National Semiconductor

September 2007

LMP7300
Micropower Precision Comparator and Precision Reference with Adjustable Hysteresis

General Description

The LMP7300 is a combination comparator and reference with ideal specifications for precision threshold detecting. The precision 2.048V reference comes with a 0.25% maximum error. The comparator features micopower (35 µW), low offset voltage (.75 mV max), and independent adjustable positive and negative hysteresis.

Hysteresis control for the comparator is accomplished through two external pins. The HYSTP pin sets the positive hysteresis and the HYSTN pin sets the negative hysteresis. The comparator design isolates the V_{IN} source impedance and the programmable hysteresis components. This isolation prevents any undesirable interaction allowing the IC to maintain a precise threshold voltage during level detection.

The combination of low offset voltage, external hysteresis control, and precision voltage reference provides an easy to use micropower precision threshold detector.

The LMP7300 open collector output makes it ideal for mixed voltage system designs. The output voltage upper rail is unconstrained by V_{CC} and can be pulled above V_{CC} to a maximum of 12V. The LMP7300 is a member of the LMP® precision amplifier family.

Features

(For V_S = 5V, typical unless otherwise noted)

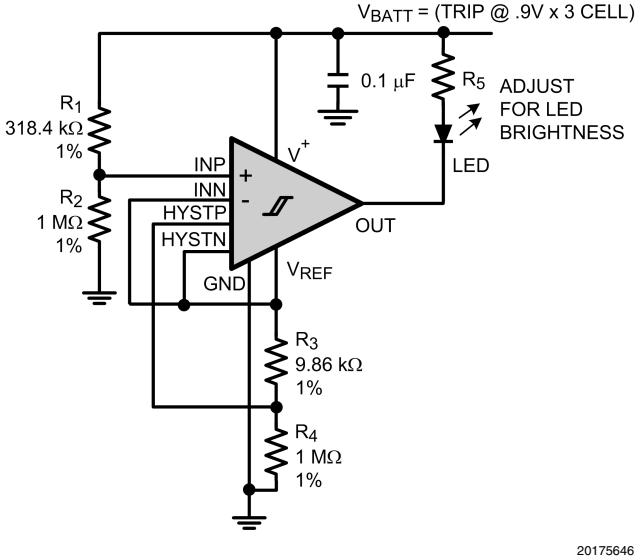
- Supply current 13 µA
- Propagation delay 4 µs
- Input offset voltage 0.3 mV
- CMRR 100 dB
- PSRR 100 dB
- Positive and negative hysteresis control
- Adjustable hysteresis 1 mV/mV
- Reference voltage 2.048V
- Reference voltage accuracy 0.25%
- Reference voltage source current 1 mA
- Wide supply voltage range 2.7V to 12V
- Operating temperature range ambient –40°C to 125°C

Applications

- Precision threshold detection
- Battery monitoring
- Battery management systems
- Zero crossing detectors

Typical Application

Micropower Precision Battery Low Voltage Detector for 3 Cell Discharge Voltage



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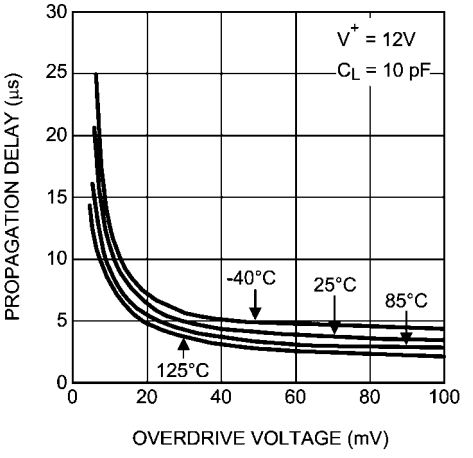

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Absolute Maximum Ratings (Note 1)

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

ESD Tolerance (Note 2)	
Human Body Model	2000V
Machine Model	200V
V_{IN} Differential	$\pm V_S$
Supply Voltage ($V_S = V^+ - V^-$)	13.6V
Voltage at Input/Output Pins	$V^+ + 0.3V$, $V^- - 0.3V$
Storage Temperature Range	−65°C to +150°C
Junction Temperature (Note 3)	+150°C
Soldering Information	
Infrared or Convection (20 sec)	235°C
Wave Soldering Lead Temp. (10 sec)	260°C

Operating Ratings (Note 1)

Temperature Range (Note 3)	−40°C to 125°C
Supply Voltage ($V_S = V^+ - V^-$)	2.7V to 12V
Package Thermal Resistance (θ_{JA} (Note 3))	
8-Pin SOIC	166°C/W
8-Pin MSOP	235°C/W

2.7V Electrical Characteristics (Note 4)

Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V^+ = 2.7V, V^- = 0V, and $V_{CM} = V^+/2$, R_{PULLUP} = 100 kΩ, C_{LOAD} = 10 pF. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
I_S	Supply Current	R_{PULLUP} = Open		9	12 **17**	µA
Comparator						
V_{OS}	Input Offset Voltage	$V_{CM} = V^+/2$		±0.07	±0.75 **±2**	mV
TCV_{OS}	Input Offset Average Drift	(Note 8)		1.8		µV/°C
I_B	Input Bias Current (Note 7)	$\lvert V_{ID}\rvert$ < 2.5V		1.2	3 **4**	nA
I_{OS}	Input Offset Current			0.15	0.5	nA
CMRR	Common Mode Rejection Ratio	1V < V_{CM} < 2.7V	80	100		dB
PSRR	Power Supply Rejection Ratio	V^+ = 2.7V to 12V	80	100		dB
V_{OL}	Output Low Voltage	I_{LOAD} = 10 mA		0.25	0.4 **0.5**	V
I_{LEAK}	Output Leakage Current	Comparator Output in High State		1		pA
HC_{LIN}	Hysteresis Control Voltage Linearity	0 < Ref-H_{YS}TP,N < 25 mV		1.000		mV/V
		25 mV < Ref-H_{YS}TP,N < 100 mV		0.950		
I_{HYS}	Hysteresis Leakage Current			1.2	3 **4**	nA
T_{PD}	Propagation Delay (High to Low)	Overdrive = 10 mV, C_L = 10 pF		12	17	µs
		Overdrive = 100 mV, C_L = 10 pF		4.5	7.6	
Reference						
V_O	Reference Voltage		2.043	2.048	2.053	V
	Line Regulation	V_{CC} = 2.7V to 12V		14	80	µV/V
	Load Regulation	I_{OUT} = 0 to 1 mA		0.2	0.5	mV/mA
$TCV_{REF/°C}$	Temperature Coefficient	−40°C to 125°C			55	ppm/°C
V_N	Output Noise Voltage	0.1 Hz to 10 Hz		80		μV_{PP}
		10 Hz to 10 kHz		100		μV_{RMS}

5V Electrical Characteristics (Note 4)

Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V^+ = 5V, V^- = 0V, and $V_{CM} = V^+/2$, R_{PULLUP} = 100 kΩ, C_{LOAD} = 10 pF. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
I_S	Supply Current	R_{PULLUP} = Open		10	13 **18**	µA
Comparator						
V_{OS}	Input Offset Voltage	$V_{CM} = V^+/2$		±0.07	±0.75 **±2**	mV
TCV_{OS}	Input Offset Average Drift	(Note 8)		1.8		µV/°C
I_B	Input Bias Current (Note 7)	$\|V_{ID}\| < 2.5V$		1.2	3 **4**	nA
I_{OS}	Input Offset Current			0.15	0.5	nA
CMRR	Common Mode Rejection Ratio	$1 \le V_{CM} \le 5V$	80	100		dB
PSRR	Power Supply Rejection Ratio	V^+ = 2.7V to 12V	80	100		dB
V_{OL}	Output Voltage Low	I_{LOAD} = 10 mA		0.25	0.4	V
I_{LEAK}	Output Leakage Current	Comparator Output in High State		1		pA
HC_{LIN}	Hysteresis Control Voltage Linearity	0 < Ref-V_{HYS}TP,N < 25 mV		1.000		mV/V
		25 mV < Ref-V_{HYS}TP,N < 100 mV		0.950		
I_{HYS}	Hysteresis Leakage Current			1.2	3 **4**	nA
TPD	Propagation Delay (High to Low)	Overdrive = 10 mV, C_L = 10 pF		12	15	µs
		Overdrive = 100 mV, C_L = 10 pF		4	7	
Reference						
V_O	Reference Voltage		2.043	2.048	2.053	V
	Line Regulation	V_{CC} = 2.7V to 12V		14	80	µV/V
	Load Regulation	I_{OUT} = 0 to 1 mA		0.2	0.5	mV/mA
$TCV_{REF/°C}$	Temperature Coefficient	–40°C to 125°C			55	ppm/°C
V_N	Output Noise Voltage	0.1 Hz to 10 Hz		80		μV_{PP}
		10 Hz to 10 kHz		100		μV_{RMS}

12V Electrical Characteristics (Note 4)

Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V^+ = 12V, V^- = 0V, and $V_{CM} = V^+/2$, R_{PULLUP} = 100 kΩ, C_{LOAD} = 10 pF. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
I_S	Supply Current	R_{PULLUP} = Open		11	14 **20**	µA
Comparator						
V_{OS}	Input Offset Voltage	$V_{CM} = V^+/2$		±0.08	±0.75 **±2**	mV
TCV_{OS}	Input Offset Average Drift	(Note 8)		1.8		µV/°C
I_B	Input Bias Current (Note 7)	$\|V_{ID}\| > 2.5V$		1.2	3 **4**	nA
I_{OS}	Input Offset Current			0.15	0.5	nA
CMRR	Common Mode Rejection Ratio	$1V \le V_{CM} \le 12V$	80	100		dB
PSRR	Power Supply Rejection Ratio	V^+ = 2.7V to 12V	80	100		dB
V_{OL}	Output Voltage Low	I_{LOAD} = 10 mA		0.25	0.4	V
I_{LEAK}	Output Leakage Current	Comparator Output in High State		1		pA

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
HC_{LIN}	Hysteresis Control Voltage Linearity	0 < Ref-V_{+HYS}TP,N < 25 mV		1.000		mV/V
		25 mV < Ref-V_{+HYS}TP,N < 100 mV		0.950		
I_{HYS}	Hysteresis Leakage Current			1.2	3 **4**	nA
TPD	Propagation Delay (High to Low)	Overdrive = 10 mV, C_L = 10 pF		11	15	µs
		Overdrive = 100 mV, C_L = 10 pF		3.5	6.8	
Reference						
V_O	Reference Voltage	T_J = 25°C	2.043	2.048	2.053	V
	Line Regulation	V_{CC} = 2.7V to 12V		14	80	µV/V
	Load Regulation	I_{OUT} = 0 to 1 mA		0.2	0.5	mV/mA
$TCV_{REF/°C}$	Temperature Coefficient	–40°C to +125°C			55	ppm/°C
V_N	Output Noise Voltage	0.1 Hz to 10 Hz		80		$µV_{PP}$
		10 Hz to 10 kHz		100		$µV_{RMS}$

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 Tables.

Note 2: Human Body Model, applicable std. MIL-STD-883, Method 3015.7. Machine Model, applicable std. JESD22-A115-A (ESD MM std. of JEDEC)

Field-Induced Charge-Device Model, applicable std. JESD22-C101-C (ESD FICDM std. of JEDEC).

Note 3: The maximum power dissipation is a function of $T_{J(MAX)}$, θ_{JA}. 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 onto a PC Board.

Note 4: Electrical Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$. No guarantee of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$.

Note 5: Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.

Note 6: Limits are 100% production tested at 25°C. Limits over the operating temperature range are guaranteed through correlations using statistical quality control (SQC) method.

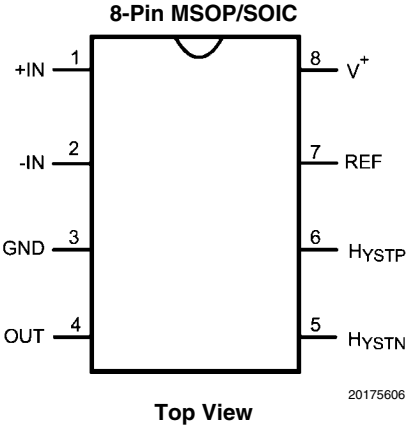
Note 7: Positive current corresponds to current flowing into the device.

Note 8: Offset voltage average drift determined by dividing the change in V_{OS} at temperature extremes, by the total temperature change.

Ordering Information

Package	Part Number	Package Marking	Transport Media	NSC Drawing
8-Pin SOIC	LMP7300MA	LMP7300MA	95 Units/Rail	M08A
	LMP7300MAX		2.5k Units Tape and Reel	
8-Pin MSOP	LMP7300MM	C31A	1k Units Tape and Reel	MUA08A
	LMP7300MMX		3.5k Units Tape and Reel	

Connection Diagram



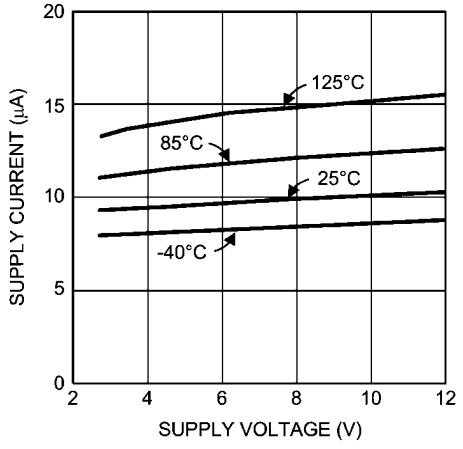
Top View

Pin Descriptions

Pin Name		Description
+IN	Non-Inverting Comparator Input	The +IN has a common-mode voltage range from 1V above the negative rail to, and including, the positive rail. Internal ESD diodes, connected from the +IN pin to the rails, protect the input stage from overvoltage. If the input voltage exceeds the rails, the diodes turn on and clamp the input to a safe level.
–IN	Inverting Comparator Input	The –IN has a common-mode voltage range from 1V above the negative rail to, and including, the positive rail. Internal ESD diodes, connected from the –IN pin to the rails, protects the input stage from overvoltage. If the input voltage exceeds the rails, the diodes turn on and clamp the input to a safe level.
GND	Ground	This pin may be connected to a negative DC voltage source for applications requiring a dual supply. If connected to a negative supply, decouple this pin with 0.1 µF ceramic capacitor to ground. The internal reference output voltage is referenced to this pin. GND is the die substrate connection.
OUT	Comparator Output	The output is an open-collector. It can drive voltage loads by using a pullup resistor, or it can drive current loads by sinking a maximum output current. This pin may be taken to a maximum of +12V with respect to the ground pin, irrespective of supply voltage.
HYSTN	Negative Hysteresis Pin	This pin sets the lower trip voltage V_{IL}. The common mode range is from 1V above the negative rail to V_{CC}. The input signal must fall below V_{IL} for the comparator to switch from high to low state.
HYSTP	Positive Hysteresis pin	This pin sets the upper trip voltage V_{IH}. The common mode range is from 1V above the negative rail to V_{CC}. The input signal must rise above V_{IH} for the comparator to switch from low to high state.
REF	Reference Voltage Output Pin	This is the output pin of a 2.048V band gap precision reference.
V^+	Positive Supply Terminal	The supply voltage range is 2.7V to 12V. Decouple this pin with 0.1 µF ceramic capacitor to ground.

Typical Performance Characteristics

Supply Current vs. Supply Voltage



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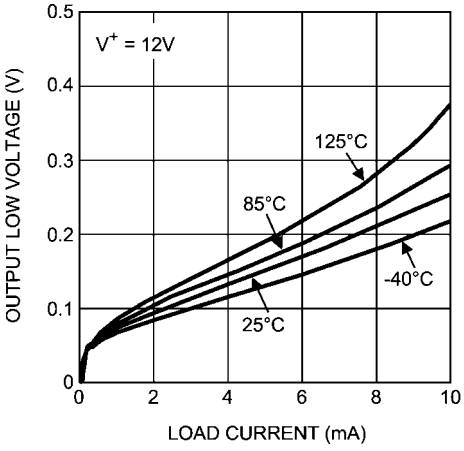
Output Low Voltage vs. Load Current



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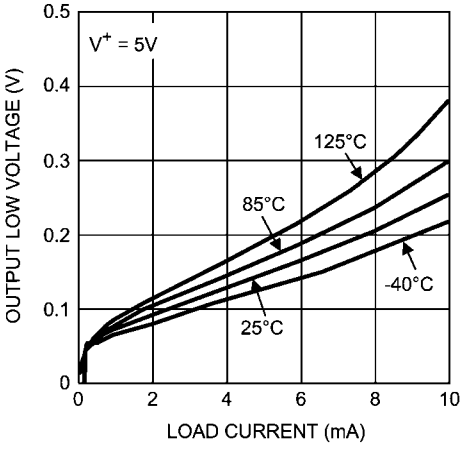
Output Low Voltage vs. Load Current



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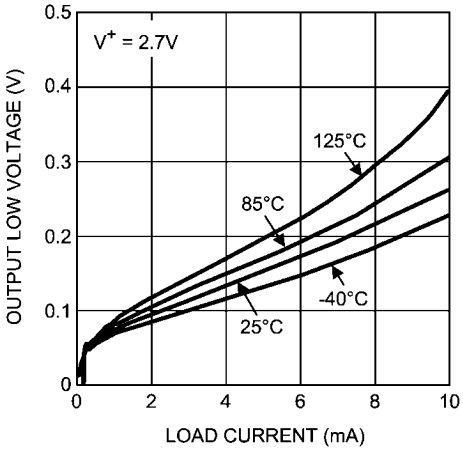
Output Low Voltage vs. Load Current



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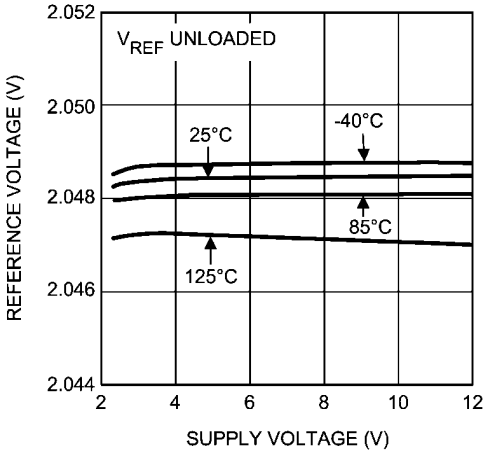
Reference Voltage vs. Supply Voltage



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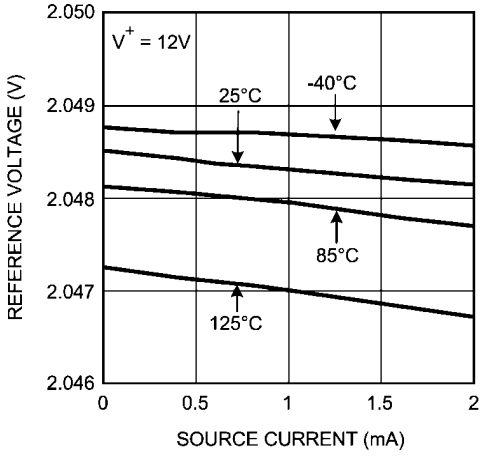
Reference Voltage vs. Source Current



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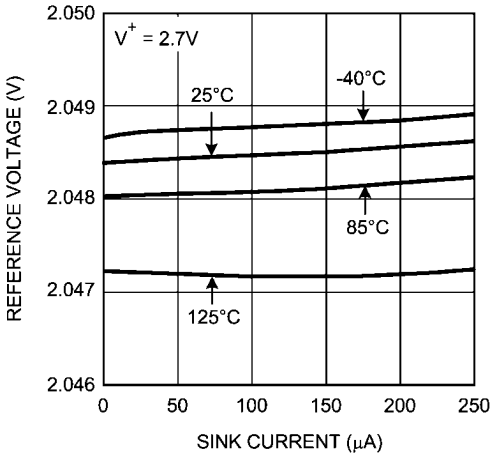
Reference Voltage vs. Sink Current



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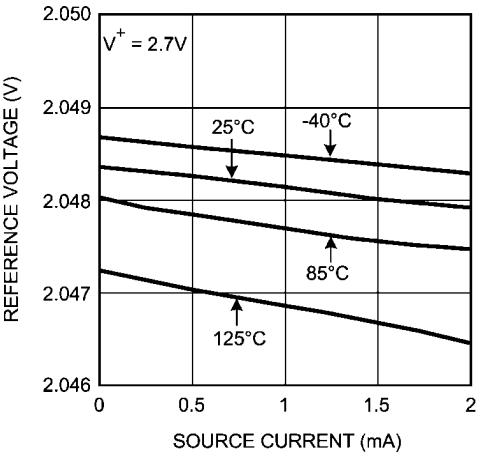
Reference Voltage vs. Source Current



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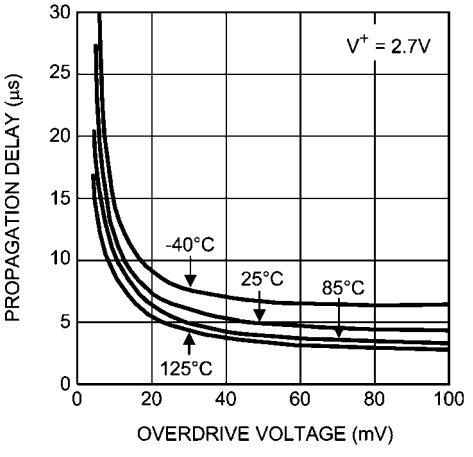
Propagation Delay vs. Overdrive Voltage



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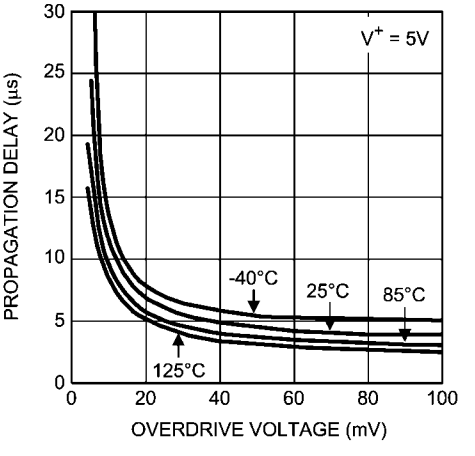
Propagation Delay vs. Overdrive Voltage



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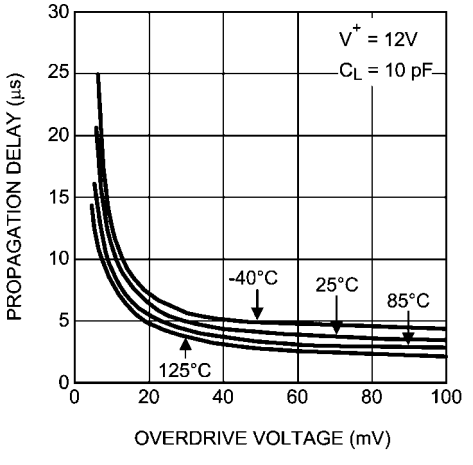
Propagation Delay vs. Overdrive Voltage



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Application Information

GENERAL DESCRIPTION

The LMP7300 is a unique combination of micropower and precision. The open collector comparator has low offset, high CMRR, high PSRR, programmable hysteresis and microamp supply current. The precision 2.048V reference provides a DAC or ADC with an accurate binary divisible voltage. The comparator and reference combination forms an ideal single IC solution for low power sensor or portable applications.

VOLTAGE REFERENCE

The reference output voltage is a band gap derived 2.048V that is trimmed to achieve typically 0.2% accuracy over the full operating temperature range of –40°C to 125°C. The trim procedure employs a curvature correction algorithm to compensate for the base emitter thermal nonlinearity inherent in band gap design topologies. The reference accuracy and the set resistor tolerance determine the magnitude and precision of the programmable hysteresis. In situations where reference noise filtering is required a 5 µF capacitor in series with a 190Ω resistor to ground are recommended.

COMPARATOR

Output Stage

The comparator employs an open collector output stage that can switch microamp loads for micropower precision threshold detection to applications requiring activating a solenoid, a lamp, or an LED. The wired-OR type output easily interfaces to TTL, CMOS, or multiple outputs, as in a window comparator application, over a range of 0.5V to 12V. The output is capable of driving greater than 10 mA output current and yet maintaining a saturation voltage below 0.4V over temperature. The supply current increases linearly when driving heavy loads so a pullup resistor of 100 kΩ or greater is recommended for micropower applications.

Fault Detection Rate

The user's choice of a pullup resistor and capacitive load determines the minimum response time and the event detection rate. By optimizing overdrive, the pullup resistor and capactive load fault update rates of 200 kHz to 250 kHz or greater can be achieved.

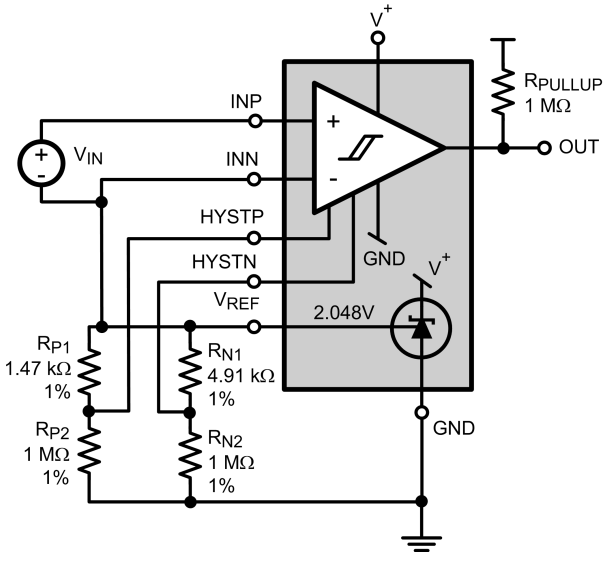
HYSTERESIS

False triggering on noise coupled into the signal path is a common problem for comparator based threshold detectors. One of the most effective solutions is to add hysteresis. Hysteresis is a circuit signal path characteristic where an amplitude delay is introduced to the normal input. Positive hysteresis forces the signal to pass the normal switch point before the output makes a low to high transition while negative hysteresis does the opposite. This is a memory effect. The comparator behaves differently based on which direction the signal is going.

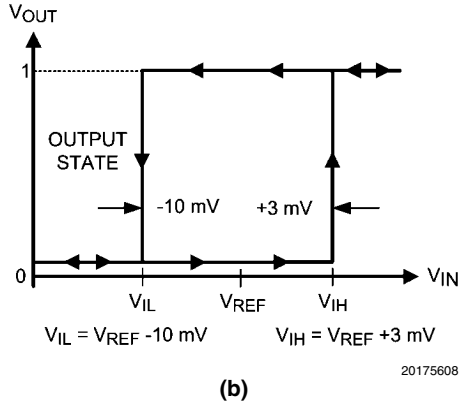
The LM7300 has been designed with a unique way of introducing hysteresis. The set points are completely independent of each other, the power supply, and the input or output conditions. The HYSTP pin sets positive hysteresis and the HYSTN pin sets the negative hysteresis in a simple way using two resistors. The pins can be tied together for the same hysteresis or tied to separate voltage taps for asymmetric hysteresis, or tied to the reference for no hysteresis. When the precision reference is used to drive the voltage tap resistor divider precise, stable threshold levels can be obtained. The maximum recommended hysteresis is about 130 mV. This places the HYSTP and HYSTN pin voltages at V_{REF} – 130 mV which is approximately the center of their input common mode range at 2.7V. For the typical example, a differential input signal voltage, V_{IN}, is applied between INP and INN, the non-inverting and inverting inputs of the comparator. A DC switch or threshold voltage, V_{TH}, is set on the negative input to keep the output off when the signal is above and on when it goes below this level. For a precision threshold tie the INN pin to V_{REF}. With the output, off the circuit is in the minimum power state. *Figure 1* through *Figure 5* demonstrate the different configurations for setting the upper threshold V_{IH} and the lower threshold V_{IL} and their relationship to the input trip point V_{REF}, by the following formulas.

$$V_{IL} = V_{REF} - V_{REF}\left(\frac{R_1}{R_1 + R_2}\right)$$

$$V_{IH} = V_{REF} + V_{REF}\left(\frac{R_1}{R_1 + R_2}\right)$$



(a)

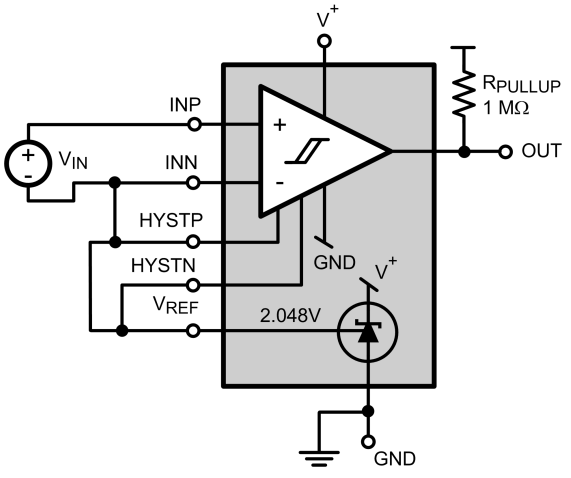


(b)

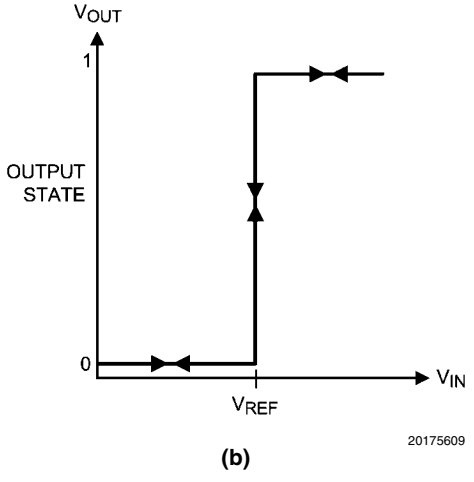
When V_{ID} = 0, INN = INP = V_{TH}

FIGURE 1. Typical Micropower Application to Set Asymmetric Positive and Negative Hysteresis of –10 mV, +3 mV

Figure 2 shows the configuration with no hysteresis when the HYSTP and HYSTN pins are connected together to V_{REF}. This configuration is not recommended because it has the highest level of false triggers due to the system noise.



(a)

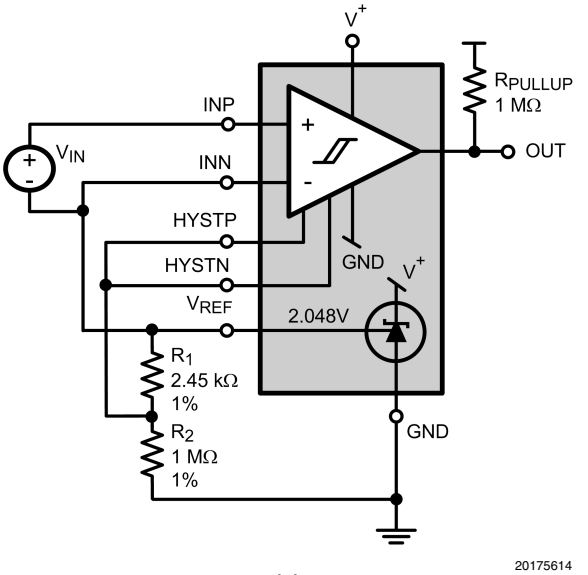


(b)

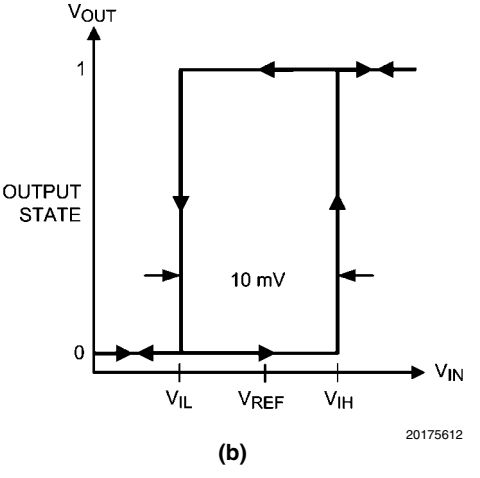
FIGURE 2. Typical Configuration for No Hysteresis

Figure 3 shows the configuration with symmetric hysteresis when the HYSTP and HYSTN pins are connected to the same voltage that is less than V_{REF}. The two trip points set a hysteresis band around the input threshold voltage V_{REF}, such that the positive band is equal to the negative band.

This configuration controls the false triggering mentioned in *Figure 2*. Symmetric hysteresis values less than 5mV to 10 mV are recommended for precise level detection applications.



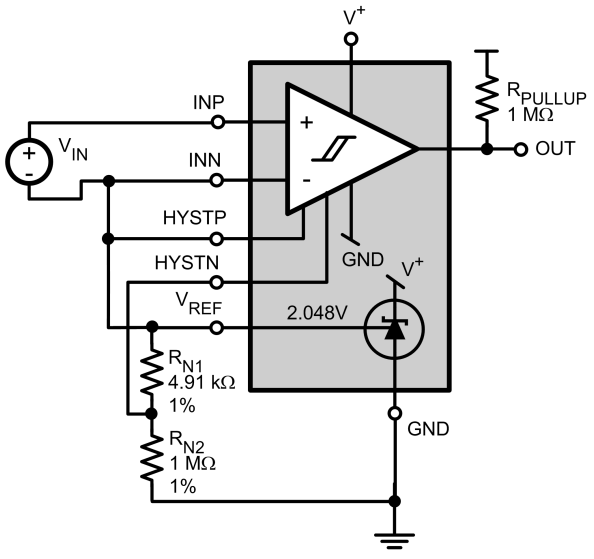
(a)



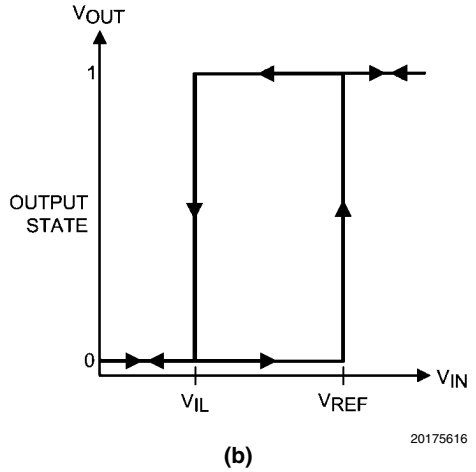
(b)

FIGURE 3. Symmetric Hysteresis ±5 mV

Figure 4 shows the case for negative hysteresis by biasing only the HYSN pin to a voltage less than V_{REF}.



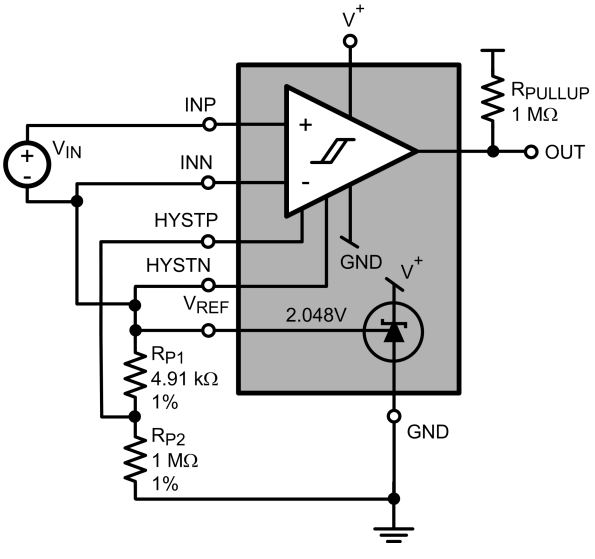
(a)



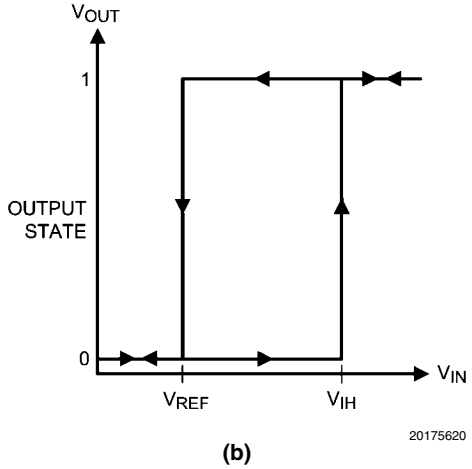
(b)

FIGURE 4. Typical Configuration for Negative Hysteresis = −10 mV

The case for setting only a positive hysteresis is demonstrated in *Figure 5*.



(a)



(b)

FIGURE 5. Connections for Positive Hysteresis = +10 mV

In the general case, as demonstrated with both positive and negative hysteresis bands in *Figure 6*, noise within these bands will have no affect on the state of the comparator output. In Example #1 the noise is well behaved and in band. The output is clean and well behaved. In Example #2, a significant amount of out of band noise is present but due to hysteresis no false triggers occur on the rising positive or falling negative edges. The hysteresis forces the signal level to move higher or lower before the output is set to the opposite state.

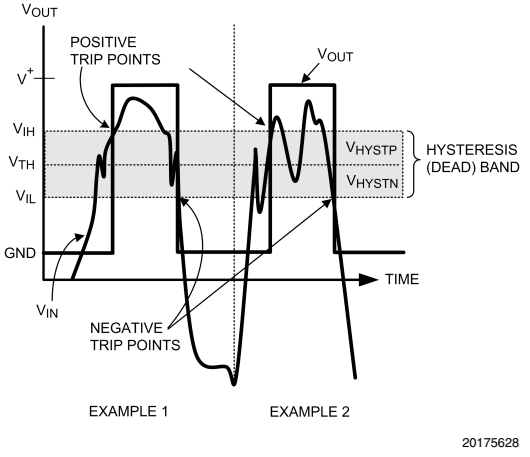


FIGURE 6. Output Response with Input Noise Less than Hysteresis Band

How Much Hysteresis Is Correct?

An effective way of determining the minimum hysteresis necessary for clean switching is to decrease the amount of hysteresis until false triggering is observed, and then use a multiple of say three times that amount of hysteresis in the final circuit. This is most easily accomplished in the breadboard phase by making R_1 and R_2 potentiometers. For applications near or above +100°C a minimum of 5 mV hysteresis is recommended due to peaking of the LMP7300 noise sensitivity at high temperatures.

LAYOUT RECOMMENDATIONS

A good PCB layout is always important to reduce output to input coupling. Positive feedback noise reduces performance. For the LMP7300 output coupling is minimized by the unique package pinout. The output is kept away from the non-inverting and inverting inputs, the reference and the hysteresis pins.

EVALUATION BOARDS

National Semiconductor provides the following PCB boards as an aid in evaluating the LMP7300 performance.

Device	Package	Evaluation Board Ordering ID
LMP7300MA	8-Pin SOIC	LMP7300MA-EVAL
LMP7300MM	8-Pin MSOP	LMP7300MM-EVAL

WINDOW COMPARATOR

Figure 8 shows two LMP7300s configured as a micropower window detector in a temperature level detection application. The circuit shown monitors the ambient temperature change. If the temperature rises outside the 15°C to 35°C window, either comparator 1 for high temp, or comparator 2 for low temp, will set low, indicating a fault condition has occurred. The open collector outputs are pulled up separately but can be wire-OR'd for a single fault indication. If the temperature returns inside the window it must overcome the 22 mV asymmetric hysteresis band established on either comparator. For the high side the temperature must drop below 34°C and for the low side the temperature must rise above 16°C for the outputs to reset high and remove the fault indication. The temperature is sensed by a 30 kΩ @ 25°C Omega Precision NTC Thermistor #44008 (±0.2% tol).

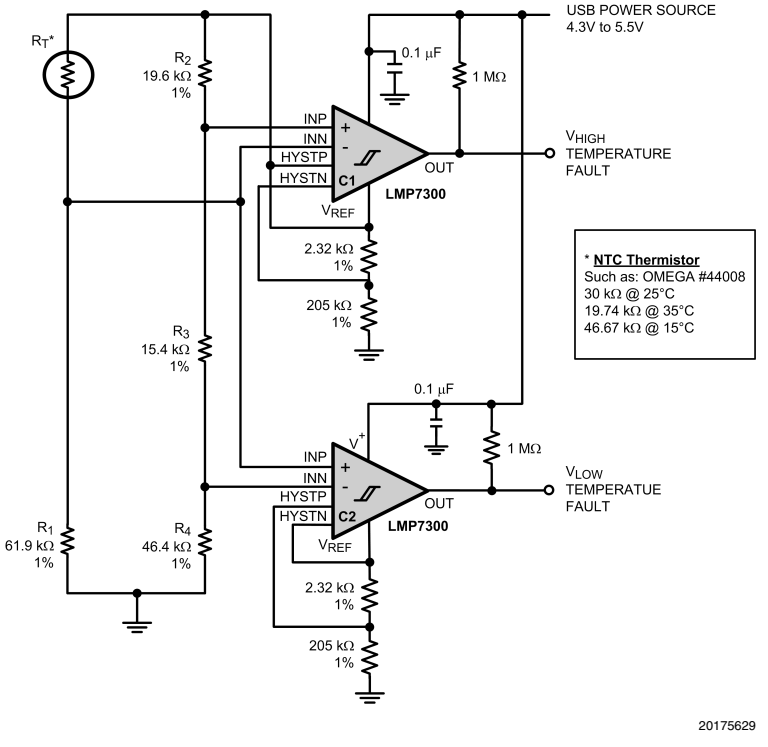


FIGURE 7. Temperature Controlled Window Detector to Monitor Ambient Temperature

PRECISION HIGH TEMPERATURE SWITCH

The LMP7300 brings accuracy and stability to simple sensor switch applications. *Figure 9* shows the LMP7300 setup in a high temperature switch configuration. The input bridge establishes the trip point at 85°C and the reset temperature at 80°C. The comparator is set up with positive hysteresis of 14.3 mV and no negative hysteresis. When the temperature is rising it trips at 85°C. The 14.3 mV hysteresis allows the temperature to drop to 80°C before reset.

The temperature sensor used is an Omega 44008 Precision NTC Thermistor. The 44008 has an accuracy of ±0.2°C. The resistance at 85°C is 3270.9Ω and at 80°C is 3840.2Ω. The trip voltage threshold is established by one half of the bridge, which is the ratio of R_{ADJ} and R_{SET}. The input signal bias is set by the second half, which is the ratio of the thermistor resistance R_{TH} and R_{SET}. The resistance values are chosen for ~50 µA bridge current to minimize the power in the thermistor. The thermistor specification states it has a 1°C/mW dissipation error. The reference voltage establishes the supply voltage for the bridge to make the circuit independent of supply voltage variation. Capacitor C_1 establishes a low frequency pole at $F_{CORNER} = 1/(2\pi C_1 * 2(R_{SET}//R_{ADJ}))$. With the resistance values chosen C_1 should be selected for Fc < 10 Hz. This will limit the thermal noise in the bridge.

The accuracy of the circuit can be calculated from the nearest resistance values chosen. For 1% resistors RADJ is 3.24 kΩ, and R_{SET} is 78.7 kΩ. The bridge gain becomes 2.488 mV/C at 85°C. In general, the higher the bridge current is allowed to be, the higher the bridge gain will be. The actual trip point found during simulation is 85.3°C and the reset point is 80.04°C. With the values chosen the worst case trip temperature uncertainty is ±1.451°C and the reset uncertainty is ±1.548°C. Accuracy could be maximized with resistors chosen to 0.1% values, 0.1% tolerance and by using the 0.1% model of the Omega 44008 thermistor.

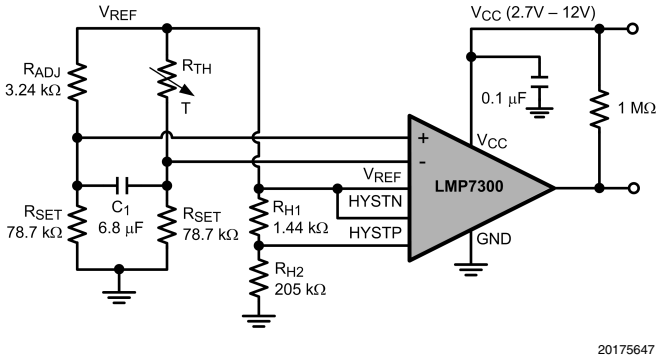
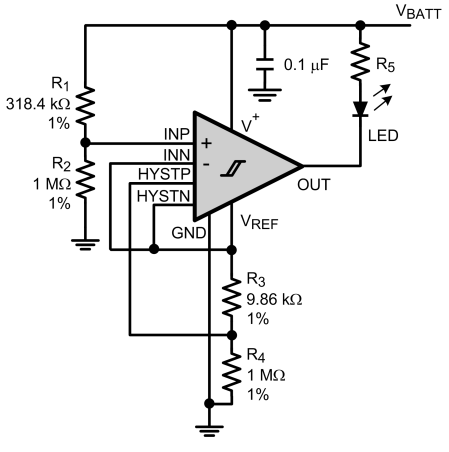


FIGURE 8. Precision High Temperature Switch

MICROPOWER PRECISION BATTERY LOW VOLTAGE DETECTOR

The ability of the LMP7300 to operate at very low supply voltages, makes it an ideal choice for low battery detection application in portable equipment. The circuit in *Figure 9* performs the function of low voltage threshold detection in a 3 cell 0.9V discharge voltage, battery monitor application. R_1 and R_2 are chosen to set the inverting input voltage equal to the non-inverting input voltage when the battery voltage is equal to the minimum operating voltage of the system. Here, the very precise reference output voltage is directly connected to the non-inverting input on the comparator and sets an accurate threshold voltage. The hysteresis is set to 0 mV negative and 20 mV positive. The output is off for voltages higher than the minimum V_{BATT}, and turns on when the circuit detects a minimum battery voltage condition.



The LED turns on when $V_{BATT} \times \frac{R_2}{R_1 + R_2} \le V_{REF}$,

so, if $\frac{V_{REF}}{V_{BATT}} = \alpha$ and R_2 is known,

then, $R_1 = R_2\left(\frac{1-\alpha}{\alpha}\right) = R_2\left(\frac{V_{BATT} - V_{REF}}{V_{REF}}\right)$

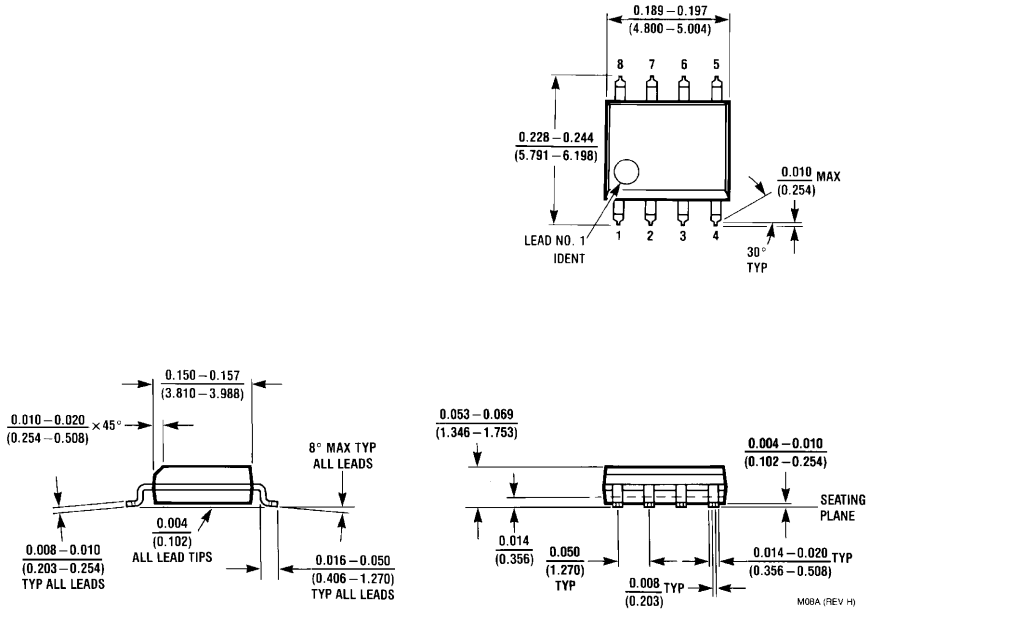
As an example:

V_{REF} = 2.048V, $V_{BATTLOW}$ = +2.7V, R_2 = 1 MΩ

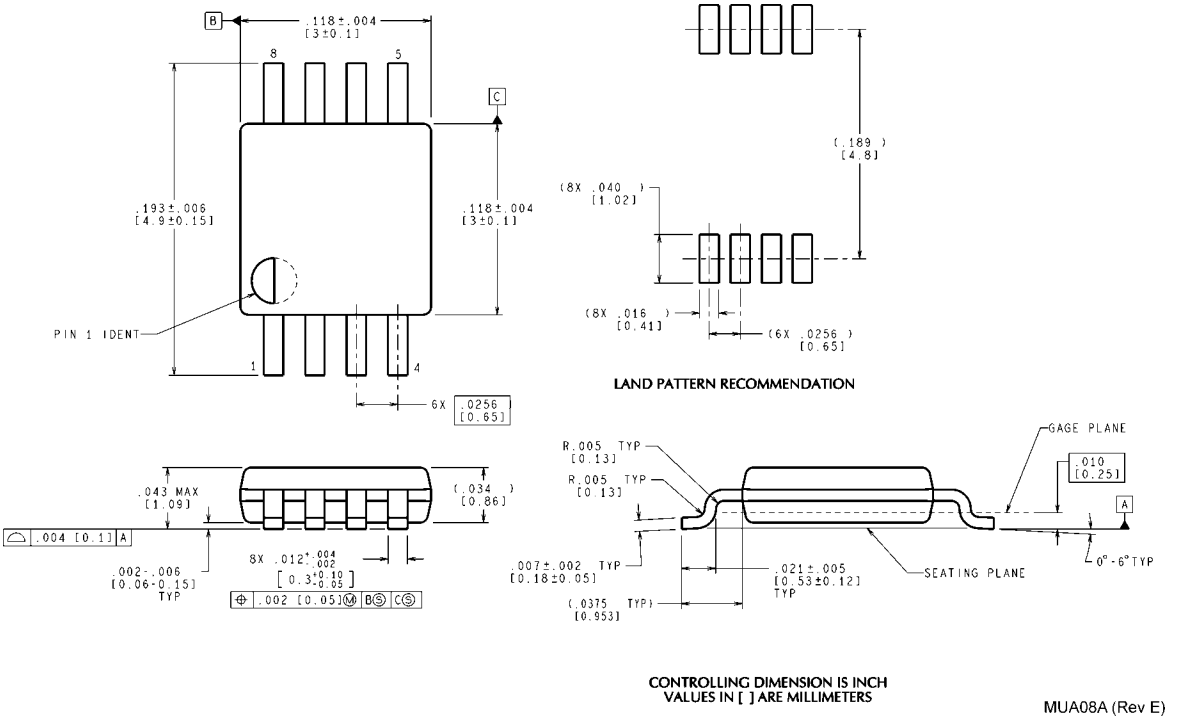
then R_1 = 318.4 kΩ

FIGURE 9. Battery Voltage Monitor for 3 Cell Discharge Voltage

Physical Dimensions inches (millimeters) unless otherwise noted



8-Pin SOIC
NS Package Number M08A



8-Pin MSOP
NS Package Number MUA08A

Notes

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