Ultralow Power Dual Comparators with Reference

FEATURES

- **Ultralow Quiescent Current: 3.5µA Typ**
- **Open-Drain Outputs Typically Sink Greater Than 20mA**
- Wide Supply Range: (LTC1841)
  Single: 2V to 11V
  Dual: ±1V to ±5.5V
- Input Voltage Range Includes the Negative Supply
- **Reference Output Drives 0.01µF Capacitor**
- **Adjustable Hysteresis**
- 12µs Propagation Delay with 10mV Overdrive
- No Current Spike When Switching

APPLICATIONS

- Battery-Powered System Monitoring
- Threshold Detectors
- Window Comparators
- Oscillator Circuits

DESCRIPTION

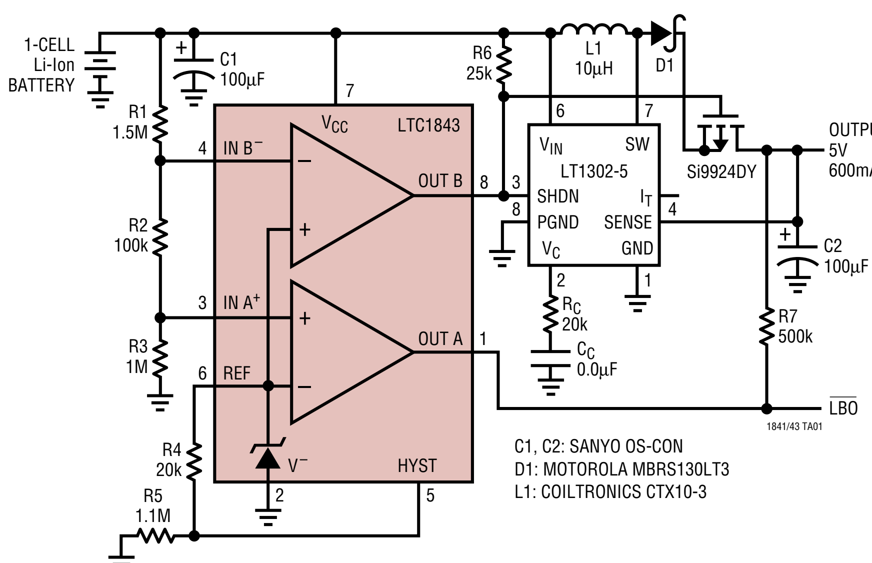
The LTC®1841/LTC1842/LTC1843 are ultralow power dual comparators with built-in reference (LTC1842/LTC1843). The comparators feature less than 5.7µA supply current over temperature, a 1.182V ±1% reference, programmable hysteresis and open-drain outputs that sink current. The reference output can drive a bypass capacitor of up to 0.01µF without oscillation.

The LTC1841 operates from a single 2V to 11V supply or a dual ±1V to ±5.5V supply. The LTC1842/LTC1843 operate from a single 2.5V to 11V supply or a dual ±1.25V to ±5.5V supply. The LTC1842/LTC1843 hysteresis is easily programmed by using two resistors and the HYST pin. The comparators' input operates from the negative supply to within 1.3V of the positive supply. The comparators' output stage can typically sink greater than 20mA. By eliminating the cross-conduction current that normally happens when the comparators change logic states, power supply glitches are eliminated.

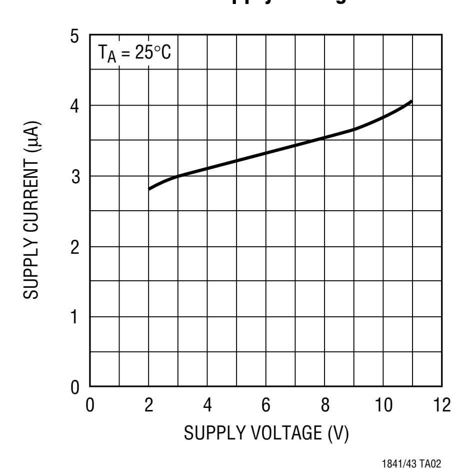
The LTC1841/LTC1842/LTC1843 are available in SO-8 packages.

TYPICAL APPLICATION

Single Li-Ion Cell to 5V Supply



LTC1843 Supply Current vs Supply Voltage



ABSOLUTE MAXIMUM RATINGS
(Note 1)

Voltage
- V^+ to V^- .... 12V to −0.3V
- IN^+, IN^-, HYST .... (V^+ + 0.3V) to (V^- – 0.3V)
- REF .... (V^+ + 0.3V) to (V^- – 0.3V)
- OUT .... 12V to (V^- – 0.3V)

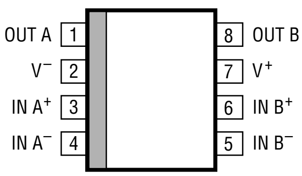
Current
- IN^+, IN^-, HYST 20mA
- REF 20mA
- OUT 50mA

OUT Short-Circuit Duration ($V^+ \le 5.5V$) ...... Continuous
Power Dissipation 500mW
Operating Temperature Range
- LTC1841C/LTC1842C/LTC1843C .... 0°C to 70°C
- LTC1841I/LTC1842I/LTC1843I .... −40°C to 85°C

Storage Temperature Range .... −65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

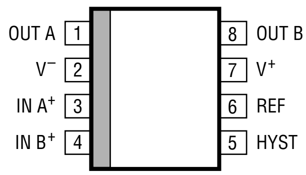
PACKAGE/ORDER INFORMATION

TOP VIEW



S8 PACKAGE
8-LEAD PLASTIC SO
T_{JMAX} = 150°C, θ_{JA} = 125°C/W

TOP VIEW



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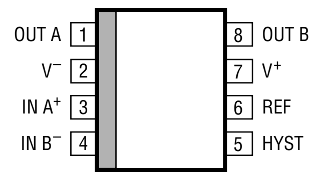


S8 PACKAGE
8-LEAD PLASTIC SO
T_{JMAX} = 150°C, θ_{JA} = 125°C/W

ORDER PART NUMBER	S8 PART MARKING	ORDER PART NUMBER	S8 PART MARKING	ORDER PART NUMBER	S8 PART MARKING
LTC1841CS8 LTC1841IS8	1841 1841I	LTC1842CS8 LTC1842IS8	1842 1842I	LTC1843CS8 LTC1843IS8	1843 1843I

Consult factory for Military grade parts.

ELECTRICAL CHARACTERISTICS
V^+ = 5V, V^- = 0V, T_A = 25°C unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Power Supply							
V^+	Supply Voltage Range	LTC1841 LTC1842/LTC1843	● ●	2.0 2.5		11 11	V V
I_{CC}	Supply Current	HYST = REF (Note 2)	●		3.5	5.7	µA
Comparator							
V_{OS}	Comparator Input Offset Voltage	(Note 3)	●		±3	±10	mV
I_{IN}	Input Leakage Current (IN^+, IN^-)	$IN^+ = IN^-$ = 2.5V (LTC1841), $IN^+ = IN^- = V_{REF}$ (LTC1842/LTC1843)	●		±0.01	±1.0	nA
V_{IN}	Comparator Input Voltage Range		●	V^-		V^+ – 1.3V	V
PSRR	Power Supply Rejection Ratio	V^+ = 2V to 11V (LTC1841), V^+ = 2.5V to 11V (LTC1842/LTC1843)			0.1	1	mV/V
CMRR	Common Mode Rejection Ratio	$V_{CM} = V^-$ to (V^+ – 1.3V) LTC1841	●		0.1	1	mV/V
V_{HYST}	Hysteresis Input Voltage Range	LTC1842/LTC1843	●	V_{REF} – 50mV		V_{REF}	V

ELECTRICAL CHARACTERISTICS $V^+ = 5V$, $V^- = 0V$, $T_A = 25°C$ unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
t_{PD}	Propagation Delay	$C_{OUT} = 10pF$, $R_{PULL-UP} = 100k$	Overdrive = 10mV Overdrive = 100mV			12 4		µs µs
I_{LEAK}	Output Leakage Current	$V_{OUT} = 12V$ (Note 2)		●		1	100	nA
V_{OL}	Output Low Voltage	$I_{OUT} = 1.8mA$		●			$V^- + 0.4V$	V
Reference (LTC1842/LTC1843)								
V_{REF}	Reference Voltage	No Load	25°C		1.174	1.182	1.190	V
			0°C to 70°C	●	1.170		1.194	V
			–40°C to 85°C	●	1.164		1.200	V
$\lvert\Delta V_{REF}\rvert$	Load Regulation	$I_{SOURCE} = 1mA$		●		1	3	mV
		$I_{SINK} = 10µA$		 ●		1.75	4 6	mV mV
e_n	Voltage Noise	100Hz to 100kHz				100		$µV_{RMS}$

$V^+ = 3V$, $V^- = 0V$, $T_A = 25°C$ unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
Power Supply								
V^+	Supply Voltage Range	LTC1841 LTC1842/LTC1843		● ●	2.0 2.5		11 11	V V
I_{CC}	Supply Current	HYST = REF (Note 2)		●		3.5	5.5	µA
Comparator								
V_{OS}	Comparator Input Offset Voltage	(Note 3)		●		±3	±10	mV
I_{IN}	Input Leakage Current (IN^+, IN^-)	$IN^+ = IN^- = 1.5V$ (LTC1841), $IN^+ = IN^- = V_{REF}$ (LTC1842/LTC1843)		●		±0.01	±1	nA
V_{IN}	Comparator Input Voltage Range			●	V^-		$V^+ – 1.3V$	V
PSRR	Power Supply Rejection Ratio	$V^+ = 2V$ to 11V (LTC 1841), $V^+ = 2.5V$ to 11V (LTC1842/LTC1843)				0.1	1	mV/V
CMRR	Common Mode Rejection Ratio	$V_{CM} = V^-$ to $(V^+ – 1.3V)$ LTC1841		●		0.1	1	mV/V
V_{HYST}	Hysteresis Input Voltage Range	LTC1842/LTC1843		●	$V_{REF} – 50mV$		V_{REF}	V
t_{PD}	Propagation Delay	$C_{OUT} = 10pF$, $R_{PULL-UP} = 100k$	Overdrive = 10mV Overdrive = 100mV			14 5		µs µs
I_{LEAK}	Output Leakage Current	$V_{OUT} = 12V$ (Note 2)		●		1	100	nA
V_{OL}	Output Low Voltage	$I_O = 0.8mA$		●			$V^- + 0.4V$	V
Reference (LTC1842/LTC1843)								
V_{REF}	Reference Voltage	No Load	25°C		1.174	1.182	1.190	V
			0°C to 70°C	●	1.170		1.194	V
			–40°C to 85°C	●	1.164		1.200	V
$\lvert\Delta V_{REF}\rvert$	Load Regulation	$I_{SOURCE} = 1mA$		●		2	6	mV
		$I_{SINK} = 10µA$		 ●		1.75	4 6	mV mV
e_n	Voltage Noise	100Hz to 100kHz				100		$µV_{RMS}$

The ● denotes specifications which apply over the full operating temperature range.

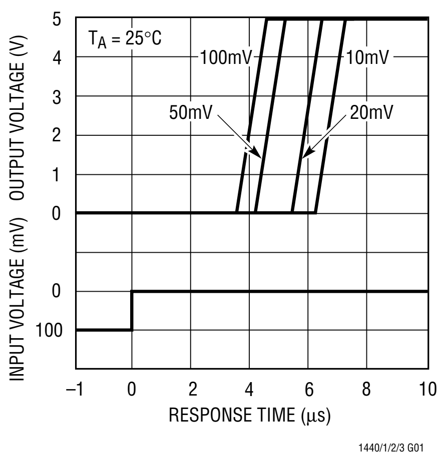
Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: $IN^+ = IN^- + 80mV$, output is in high impedance state.

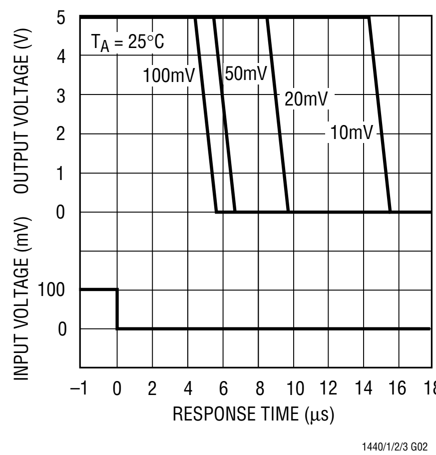
Note 3: $V_{CM} = 1/2(V^+ – V^-)$ for LTC1841, $V_{CM} = V_{REF}$ for LTC1842/LTC1843.

TYPICAL PERFORMANCE CHARACTERISTICS

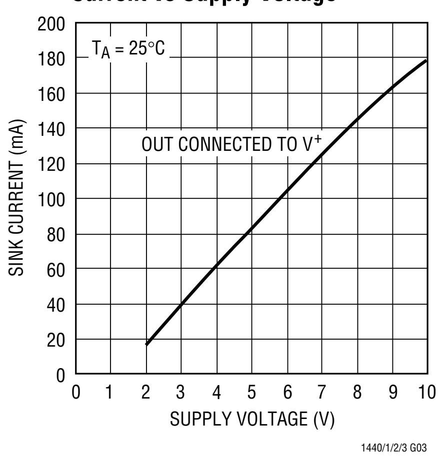
Comparator Response Time vs Input Overdrive, with $R_{PULL\text{-}UP}$ = 5k



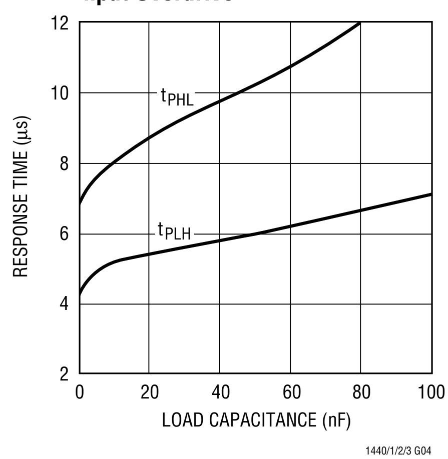
Comparator Response Time vs Input Overdrive, with $R_{PULL\text{-}UP}$ = 5k



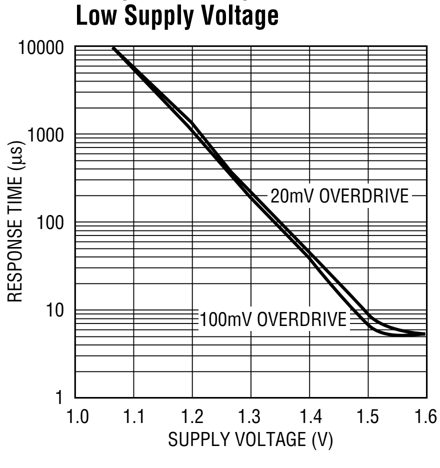
Comparator Short-Circuit Sink Current vs Supply Voltage



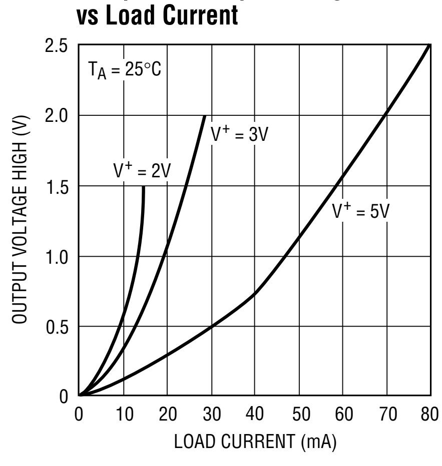
Comparator Response Time vs Load Capacitance with 100mV Input Overdrive



Comparator Response Time at Low Supply Voltage

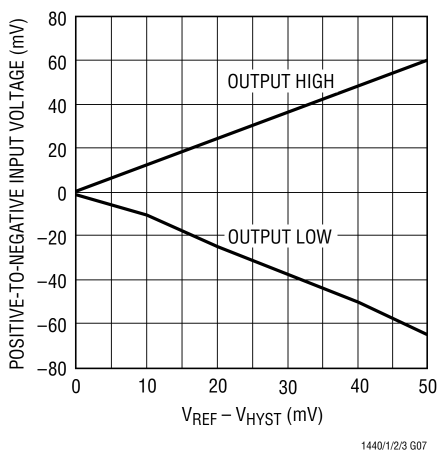


Comparator Output Voltage Low vs Load Current

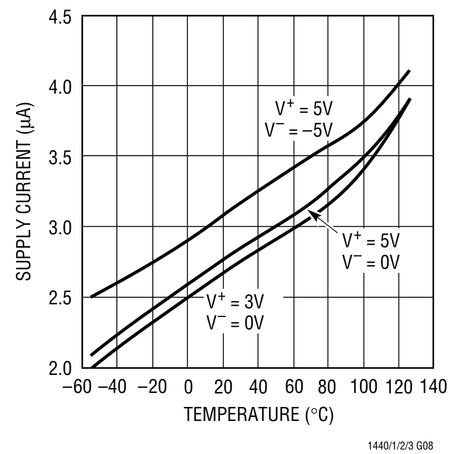


TYPICAL PERFORMANCE CHARACTERISTICS

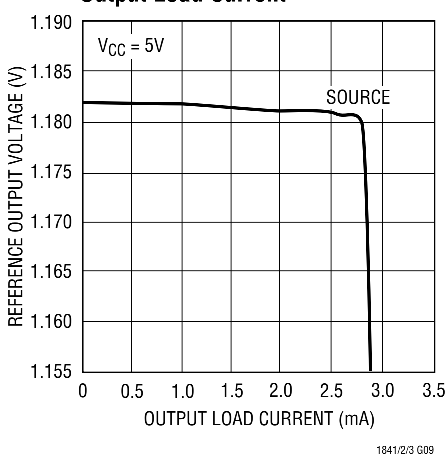
LTC1842/LTC1843
Hysteresis Control



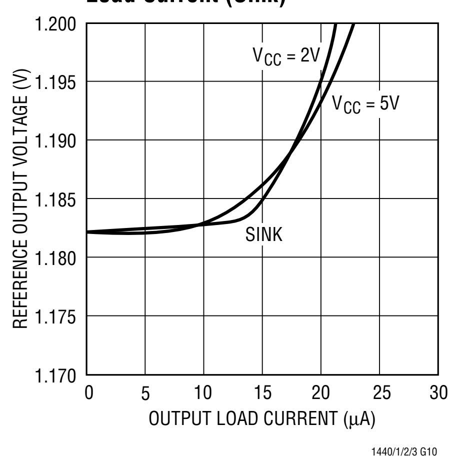
LTC1842/LTC1843
Supply Current vs Temperature



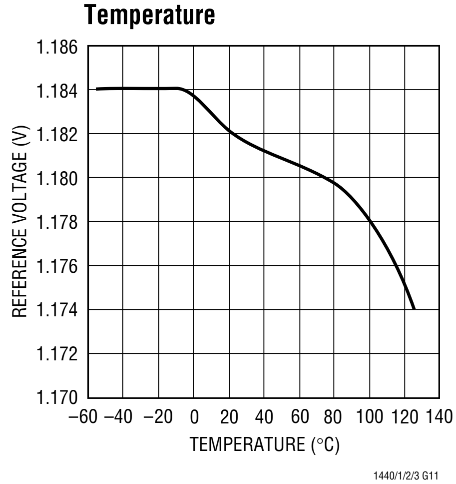
Reference Output Voltage vs Output Load Current



Reference Output Voltage vs Output Load Current (Sink)



Reference Voltage vs Temperature



PIN FUNCTIONS

OUT A (Pin 1): Comparator A Open-Drain Output. Output can typically sink greater than 20mA.

V^- (Pin 2): Negative Supply.

IN A^+ (Pin 3): Noninverting Input of Comparator A. Input common mode range extends from V^- to $V^+ - 1.3V$. Input current is typically 10pA at 25°C.

IN A^- (Pin 4) (LTC1841): Inverting Input of Comparator A. Input common mode range extends from V^- to $V^+ - 1.3V$. Input current is typically 10pA at 25°C.

IN B^+ (Pin 4) (LTC1842): Noninverting Input of Comparator B. Input common mode range extends from V^- to $V^+ - 1.3V$. Input current is typically 10pA at 25°C.

IN B^- (Pin 4) (LTC1843): Inverting Input of Comparator B. Input common mode range extends from V^- to $V^+ - 1.3V$. Input current is typically 10pA at 25°C.

IN B^- (Pin 5) (LTC1841): Inverting Input of Comparator B. Input common mode range extends from V^- to $V^+ - 1.3V$. Input current is typically 10pA at 25°C.

HYST (Pin 5) (LTC1842/LTC1843): Hysteresis Input. Connect to REF if not used. Input voltage range is from V_{REF} to $V_{REF} - 50mV$.

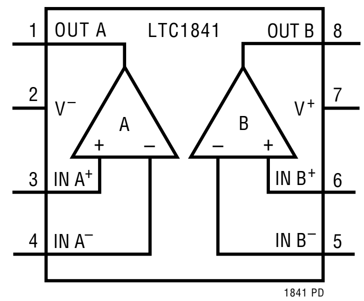
IN B^+ (Pin 6) (LTC1841): Noninverting Input of Comparator B. Input common mode range extends from V^- to $V^+ - 1.3V$. Input current is typically 10pA at 25°C.

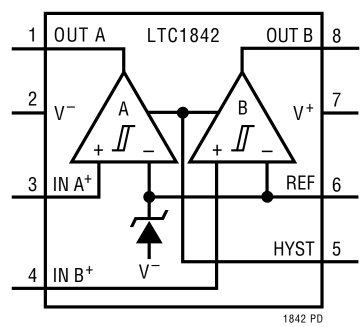
REF (Pin 6) (LTC1842/LTC1843): Reference Output. 1.182V with respect to V^-. Can typically source greater than 1mA and sink 10µA at 25°C. Can drive 0.01µF bypass capacitor without oscillation.

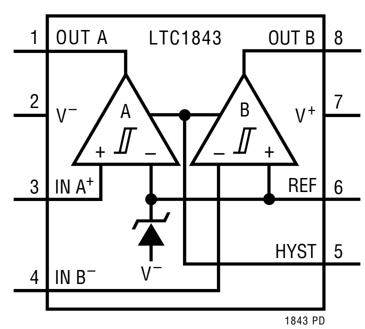
V^+ (Pin 7) (LTC1841): Positive Supply. 2V to 11V.

V^+ (Pin 7) (LTC1842/LTC1843): Positive Supply. 2.5V to 11V.

OUT B (Pin 8): Comparator B Open-Drain Output. Output can typically sink greater than 20mA.







APPLICATIONS INFORMATION

The LTC1841/LTC1842/LTC1843 are dual micropower comparators with a built-in 1.182V reference (LTC1842/LTC1843). Features include programmable hysteresis, wide supply voltage range (2V to 11V) and the ability for the reference to drive up to a 0.01µF capacitor without oscillation. The comparators' open-drain outputs can typically sink greater than 20mA and the supply current glitches that normally occur when switching logic states have been eliminated.

Power Supplies

The comparators operate from a single 2V to 11V (2.5V to 11V for LTC1842/LTC1843) or dual ±1V to ±5.5V supply (±1.25V to ±5.5V for LTC1842/LTC1843). If the reference output is required to source more than 1mA or the supply source impedance is high, V^+ should be bypassed with a 0.1µF capacitor.

Comparator Inputs

The comparators' input can swing from the negative supply V^- to within 1.3V (max) of the positive supply V^+. The input can be forced 300mV below V^- or above V^+ without damage and the typical input leakage current is only ±10pA.

Comparator Outputs

Each comparator output is an open-drain pull-down to V^- typically capable of sinking greater than 20mA. The low output leakage current while in three-state mode allows a high value pull-up resistor to be used. The open-drain outputs can be wire OR-ed or used in level shifting applications.

Voltage Reference

The internal bandgap reference has an output voltage of 1.182V referenced to V^-. The reference accuracy is 1.5% from –40°C to 85°C. It can typically source greater than 1mA and sink up to 10µA with a 5V supply. The reference can drive a bypass capacitor of up to 0.01µF without oscillation. By inserting a series resistor, capacitance values up to 100µF can be used (Figure 1).

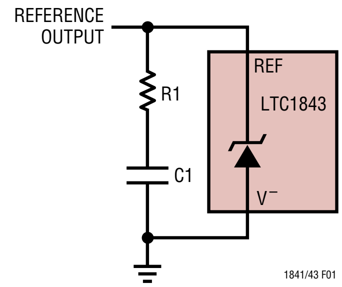


Figure 1. Damping the Reference Output

Figure 2 shows the resistor value required for different capacitor values to achieve critical damping. Bypassing the reference can help prevent false tripping of the comparators by preventing glitches on V^+ or reference load transients from disturbing the reference output voltage.

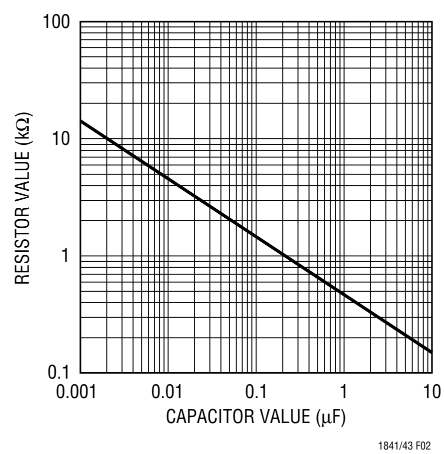


Figure 2. Damping Resistance vs Bypass Capacitor Value

Figure 3 shows the bypassed reference output with a square wave applied to the V^+ pin. Resistors R2 and R3 set a 10mV hysteresis voltage band while R1 damps the reference response. Note that the comparator output doesn't trip.

APPLICATIONS INFORMATION

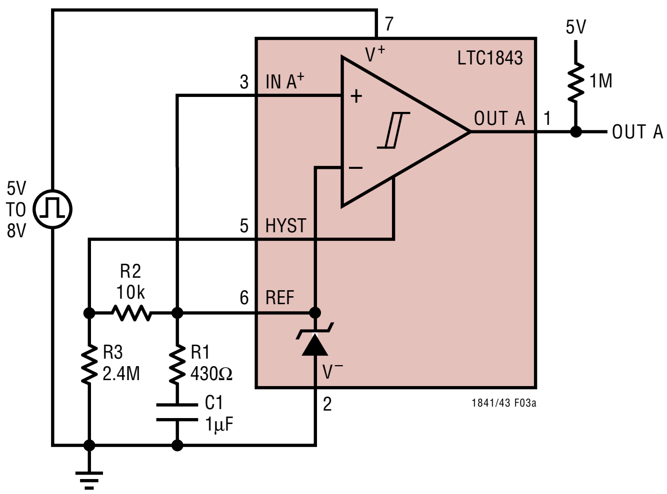


Figure 3a. Power Supply Transient Test Circuit

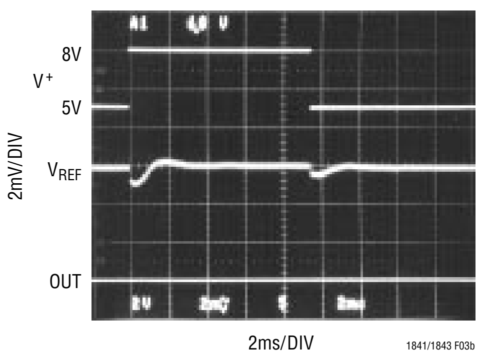


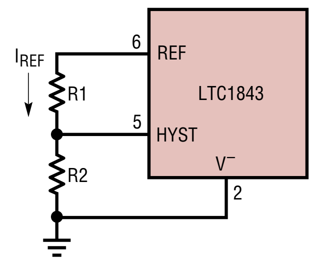
Figure 3b. Power Supply Transient Rejection

Hysteresis

Hysteresis can be added to the LTC1842/LTC1843 by connecting a resistor (R1) between the REF and HYST pins and a second resistor (R2) from HYST to V^- (Figure 4).

The difference between the upper and lower threshold voltages, or hysteresis voltage band (V_{HB}), is equal to twice the voltage difference between the REF and HYST pins.

As more hysteresis is added, the upper threshold increases the same amount as the low threshold decreases. The maximum voltage allowed between REF and HYST pins is 50mV, producing a maximum hysteresis voltage band of 100mV. The hysteresis band may vary by up to



$$R1 = \frac{V_{HB}}{(2)(I_{REF})}$$

$$R2 = \frac{\left(1.182V - \frac{V_{HB}}{2}\right)}{I_{REF}}$$

Figure 4. Programmable Hysteresis

15%. If hysteresis is not wanted, the HYST pin should be shorted to REF. Acceptable values for I_{REF} range are from 0.1μA to 5μA. If 2.4M is chosen for R2, then the value of R1 is equal to the value of V_{HB}.

Window Detector

The LTC1843 is ideal for use as a micropower window detector as shown in Figure 5. The values of R1, R2 and R3 are selected for a 4.5V undervoltage threshold and a 5.5V overvoltage threshold. R4 and R5 set the hysteresis voltage. The following design procedure can be used to select the component values:

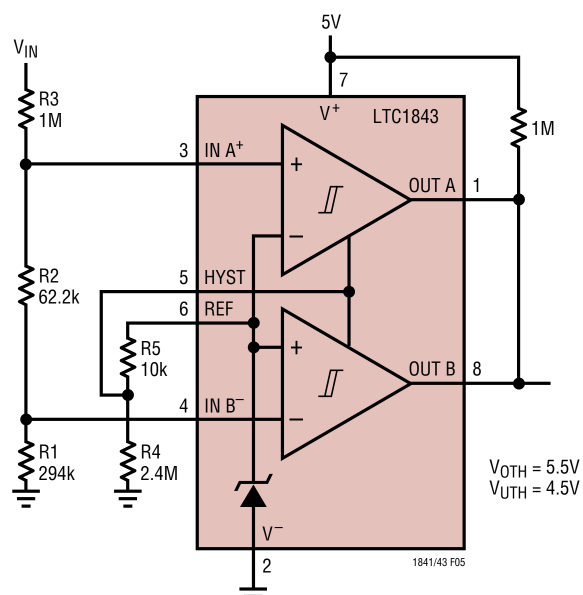


Figure 5. Dual Level Detector

APPLICATIONS INFORMATION

1. Choose the required hysteresis voltage band and calculate values for R4 and R5 according to the formulas in the hysteresis section. In this example, ±5mV of hysteresis has been added at the comparator input ($V_H = V_{HB}/2$). Note that the hysteresis apparent at V_{IN} will be larger because of the input resistor divider.

2. Select R1. The leakage current into IN B^- is under 1nA so the current through R1 should exceed 100nA, to ensure threshold accuracy. R1 values up to about 10M can be used, but values in the 100k to 1M range are usually easier to deal with. In this example choose R1 = 294k.

3. Calculate R2 + R3. The overvoltage threshold should be set at 5.5V. The design equation is as follows:

$$
\begin{aligned}
R2 + R3 &= R1\left(\frac{V_{UTH}}{V_{REF} + V_H} - 1\right)\\
&= 294k\left(\frac{5.5}{1.182 + 0.005} - 1\right)\\
&= 1.068M
\end{aligned}
$$

4. Calculate R2. The undervoltage threshold should be set at 4.5V. The design equation is as follows:

$$
\begin{aligned}
R2 &= \left(R1 + R2 + R3\right)\frac{V_{REF} - V_H}{V_{LTH}} - R1\\
&= \left(294k + 1.068M\right)\frac{1.182 - 0.005}{4.5} - 294k\\
&= 62.2k
\end{aligned}
$$

Choose R2 = 61.9k (1% standard value)

5. Calculate R3:

$$
\begin{aligned}
R3 &= (R2 + R3) - R2\\
&= 1.068M - 61.9k\\
&= 1.006M
\end{aligned}
$$

Choose R3 = 1M (1% standard value)

6. Verify the resistor values. The equations are as follows, evaluated for the above example:

Overvoltage threshold:

$$
\begin{aligned}
V_{OTH} &= \left(V_{REF} + V_H\right)\frac{R1 + R2 + R3}{R1}\\
&= 5.474V
\end{aligned}
$$

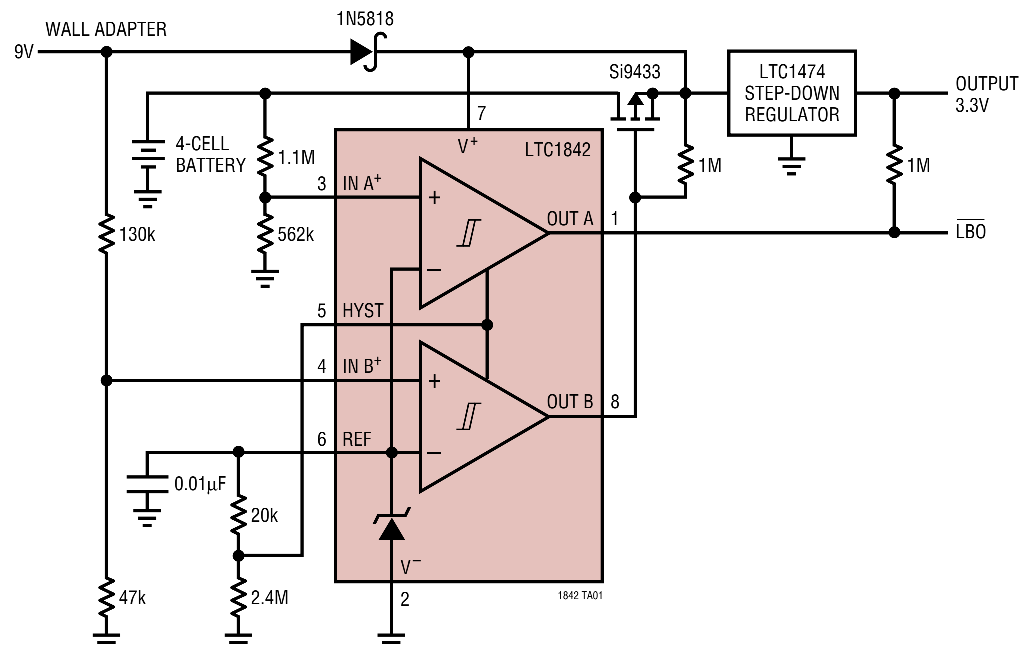
Undervoltage threshold:

$$
\begin{aligned}
V_{UTH} &= \left(V_{REF} - V_H\right)\frac{R1 + R2 + R3}{R1 + R2}\\
&= 4.484V
\end{aligned}
$$

where the hysteresis voltage $V_H = \left(V_{REF}\right)\left(\frac{R5}{R4}\right)$

TYPICAL APPLICATION

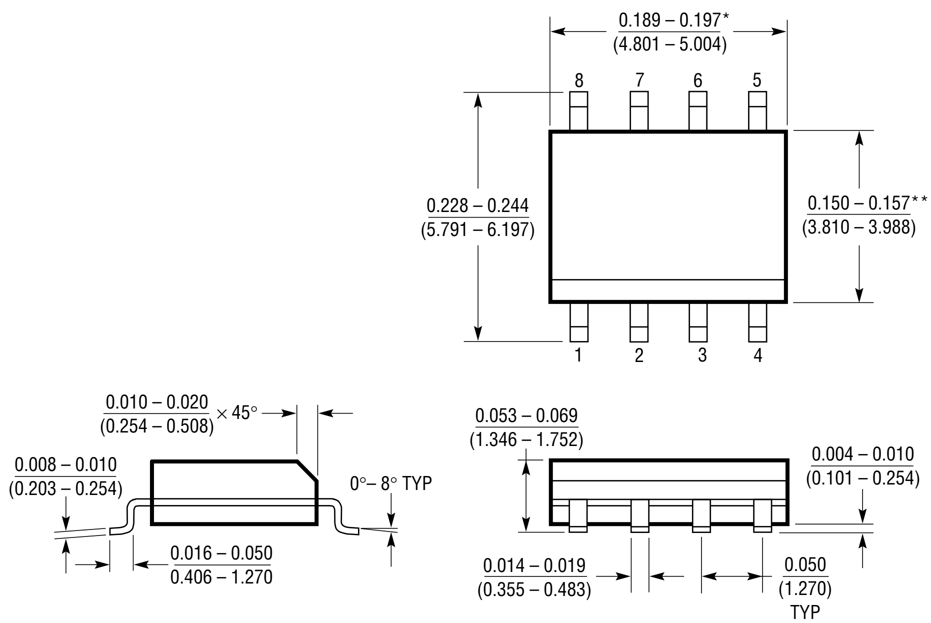
Battery Switchover Circuit



PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

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



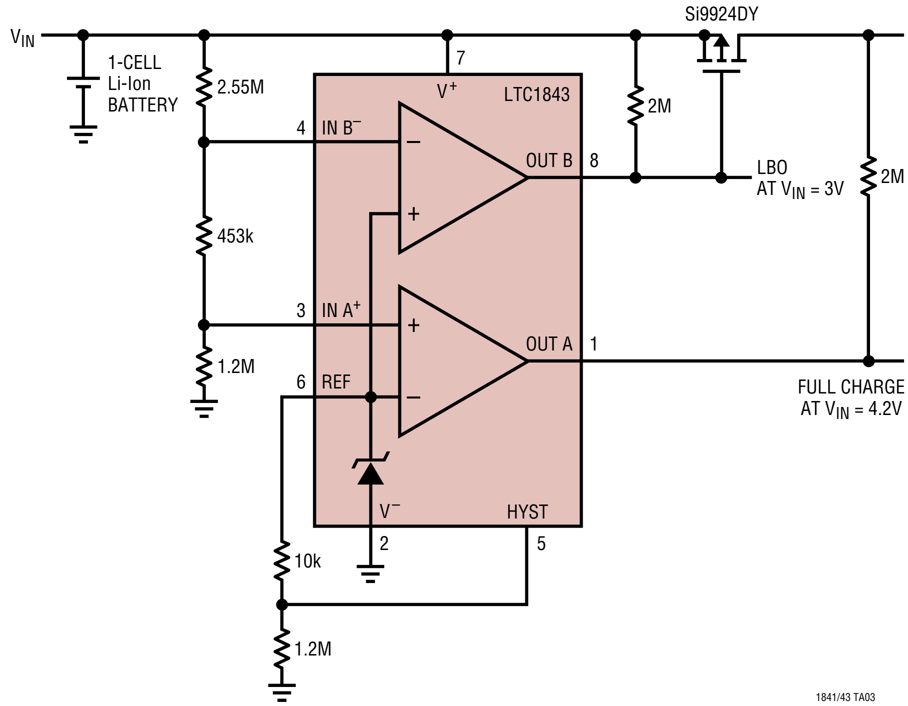
*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

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

SO8 0996

TYPICAL APPLICATION

Low-Battery Load Disconnect and Charge Termination



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT®1178/LT1179	Dual/Quad 17µA Precision Single Supply Op Amps	70µV Max V_{OS}, 5nA Max I_{BIAS}
LT1351	Single 250µA, 3MHz, 200V/µs Op Amp with Shutdown	C-Load™ Op Amp Stable Driving Any Capacitive Load
LT1352/LT1353	Dual/Quad 250µA, 3MHz, 200V/µs Op Amps	C-Load Op Amps Stable Driving Any Capacitive Load
LTC1440/LTC1540	Micropower Comparator with 1% Reference	1.182V ±1% Reference, ±10mV (Max) Input Offset
LTC1441/LTC1442	Micropower Dual Comparator with 1% Reference	1.182V ±1% Reference (LTC1442)
LTC1443/LTC1444/LTC1445	Micropower Quad Comparator with 1% Reference	LTC1443 Has 1.182V Reference, LTC1444/LTC1445 Have 1.221V Reference and Adjustable Hysteresis
LTC1474	Low Quiescent Current High Efficiency Step-Down Switching Regulator	10µA Standby Current, 92% Efficiency, Space Saving 8-Pin MSOP Package
LT1495	1.5µA Max, Dual Precision Rail-to-Rail Input and Output Op Amp	375µV Max V_{OS}, 250pA I_{BIAS}, 25pA I_{OS}
LT1521	300mA Low Dropout Regulator with Micropower Quiescent Current and Shutdown	0.5V Dropout Voltage, 12µA Quiescent Current, Adjustable Output 3V, 3.3V and 5V Fixed
LTC1541/LTC1542	Micropower Op Amp, Comparator and Reference	1.200V ±0.8% Reference (LTC1541) Op Amp Outputs Stable with 1000pF Load
LT1634	Micropower Precision Shunt Voltage Reference	1.25V Output, 10µA Operating Current, 0.1% Initial Accuracy 10ppm/°C Max Drift

C-Load is a trademark of Linear Technology Corporation.

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