



# Nanopower, 1.8V, SOT23 Comparator with Voltage Reference

## FEATURES

- **LOW QUIESCENT CURRENT:** 5µA (max)
- **INTEGRATED VOLTAGE REFERENCE:** 1.242V
- **INPUT COMMON-MODE RANGE:**  
200mV Beyond Rails
- **VOLTAGE REFERENCE INITIAL ACCURACY:** 1%
- **OPEN-DRAIN LOGIC COMPATIBLE OUTPUT:**  
TLV3011
- **PUSH-PULL OUTPUT:** TLV3012
- **LOW-SUPPLY VOLTAGE:** 1.8V to 5.5V
- **FAST RESPONSE TIME:** 6µs Propagation Delay  
with 100mV Overdrive (TLV3011:  $R_{PULL-UP} = 10k\Omega$ )
- **MicroSIZE PACKAGES:** SOT23-6 and SC70-6

## APPLICATIONS

- **BATTERY-POWERED LEVEL DETECTION**
- **DATA ACQUISITION**
- **SYSTEM MONITORING**
- **OSCILLATORS**
- **SENSOR SYSTEMS:**  
Smoke Detectors, Light Sensors, Alarms

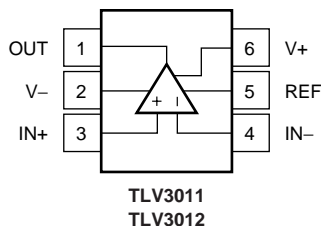
## DESCRIPTION

The TLV3011 is a low-power, open-drain output comparator; the TLV3012 is a push-pull output comparator. Both feature an uncommitted on-chip voltage reference. Both have 5µA (max) quiescent current, input common-mode range 200mV beyond the supply rails, and single-supply operation from 1.8V to 5.5V. The integrated 1.242V series voltage reference offers low 100ppm/°C (max) drift, is stable with up to 10nF capacitive load, and can provide up to 0.5mA (typ) of output current.

The TLV3011 and TLV3012 are available in the tiny SOT23-6 package for space-conservative designs. It is also available in the SC70 package for even greater board area savings. Both versions are specified for the temperature range of -40°C to +125°C.

## TLV3011 and TLV3012 RELATED PRODUCTS

PRODUCT	FEATURES
TLV349x	1.2µA, 1.8V to 5.5V Push-Pull Comparator
TLV370x	560nA, 2.5V to 16V Push-Pull CMOS Output Comparator
TLV340x	550nA, 2.5V to 16V Open-Drain Comparator



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## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

Supply Voltage .....	+7V
Signal Input Terminals, Voltage <sup>(2)</sup> .....	-0.5V to (V+) + 0.5V
Current <sup>(2)</sup> .....	±10mA
Output Short-Circuit <sup>(3)</sup> .....	Continuous
Operating Temperature .....	-55°C to +150°C
Storage Temperature .....	-55°C to +150°C
Junction Temperature .....	+150°C
Lead Temperature (soldering, 10s) .....	+300°C
ESD Rating (Human Body Model) .....	2000V

NOTE: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

(2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current limited to 10mA or less.

(3) Short-circuit to ground.



## ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

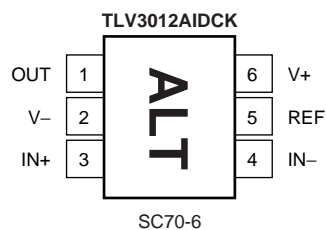
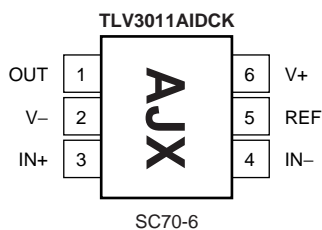
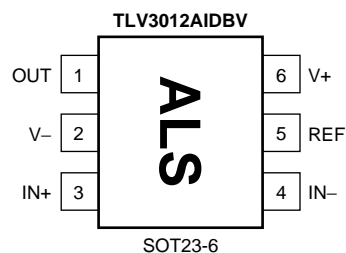
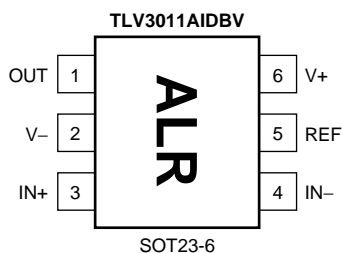
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## PACKAGE/ORDERING INFORMATION

For the most current package and ordering information, see the Package Option Addendum located at the end of this data sheet.

## PIN CONFIGURATIONS

Top View



NOTE: Pin 1 is determined by orienting package marking as shown.

# ELECTRICAL CHARACTERISTICS: $V_S = +1.8V$ to $+5.5V$

**Boldface** limits apply over the specified temperature range,  $T_A = -40^{\circ}C$  to  $+125^{\circ}C$ .

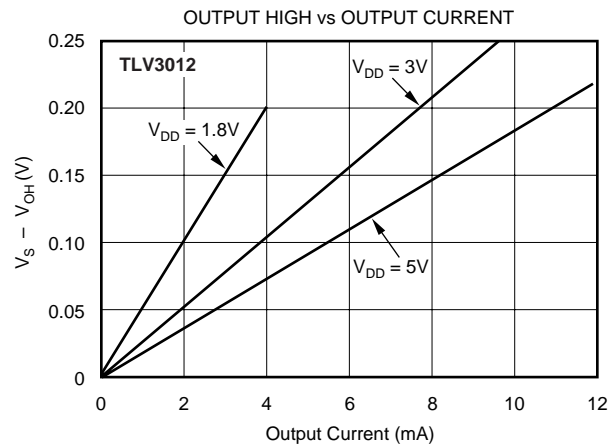
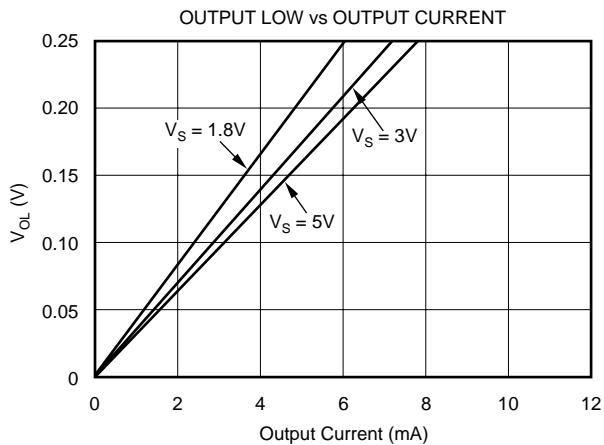
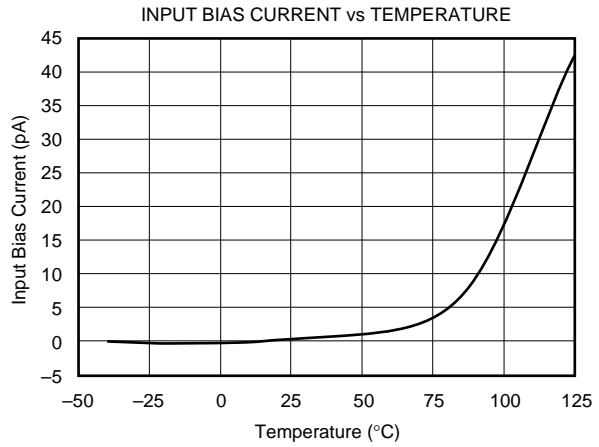
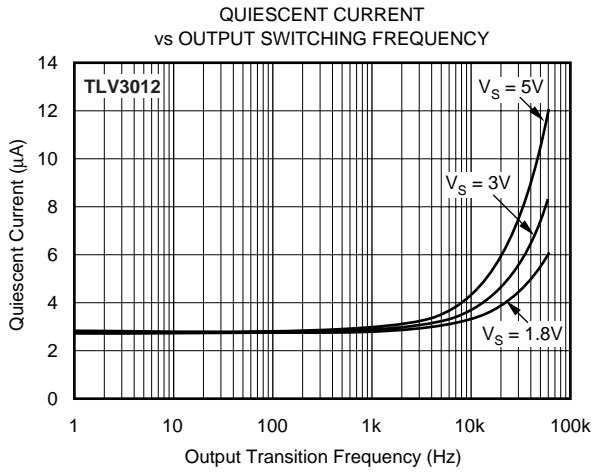
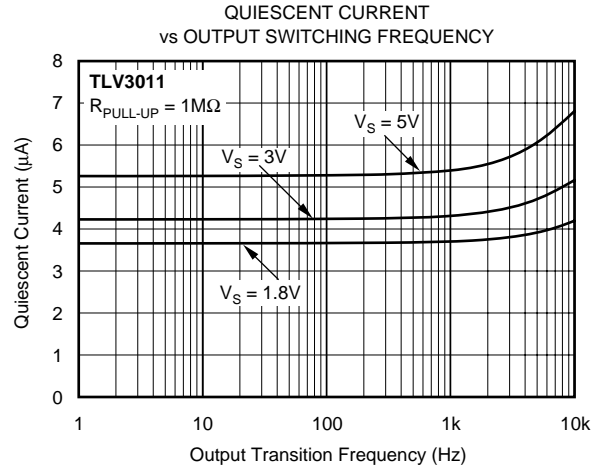
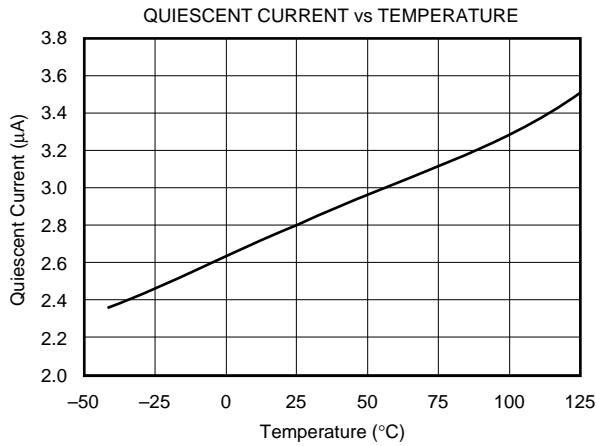
At  $T_A = +25^{\circ}C$ ,  $V_{OUT} = V_S$ , unless otherwise noted; for TLV3011,  $R_{PULL-UP} = 10k\Omega$  connected to  $V_S$ .

PARAMETER	CONDITION	TLV3011, TLV3012			UNITS
		MIN	TYP	MAX	
<b>OFFSET VOLTAGE</b> Input Offset Voltage <b>vs Temperature</b> vs Power Supply	$V_{OS}$ $dV_{OS}/dT$ PSRR $V_{CM} = 0V, I_O = 0V$ $T_A = -40^{\circ}C$ to $+125^{\circ}C$ $V_S = 1.8V$ to $5.5V$		0.5 $\pm 12$ 100	12  1000	mV $\mu V/^{\circ}C$ $\mu V/V$
<b>INPUT BIAS CURRENT</b> Input Bias Current Input Offset Current	$I_B$ $I_{OS}$ $V_{CM} = V_S/2$ $V_{CM} = V_S/2$		$\pm 1$ $\pm 1$	$\pm 10$ $\pm 10$	pA pA
<b>INPUT VOLTAGE RANGE</b> Common-Mode Voltage Range Common-Mode Rejection Ratio	$V_{CM}$ CMRR $V_{CM} = -0.2V$ to $(V+) - 1.5V$ $V_{CM} = -0.2V$ to $(V+) + 0.2V$	$(V-) - 0.2V$ 60 54	74 62	$(V+) + 0.2V$	V dB dB
<b>INPUT IMPEDANCE</b> Common-Mode Differential			$10^{13} \parallel 2$ $10^{13} \parallel 4$		$\Omega \parallel pF$ $\Omega \parallel pF$
<b>SWITCHING CHARACTERISTICS</b> Propagation Delay Time, Low-to-High Propagation Delay Time, High-to-Low Rise Time, TLV3011 Rise Time, TLV3012 Fall Time	$t_{PLH}$ $t_{PHL}$ $t_R$ $t_F$ $f = 10kHz, V_{STEP} = 1V$ Input Overdrive = 10mV Input Overdrive = 100mV Input Overdrive = 10mV Input Overdrive = 100mV $C_L = 10pF$ $C_L = 10pF$		12 6 13.5 6.5 See Note 1 100 100		$\mu s$ $\mu s$ $\mu s$ $\mu s$ ns ns
<b>OUTPUT</b> Voltage Output Low from Rail Voltage Output High From Rail, TLV3012 Short-Circuit Current, TLV3012	$V_{OL}$ $I_{OUT} = -5mA$ $I_{OUT} = 5mA$ $V_S = 5V$		160 90 See Typical Characteristics	200 200	mV mV
<b>VOLTAGE REFERENCE</b> Initial Accuracy Temperature Drift Load Regulation Sourcing Sinking Output Current Line Regulation	$V_{OUT}$ $dV_{OUT}/dT$ $dV_{OUT}/dI_{LOAD}$ $I_{LOAD}$ $dV_{OUT}/dV_{IN}$ $V_{IN} = 5V$ $-40^{\circ}C \leq T_A \leq 125^{\circ}C$ $0mA < I_{SOURCE} \leq 0.5mA$ $0mA < I_{SINK} \leq 0.5mA$ $1.8V \leq V_{IN} \leq 5.5V$	1.230	1.242 40 0.36 6.6 0.5 10	1.254 $\pm 1$ 100 1 1 100	V % ppm/ $^{\circ}C$ mV/mA mV/mA mA $\mu V/V$
<b>NOISE</b> Reference Voltage Noise	$f = 0.1Hz$ to $10Hz$		0.2		mV <sub>PP</sub>
<b>POWER SUPPLY</b> Specified Voltage Operating Voltage Range Quiescent Current	$V_S$ $I_Q$ $V_S = 5V, V_O = High$	1.8 1.8		5.5 5.5 5	V V $\mu A$
<b>TEMPERATURE RANGE</b> Specified Range Operating Range Storage Range Thermal Resistance, $\theta_{JA}$ SOT23-6 SC70-6		-40 -55 -55		+125 +150 +150	$^{\circ}C$ $^{\circ}C$ $^{\circ}C$ $^{\circ}C/W$ $^{\circ}C/W$

NOTE: (1)  $t_R$  dependent on  $R_{PULL-UP}$  and  $C_{LOAD}$ .

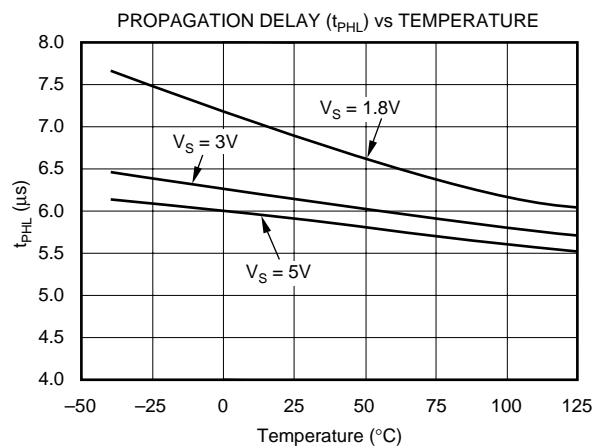
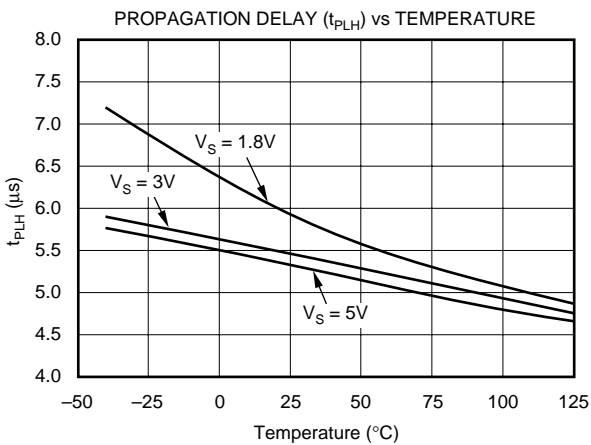
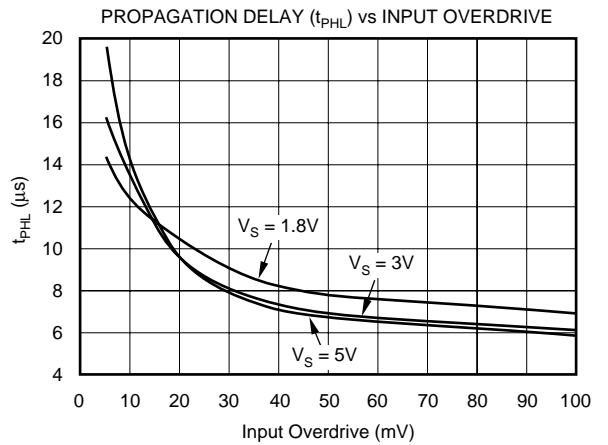
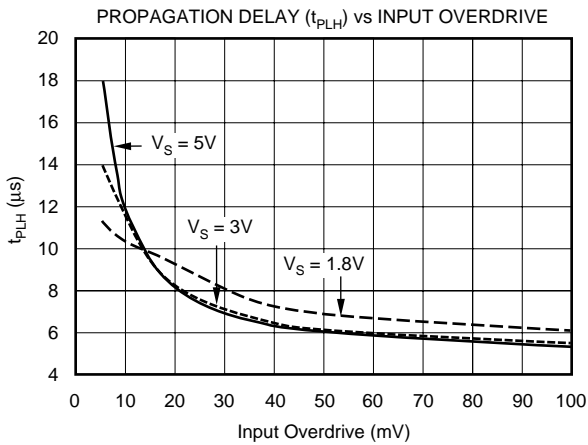
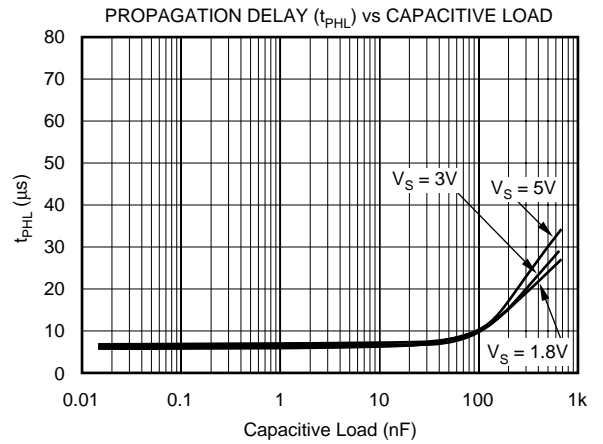
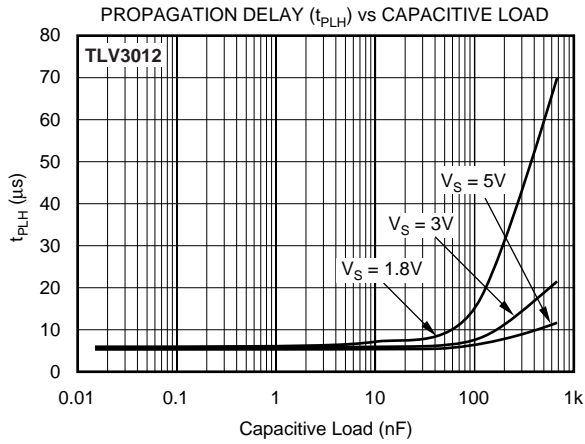
# TYPICAL CHARACTERISTICS

At  $T_A = +25^\circ\text{C}$ ,  $V_S = +1.8\text{V}$  to  $+5.5\text{V}$ ,  $R_{\text{PULL-UP}} = 10\text{k}\Omega$ , and Input Overdrive =  $100\text{mV}$ , unless otherwise noted.



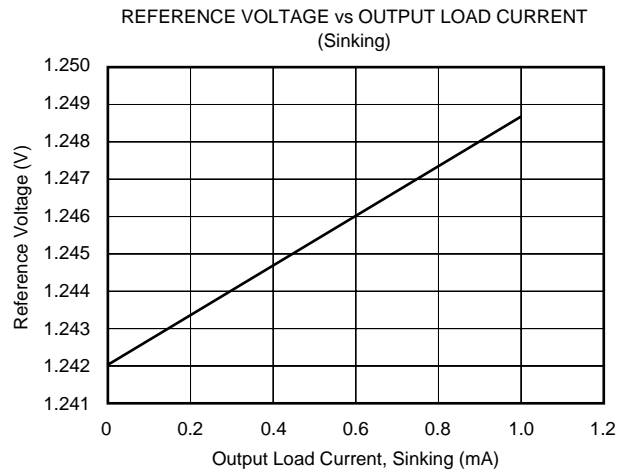
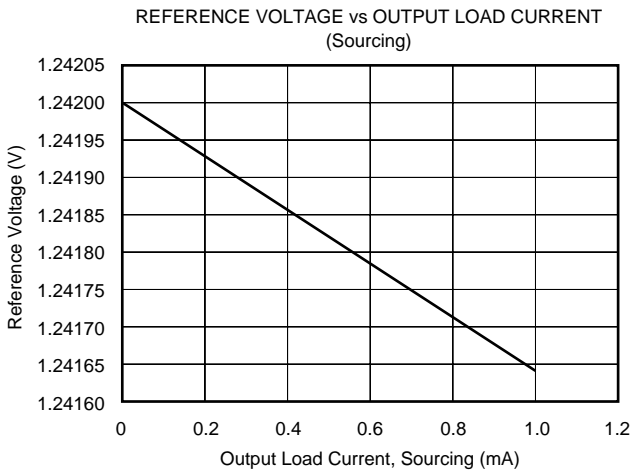
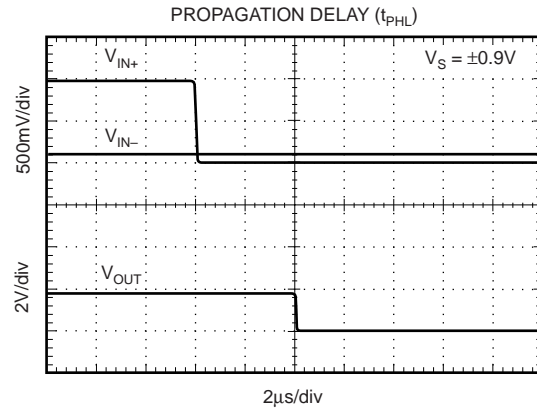
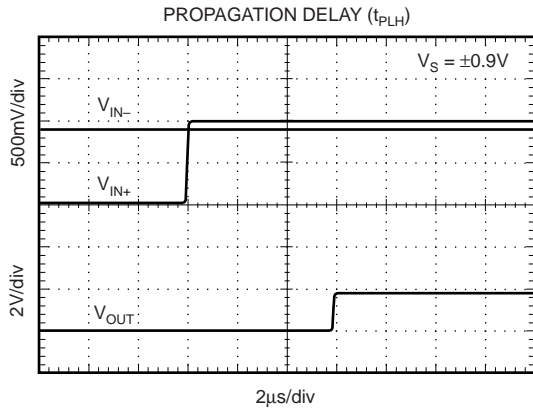
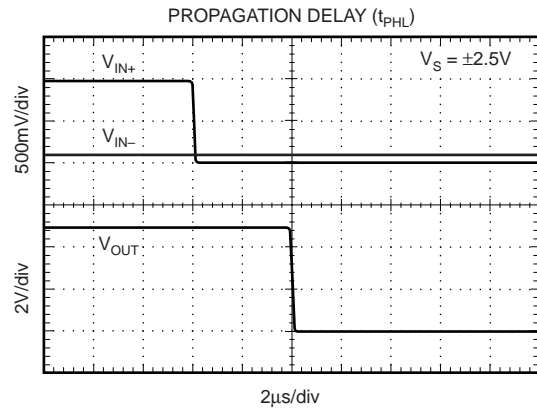
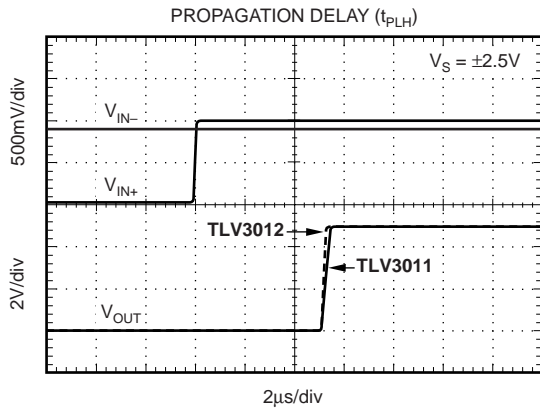
# TYPICAL CHARACTERISTICS (Cont.)

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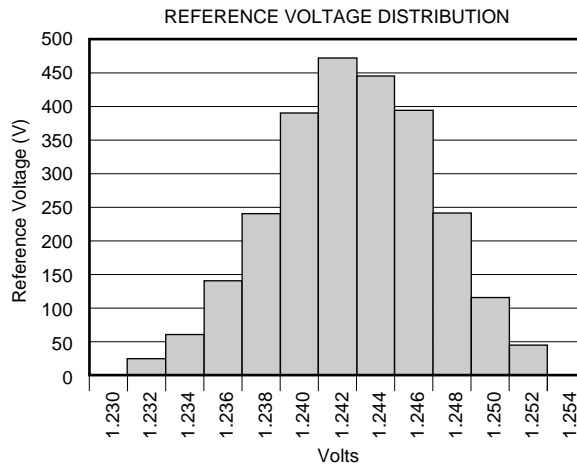
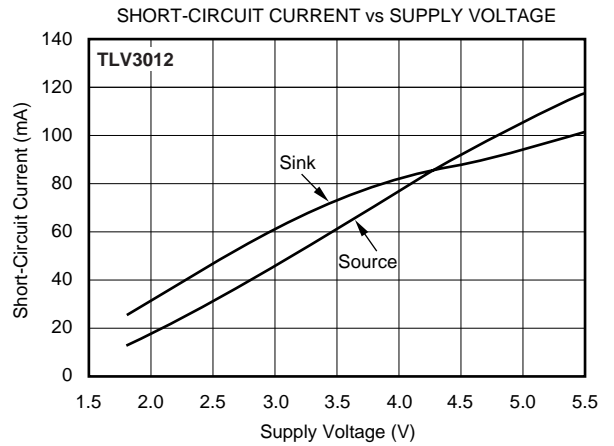
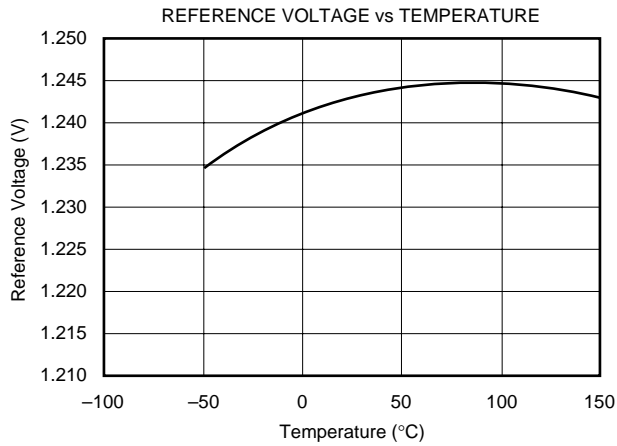
# TYPICAL CHARACTERISTICS (Cont.)

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# TYPICAL CHARACTERISTICS (Cont.)

At  $T_A = +25^\circ\text{C}$ ,  $V_S = +1.8\text{V}$  to  $+5.5\text{V}$ ,  $R_{\text{PULL-UP}} = 10\text{k}\Omega$ , and Input Overdrive =  $100\text{mV}$ , unless otherwise noted.



# APPLICATIONS INFORMATION

The TLV3011 is a low-power, open-drain comparator with on-chip 1.242V series reference. The open-drain output allows multiple devices to be driven by a single pull-up resistor to accomplish an OR function, making the TLV3011 useful for logic applications.

The TLV3012 comparator with on-chip 1.242V series reference has a push-pull output stage optimal for reduced power budget applications and features no shoot-through current.

A typical supply current of 2.8µA and tiny packaging combine with 1.8V supply requirements to make the TLV3011 and TLV3012 optimal for battery and portable designs.

## BOARD LAYOUT

Typical connections for the TLV3011 and TLV3012 are shown in Figure 1. The TLV3011 is an open-drain output device. A pull-up resistor must be connected between the comparator output and supply to enable operation.

To minimize supply noise, power supplies should be capacitively decoupled by a 0.01µF ceramic capacitor in parallel with a 10µF electrolytic capacitor. Comparators are sensitive to input noise, and precautions such as proper grounding (use of ground plane), supply bypassing, and guarding of high-impedance nodes will minimize the effects of noise and help to ensure specified performance.

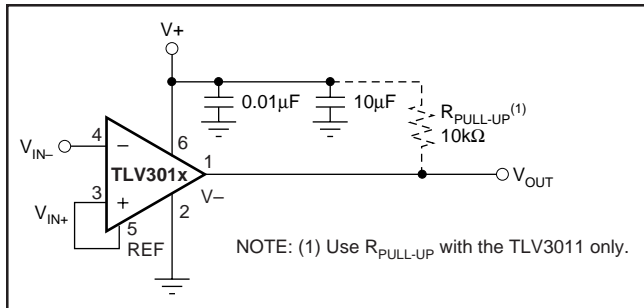


FIGURE 1. Basic Connections of the TLV3011 and TLV3012.

## OPEN-DRAIN OUTPUT (TLV3011)

The open-drain output of the TLV3011 is useful in logic applications. The value of the pull-up resistor and supply voltage used will affect current consumption due to additional current drawn when the output is in a low state. This effect can be seen in the typical curve *Quiescent Current vs Output Switching Frequency*.

## EXTERNAL HYSTERESIS

Comparator inputs have no noise immunity within the range of specified offset voltage (±12mV). For noisy input signals, the comparator output may display multiple switching as input signals move through the switching threshold. The typical comparator threshold of the TLV3011 and TLV3012 is ±0.5mV. To prevent multiple switching within the comparator threshold of the TLV3011 or TLV3012, external hysteresis

may be added by connecting a small amount of feedback to the positive input. Figure 2 shows a typical topology used to introduce hysteresis, described by the equation:

$$V_{HYST} = \frac{V^+ \times R_1}{R_1 + R_2}$$

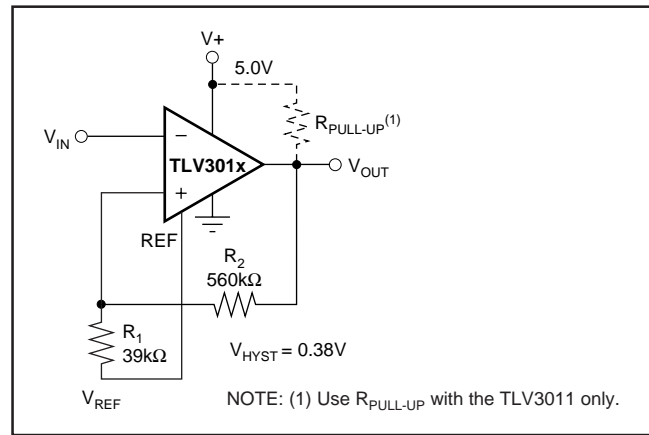


FIGURE 2. Adding Hysteresis.

$V_{HYST}$  will set the value of the transition voltage required to switch the comparator output by increasing the threshold region, thereby reducing sensitivity to noise.

# APPLICATIONS

## BATTERY LEVEL DETECT

The low power consumption and 1.8V supply voltage of the TLV3011 make it an excellent candidate for battery-powered applications. Figure 3 shows the TLV3011 configured as a low battery level detector for a 3V battery.

$$\text{Battery-Okay Trip Voltage} = 1.242 \frac{R_1 + R_2}{R_2}$$

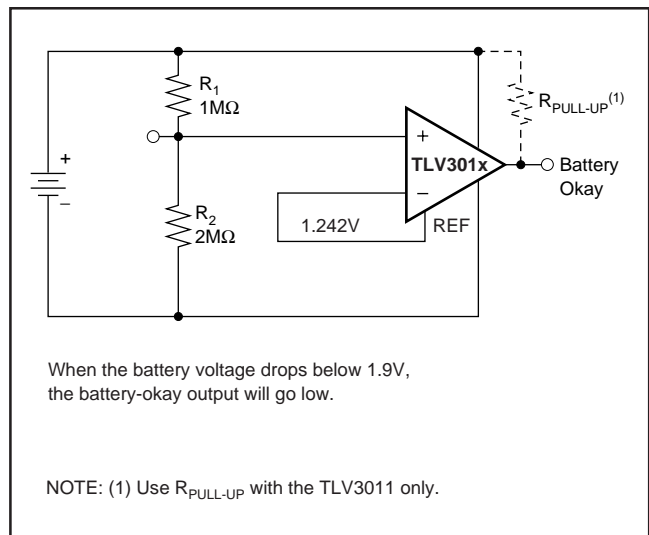


FIGURE 3. TLV3011 Configured as a Low Battery Level Detector.



## POWER-ON RESET

The reset circuit shown in Figure 4 provides a time delayed release of reset to the MSP430 microcontroller. Operation of the circuit is based on a stabilization time constant of the supply voltage, rather than on a predetermined voltage value. The negative input is a reference voltage created by the internal voltage reference. The positive input is an RC circuit that provides a power-up delay. When power is applied, the output of the comparator is low, holding the processor in the reset condition. Only after allowing time for the supply voltage to stabilize does the positive input of the comparator become higher than the negative input, resulting in a high output state, releasing the processor for operation. The stabilization time required for the supply voltage is adjustable by the selection of the RC component values. Use of a lower-valued resistor in this portion of the circuit will not increase current consumption because no current flows through the RC circuit after the supply has stabilized.

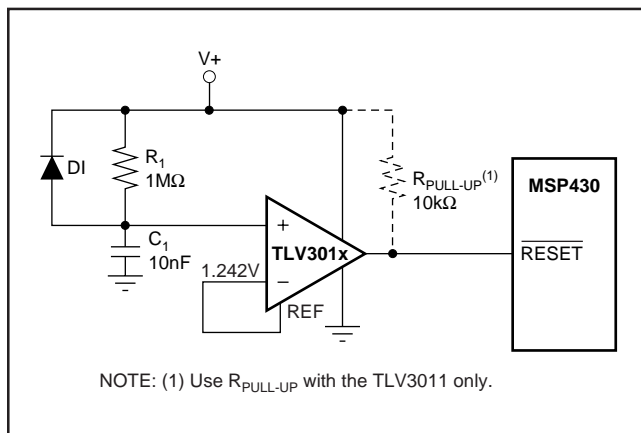


FIGURE 4. The TLV3011 or TLV3012 Configured as a Power Up Reset Circuit for the MSP430.

The reset delay needed depends on the power-up characteristics of the system power supply.  $R_1$  and  $C_1$  are selected to allow enough time for the power supply to stabilize.  $D_1$  provides rapid reset if power is lost. In this example, the  $R_1 \cdot C_1$  time constant is 10mS.

## RELAXATION OSCILLATOR

The TLV3012 can be configured as a relaxation oscillator as in Figure 5 to provide a simple and inexpensive clock output. The capacitor is charged at a rate of  $T = 0.69RC$ . It also discharges at a rate of  $0.69RC$ . Therefore, the period is  $T = 1.38RC$ .  $R_1$  may be a different value than  $R_2$ .

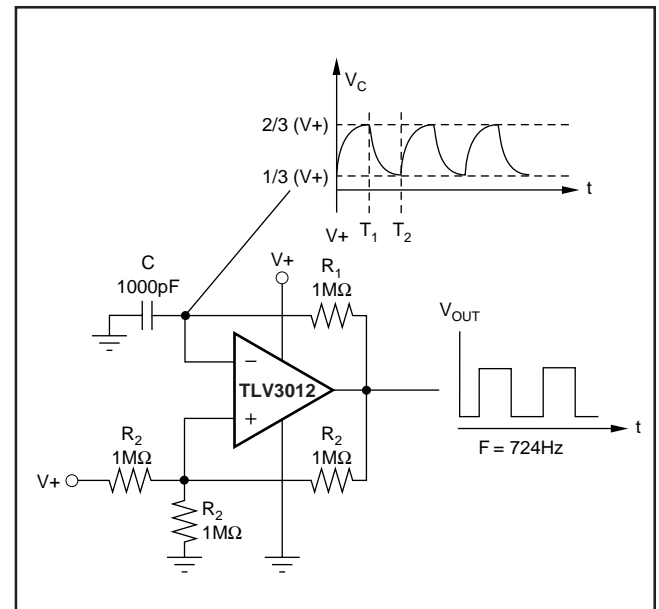


FIGURE 5. TLV3012 Configured as a Relaxation Oscillator.

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
TLV3011AIDBVR	ACTIVE	SOT-23	DBV	6	3000	TBD	CU NIPDAU	Level-1-235C-UNLIM
TLV3011AIDBVT	ACTIVE	SOT-23	DBV	6	250	TBD	CU NIPDAU	Level-1-235C-UNLIM
TLV3011AIDCKR	ACTIVE	SC70	DCK	6	3000	TBD	A42 SNPB	Level-1-240C-UNLIM
TLV3011AIDCKT	ACTIVE	SC70	DCK	6	250	TBD	A42 SNPB	Level-1-240C-UNLIM
TLV3012AIDBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV3012AIDBVRG4	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV3012AIDBVT	ACTIVE	SOT-23	DBV	6	250	TBD	CU NIPDAU	Level-1-235C-UNLIM
TLV3012AIDCKR	ACTIVE	SC70	DCK	6	3000	TBD	A42 SNPB	Level-1-240C-UNLIM
TLV3012AIDCKT	ACTIVE	SC70	DCK	6	250	TBD	A42 SNPB	Level-1-240C-UNLIM

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBsolete:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS) or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

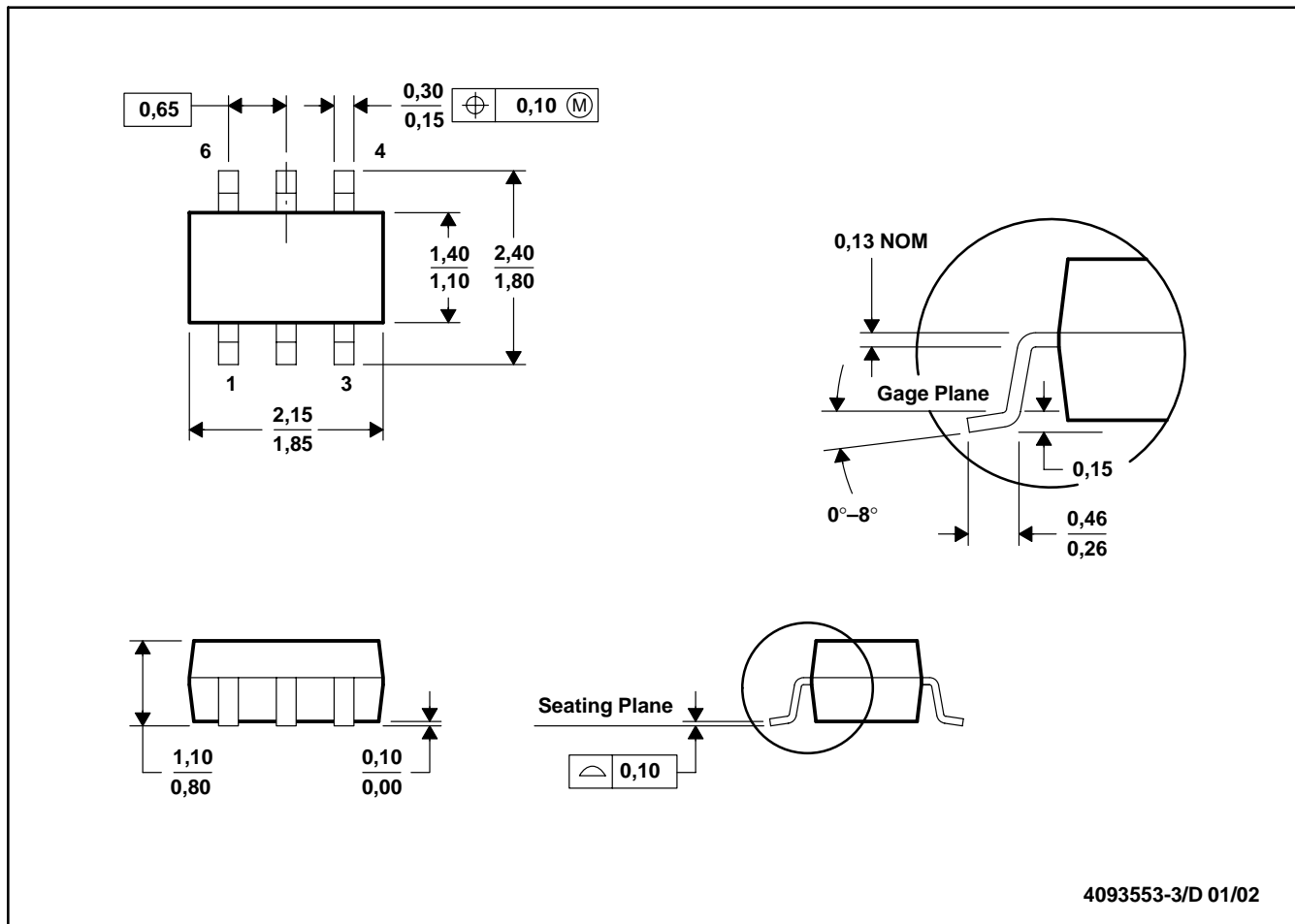
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DCK (R-PDSO-G6)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion.  
 D. Falls within JEDEC MO-203

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