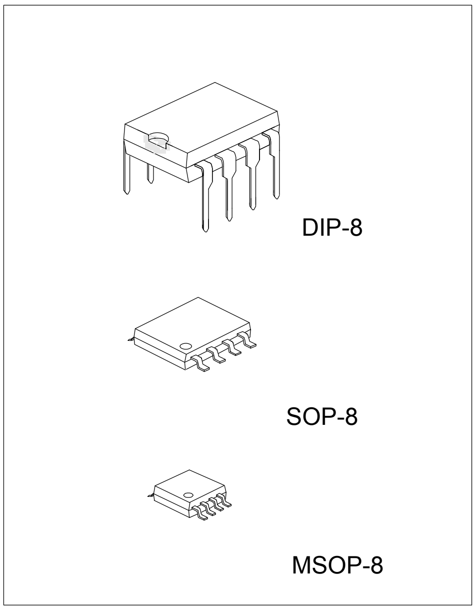
# DUAL GENERAL PURPOSE, LOW VOLAGE, COMPARATORS




## ■ DESCRIPTION

The UTC **LMV393** is a low voltage (2.7-5V) version of the dual comparators. Its noise performance has been improved by using bipolar differential input and output stages. These comparators also have a unique characteristic in that the input common-mode voltage range includes ground even though operated from a single power supply voltage.

The UTC **LMV393** is designed for applications in consumer automotive, mobile communications, notebooks and PDA's, battery powered electronics, general purpose portable device, general purpose low voltage applications.

## ■ FEATURES

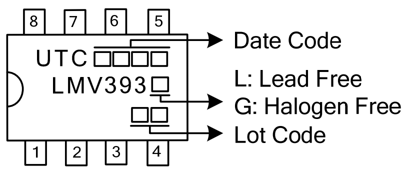
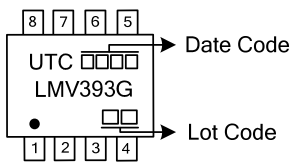
* High Precision Comparator.
* Low Operating Voltage 2.7-5V.
* Low Supply Current 100μA/Channel (Typical).
* Low Input Bias Current 100nA (Typical).
* Low Input Offset Current 2nA (Typical).
* Input Common Mode Voltage Range Includes Ground.
* Low Output Saturation Voltage 0.2V.

## ■ ORDERING INFORMATION

| Ordering Number | | Package | Packing |
|---|---|---|---|
| Lead Free | Halogen Free | | |
| LMV393L-D08-T | LMV393G-D08-T | DIP-8 | Tube |
| - | LMV393G-S08-R | SOP-8 | Tape Reel |
| - | LMV393G-SM1-R | MSOP-8 | Tape Reel |

| LMV393L-D08-R | |
|---|---|
| (1)Packing Type | (1) R: Tape Reel, T: Tube |
| (2)Package Type | (2) D08: DIP-8, S08: SOP-8, SM1: MSOP-8 |
| (3)Green Package | (3) L: Lead Free, G: Halogen Free and Lead Free |

## ■ MARKING

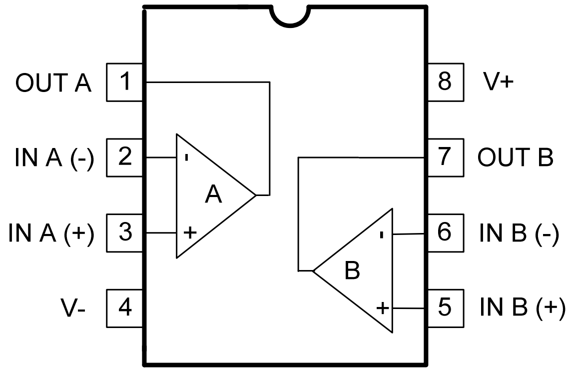
| DIP-8 | SOP-8 / MSOP-8 |
|---|---|
|  |  |



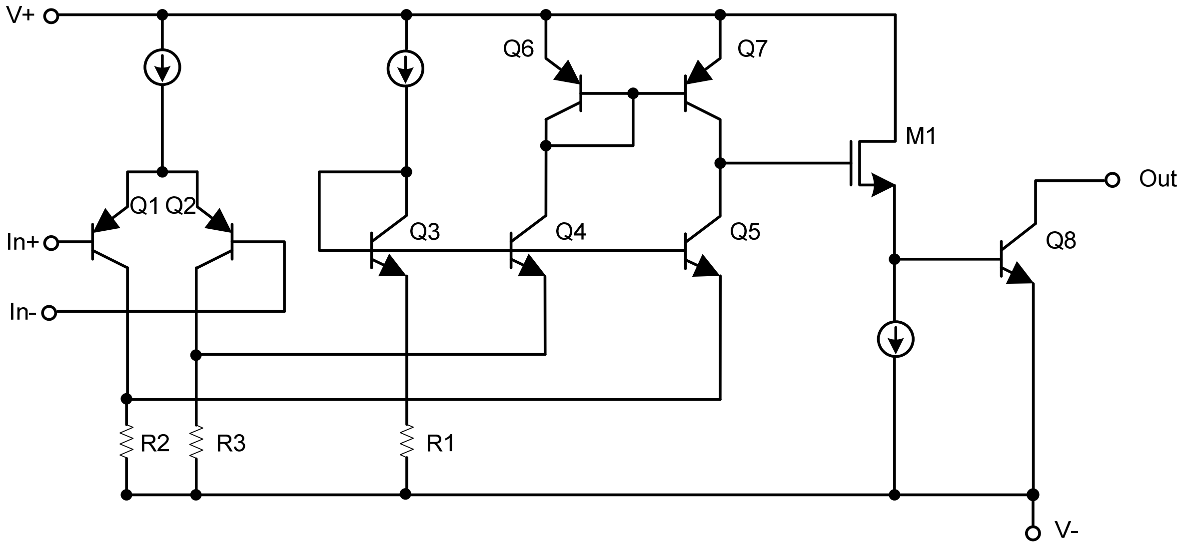


## ■ PIN CONFIGURATION




## ■ BLOCK DIAGRAM



## ■ ABSOLUTE MAXIMUM RATINGS

| PARAMETER | SYMBOL | RATINGS | UNIT |
|---|---|---|---|
| Supply Voltage | $V_{CC}$ | 2.7 ~ 5.0 | V |
| Differential Input Voltage | $V_{IN(DIFF)}$ | ±$V_{CC}$ | V |
| Voltage on Any Pin (Referred to V- pin) | | 5.5 | V |
| Junction Temperature | $T_J$ | +150 | °C |
| Operating Temperature | $T_{OPR}$ | -40 ~ +85 | °C |
| Storage Temperature | $T_{STG}$ | -65 ~ +150 | °C |

Note Absolute maximum ratings are those values beyond which the device could be permanently damaged. Absolute maximum ratings are stress ratings only and functional device operation is not implied.

## ■ THERMAL DATA

| PARAMETER | | SYMBOL | RATINGS | UNIT |
|---|---|---|---|---|
| Junction to Ambient | DIP-8 | $\theta_{JA}$ | 100 | °C /W |
| | SOP-8 | | 150 | |
| | MSOP-8 | | 190 | |

## ■ DC ELECTRICAL CHARACTERISTICS ($T_J$=25°C, $V^-$=0V, unless otherwise specified.)

| PARAMETER | | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| Input Offset Voltage | | $V_{I(OFF)}$ | | | 1.7 | 7 | mV |
| Input Offset Voltage Average Drift | | $I_{I(OFF)}$ | | | 5 | | μV/°C |
| Input Bias Current | | $I_{I(BIAS)}$ | | | 100 | 250 | nA |
| Input Offset Current | | $I_{I(OFF)}$ | | | 2 | 50 | nA |
| Input Voltage Range | | $V_{IN}$ | | | -0.1<br>4.2 | | V |
| Supply Current | | $I_{CC}$ | | | 100 | 200 | μA |
| Voltage Gain | | $G_V$ | | 20 | 50 | | V/mV |
| Saturation Voltage | | $V_{SAT}$ | $I_{O(SINK)} \leq 4$mA | | 200 | 400 | mV |
| Output Sink Current | 2.7V | $I_{O(SINK)}$ | $V_{OUT} \leq 1.5$V | 5 | 40 | | mA |
| | 5.0V | | | 10 | 50 | | |
| Output Leakage Current | | $I_{O(LEAK)}$ | | | 0.003 | 1 | μA |

## ■ AC ELECTRICAL CHARACTERISTICS ($T_J$=25°C, $R_L$=5.1kΩ, V-=0V, unless otherwise specified.)

| PARAMETER | | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| Propagation Delay (High to Low) | 2.7V | $t_{PHL}$ | Input Overdrive=10mV | | 9 | | us |
| | 5.0V | | | | 8 | | |
| | 2.7V | | Input Overdrive=100mV | | 3.8 | | |
| | 5.0V | | | | 3.4 | | |
| Propagation Delay (Low to High) | 2.7V | $t_{PLH}$ | Input Overdrive=10mV | | 2 | | us |
| | 5.0V | | | | 3 | | |
| | 2.7V | | Input Overdrive=100mV | | 0.7 | | |
| | 5.0V | | | | 0.8 | | |

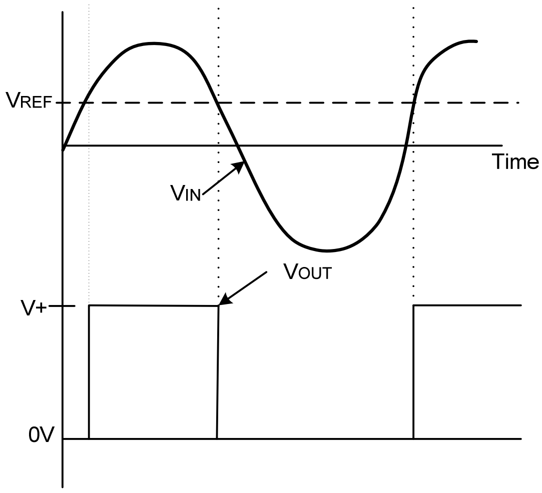
## ■ APPLICATION CIRCUITS

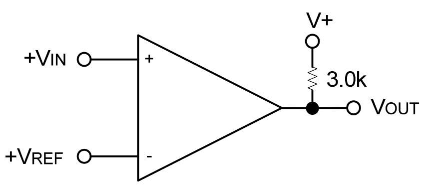
**Basic Comparator**

A basic comparator circuit can convert analog signals to a digital output. The UTC **LMV393** needs a pull-up resistor connected to the positive supply voltage which can make output switch properly. So that when the internal output transistor is off, the output voltage will be pulled up to the external positive voltage.

The resister should be chosen properly. The higher resister can reduce the power dissipation. the lower resister can improve the capacity of loading output. The range of resister should between 1k to 10kΩ.

The Output voltage of the comparator will be high if the input voltage at the non-inverting pin is greater than the reference voltage at the inverting pin. On the other hand it will be low.




Basic Comparator

**Comparator with Hysteresis**

The comparator may oscillate or produce a noisy output if the applied differential input voltage is near the comparator's offset voltage, especially when the input signal is moving slowly across the comparator's switching threshold. Addition of hysteresis or positive feedback can solve this problem.

**Inverting Comparator with Hysteresis**

It requires a three resistor network that is referenced to the supply voltage $V_{CC}$ of the comparator. When the output voltage is high, these resistors can be represented as R1 // R3 in series with R2. The lower set input voltage is defined as:

$$Va_1 = \frac{V_{CC}R_2}{(R_1//R_3)+R_2}$$

■ APPLICATION CIRCUITS(Cont.)

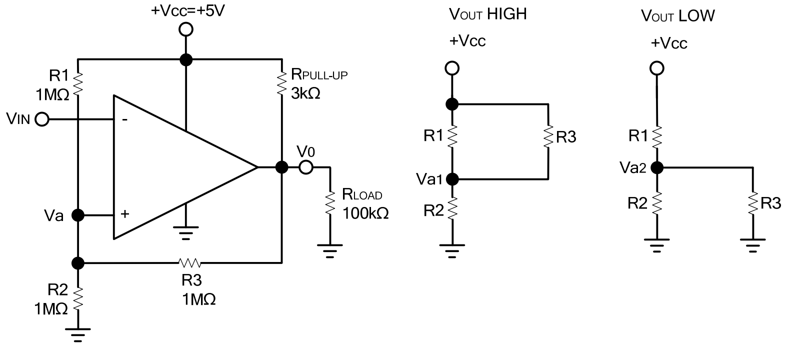
When $V_{IN} > V_a$ the output voltage is low close to ground. It can be presented as $R_2$ // $R_3$ in series with $R_1$. The upper trip voltage $V_{a2}$ is defined as

$$Va\,2 = \frac{V_{CC}(R_2//R_3)}{(R_2//R_3)+R_1}$$

The total hysteresis provided by the network is defined as:

$$\Delta Va = Va1 - Va2$$

To assure that the comparator will always switch correctly, the resistors values should be chosen as follow: $R_{PULL-UP} << R_{LOAD}$ and $R_1 > R_{PULL-UP}$.




Inverting Comparator with Hysteresis

**Non-Inverting Comparator with Hysteresis**

It requires a two resistor network to implement a non inverting comparator with hysteresis and with a voltage reference at the inverting input. So when $V_{IN}$ is low, the output is also low. If the output will switch from low to high, $V_{IN}$ must rise up to $V_{IN1}$, and $V_{IN1}$ can be calculated by:

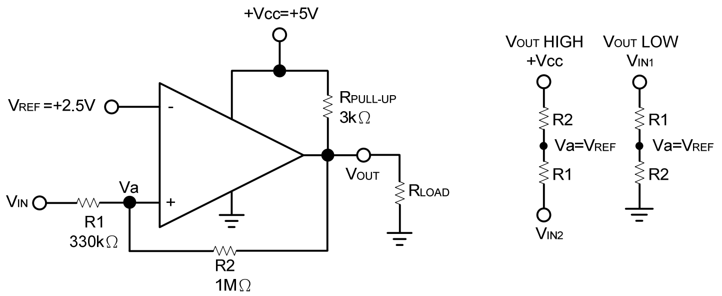
$$V_{IN1} = \frac{V_{REF}(R_1+R_2)}{R_2}$$

When $V_{IN}$ is high, the output is also high, in order to make the comparator switch back to low, $V_{IN}$ can be calculated by:

$$V_{IN2} = \frac{V_{REF}(R_1+R_2) - V_{CC}R_1}{R_2}$$

The hysteresis of this circuit is the difference between $V_{IN1}$ and $V_{IN2}$.

$$\Delta V_{IN} = V_{CC}R_1/R_2$$

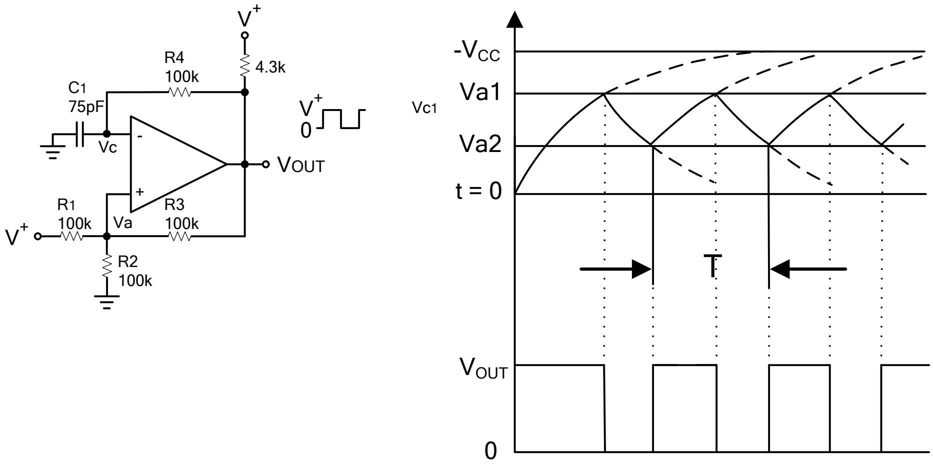



Non-Inverting Comparator with Hysteresis

## ■ APPLICATION CIRCUITS(Cont.)

**Square Wave Oscillator**

Comparators are suitable for oscillator applications. This application uses the minimum number of external components. The output frequency is set by the RC time constant which is determined by capacitor C1 and the resistor in the negative feedback $R_4$ of the comparator. Capacitive load at the output would degrade the output slew rate and limit the maximum operating frequency.




Squarewave Oscillator

At first, assume that the output is high, so the voltage at the inverting input $V_C$ is less than the voltage at the non-inverting input Va, the capacitor $C_1$ has to be discharged. When it has charged up to value equal to the positive input voltage $V_{a1}$, the comparator output will switch.

$V_{a1}$ will be given by:

$$V_{a1} = \frac{V_{CC}R_2}{R_2 + (R_1/R_2)}$$

If: $R_1$=$R_2$=$R_3$

Then:

$$V_{a1} = \frac{2V_{CC}}{3}$$

When the output switches to ground, the value of Va is reset by the resistor network:

$$V_{a2} = \frac{V_{CC}}{3}$$

Then capacitor C1 discharge through a resistor towards ground. The output will return to its high state when the voltage across the capacitor has discharged to a value equal to $V_{a2}$.The time to charge the capacitor can be calculated from:

$$V_C = V_{max}\, e^{\frac{-t}{RC}}$$

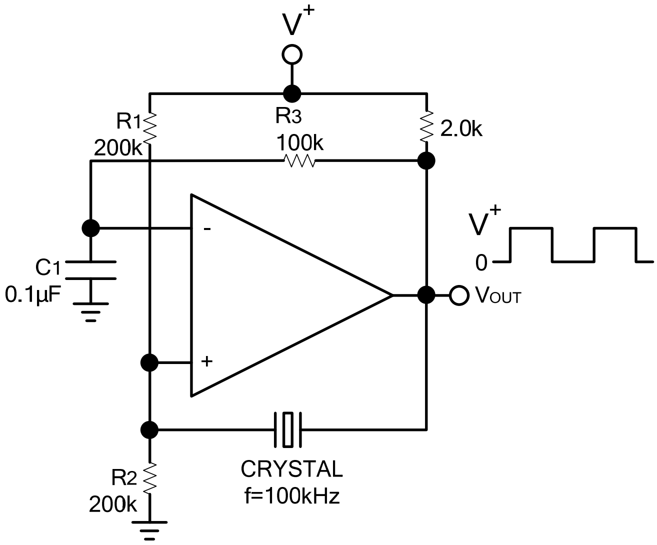
Where $V_{MAX}$ =2$V_{CC}$/3 and $V_C$ = $V_{CC}$/3

One period will be given by: 1/freq = 2t or calculating the exponential gives: 1/freq = 2(0.694) $R_4$ $C_1$Resistors $R_3$ and $R_4$ must be at least two times larger than $R_5$ to insure a reasonable $V_O$. The frequency stability of this circuit should strictly be a function of the external components.

## ■ APPLICATION CIRCUITS(Cont.)

**Free Running Multivibrator**

This oscillator circuit can generate a train of stable clock for precise timekeeping applications. We can obtain it by using a resonator as the feedback component. A quartz crystal in its series-resonant mode can make the circuit oscillating well. For the comparator be switching symmetrically about $+V_{CC}/2$, the value of $R_1$ and $R_2$ must choose equal. The RC time constant of R3 and $C_1$ is set to be several times greater than the period of the oscillating frequency. When choose crystal, be sure to order series resonant with desired temperature coefficient.




Crystal controlled Oscillator

**Pulse generator with variable duty cycle:**

A pulse generator with variable duty cycle can be obtained by creating two separated paths for $C_1$ charge and discharge into the basic square wave generator. One path, through $R_2$ and $D_2$ will charge the capacitor and set the pulse width ($t_1$). The other path, $R_1$ and $D_1$ will discharge the capacitor and set the time between pulses ($t_2$).

Varying resistor $R_1$, $R_2$ can alter the time between pulses and the pulse width. Both controls also change the frequency of the generator.

The pulse width and time between pulses can be found from:

$$V_1 = V_{max}(1 - e^{-t_1/R_4C_1}) \quad \text{Rise time}$$

$$V_1 = V_{max}(1 - e^{-t_2/R_5C_1}) \quad \text{Fall time}$$

Where

$$V_{max} = \frac{2V_{CC}}{3}$$

And

$$V_1 = \frac{2V_{max}}{3} = \frac{V_{CC}}{3}$$

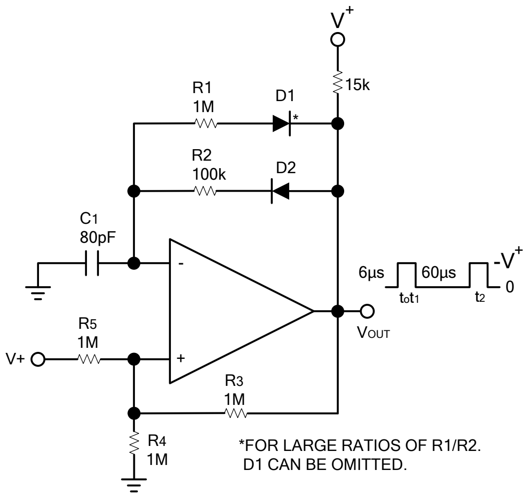
then

$$\frac{1}{2} = e^{-t_1/R_4C_1}$$

$t_2$ is then given by:

$$\frac{1}{2} = e^{-t_2/R_5C_1}$$

■ APPLICATION CIRCUITS(Cont.)




Pulse Generator

At last, we get,

$$t_1 = R_4 C_1 \ln 2$$

$$t_2 = R_5 C_1 \ln 2$$

These terms have a slight error because $V_{max}$ is not exactly equal to 2/3 $V_{CC}$ but is actually reduced by the diode drop to:

$$V_{max} = \frac{2}{3}(V_{CC} - V_{BE})$$

$$\frac{1}{2(1 - V_{BE})} = e^{-t_1/R_4C_1}$$

$$\frac{1}{2(1 - V_{BE})} = e^{-t_2/R_5C_1}$$

And that's the exact value we get.

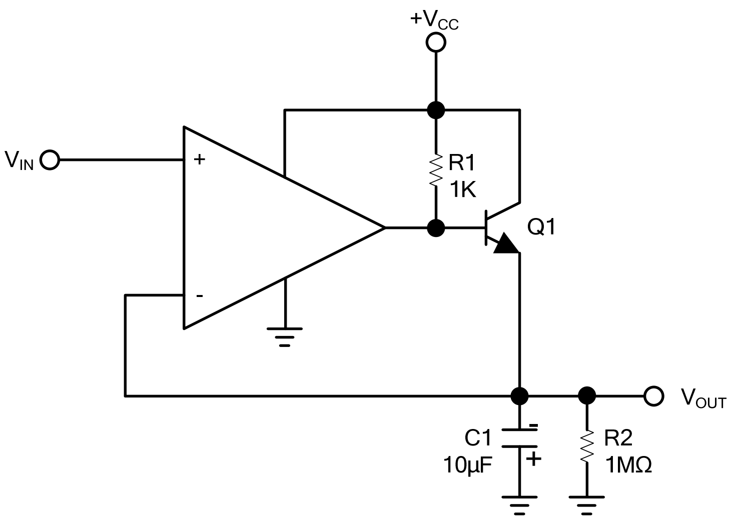
$$t_1 = R_4 C_1 \ \ln 2(1 - V_{BE})$$

$$t_2 = R_5 C_1 \ \ln 2(1 - V_{BE})$$

■ APPLICATION CIRCUITS(Cont.)

**Positive Peak Detector:**

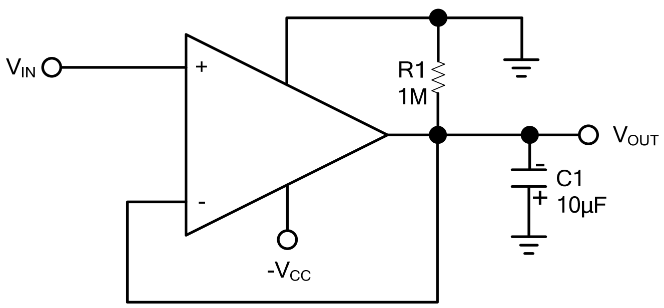
Positive peak detector is basically the comparator operated as a unit gain follower with a large holding capacitor from the output to ground. Additional transistor is added to the output to provide a low impedance current source. When the output of the comparator goes high, current is passed through the transistor to charge up the capacitor. The only discharge path will be the 1M ohm resistor shunting C1 and any load that is connected to the output. The decay time can be altered simply by changing the 1MΩ resistor. The output should be used through a high impedance follower to a avoid loading the output of the peak detector.




Positive Peak Detector

**Negative Peak Detector:**

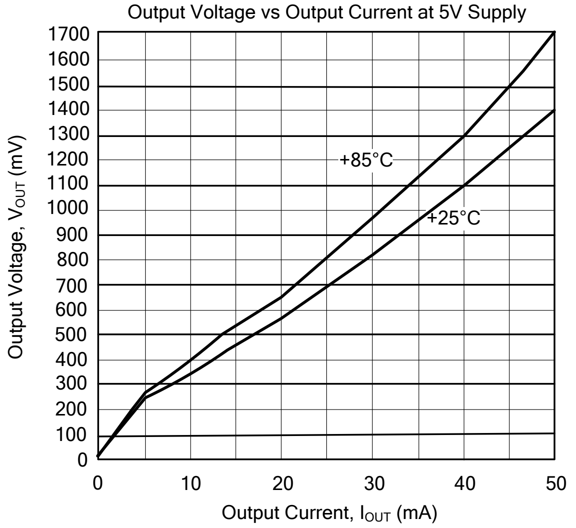
For the negative detector, the output transistor of the comparator acts as a low impedance current sink. The only discharge path will be the 1MΩ resistor and any load impedance used. Decay time is changed by varying the 1MΩ resistor.



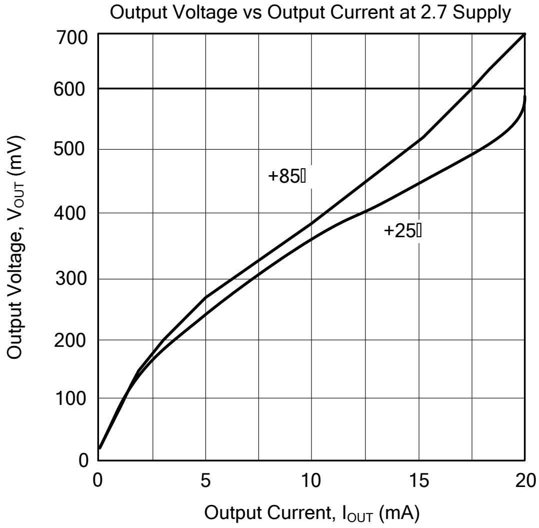

Negative Peak Detector

## ■ TYPICAL CHARACTERISTICS

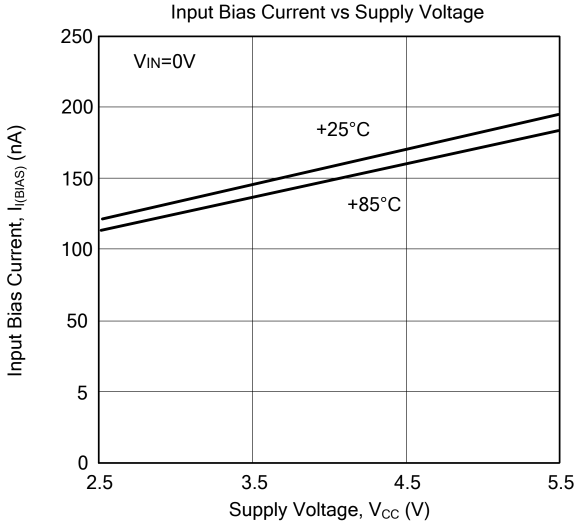
Output Voltage vs Output Current at 5V Supply



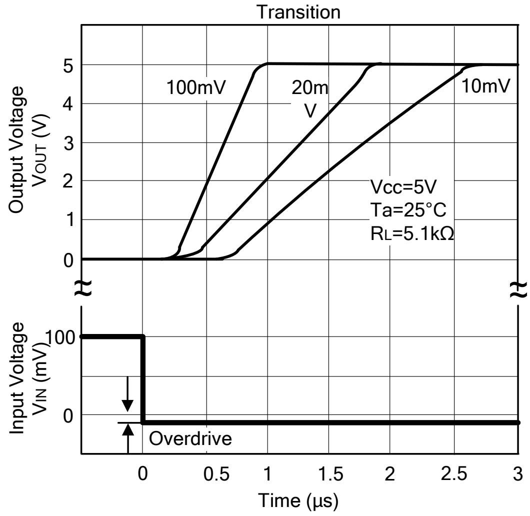

Output Voltage vs Output Current at 2.7 Supply



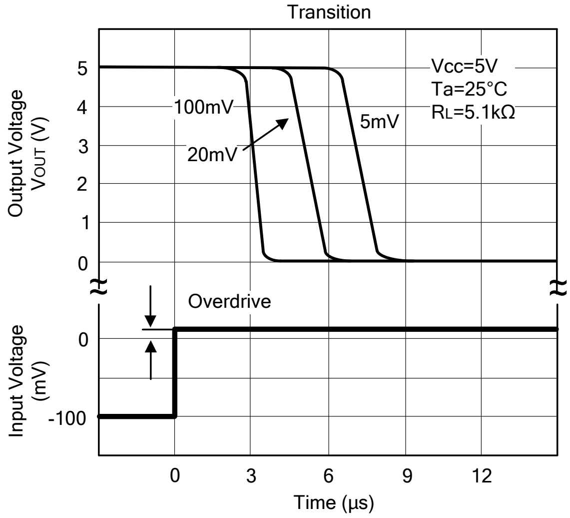

Input Bias Current vs Supply Voltage



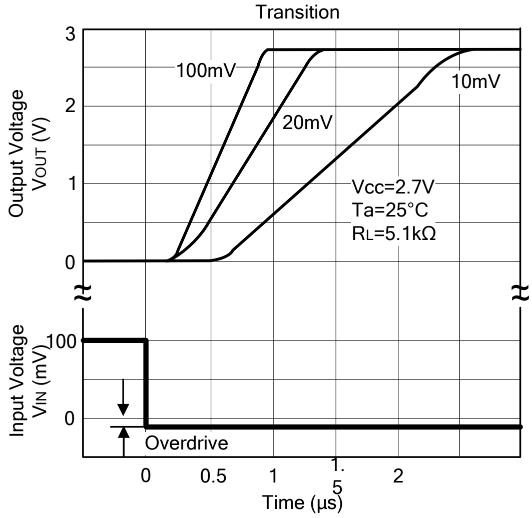

Response Time vs Input Overdrives Negative Transition




Response Time for Input Overdrive Positive Transition




Response Time vs Input Overdrives Negative Transition



■ TYPICAL CHARACTERISTICS (Cont.)