

## ABSOLUTE MAXIMUM RATINGS

**(Note 1)**

V<sub>CC</sub> Voltage..... -0.3V to 6.5V

V<sub>IN</sub> Voltage ..... -0.3V to 6.5V

### Input Voltage

Transmitters .....  $-0.3\text{V}$  to  $(V_{CC} + 0.3\text{V})$

Receivers ..... -18V to 18V

Logic Pins .....  $-0.3\text{V}$  to  $(V_{CC} + 0.3\text{V})$

### Output Voltage

Transmitters ..... ( $V_{FF} - 0.3V$ ) to ( $V_{DD} + 0.3V$ )

Receivers .....  $-0.3V$  to  $(V_{IN} + 0.3V)$ 

V<sub>FF</sub>..... -10V to 0.3V

$V_{DD}$  ..... -0.3V to 10V

### Short-Circuit Duration

Transmitter Output ..... Indefinite

Receiver Output..... Indefinite

 $V_{FF} \dots\dots\dots 30 \text{ sec}$ 

### Operating Temperature Range

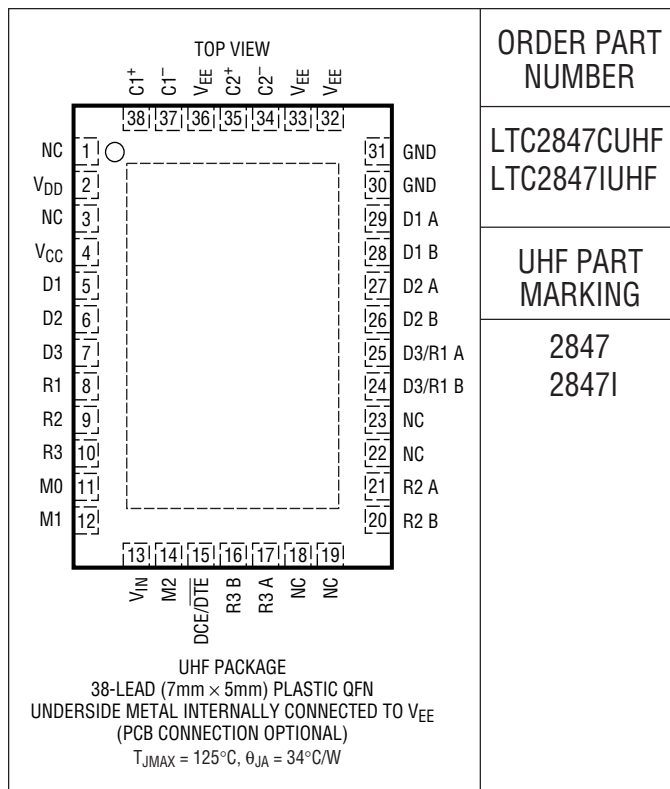
LTC2847C ..... 0°C to 70°C

LTC2847 | ..... -40°C to 85°C

Storage Temperature Range ..... -65°C to 150°C

Lead Temperature (Soldering, 10 sec)..... 300°C

## PACKAGE/ORDER INFORMATION



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

## ELECTRICAL CHARACTERISTICS

**ELECTRICAL CHARACTERISTICS** The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V_{CC} = 5\text{V}$ ,  $V_{IN} = 3.3\text{V}$ , unless otherwise noted (Notes 2, 3)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
<b>Supplies</b>						
I <sub>CC</sub>	V <sub>CC</sub> Supply Current (DCE Mode, All Digital Pins = GND or V <sub>IN</sub> )	RS530, RS530-A, X.21 Modes, No Load		14		mA
		RS530, RS530-A, X.21 Modes, Full Load	●	100	130	mA
		V.35 Mode	●	126	170	mA
		V.28 Mode, No Load		20		mA
		V.28 Mode, Full Load	●	35	75	mA
		No-Cable Mode	●	300	900	μA
I <sub>VIN</sub>	V <sub>IN</sub> Supply Current (DCE Mode, All Digital Pins = GND or V <sub>IN</sub> )	All Modes Except No-Cable Mode		405		μA
P <sub>D</sub>	Internal Power Dissipation (DCE Mode)	RS530, RS530-A, X.21 Modes, Full Load		410		mW
		V.35 Mode, Full Load		625		mW
		V.28 Mode, Full Load		150		mW
V <sup>+</sup>	Positive Charge Pump Output Voltage	V.11 or V.28 Mode, No Load	●	8	9.3	V
		V.35 Mode	●	7	8.0	V
		V.28 Mode, with Load	●	8	8.7	V
		V.28 Mode, with Load, I <sub>DD</sub> = 10mA			6.5	V

# ELECTRICAL CHARACTERISTICS

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SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$V^-$	Negative Charge Pump Output Voltage	V.28 Mode, No Load	●	–9.6		V
		V.28 Mode, Full Load	●	–7.5	–8.5	V
		V.35 Mode	●	–5.5	–6.5	V
		RS530, RS530-A, X.21 Modes, Full Load	●	–4.5	–6.0	V
$f_{OSC}$	Charge Pump Oscillator Frequency			500		kHz
$t_r$	Charge Pump Rise Time	No-Cable Mode/Power-Off to Normal Operation		2		ms

## Logic Inputs and Outputs

$V_{IH}$	Logic Input High Voltage	D1, D2, D3, M0, M1, M2, DCE/ $\overline{\text{DTE}}$	●	2.0		V
$V_{IL}$	Logic Input Low Voltage	D1, D2, D3, M0, M1, M2, DCE/ $\overline{\text{DTE}}$	●		0.8	V
$I_{IN}$	Logic Input Current	D1, D2, D3	●		$\pm 10$	$\mu\text{A}$
		M0, M1, M2, DCE/ $\overline{\text{DTE}} = \text{GND}$	●	–30	–75	$\mu\text{A}$
		M0, M1, M2, DCE/ $\overline{\text{DTE}} = V_{IN}$	●		$\pm 10$	$\mu\text{A}$
$V_{OH}$	Output High Voltage	$I_O = -3\text{mA}$	●	2.7	3	V
$V_{OL}$	Output Low Voltage	$I_O = 1.6\text{mA}$	●		0.2	V
$I_{OSR}$	Output Short-Circuit Current	$0\text{V} \leq V_O \leq V_{IN}$	●		$\pm 50$	mA
$I_{OZR}$	Three-State Output Current	M0 = M1 = M2 = $V_{IN}$ , $V_O = \text{GND}$	●	–30	–85	$\mu\text{A}$
		M0 = M1 = M2 = $V_{IN}$ , $V_O = V_{IN}$	●		$\pm 10$	$\mu\text{A}$

## V.11 Driver

V <sub>ODO</sub>	Open Circuit Differential Output Voltage	R <sub>L</sub> = 1.95k (Figure 1)	●	±5			V
V <sub>ODL</sub>	Loaded Differential Output Voltage	R <sub>L</sub> = 50Ω (Figure 1) R <sub>L</sub> = 50Ω (Figure 1)	●	0.5V <sub>ODO</sub> ±2	0.67V <sub>ODO</sub>		V V
ΔV <sub>OD</sub>	Change in Magnitude of Differential Output Voltage	R <sub>L</sub> = 50Ω (Figure 1)	●	0.2			V
V <sub>OC</sub>	Common Mode Output Voltage	R <sub>L</sub> = 50Ω (Figure 1)	●	3			V
ΔV <sub>OC</sub>	Change in Magnitude of Common Mode Output Voltage	R <sub>L</sub> = 50Ω (Figure 1)	●	0.2			V
I <sub>SS</sub>	Short-Circuit Current	V <sub>OUT</sub> = GND		±150			mA
I <sub>OZ</sub>	Output Leakage Current	V <sub>A</sub>   and  V <sub>B</sub>   ≤ 0.25V, Power Off or No-Cable Mode or Driver Disabled	●	±1	±100		μA
t <sub>r</sub> , t <sub>f</sub>	Rise or Fall Time	(Figures 2, 13)	●	2	15	25	ns
t <sub>PLH</sub>	Input to Output Rising	(Figures 2, 13)	●	15	40	65	ns
t <sub>PHL</sub>	Input to Output Falling	(Figures 2, 13)	●	15	40	65	ns
Δt	Input to Output Difference,  t <sub>PLH</sub> – t <sub>PHL</sub>	(Figures 2, 13)	●	0	3	12	ns
t <sub>SKEW</sub>	Output to Output Skew	(Figures 2, 13)		3			ns

# ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V_{CC} = 5\text{V}$ ,  $V_{IN} = 3.3\text{V}$ , unless otherwise noted (Notes 2, 3)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V.11 Receiver							
V <sub>TH</sub>	Input Threshold Voltage	−7V ≤ V <sub>CM</sub> ≤ 7V	●	−0.2		0.2	V
ΔV <sub>TH</sub>	Input Hysteresis	−7V ≤ V <sub>CM</sub> ≤ 7V	●		15	40	mV
R <sub>IN</sub>	Input Impedance	−7V ≤ V <sub>CM</sub> ≤ 7V (Figure 3)	●	100	103		Ω
t <sub>r</sub> , t <sub>f</sub>	Rise or Fall Time	C <sub>L</sub> = 50pF (Figures 4, 14)			15		ns
t <sub>PLH</sub>	Input to Output Rising	C <sub>L</sub> = 50pF (Figures 4, 14)	●		50	90	ns
t <sub>PHL</sub>	Input to Output Falling	C <sub>L</sub> = 50pF (Figures 4, 14)	●		50	90	ns
Δt	Input to Output Difference,  t <sub>PLH</sub> − t <sub>PHL</sub>	C <sub>L</sub> = 50pF (Figures 4, 14)	●	0	4	25	ns
V.35 Driver							
V <sub>OD</sub>	Differential Output Voltage	Open Circuit, R <sub>L</sub> = 1.95k (Figure 5) With Load, −4V ≤ V <sub>CM</sub> ≤ 4V (Figure 6)	●	±0.44	±0.55	±1.2 ±0.66	V V
V <sub>OA</sub> , V <sub>OB</sub>	Single-Ended Output Voltage	Open Circuit, R <sub>L</sub> = 1.95k (Figure 5)	●			±1.2	V
V <sub>OC</sub>	Transmitter Output Offset	R <sub>L</sub> = 50Ω (Figure 5)	●			±0.6	V
I <sub>OH</sub>	Transmitter Output High Current	V <sub>A</sub> , V <sub>B</sub> = 0V	●	−9	−11	−13	mA
I <sub>OL</sub>	Transmitter Output Low Current	V <sub>A</sub> , V <sub>B</sub> = 0V	●	9	11	13	mA
I <sub>OZ</sub>	Transmitter Output Leakage Current	V <sub>A</sub>   and  V <sub>B</sub>   ≤ 0.25V	●		±1	±100	μA
R <sub>OD</sub>	Transmitter Differential Mode Impedance		●	50	100	150	Ω
R <sub>OC</sub>	Transmitter Common Mode Impedance	−2V ≤ V <sub>CM</sub> ≤ 2V (Figure 7)		135	150	165	Ω
t <sub>r</sub> , t <sub>f</sub>	Rise or Fall Time	(Figures 8, 13)			5		ns
t <sub>PLH</sub>	Input to Output	(Figures 8, 13)	●	15	35	65	ns
t <sub>PHL</sub>	Input to Output	(Figures 8, 13)	●	15	35	65	ns
Δt	Input to Output Difference,  t <sub>PLH</sub> − t <sub>PHL</sub>	(Figures 8, 13)	●		0	16	ns
t <sub>SKEW</sub>	Output to Output Skew	(Figures 8, 13)			4		ns
V.35 Receiver							
V <sub>TH</sub>	Differential Receiver Input Threshold Voltage	−2V ≤ V <sub>CM</sub> ≤ 2V (Figure 9)	●	−0.2		0.2	V
ΔV <sub>TH</sub>	Receiver Input Hysteresis	−2V ≤ V <sub>CM</sub> ≤ 2V (Figure 9)	●		15	40	mV
R <sub>ID</sub>	Receiver Differential Mode Impedance	−2V ≤ V <sub>CM</sub> ≤ 2V	●	90	103	110	Ω
R <sub>IC</sub>	Receiver Common Mode Impedance	−2V ≤ V <sub>CM</sub> ≤ 2V (Figure 10)		135	150	165	Ω
t <sub>r</sub> , t <sub>f</sub>	Rise or Fall Time	C <sub>L</sub> = 50pF (Figures 4, 14)			15		ns
t <sub>PLH</sub>	Input to Output	C <sub>L</sub> = 50pF (Figures 4, 14)	●		50	90	ns
t <sub>PHL</sub>	Input to Output	C <sub>L</sub> = 50pF (Figures 4, 14)	●		50	90	ns
Δt	Input to Output Difference,  t <sub>PLH</sub> − t <sub>PHL</sub>	C <sub>L</sub> = 50pF (Figures 4, 14)	●	0	4	25	ns
V.28 Driver							
V <sub>O</sub>	Output Voltage	Open Circuit R <sub>L</sub> = 3k (Figure 11)	● ●	±5	±8.5	±10	V V
I <sub>SS</sub>	Short-Circuit Current	V <sub>OUT</sub> = GND	●			±150	mA
R <sub>OZ</sub>	Power-Off Resistance	−2V < V <sub>O</sub> < 2V, Power Off or No-Cable Mode	●	300			Ω
SR	Slew Rate	R <sub>L</sub> = 7k, C <sub>L</sub> = 0 (Figures 11, 15)	●	4		30	V/μs
t <sub>PLH</sub>	Input to Output	R <sub>L</sub> = 3k, C <sub>L</sub> = 2500pF (Figures 11, 15)	●		1.5	2.5	μs
t <sub>PHL</sub>	Input to Output	R <sub>L</sub> = 3k, C <sub>L</sub> = 2500pF (Figures 11, 15)	●		1.5	2.5	μs

## ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V_{CC} = 5\text{V}$ ,  $V_{IN} = 3.3\text{V}$ , unless otherwise noted (Notes 2, 3)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V.28 Receiver							
V <sub>THL</sub>	Input Low Threshold Voltage	(Figure 12)	●	0.8			V
V <sub>TLH</sub>	Input High Threshold Voltage	(Figure 12)	●	2			V
ΔV <sub>TH</sub>	Receiver Input Hysteresis	(Figure 12)	●	0	0.05	0.3	V
R <sub>IN</sub>	Receiver Input Impedance	−15V ≤ V <sub>A</sub> ≤ 15V	●	3	5	7	kΩ
t <sub>r</sub> , t <sub>f</sub>	Rise or Fall Time	C <sub>L</sub> = 50pF (Figures 12, 16)		15			ns
t <sub>PLH</sub>	Input to Output	C <sub>L</sub> = 50pF (Figures 12, 16)	●	60      300			ns
t <sub>PHL</sub>	Input to Output	C <sub>L</sub> = 50pF (Figures 12, 16)	●	160      300			ns

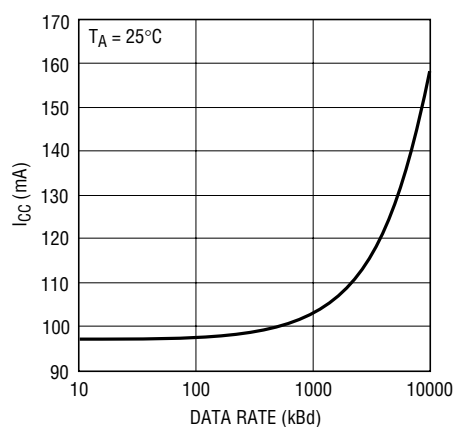
**Note 1:** Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

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

**Note 3:** All typicals are given for  $V_{CC} = 5\text{V}$ ,  $V_{IN} = 3.3\text{V}$ ,  $C_{VCC} = C_{VIN} = 10\mu\text{F}$ ,  $C_{VDD} = 1\mu\text{F}$ ,  $C_{VEE} = 3.3\mu\text{F}$  and  $T_A = 25^\circ\text{C}$ .

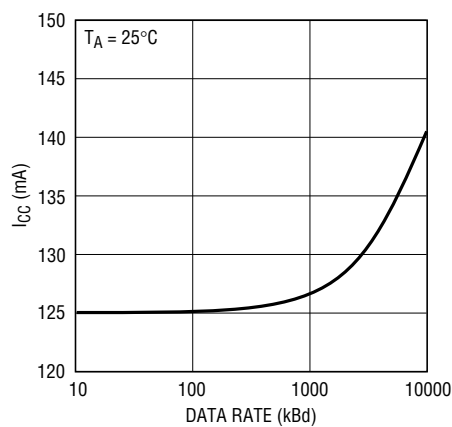
## TYPICAL PERFORMANCE CHARACTERISTICS

**V.11 Mode  $I_{CC}$  vs Data Rate**



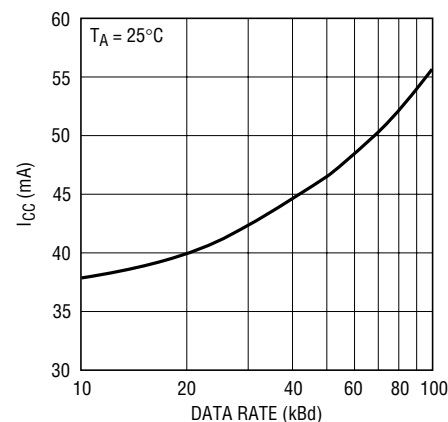
2846 G04

**V.35 Mode  $I_{CC}$  vs Data Rate**



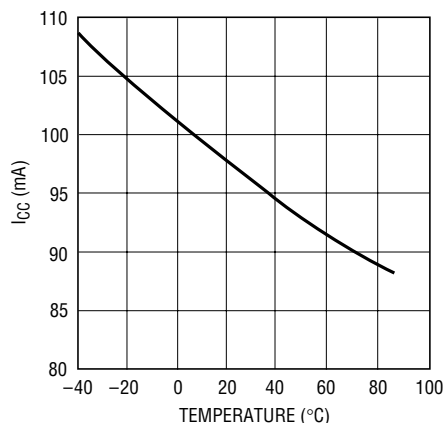
2846 G05

**V.28 Mode  $I_{CC}$  vs Data Rate**



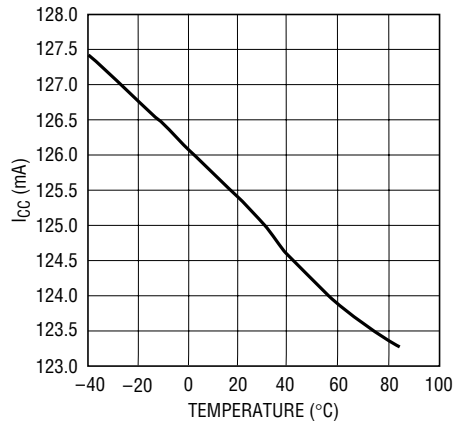
2846 G06

**V.11 Mode  $I_{CC}$  vs Temperature**



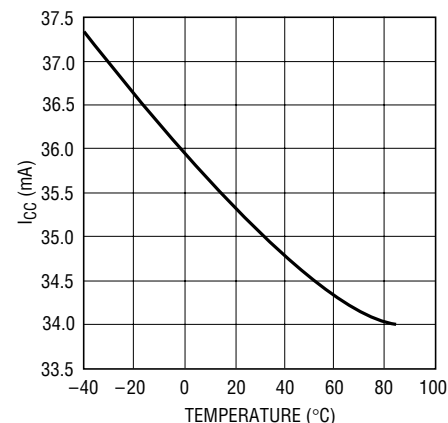
2846 G07

**V.35 Mode  $I_{CC}$  vs Temperature**



2846 G08

**V.28 Mode  $I_{CC}$  vs Temperature**



3846 G09  
sn2847 2847fs

## PIN FUNCTIONS

**NC (Pins 1,3,18,19,22,23):** No Connect.

**V<sub>DD</sub> (Pin 2):** Generated Positive Supply Voltage for V.28. Connect a 1 $\mu$ F capacitor to ground.

**V<sub>CC</sub> (Pin 4):** Input Supply Pin. Input supply to charge pump and transceiver.  $4.75V \leq V_{CC} \leq 5.25V$ . Connect a 1 $\mu$ F capacitor to GND.

**D1 (Pin 5):** TTL Level Driver 1 Input.

**D2 (Pin 6):** TTL Level Driver 2 Input.

**D3 (Pin 7):** TTL Level Driver 3 Input.

**R1 (Pin 8):** CMOS Level Receiver 1 Output with Pull-Up to V<sub>IN</sub> when Three-Stated.

**R2 (Pin 9):** CMOS Level Receiver 2 Output with Pull-Up to V<sub>IN</sub> when Three-Stated.

**R3 (Pin 10):** CMOS Level Receiver 3 Output with Pull-Up to V<sub>IN</sub> when Three-Stated.

**M0 (Pin 11):** TTL Level Mode Select Input 0 with Pull-Up to V<sub>IN</sub>. See Table 1.

**M1 (Pin 12):** TTL Level Mode Select Input 1 with Pull-Up to V<sub>IN</sub>. See Table 1.

**V<sub>IN</sub> (Pin 13):** Input Supply Pin. Input supply to digital interface including receiver output drivers.  $3V \leq V_{IN} \leq 5.25V$ . Connect to V<sub>CC</sub> (Pin 4) or to separate supply for lower receiver output swing. Connect a 1 $\mu$ F capacitor to GND.

**M2 (Pin 14):** TTL Level Mode Select Input 2 with Pull-Up to V<sub>IN</sub>. See Table 1.

**DCE/ $\overline{DTE}$  (Pin 15):** TTL Level Mode Select Input with Pull-Up to V<sub>IN</sub>. See Table 1.

**R3 B (Pin 16):** Receiver 3 Noninverting Input.

**R3 A (Pin 17):** Receiver 3 Inverting Input.

**R2 B (Pin 20):** Receiver 2 Noninverting Input.

**R2 A (Pin 21):** Receiver 2 Inverting Input.

**D3/R1 B (Pin 24):** Receiver 1 Noninverting Input and Driver 3 Noninverting Output.

**D3/R1 A (Pin 25):** Receiver 1 Inverting Input and Driver 3 Inverting Output.

**D2 B (Pin 26):** Driver 2 Noninverting Output.

**D2 A (Pin 27):** Driver 2 Inverting Output.

**D1 B (Pin 28):** Driver 1 Noninverting Output.

**D1 A (Pin 29):** Driver 1 Inverting Output.

**GND (Pins 30,31):** Transceiver Ground.

**V<sub>EE</sub> (Pins 32,33,36):** Generated Negative Supply Voltage. Connect a 3.3 $\mu$ F capacitor to GND. Exposed pad can also be connected to V<sub>EE</sub>.

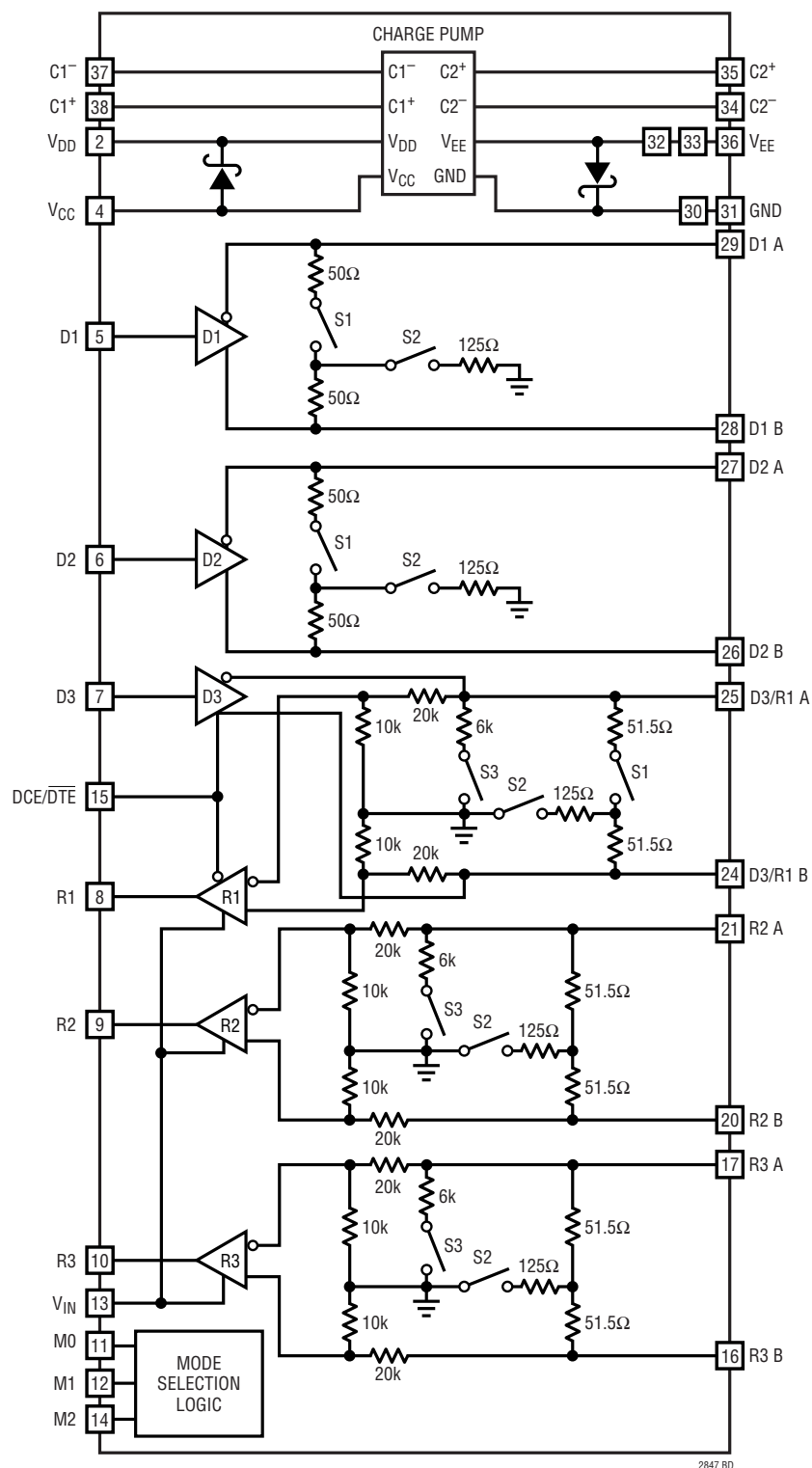
**C2<sup>-</sup> (Pin 34):** Capacitor C2 Negative Terminal. Connect a 1 $\mu$ F capacitor between C2<sup>+</sup> and C2<sup>-</sup>.

**C2<sup>+</sup> (Pin 35):** Capacitor C2 Positive Terminal. Connect a 1 $\mu$ F capacitor between C2<sup>+</sup> and C2<sup>-</sup>.

**C1<sup>-</sup> (Pin 37):** Capacitor C1 Negative Terminal. Connect a 1 $\mu$ F capacitor between C1<sup>+</sup> and C1<sup>-</sup>.

**C1<sup>+</sup> (Pin 38):** Capacitor C1 Positive Terminal. Connect a 1 $\mu$ F capacitor between C1<sup>+</sup> and C1<sup>-</sup>.

## BLOCK DIAGRAM



## TEST CIRCUITS

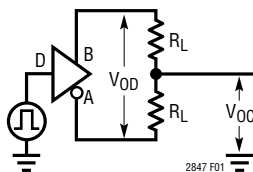


Figure 1. V.11 Driver DC Test Circuit

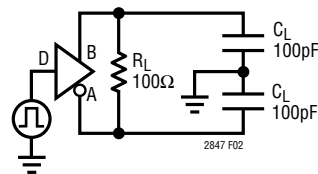


Figure 2. V.11 Driver AC Test Circuit

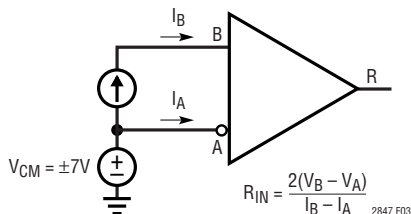


Figure 3. Input Impedance Test Circuit

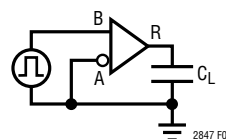


Figure 4. V.11, V.35 Receiver AC Test Circuit

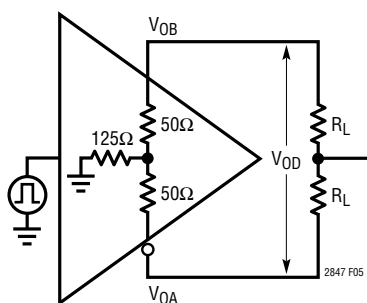


Figure 5. V.35 Driver Open-Circuit Test

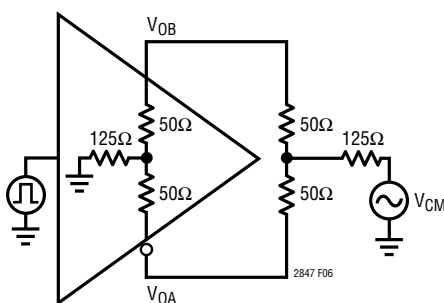


Figure 6. V.35 Driver Test Circuit

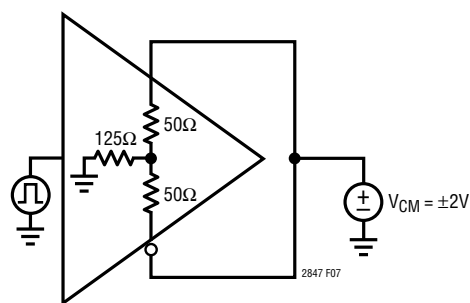


Figure 7. V.35 Driver Common Mode Impedance Test Circuit

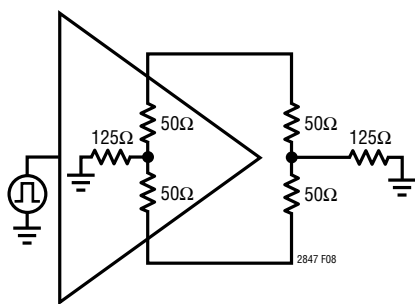


Figure 8. V.35 Driver AC Test Circuit

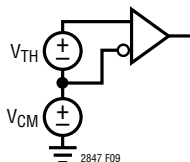


Figure 9. V.35 Receiver DC Test Circuit

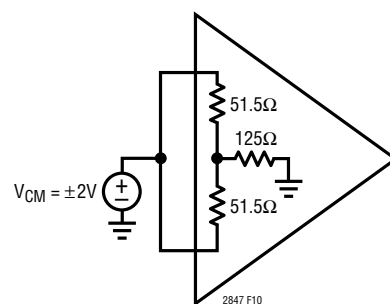


Figure 10. Receiver Common Mode Impedance Test Circuit

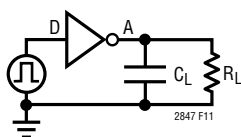


Figure 11. V.28 Driver Test Circuit

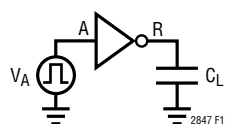


Figure 12. V.28 Receiver Test Circuit

## MODE SELECTION

Table 1

Mode Name	M2	M1	M0	DCE/ DTE	D1,2 (Note 1)	D3 (Note 1)	D1		D2		D3		R1 (Note 2)		R2 (Note 2)		R3 (Note 2)		R1 (Note 3)	R2,R3 (Note 3)	V <sub>DD</sub> (Note 4)	V <sub>EE</sub> (Note 5)
							A	B	A	B	A	B	A	B	A	B	A	B				
Not Used (Default V.11)	0	0	0	0	TTL	X	V.11	V.11	V.11	V.11	Z	Z	V.11	V.11	V.11	V.11	V.11	V.11	CMOS	CMOS	9.3V	-6V
RS530A	0	0	1	0	TTL	X	V.11	V.11	V.11	V.11	Z	Z	V.11	V.11	V.11	V.11	V.11	V.11	CMOS	CMOS	9.3V	-6V
RS530	0	1	0	0	TTL	X	V.11	V.11	V.11	V.11	Z	Z	V.11	V.11	V.11	V.11	V.11	V.11	CMOS	CMOS	9.3V	-6V
X.21	0	1	1	0	TTL	X	V.11	V.11	V.11	V.11	Z	Z	V.11	V.11	V.11	V.11	V.11	V.11	CMOS	CMOS	9.3V	-6V
V.35	1	0	0	0	TTL	X	V.35	V.35	V.35	V.35	Z	Z	V.35	V.35	V.35	V.35	V.35	V.35	CMOS	CMOS	8V	-6.5V
RS449/V.36	1	0	1	0	TTL	X	V.11	V.11	V.11	V.11	Z	Z	V.11	V.11	V.11	V.11	V.11	V.11	CMOS	CMOS	9.3V	-6V
V.28/RS232	1	1	0	0	TTL	X	V.28	Z	V.28	Z	Z	Z	V.28	30k	V.28	30k	V.28	30k	CMOS	CMOS	8.7V	-8.5V
No Cable	1	1	1	0	X	X	Z	Z	Z	Z	Z	Z	30k	30k	30k	30k	30k	30k	Z	Z	4.7V	0.3V
Not Used (Default V.11)	0	0	0	1	TTL	TTL	V.11	V.11	V.11	V.11	V.11	V.11	30k	30k	V.11	V.11	V.11	V.11	Z	CMOS	9.3V	-6V
RS530A	0	0	1	1	TTL	TTL	V.11	V.11	V.11	V.11	V.11	V.11	30k	30k	V.11	V.11	V.11	V.11	Z	CMOS	9.3V	-6V
RS530	0	1	0	1	TTL	TTL	V.11	V.11	V.11	V.11	V.11	V.11	30k	30k	V.11	V.11	V.11	V.11	Z	CMOS	9.3V	-6V
X.21	0	1	1	1	TTL	TTL	V.11	V.11	V.11	V.11	V.11	V.11	30k	30k	V.11	V.11	V.11	V.11	Z	CMOS	9.3V	-6V
V.35	1	0	0	1	TTL	TTL	V.35	V.35	V.35	V.35	V.35	V.35	30k	30k	V.35	V.35	V.35	V.35	Z	CMOS	8V	-6.5V
RS449/V.36	1	0	1	1	TTL	TTL	V.11	V.11	V.11	V.11	V.11	V.11	30k	30k	V.11	V.11	V.11	V.11	Z	CMOS	9.3V	-6V
V.28/RS232	1	1	0	1	TTL	TTL	V.28	Z	V.28	Z	V.28	Z	30k	30k	V.28	30k	V.28	30k	Z	CMOS	8.7V	-8.5V
No Cable	1	1	1	1	X	X	Z	Z	Z	Z	Z	Z	30k	30k	30k	30k	30k	30k	Z	Z	4.7V	0.3V

**Note 1:** Driver inputs are TTL level compatible.

**Note 2:** Unused receiver inputs are terminated with 30k to ground. In addition, R2 and R3 are always terminated by a 103 $\Omega$  differential impedance (see Block Diagram on page 7).

**Note 3:** Receiver Outputs are CMOS level compatible and have a weak pull up to V<sub>IN</sub> when Z.

**Note 4:** V<sub>DD</sub> values shown are typical values for V<sub>CC</sub> = 5V, V<sub>IN</sub> = 3.3V and T<sub>A</sub> = 25°C with LTC2847 under full load for each mode.

**Note 5:** V<sub>EE</sub> values shown are typical values for V<sub>CC</sub> = 5V, V<sub>IN</sub> = 3.3V and T<sub>A</sub> = 25°C with LTC2847 under full load for each mode.

## SWITCHING TIME WAVEFORMS

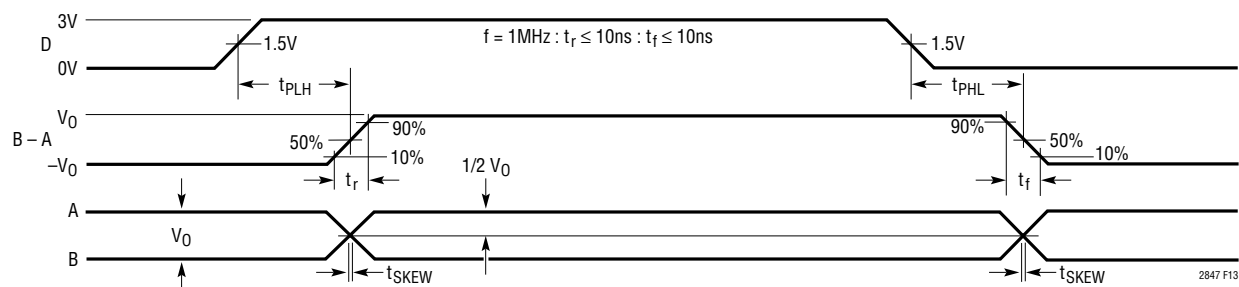


Figure 13. V.11, V.35 Driver Propagation Delays

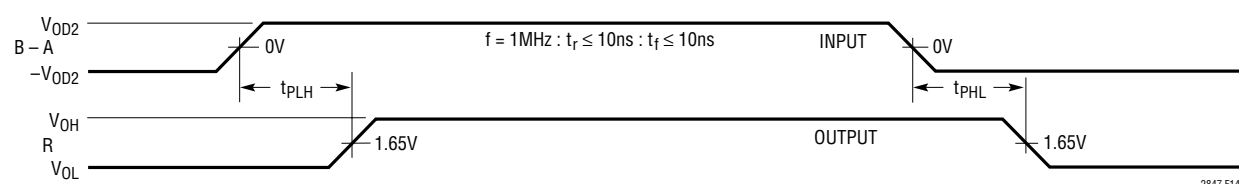


Figure 14. V.11, V.35 Receiver Propagation Delays

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## SWITCHING TIME WAVEFORMS



Figure 15. V.28 Driver Propagation Delays

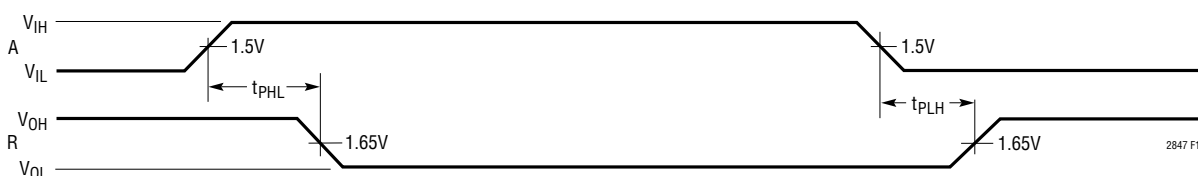


Figure 16. V.28 Receiver Propagation Delays

## APPLICATIONS INFORMATION

### Overview

The LTC2847 consists of a charge pump and a 3-driver/3-receiver transceiver. The 5V  $V_{CC}$  input powers the charge pump and transceiver. The charge pump generates the  $V_{DD}$  and  $V_{EE}$  supplies. The LTC2847's  $V_{DD}$  and  $V_{EE}$  supplies can be used to power a companion chip like the LTC2845. The  $V_{IN}$  input powers the digital interface including the receiver output drivers. Having a separate pin to power the digital interface allows the flexibility of controlling the receiver output swing to interface with 5V or 3.3V logic.

The LTC2847 and LTC2845 form a complete software-selectable DTE or DCE interface port that supports the RS232, RS449, EIA530, EIA530-A, V.35, V.36 and X.21 protocols. Cable termination is provided on-chip, eliminating the need for discrete termination designs.

A complete DCE-to-DTE interface operating in EIA530 mode is shown in Figure 17. The LTC2847 half of each port is used to generate and appropriately terminate the clock and data signals. The LTC2845 is used to generate the control signals along with LL (local loopback),

RL (Remote Loop-Back), TM (Test Mode) and RI (Ring Indicate).

### Mode Selection

The interface protocol is selected using the mode select pins M0, M1 and M2 (see Table 1).

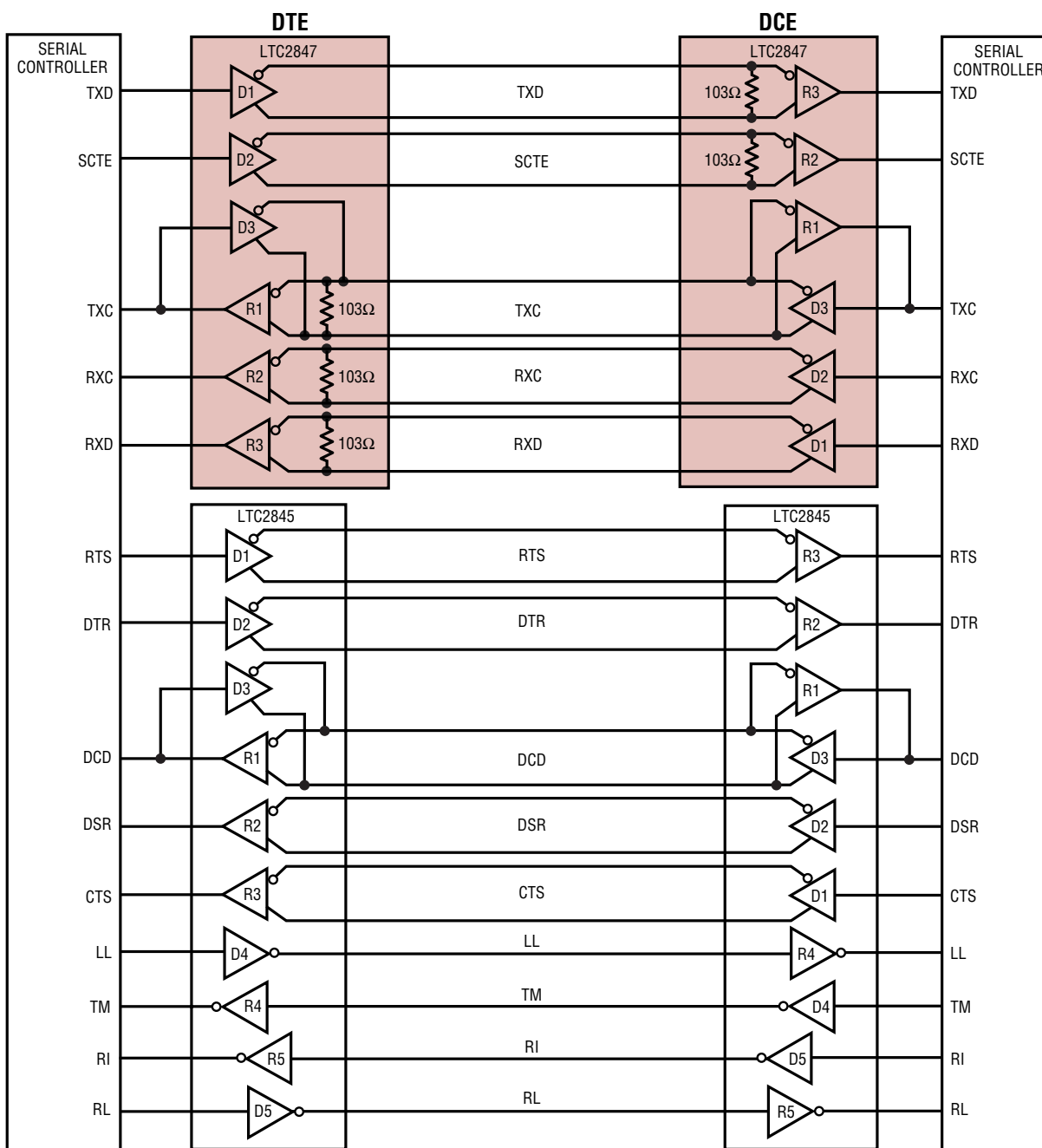
For example, if the port is configured as a V.35 interface, the mode selection pins should be M2 = 1, M1 = 0, M0 = 0. For the control signals, the drivers and receivers will operate in V.28 (RS232) electrical mode. For the clock and data signals, the drivers and receivers will operate in V.35 electrical mode. The DCE/DTE pin will configure the port for DCE mode when high, and DTE when low.

The interface protocol may be selected simply by plugging the appropriate interface cable into the connector. The mode pins are routed to the connector and are left unconnected (1) or wired to ground (0) in the cable as shown in Figure 18. The internal pull-up current sources will ensure a binary 1 when a pin is left unconnected.

The mode selection may also be accomplished by using jumpers to connect the mode pins to ground or  $V_{IN}$ .

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## APPLICATIONS INFORMATION



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Figure 17. Complete Multiprotocol Interface in EIA530 Mode

When the cable is removed, leaving all mode pins unconnected, the LTC2847/LTC2845 will enter no-cable mode. In this mode the LTC2847/LTC2845 supply current drops to less than 1000 $\mu$ A and the LTC2847/LTC2845 driver outputs are forced into a high impedance state. At the same time, the R2 and R3 receivers of the LTC2847 are differentially terminated with 103 $\Omega$  and the other receiv-

ers on the LTC2847 and LTC2845 are terminated with 30k $\Omega$  to ground.

### Cable Termination

Traditional implementations used expensive relays to switch resistors or required the user to change termination modules every time a new interface standard was

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## APPLICATIONS INFORMATION

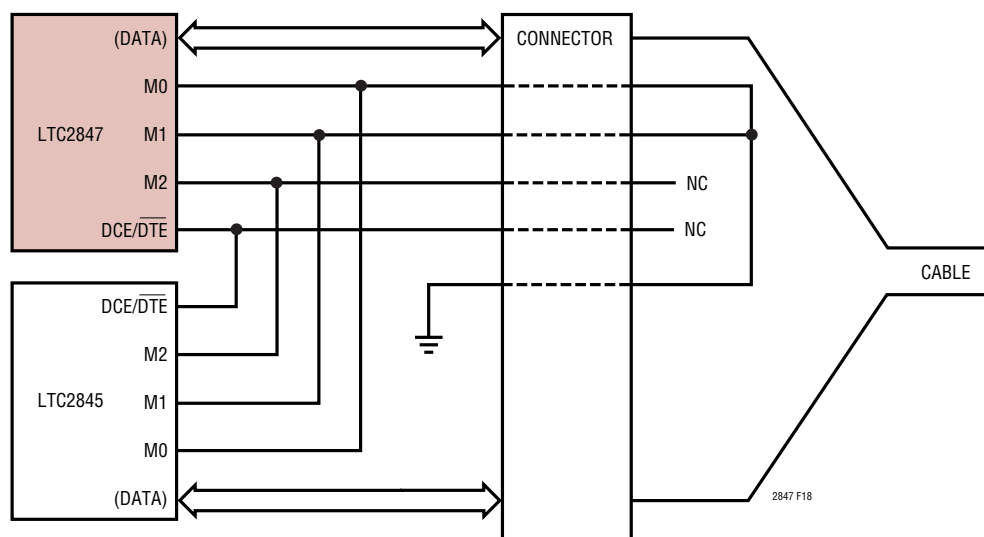


Figure 18. Single Port DCE V.35 Mode Selection in the Cable

selected. Switching the terminations with FETs is difficult because the FETs must remain off when the signal voltage is beyond the supply voltage. Alternatively, custom cables may contain termination in the cable head or route signals to various terminations on the board.

The LTC2847/LTC2845 chip set solves the cable termination switching problem by automatically providing the appropriate termination and switching on-chip for the V.10 (RS423), V.11 (RS422), V.28 (RS232) and V.35 electrical protocols.

### V.10 (RS423) Interface

All V.10 drivers and receivers necessary for the RS449, EIA530, EIA530-A, V.36 and X.21 protocols are implemented on the LTC2845.

A typical V.10 unbalanced interface is shown in Figure 19. A V.10 single-ended generator with output A and ground C is connected to a differential receiver with input A' connected to A, and ground C' connected via the signal return to ground C. Usually, no cable termination is required for V.10 interfaces, but the receiver inputs must be compliant with the impedance curve shown in Figure 20.

The V.10 receiver configuration in the LTC2845 is shown in Figure 21. In V.10 mode, switch S3 inside the LTC2845 is turned off. The noninverting input is disconnected inside the LTC2845 receivers and connected to ground.

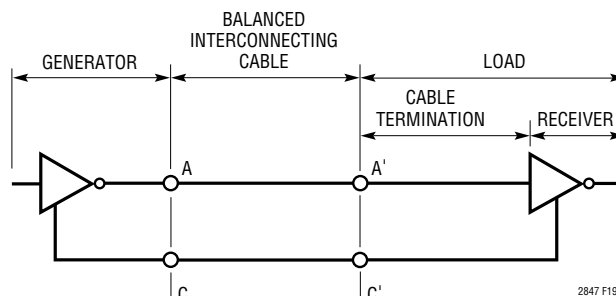


Figure 19. Typical V.10 Interface

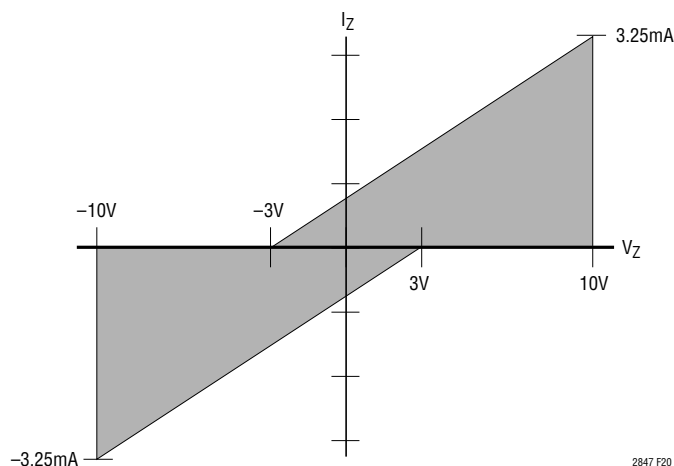


Figure 20. V.10 Receiver Input Impedance

## APPLICATIONS INFORMATION

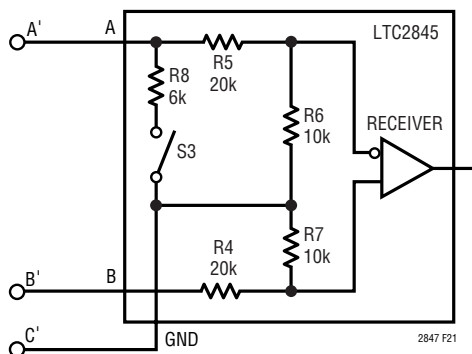


Figure 21. V.10 Receiver Configuration

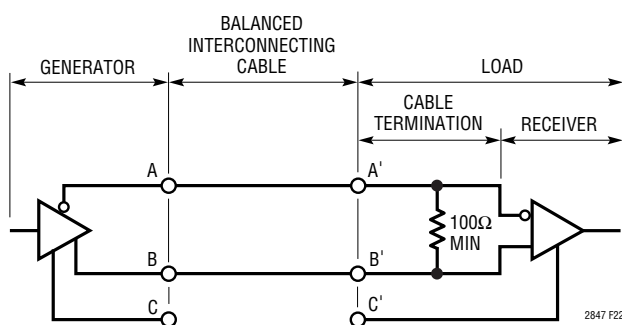


Figure 22. Typical V.11 Interface

The cable termination is then the 30k input impedance to ground of the LTC2845 V.10 receiver.

### V.11 (RS422) Interface

A typical V.11 balanced interface is shown in Figure 22. A V.11 differential generator with outputs A and B and ground C is connected to a differential receiver with input A' connected to A, input B' connected to B, and ground C' connected via the signal return to ground C. The V.11 interface has a differential termination at the receiver end that has a minimum value of 100Ω. The termination resistor is optional in the V.11 specification, but for the high speed clock and data lines, the termination is essential to prevent reflections from corrupting the data. The receiver inputs must also be compliant with the impedance curve shown in Figure 20.

In V.11 mode, all switches are off except S1 of the LTC2847's receivers which connects a 103Ω differential

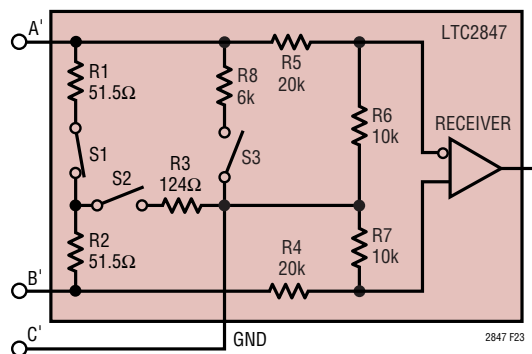


Figure 23. V.11 Receiver Configuration

termination impedance to the cable as shown in Figure 23<sup>1</sup>. The LTC2845 only handles control signals, so no termination other than its V.11 receivers' 30k input impedance is necessary.

### V.28 (RS232) Interface

A typical V.28 unbalanced interface is shown in Figure 24. A V.28 single-ended generator with output A and ground C is connected to a single-ended receiver with input A' connected to A and ground C' connected via the signal return to ground C.

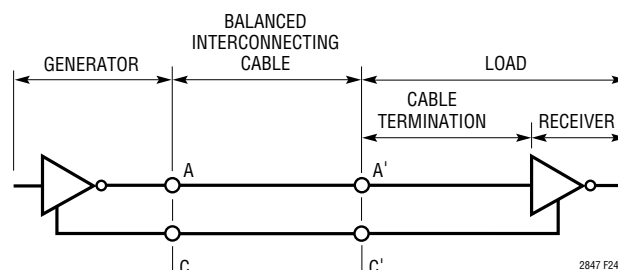


Figure 24. Typical V.28 Interface

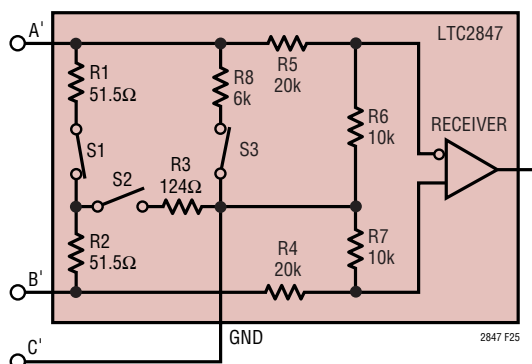


Figure 25. V.28 Receiver Configuration

<sup>1</sup>Actually, there is no switch S1 in receivers R2 and R3. However, for simplicity, all termination networks on the LTC2847 can be treated identically if it is assumed that an S1 switch exists and is always closed on the R2 and R3 receivers.

## APPLICATIONS INFORMATION

In V.28 mode, S3 is closed inside the LTC2847/LTC2845 which connects a 6k (R8) impedance to ground in parallel with 20k (R5) plus 10k (R6) for a combined impedance of 5k as shown in Figure 25. Proper termination is only provided when the B input of the receivers is floating, since S1 of the LTC2847's R2 and R3 receivers remains on in V.28 mode<sup>1</sup>. The noninverting input is disconnected inside the LTC2847/LTC2845 receiver and connected to a TTL level reference voltage to give a 1.4V receiver trip point.

### V.35 Interface

A typical V.35 balanced interface is shown in Figure 26. A V.35 differential generator with outputs A and B and ground C is connected to a differential receiver with input A' connected to A, input B' connected to B, and ground C' connected via the signal return to ground C. The V.35 interface requires a T or delta network termination at the receiver end and the generator end. The receiver differential impedance measured at the connector must be  $100\Omega \pm 10\Omega$ , and the impedance between shorted terminals (A' and B') and ground (C') must be  $150\Omega \pm 15\Omega$ .

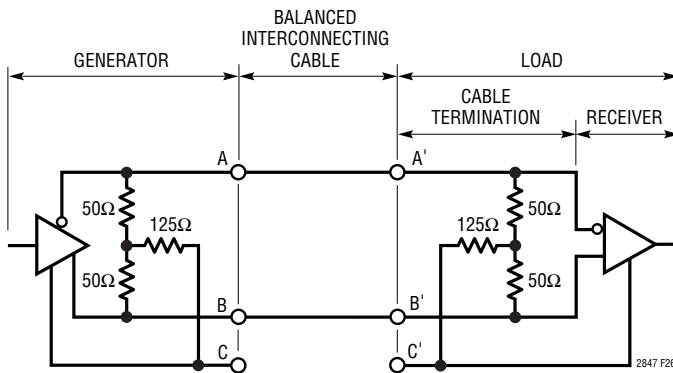


Figure 26. Typical V.35 Interface

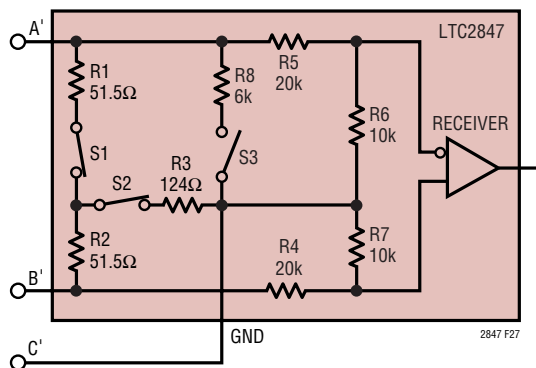


Figure 27. V.35 Receiver Configuration

In V.35 mode, both switches S1 and S2 inside the LTC2847 are on, connecting a T network impedance as shown in Figure 27. The 30k input impedance of the receiver is placed in parallel with the T network termination, but does not affect the overall input impedance significantly.

The generator differential impedance must be  $50\Omega$  to  $150\Omega$  and the impedance between shorted terminals (A and B) and ground (C) must be  $150\Omega \pm 15\Omega$ .

### No-Cable Mode

The no-cable mode ( $M0 = M1 = M2 = 1$ ) is intended for the case when the cable is disconnected from the connector. The charge pump, bias circuitry, drivers and receivers are turned off, the driver outputs are forced into a high impedance state, and the  $V_{CC}$  supply current to the transceiver drops to less than  $300\mu A$  while its  $V_{IN}$  supply current drops to less than  $10\mu A$ . Note that the LTC2847's R2 and R3 receivers continue to be terminated by a  $103\Omega$  differential impedance.

### Charge Pump

The LTC2847 uses an internal capacitive charge pump to generate  $V_{DD}$  and  $V_{EE}$  as shown in Figure 28. A voltage doubler generates about 8V on  $V_{DD}$  and a voltage inverter generates about  $-7.5V$  on  $V_{EE}$ . Four  $1\mu F$  surface mounted tantalum or ceramic capacitors are required for C1, C2, C3 and C5. The  $V_{EE}$  capacitor C4 should be a minimum of  $3.3\mu F$ . All capacitors are 16V and should be placed as close as possible to the LTC2847 to reduce EMI.

### Receiver Fail-Safe

All LTC2847/LTC2845 receivers feature fail-safe operation in all modes. If the receiver inputs are left floating or are shorted together by a termination resistor, the receiver output will always be forced to a logic high.

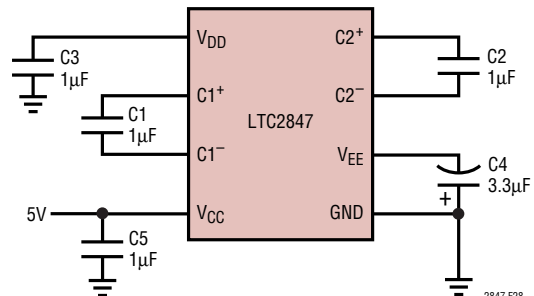


Figure 28. Charge Pump

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## TYPICAL APPLICATIONS

### DTE vs DCE Operation

The DCE/ $\overline{\text{DTE}}$  pin acts as an enable for Driver 3/Receiver 1 in the LTC2847, and Driver 3/Receiver 1 in the LTC2845.

The LTC2847/LTC2845 can be configured for either DTE or DCE operation in one of two ways: a dedicated DTE or DCE port with a connector of appropriate gender or a port with one connector that can be configured for DTE or DCE operation by rerouting the signals to the LTC2847/LTC2845 using a dedicated DTE cable or dedicated DCE cable.

A dedicated DTE port using a DB-25 male connector is shown in Figure 29. The interface mode is selected by logic outputs from the controller or from jumpers to either  $V_{IN}$  or GND on the mode select pins. A dedicated DCE port using a DB-25 female connector is shown in Figure 30.

A port with one DB-25 connector, that can be configured for either DTE or DCE operation is shown in Figure 31. The configuration requires separate cables for proper signal routing in DTE or DCE operation. For example, in DTE mode, the TXD signal is routed to Pins 2 and 14 via the LTC2847's Driver 1. In DCE mode, Driver 1 now routes the RXD signal to Pins 2 and 14.

### Power Dissipation Calculations

The LTC2847 takes in 5V  $V_{CC}$ .  $V_{DD}$  and  $V_{EE}$  are in turn produced from  $V_{CC}$  with an internal charge pump at approximately 80% and 70% efficiency respectively. Current drawn internally from  $V_{DD}$  or  $V_{EE}$  translates directly into a higher  $I_{CC}$ . The LTC2847 dissipates power according to the equation:

$$P_{DISS(2847)} = V_{CC} \cdot I_{CC} - N_D \cdot P_{RT} + N_R \cdot P_{RT} \quad (1)$$

$P_{RT}$  refers to the power dissipated by each driver in a receiver termination on the far end of the cable while  $N_D$  is the number of drivers. Conversely, current from the far end drivers dissipate power  $N_R \cdot P_{RT}$  in the internal receiver termination where  $N_R$  is the number of receivers.

### LTC2847 Power Dissipation

Consider an LTC2847 in X.21, DCE mode (three V.11 drivers and two V.11 receivers). From the Electrical Characteristics Table,  $I_{CC}$  at no load = 14mA,  $I_{CC}$  at full load = 100mA. Each receiver termination is 100 $\Omega$  ( $R_{RT}$ ) and

current going into each receiver termination =  $(100\text{mA} - 14\text{mA})/3 = 28.7\text{mA}$  ( $I_{RT}$ ).

$$P_{RT} = (I_{RT})^2 \cdot R_{RT} \quad (2)$$

From Equation (2),  $P_{RT} = 82.4\text{mW}$  and from Equation (1), DC power dissipation  $P_{DISS(2847)} = 5V \cdot 100\text{mA} - 3 \cdot 82.4\text{mW} + 2 \cdot 82.4\text{mW} = 418\text{mW}$ .

Consider the above example running at a baud rate of 10MBd. From the Typical Characteristic for "V.11 Mode  $I_{CC}$  vs Data Rate," the  $I_{CC}$  at 10MBd is 160mA.  $I_{CC}$  increases with baud rate due to driver transient dissipation. From Equation (1), AC power dissipation  $P_{DISS(2847)} = 5V \cdot 160\text{mA} - 3 \cdot 82.4\text{mW} + 2 \cdot 82.4\text{mW} = 718\text{mW}$ .

### LTC2845 Power Dissipation

If a LTC2845 is used to form a complete DCE port with the LTC2847, it will be running in the X.21 mode (three V.11 drivers and two V.10 drivers, two V.11 receivers and two V.10 receivers, all with internal 30k termination). In addition to  $V_{CC}$ , it uses the  $V_{DD}$  and  $V_{EE}$  outputs from the LTC2847. Negligible power is dissipated in the large internal receiver termination of the LTC2845 so the  $N_R \cdot P_{RT}$  term of Equation (1) can be omitted. Thus Equation (1) is modified as follows:

$$P_{DISS(2845)} = (V_{CC} \cdot I_{CC}) + (V_{DD} \cdot I_{DD}) + (V_{EE} \cdot I_{EE}) - N_D \cdot P_{RT} \quad (3)$$

Since power is drawn from the supplies of the LTC2847 ( $V_{DD}$  and  $V_{EE}$ ) at less than 100% efficiency, the LTC2847 dissipates extra power to source  $P_{DISS(2845)}$  and  $P_{RT}$ :

$$\begin{aligned} P_{DISS1(2847)} &= 125\% \cdot (V_{DD} \cdot I_{DD}) + 143\% \cdot (V_{EE} \cdot I_{EE}) - P_{DISS(2845)} - N_D \cdot P_{RT} \\ &= 25\% \cdot (V_{DD} \cdot I_{DD}) + 43\% \cdot (V_{EE} \cdot I_{EE}) \end{aligned} \quad (4)$$

From the LTC2845 Electrical Characteristics Table, for  $V_{CC} = 5V$ ,  $V_{DD} = 8V$  and  $V_{EE} = -5.5V$ :

$I_{CC}$ at no load	2.7mA
$I_{CC}$ at full load with all drivers high	110mA
$I_{EE}$ at no load	2mA
$I_{EE}$ at full load with both V.10 drivers low	23mA
$I_{DD}$ at no load	0.3mA
$I_{DD}$ at full load	0.3mA

## TYPICAL APPLICATIONS

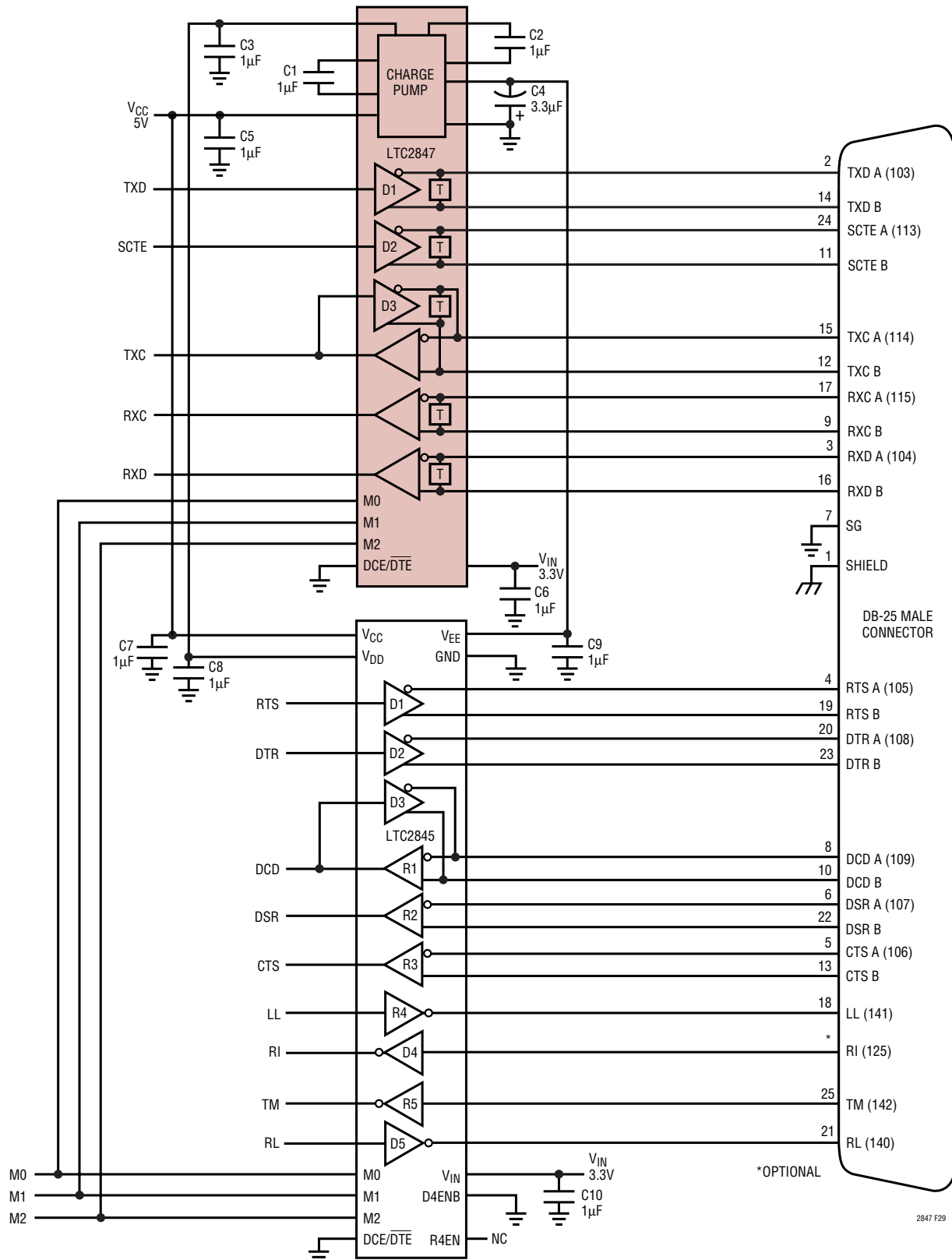


Figure 29. Controller-Selectable Multiprotocol DTE Port with DB-25 Connector

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## TYPICAL APPLICATIONS

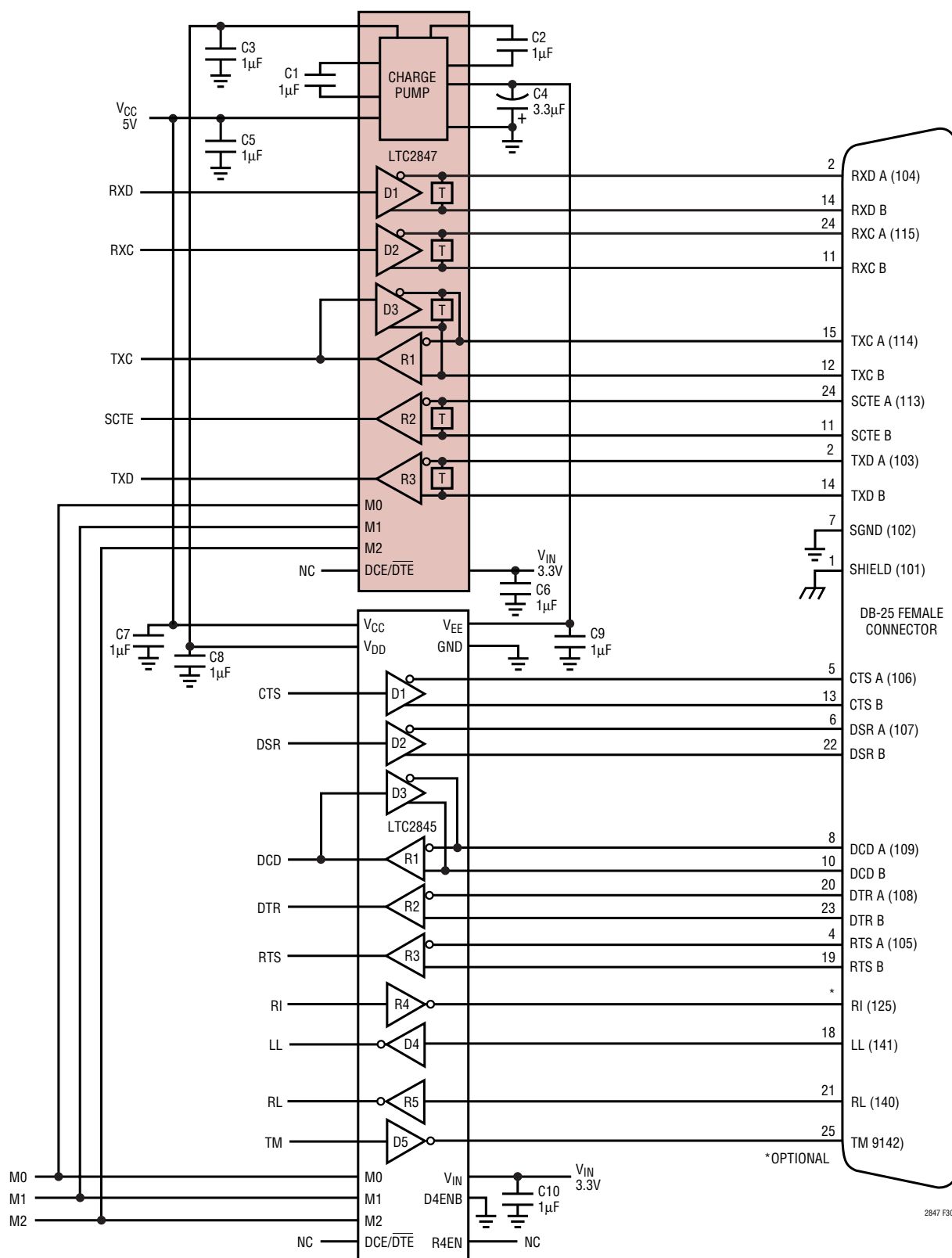


Figure 30. Controller-Selectable DCE Port with DB-25 Connector

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## TYPICAL APPLICATIONS

The V.11 drivers are driven between  $V_{CC}$  and GND while the V.10 drivers are driven between  $V_{CC}$  and  $V_{EE}$ . Assume that the V.11 driver outputs are high and V.10 driver outputs low. Current going into each  $100\Omega$  V.11 receiver termination =  $(110\text{mA} - 2.7\text{mA}) - 23\text{mA}/3 = 28.1\text{mA}$ . Current going into each  $450\Omega$  V.10 receiver termination =  $23\text{mA} - 2\text{mA}/2 = 10.5\text{mA}$ . From Equation (2), V.11  $P_{RT} = 79\text{mW}$  and V.10  $P_{RT} = 49.6\text{mW}$ .

From Equation (3),  $P_{DISS(2845)} = 5V \cdot (110\text{mA} - 23\text{mA}) + (8V \cdot 0.3\text{mA}) + 5.5V \cdot 23\text{mA} - 3 \cdot 79\text{mW} - 2 \cdot 49.6\text{mW} =$

$228\text{mW}$ . Since the LTC2845 runs slow control signals, the AC power dissipation can be assumed to be equal to the DC power dissipation.

The extra power dissipated in the LTC2847 due to LTC2845 is given by Equation(4),  $P_{DISS1(2847)} = 25\% \cdot (8V \cdot 0.3\text{mA}) + 43\% \cdot (5.5V \cdot 23\text{mA}) = 55\text{mW}$ . So for an X.21 DCE port running at 10MBd, the LTC2847 dissipates approximately  $718\text{mW} + 55\text{mW} = 773\text{mW}$  while the LTC2845 dissipates  $228\text{mW}$ .

## RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC1321	Dual RS232/RS485 Transceiver	Two RS232 Driver/Receiver Pairs or Two RS485 Driver/Receiver Pairs
LTC1334	Single 5V RS232/RS485 Multiprotocol Transceiver	Two RS232 Driver/Receiver or Four RS232 Driver/Receiver Pairs
LTC1343	Software-Selectable Multiprotocol Transceiver	4-Driver/4-Receiver for Data and Clock Signals
LTC1344A	Software-Selectable Cable Terminator	Perfect for Terminating the LTC1543 (Not Needed with LTC1546)
LTC1345	Single Supply V.35 Transceiver	3-Driver/3-Receiver for Data and Clock Signals
LTC1346A	Dual Supply V.35 Transceiver	3-Driver/3-Receiver for Data and Clock Signals
LTC1543	Software-Selectable Multiprotocol Transceiver	Terminated with LTC1344A for Data and Clock Signals, Companion to LTC1544 or LTC1545 for Control Signals
LTC1544	Software-Selectable Multiprotocol Transceiver	Companion to LTC1546 or LTC1543 for Control Signals Including LL
LTC1545	Software-Selectable Multiprotocol Transceiver	5-Driver/5-Receiver Companion to LTC1546 or LTC1543 for Control Signals Including LL, TM and RL
LTC1546	Software-Selectable Multiprotocol Transceiver	3-Driver/3-Receiver with Termination for Data and Clock Signals
LTC2844	3.3V Software-Selectable Multiprotocol Transceiver	Companion to LTC2846 for Control Signals Including LL
LTC2845	3.3V Software-Selectable Multiprotocol Transceiver	5-Driver/5-Receiver Companion to LTC2846 or LTC2847 for Control Signals Including LL, TM and RL
LTC2846	3.3V Software-Selectable Multiprotocol Transceiver	3.3V Supply, 3-Driver/3-Receiver with Termination for Data and Clock Signals, Generates the Required 5V and $\pm 8V$ Supplies for LTC2846 Companion Parts