THE DATASHEET OF

LTC2871IUHF#PBF

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
- H-Grade Available for the LTC2870 (–40°C to 125°C)
- Available in 28-Pin 4mm × 5mm QFN and TSSOP (LTC2870), and 38-Pin 5mm × 7mm QFN and TSSOP (LTC2871)

APPLICATIONS

- Software Selectable RS232/RS485/RS422 Interface
- 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 tiny 2mm × 1.6mm inductor and one capacitor, eliminating the need for multiple supplies for driving RS232 levels.

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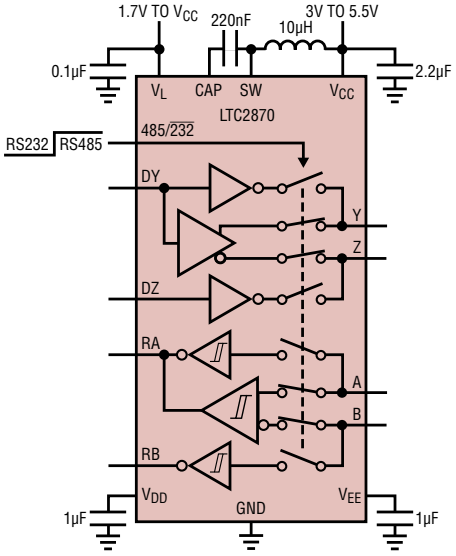
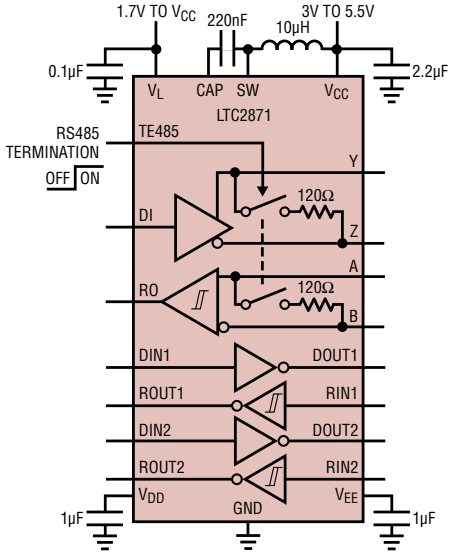
TYPICAL APPLICATIONS

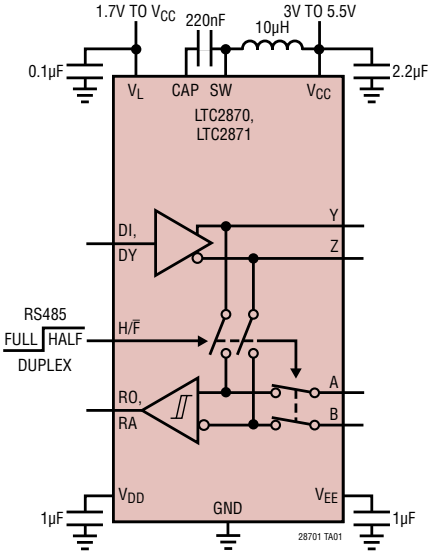
Protocol Switching with Automatic Termination Selection



Simultaneous Protocols and RS485 Termination Switching



RS485 Duplex Switching

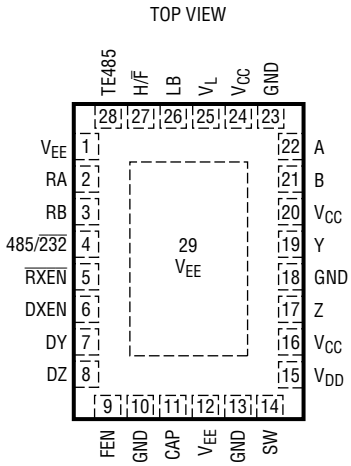


ABSOLUTE MAXIMUM RATINGS (Notes 1 and 2)

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
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
LTC2870H ..... –40°C to 125°C
Storage Temperature Range ..... –65°C to 125°C
Lead Temperature (Soldering, 10 sec)
FE package ..... 300°C

PIN CONFIGURATION

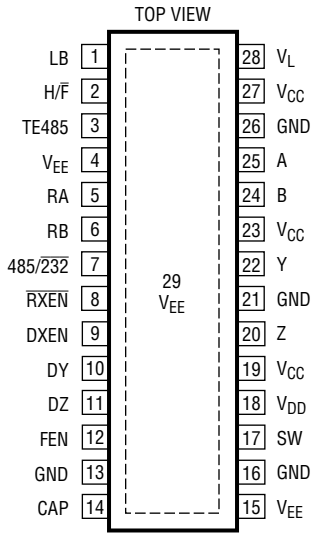
LTC2870



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

T_{JMAX} = 150°C, θ_{JA} = 43°C/W
EXPOSED PAD (PIN 29) IS V_{EE},
MUST BE SOLDERED TO PCB

LTC2870



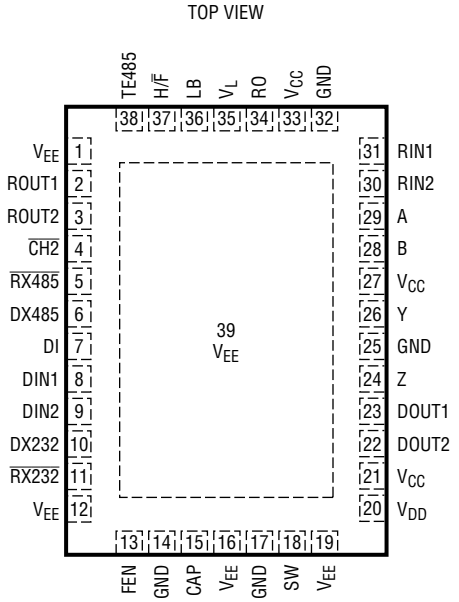
FE PACKAGE
28-LEAD PLASTIC TSSOP

T_{JMAX} = 150°C, θ_{JA} = 30°C/W
EXPOSED PAD (PIN 29) IS V_{EE},
MUST BE SOLDERED TO PCB

PIN CONFIGURATIONS

LTC2871

TOP VIEW

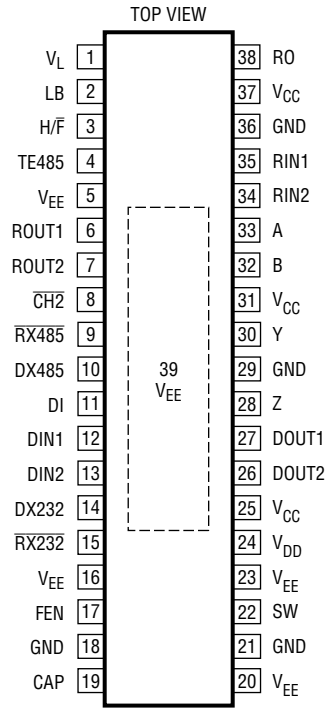


UHF PACKAGE
38-LEAD (5mm × 7mm) PLASTIC QFN

T_{JMAX} = 150°C, θ_{JA} = 34°C/W
EXPOSED PAD (PIN 39) IS V_{EE},
MUST BE SOLDERED TO PCB

LTC2871

TOP VIEW



FE PACKAGE
38-LEAD PLASTIC SSOP

T_{JMAX} = 150°C, θ_{JA} = 28°C/W
EXPOSED PAD (PIN 39) IS V_{EE},
MUST BE SOLDERED TO PCB

ORDER INFORMATION

http://www.linear.com/product/LTC2870#orderinfo

LEAD FREE FINISH	TAPE AND REEL	PART MARKING	PACKAGE DESCRIPTION	TEMPERATURE RANGE
LTC2870CFE#PBF LTC2870IFE#PBF	LTC2870CFE#TRPBF LTC2870IFE#TRPBF	LTC 2870FE LTC 2870FE	28-Lead Plastic TSSOP 28-Lead Plastic TSSOP	0°C to 70°C –40°C to 85°C
LTC2870CUFD#PBF LTC2870IUFD#PBF LTC2870HUFD#PBF	LTC2870CUFD#TRPBF LTC2870IUFD#TRPBF LTC2870HUFD#TRPBF	2870 2870 2870	28-Lead (4mm × 5mm) Plastic QFN 28-Lead (4mm × 5mm) Plastic QFN 28-Lead (4mm × 5mm) Plastic QFN	0°C to 70°C –40°C to 85°C –40°C to 125°C
LTC2871CFE#PBF LTC2871IFE#PBF	LTC2871CFE#TRPBF LTC2871IFE#TRPBF	LTC2871FE LTC2871FE	38-Lead Plastic TSSOP 38-Lead Plastic TSSOP	0°C to 70°C –40°C to 85°C
LTC2871CUHF#PBF LTC2871IUHF#PBF	LTC2871CUHF#TRPBF LTC2871IUHF#TRPBF	2871 2871	38-Lead (5mm × 7mm) Plastic QFN 38-Lead (5mm × 7mm) Plastic QFN	0°C to 70°C –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	TEMPERATURE GRADES
LTC2870	(0 + 0), (1 + 0), (0 + 2)	28-Lead QFN, 28-Lead TSSOP	C, I, H (QFN)
LTC2871	(0 + 0), (1 + 0), (1 + 1), (1 + 2), (0 + 1), (0 + 2)	38-Lead QFN, 38-Lead TSSOP	C, I

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) DX485 = DX232 = TE485 = FEN = H/$\overline{F}$ = 0V, $\overline{RX485}$ = $\overline{RX232}$ = 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, 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, DI/DIN1/DIN2 = 0V or V_L (LTC2871)	●		0	5	µA
RS485 Driver							
$\|V_{OD}\|$	Differential Output Voltage	R_L = ∞, V_{CC} = 3V (Figure 1) R_L = 27Ω, V_{CC} = 3V (Figure 1) R_L = 50Ω, V_{CC} = 3.13V (Figure 1)	● ● ●	1.5 1.5 2		6 V_{CC} V_{CC}	V V V
$\Delta\|V_{OD}\|$	Difference in Magnitude of Differential Output Voltage for Complementary Output States	R_L = 27Ω, V_{CC} = 3V (Figure 1) R_L = 50Ω, V_{CC} = 3.13V (Figure 1)	● ●			0.2 0.2	V V
V_{OC}	Common Mode Output Voltage	R_L = 27Ω or 50Ω (Figure 1)	●			3	V
$\Delta\|V_{OC}\|$	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)			220		mV
	Differential Input Failsafe Threshold Voltage	–7V ≤ (A or B) ≤ 12V, (A-B) Rising (Note 5)	●	–200	–70	0	mV
	Input DC Failsafe Hysteresis	B = 0V (Note 5)			35		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 RS232 Receiver Enabled DOUT1 or DOUT2 (LTC2871) = ±15V	● ●			±156 ±10	µA 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) 1.7V ≤ V_L ≤ 5.5V	●			0.4	V
	Output High Voltage	I(RA, RB, ROUT1, ROUT2) = –1mA (Sourcing) 1.7V ≤ V_L ≤ 5.5V	●	V_L – 0.4			V
	Input Resistance	–15V ≤ (A, B, RIN1, RIN2) ≤ 15V, 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 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

SWITCHING 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 R_L = 3kΩ, C_L = 500pF (Note 3)	● ●	100 500			kbps kbps
	Driver Slew Rate (Figure 9)	R_L = 3kΩ, C_L = 2500pF R_L = 3kΩ, C_L = 50pF	● ●	4		 30	V/µs 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.

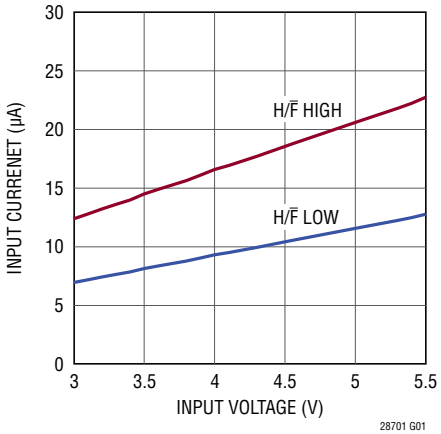
Note 6: This IC includes overtemperature protection that is intended to protect the device during momentary overload conditions. Overtemperature protection activates at a junction temperature exceeding 150°C. Continuous operation above the specified maximum operating junction temperature may result in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

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

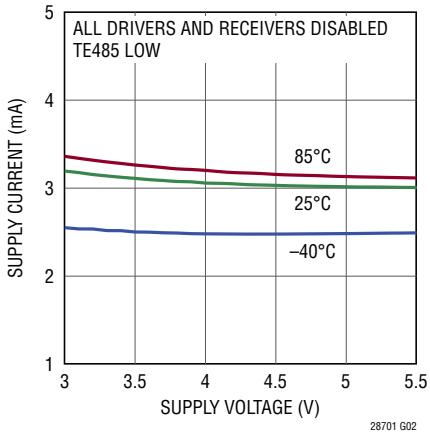
TYPICAL PERFORMANCE CHARACTERISTICS

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

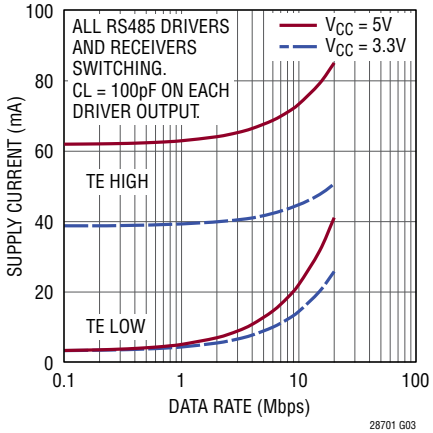
V_{CC} Supply Current vs Supply Voltage in Shutdown Mode



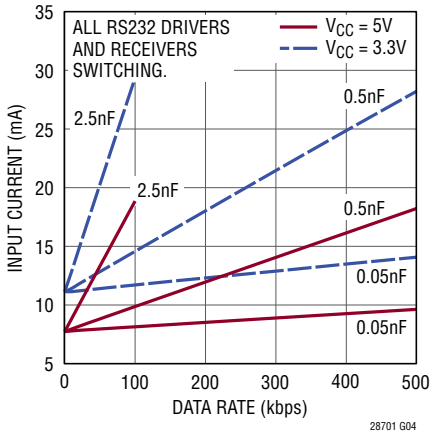
V_{CC} Supply Current vs Supply Voltage in Fast Enable Mode



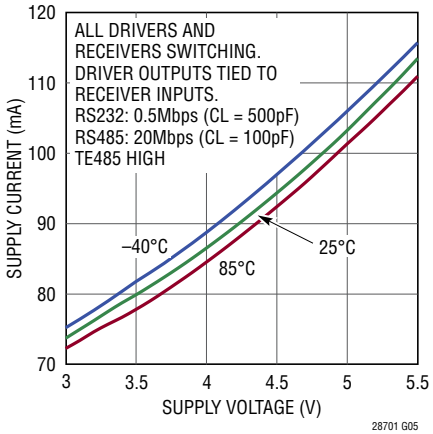
V_{CC} Supply Current vs RS485 Data Rate



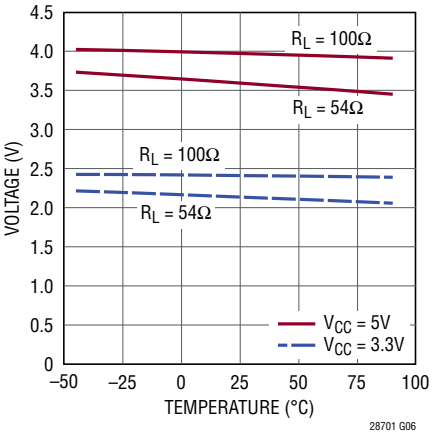
V_{CC} Supply Current vs RS232 Data Rate



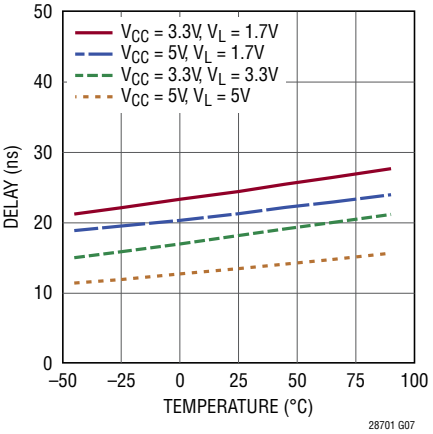
V_{CC} Supply Current vs Supply Voltage, All Transceivers at Max Rate (LTC2871)



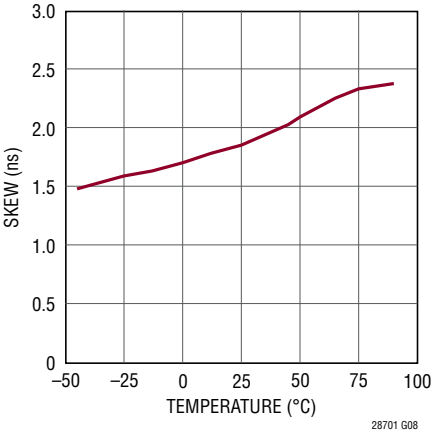
RS485 Driver Differential Output Voltage vs Temperature



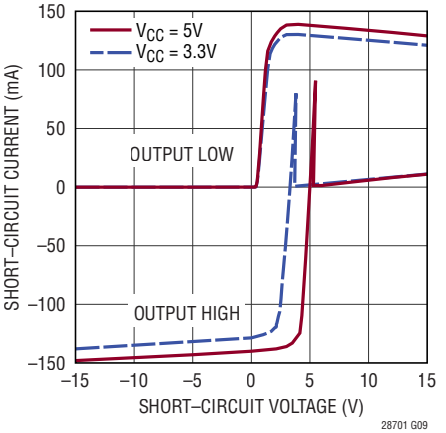
RS485 Driver Propagation Delay vs Temperature



RS485 Driver Skew vs Temperature



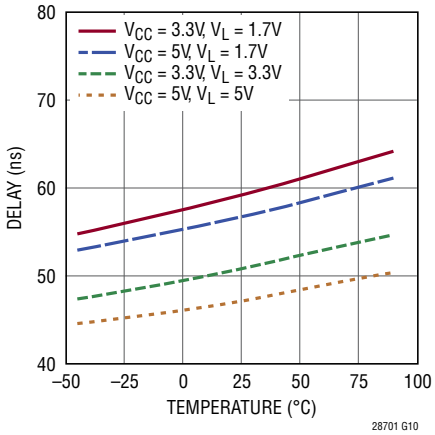
RS485 Driver Short-Circuit Current vs Short-Circuit Voltage



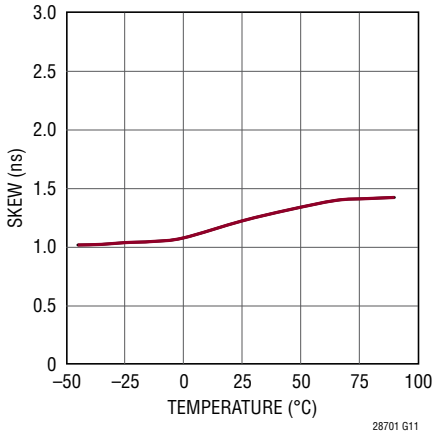
TYPICAL PERFORMANCE CHARACTERISTICS

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

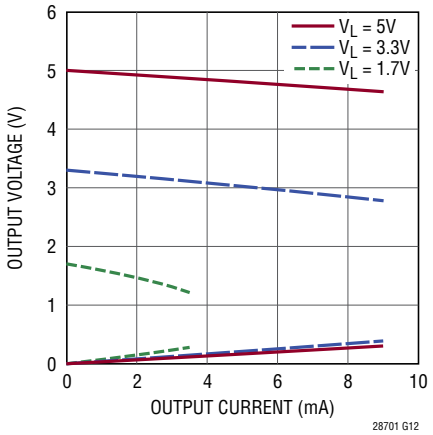
RS485 Receiver Propagation Delay vs Temperature



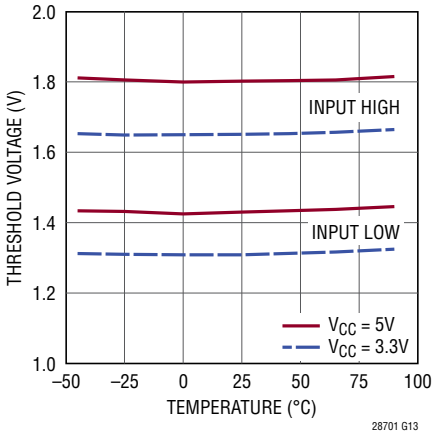
RS485 Receiver Skew vs Temperature



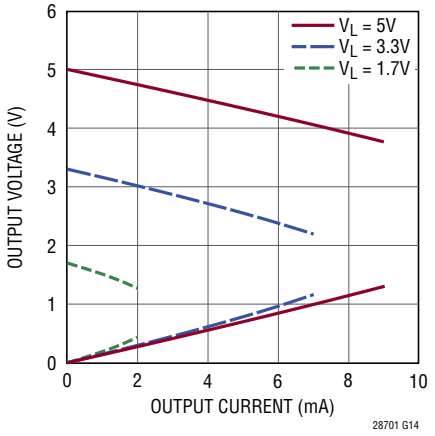
RS485 Receiver Output Voltage vs Load Current



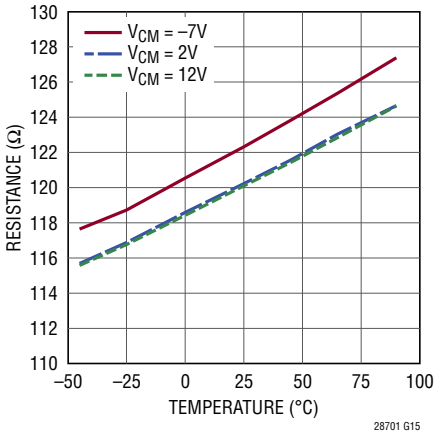
RS232 Receiver Input Threshold vs Temperature



RS232 Receiver Output Voltage vs Load Current



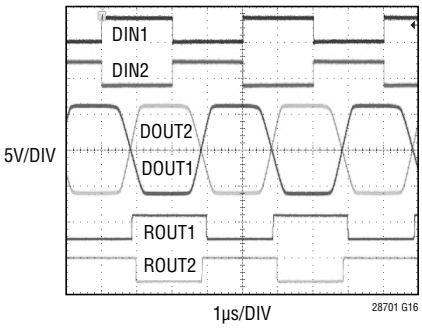
RS485 Termination Resistance vs Temperature



TYPICAL PERFORMANCE CHARACTERISTICS

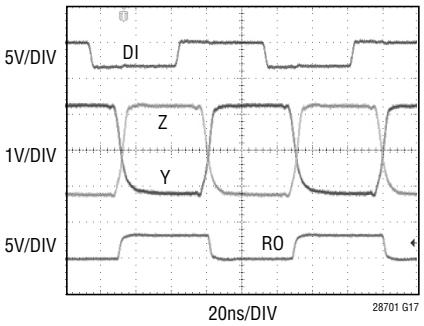
T_A = 25°C, V_{CC} = V_L = 3.3V, unless otherwise noted.

RS232 Operation at 500kbps



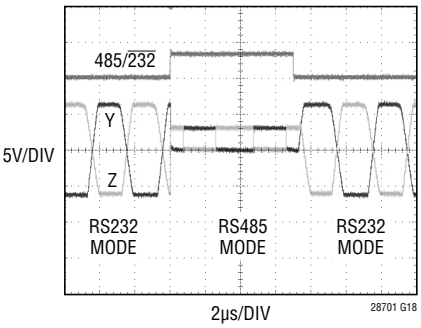
WRAPPING DATA
DOUT LOADS: 5kΩ + 50pF

RS485 Operation at 20Mbps

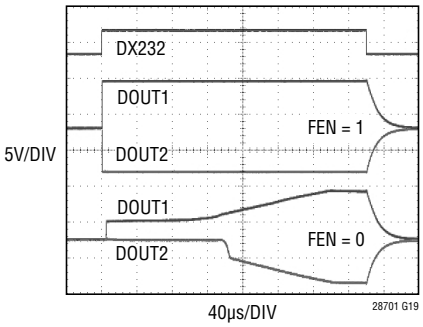


H/F̄ HIGH
Y, Z LOADS: 120Ω (DIFF) + 50pF

LTC2870 Drivers Changing Modes

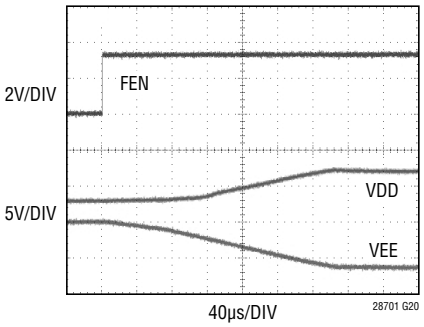


RS232 Driver Outputs Enabling and Disabling

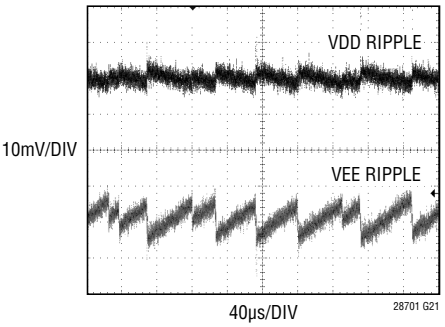


TOP CURVES: FAST ENABLE ↔ DX232
BOTTOM CURVES: SHUTDOWN ↔ DX232

V_{DD} and V_{EE} Powering Up



V_{DD} and V_{EE} Ripple



FAST ENABLE MODE,
ALL DRIVERS AND RECEIVERS DISABLED.

PIN FUNCTIONS

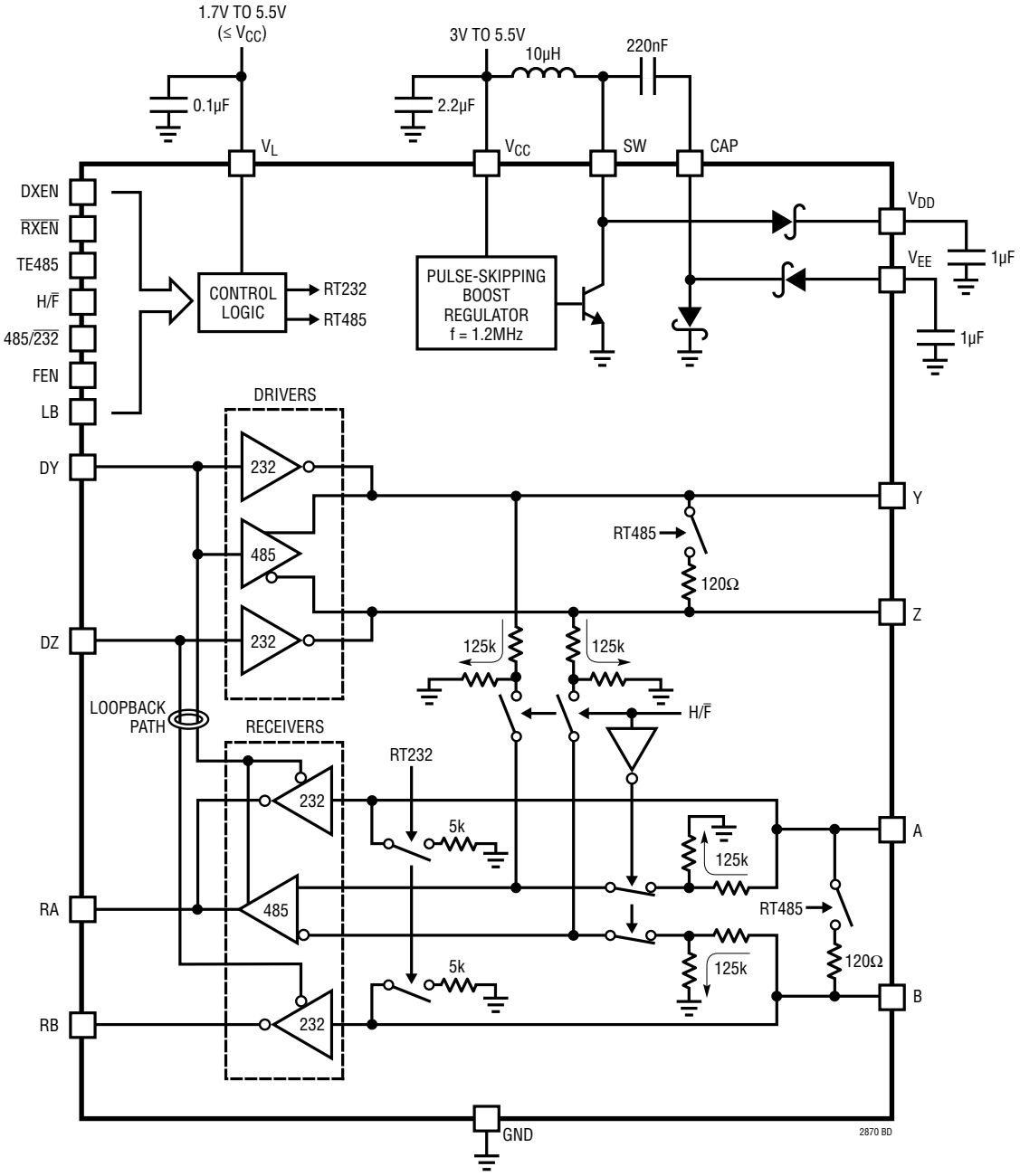
PIN NAME	LTC2870 QFN	LTC2870 TSSOP	LTC2871 QFN	LTC2871 TSSOP	DESCRIPTION
V_{CC}	16, 20, 24	19, 23, 27	21, 27, 33	25, 31, 37	Input Supply (3V to 5.5V). Tie all three pins together and connect a 2.2µF or larger capacitor between V_{CC} (adjacent to V_{DD}) and GND.
V_L	25	28	35	1	Logic Supply (1.7V to 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} (the V_{EE} pin sequentially after CAP) 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. Do not float.
DIN2			9	13	RS232 Driver Input 2. Do not float.
DOUT1			23	27	RS232 Driver Output 1.
DOUT2			22	26	RS232 Driver Output 2.
DI			7	11	RS485 Driver Input. Do not float.
DY	7	10			RS485 Driver Input or RS232 Driver Input 1. Do not float.
DZ	8	11			RS232 Driver Input 2. Do not float.
Y	19	22	26	30	RS485 Positive Driver Output. RS232 Driver Output 1 (LTC2870). 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). RS485 Negative Receiver Input (LTC2870 or LTC2871 in Half-Duplex Mode).

PIN FUNCTIONS

PIN NAME	LTC2870 QFN	LTC2870 TSSOP	LTC2871 QFN	LTC2871 TSSOP	DESCRIPTION
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. Do not float.
$\overline{RXEN}$	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/$\overline{232}$. Do not float.
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/$\overline{232}$. Do not float.
$\overline{RX232}$			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. Do not float.
$\overline{RX485}$			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. Do not float.
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. Do not float.
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. Do not float.
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. Do not float.
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. Do not float.
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). Do not float.
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. Do not float.
$\overline{CH2}$			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. Has no effect on RS485 operation. Do not float.

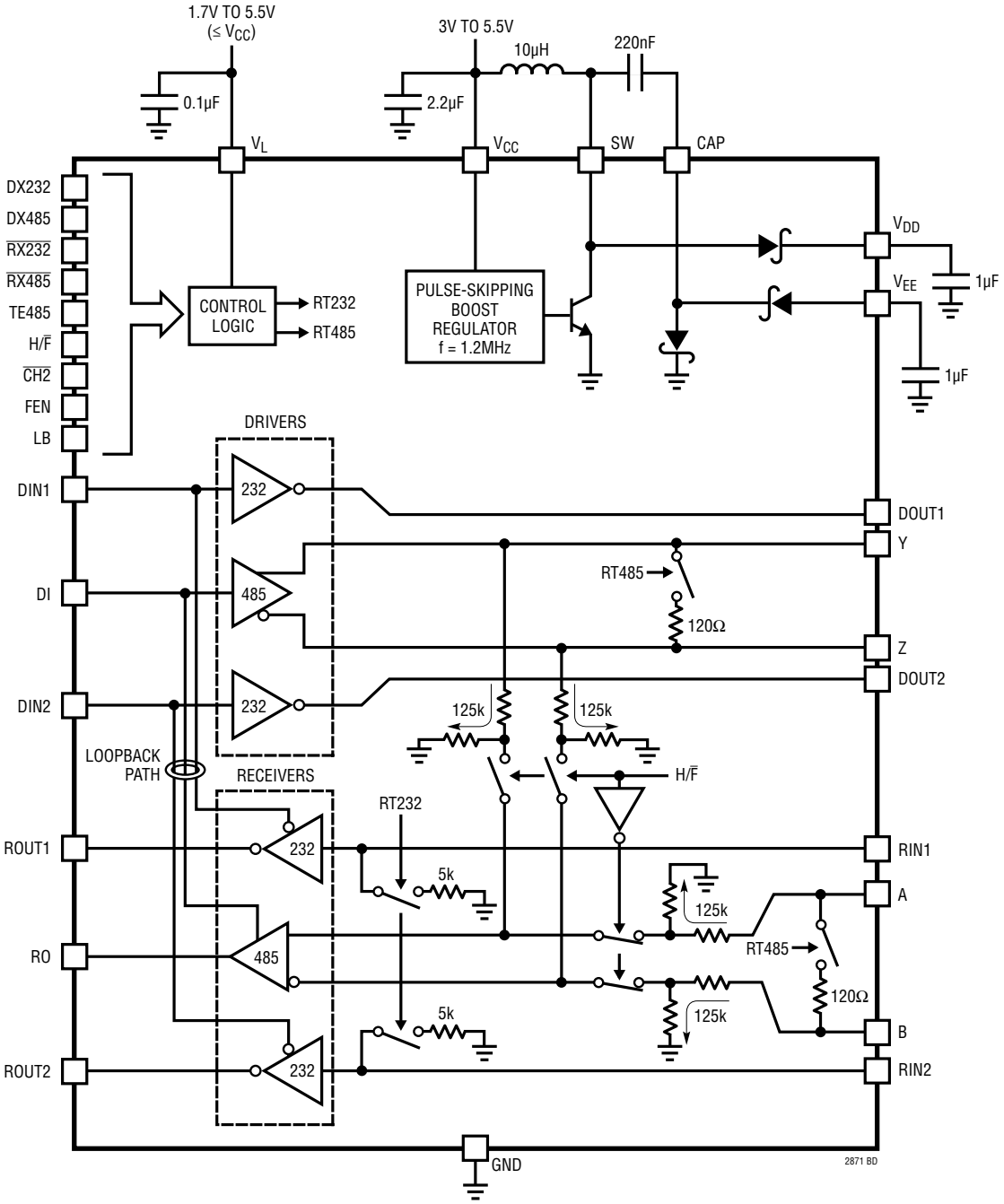
BLOCK DIAGRAM

LTC2870



BLOCK DIAGRAM

LTC2871



TEST CIRCUITS

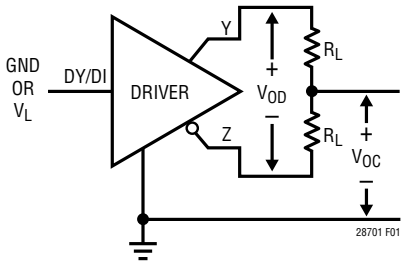


Figure 1. RS485 Driver DC Characteristics

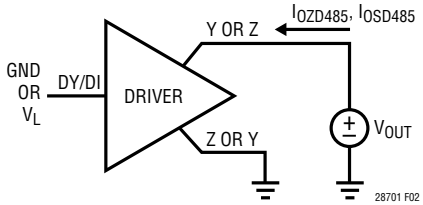


Figure 2. RS485 Driver Output Current

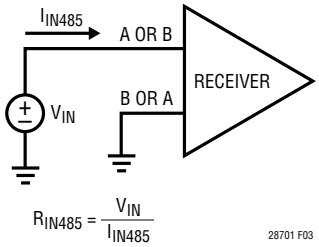


Figure 3. RS485 Receiver Input Current and Resistance (Note 5)

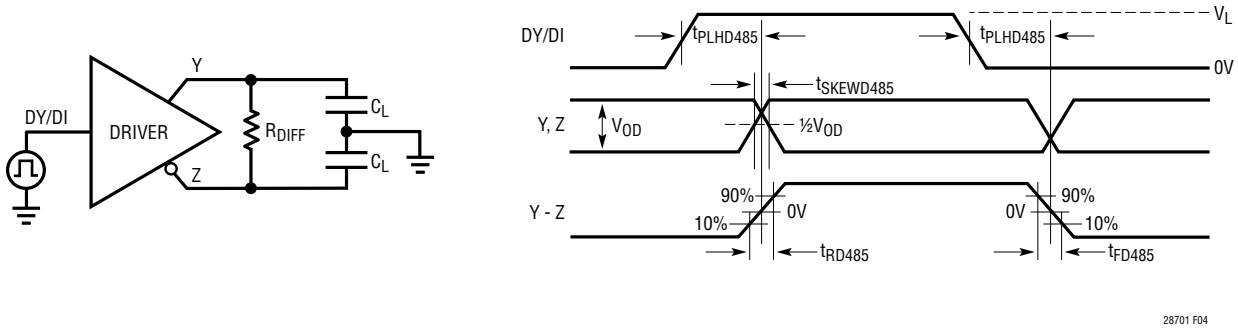


Figure 4. RS485 Driver Timing Measurement

TEST CIRCUITS

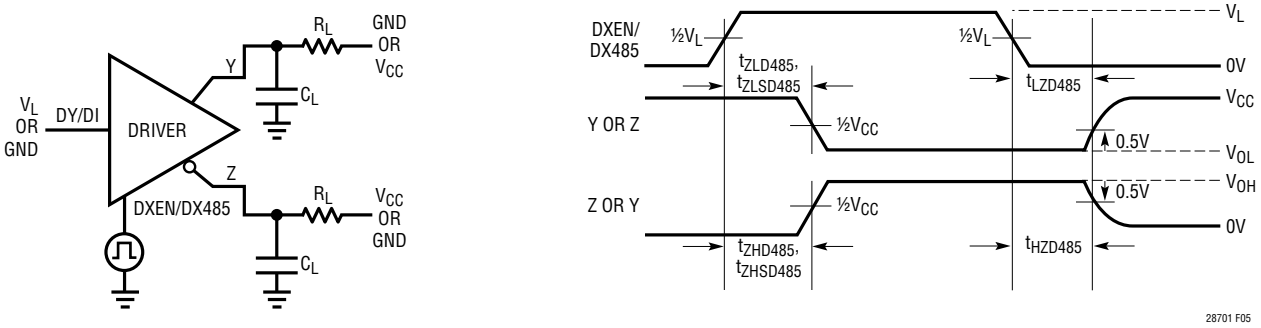


Figure 5. RS485 Driver Enable and Disable Timing Measurements

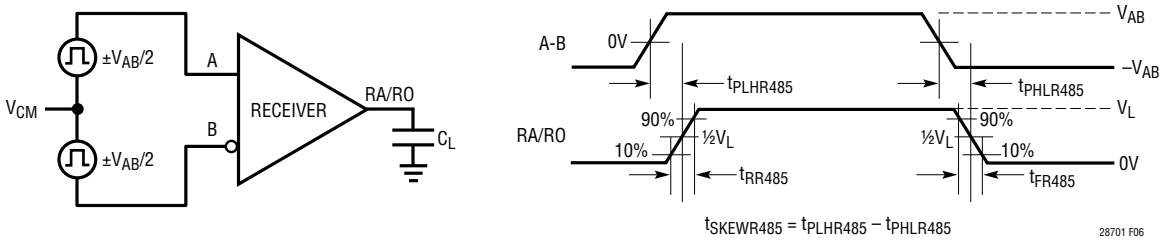


Figure 6. RS485 Receiver Propagation Delay Measurements (Note 5)

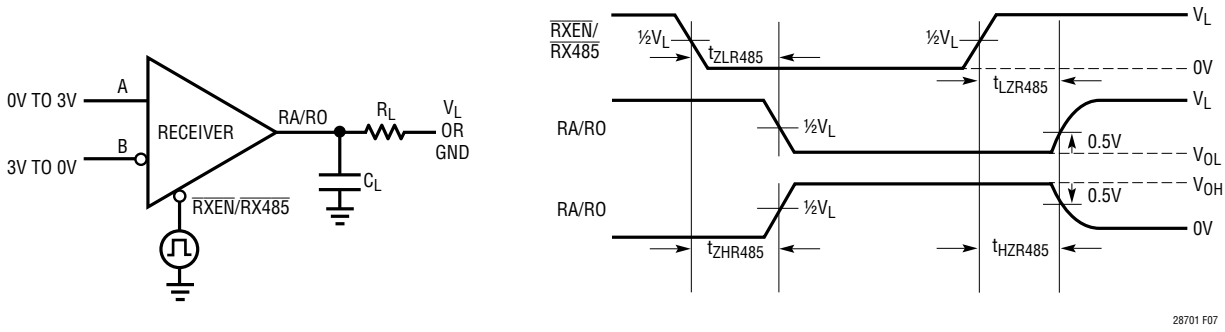


Figure 7. RS485 Receiver Enable and Disable Timing Measurements (Note 5)

TEST CIRCUITS

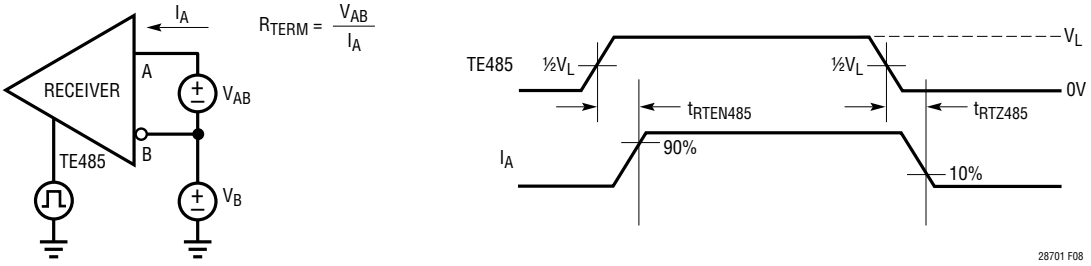


Figure 8. RS485 Termination Resistance and Timing Measurements (Note 5)

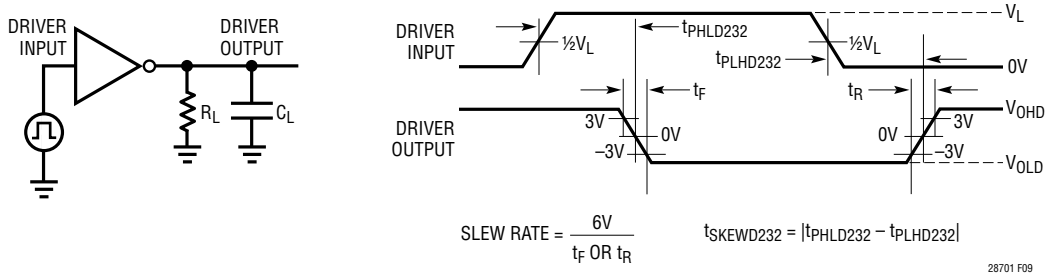


Figure 9. RS232 Driver Timing and Slew Rate Measurements

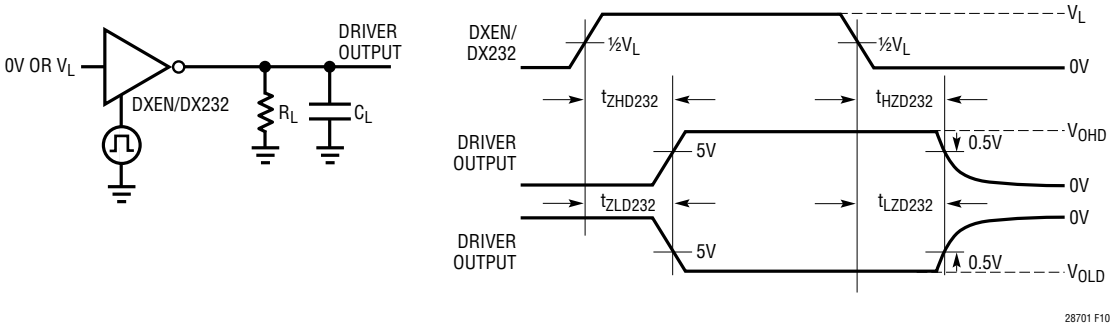


Figure 10. RS232 Driver Enable and Disable Times

TEST CIRCUITS

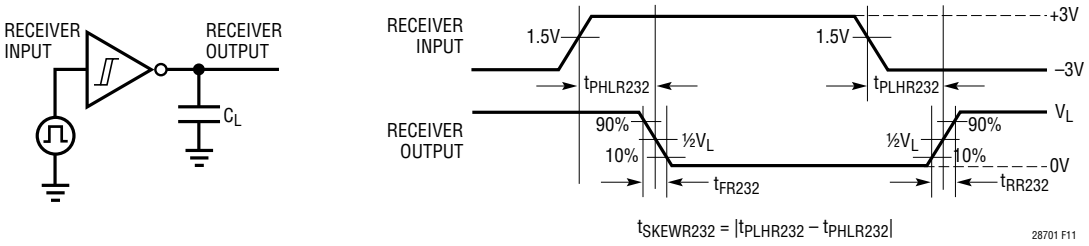


Figure 11. RS232 Receiver Timing Measurements

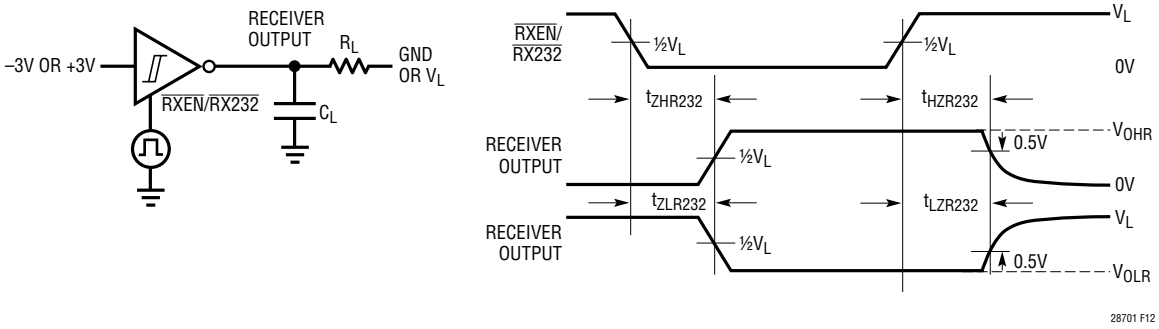


Figure 12. RS232 Receiver Enable and Disable Times

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. 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.

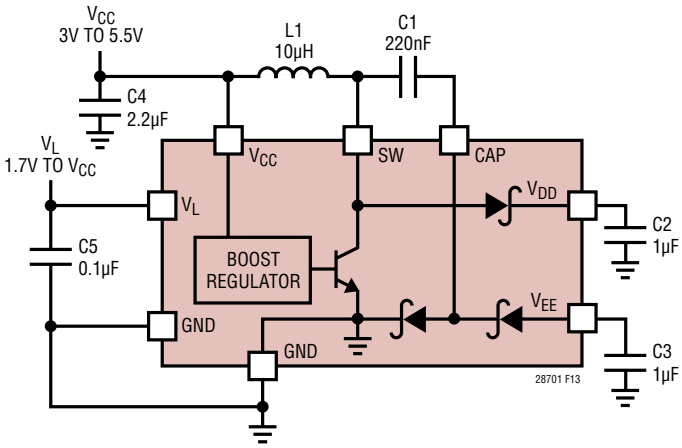


Figure 13. DC/DC Converter with Required External Components

Figure 14 shows the layout of external components on the bottom of the demonstration circuit for the LTC2871 (Demo Circuit 1786A). Refer to Layout Considerations section for further guidance.

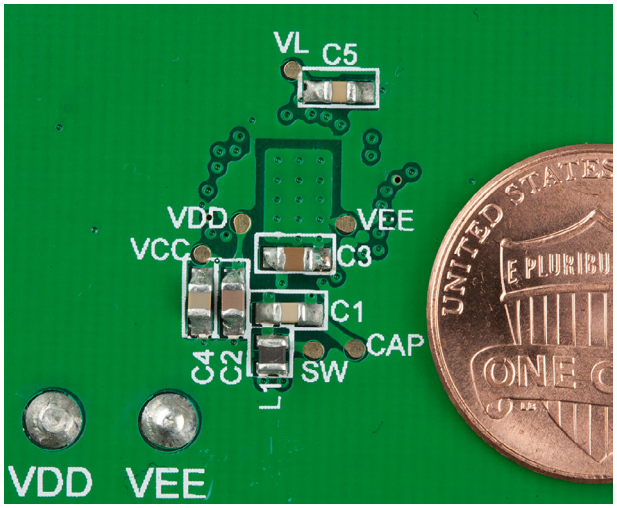


Figure 14. Demo Circuit 1786A (Bottom) Showing Layout of External Devices. U.S. Penny Included for Scale

APPLICATIONS INFORMATION

Multiple LTC2870 or LTC2871 devices can be powered using the boost regulator from only one of the devices, requiring only one inductor and flying cap. Since the RS232 drivers provide the primary load to the circuit, the following guidelines apply:

1. No more than four RS232 drivers can be supplied from a single device.
2. If more than two RS232 drivers are being supplied from a single device, then the inductor, L1, must be increased to 22µH and the flying cap, C1, must be increased to 470nH, and V_{DD} and V_{EE} bypass caps must be increased to 2.2µF.
3. Ground the SW pin on devices with inactive boost converters.
4. Connect CAP pins together for all devices.
5. Connect V_{EE} pins together for all devices.
6. Connect V_{DD} pins together for all devices.

Figures 51 and 52 show examples of connecting two devices and four devices.

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 very 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 CBC2016T100M	245 380	1.07 1.07	2 × 1.6 × 1.6 2 × 1.6 × 1.6	Taiyo Yuden www.t-yuden.com
FSLB2520-100K	220	1.1	2.5 × 2 × 1.6	Toko 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.

Running with External V_{DD} and V_{EE} Supplies

The inductor and flying cap, C1, can be omitted only if V_{DD} and V_{EE} are externally supplied. Bypass caps on V_{DD} and V_{EE} must remain in place. In this circumstance, ground the SW pin and float the CAP pin. External supplies must not exceed the ABSMAX levels of ±7.5V. Ideal supply levels are 7.3V and –6.5V as these are each just wider than the regulation points of 7.2V and –6.3V so the internal feedback is satisfied and the switching stops. Lower voltages can be used even at –6V and +6V but the internal boost regulator will be switching. This may cause some switching noise but will not harm the part. V_{DD} and V_{EE} supplies must be present for proper operation in all modes except shutdown, including RS485-only mode.

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 15. This precaution is not relevant for supply voltages below 4.5V or rise times longer than 10µs.

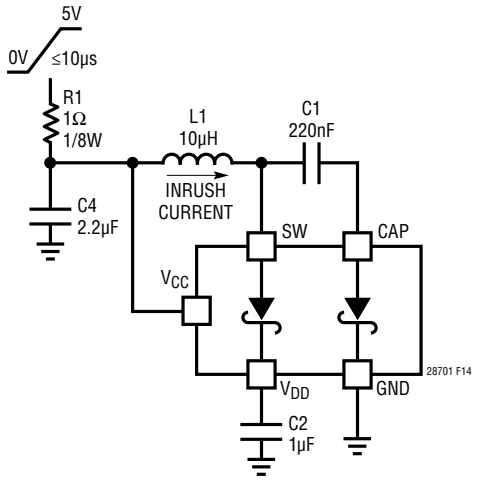


Figure 15. Supply Current Overshoot Protection for Input Supplies of 4.5V of Higher

APPLICATIONS INFORMATION

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 150mA 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}.

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 16, for a differential signal approaching from a negative direction, the threshold is typically +110mV. When approaching from the positive direction, the threshold is typically –110mV. Each of these thresholds has about 35mV 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.

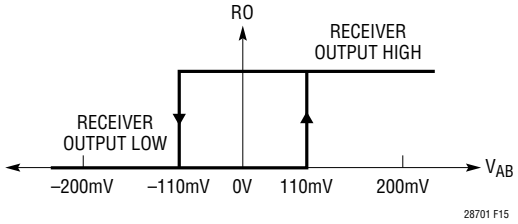


Figure 16. RS485 Receiver Input Threshold Characteristics

APPLICATIONS INFORMATION

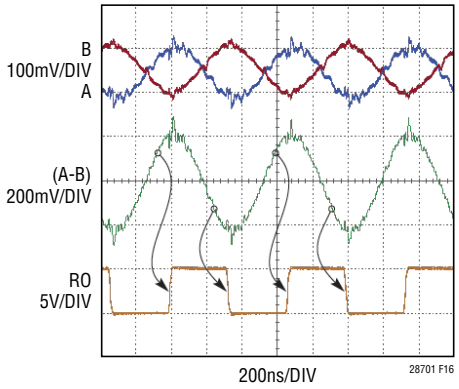


Figure 17. A 3Mbps Signal Driven Down 4000ft of CAT 5e Cable. Top Traces: Received Signals After Transmission Through Cable; Middle Trace: Math Showing Differences of Top Two Signals; Bottom Trace: Receiver Output

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 17, where a signal is driven through 4000 feet of CAT5e cable at 3Mbps. Even though the differential signal peaks at just over ±200mV 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 220mV for normal signals transitioning through the window region in less than approximately 0.7µs. Increasingly slower signals will have increasingly less effective hysteresis, limited by the DC failsafe value of about 35mV.

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 0.7µs. 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.

If a twisted pair has unbalanced capacitance from its two conductors to AC ground, common mode transients can translate into small differential voltages. If the common mode event is large and fast enough, the resulting differential voltage can cause a receiver, whose inputs are undriven, to change state momentarily. In these extreme conditions, high quality shielded cable is recommended. If necessary, biasing resistors can be used on the bus to pull the resting signal farther from the receivers failsafe threshold.

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.

APPLICATIONS INFORMATION

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 18.

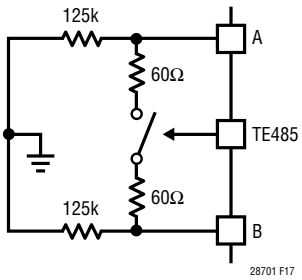


Figure 18. Equivalent RS485 Receiver Input Resistance Into A and B (Note 5)

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.

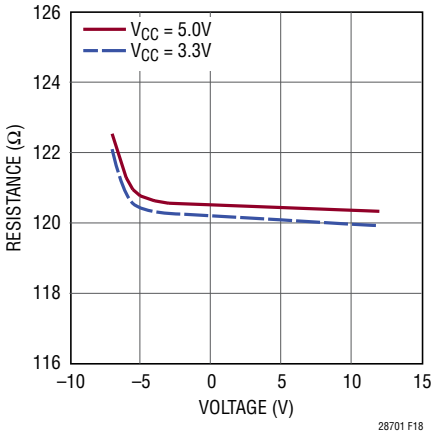


Figure 19. Typical Resistance of the Enabled RS485 Terminator vs Common Mode Voltage on A /B

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 19.

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.

RS485 Polarity and the LTC1334, LTC1387

The LTC2870/LTC2871 receiver uses A as the positive input and B as the negative input. The receiver output is a logic high when A–B is positive. For the RS485 driver, a high input produces a positive differential voltage on Y – Z. In contrast, the LTC1334 and LTC1387 dual protocol devices use the opposite RS485 convention: A is the negative receiver input, B is the positive receiver input, Y is the negative driver output, and Z is the positive driver output.

APPLICATIONS INFORMATION

The TIA/EIA-485 and TIA/EIA-422 standards do not definitively specify the polarity of the driver input (DI) or receiver output (RO) that correspond to the bus polarity (Y/Z/A/B). This has caused some contention among manufacturers of early devices, with some using one polarity and others using its opposite. However, today nearly all manufacturers, including Linear Technology, agree on the convention of A–B and Y–Z being positive for a logic high on DI and RO.

Because the LTC2870 was not designed to be a direct replacement of the LTC1387, the polarity of the RS485/422 signaling was updated to the more modern convention.

For LTC2870 signal compatibility with the LTC1387 or LTC1334, if the polarity of the RS485 cannot be reversed in the software, exclusive-OR logic gates can be used at the driver input and receiver outputs. Tie one of the logic gate inputs to RS485/RS232# and the other to DY or RA. When RS232 mode is selected, the signal is passed without inversion but in RS485 mode the output signal becomes inverted.

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.

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 20. 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.

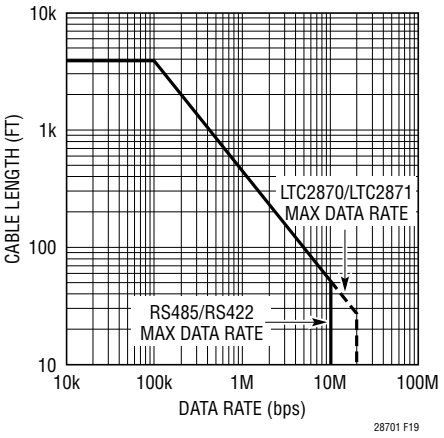


Figure 20. Cable Length vs Data Rate (RS485/RS422 Standard Shown in Vertical Solid Line)

APPLICATIONS INFORMATION

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. Figure 14, shows an excellent example of a layout for these external components on the bottom of the LTC2871 Demo Circuit 1786A.

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. External Components not shown.

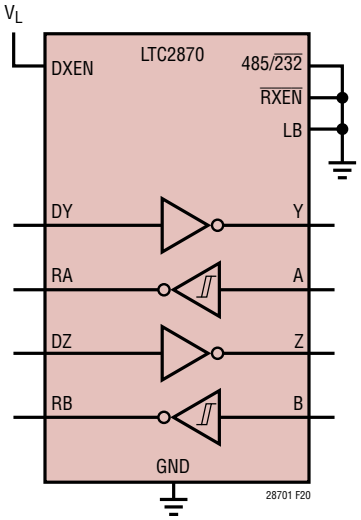


Figure 21. LTC2870 in RS232 Mode

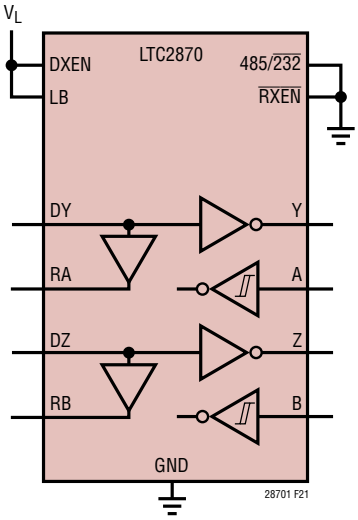


Figure 22. LTC2870 in RS232 Mode with Loopback

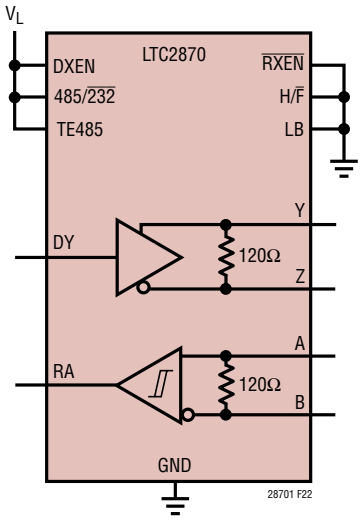


Figure 23. LTC2870 in RS485 Mode, Terminated

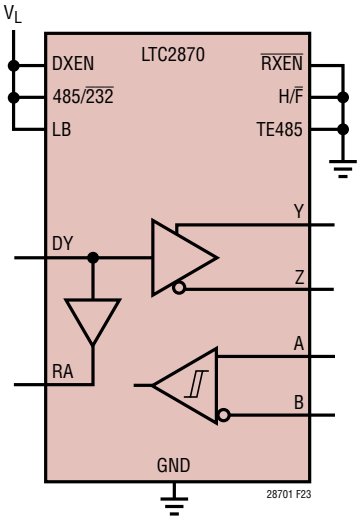


Figure 24. LTC2870 in RS485 Mode in Loopback

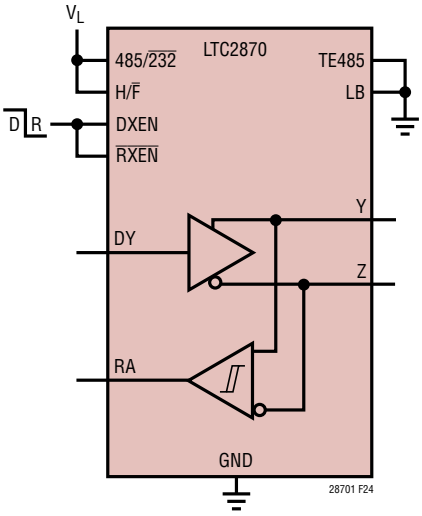


Figure 25. LTC2870 in RS485 Mode Half-Duplex

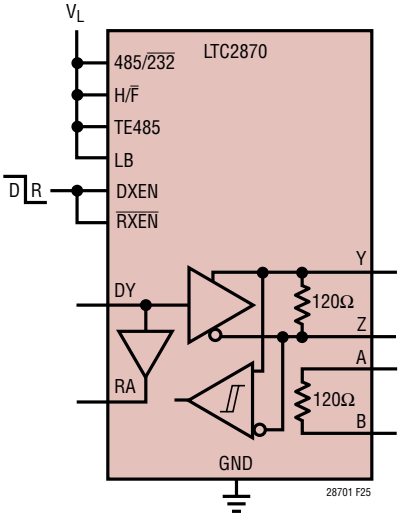


Figure 26. LTC2870 in RS485 Mode, Half-Duplex, with Loopback and Terminated

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. External Components not shown.

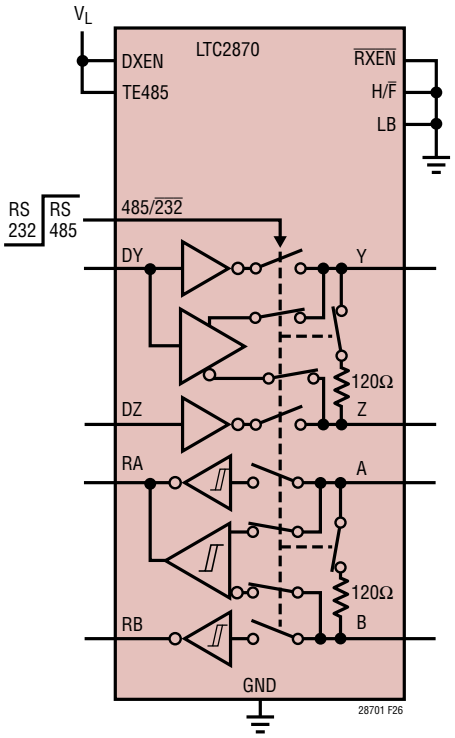


Figure 27. LTC2870 Protocol Switching

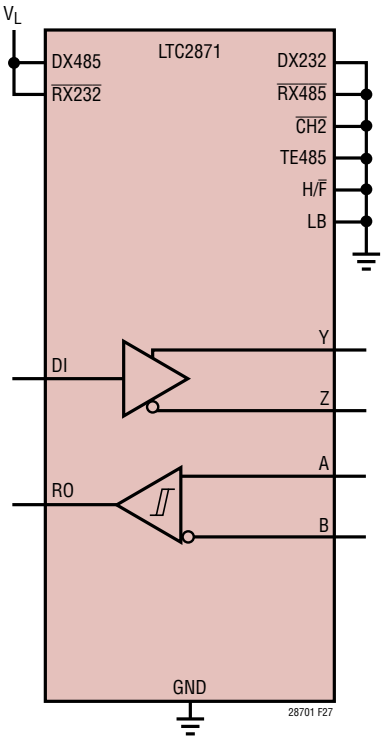


Figure 28. LTC2871 in RS485 Mode

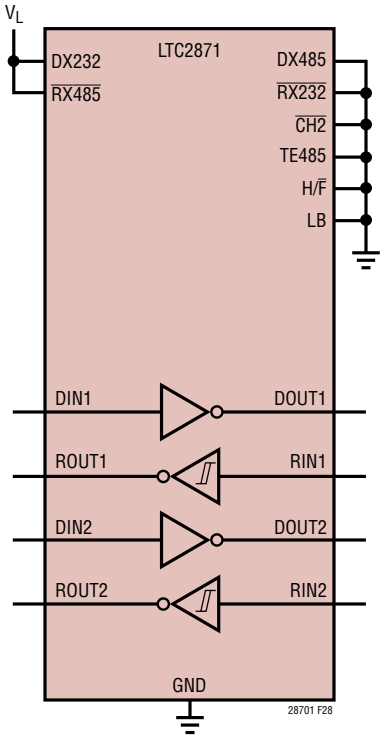


Figure 29. LTC2871 in RS232 Mode

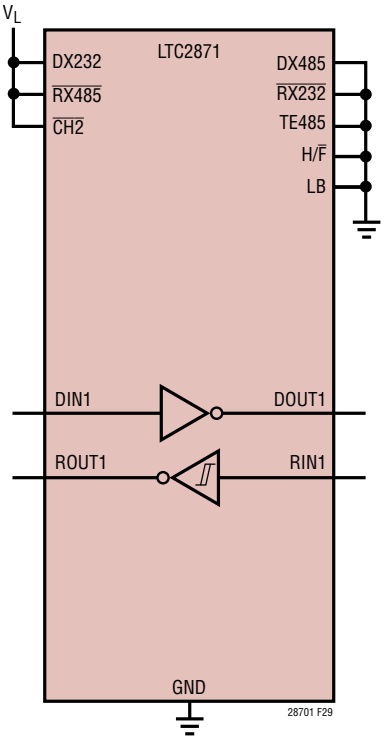


Figure 30. LTC2871 Single RS232 Channel Active

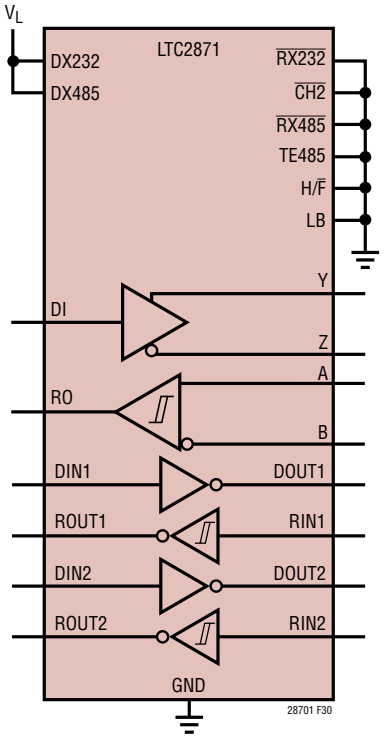


Figure 31. LTC2871 in RS485 and RS232 Mode

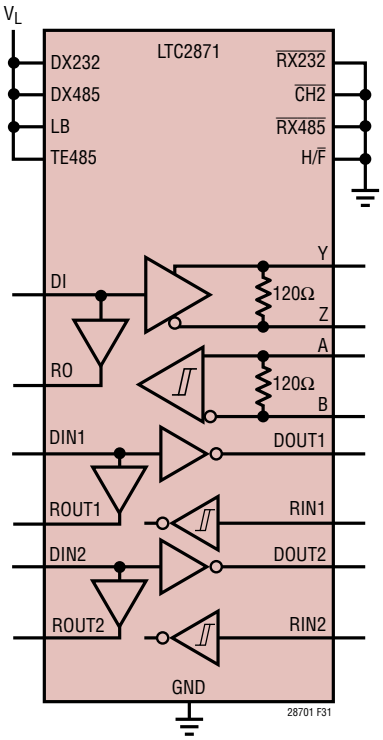


Figure 32. LTC2871 in RS485 and RS232 Mode with Loopback and RS485 Termination

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. External Components not shown.

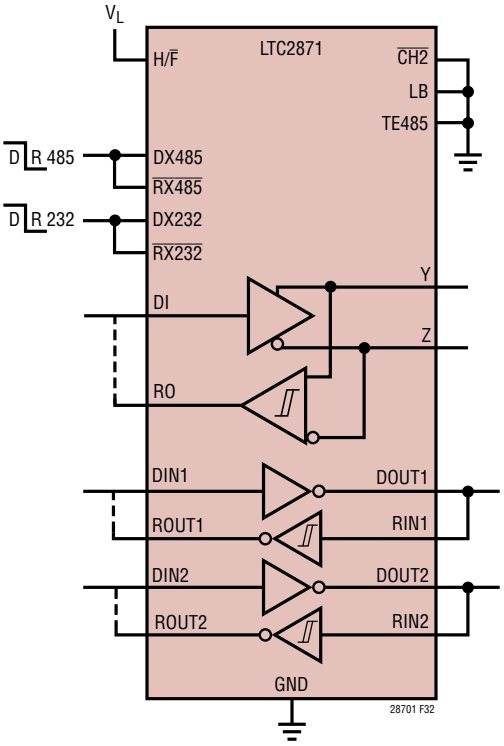


Figure 33. LTC2871 in RS485 and RS232 Mode, Both Half-Duplex

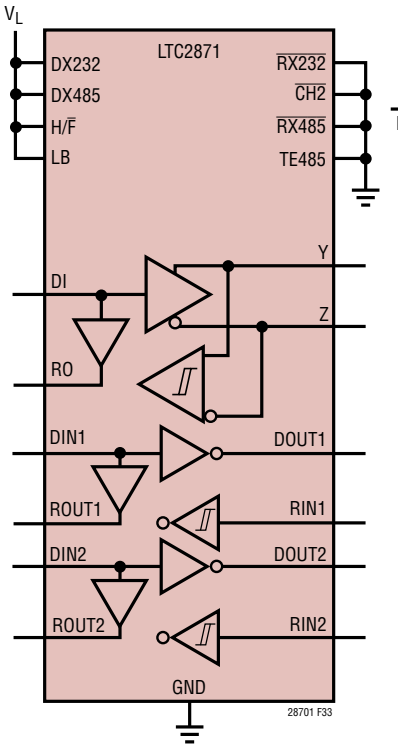


Figure 34. LTC2871 in RS485 and RS232 Mode, RS485 Half-Duplex, Loopback

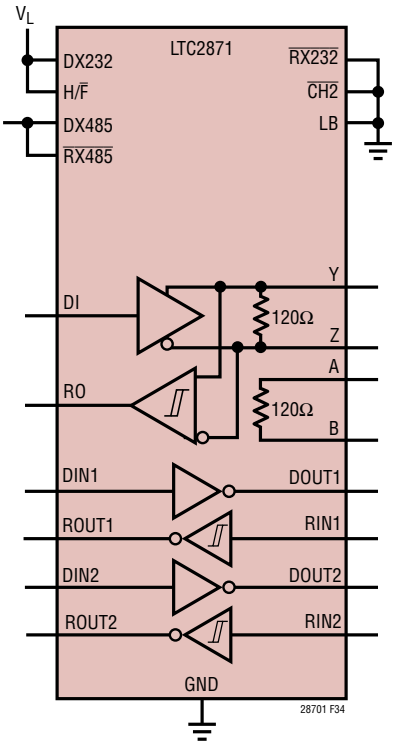


Figure 35. LTC2871 in RS485 and RS232 Mode, RS485 Half-Duplex, Terminated

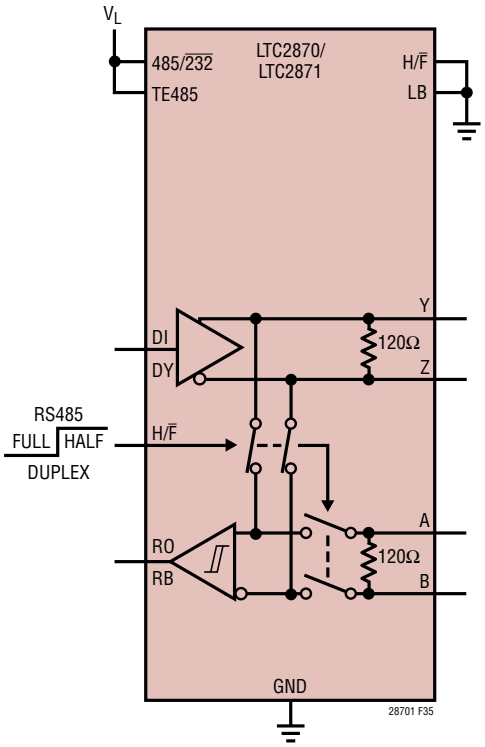


Figure 36. RS485 Duplex Switching

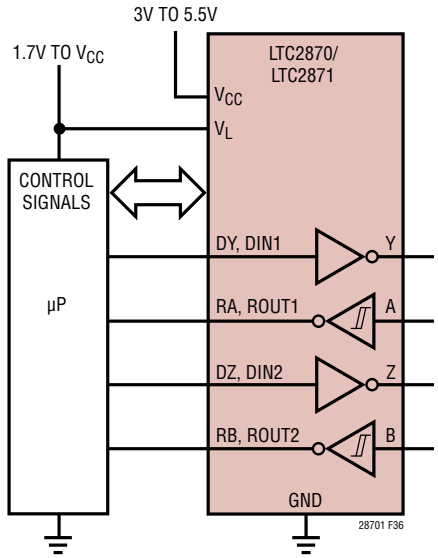


Figure 37. Microprocessor Interface

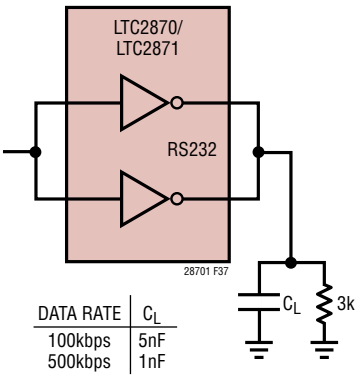


Figure 38. Driving Larger RS232 Loads

TYPICAL APPLICATIONS

Logic input pins not shown are tied to a valid logic state. External Components not shown.

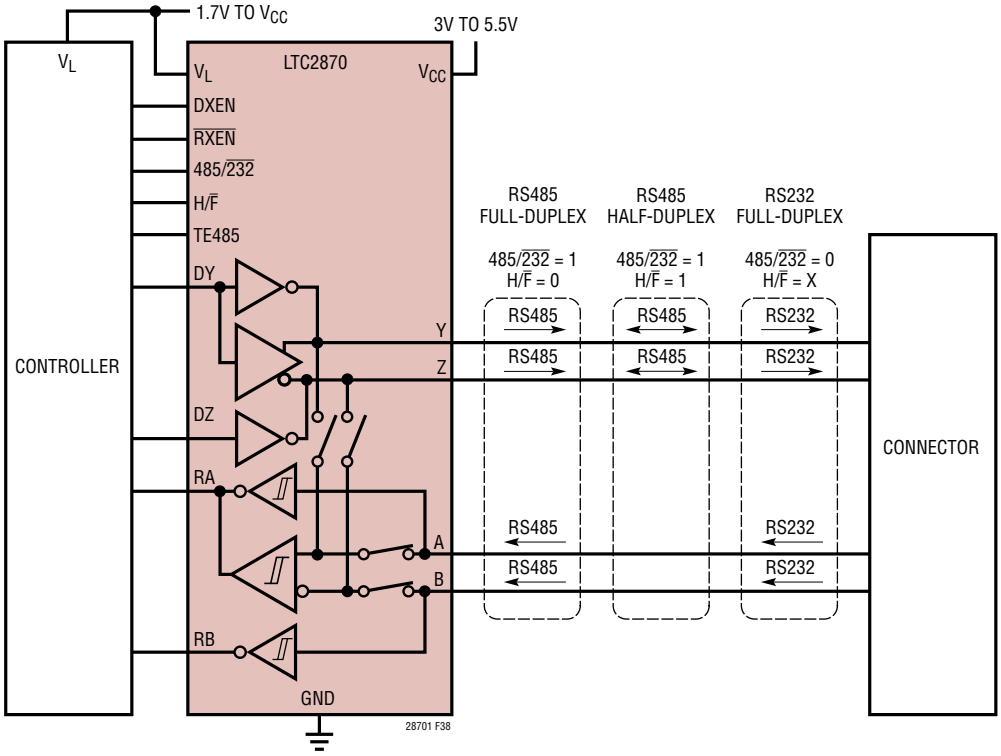


Figure 39. LTC2870: Making Use of Shared I/O for Various Communication Configurations

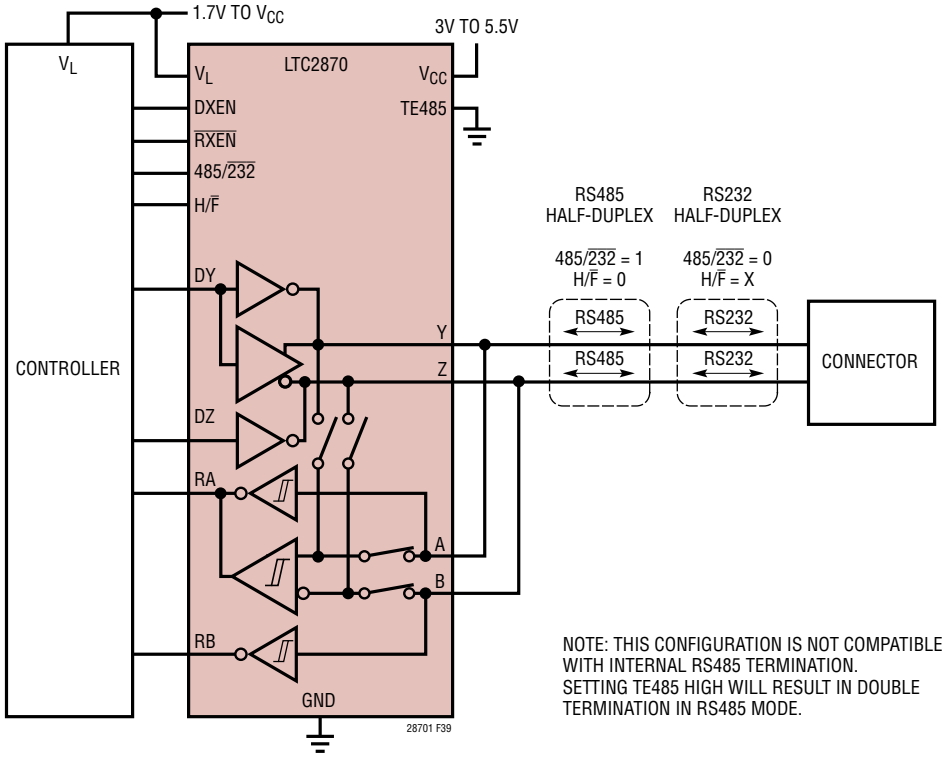


Figure 40. LTC2870: Using External Connections for Half-Duplex RS232 or RS485 Operation

TYPICAL APPLICATIONS

Logic input pins not shown are tied to a valid logic state. External Components not shown.

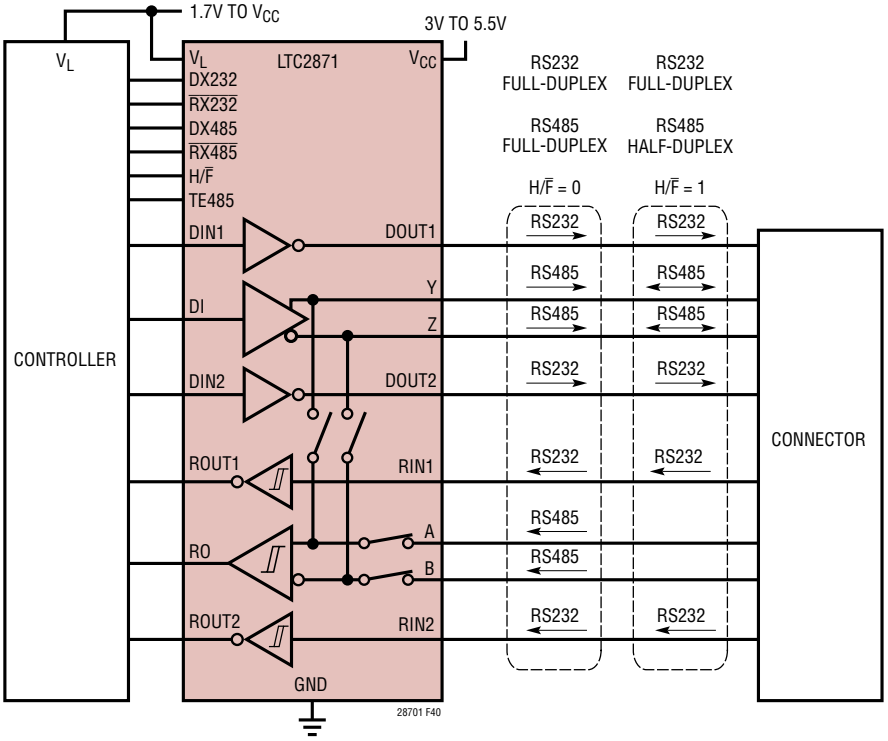


Figure 41. LTC2871: Various Communication Configurations

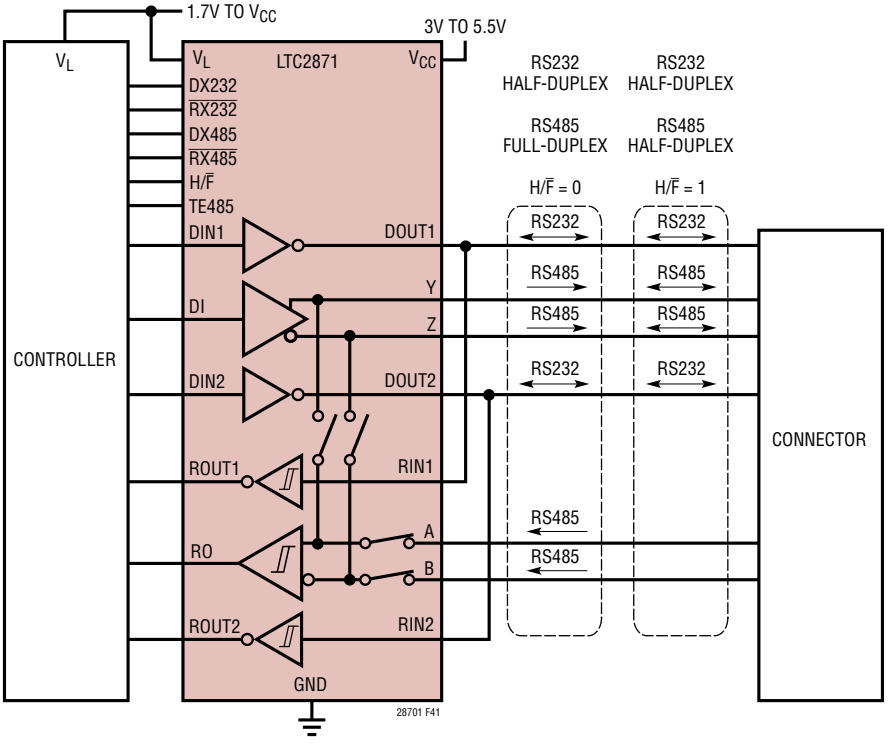
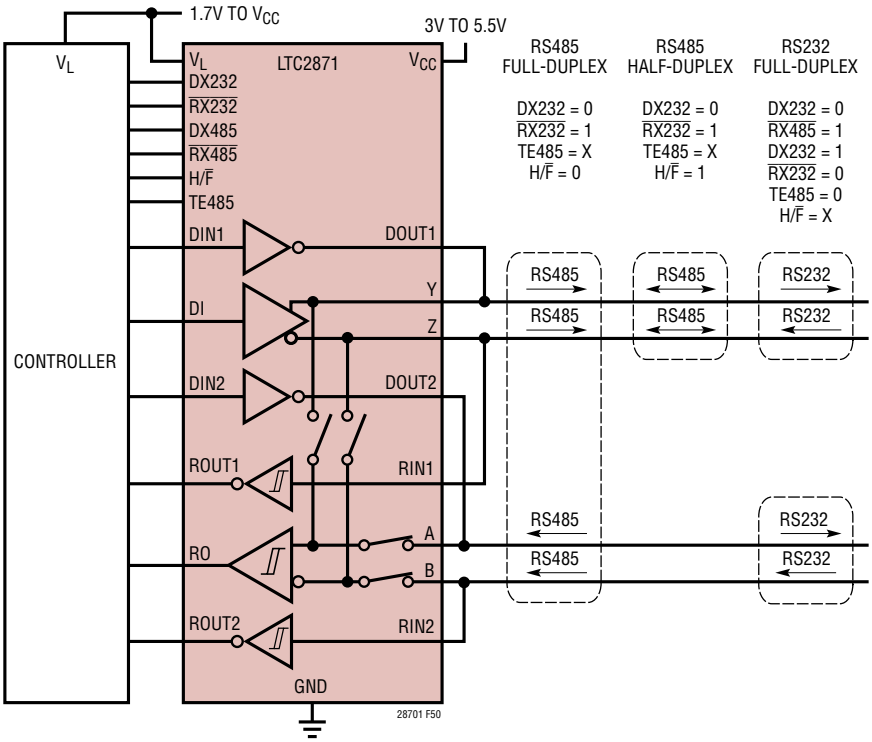


Figure 42. LTC2871: More Communication Configurations Using External Connections

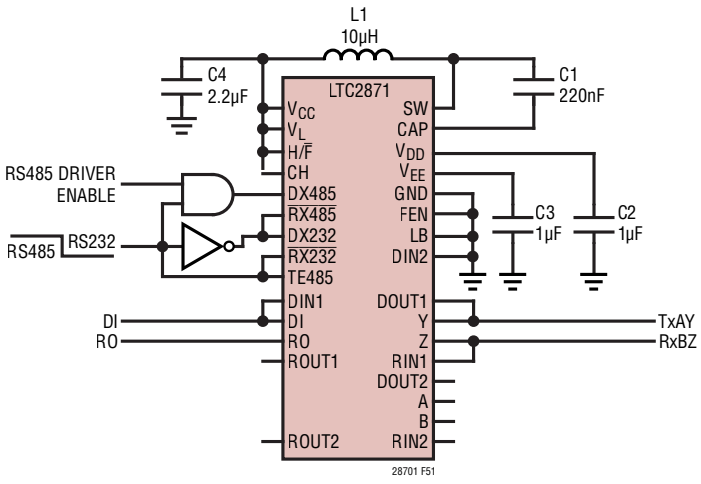
TYPICAL APPLICATIONS

Logic input pins not shown are tied to a valid logic state. External Components not shown.



This configuration allows for a two-wire interface (top two wires) operating in either RS485 half-duplex or RS232 full-duplex mode. A second pair of wires (bottom two wires) allows a second RS232 interface operating in full duplex mode and also allows for RS485 operating in full duplex mode. The two-wire application is comparable to the LTC1387 data sheet, Figure 14.

Figure 43. LTC2871: Using External Connections for RS485 (Half or Full Duplex) and RS232 (Full Duplex)



Two logic gates were added (optional) to simplify the control signals needed from the controller.

Figure 44. Schematic Implementation of Figure 43, Above, Using a Single Pair of Wires for the Bus I/O

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. External Components not shown.

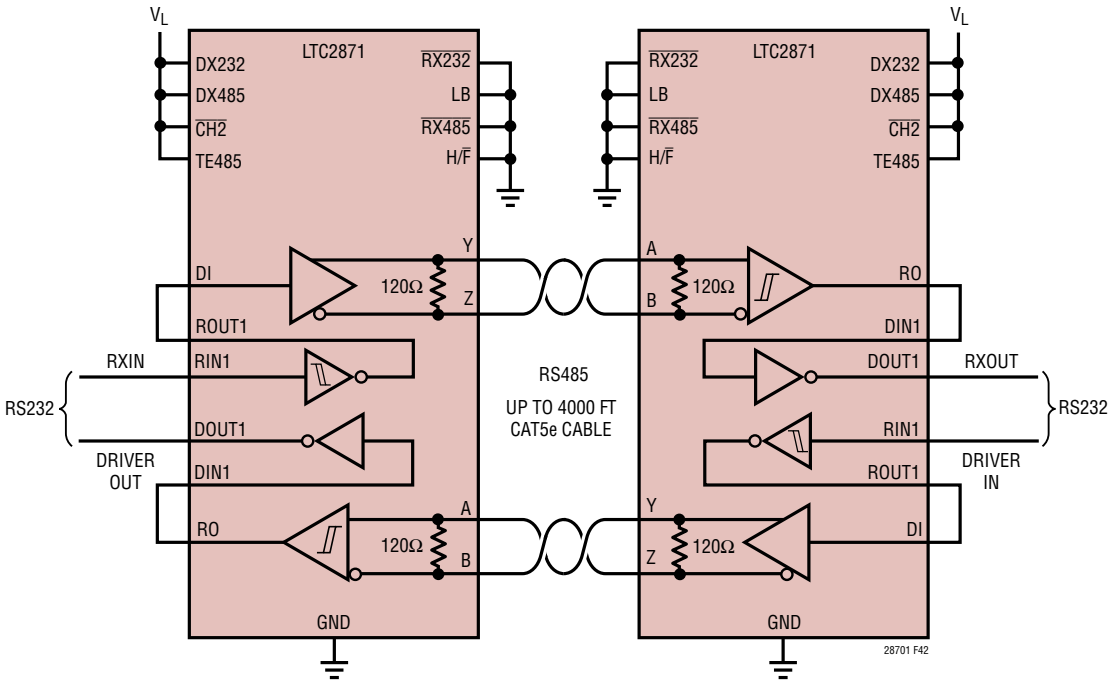


Figure 45. RS232 Extension Cord Using RS232 to RS485 Conversion

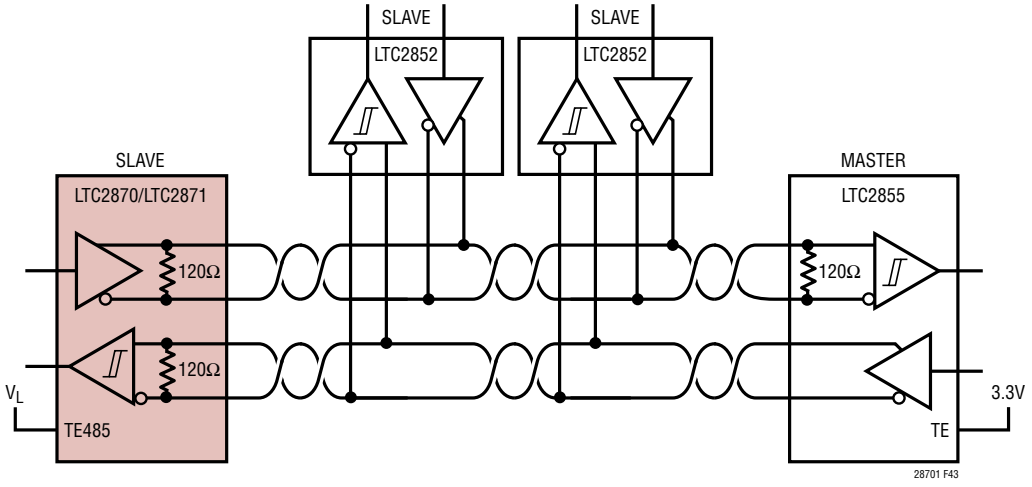


Figure 46. RS485 Full-Duplex Network

TYPICAL APPLICATIONS

Logic input pins not shown are tied to a valid logic state. External Components not shown.

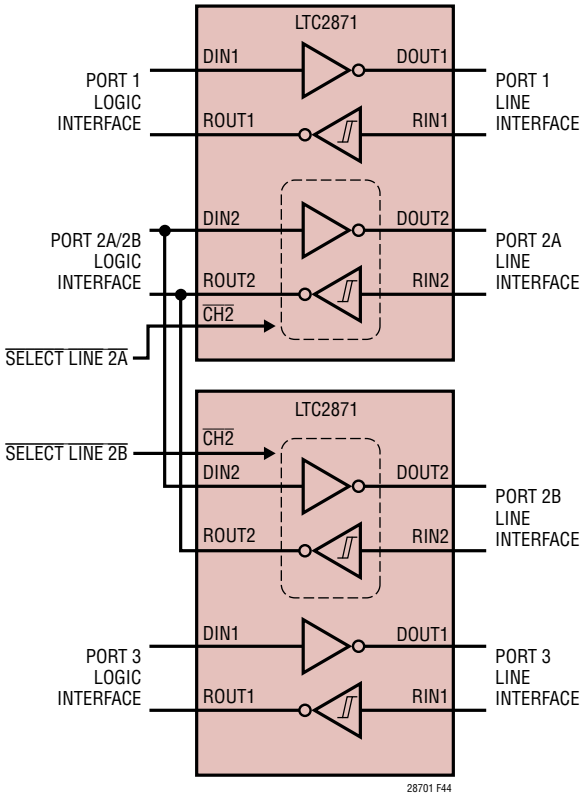


Figure 47. RS232 Triple Transceiver with Selectable Line Interface

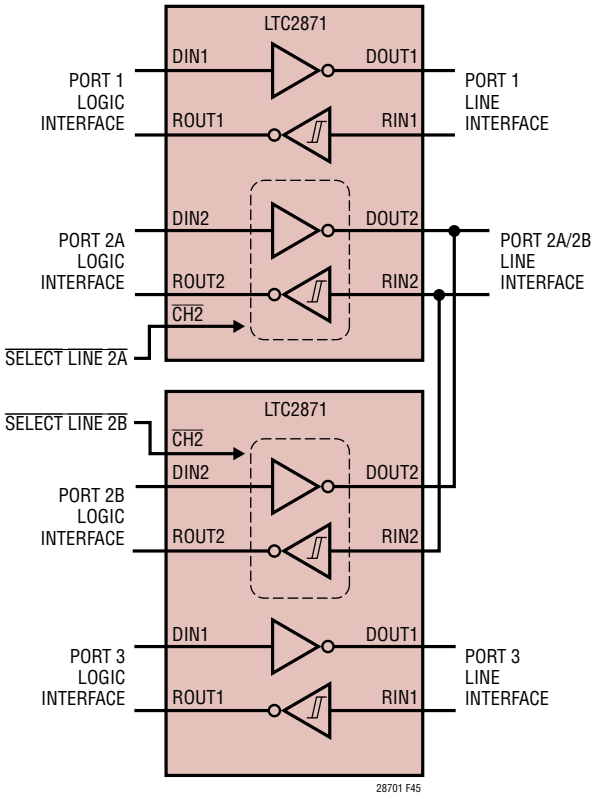


Figure 48. RS232 Triple Transceiver with Selectable Logic Interface

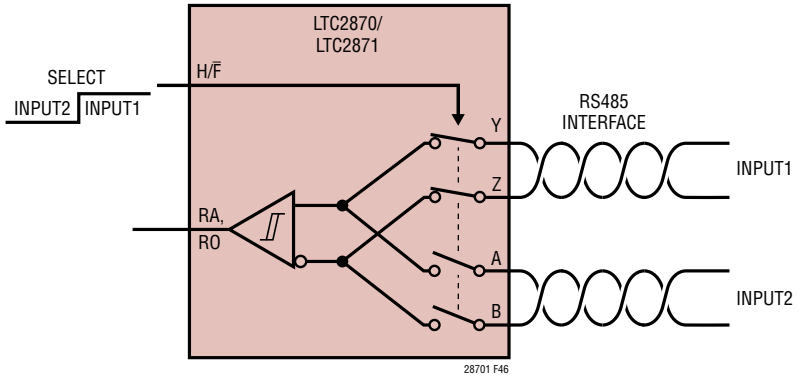


Figure 49. RS485 Receiver with Multiplexed Inputs

TYPICAL APPLICATIONS

Logic input pins not shown are tied to a valid logic state.

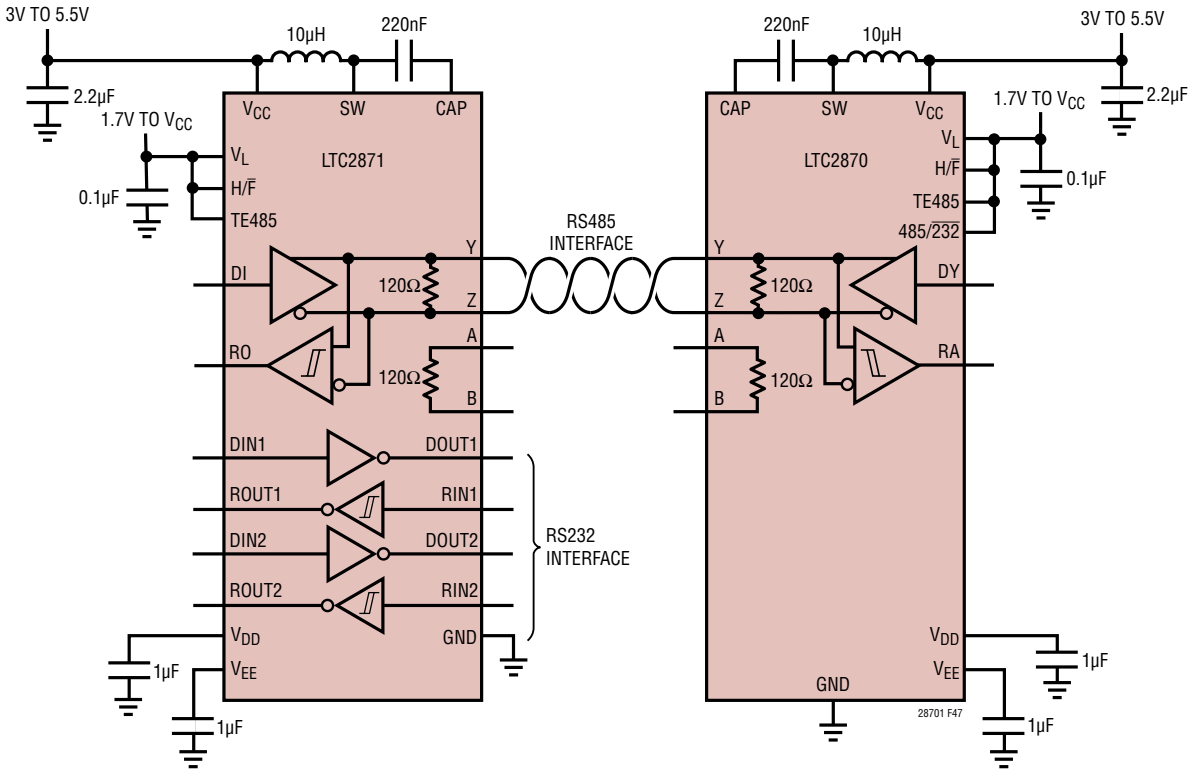
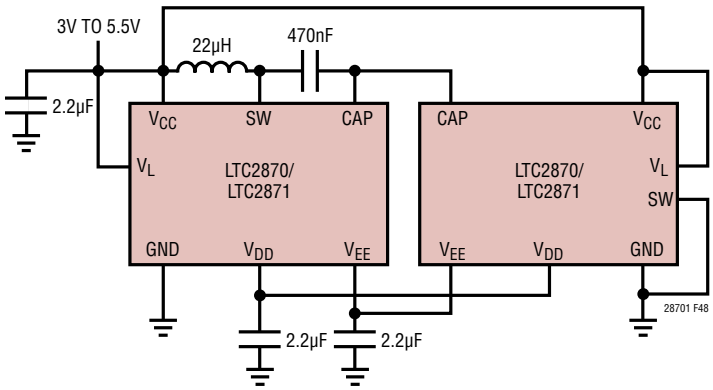


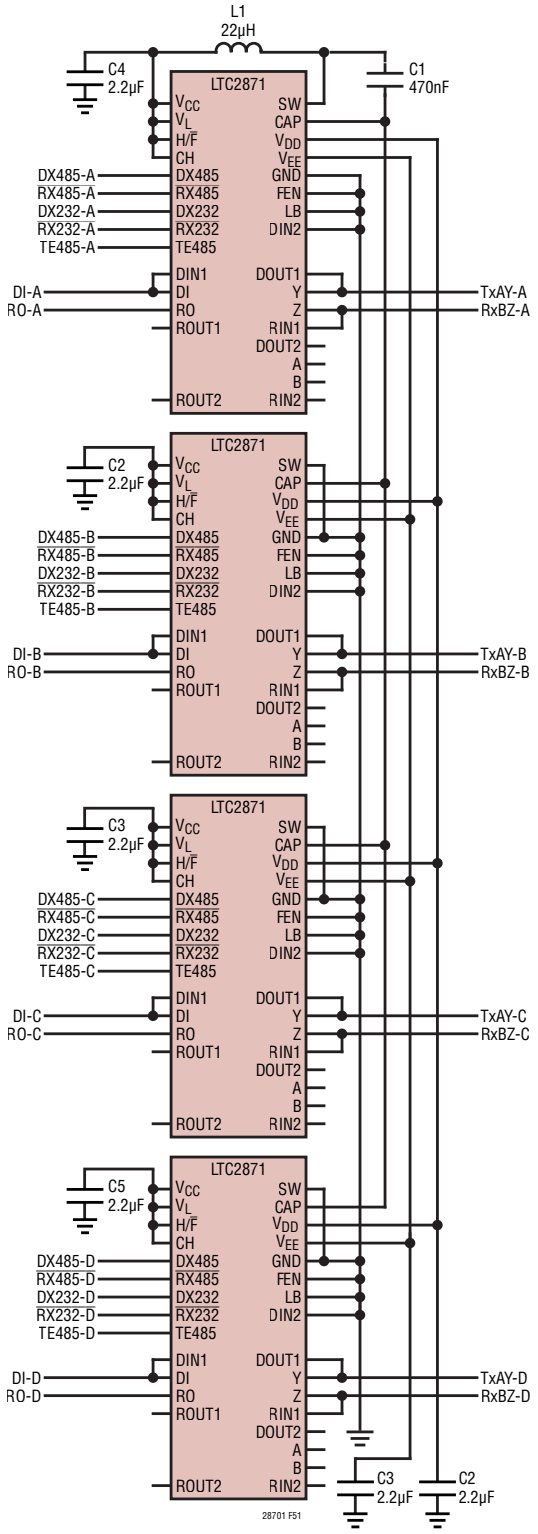
Figure 50. Typical Supply Connections with External Components Shown



INDUCTOR: TAIYO YUDEN CBC2518T220M,
MURATA LQH32CN220K53

Figure 51. Running Two LTC2870 or LTC2871 Devices from One Shared Power Source

TYPICAL APPLICATIONS



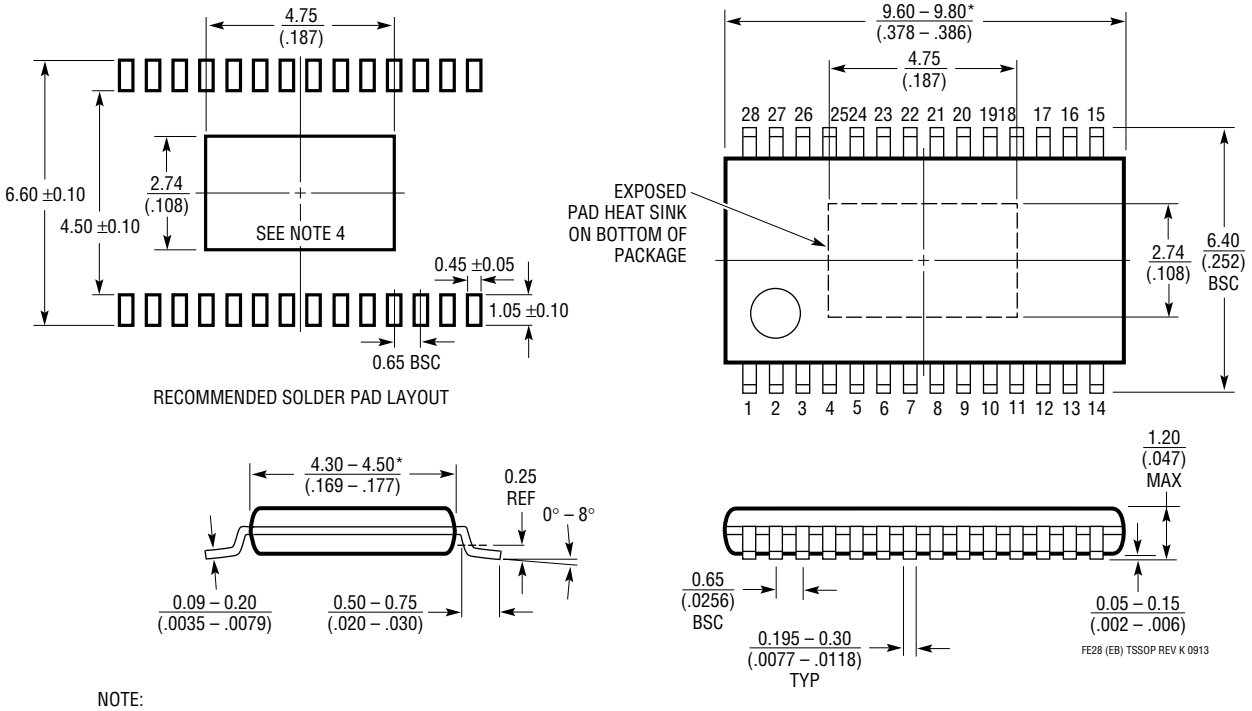
Each channel supports half-duplex RS485 or full-duplex RS232. Up to four RS232 drivers can be operated simultaneously using one inductor and flying cap as shown. I/O interface on left can be simplified with additional logic gates as shown in Figure 44

Figure 52. Quad Transceiver

PACKAGE DESCRIPTION

Please refer to http://www.linear.com/product/LTC2870#packaging for the most recent package drawings.

FE Package
28-Lead Plastic TSSOP (4.4mm)
(Reference LTC DWG # 05-08-1663 Rev K)
Exposed Pad Variation EB

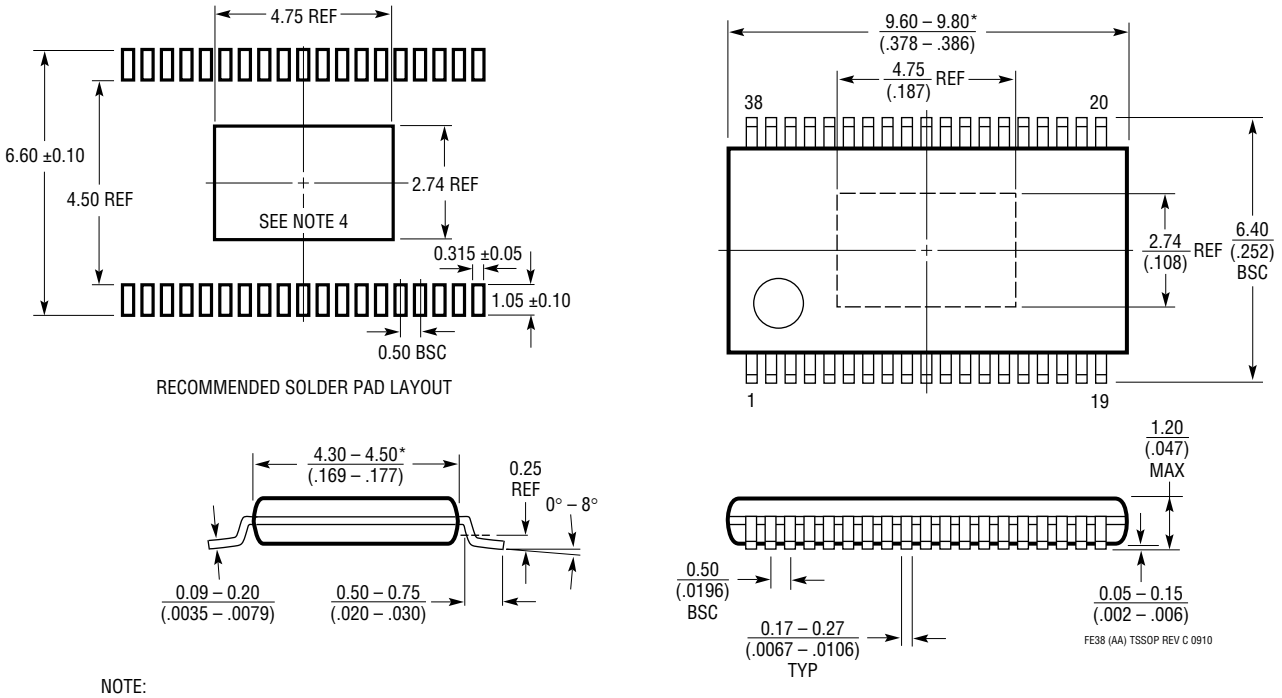


NOTE:
1. CONTROLLING DIMENSION: MILLIMETERS
2. DIMENSIONS ARE IN MILLIMETERS (INCHES)
3. DRAWING NOT TO SCALE
4. RECOMMENDED MINIMUM PCB METAL SIZE FOR EXPOSED PAD ATTACHMENT
*DIMENSIONS DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.150mm (.006") PER SIDE

PACKAGE DESCRIPTION

Please refer to http://www.linear.com/product/LTC2870#packaging for the most recent package drawings.

FE Package
38-Lead Plastic TSSOP (4.4mm)
(Reference LTC DWG # 05-08-1772 Rev C)
Exposed Pad Variation AA

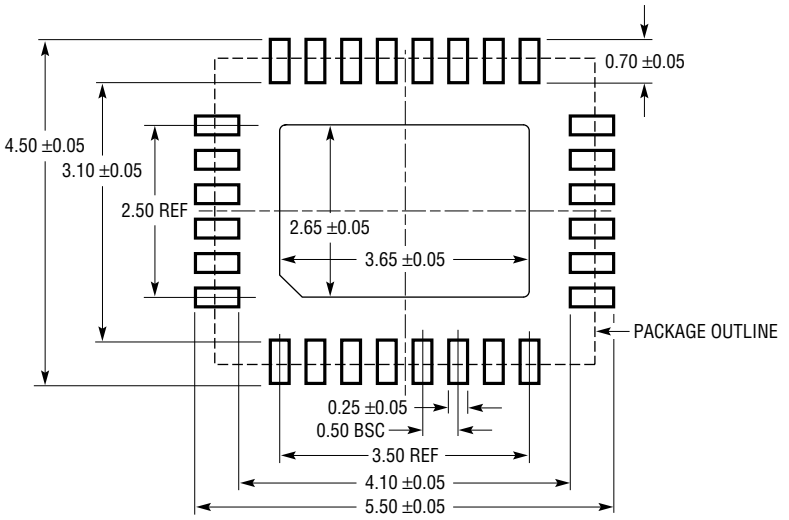


NOTE:
1. CONTROLLING DIMENSION: MILLIMETERS
2. DIMENSIONS ARE IN MILLIMETERS (INCHES)
3. DRAWING NOT TO SCALE
4. RECOMMENDED MINIMUM PCB METAL SIZE FOR EXPOSED PAD ATTACHMENT
*DIMENSIONS DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.150mm (.006") PER SIDE

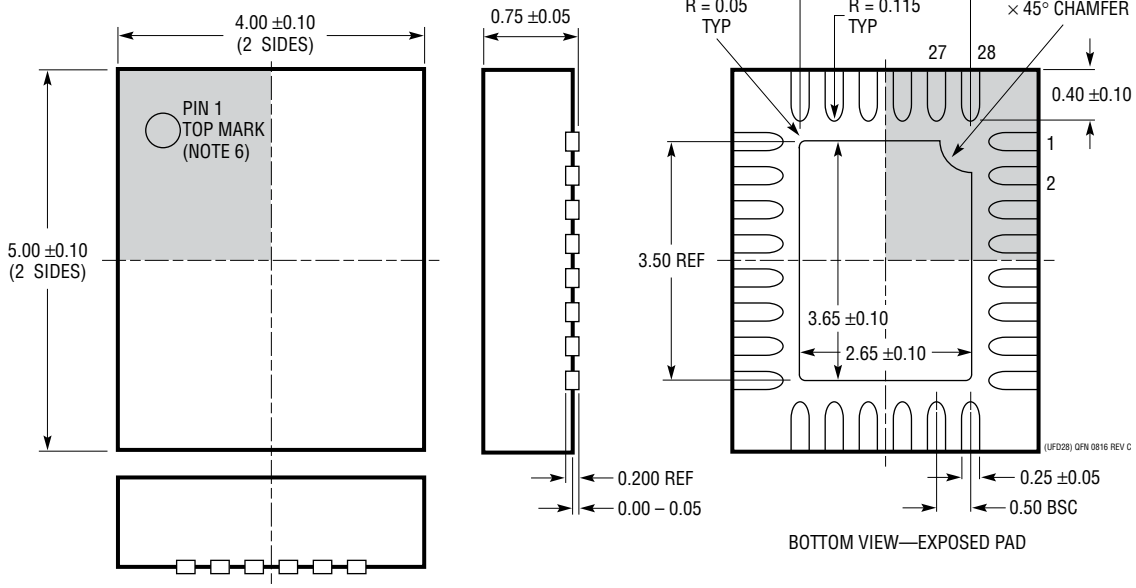
PACKAGE DESCRIPTION

Please refer to http://www.linear.com/product/LTC2870#packaging for the most recent package drawings.

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



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



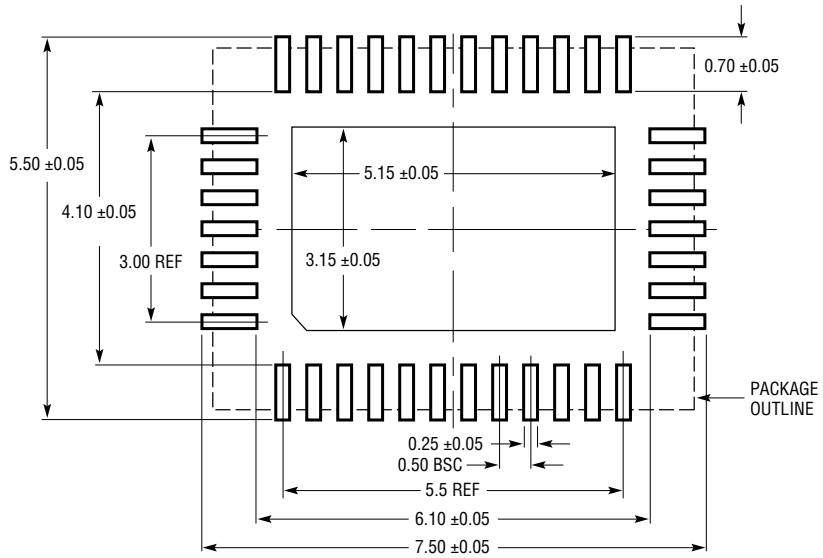
BOTTOM VIEW—EXPOSED PAD

NOTE:
1. DRAWING PROPOSED TO BE MADE A JEDEC PACKAGE OUTLINE MO-220 VARIATION (WGHD-3).
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

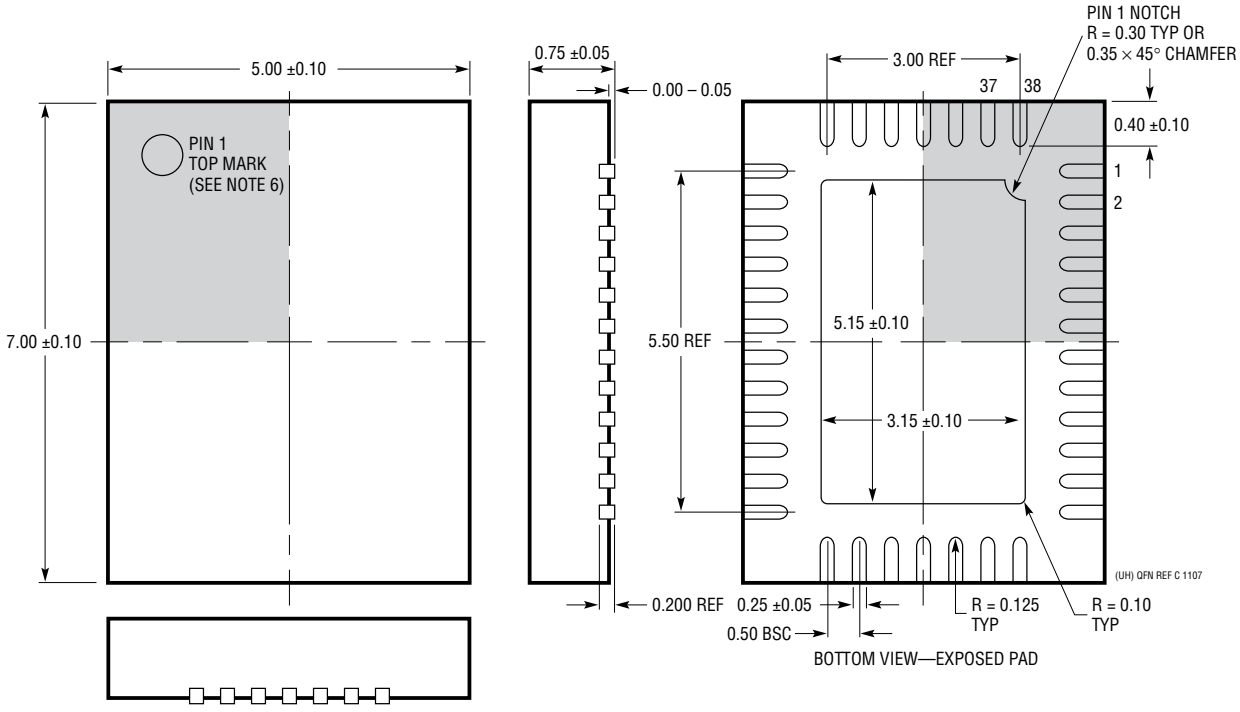
PACKAGE DESCRIPTION

Please refer to http://www.linear.com/product/LTC2870#packaging for the most recent package drawings.

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

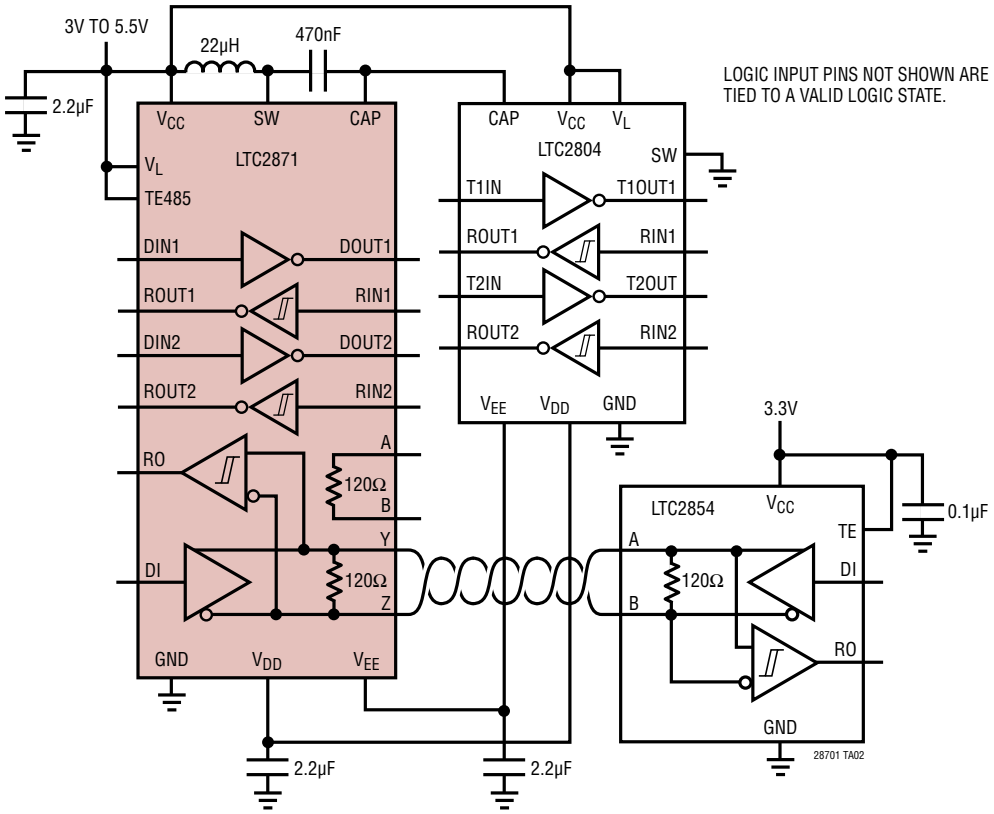
REVISION HISTORY

REV	DATE	DESCRIPTION	PAGE NUMBER
A	11/14	Added H-Grade (–40°C to 125°C)	1-40
		Removed Absolute Maximum Ratings for $V_{DD} – V_{EE}$	2
		Increased T_{JMAX} to 150°C	3
		Noted which pins should not float	10-11
		Expanded DC/DC Converter Applications section	20-21
		Added Running with External V_{DD} and V_{EE} Supplies Applications section	21
		Expanded RS485 Biasing Resistors Not Required Applications section	23
		Added RS485 Polarity and the LTC1334, LTC1387 Applications section	24-25
		Added Standards Compatibility Applications section	26
		Revised Figures 25, 26, and 35	27, 29
		Added Figures 43, 44, and 52	32, 36
B	08/17	Increased Input Hysteresis (TYP), decreased Differential Input Failsafe Threshold Voltage (TYP), and increased Input DC Failsafe Hysteresis.	4
		Increased maximum V_{CC} back-current in fault condition.	22

Information furnished by Linear Technology Corporation is believed to be accurate and reliable. However, no responsibility is assumed for its use. Linear Technology Corporation makes no representation that the interconnection of its circuits as described herein will not infringe on existing patent rights.

TYPICAL APPLICATION

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



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC2873	RS232/RS485 Single-Bus Multiprotocol Transceiver with Integrated Termination	One RS232 Transceiver and One RS485 Transceiver on the Same Bus Pins. 3V to 5.5V Supply with 1.7V to 5.5V Logic Interface
LTC2872	RS232/RS485 Dual Multiprotocol Transceiver with Integrated Termination	Four RS232 Transceivers and Two RS485 Transceivers. 3V to 5.5V Supply with 1.7V to 5.5V Logic Interface, Automatic Selection of Termination Resistors, Duplex Control, Logic Supply Pin
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, 2500V_{RMS} Isolation with Integrated DC/DC Converter, Integrated, Switchable, 120Ω Termination Resistor, 15kV ESD
LTM2885	6500V_{RMS} Isolated RS485/RS232 µModule Transceiver + Power	20Mbps, 6500V_{RMS} Isolation with Integrated DC/DC Converter, Integrated Switchable 120Ω Termination Resistor, ±15kV ESD, 5V Supply
LTM2882	Dual Isolated RS232 µModule Transceiver + Power	1Mbps, 2500V_{RMS} Isolation with Integrated DC/DC Converter, ±10kV ESD

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