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: 6µA (Typ.), Shutdown Mode: 0.1µA (Typ.)
• Rail-to-Rail Inputs and Outputs
• Operates Down to VDD = 1.8V
• Programmable Hysteresis

Applications

• Power Management Circuits
• Battery Operated Equipment
• Consumer Products

Device Selection Table

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC1031CEUA</td>
<td>8-Pin MSOP</td>
<td>-40°C to +85°C</td>
</tr>
</tbody>
</table>

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 VDD = 1.8V. Typical active supply current is 6µA. 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 0.1µA (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.
### 1.0 ELECTRICAL CHARACTERISTICS

**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage ......................................................6.0V  
Voltage on Any Pin ...........(VSS – 0.3V) to (VDD + 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 VDD = 3.0V; TA = -40° to +85°C, and VDD = 1.8V to 5.5V, unless otherwise specified.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDD</td>
<td>Supply Voltage</td>
<td>1.8</td>
<td>—</td>
<td>5.5</td>
<td>V</td>
<td>All Outputs Open, SHDN = VDD</td>
</tr>
<tr>
<td>IQ</td>
<td>Supply Current, Operating</td>
<td>—</td>
<td>6</td>
<td>10</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>ISHDN</td>
<td>Supply Current, Shutdown</td>
<td>—</td>
<td>—</td>
<td>0.1</td>
<td>µA</td>
<td>SHDN = VSS</td>
</tr>
<tr>
<td>VIH</td>
<td>Input High Threshold</td>
<td>80% VDD</td>
<td>—</td>
<td>—</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>VIL</td>
<td>Input Low Threshold</td>
<td>—</td>
<td>—</td>
<td>20% VDD</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>ISIH</td>
<td>Shutdown Input Current</td>
<td>—</td>
<td>—</td>
<td>±100 nA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RROUT (SD)</td>
<td>Output Resistance in Shutdown</td>
<td>20</td>
<td>—</td>
<td>—</td>
<td>MΩ</td>
<td>SHDN = VSS</td>
</tr>
<tr>
<td>COUT (SD)</td>
<td>Output Capacitance in Shutdown</td>
<td>—</td>
<td>—</td>
<td>5</td>
<td>pF</td>
<td>SHDN = VSS</td>
</tr>
<tr>
<td>TSEL</td>
<td>Select Time</td>
<td>—</td>
<td>20</td>
<td>—</td>
<td>µsec</td>
<td>VOUT Valid from SHDN = VIL</td>
</tr>
<tr>
<td>TDSEL</td>
<td>Deselect Time</td>
<td>—</td>
<td>500</td>
<td>—</td>
<td>nsec</td>
<td>VOUT Invalid from SHDN = VIL</td>
</tr>
<tr>
<td>VCMR</td>
<td>Common-Mode Voltage Range</td>
<td>VSS – 0.2</td>
<td>—</td>
<td>VDD + 0.2</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>VOS</td>
<td>Input Offset Voltage (Note 1)</td>
<td>-5</td>
<td>—</td>
<td>+5</td>
<td>mV</td>
<td>VDD = 3V, VCM = 1.5V</td>
</tr>
<tr>
<td>IB</td>
<td>Input Bias Current</td>
<td>—</td>
<td>—</td>
<td>±100</td>
<td>pA</td>
<td></td>
</tr>
<tr>
<td>VOH</td>
<td>Output High Voltage</td>
<td>VDD – 0.3</td>
<td>—</td>
<td>—</td>
<td>V</td>
<td>RL = 10kΩ to VSS</td>
</tr>
<tr>
<td>VOL</td>
<td>Output Low Voltage</td>
<td>—</td>
<td>—</td>
<td>0.3</td>
<td>V</td>
<td>RL = 10kΩ to VDD</td>
</tr>
<tr>
<td>CMRR</td>
<td>Common-Mode Rejection Ratio</td>
<td>66</td>
<td>—</td>
<td>—</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>PSRR</td>
<td>Power Supply Rejection Ratio</td>
<td>60</td>
<td>—</td>
<td>—</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>ISRC</td>
<td>Output Source Current</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>ISINK</td>
<td>Output Sink Current</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>VHYST</td>
<td>Voltage Range at HYST Pin</td>
<td>VREF – 0.08</td>
<td>—</td>
<td>VREF</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>IHYST</td>
<td>Hysteresis Input Current</td>
<td>—</td>
<td>—</td>
<td>±100</td>
<td>nA</td>
<td></td>
</tr>
<tr>
<td>IPD1</td>
<td>Response Time</td>
<td>—</td>
<td>4</td>
<td>—</td>
<td>µsec</td>
<td>100mV Overdrive; CL = 100pF</td>
</tr>
<tr>
<td>IPD2</td>
<td>Response Time</td>
<td>—</td>
<td>6</td>
<td>—</td>
<td>µsec</td>
<td>100mV Overdrive; CL = 100pF</td>
</tr>
</tbody>
</table>

**Note 1:** VOS is measured as (VUT + VLT – 2VREF)/2 where VUT is the upper hysteresis threshold and VLT is the lower hysteresis threshold with VREF – VHYST set to 10mV. This represents the asymmetry of the hysteresis thresholds around VREF.
TC1031 ELECTRICAL SPECIFICATIONS (CONTINUED)

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

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

**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 \( V_{REF} \).
### 2.0 PIN DESCRIPTIONS

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

#### TABLE 2-1: PIN FUNCTION TABLE

<table>
<thead>
<tr>
<th>Pin No. (8-Pin MSOP)</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VSS</td>
<td>Negative power supply.</td>
</tr>
<tr>
<td>2</td>
<td>SHDN</td>
<td>Shutdown input.</td>
</tr>
<tr>
<td>3</td>
<td>IN+</td>
<td>Comparator non-inverting input.</td>
</tr>
<tr>
<td>4</td>
<td>IN-</td>
<td>Comparator inverting input.</td>
</tr>
<tr>
<td>5</td>
<td>HYST</td>
<td>Adjustable hysteresis input.</td>
</tr>
<tr>
<td>6</td>
<td>VREF</td>
<td>Voltage reference output.</td>
</tr>
<tr>
<td>7</td>
<td>VDD</td>
<td>Positive power supply.</td>
</tr>
<tr>
<td>8</td>
<td>OUT</td>
<td>Comparator output.</td>
</tr>
</tbody>
</table>
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

SHDN at VIL disables both the comparator and voltage reference and reduces the supply current to less than 0.1µA. The SHDN input cannot be allowed to float; when not used, connect it to VDD. 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 latchup will occur when the device is driven to its enabled state when SHDN is set to VIH.

3.4 Programmable Hysteresis

Hysteresis is added to the comparators by connecting a resistor R1 between the VREF and HYST pins and another resistor R2 between the HYST pin and VSS. For no hysteresis VREF should be directly connected to HYST. The hysteresis, VHB, is equal to twice the voltage difference between the VREF and HYST pins, where:

\[ V_{HB} = \frac{2 \cdot V_{REF} \cdot R_1}{R_1 + R_2} \]  

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

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)

![Graphs showing reference voltage and supply current vs. supply voltage for different temperatures.](image-url)

- Reference Voltage vs. Supply Voltage
- Supply Current vs. Supply Voltage

- Supply Voltage (V) vs. Reference Voltage (V)
- Supply Voltage (V) vs. Supply Current (µA)
- Temperature conditions: TA = 85°C, TA = 25°C, TA = -40°C
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

User Direction of Feed

PIN 1

Standard Reel Component Orientation for TR Suffix Device

Carrier Tape, Number of Components Per Reel and Reel Size

<table>
<thead>
<tr>
<th>Package</th>
<th>Carrier Width (W)</th>
<th>Pitch (P)</th>
<th>Part Per Full Reel</th>
<th>Reel Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-Pin MSOP</td>
<td>12 mm</td>
<td>8 mm</td>
<td>2500</td>
<td>13 in</td>
</tr>
</tbody>
</table>

6.3 Package Dimensions

8-Pin MSOP

Dimensions: inches (mm)
Sales and Support

Data Sheets
Products supported by a preliminary Data Sheet may have an errata sheet describing minor operational differences and recommended workarounds. To determine if an errata sheet exists for a particular device, please contact one of the following:

1. Your local Microchip sales office
2. The Microchip Corporate Literature Center U.S. FAX: (480) 792-7277
3. The Microchip Worldwide Site (www.microchip.com)

Please specify which device, revision of silicon and Data Sheet (include Literature #) you are using.

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