

# 12ns, Single Supply Ground-Sensing Comparator

## FEATURES

- Ultra Fast (12ns Typ)
- Operates off **Single** 5V Supply or  $\pm 5V$
- Input Common Mode Extends to Negative Supply
- No Minimum Input Slew Rate Requirement
- Complementary TTL Output
- Inputs Can Exceed the Positive Supply Up to 15V without Damaging the Comparator
- Low Offset Voltage
- Pin-Compatible with LT1016
- Output Latch Capability
- Available in 8-Lead PDIP and SO Packages

## APPLICATIONS

- High Speed A/D Converters
- Zero Crossing Detectors
- Current Sense for Switching Regulators
- Extended Range V to F Converters
- Fast Pulse Height/Width Discriminators
- High Speed Triggers
- Line Receivers
- High Speed Sampling Circuits

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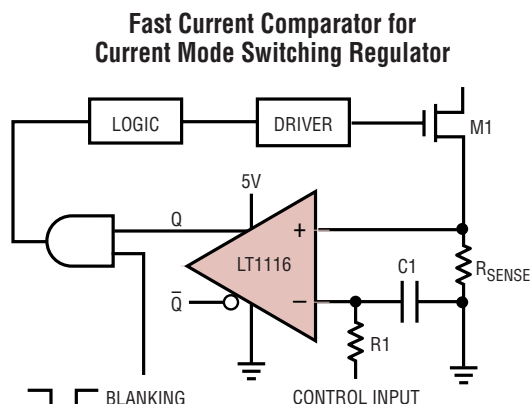
## DESCRIPTION

The LT<sup>®</sup>1116 is an ultra fast (12ns) comparator designed for sensing signals near the negative supply. The input common mode range extends from 2.5V below the positive supply down to the negative supply rail. Like the LT1016, this comparator is specifically designed to interface directly to TTL logic with complementary outputs. The comparator may operate from either a single 5V supply or dual  $\pm 5V$  supplies. Tight offset voltage specifications and high gain allow the LT1116 to be used in precision applications.

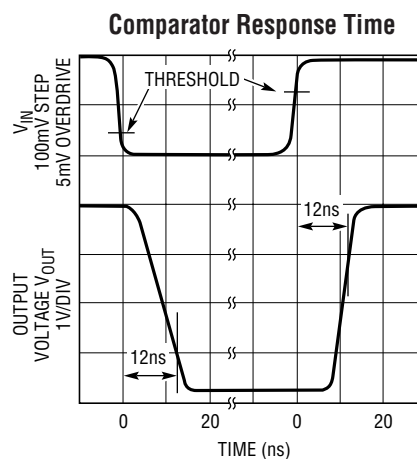
The LT1116 is designed for improved speed and stability for a wide range of operating conditions. The output stage provides active drive in both directions for maximum speed into TTL logic or passive loads, yet it has minimal cross-conduction current. Unlike other fast comparators, the LT1116 remains stable even for slow transitions through the active region, which eliminates the need to specify a minimum input slew rate.

The LT1116 has an internal, TTL compatible latch for retaining data at the outputs. The latch holds data as long as the latch pin is held high. Device parameters such as gain, offset, and negative power supply current are not significantly affected by variations in negative supply voltage.

## TYPICAL APPLICATION



LT1116 • TA01



LT1116 • TA02

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

|                                            |                        |
|--------------------------------------------|------------------------|
| Supply Voltage ( $V^+$ ) to GND .....      | 7V                     |
| Negative Supply Voltage ( $V^-$ ) .....    | -7V to GND             |
| Voltage                                    |                        |
| Differential Input Voltage .....           | $\pm 15V$              |
| Inputs Voltage (Either Input) .....        | ( $V^-$ ) -0.3V to 15V |
| Latch Pin Voltage .....                    | Equal to Supplies      |
| Output Current (Continuous) .....          | $\pm 20mA$             |
| Operating Temperature Range .....          | 0°C to 70°C            |
| Storage Temperature Range .....            | -65°C to 150°C         |
| Lead Temperature (Soldering, 10 sec) ..... | 300°C                  |

## PACKAGE/ORDER INFORMATION

|                                                                                                                                                                                                                            |                                                                                                                                           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| <p>TOP VIEW</p> <p>N8 PACKAGE<br/>8-LEAD PDIP<br/><math>T_{JMAX} = 100^\circ C</math>, <math>\theta_{JA} = 130^\circ C/W</math></p>                                                                                        | <p>TOP VIEW</p> <p>S8 PACKAGE<br/>8-LEAD PLASTIC SO<br/><math>T_{JMAX} = 100^\circ C</math>, <math>\theta_{JA} = 160^\circ C/W</math></p> |
| ORDER PART NUMBER                                                                                                                                                                                                          | ORDER PART NUMBER                                                                                                                         |
| LT1116CN8                                                                                                                                                                                                                  | LT1116CS8                                                                                                                                 |
|                                                                                                                                                                                                                            | S8 PART MARKING                                                                                                                           |
|                                                                                                                                                                                                                            | 1116                                                                                                                                      |
| <p><b>Order Options</b> Tape and Reel: Add #TR<br/> Lead Free: Add #PBF Lead Free Tape and Reel: Add #TRPBF<br/> Lead Free Part Marking: <a href="http://www.linear.com/leadfree/">http://www.linear.com/leadfree/</a></p> |                                                                                                                                           |

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

## ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over full operating temperature range, otherwise specifications are at  $T_A = 25^\circ C$ .  $V^+ = 5V$ ,  $V^- = 5V$ ,  $V_{OUT} (Q) = 1.4V$ , LATCH = 0V. Specifications for  $V_{OS}$ ,  $I_B$ , CMRR, and Voltage Gain are valid for single supply operation,  $V^+ = 5V$ ,  $V^- = 0V$ , unless noted.

| SYMBOL                           | PARAMETERS                   | CONDITIONS                                                                            | MIN        | TYP        | MAX                   | UNITS            |
|----------------------------------|------------------------------|---------------------------------------------------------------------------------------|------------|------------|-----------------------|------------------|
| $V_{OS}$                         | Input Offset Voltage         | $R_S \leq 100\Omega$ (Note 2)                                                         |            | 1.0        | $\pm 3.0$<br>3.5      | mV<br>mV         |
| $\frac{\Delta V_{OS}}{\Delta T}$ | Input Offset Voltage Drift   |                                                                                       |            | 5          |                       | $\mu V/^\circ C$ |
| $I_{OS}$                         | Input Offset Current         | (Note 2)                                                                              |            | 0.5        | 2                     | $\mu A$          |
| $I_B$                            | Input Bias Current, Sourcing | (Note 3)                                                                              |            | 10         | 20                    | $\mu A$          |
|                                  | Input Voltage Range          | Arbitrary Supply Range<br>Single 5V Supply                                            | $V^-$<br>0 |            | ( $V^+$ ) -2.5<br>2.5 | V<br>V           |
| CMRR                             | Common Mode Rejection Ratio  | $-5V \leq V_{CM} \leq 2.5V$ , $V_S = \pm 5V$<br>$0V \leq V_{CM} \leq 2.5V$            | 75<br>65   | 90<br>90   |                       | dB<br>dB         |
| PSRR                             | Power Supply Rejection Ratio | Positive Supply, $4.6V \leq V^+ \leq 5.4V$<br>Negative Supply, $-7 \leq V^- \leq -2V$ | 60<br>80   | 75<br>100  |                       | dB<br>dB         |
| $A_V$                            | Small Signal Voltage Gain    | $1V \leq V_{OUT} \leq 2V$                                                             | 1400       | 3000       |                       | V/V              |
| $I^+$                            | Positive Supply Current      |                                                                                       |            | 27         | 38                    | mA               |
| $I^-$                            | Negative Supply Current      |                                                                                       |            | 5          | 7                     | mA               |
| $V_{OH}$                         | Output High Voltage          | $I_{SOURCE} = 1mA$<br>$I_{SOURCE} = 10mA$                                             | 2.7<br>2.4 | 3.4<br>3.0 |                       | V<br>V           |
| $V_{OL}$                         | Output Low Voltage           | $I_{SINK} = 4mA$<br>$I_{SINK} = 10mA$                                                 |            | 0.3<br>0.4 | 0.5                   | V<br>V           |

# ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V^+ = 5\text{V}$ ,  $V^- = -5\text{V}$ ,  $V_{\text{OUT}} = (Q) = 1.4\text{V}$ , LATCH = 0V, unless noted.

| SYMBOL                 | PARAMETERS                     | CONDITIONS                                                      | MIN | TYP | MAX      | UNITS         |
|------------------------|--------------------------------|-----------------------------------------------------------------|-----|-----|----------|---------------|
| $V_{\text{IH}}$        | + Positive Latch Threshold     | ●                                                               | 2.0 |     |          | V             |
| $V_{\text{IL}}$        | – Latch Threshold              | ●                                                               |     |     | 0.8      | V             |
| $I_{\text{IL}}$        | Latch Input Current            | $V_{\text{LATCH}} = 0\text{V}$<br>●                             |     | –20 | –500     | $\mu\text{A}$ |
| $t_{\text{PD}}$        | Propagation Delay              | $\Delta V_{\text{IN}} = 100\text{mV}$ , OD = 5mV (Note 4)<br>●  |     | 12  | 16<br>18 | ns<br>ns      |
| $t_{\text{PD}}$        | Propagation Delay              | $\Delta V_{\text{IN}} = 100\text{mV}$ , OD = 20mV (Note 4)<br>● |     | 10  | 14<br>16 | ns<br>ns      |
| $\Delta t_{\text{PD}}$ | Differential Propagation Delay | $\Delta V_{\text{IN}} = 100\text{mV}$ , OD = 5mV (Note 4)       |     |     | 3        | ns            |
| $t_{\text{SU}}$        | Latch Set-Up Time              | (Note 5)                                                        |     | 2   |          | ns            |
| $t_{\text{H}}$         | Latch Hold Time                | (Note 5)                                                        |     | 2   |          | ns            |

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

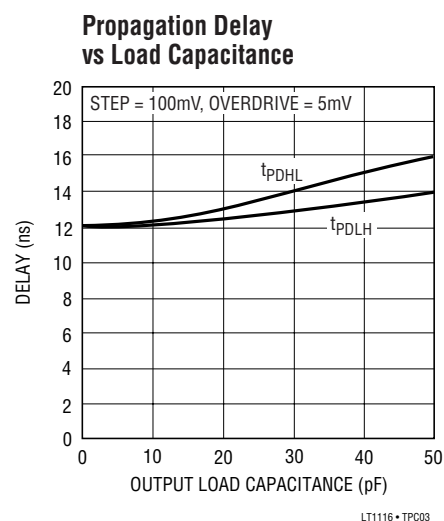
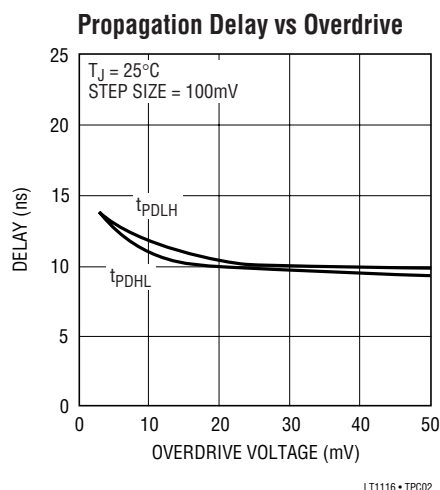
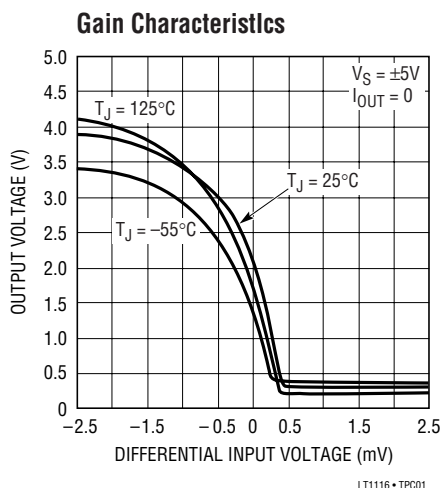
**Note 2:** Input offset voltage is defined as the average of two offset voltages measured by forcing first the Q output to 1.4V then forcing the  $\bar{Q}$  output to 1.4V.

**Note 3:** Input bias current is defined as the average of the two input currents.

**Note 4:**  $t_{\text{PD}}$  and  $\Delta t_{\text{PD}}$  cannot be measured in automatic handling equipment with low values of overdrive. The LT1116 is sample tested with a 1V step and 500mV overdrive. Correlation tests have shown that  $t_{\text{PD}}$  and  $\Delta t_{\text{PD}}$  can be guaranteed with this test if additional DC tests are performed to verify internal bias conditions are correct. For low overdrive conditions  $V_{\text{OS}}$  is added to the measured overdrive.

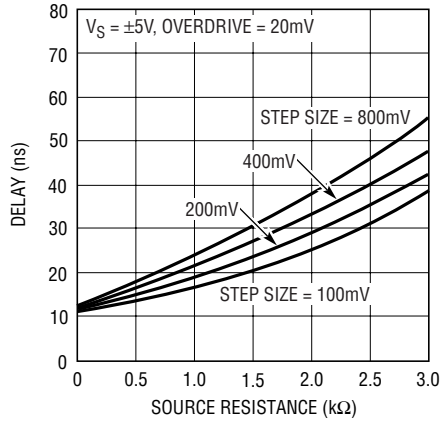
**Note 5:** Input latch set-up time,  $t_{\text{SU}}$ , is the interval in which the input signal must be stable prior to asserting the latch signal. The hold time,  $t_{\text{H}}$ , is the interval after the latch is asserted in which the input signal must be stable.

# TYPICAL PERFORMANCE CHARACTERISTICS



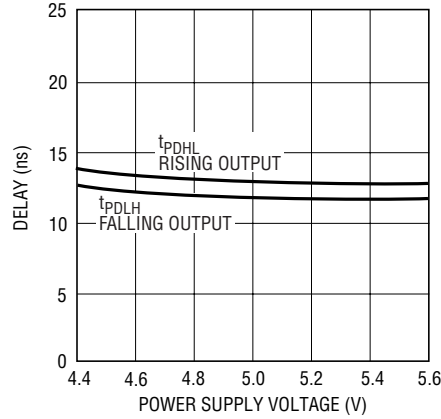
# TYPICAL PERFORMANCE CHARACTERISTICS

**Propagation Delay vs Source Resistance**



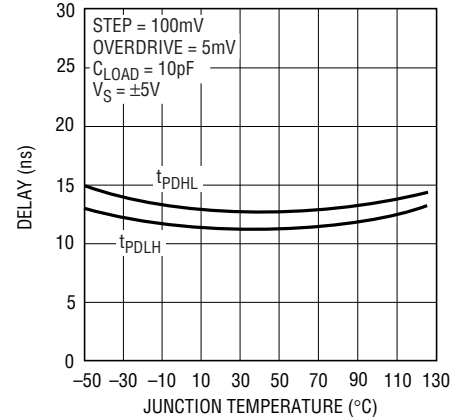
LT1116 • TPC04

**Propagation Delay vs Positive Supply**



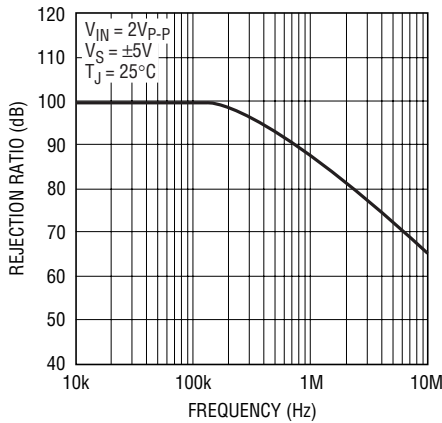
LT1116 • TPC05

**Propagation Delay vs Temperature**



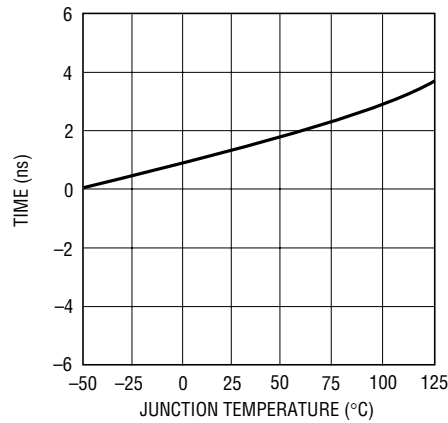
LT1116 • TPC06

**Common Mode Rejection**



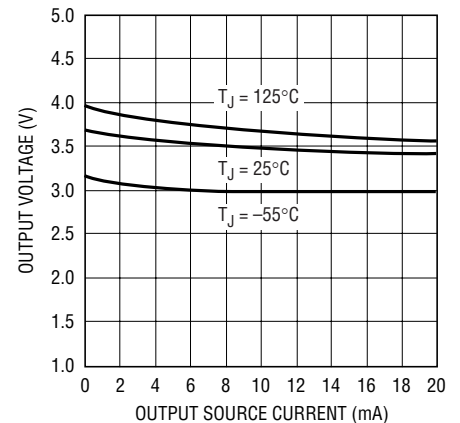
LT1116 • TPC07

**Latch Set-Up Time**



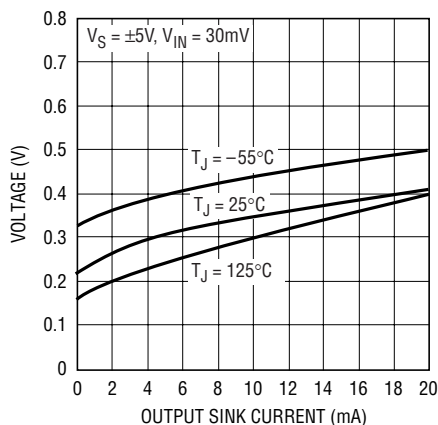
LT1116 • TPC08

**Output High Voltage ( $V_{OH}$ )**



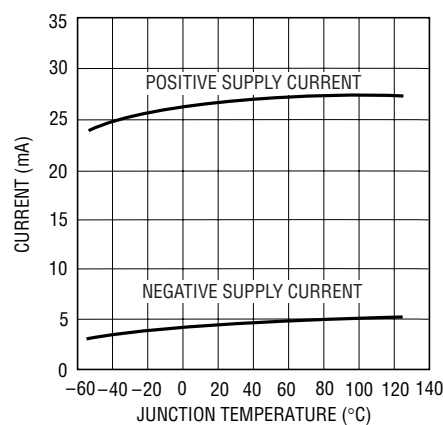
LT1116 • TPC09

**Output Low Voltage ( $V_{OL}$ )**



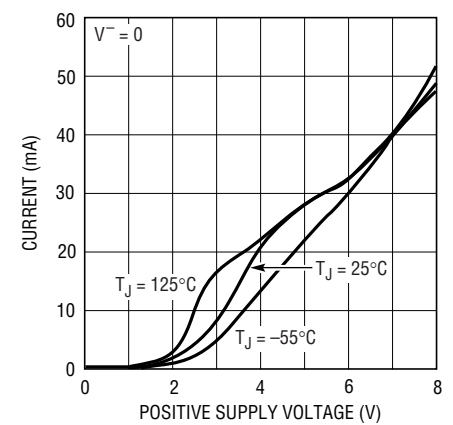
LT1116 • TPC10

**Supply Current vs Temperature**



LT1116 • TPC11

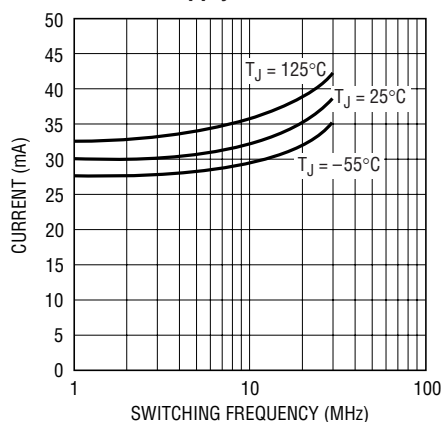
**Positive Supply Current**



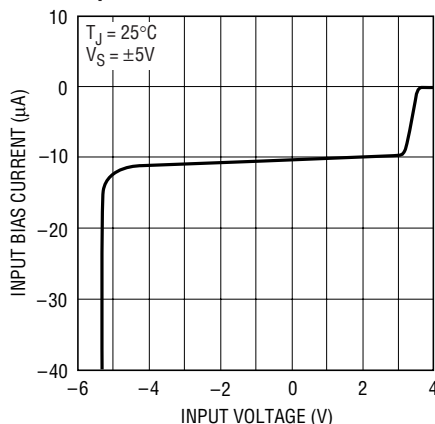
LT1116 • TPC12

# TYPICAL PERFORMANCE CHARACTERISTICS

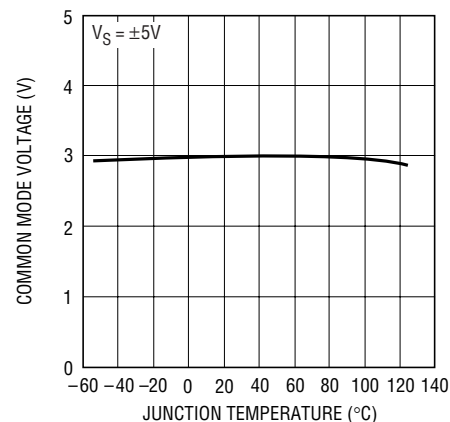
Positive Supply Current



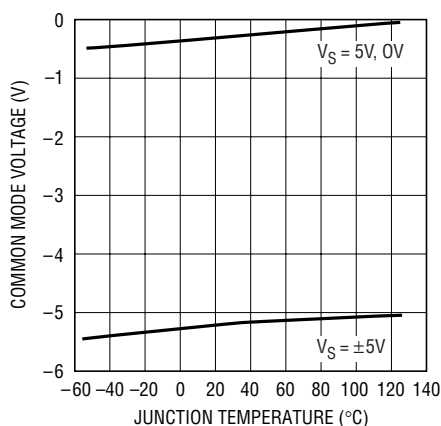
Input Bias Current



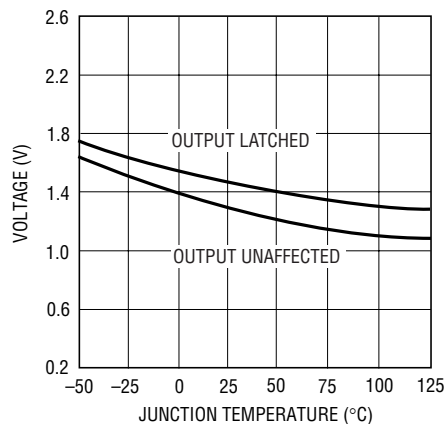
Positive Common Mode Limit



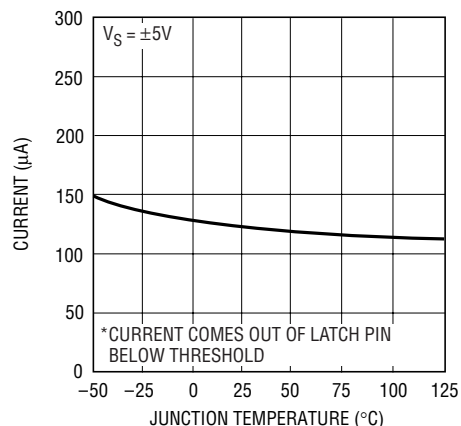
Negative Common Mode Limit



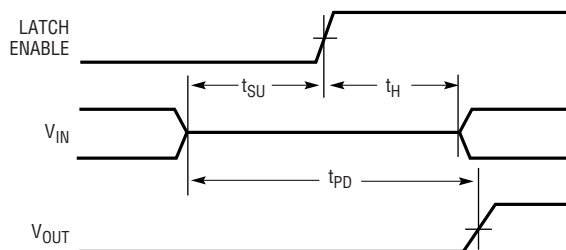
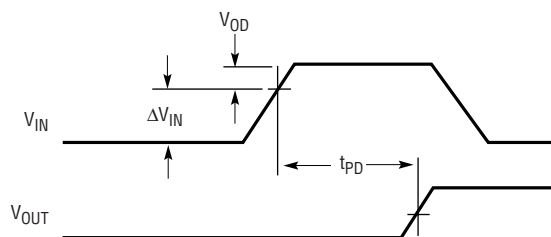
Latch Pin Threshold



Latch Pin Current\*



# TIMING DIAGRAMS



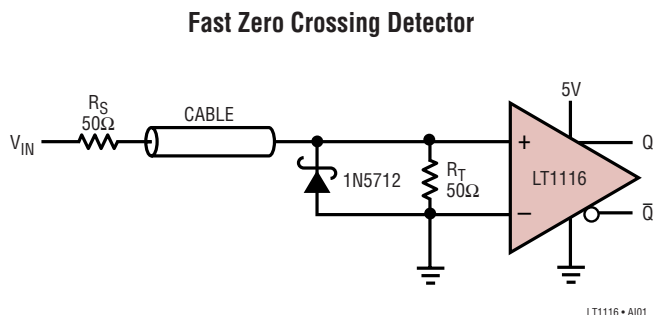
## APPLICATIONS INFORMATION

### Common Mode Considerations

The LT1116 is specified for a common mode range of 0V to 2.5V with a single 5V supply, and -5V to 2.5V with  $\pm 5V$  supplies. The common mode range is defined as the DC input for which the output responds correctly to small changes in the input differential. Input signals can exceed the positive common mode limit up to the 15V absolute maximum rating without damaging the comparator. There will, however, be an increase in propagation delay of up to 10ns when the input signal switches back into the common mode range. When input signals fall below the negative common mode limit, the internal PN diode formed with the substrate can turn on (resulting in significant charge flow throughout the die). A Schottky clamp diode, between the input and the negative rail, speeds up recovery from negative overdrive by preventing the substrate diode from turning on. The zero crossing detector in Figure 1 demonstrates the use of a fast clamp diode. Recovery, from 500mV overdrive below  $V^-$ , for this circuit is approximately 18ns.

### Input Characteristics

Each input to the LT1116 is buffered with a fast PNP follower—input bias current therefore does not vary significantly throughout the common mode range. When either input exceeds the positive common mode limit, the bias current drops to zero. Inputs that fall more than one diode and drop below  $V^-$  will forward bias the substrate or clamp diode, causing large input current to flow.



**Figure 1. The Zero Crossing Detector Terminates the Transmission Line At Its 50Ω Characteristic Impedance. Negative Inputs Should Not Fall Below -2V to keep the Signal Current Within the Clamp Diode's Maximum Forward Rating. Positive Inputs Should not Exceed the Devices Absolute Maximum Ratings nor the Power Rating on the Terminating Resistor**

Single ended input resistance is about 5MΩ, and remains roughly constant over the input common mode range. The common mode resistance is about 2.5MΩ with zero differential input voltage, and does not change significantly with the absolute value of differential input.

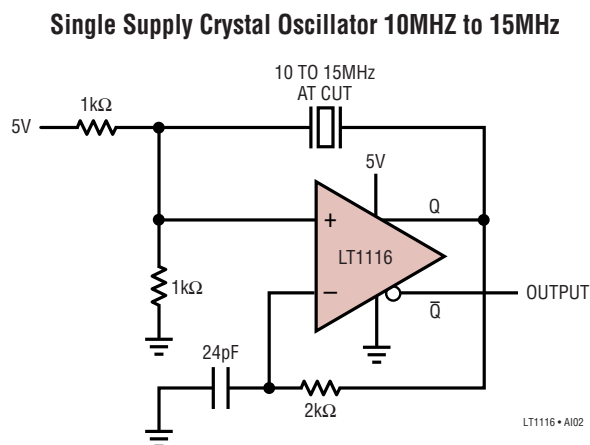
Effective input capacitance, typically 5pF, is determined by measuring the resulting change in propagation delay for a 1kΩ change in source resistance.

### Latch Pin Dynamics

The internal latch uses local regenerative feedback to shorten set-up and hold times. Driving the latch pin high retains the output state. The latch pin floats to a high state when disconnected, so it must be driven low for flow-through operation. The set-up time required to guarantee detecting a given transition of the inputs is 2ns. The inputs must also remain stable for a 2ns hold time after latch is asserted. New data will appear at the output approximately 10ns to 12ns after the latch goes low. The latch pin has no built-in hysteresis, and is designed to be driven from TTL or CMOS logic gates.

### Additional Information

Linear Technology's Application Note 13 provides an extensive discussion of design techniques for high speed comparators.

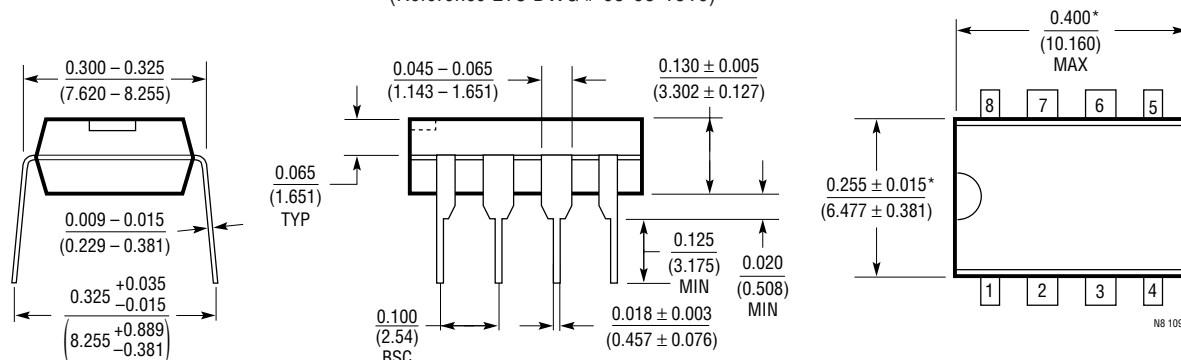


**Figure 2. This Single Supply Crystal Oscillator Utilizes Crystals From 10MHz To 15MHz Without Component Changes**



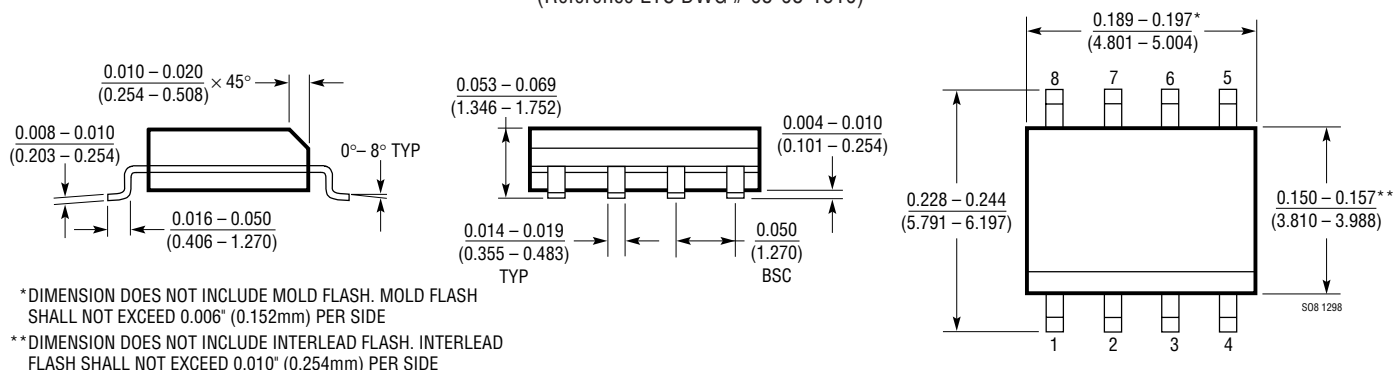
## PACKAGE DESCRIPTION

### N8 Package 8-Lead PDIP (Narrow .300 Inch) (Reference LTC DWG # 05-08-1510)



\*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.  
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm)

### S8 Package 8-Lead Plastic Small Outline (Narrow .150 Inch) (Reference 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

## RELATED PARTS

| PART NUMBER   | DESCRIPTION                    | COMMENTS                                                     |
|---------------|--------------------------------|--------------------------------------------------------------|
| LT1016        | 10ns Precision Comparator      | Complementary Outputs with Latch, LT1116 Pinout              |
| LT1394        | 7ns Single Supply Comparator   | 6mA, 100MHz Toggle Rate, LT1116 Pinout                       |
| LT1671        | 60ns Single Supply Comparator  | 450 $\mu$ A, 0.8mV Offset, LT1116 Pinout                     |
| LT1713/LT1714 | 7ns Single/Dual Comparator     | Rail-to-Rail Input and Output, 2.7V to + 5.5V Operation      |
| LT1715        | 4ns Dual Comparator            | Independent Input/Output Supplies, 150MHz Toggle Rate        |
| LT1719        | 4.5ns Single Supply Comparator | Independent Input/Output Supplies, 3V/5V                     |
| LT1720/LT1721 | 4.5ns Dual/Quad Comparator     | 4mA per Comparator, Input 100mV Below V <sub>-</sub> , 3V/5V |