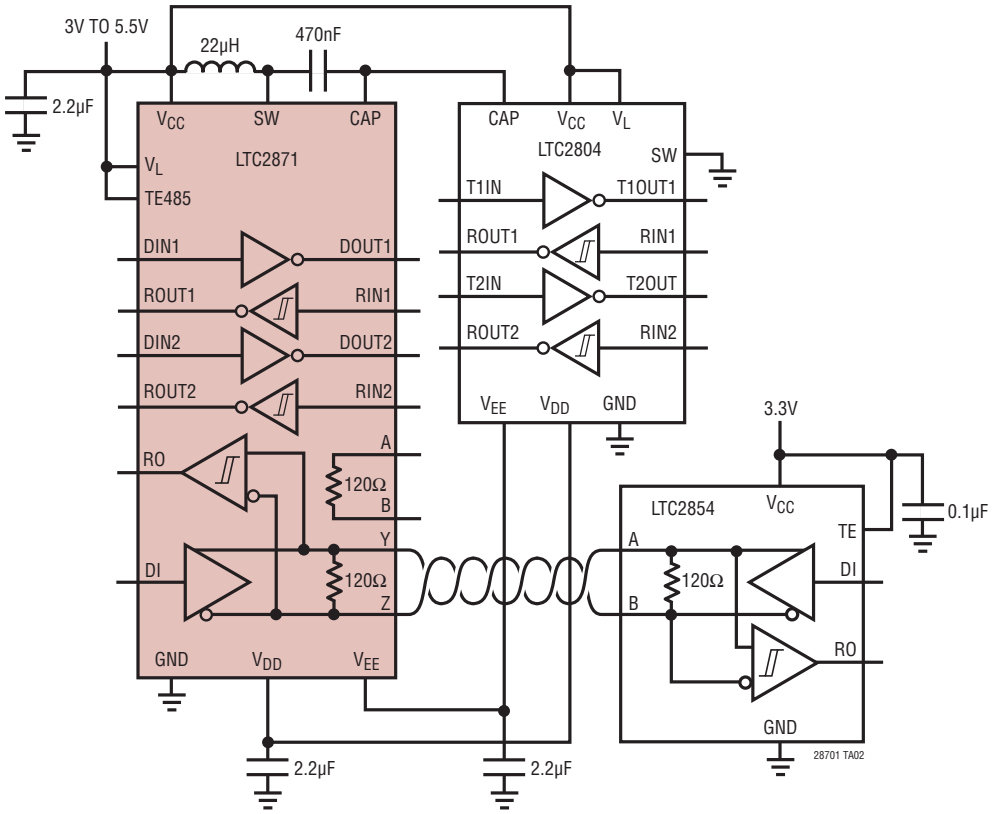

RECOMMENDED SOLDER PAD LAYOUT
APPLY SOLDER MASK TO AREAS THAT ARE NOT SOLDERED




NOTE:
1. DRAWING CONFORMS TO JEDEC PACKAGE OUTLINE M0-220 VARIATION WHKD
2. DRAWING NOT TO SCALE
3. ALL DIMENSIONS ARE IN MILLIMETERS
4. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.20mm ON ANY SIDE
5. EXPOSED PAD SHALL BE SOLDER PLATED
6. SHADED AREA IS ONLY A REFERENCE FOR PIN 1 LOCATION ON THE TOP AND BOTTOM OF PACKAGE

## TYPICAL APPLICATION

**Quad RS232 Transceiver with RS485 Communication Over Half-Duplex, Terminated Bus**




## RELATED PARTS

| PART NUMBER | DESCRIPTION | COMMENTS |
|---|---|---|
| LTC1334 | Single 5V RS232/RS485 Multiprotocol Transceiver | Dual Port, Single 5V Supply, Configurable, 10kV ESD |
| LTC1387 | Single 5V RS232/RS485 Multiprotocol Transceiver | Single Port, Configurable |
| LTC2801/LTC2802/ LTC2803/LTC2804 | 1.8V to 5.5V RS232 Single and Dual Transceivers | Up to 1Mbps, 10kV ESD, Logic Supply Pin, Tiny DFN Packages |
| LTC2854/LTC2855 | 3.3V 20Mbps RS485 Transceiver with Integrated Switchable Termination | 3.3V Supply, Integrated, Switchable, 120Ω Termination Resistor, 25kV ESD |
| LTC2859/LTC2861 | 20Mbps RS485 Transceiver with Integrated Switchable Termination | 5V Supply, Integrated, Switchable, 120Ω Termination Resistor, 15kV ESD |
| LTM2881 | Complete Isolated RS485/RS422 µModule Transceiver + Power | 20Mbps, 2500$V_{RMS}$ Isolation with Integrated DC/DC Converter, Integrated, Switchable, 120Ω Termination Resistor, 15kV ESD |
| LTM2882 | Dual Isolated RS232 µModule Transceiver + Power | 1Mbps, 2500$V_{RMS}$ Isolation with Integrated DC/DC Converter, ±10kV ESD |


Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408) 432-1900 • FAX: (408) 434-0507 • www.linear.com
LT 1210 • PRINTED IN USA