

# Ultralow Power Single/Dual Comparator with Reference

## FEATURES

- **Ultralow Quiescent Current: 2.1 $\mu$ A Typ (LTC1440)**
- **Reference Output Drives 0.01 $\mu$ F Capacitor**
- **Adjustable Hysteresis (LTC1440/LTC1442)**
- **Wide Supply Range:**  
 Single: 2V to 11V  
 Dual:  $\pm 1$ V to  $\pm 5.5$ V
- **Input Voltage Range Includes the Negative Supply**
- **TTL/CMOS Compatible Outputs**
- **12 $\mu$ s Propagation Delay with 10mV Overdrive**
- **No Crowbar Current**
- **40mA Continuous Source Current**
- **Pin Compatible Upgrades for MAX921/922/923**
- **3mm x 3mm x 0.75mm DFN Package (LTC1440)**

## APPLICATIONS

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

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## DESCRIPTION

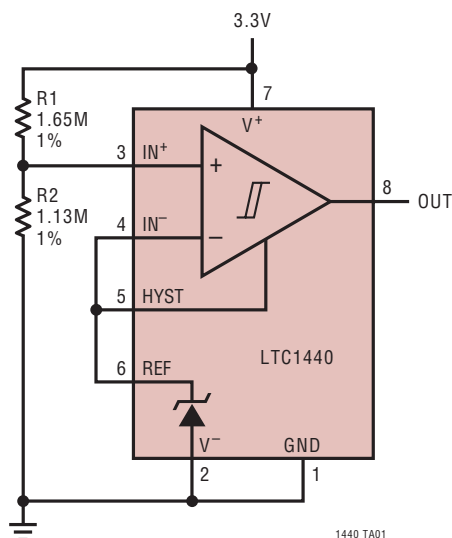
The LTC<sup>®</sup>1440/LTC1441/LTC1442 are ultralow power single and dual comparators with built-in references. The comparators feature less than 3.7 $\mu$ A supply current over temperature (LTC1440), a 1.182V  $\pm 1\%$  reference, programmable hysteresis (LTC1440/LTC1442) and TTL/CMOS outputs that sink and source current. The reference output can drive a bypass capacitor of up to 0.01 $\mu$ F without oscillation.

The comparators operate from a single 2V to 11V supply or a dual  $\pm 1$ V to  $\pm 5.5$ V supply (LTC1440). Comparator hysteresis is easily programmed by using two resistors and the HYST pin (LTC1440/LTC1442). Each comparator's input operates from the negative supply to within 1.3V of the positive supply. The comparator output stage can continuously source up to 40mA. By eliminating the cross-conducting current that normally happens when the comparator changes logic states, the power supply glitches are eliminated.

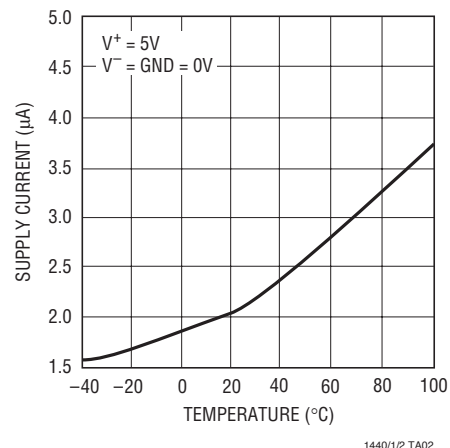
The LTC1440 is available in 8-pin PDIP, SO, MSOP and DFN packages. The LTC1441/LTC1442 are available in 8-pin PDIP and SO packages.

## TYPICAL APPLICATION

Micropower 2.9V  $V_{CC}$  Threshold Detector



LTC1440 Supply Current vs Temperature



1440/1/2 TA02

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

### Voltage

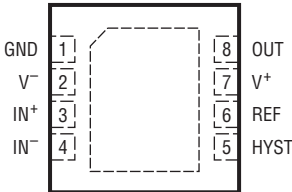
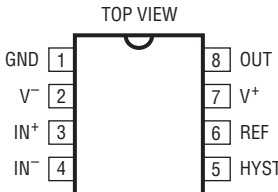
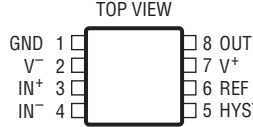
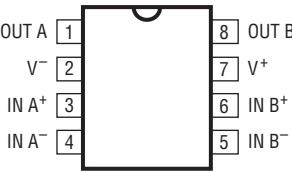
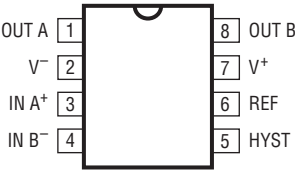
$V^+$  to  $V^-$ ,  $V^+$  to GND, GND to  $V^-$  ..... 12V to  $-0.3V$   
 $IN^+$ ,  $IN^-$ , HYST ..... ( $V^+ + 0.3V$ ) to ( $V^- - 0.3V$ )  
 REF ..... ( $V^+ + 0.3V$ ) to ( $V^- - 0.3V$ )  
 OUT (LTC1440) ..... ( $V^+ + 0.3V$ ) to (GND  $- 0.3V$ )  
 OUT (LTC1441/LTC1442) ... ( $V^+ + 0.3V$ ) to ( $V^- - 0.3V$ )

### Current

$IN^+$ ,  $IN^-$ , HYST ..... 20mA  
 REF ..... 20mA  
 OUT ..... 50mA

OUT Short-Circuit Duration ( $V^+ \leq 5.5V$ ) ..... Continuous  
 Power Dissipation ..... 500mW  
 Operating Temperature Range  
   LTC144XC .....  $0^\circ C$  to  $70^\circ C$   
   LTC144XI .....  $-40^\circ C$  to  $85^\circ C$   
 Storage Temperature Range .....  $-65^\circ C$  to  $150^\circ C$   
 Storage Temperature Range  
   (DD Package) .....  $-65^\circ C$  to  $125^\circ C$   
 Junction Temperature .....  $150^\circ C$   
 Junction Temperature (DD Package) .....  $125^\circ C$   
 Lead Temperature (Soldering, 10 sec) .....  $300^\circ C$

## PACKAGE/ORDER INFORMATION

|                                                                                                                                                                                                                                                                                                                                                                |                   |                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                |                                                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|
| <div><p>TOP VIEW</p><p>DD PACKAGE<br/>8-LEAD (3mm x 3mm) PLASTIC DFN</p><p><math>T_{JMAX} = 125^{\circ}C</math>, <math>\theta_{JA} = 160^{\circ}C/W</math> (DD)<br/>UNDERSIDE METAL CONNECTED TO <math>V^{-}</math><br/>(PCB CONNECTION OPTIONAL)</p></div>                  |                   | <div><p>TOP VIEW</p><p>N8 PACKAGE 8-LEAD PDIP    S8 PACKAGE 8-LEAD PLASTIC SO</p><p><math>T_{JMAX} = 150^{\circ}C</math>, <math>\theta_{JA} = 130^{\circ}C/W</math> (N8)<br/><math>T_{JMAX} = 150^{\circ}C</math>, <math>\theta_{JA} = 175^{\circ}C/W</math> (S8)</p></div> |                                                                                                                                                                                                                                                                                                                                                                 | <div><p>TOP VIEW</p><p>MS8 PACKAGE<br/>8-LEAD PLASTIC MSOP</p><p><math>T_{JMAX} = 150^{\circ}C</math>, <math>\theta_{JA} = 250^{\circ}C/W</math></p></div> |                                                      |
| ORDER PART NUMBER                                                                                                                                                                                                                                                                                                                                              | DD8 PART MARKING* | ORDER PART NUMBER                                                                                                                                                                                                                                                                                                                                             | S8 PART MARKING                                                                                                                                                                                                                                                                                                                                                 | ORDER PART NUMBER                                                                                                                                                                                                                              | MS8 PART MARKING*                                    |
| LTC1440CDD<br>LTC1440IDD                                                                                                                                                                                                                                                                                                                                       | LBTH              | LTC1440CN8<br>LTC1440CS8<br>LTC1440IN8<br>LTC1440IS8                                                                                                                                                                                                                                                                                                          | 1440<br>1440<br>1440I<br>1440I                                                                                                                                                                                                                                                                                                                                  | LTC1440CMS8<br>LTC1440IMS8                                                                                                                                                                                                                     | LTBX                                                 |
| <div><p>TOP VIEW</p><p>N8 PACKAGE 8-LEAD PDIP    S8 PACKAGE 8-LEAD PLASTIC SO</p><p><math>T_{JMAX} = 150^{\circ}C</math>, <math>\theta_{JA} = 130^{\circ}C/W</math> (N8)<br/><math>T_{JMAX} = 150^{\circ}C</math>, <math>\theta_{JA} = 175^{\circ}C/W</math> (S8)</p></div> |                   | ORDER PART NUMBER                                                                                                                                                                                                                                                                                                                                             | <div><p>TOP VIEW</p><p>N8 PACKAGE 8-LEAD PDIP    S8 PACKAGE 8-LEAD PLASTIC SO</p><p><math>T_{JMAX} = 150^{\circ}C</math>, <math>\theta_{JA} = 130^{\circ}C/W</math> (N8)<br/><math>T_{JMAX} = 150^{\circ}C</math>, <math>\theta_{JA} = 175^{\circ}C/W</math> (S8)</p></div> |                                                                                                                                                                                                                                                | ORDER PART NUMBER                                    |
|                                                                                                                                                                                                                                                                                                                                                                |                   | LTC1441CN8<br>LTC1441CS8<br>LTC1441IN8<br>LTC1441IS8                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                | LTC1442CN8<br>LTC1442CS8<br>LTC1442IN8<br>LTC1442IS8 |
|                                                                                                                                                                                                                                                                                                                                                                |                   | S8 PART MARKING                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                | S8 PART MARKING                                      |
|                                                                                                                                                                                                                                                                                                                                                                |                   | 1441<br>1441I                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                | 1442<br>1442I                                        |

Order Options

Tape and Reel: Add #TR

Lead Free: Add #PBF

Lead Free Tape and Reel: Add #TRPBF

Lead Free Part Marking: <http://www.linear.com/leadfree/>

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

\* The temperature grade is identified by a label on the shipping container.

# ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V^+ = 5\text{V}$  and  $V^- = \text{GND} = 0\text{V}$  unless otherwise noted.

| SYMBOL              | PARAMETER                                                                                  | CONDITIONS                                                                             |                                                                                                        |             | MIN                     | TYP            | MAX                                 | UNITS             |
|---------------------|--------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|-------------|-------------------------|----------------|-------------------------------------|-------------------|
| Power Supply        |                                                                                            |                                                                                        |                                                                                                        |             |                         |                |                                     |                   |
| V <sup>+</sup>      | Supply Voltage Range                                                                       |                                                                                        |                                                                                                        | ●           | 2.0                     |                | 11.0                                | V                 |
| I <sub>CC</sub>     | Supply Current                                                                             | IN <sup>+</sup> = IN <sup>−</sup> + 80mV<br>HYST = REF (LTC1440/LTC1442)               | LTC1440 0°C ≤ T <sub>A</sub> ≤ 70°C<br>−40°C ≤ T <sub>A</sub> ≤ 85°C                                   | ●<br>●      |                         | 2.1            | 4.0<br>4.4                          | μA<br>μA          |
|                     |                                                                                            |                                                                                        | LTC1441<br>LTC1442                                                                                     | ●<br>●      |                         | 3.5<br>3.5     | 5.7<br>5.7                          | μA<br>μA          |
| Comparator          |                                                                                            |                                                                                        |                                                                                                        |             |                         |                |                                     |                   |
| V <sub>OS</sub>     | Comparator Input Offset Voltage                                                            | V <sub>CM</sub> = 2.5V                                                                 |                                                                                                        | ●           |                         | ±3             | ±10                                 | mV                |
| I <sub>IN</sub>     | Input Leakage Current (IN <sup>+</sup> , IN <sup>−</sup> )<br>Input Leakage Current (HYST) | V <sub>IN<sup>+</sup></sub> = V <sub>IN<sup>−</sup></sub> = 2.5V                       |                                                                                                        | ●<br>●      |                         | ±0.01<br>±0.02 | ±1.0<br>±1.0                        | nA<br>nA          |
| V <sub>CM</sub>     | Comparator Input Common Mode Range                                                         |                                                                                        |                                                                                                        | ●           | V <sup>−</sup>          |                | V <sup>+</sup> − 1.3V               | V                 |
| CMRR                | Common Mode Rejection Ratio                                                                | V <sup>−</sup> to V <sup>+</sup> − 1.3V                                                |                                                                                                        |             |                         | 0.1            | 1                                   | mV/V              |
| PSRR                | Power Supply Rejection Ratio                                                               | V <sup>+</sup> = 2V to 11V (LTC1441)<br>V <sup>+</sup> = 2.5V to 11V (LTC1440/LTC1442) |                                                                                                        |             |                         | 0.1<br>0.1     | 1<br>1                              | mV/V<br>mV/V      |
| NOISE               | Voltage Noise                                                                              | 100Hz to 100kHz                                                                        |                                                                                                        |             |                         | 100            |                                     | μV <sub>RMS</sub> |
| V <sub>HYST</sub>   | Hysteresis Input Voltage Range                                                             | LTC1440/LTC1442                                                                        |                                                                                                        | ●           | REF − 50mV              |                | REF                                 | V                 |
| t <sub>PD</sub>     | Propagation Delay                                                                          | C <sub>OUT</sub> = 100pF<br>Overdrive = 10mV<br>Overdrive = 100mV                      |                                                                                                        |             |                         | 15<br>8        |                                     | μs<br>μs          |
| V <sub>OH</sub>     | Output High Voltage                                                                        | I <sub>O</sub> = −13mA                                                                 |                                                                                                        | ●           | V <sup>+</sup> − 0.4V   |                |                                     | V                 |
| V <sub>OL</sub>     | Output Low Voltage                                                                         | I <sub>O</sub> = 1.8mA<br>LTC1440<br>LTC1441/LTC1442                                   |                                                                                                        | ●<br>●      |                         |                | GND + 0.4V<br>V <sup>−</sup> + 0.4V | V<br>V            |
| Reference           |                                                                                            |                                                                                        |                                                                                                        |             |                         |                |                                     |                   |
| V <sub>REF</sub>    | Reference Voltage                                                                          | No Load                                                                                | LTC1440/LTC1442<br>0°C ≤ T <sub>A</sub> ≤ 70°C<br>−40°C ≤ T <sub>A</sub> ≤ 85°C<br>LTC1440 (MSOP, DFN) | ●<br>●<br>● | 1.170<br>1.164<br>1.164 |                | 1.194<br>1.200<br>1.200             | V<br>V<br>V       |
| I <sub>SOURCE</sub> | Reference Output Source Current                                                            | ΔV <sub>REF</sub> ≤ 1mV (LTC1442)                                                      |                                                                                                        | ●           | 100                     |                |                                     | μA                |
| I <sub>SINK</sub>   | Reference Output Sink Current                                                              | ΔV <sub>REF</sub> ≤ 2.5mV (LTC1442)                                                    |                                                                                                        |             | 10                      | 20             |                                     | μA                |
| ΔV <sub>REF</sub>   | Reference Source Current                                                                   | 0 ≤ I <sub>SOURCE</sub> ≤ 2mA (LTC1440)                                                |                                                                                                        | ●           |                         | 0.8            | 5                                   | mV                |
|                     | Reference Sink Current                                                                     | 0 ≤ I <sub>SINK</sub> ≤ 10μA (LTC1440)                                                 |                                                                                                        | ●           |                         | 0.5            | 1.5<br>5                            | mV<br>mV          |
| NOISE               | Voltage Noise                                                                              | 100Hz to 100kHz                                                                        |                                                                                                        |             |                         | 100            |                                     | μV <sub>RMS</sub> |

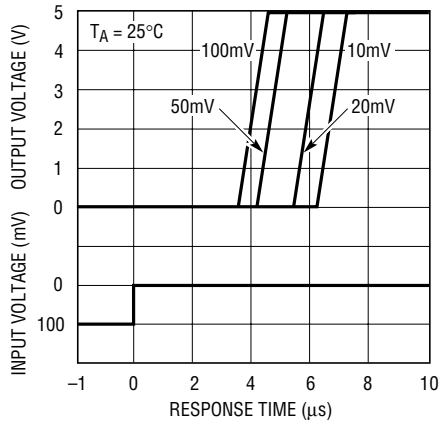
# LTC1440/LTC1441/LTC1442

**ELECTRICAL CHARACTERISTICS** The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V^+ = 3\text{V}$  and  $V^- = \text{GND} = 0\text{V}$  unless otherwise noted.

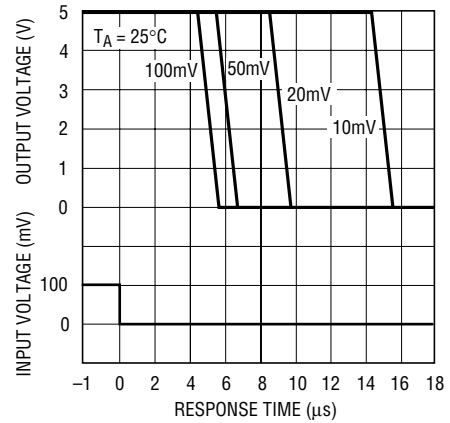
| SYMBOL              | PARAMETER                                 | CONDITIONS                                                                  |                                                          | MIN                        | TYP        | MAX                        | UNITS                      |
|---------------------|-------------------------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------|----------------------------|------------|----------------------------|----------------------------|
| <b>Power Supply</b> |                                           |                                                                             |                                                          |                            |            |                            |                            |
| $V^+$               | Supply Voltage Range                      |                                                                             | ●                                                        | 2                          |            | 11                         | V                          |
| $I_{CC}$            | Supply Current                            | $IN^+ = IN^- + 80\text{mV}$<br>$\text{HYST} = \text{REF}$ (LTC1440/LTC1442) | LTC1440 $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ | ●                          | 2          | 3.9                        | $\mu\text{A}$              |
|                     |                                           |                                                                             | $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$       | ●                          |            | 4.3                        | $\mu\text{A}$              |
|                     |                                           | LTC1441                                                                     | ●                                                        |                            | 3.5        | 5.7                        | $\mu\text{A}$              |
|                     |                                           | LTC1442                                                                     | ●                                                        |                            | 3.5        | 5.7                        | $\mu\text{A}$              |
| <b>Comparator</b>   |                                           |                                                                             |                                                          |                            |            |                            |                            |
| $V_{OS}$            | Comparator Input Offset Voltage           | $V_{CM} = 1.5\text{V}$                                                      | ●                                                        |                            | $\pm 3$    | $\pm 10$                   | mV                         |
| $I_{IN}$            | Input Leakage Current ( $IN^+$ , $IN^-$ ) | $V_{IN^+} = V_{IN^-} = 1.5\text{V}$                                         | ●                                                        |                            | $\pm 0.01$ | $\pm 1$                    | nA                         |
|                     | Input Leakage Current (HYST)              |                                                                             | ●                                                        |                            | $\pm 0.02$ | $\pm 1$                    | nA                         |
| $V_{CM}$            | Comparator Input Common Mode Range        |                                                                             | ●                                                        | $V^-$                      |            | $V^+ - 1.3\text{V}$        | V                          |
| CMRR                | Common Mode Rejection Ratio               | $V^-$ to $V^+ - 1.3\text{V}$                                                |                                                          |                            | 0.1        | 1                          | mV/V                       |
| PSRR                | Power Supply Rejection Ratio              | $V^+ = 2\text{V}$ to $11\text{V}$ (LTC1441)                                 |                                                          |                            | 0.1        | 1                          | mV/V                       |
|                     |                                           | $V^+ = 2.5\text{V}$ to $11\text{V}$ (LTC1440/LTC1442)                       |                                                          |                            | 0.1        | 1                          | mV/V                       |
| NOISE               | Voltage Noise                             | 100Hz to 100kHz                                                             |                                                          |                            | 100        |                            | $\mu\text{V}_{\text{RMS}}$ |
| $V_{\text{HYST}}$   | Hysteresis Input Voltage Range            | LTC1440/LTC1442                                                             | ●                                                        | $\text{REF} - 50\text{mV}$ |            | REF                        | V                          |
| $t_{PD}$            | Propagation Delay                         | $C_{OUT} = 100\text{pF}$                                                    |                                                          |                            | 14         |                            | $\mu\text{s}$              |
|                     |                                           | Overdrive = 10mV                                                            |                                                          |                            | 5          |                            | $\mu\text{s}$              |
|                     |                                           | Overdrive = 100mV                                                           |                                                          |                            |            |                            |                            |
| $V_{OH}$            | Output High Voltage                       | $I_O = -8\text{mA}$                                                         | ●                                                        | $V^+ - 0.4\text{V}$        |            |                            | V                          |
| <b>Comparator</b>   |                                           |                                                                             |                                                          |                            |            |                            |                            |
| $V_{OL}$            | Output Low Voltage                        | $I_O = 0.8\text{mA}$                                                        |                                                          |                            |            | $\text{GND} + 0.4\text{V}$ | V                          |
|                     |                                           |                                                                             | ●                                                        |                            |            | $V^- + 0.4\text{V}$        | V                          |
| <b>Reference</b>    |                                           |                                                                             |                                                          |                            |            |                            |                            |
| $V_{REF}$           | Reference Voltage                         | No Load                                                                     | LTC1440/LTC1442                                          |                            |            |                            |                            |
|                     |                                           |                                                                             | $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$         | ●                          | 1.170      | 1.182                      | 1.194                      |
|                     |                                           |                                                                             | $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$       | ●                          | 1.164      |                            | 1.200                      |
|                     |                                           |                                                                             | LTC1440 (MSOP, DFN)                                      | ●                          | 1.164      |                            | 1.200                      |
| $I_{SOURCE}$        | Reference Output Source Current           | $\Delta V_{REF} \leq 1\text{mV}$ (LTC1442)                                  | ●                                                        | 60                         | 120        |                            | $\mu\text{A}$              |
| $I_{SINK}$          | Reference Output Sink Current             | $\Delta V_{REF} \leq 2.5\text{mV}$ (LTC1442)                                |                                                          | 10                         | 20         |                            | $\mu\text{A}$              |
| $\Delta V_{REF}$    | Reference Source Current                  | $0 \leq I_{SOURCE} \leq 1\text{mA}$ (LTC1440)                               | ●                                                        |                            | 0.8        | 5.5                        | mV                         |
|                     | Reference Sink Current                    | $0 \leq I_{SINK} \leq 10\mu\text{A}$ (LTC1440)                              | ●                                                        |                            | 0.5        | 1.5                        | mV                         |
|                     |                                           |                                                                             | ●                                                        |                            |            | 5                          | mV                         |
| NOISE               | Voltage Noise                             | 100Hz to 100kHz                                                             |                                                          |                            | 100        |                            | $\mu\text{V}_{\text{RMS}}$ |

**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.

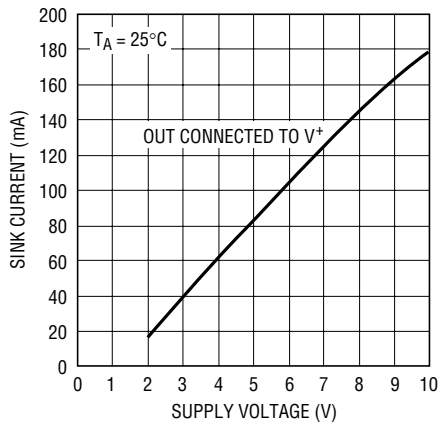
## TYPICAL PERFORMANCE CHARACTERISTICS

Comparator Response Time vs  
Input Overdrive

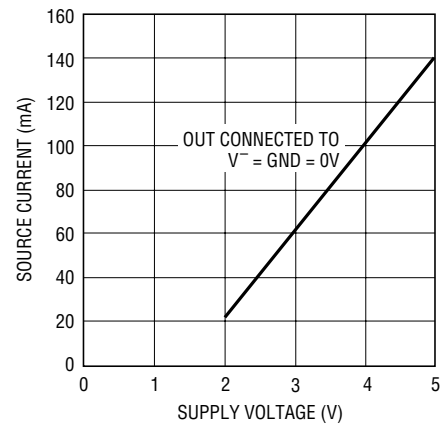
1440/1/2 G01

Comparator Response Time vs  
Input Overdrive

1440/1/2 G02

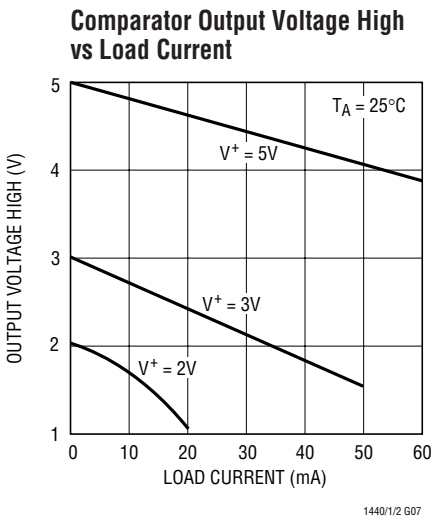
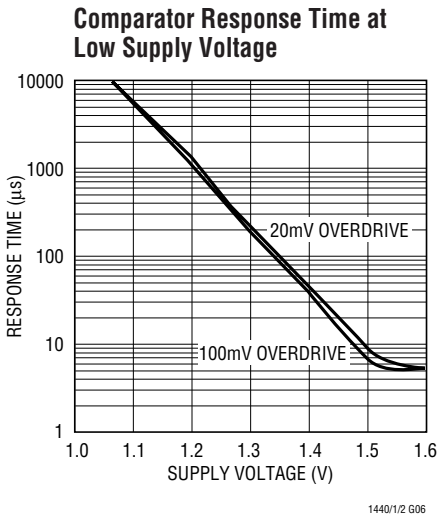
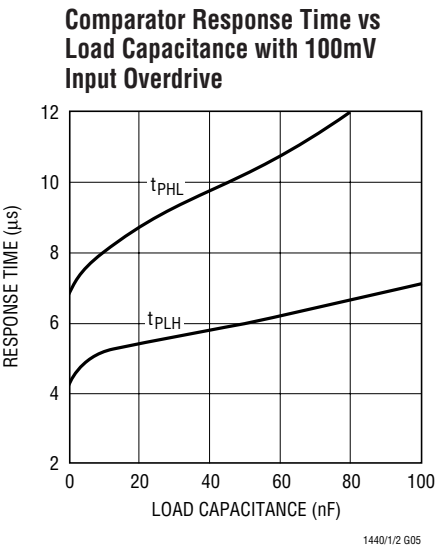
Comparator Short-Circuit Sink  
Current vs Supply Voltage

1440/1/2 G03

Comparator Short-Circuit Source  
Current vs Supply Voltage

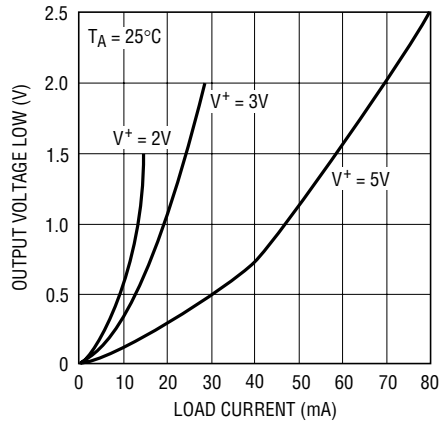
1440/1/2 G04

TYPICAL PERFORMANCE CHARACTERISTICS



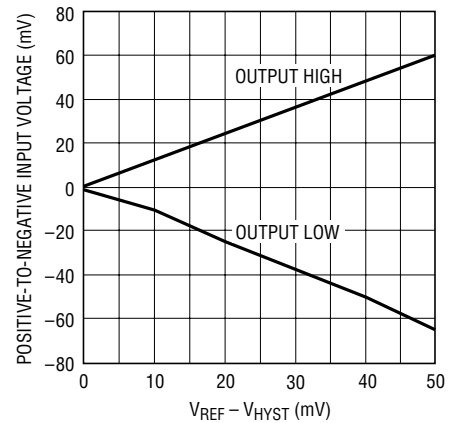
# TYPICAL PERFORMANCE CHARACTERISTICS

Comparator Output Voltage Low  
vs Load Current



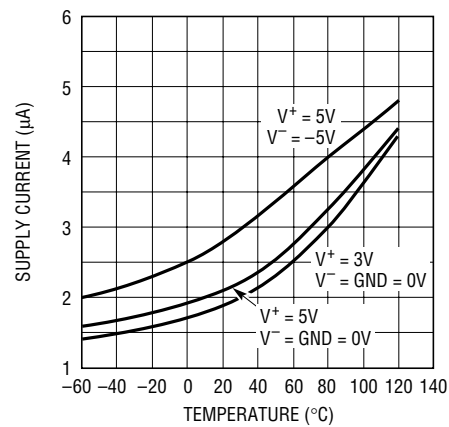
1440/1/2 G08

LTC1440/LTC1442  
Hysteresis Control



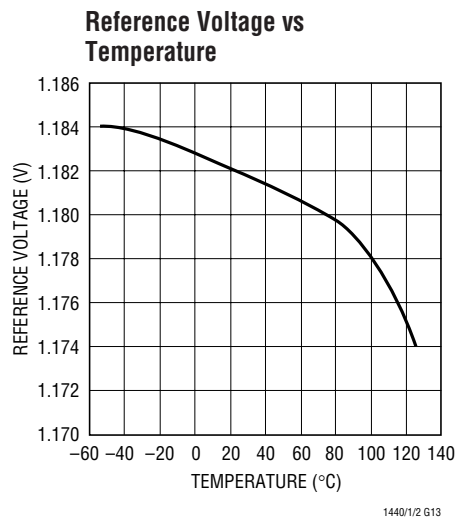
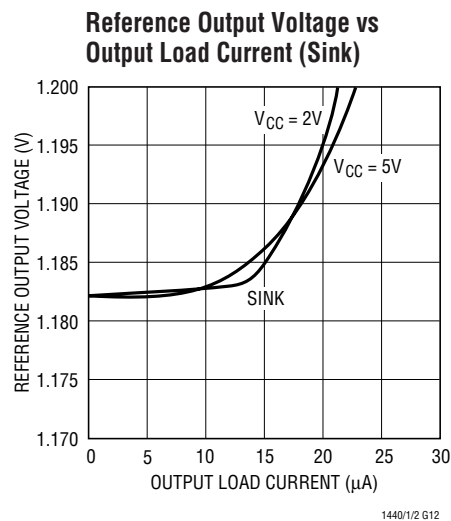
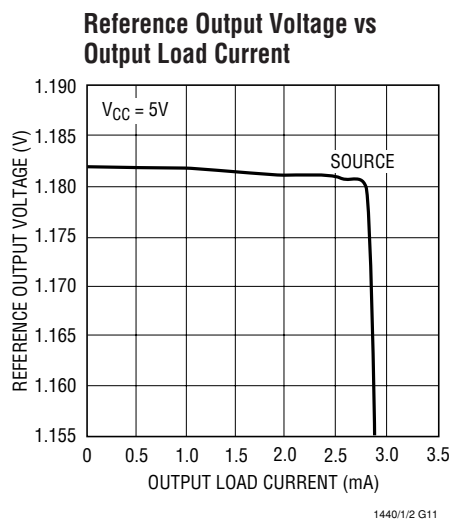
1440/1/2 G09

LTC1440  
Supply Current vs Temperature

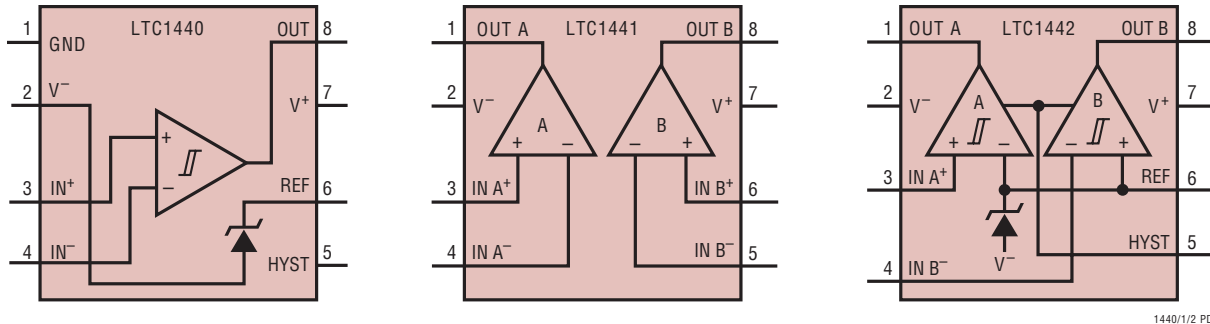


1440/1/2 G10

TYPICAL PERFORMANCE CHARACTERISTICS



## PIN FUNCTIONS

**LTC1440**

**GND (Pin 1):** Ground. Connect to V<sup>-</sup> for single supply operation.

**V<sup>-</sup> (Pin 2):** Negative Supply. Connect to ground for single supply operation. Potential should be more negative than GND.

**IN<sup>+</sup> (Pin 3):** Noninverting Comparator Input. Input common mode range from V<sup>-</sup> to V<sup>+</sup> -1.3V. Input current typically 10pA at 25°C.

**IN<sup>-</sup> (Pin 4):** Inverting Comparator Input. Input common mode range from V<sup>-</sup> to V<sup>+</sup> -1.3V. Input current typically 10pA at 25°C.

**HYST (Pin 5):** Hysteresis Input. Connect to REF if not used. Input voltage range is from V<sub>REF</sub> to V<sub>REF</sub> - 50mV.

**REF (Pin 6):** Reference Output. 1.182V with respect to V<sup>-</sup>. Can source up to 200μA and sink 15μA at 25°C. Drive 0.01μF bypass capacitor without oscillation.

**V<sup>+</sup> (Pin 7):** Positive Supply. 2V to 11V.

**OUT (Pin 8):** Comparator CMOS Output. Swings from GND to V<sup>+</sup>. Output can source up to 40mA and sink 5mA.

**LTC1441**

**OUT A (Pin 1):** Comparator A CMOS Output. Swings from V<sup>-</sup> to V<sup>+</sup>. Output can source up to 40mA and sink 5mA.

**V<sup>-</sup> (Pin 2):** Negative Supply.

**IN A<sup>+</sup> (Pin 3):** Noninverting Input of Comparator A. Input common mode range from V<sup>-</sup> to V<sup>+</sup> -1.3V. Input current typically 10pA at 25°C.

**IN A<sup>-</sup> (Pin 4):** Inverting Input of Comparator A. Input common mode range from V<sup>-</sup> to V<sup>+</sup> -1.3V. Input current typically 10pA at 25°C.

**IN B<sup>-</sup> (Pin 5):** Inverting Input of Comparator B. Input common mode range from V<sup>-</sup> to V<sup>+</sup> -1.3V. Input current typically 10pA at 25°C.

**IN B<sup>+</sup> (Pin 6):** Noninverting Input of Comparator B. Input common mode range from V<sup>-</sup> to V<sup>+</sup> -1.3V. Input current typically 10pA at 25°C.

**V<sup>+</sup> (Pin 7):** Positive Supply. 2V to 11V.

**OUT B (Pin 8):** Comparator B CMOS Output. Swings from V<sup>-</sup> to V<sup>+</sup>. Output can source up to 40mA and sink 5mA.

**LTC1442**

**OUT A (Pin 1):** Comparator A CMOS Output. Swings from V<sup>-</sup> to V<sup>+</sup>. Output can source up to 40mA and sink 5mA.

**V<sup>-</sup> (Pin 2):** Negative Supply.

**IN A<sup>+</sup> (Pin 3):** Noninverting Input of Comparator A. Input common mode range from V<sup>-</sup> to V<sup>+</sup> -1.3V. Input current typically 10pA at 25°C.

**IN B<sup>-</sup> (Pin 4):** Inverting Input of Comparator B. Input common mode range from V<sup>-</sup> to V<sup>+</sup> -1.3V. Input current typically 10pA at 25°C.

**HYST (Pin 5):** Hysteresis Input. Connect to REF if not used. Input voltage range is from V<sub>REF</sub> to V<sub>REF</sub> - 50mV.

**REF (Pin 6):** Reference Output. 1.182V with respect to V<sup>-</sup>. Can source up to 200μA and sink 15μA at 25°C. Drive 0.01μF bypass capacitor without oscillation.

**V<sup>+</sup> (Pin 7):** Positive Supply. 2V to 11V.

**OUT B (Pin 8):** Comparator B CMOS Output. Swings from V<sup>-</sup> to V<sup>+</sup>. Output can source up to 40mA and sink 5mA.

## APPLICATIONS INFORMATION

LTC1440/LTC1441/LTC1442 are a family of micropower comparators with built-in 1.182V reference. Features include programmable hysteresis (LTC1440/LTC1442), wide supply voltage range (2V to 11V) and the ability of the reference to drive up to a 0.01 $\mu$ F capacitor without oscillation. The comparators' CMOS outputs can source up to 40mA and the supply current glitches, that normally occur when switching logic states, have been eliminated.

### Power Supplies

The comparator family operates from a single 2V to 11V supply. The LTC1440 includes a separate ground for the comparator output stage, allowing a split supply ranging from  $\pm 1$ V to  $\pm 5.5$ V. Connecting  $V^-$  to GND on the LTC1440 will allow single supply operation. If the comparator output is required to source more than 1mA, or the supply source impedance is high,  $V^+$  should be bypassed with a 0.1 $\mu$ F capacitor.

### Comparator Inputs

The comparator inputs can swing from the negative supply  $V^-$  to within 1.3V max of the positive supply  $V^+$ . The inputs can be forced 300mV below  $V^-$  or above  $V^+$  without damage and the typical input leakage current is only  $\pm 10$ pA.

### Comparator Outputs

The LTC1440 comparator output swings between GND and  $V^+$  to assure TTL compatibility with a split supply. The LTC1441 and LTC1442 outputs swing between  $V^-$  and  $V^+$ . The outputs are capable of sourcing up to 40mA and sinking up to 5mA while still maintaining microampere quiescent currents. The output stage does not generate crowbar switching currents during transitions which helps minimize parasitic feedback through the supply pins.

### Voltage Reference

The internal bandgap reference has a voltage of 1.182V referenced to  $V^-$ . The reference accuracy is 1.5% from  $-40^\circ\text{C}$  to  $85^\circ\text{C}$ . It can source up to 200 $\mu$ A and sink up to 20 $\mu$ A with a 5V supply. The reference can drive a bypass

capacitor of up to 0.01 $\mu$ F without oscillation and by inserting a series resistor, capacitance values up to 100 $\mu$ F can be used (Figure 1).

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

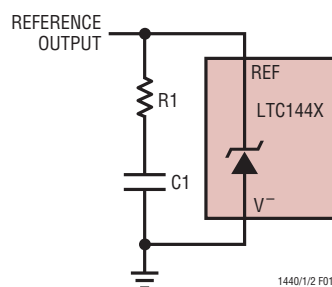


Figure 1. Damping the Reference Output

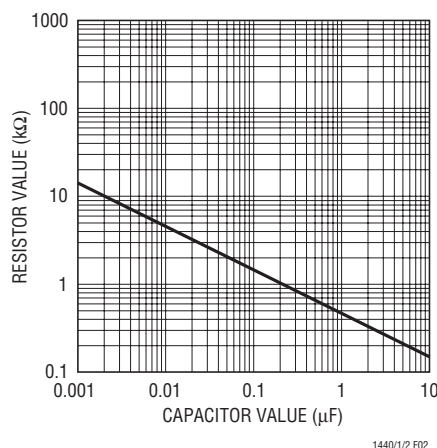


Figure 2. Damping Resistance vs Bypass Capacitor Value

## APPLICATIONS INFORMATION

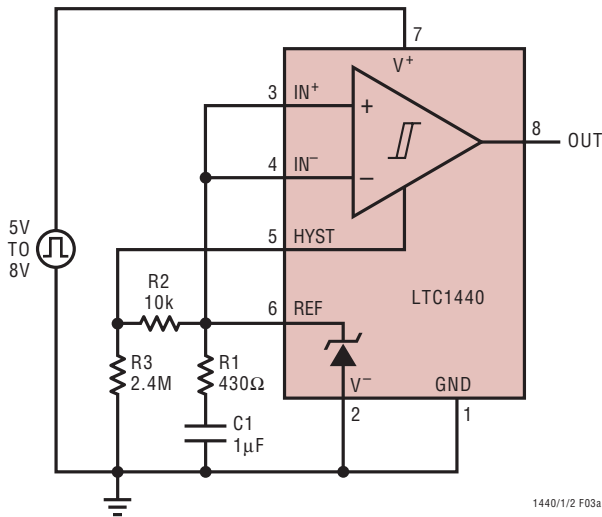


Figure 3a. Reference Transient Response Test Circuit

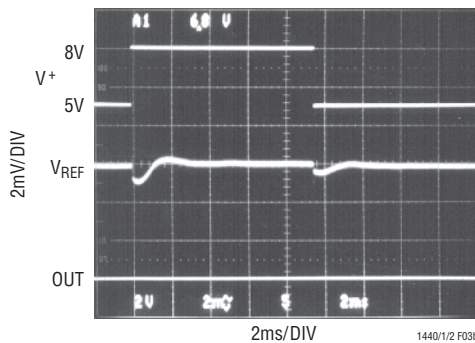


Figure 3b. Reference and Comparator Output Transient Response

### Hysteresis

Hysteresis can be added to the LTC1440 by connecting a resistor (R1) between the REF and HYST pins and a second resistor (R2) from HYST to V<sup>-</sup> (Figure 4).

The difference between the upper and lower threshold voltages, or hysteresis voltage band (V<sub>HB</sub>), is equal to twice the voltage difference between the REF and HYST pins.

When 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 could vary by

up to 15%. If hysteresis is not wanted, the HYST pin should be shorted to REF. Acceptable values for I<sub>REF</sub> range from 0.1μA to 5μA. If 2.4M is chosen for R2, then the value of R1 is equal to the value of V<sub>HB</sub>.

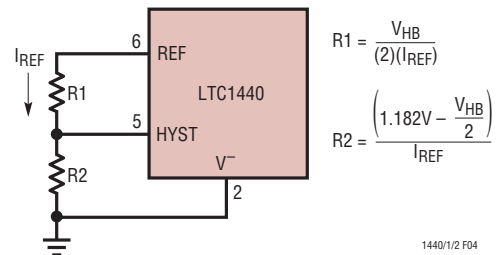


Figure 4. Programmable Hysteresis

### Level Detector

The LTC1440 is ideal for use as a micropower level detector as shown in Figure 5. R1 and R2 form a voltage divider from V<sub>IN</sub> to the noninverting comparator input. R3 and R4 set the hysteresis voltage, and R5 and C1 bypass the reference output. The following design procedure can be used to select the component values:

1. Choose the V<sub>IN</sub> voltage trip level, in this example 4.65V.

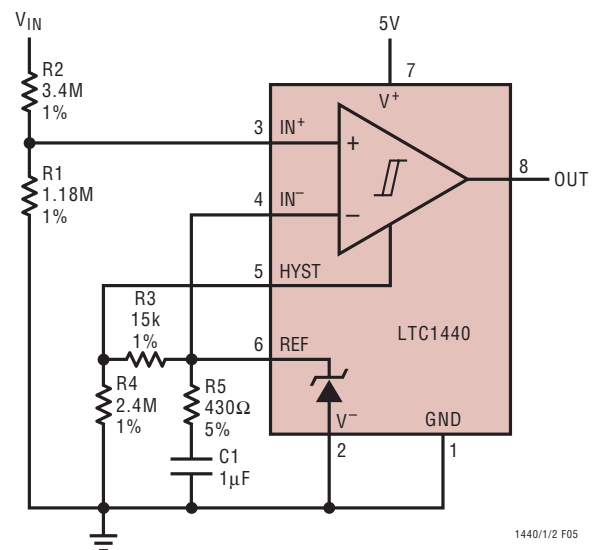


Figure 5. Glitch-Free Level Detector with Hysteresis

## APPLICATIONS INFORMATION

2. Calculate the required resistive divider ratio.

$$\text{Ratio} = V_{\text{REF}}/V_{\text{IN}}$$

$$\text{Ratio} = 1.182\text{V}/4.65\text{V} = 0.254$$

3. Choose the required hysteresis voltage band at the input  $V_{\text{HBIN}}$ , in this example 60mV. Calculate the hysteresis voltage band referred to the comparator input  $V_{\text{HB}}$ .

$$V_{\text{HB}} = (V_{\text{HBIN}})(\text{Ratio})$$

$$V_{\text{HB}} = (60\text{mV})(0.254)$$

$$V_{\text{HB}} = 15.24\text{mV}$$

4. Choose the values for R3 and R4 to set the hysteresis.

$$R4 = 2.4\text{M}$$

$$R3(\text{k}\Omega) = V_{\text{HB}} = 15\text{k}$$

5. Choose the values for R1 and R2 to set the trip point.

$$R1 = \frac{V_{\text{REF}}}{I_{\text{BIAS}}} = \frac{1.182\text{V}}{1\mu\text{A}} = 1.18\text{M}$$

$$R2 = R1 \left[ \frac{V_{\text{IN}}}{V_{\text{REF}} + \frac{V_{\text{HB}}}{2}} - 1 \right]$$

$$R2 = 1.18\text{M} \left[ \frac{4.65\text{V}}{1.182\text{V} + \frac{15\text{mV}}{2}} - 1 \right]$$

$$R2 = 3.40\text{M}$$

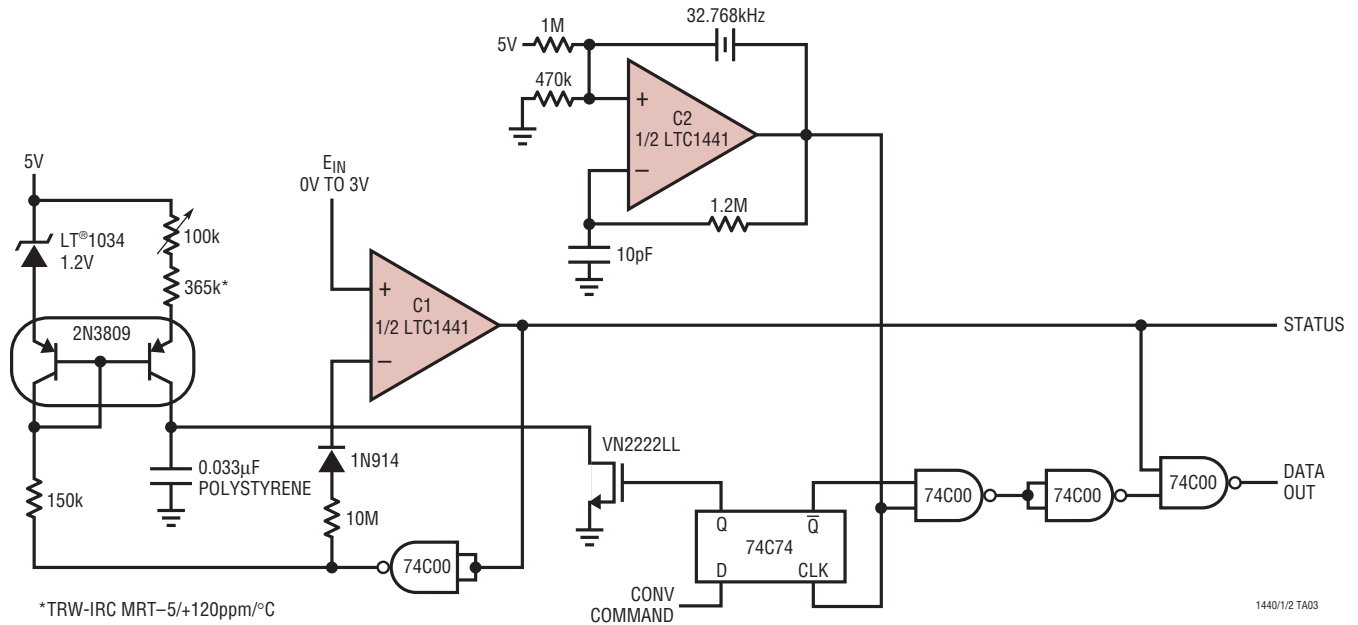
## Low Voltage Operation

It is important to note that the voltage references internal to the LTC1440 and LTC1442 can exceed the common mode range of the comparators at low supply voltages. The input common mode range of the LTC1440/LTC1441/LTC1442 comparators is guaranteed to extend up to  $(V^+ - 1.3\text{V})$ . Therefore, if one of the comparator inputs is at the 1.182V reference voltage, the minimum supply voltage is 2.5V for a valid output reading.

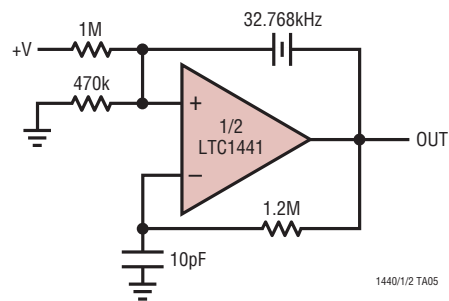
The guaranteed minimum operating voltage for the LTC1440/LTC1441/LTC1442 is 2V (or  $\pm 1\text{V}$ ). However, both the reference and comparator(s) will function with a supply voltage as low as 1.5V, but performance will degrade as the voltage goes below 2V. The voltage reference temperature coefficient will degrade slightly, and the comparators will have less output drive with an increase in propagation delay. At the reduced supply voltages, the input common mode range of the comparator(s) will still typically extend from the negative supply to approximately 1.1V below the positive supply.

## TYPICAL APPLICATIONS

## 10-Bit 30 $\mu$ A A/D Converter

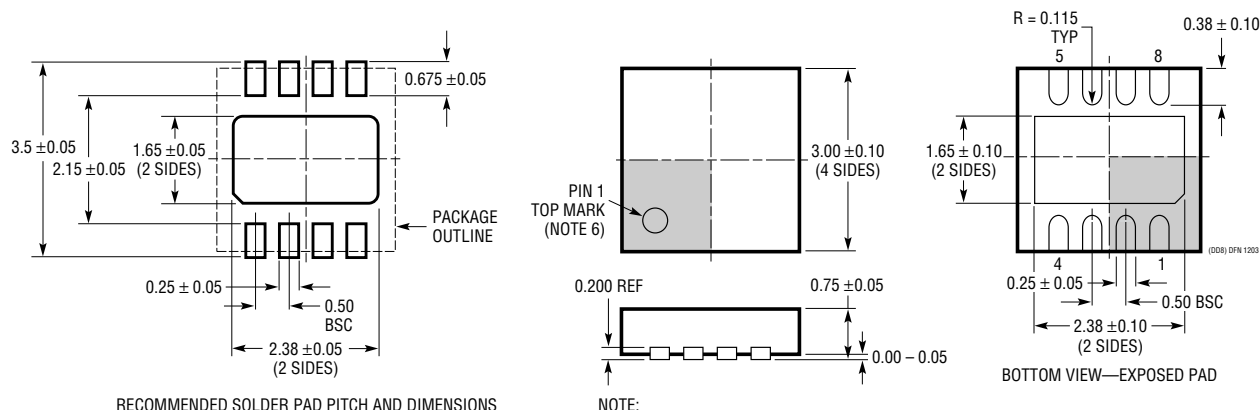


### 32.768kHz “Watch Crystal” Oscillator



## PACKAGE DESCRIPTION

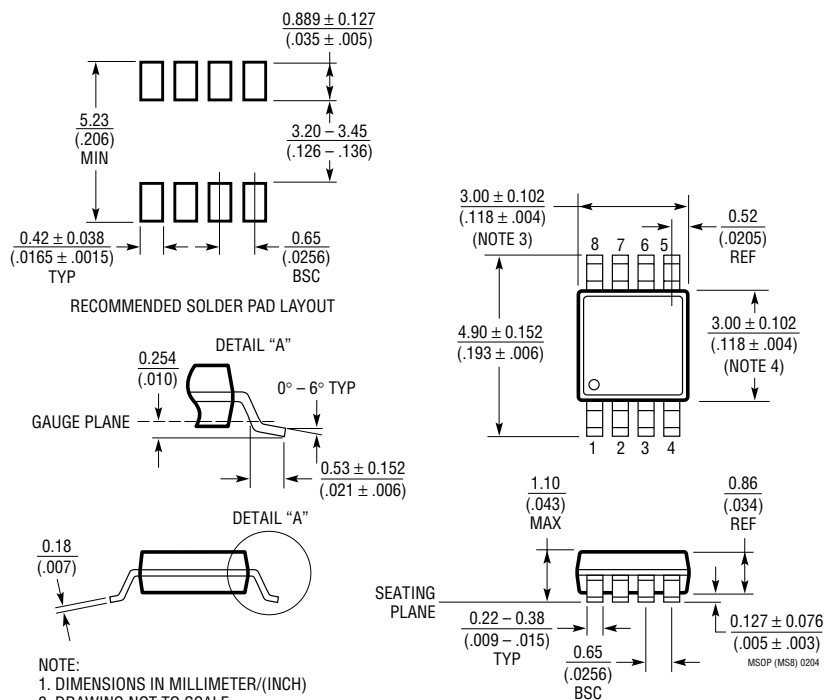
### DD Package 8-Lead Plastic DFN (3mm × 3mm) (Reference LTC DWG # 05-08-1698)



#### NOTE:

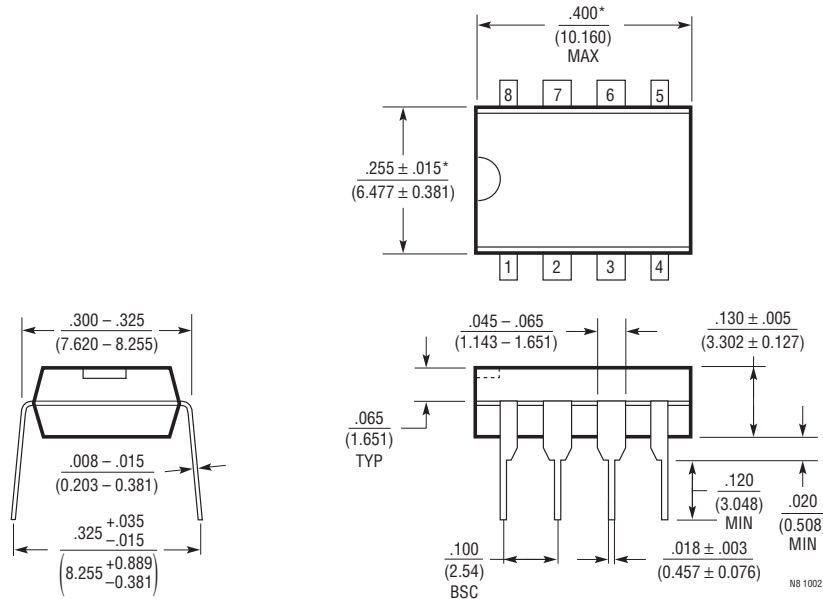
1. DRAWING TO BE MADE A JEDEC PACKAGE OUTLINE M0-229 VARIATION OF (WEED-1)
2. DRAWING NOT TO SCALE
3. ALL DIMENSIONS ARE IN MILLIMETERS
4. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.15mm ON ANY SIDE
5. EXPOSED PAD SHALL BE SOLDER PLATED
6. SHADED AREA IS ONLY A REFERENCE FOR PIN 1 LOCATION ON TOP AND BOTTOM OF PACKAGE

### MS8 Package 8-Lead Plastic MSOP (Reference LTC DWG # 05-08-1660)



## PACKAGE DESCRIPTION

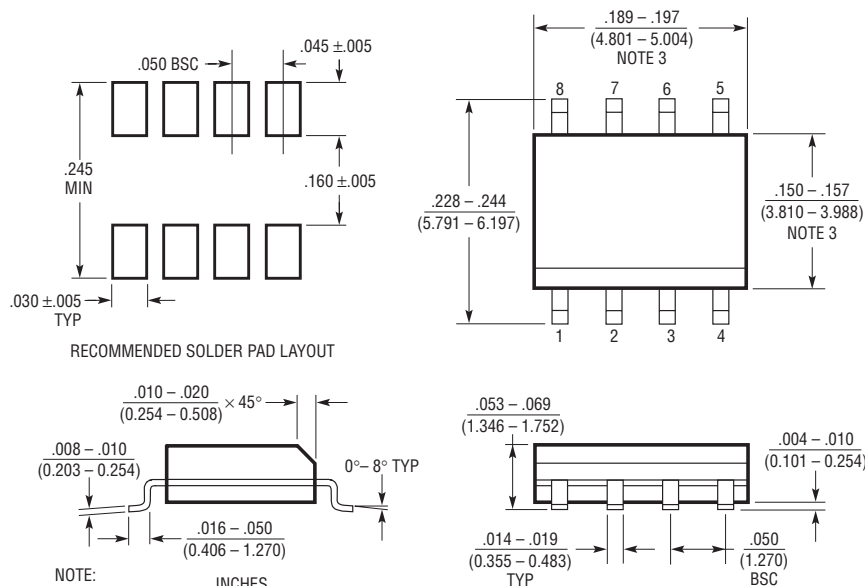
### N8 Package 8-Lead PDIP (Narrow 0.300) (LTC DWG # 05-08-1510)



NOTE:

1. DIMENSIONS ARE  $\frac{\text{INCHES}}{\text{MILLIMETERS}}$ \*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.  
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)

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



NOTE:

1. DIMENSIONS IN  $\frac{\text{INCHES}}{\text{MILLIMETERS}}$ 

2. DRAWING NOT TO SCALE

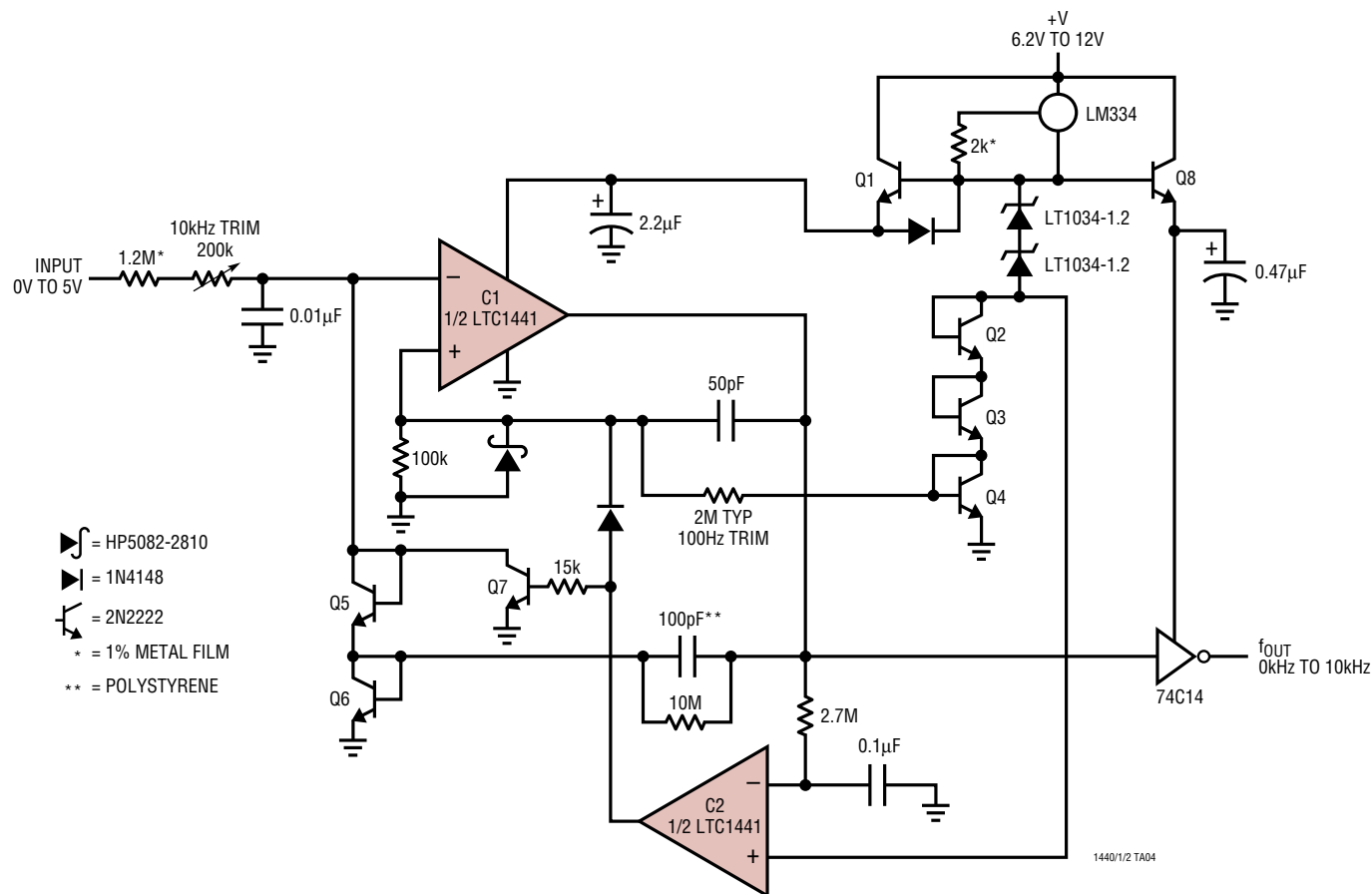
3. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.  
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006" (0.15mm)

S08 0303

144012fd

## TYPICAL APPLICATION

10kHz V/F Converter



## RELATED PARTS

| PART NUMBER                   | DESCRIPTION                                                           | COMMENTS                                                               |
|-------------------------------|-----------------------------------------------------------------------|------------------------------------------------------------------------|
| LTC1443                       | 1.182V Reference with Micropower Quad Comparators                     | 1% Accuracy, 8.5μA Maximum Current, Ref Output Drives 0.01μF           |
| LTC1444/LTC1445               | 1.2V Reference with Quad Comparator with Adjustable Hysteresis        | 1% Accuracy, 8.5μA Maximum Current, Ref Output Drives 0.01μF           |
| LTC1540                       | 1.182V Reference with Nanopower Comparator with Adjustable Hysteresis | DFN Package 0.3μA Quiescent Current (Typical), Reference Drives 0.01μF |
| LTC1541                       | 1.2V Reference with Micropower Amplifier and Comparator               | DFN Package 1.25% Accuracy, Rail-to-Rail Out, Low Offset Amplifier     |
| LTC1842/LTC1843               | 1.82V Reference with Dual Comparators with Adjustable Hysteresis      | 1% Accuracy, Open-Drain Out, Reference Drives 0.01μF                   |
| LTC1998                       | 1.2 Reference with Comparator with Adjustable Thresholds              | Li-Ion Low Battery Monitor, SOT23, 1% Accuracy                         |
| LT6700-1<br>LT6700-2/LT6700-3 | 0.4 Reference with Low Voltage Dual Comparators                       | SOT23, 1.4V to 18.5V Supply Range, ±2% Over Temperature                |