# LMV7251,LMV7255

***LMV7251/LMV7255 1.8V Low Voltage Comparator with Rail-to-Rail Input***

Literature Number: SNOS928D

National Semiconductor

# LMV7251/LMV7255

**OBSOLETE**
October 13, 2011

# 1.8V Low Voltage Comparator with Rail-to-Rail Input

## General Description

The LMV7251/LMV7255 are rail-to-rail input low voltage comparators, which can operate at supply voltage range of 1.8V to 5.0V. The LMV7251/LMV7255 are available in space saving SC-70 or SOT23-5 packages. These comparators are ideal for low voltage and space critical designs.

The LMV7251 features a push-pull output stage. This feature allows operation with minimum power consumption when driving a load.

The LMV7255 features an open drain output. This allows the connection of an external resistor at the output. The output of the comparator can be used as a level shifter.

The IC's are built with National Semiconductor's advance Submicron Silicon-Gate BiCMOS process. The LMV7251/LMV7255 have bipolar inputs for improved noise performance and CMOS outputs for better rail-to-rail output performance.

## Features

($V_S$ = 1.8V, $T_A$ = 25°C, Typical values unless specified).

- Single or Dual Supplies
- Low supply voltage — 1.8V to 5.0V
- Ultra low supply current — 11µA
- Low input bias current — 14nA
- Low input offset current — 200pA
- Low input offset voltage — +/−0.3mV
- Response time — 670ns (20mV overdrive)
- Input common mode voltage — 0.1V beyond rails

## Applications

- Mobile communications
- Laptops and PDA's
- Battery powered electronics
- General purpose low voltage applications

## Typical Circuit

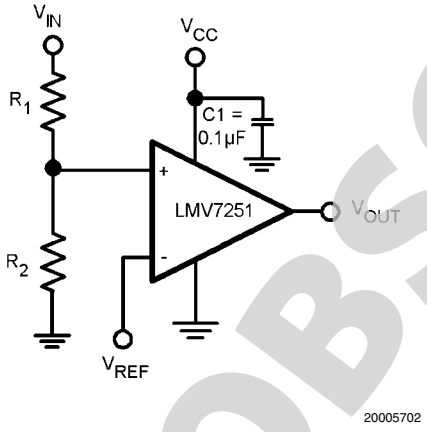
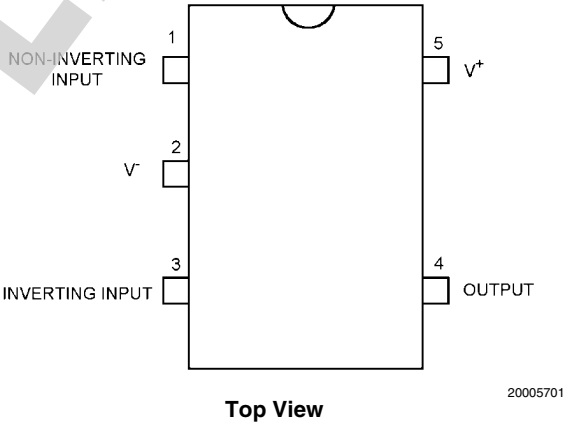



**FIGURE 1. Threshold Detector**

## Connection Diagram




**Top View**



## Absolute Maximum Ratings (*Note 1*)

**If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.**

| | |
|---|---|
| ESD Tolerance | 1KV (*Note 2*) |
| | 200V (*Note 6*) |
| $V_{IN}$ Differential | +/−Supply Voltage |
| Supply Voltage ($V^+$ - $V^-$) | 5.5V |
| Voltage at Input/Output pins | $V^+$ +0.1V, $V^-$ −0.1V |
| Soldering Information | |
| Infrared or Convection (20 sec.) | 235°C |
| Wave Soldering (10 sec.) | 260°C |
| Storage Temperature Range | −65°C to +150°C |
| Junction Temperature (*Note 4*) | +150°C |

## Operating Ratings (*Note 1*)

| | |
|---|---|
| Supply Voltage $V^+$ | 1.8V to 5.0V |
| Junction Temperature Range (*Note 3*) | −40°C to +85°C |
| Package Thermal Resisance (*Note 3*) | |
| SOT23-5 | 325°C/W |
| SC-70 | 265°C/W |

## 1.8V Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_J$ = 25°C, $V^+$ = 1.8V, $V^-$ = 0V. **Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Condition | Typ (*Note 4*) | Limits (*Note 5*) | Units |
|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | | 0.3 | 6<br>**8** | mV<br>max |
| TC $V_{OS}$ | Input Offset Average Drift | $V_{CM}$ = 0.9V (*Note 7*) | 10 | | uV/C |
| $I_B$ | Input Bias Current | | 14 | | nA |
| $I_{OS}$ | Input Offset Current | | 200 | | pA |
| $I_S$ | Supply Current | | 11 | 15<br>**17** | µA<br>max |
| $I_{SC}$ | Output Short Circuit Current | Sourcing, $V_O$ = 0.9V (LMV7251 only) | 8 | 4 | mA<br>min |
| | | Sinking, $V_O$ = 0.9V | 11.6 | 5 | |
| $I_{LEAKAGE}$ | Output Leakage Current | $V_O$ = 1.8V (LMV7255 only) | 300 | | pA |
| $V_{OH}$ | Output Voltage High | $I_O$ = 1.5mA (LMV7251 only) | 1.72 | 1.675 | V<br>min |
| $V_{OL}$ | Output Voltage Low | $I_O$ = −1.5mA | 65 | 125 | mV<br>max |
| $V_{CM}$ | Input Common Voltage Range | CMRR > 45 dB | | 1.9 | V<br>max |
| | | | | −0.1 | V<br>min |
| CMRR | Common Mode Rejection Ratio | 0 < $V_{CM}$ < 1.8V | 72 | 47 | dB<br>min |
| PSRR | Power Supply Rejection Ratio | $V^+$ = 1.8V to 5V | 79 | 55 | dB<br>min |





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## 1.8V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_J$ = 25°C, $V^+$ = 1.8V, $V^-$ = 0V, $V_{CM}$ = 0.5V, $V_O$ = $V^+$/2. **Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Condition | Typ (*Note 5*) | Limits (*Note 6*) | Units |
|---|---|---|---|---|---|
| $t_{PHL}$ | Propagation Delay (High to Low) | Input Overdrive = 20mV<br>Load = 50pF//5kΩ | 720 | | ns |
| | | Input Overdrive = 50mV<br>Load = 50pF//5kΩ | 380 | | ns |
| $t_{PLH}$ | Propagation Delay (Low to High) | Input Overdrive = 20mV<br>Load = 50pF//5kΩ | 670 | | ns |
| | | Input Overdrive = 50mV<br>Load = 50pF//5kΩ | 400 | | ns |

## 2.7V Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_J$ = 25°C, $V^+$ = 2.7V, $V^-$ = 0V. **Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Conditions | Typ (*Note 5*) | Limits (*Note 6*) | Units |
|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | | 0.03 | 6<br>**8** | mV<br>max |
| TC $V_{OS}$ | Input Offset Average Drift | $V_{CM}$ = 1.35V (*Note 7*) | 10 | | µV/C |
| $I_B$ | Input Bias Current | | 15 | | nA |
| $I_{OS}$ | Input offset Current | | 210 | | pA |
| $I_S$ | Supply Current | | 11 | 18<br>**22** | µA<br>max |
| $I_{SC}$ | Output Short Circuit Current | Sourcing, $V_O$ = 1.35V<br>(LMV7251 only) | 28 | 15 | mA |
| | | Sinking, $V_O$ = 1.35V | 28 | 15 | |
| $I_{LEAKAGE}$ | Output Leakage Current | $V_O$ = 2.7V,<br>(LMV7255 only) | 320 | | pA |
| $V_{OH}$ | Output Voltage High | $I_O$ = 2mA<br>(LMV7251 only) | 2.63 | 2.575 | V<br>min |
| $V_{OL}$ | Output Voltage Low | $I_O$ = −2mA | 61 | 125 | mV<br>max |
| $V_{CM}$ | Input Common Voltage Range | CMRR > 45dB | | 2.8 | V<br>max |
| | | | | −0.1 | V<br>min |
| CMRR | Common Mode Rejection Ratio | 0 < $V_{CM}$ < 2.7V | 75 | 46 | dB<br>min |
| PSRR | Power Supply Rejection Ratio | $V^+$ = 1.8V to 5V | 79 | 55 | dB<br>min |





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## 2.7V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_J$ = 25°C, $V^+$ = 2.7V, $V^-$ = 0V. **Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Condition | Typ (*Note 5*) | Limits (*Note 6*) | Units |
|---|---|---|---|---|---|
| $t_{PHL}$ | Propagation Delay (High to Low) | Input Overdrive = 20mV<br>Load = 50pF//5kΩ | 830 | | ns |
| | | Input Overdrive = 50mV<br>Load = 50pF//5kΩ | 430 | | ns |
| $t_{PLH}$ | Propagation Delay (Low to High) | Input Overdrive = 20mV<br>Load = 50pF//5kΩ | 730 | | ns |
| | | Input Overdrive = 50mV<br>Load = 50pF//5kΩ | 410 | | ns |

## 5V Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_J$ = 25°C, $V^+$ = 5V, $V^-$ = 0V. **Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Conditions | Typ (*Note 5*) | Limits (*Note 6*) | Units |
|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | | 0.03 | 6<br>**8** | mV<br>max |
| TC $V_{OS}$ | Input Offset Average Drift | $V_{CM}$ = 2.5V (*Note 7*) | 10 | | µV/C |
| $I_B$ | Input Bias Current | | 16 | | nA |
| $I_{OS}$ | Input Offset Current | | 220 | | pA |
| $I_S$ | Supply Current | | 12 | 20<br>**25** | µA<br>max |
| $I_{SC}$ | Output Short Circuit Current | Sourcing, $V_O$ = 2.5V<br>(LMV7251 only) | 82 | 50 | mA<br>min |
| | | Sinking, $V_O$ = 2.5V | 78 | 50 | |
| $I_{LEAKAGE}$ | Output Leakage Current | $V_O$ = 5V,<br>(LMV7255 only) | 375 | | pA |
| $V_{OH}$ | Output Voltage High | $I_O$ = 4mA | 4.9 | 4.82 | V<br>min |
| $V_{OL}$ | Output Voltage Low | $I_O$ = −4mA | 90 | 180 | mV<br>max |



**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics.

**Note 2:** Human body model, 1.5kΩ in series with 100pF.

**Note 3:** The maximum power dissipation is a function of $T_{J(max)}$, $\theta_{JA}$, and $T_A$. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(max)} - T_A)/\theta_{JA}$. All numbers apply for packages soldered directly into a PC board.

**Note 4:** Typical values represent the most likely parametric norm.

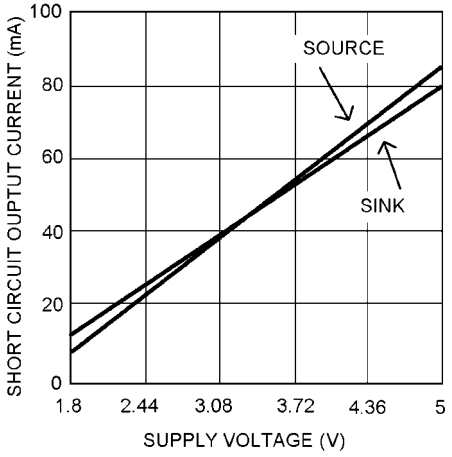
**Note 5:** All limits are guaranteed by testing or statistical analysis.

**Note 6:** Machine Model, 0Ω in series with 200pF.

**Note 7:** Offset Voltage average drift determined by dividing the change in $V_{OS}$ at temperature extremes into the total temperature change.

## Typical Performance Characteristics ($T_A$ = 25°C, Unless otherwise specified).

**Short Circuit Current vs. Supply Voltage**

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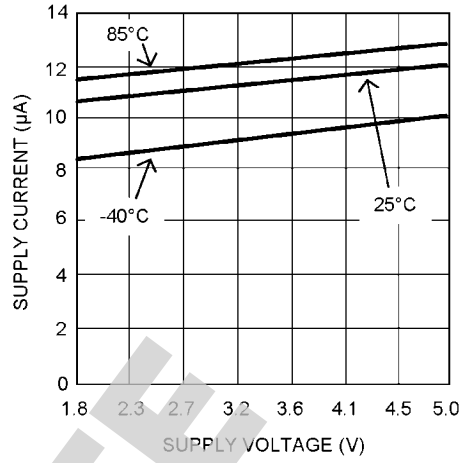
**Supply Current vs. Supply Voltage**

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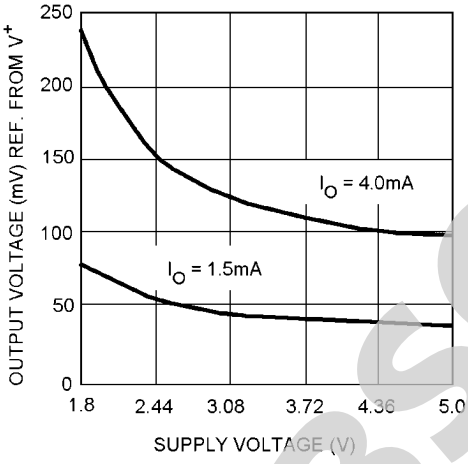
**Output Voltage vs. Supply Voltage**

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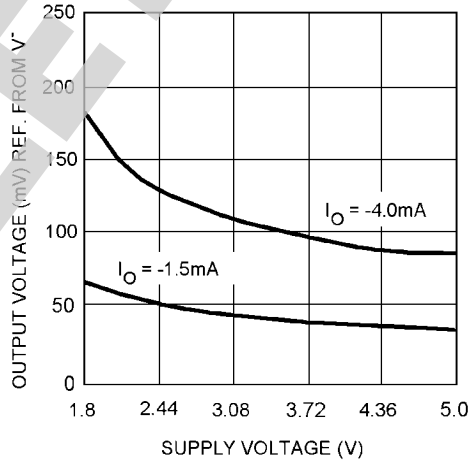
**Output Voltage vs. Supply Voltage**

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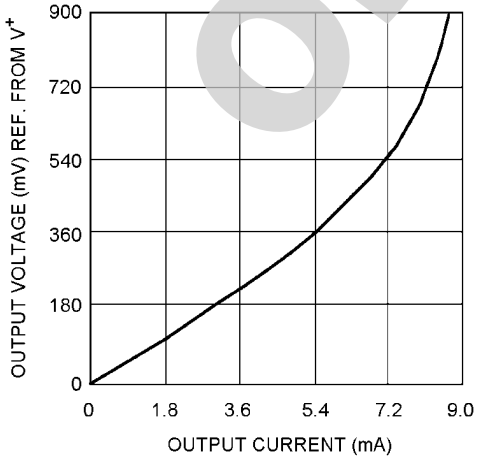
**Output Voltage vs. Output Current @1.8V Supply Voltage**

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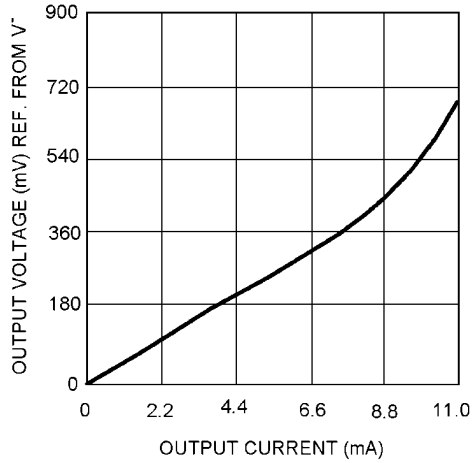
**Output Voltage vs. Output Current @1.8V Supply Voltage**

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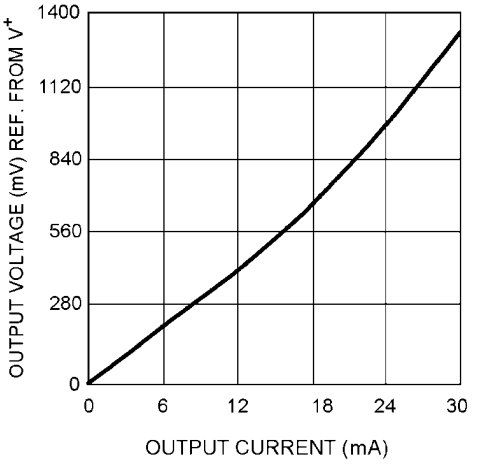
**Output Voltage vs. Output Current @2.7V Supply Voltage**

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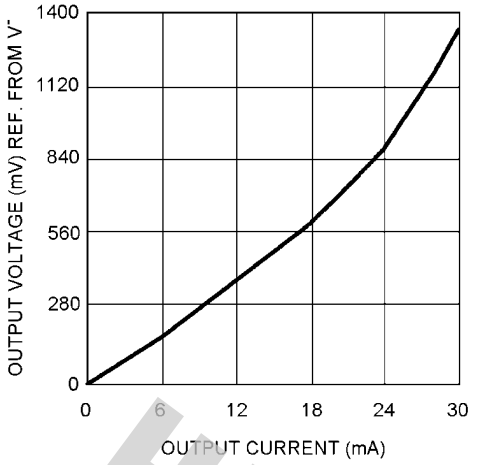
**Output Voltage vs. Output Current @2.7V Supply Voltage**

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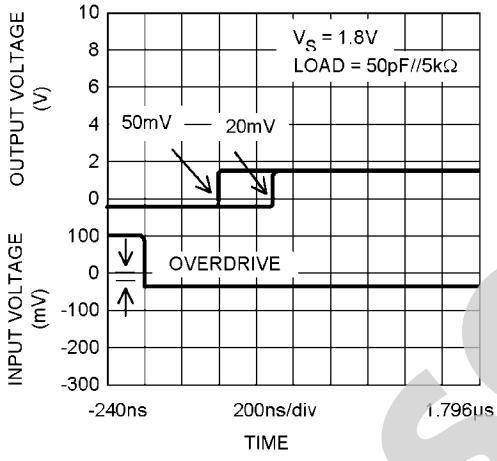
**Response Time for Various Input Overdrives - $t_{PLH}$**

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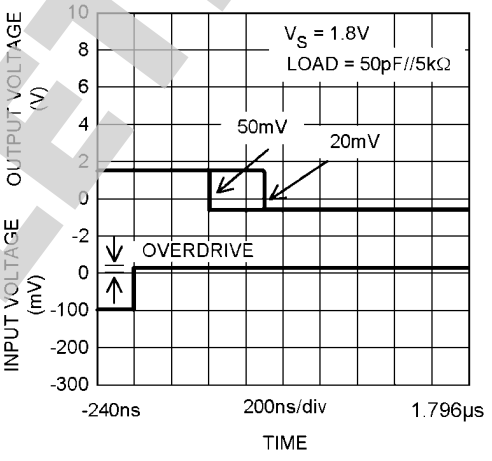
**Response Time for Various Input Overdrives - $t_{PHL}$**

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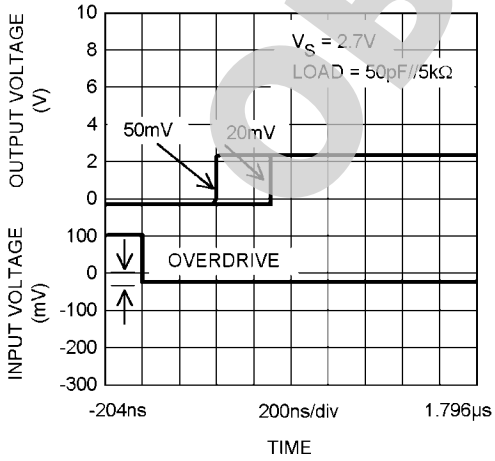
**Response Time for Various Input Overdrives - $t_{PLH}$**

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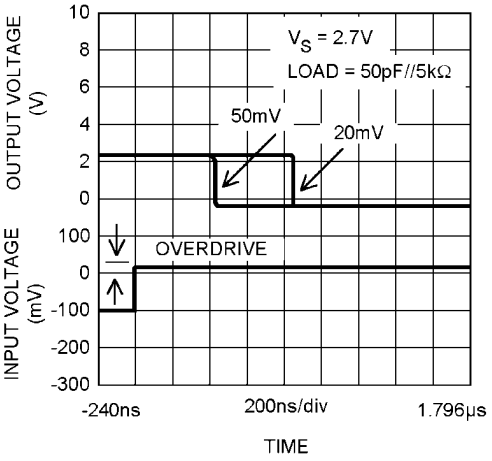
**Response Time for Various Input Overdrives - $t_{PHL}$**

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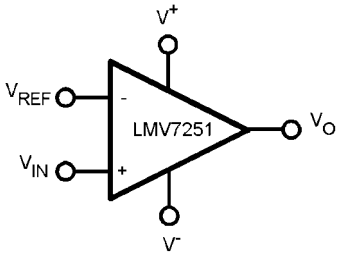
# Application Info

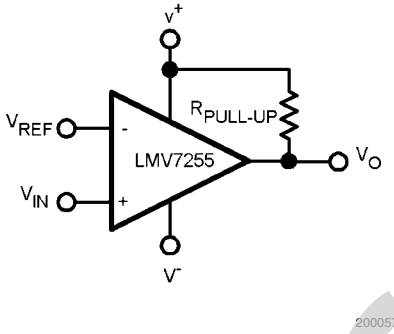
## BASIC COMPARATORS

A comparator is quite often used to convert an analog signal to a digital signal. The comparator compares an input voltage ($V_{IN}$) at the non-inverting pin to the reference voltage ($V_{REF}$) at the inverting pin. If $V_{IN}$ is less than $V_{REF}$ the output ($V_O$) is low ($V_{OL}$). However, if $V_{IN}$ is greater than $V_{REF}$, the output voltage ($V_O$) is high ($V_{OH}$).

**LMV7251**




**LMV7255**




**Input/Output**

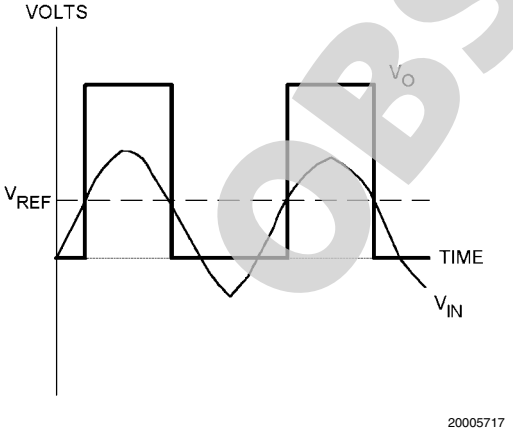



**FIGURE 2. Basic Comparator**

## HYSTERESIS

The basic comparator configuration may oscillate or produce a noisy output if the applied differential input is near the comparator's input offset voltage. This tends to occur when the voltage on the input is equal or very close to the other input voltage. Adding hysteresis can prevent this problem. Hysteresis creates two switching thresholds (one for the rising input voltage and the other for the falling input voltage). Hysteresis is the voltage difference between the two switching thresholds. When both inputs are nearly equal, hysteresis causes one input to effectively move quickly pass the other. Thus, effectively moving the input out of region that oscillation may occur.

Hysteresis can easily be added to a comparator in a non-inverting configuration with two resistors and positive feedback *Figure 3*. The output will switch from low to high when $V_{IN}$ rises up to $V_{IN1}$, where $V_{IN1}$ is calculated by

$$V_{IN1} = (V_{REF} (R1 + R2))/ R2$$

The output will switch from high to low when $V_{IN}$ falls to $V_{IN2}$, where $V_{IN2}$ is calculated by

$$V_{IN2} = (V_{REF} (R1 + R2) - V_{CC} R1) / R2$$

The Hysteresis is the difference between $V_{IN1}$ and $V_{IN2}$.

$\Delta V_{IN} = V_{IN1} - V_{IN2} = ((V_{REF} (R1 + R2)) / R2) - ((V_{REF} (R1 + R2) - V_{CC} R1) / R2) = V_{CC} R1 / R2$.

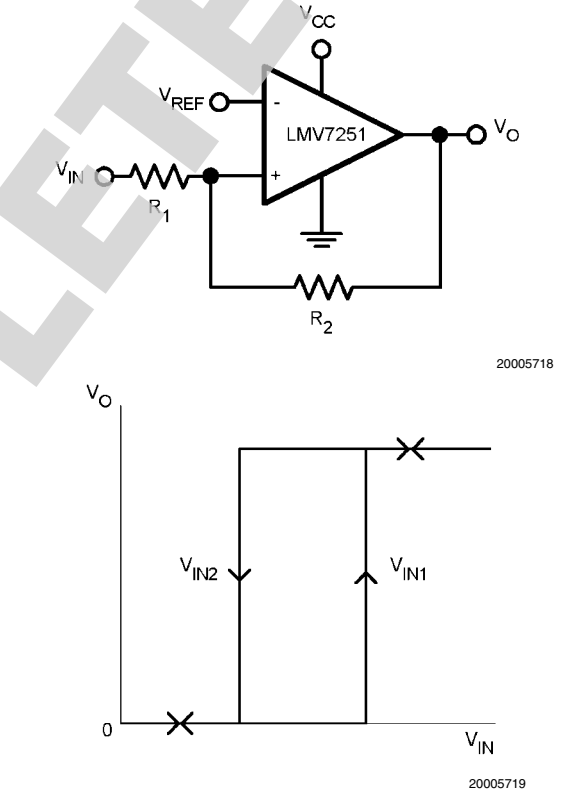



**FIGURE 3. Non-Inverting Comparator Configuration — LMV7251**

For an inverting configured comparator, hysteresis can be added with a three resistor network and positive feedback. When input voltage ($V_{IN}$) at the inverting node is less than non-inverting node ($V_T$), the output is high. The equivalent circuit for the three resistor network is R1 in parallel with R3 and in series with R2. The lower threshold voltage $V_{T1}$ is calculated by:

$$V_{T1} = ((V_{CC} R2) / ((R1 R3) / (R1+ R3)) + R2)$$

When $V_{IN}$ is greater than $V_T$, the output voltage is low. The equivalent circuit for the three resistor network is R2 in parallel with R3 and in series with R1. The upper threshold voltage $V_{T2}$ is calculated by:

$$V_{T2} = V_{CC} ((R2 R3) / (R2 + R3)) / ((R1 + ((R2 R3) / (R2 + R3))$$





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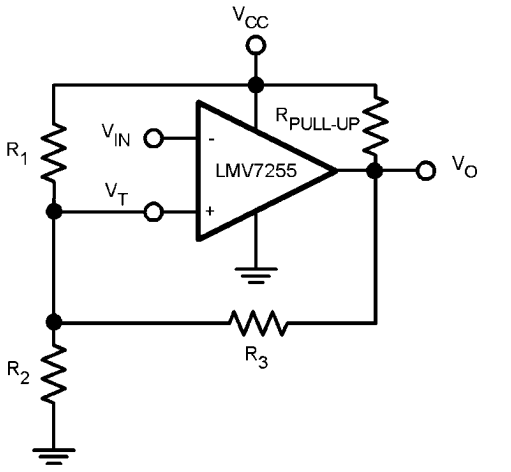
The hysteresis is defined as

$\Delta V_{IN} = V_{T1} - V_{T2} = ((V_{CC}\ R2) / ((R1\ R3) / (R1+ R3)) + R2) - (V_{CC}\ ((R2\ R3) / (R2 + R3)) / ((R1 + ((R2\ R3) / (R2 + R3)))$

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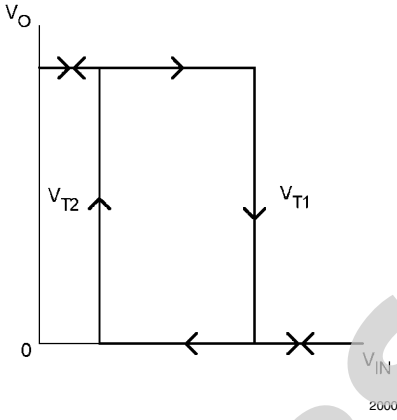


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**FIGURE 4. Inverting Configured Comparator — LMV7255**

## INPUT STAGE

The LMV7251 and LMV7255 have rail-to-rail input stages. The input common mode voltage range is from −100mV to ($V_{CC}$ + 100mV).

## OUTPUT STAGE

The LMV7251 has a push-pull CMOS output stage. Large push-pull output drivers allows rail-to-rail output swings with load currents in the miliampere range.

The LMV7255 has a open drain CMOS output stage. This requires an external pull-up resistor connected between the positive supply voltage and the output. The external pull-up resistor should be high enough resistance so to avoid excessive power dissipation. In addition, the pull-up resistor should be low enough resistance to enable the comparator to switch with the load circuitry connected.

## POWER SUPPLY CONSIDERATIONS

The LMV7251/LMV7255 are well suited for many battery-powered applications. The LMV7251/LMV7255 can operate from single power supply of +1.8V to +5V. The device typically consumes only 11µA with a 2.7V supply. With a high power supply rejection ratio (PSRR) of 79 dB (typical), the comparator is well suited for operating under conditions of a decaying battery voltage.

Power supply decoupling is critical and improves stability. Place decoupling capacitors 0.1µF as close as possible to the V+ pin. For split supply applications, place decoupling capacitors 0.1µF on both the V+ and V− pins. The decoupling capacitors will help keep the comparator from oscillating under various load conditions.

## Ordering Information

| Package | Ordering Info | Pkg Marking | Supplied As | NSC Drawing |
|---|---|---|---|---|
| 5-Pin SOT23-5 | LMV7251M5 | C16A | 1k Units Tape and Reel | MF05A |
| | LMV7251M5X | C16A | 3k units Tape and Reel | |
| | LMV7255M5 | C18A | 1k Units Tape and Reel | |
| | LMV7255M5X | C18A | 3k units Tape and Reel | |
| 5-Pin SC-70 | LMV7251M7 | C17 | 1k Units Tape and Reel | MAA05A |
| | LMV7251M7X | C17 | 3k units Tape and Reel | |
| | LMV7255M7 | C19 | 1k Units Tape and Reel | |
| | LMV7255M7X | C19 | 3k units Tape and Reel | |





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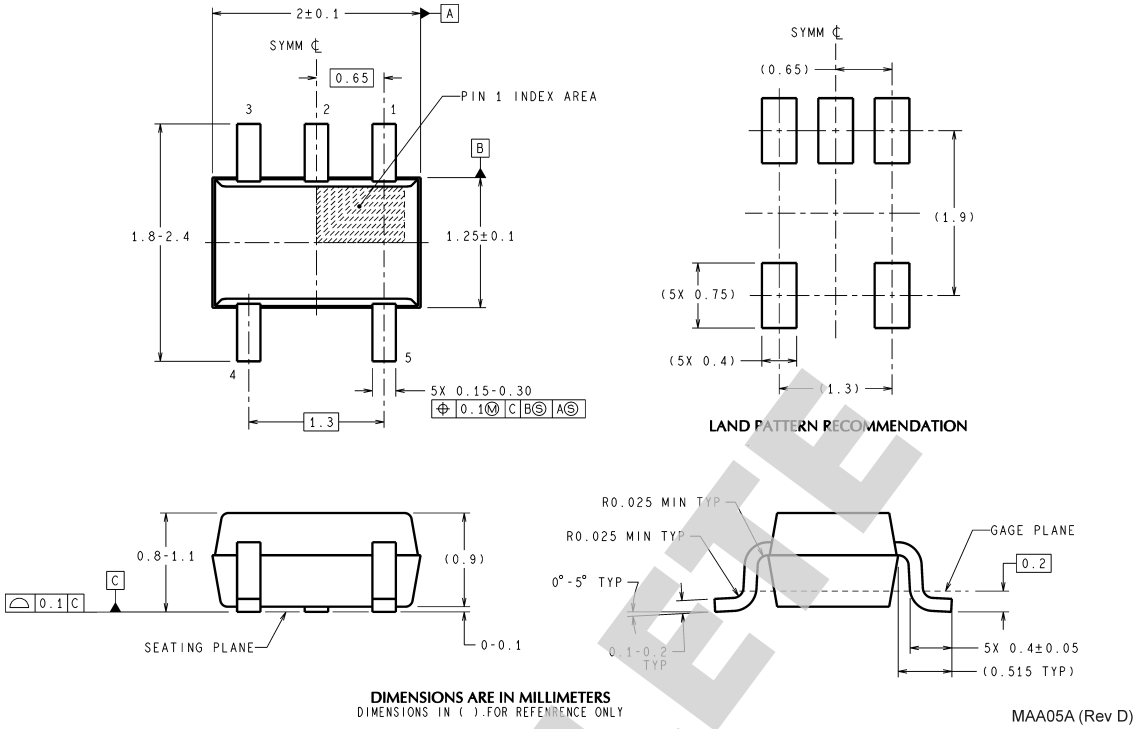
## Physical Dimensions inches (millimeters) unless otherwise noted

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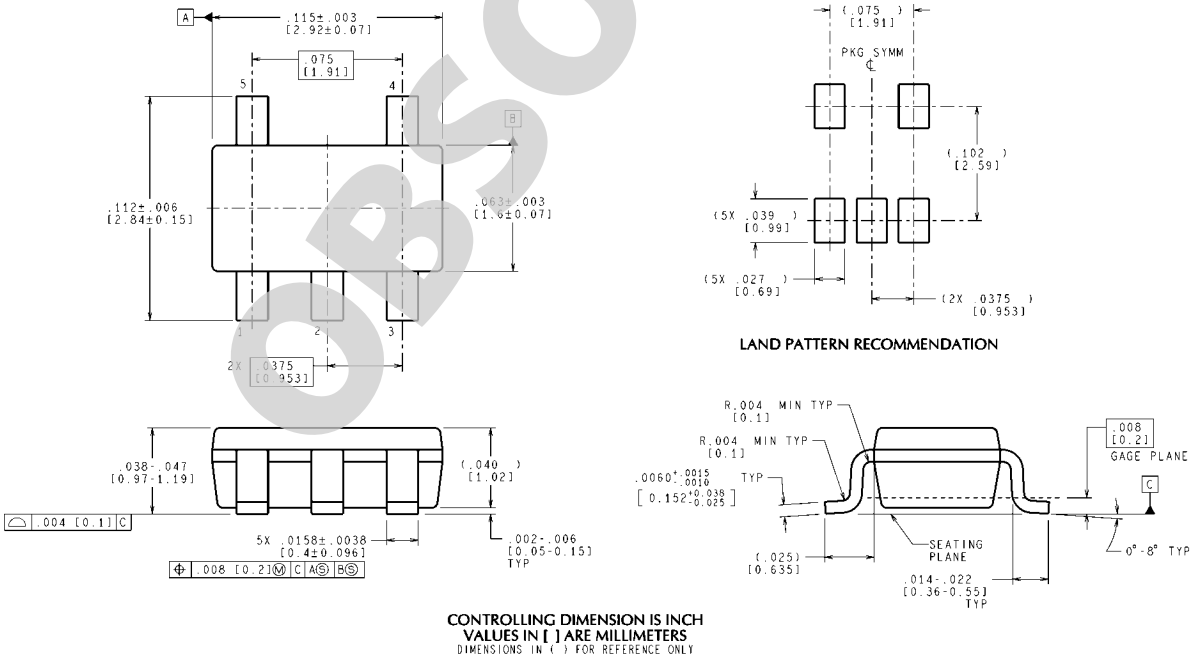
DIMENSIONS IN ( ) FOR REFERENCE ONLY

MAA05A (Rev D)

**5-Pin SC70-5**
**NS Package Number MAA05A**

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MF05A (Rev D)

**5-Pin SOT23-5**
**NS Package Number MF05A**

# Notes

# Notes

**For more National Semiconductor product information and proven design tools, visit the following Web sites at: www.national.com**

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