

## Linear Building Block – Low Power Voltage Reference with Programmable Hysteresis Comparator and Shutdown

### Features

- Combines Comparator and Voltage Reference in a Single Package
- Optimized for Single Supply Operation
- Small Package: 8-Pin MSOP
- Ultra Low Input Bias Current: Less than 100pA
- Low Quiescent Current, Active: 6 $\mu$ A (Typ.), Shutdown Mode: 0.1 $\mu$ A (Typ.)
- Rail-to-Rail Inputs and Outputs
- Operates Down to  $V_{DD} = 1.8V$
- Programmable Hysteresis

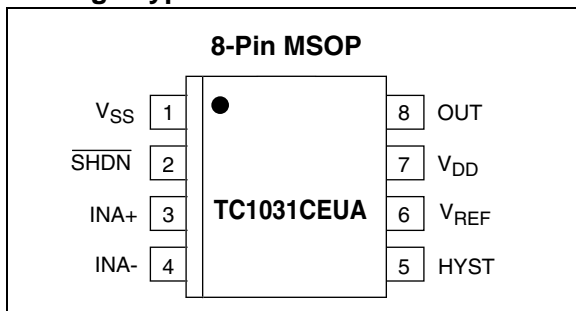
### Applications

- Power Management Circuits
- Battery Operated Equipment
- Consumer Products

### Device Selection Table

Part Number	Package	Temperature Range
TC1031CEUA	8-Pin MSOP	-40°C to +85°C

### Package Type



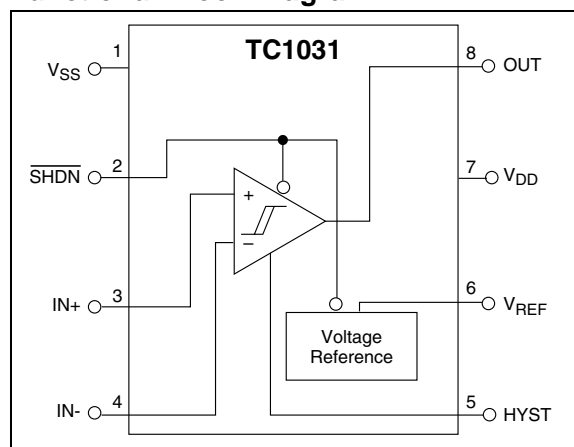
### General Description

The TC1031 is a low-power comparator and voltage reference designed specifically for low-power applications. The TC1031 is designed for operation from a single supply, however operation from dual supplies is also possible. The power supply current drain is independent of the magnitude of the power supply voltage. The TC1031 can operate from two 1.5V alkaline cells, and operation is ensured to  $V_{DD} = 1.8V$ . Typical active supply current is 6 $\mu$ A. Rail-to-rail inputs and outputs allow operation from low supply voltages with large input and output signal swings.

The TC1031 provides a simple method for adding user-adjustable hysteresis without feedback or complex external circuitry. Hysteresis is adjusted with a simple resistor divider on the HYST input. A shutdown input, SHDN, disables the comparator and voltage reference and reduces supply current to less than 0.1 $\mu$ A (maximum) when taken low.

The TC1031 is packaged in a space-saving 8-Pin MSOP, making it ideal for applications requiring high integration, small size and low power.

### Functional Block Diagram



# TC1031

## 1.0 ELECTRICAL CHARACTERISTICS

### ABSOLUTE MAXIMUM RATINGS\*

Supply Voltage .....	6.0V
Voltage on Any Pin .....	( $V_{SS} - 0.3V$ ) to ( $V_{DD} + 0.3V$ )
Junction Temperature.....	+150°C
Operating Temperature Range.....	-40°C to +85°C
Storage Temperature Range .....	-55°C to +150°C

\*Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions above those indicated in the operation sections of the specifications is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

### TC1031 ELECTRICAL SPECIFICATIONS

Electrical Characteristics: Typical values apply at 25°C and $V_{DD} = 3.0V$ ; $T_A = -40^\circ$ to $+85^\circ C$ , and $V_{DD} = 1.8V$ to $5.5V$ , unless otherwise specified.						
Symbol	Parameter	Min	Typ	Max	Units	Test Conditions
$V_{DD}$	Supply Voltage	1.8	—	5.5	V	
$I_Q$	Supply Current, Operating	—	6	10	$\mu A$	All Outputs Open, $\overline{SHDN} = V_{DD}$
$I_{SHDN}$	Supply Current, Shutdown	—	—	0.1	$\mu A$	$\overline{SHDN} = V_{SS}$
<b>Shutdown Input</b>						
$V_{IH}$	Input High Threshold	80% $V_{DD}$	—	—	V	
$V_{IL}$	Input Low Threshold	—	—	20% $V_{DD}$	V	
$I_{SI}$	Shutdown Input Current	—	—	$\pm 100$	nA	
<b>Comparator</b>						
$R_{OUT} (SD)$	Output Resistance in Shutdown	20	—	—	$M\Omega$	$\overline{SHDN} = V_{SS}$
$C_{OUT} (SD)$	Output Capacitance in Shutdown	—	—	5	pF	$\overline{SHDN} = V_{SS}$
$T_{SEL}$	Select Time	—	20	—	$\mu sec$	$V_{OUT}$ Valid from $\overline{SHDN} = V_{IH}$ $R_L = 10k\Omega$ to $V_{SS}$
$T_{DESEL}$	Deselect Time	—	500	—	nsec	$V_{OUT}$ Invalid from $\overline{SHDN} = V_{IL}$ $R_L = 10k\Omega$ to $V_{SS}$
$V_{ICMR}$	Common-Mode Input Voltage Range	$V_{SS} - 0.2$	—	$V_{DD} + 0.2$	V	
$V_{OS}$	Input Offset Voltage ( <b>Note 1</b> )	-5	—	+5	mV	$V_{DD} = 3V$ , $V_{CM} = 1.5V$
$I_B$	Input Bias Current	—	—	$\pm 100$	pA	$T_A = 25^\circ C$ $IN+, IN- = V_{DD}$ to $V_{SS}$
$V_{OH}$	Output High Voltage	$V_{DD} - 0.3$	—	—	V	$R_L = 10k\Omega$ to $V_{SS}$
$V_{OL}$	Output Low Voltage	—	—	0.3	V	$R_L = 10k\Omega$ to $V_{DD}$
CMRR	Common Mode Rejection Ratio	66	—	—	dB	$T_A = 25^\circ C$ , $V_{DD} = 5V$ $V_{CM} = V_{DD}$ to $V_{SS}$
PSRR	Power Supply Rejection Ratio	60	—	—	dB	$T_A = 25^\circ C$ , $V_{DD} = 1.8V$ to $5V$ $V_{CM} = 1.2V$
$I_{SRC}$	Output Source Current	1	—	—	mA	$IN+ = V_{DD}$ , $IN- = V_{SS}$ $V_{DD} = 1.8V$ , Output Shorted to $V_{SS}$
$I_{SINK}$	Output Sink Current	2	—	—	mA	$IN+ = V_{SS}$ , $IN- = V_{DD}$ , $V_{DD} = 1.8V$ , Output Shorted to $V_{DD}$
$V_{HYST}$	Voltage Range at HYST Pin	$V_{REF} - 0.08$	—	$V_{REF}$	V	
$I_{HYST}$	Hysteresis Input Current	—	—	$\pm 100$	nA	
$t_{PD1}$	Response Time	—	4	—	$\mu sec$	100mV Overdrive; $C_L = 100pF$
$t_{PD2}$	Response Time	—	6	—	$\mu sec$	100mV Overdrive; $C_L = 100pF$

**Note 1:**  $V_{OS}$  is measured as  $(V_{UT} + V_{LT} - 2V_{REF})/2$  where  $V_{UT}$  is the upper hysteresis threshold and  $V_{LT}$  is the lower hysteresis threshold with  $V_{REF} - V_{HYST}$  set to 10mV. This represents the asymmetry of the hysteresis thresholds around  $V_{REF}$

## TC1031 ELECTRICAL SPECIFICATIONS (CONTINUED)

**Electrical Characteristics:** Typical values apply at 25°C and  $V_{DD} = 3.0V$ ;  $T_A = -40^\circ$  to  $+85^\circ C$ , and  $V_{DD} = 1.8V$  to  $5.5V$ , unless otherwise specified.

Symbol	Parameter	Min	Typ	Max	Units	Test Conditions
<b>Voltage Reference</b>						
$V_{REF}$	Reference Voltage	1.176	1.200	1.224	V	
$I_{REF(SOURCE)}$	Source Current	50	—	—	$\mu A$	
$I_{REF(SINK)}$	Sink Current	50	—	—	$\mu A$	
$R_{OUT(SD)}$	Output Resistance in Shutdown	20	—	—	$M\Omega$	$\overline{SHDN} = V_{SS}$
$C_{OUT(SD)}$	Output Capacitance in Shutdown	—	—	5	pF	$\overline{SHDN} = V_{SS}$
$T_{SEL}$	Select Time	—	200	—	$\mu sec$	REF Valid from $\overline{SHDN} = V_{IH}$ $R_L = 100k\Omega$ to $V_{SS}$
$T_{DESEL}$	Deselect Time	—	10	—	$\mu sec$	REF Invalid from $\overline{SHDN} = V_{IL}$ $R_L = 100k\Omega$
$C_{L(REF)}$	Load Capacitance	—	—	100	pF	
$E_{VREF}$	Voltage Noise	—	20	—	$\mu V_{RMS}$	100Hz to 100kHz
$e_{VREF}$	Noise Density	—	10	—	$\mu V/\sqrt{Hz}$	1kHz

**Note 1:**  $V_{OS}$  is measured as  $(V_{UT} + V_{LT} - 2V_{REF})/2$  where  $V_{UT}$  is the upper hysteresis threshold and  $V_{LT}$  is the lower hysteresis threshold with  $V_{REF} - V_{HYST}$  set to 10mV. This represents the asymmetry of the hysteresis thresholds around  $V_{REF}$

# TC1031

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## 2.0 PIN DESCRIPTIONS

The description of the pins are listed in Table 2-1.

**TABLE 2-1: PIN FUNCTION TABLE**

Pin No. (8-Pin MSOP)	Symbol	Description
1	$V_{SS}$	Negative power supply.
2	$\overline{SHDN}$	Shutdown input.
3	IN+	Comparator non-inverting input.
4	IN-	Comparator inverting input.
5	HYST	Adjustable hysteresis input.
6	$V_{REF}$	Voltage reference output.
7	$V_{DD}$	Positive power supply.
8	OUT	Comparator output.

## 3.0 DETAILED DESCRIPTION

The TC1031 is one of a series of very low-power, linear building block products targeted at low-voltage, single-supply applications. Minimum operating voltage for the device is 1.8V, and typical supply current is only 6µA (fully enabled). It combines one comparator and a voltage reference in a single package. The comparator and reference outputs are in a high-impedance state during shutdown.

### 3.1 Comparator

The TC1031 contains one comparator with programmable hysteresis. The range of the inputs extends beyond both supply voltages by 200mV. The comparator outputs will swing to within several millivolts of the supplies depending on the load current being driven.

The comparator exhibits a propagation delay and supply current which is largely independent of supply voltage. The low input bias current and offset voltage make it suitable for high impedance precision applications.

The comparator is disabled during shutdown and has high-impedance output.

### 3.2 Voltage Reference

A 2.0% tolerance, internally biased, 1.20V bandgap voltage reference is included in the TC1031. It has a push-pull output capable of sourcing and sinking at least 50µA. The voltage reference is disabled during shutdown, with a high-impedance output.

### 3.3 Shutdown Input

$\overline{\text{SHDN}}$  at  $V_{IL}$  disables both the comparator and voltage reference and reduces the supply current to less than 0.1µA. The  $\overline{\text{SHDN}}$  input cannot be allowed to float; when not used, connect it to  $V_{DD}$ . The outputs are in a high impedance state when the TC1031 is disabled. The comparator's inputs and output can be driven from rail-to-rail by an external voltage when the TC1031 is disabled. No latching will occur when the device is driven to its enabled state when  $\overline{\text{SHDN}}$  is set to  $V_{IH}$ .

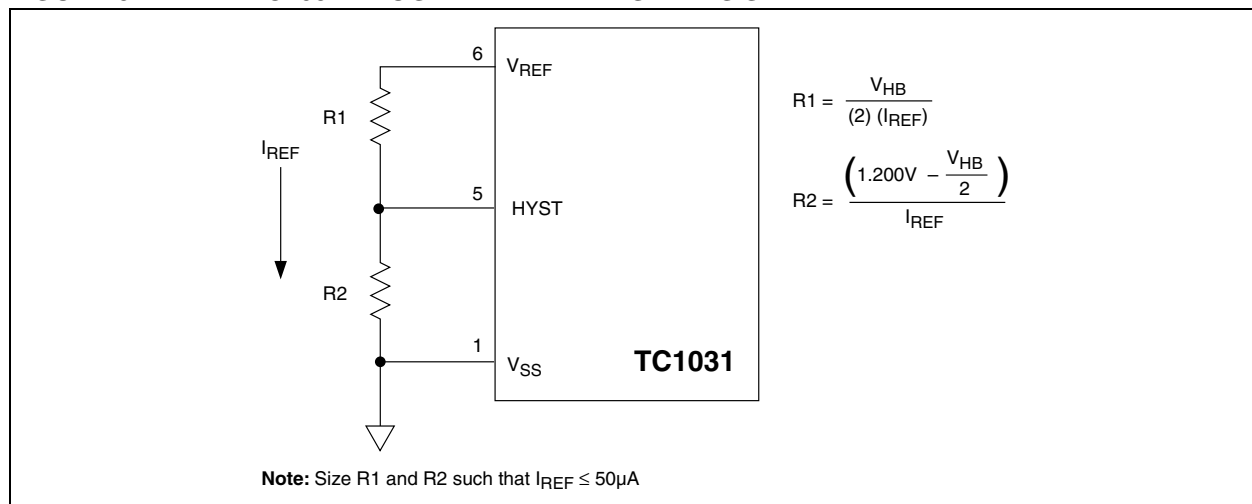
### 3.4 Programmable Hysteresis

Hysteresis is added to the comparators by connecting a resistor R1 between the  $V_{REF}$  and HYST pins and another resistor R2 between the HYST pin and  $V_{SS}$ . For no hysteresis  $V_{REF}$  should be directly connected to HYST. The hysteresis,  $V_{HB}$ , is equal to twice the voltage difference between the  $V_{REF}$  and HYST pins, where:

$$V_{HB} = 2 * V_{REF} * R1 / (R1 + R2) \quad (\text{See Figure 3-1})$$

and is symmetrical around the normal (without hysteresis) threshold of the comparator. The maximum voltage allowed between the  $V_{REF}$  and HYST pins is 80mV, giving a maximum hysteresis of 160mV.

**FIGURE 3-1: TC1031 PROGRAMMABLE HYSTERESIS**

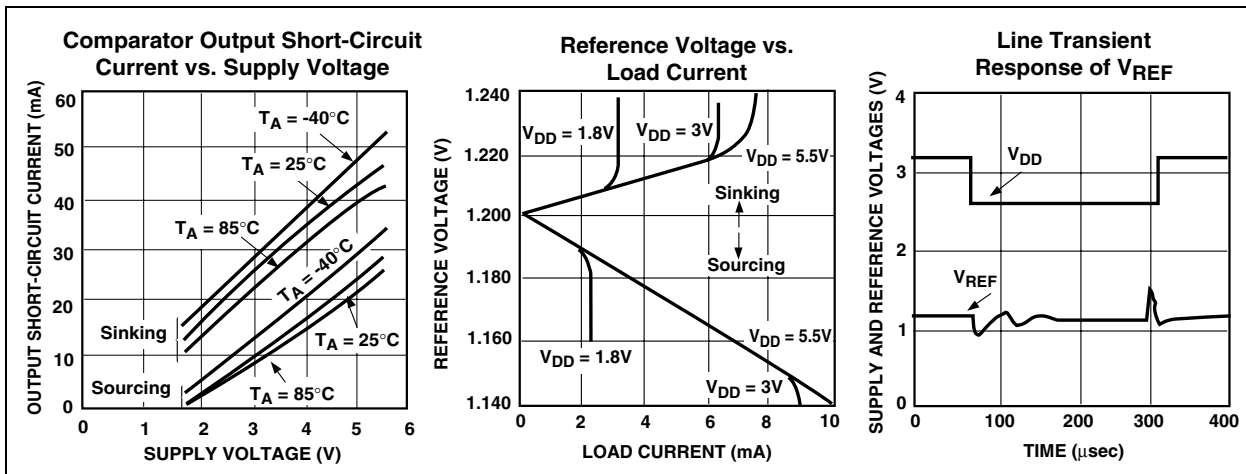
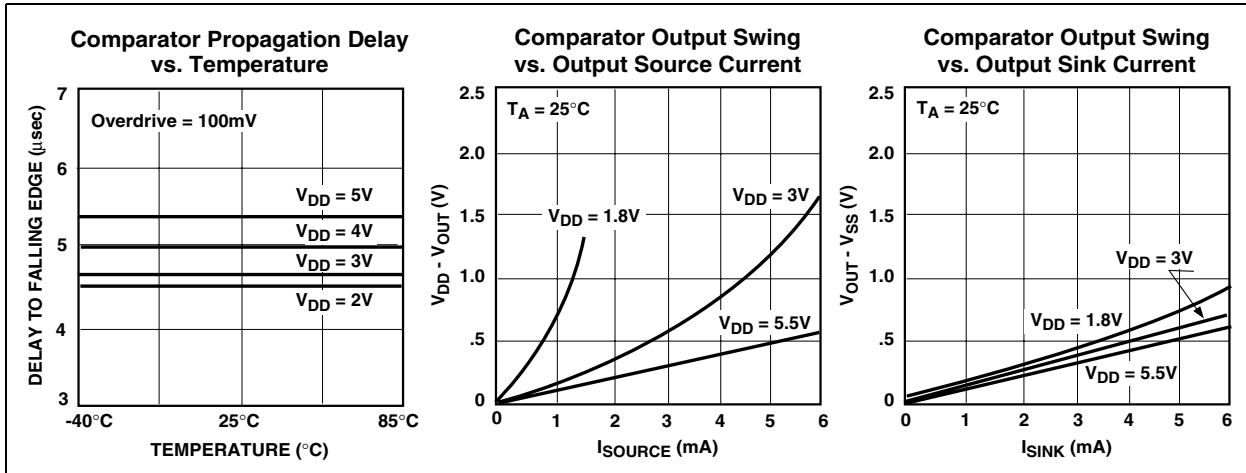
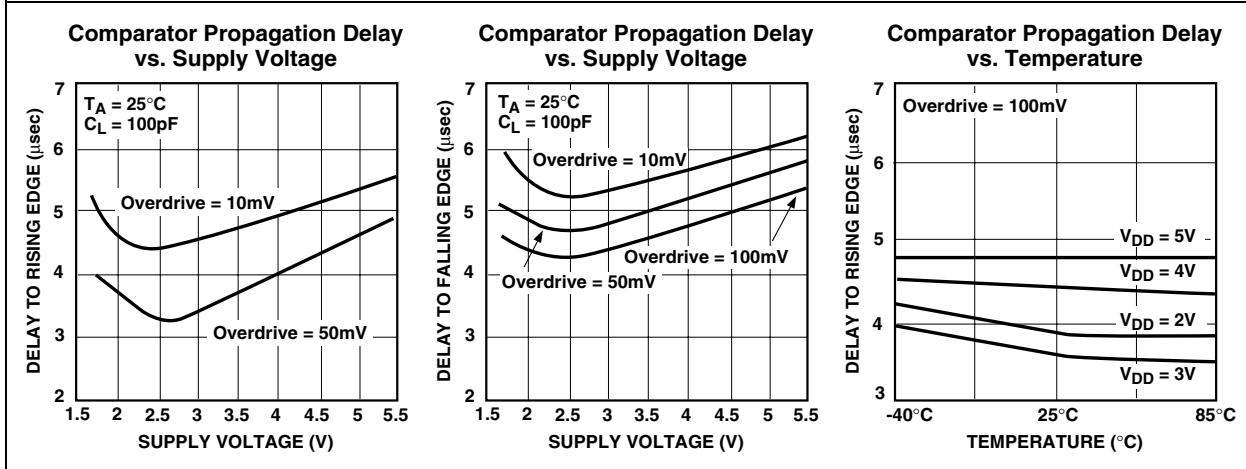


## 4.0 TYPICAL APPLICATIONS

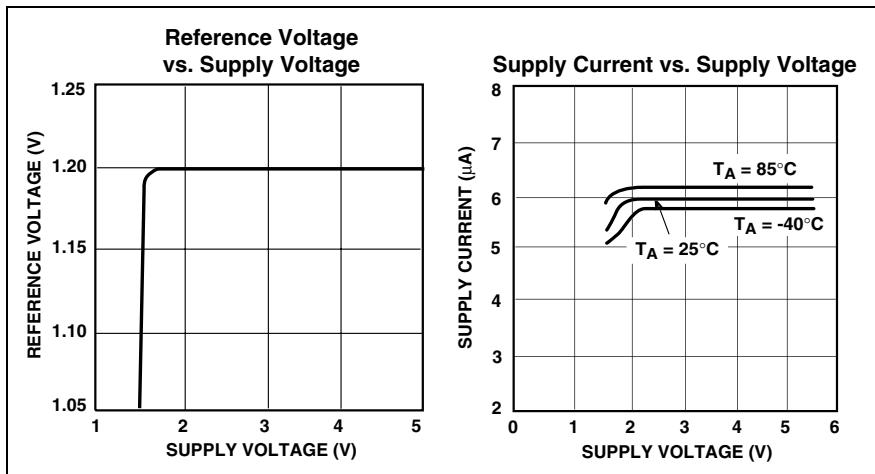
The TC1031 lends itself to a wide variety of applications, particularly in battery-powered systems. It typically finds application in power management, processor supervisory and interface circuitry.

## 5.0 TYPICAL CHARACTERISTICS

**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.



## 5.0 TYPICAL CHARACTERISTICS (CONTINUED)



# TC1031

## 6.0 PACKAGING INFORMATION

### 6.1 Package Marking Information

Package marking data not available at this time.

### 6.2 Taping Form

**Component Taping Orientation for 8-Pin MSOP Devices**

Standard Reel Component Orientation  
for TR Suffix Device

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin MSOP	12 mm	8 mm	2500	13 in

### 6.3 Package Dimensions

**8-Pin MSOP**

**Dimensions: inches (mm)**



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# TC1031

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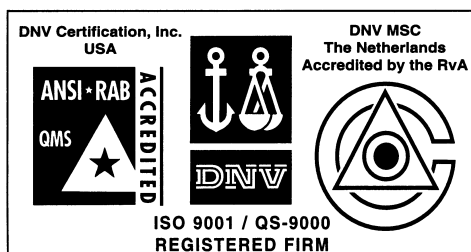
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