TC1028

Linear Building Block – Dual Low Power Comparator and Voltage Reference with Shutdown

Features

- Combines Two Comparators and a 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, Operating: 10µA (Typ.) Shutdown Mode: 0.05µA (Typ.)
- Rail-to-Rail Inputs and Outputs
- Operates Down to V_{DD} = 1.8V

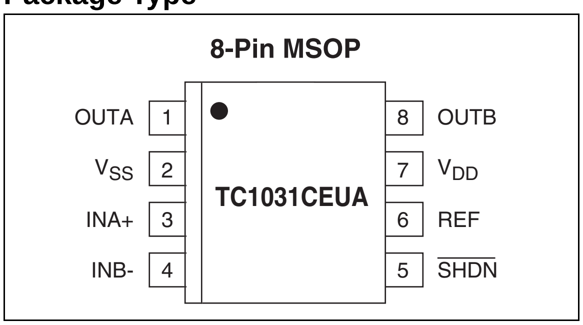
Applications

- Power Supply Circuits
- Battery Operated Equipment
- Consumer Products
- Replacements for Discrete Components

Device Selection Table

Part Number	Package	Temperature Range
TC1028CEUA	8-Pin MSOP	-40°C to +85°C

Package Type



General Description

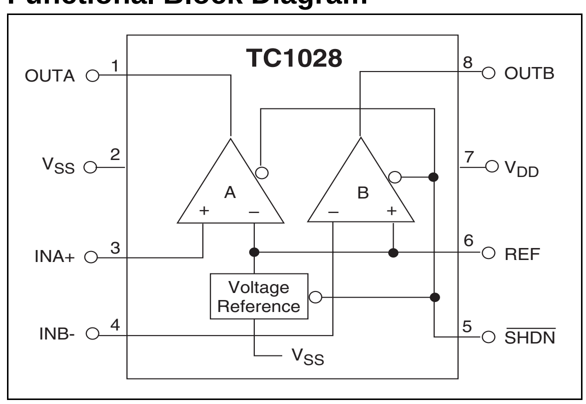
The TC1028 is a mixed-function device combining two comparators and a voltage reference in a single 8-pin package. The inverting input of Comparator A and the non-inverting input of Comparator B are internally connected to the reference.

This increased integration allows the user to replace two packages, which saves space, lowers supply current and increases system performance. The TC1028 operates from two 1.5V alkaline cells down to V_{DD} = 1.8V. It requires only 10µA typical of supply current, which significantly extends battery life. A low power shutdown input ($\overline{SHDN}$) disables the entire chip, placing all outputs in a high-impedance state. This mode saves battery power and allows comparator outputs to share common analog lines (multiplexing). Shutdown current is 0.05µA typical.

Rail-to-rail inputs and outputs allow operation from low supply voltages with large input and output signal swings.

Packaged in an 8-Pin MSOP, the TC1028 is ideal for applications requiring low power level detection.

Functional Block Diagram



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.

TC1028 ELECTRICAL SPECIFICATIONS

Electrical Characteristics: Typical values apply at 25°C and V_{DD} = 3.0V. Minimum and maximum values apply for T_A = -40° to +85°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	—	10	15	µA	All outputs unloaded, $\overline{SHDN}$ = V_{DD}
I_{SHDN}	Supply Current, Shutdown	—	0.05	0.1	µA	$\overline{SHDN}$ = V_{SS}
Shutdown Input						
V_{IH}	Input High Threshold	80% V_{DD}	—	—	V	
V_{IL}	Input Low Threshold	—	—	20% V_{DD}	V	
I_{SI}	Shutdown Input Current	—	—	±100	nA	
Comparators						
R_{OUT}	Output Resistance in Shutdown	20	—	—	MΩ	$\overline{SHDN}$ = V_{SS}
C_{OUT}	Output Capacitance in Shutdown	—	—	5	pF	$\overline{SHDN}$ = V_{SS}
T_{SEL}	Select Time	—	20	—	µsec	V_{OUT} Valid from $\overline{SHDN}$ = V_{IH}
T_{DESEL}	Deselect Time	—	500	—	nsec	V_{OUT} Invalid from $\overline{SHDN}$ = V_{IL} R_L =10kΩ to V_{SS}
V_{IR}	Input Voltage Range	V_{SS} – 0.2	—	V_{DD} + 0.2	V	
V_{OS}	Input Offset Voltage	-5 -5	—	+5 +5	mV	V_{DD} = 3V, T_A = 25°C T_A = -40°C to 85°C
I_B	Input Bias Current	—	—	±100	pA	T_A =25°C, INA+, INB- = V_{DD} to V_{SS}
V_{OH}	Output High Voltage	V_{DD} – 0.3	—	—	V	R_L = 10kΩ to V_{SS}
V_{OL}	Output Low Voltage	—	—	0.3	V	R_L = 10kΩ to V_{DD}
CMRR	Common Mode Rejection Ratio	66	—	—	dB	T_A = 25°C, V_{DD} = 5V V_{CM} = V_{DD} to V_{SS}
PSRR	Power Supply Rejection Ratio	60	—	—	dB	T_A = 25°C, V_{DD} = 1.8V to 5V
I_{SRC}	Output Source Current	1	—	—	mA	INA+ = V_{DD}, INB- = V_{SS} Output Shorted to V_{SS} V_{DD} = 1.8V
I_{SINK}	Output Sink Current	2	—	—	mA	INA+ = V_{SS}, INB- = V_{DD} Output Shorted to V_{DD} V_{DD} = 1.8V
t_{PD1}	Response Time	—	4	—	µsec	100mV Overdrive, C_L = 100pF
t_{PD2}	Response Time	—	6	—	µsec	10mV Overdrive, C_L = 100pF
Voltage Reference						
V_{REF}	Reference Voltage	1.176	1.200	1.224	V	
$I_{REF(SOURCE)}$	Source Current	50	—	—	µA	
$I_{REF(SINK)}$	Sink Current	50	—	—	µA	
$C_{L(REF)}$	Load Capacitance	—	—	100	pF	
R_{OUT}(SD)	Output Resistance in Shutdown	20	—	—	MΩ	$\overline{SHDN}$ = V_{SS}
C_{OUT}(SD)	Output Capacitance in Shutdown	—	—	5	pF	$\overline{SHDN}$ = V_{SS}

TC1028 ELECTRICAL SPECIFICATIONS (CONTINUED)

Electrical Characteristics: Typical values apply at 25°C and V_{DD} = 3.0V. Minimum and maximum values apply for T_A = -40° to +85°C, and V_{DD} = 1.8V to 5.5V, unless otherwise specified.

Symbol	Parameter	Min	Typ	Max	Units	Test Conditions
T_{SEL}	Select Time	—	200	—	µsec	REF Valid from $\overline{SHDN}$ = V_{IH} R_L = 100kΩ to V_{SS}
T_{DESEL}	Deselect Time	—	10	—	µsec	REF Invalid from $\overline{SHDN}$ = V_{IL} R_L = 100kΩ to V_{SS}
$C_{L(REF)}$	Load Capacitance	—	—	100	pF	
E_{VREF}	Noise Voltage	—	20	—	μV_{RMS}	100Hz TO 100kHz
e_{VREF}	Noise Voltage Density	—	1.0	—	$\mu V/\sqrt{Hz}$	1kHz

2.0 PIN DESCRIPTION

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	OUTA	Comparator output.
2	V_{SS}	Negative power supply.
3	INA+	Non-inverting input to Comparator A.
4	INB-	Inverting input to Comparator B.
5	$\overline{SHDN}$	Shutdown input.
6	REF	Voltage reference.
7	V_{DD}	Positive power supply.
8	OUTB	Comparator output.

3.0 DETAILED DESCRIPTION

The TC1028 is one of a series of very low power, linear building block products targeted at low voltage, single supply applications. The TC1028 minimum operating voltage is 1.8V and typical supply current is only 10µA (fully enabled). It combines two comparators and a voltage reference in a single package. The shutdown mode disables both comparators and the reference. All of the outputs are in a high impedance state during shutdown.

3.1 Comparators

The TC1028 contains two comparators. The comparator's input range extends beyond both supply voltages by 200mV and the outputs will swing to within several millivolts of the supplies depending on the load current being driven. The inverting input of Comparator A and the non-inverting input of Comparator B are internally connected the output of the voltage reference.

The comparators exhibit a propagation delay and supply current which are largely independent of supply voltage. The low input bias current and offset voltage make them suitable for high impedance precision applications. Both comparators are disabled during shutdown and have high impedance outputs.

3.2 Voltage Reference

A 2.0% tolerance, internally biased, 1.20V bandgap voltage reference is included in the TC1028. It has a push-pull output capable of sourcing and sinking 50µA. The voltage reference is disabled during shutdown, with a high impedance output.

3.3 Shutdown Input

$\overline{SHDN}$ at V_{IL} disables the entire part. The $\overline{SHDN}$ input cannot be allowed to float; when not used, connect it to V_{DD}. All outputs are in a high impedance state when shutdown is active. The disabled comparators' inputs and outputs can be driven from rail-to-rail by an external voltage when the TC1028 is in shutdown. No latchup will occur when the device is driven to its enabled state when $\overline{SHDN}$ is set to V_{IH}.

4.0 TYPICAL APPLICATIONS

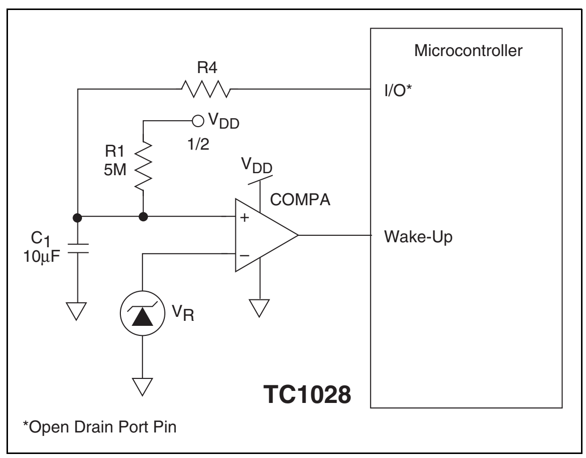
The TC1028 lends itself to a wide variety of applications, particularly in battery-powered systems. It typically finds application in power management, processor supervisory and interface circuitry.

4.1 Wake-Up Timer

Many microcontrollers have a low-power "sleep" mode that significantly reduces their supply current. Typically, the microcontroller is placed in this mode via a software instruction, and returns to a fully-enabled state upon reception of an external signal ("wake-up"). The wake-up signal is usually supplied by a hardware timer. Most system applications demand that this timer have a long duration (typically seconds or minutes), and consume as little supply current as possible.

The circuit shown in Figure 4-1 is a wake-up timer made from Comparator A. Capacitor C1 charges through R1 until a voltage equal to V is reached, at which point the "wake-up" is driven active. Upon wake-up, the microcontroller resets the timer by forcing a logic low on a dedicated, open drain I/O port pin. This discharges C1 through R4 (the value of R4 is chosen to limit maximum current sunk by the I/O port pin). With a 3V supply, the circuit as shown consumes typically 10µA and furnishes a nominal timer duration of 25 seconds.

FIGURE 4-1: WAKE-UP TIMER



4.2 Precision Battery Monitor

Figure 4-2 is a precision battery low/battery dead monitoring circuit. Typically, the battery low output warns the user that a battery dead condition is imminent. Battery dead typically initiates a forced shutdown to prevent operation at low internal supply voltages (which can cause unstable system operation).

The circuit in Figure 4-2 uses a single TC1028, a TC1034, and only six external resistors. COMPA and COMPB provide precision voltage detection using V_R as a reference. Resistors R2 and R4 set the detection threshold for BATT LOW, while resistors R1 and R3 set the detection threshold for BATT FAIL. The component values shown assert BATT LOW at 2.2V (typical) and BATT FAIL at 2.0 (typical). Total current consumed by this circuit is typically 16µA at 3V. Resistors R5 and R6 provide hysteresis for comparators COMPA and COMPB, respectively.

4.3 External Hysteresis (Comparator)

Hysteresis can be set externally with two resistors using positive feedback techniques (see Figure 4-3). The design procedure for setting external comparator hysteresis is as follows:

1. Choose the feedback resistor R_C. Since the input bias current of the comparator is at most 100pA, the current through R_C can be set to 100nA (i.e., 1000 times the input bias current) and retain excellent accuracy. The current through R_C at the comparator's trip point is V_R / R_C where V_R is a stable reference voltage.
2. Determine the hysteresis voltage (V_{HY}) between the upper and lower thresholds.
3. Calculate R_A as follows:

EQUATION 4-1:

$$R_A = R_C\left(\frac{V_{HY}}{V_{DD}}\right)$$

4. Choose the rising threshold voltage for V_{SRC} (V_{THR}).
5. Calculate R_B as follows:

EQUATION 4-2:

$$R_B = \frac{1}{\left[\left(\frac{V_{THR}}{V_R \times R_A}\right) - \frac{1}{R_A} - \frac{1}{R_C}\right]}$$

6. Verify the threshold voltages with these formulas:

   V_{SRC} rising:

EQUATION 4-3:

$$V_{THR} = (V_R)(R_A)\left[\left(\frac{1}{R_A}\right) + \left(\frac{1}{R_B}\right) + \left(\frac{1}{R_C}\right)\right]$$

   V_{SRC} falling:

EQUATION 4-4:

$$V_{THF} = V_{THR} - \left[\left(\frac{R_A \times V_{DD}}{R_C}\right)\right]$$

FIGURE 4-2: PRECISION BATTERY MONITOR

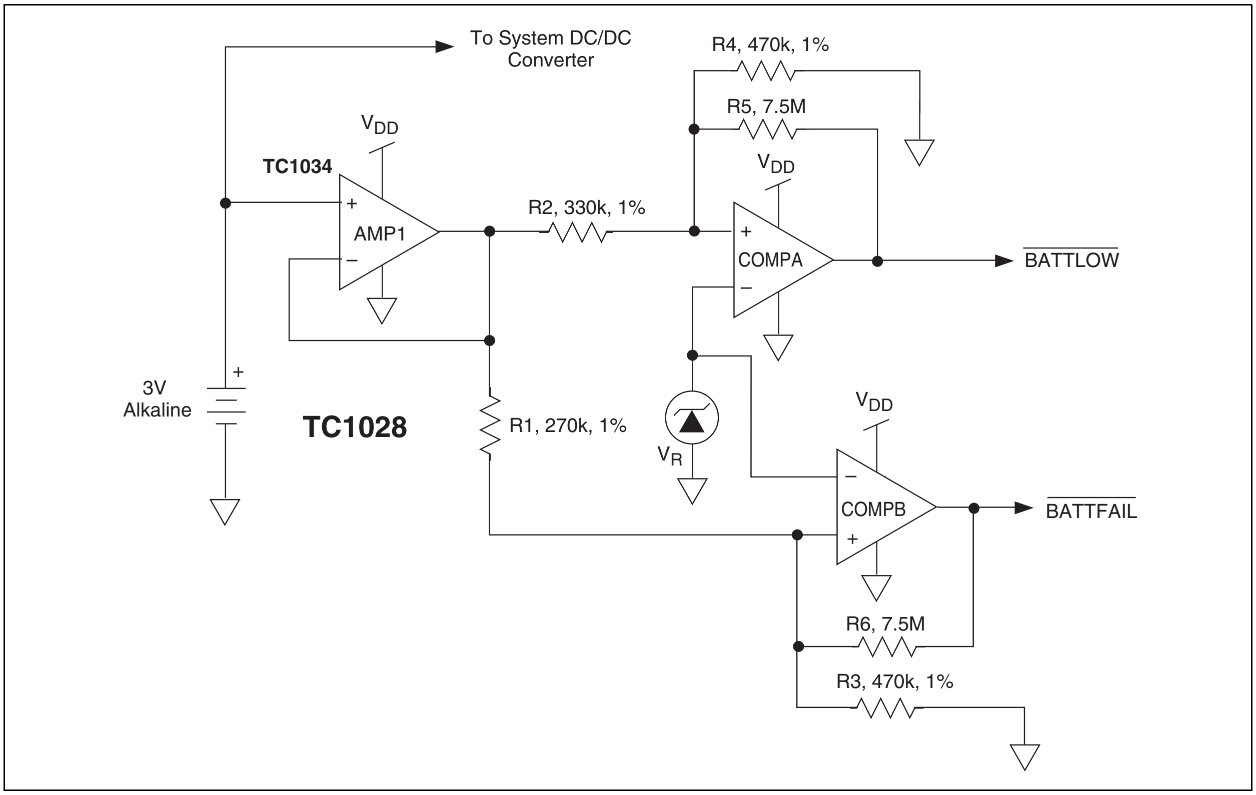
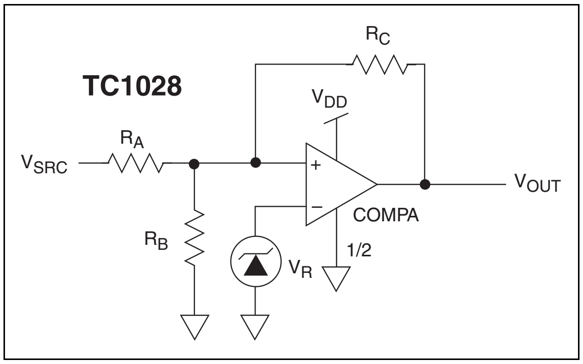


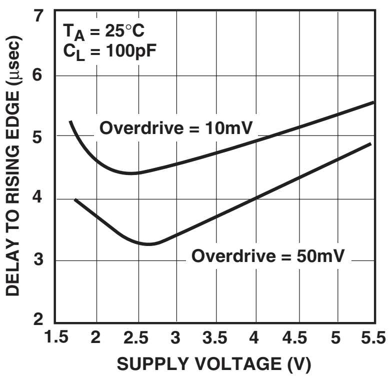
FIGURE 4-3: COMPARATOR EXTERNAL HYSTERESIS CONFIGURATION



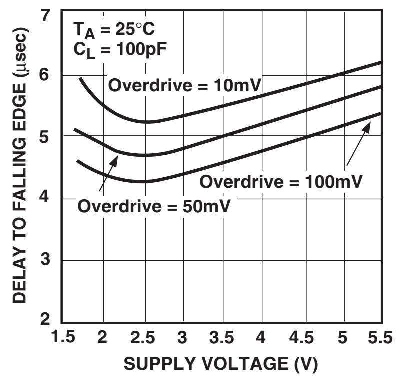
5.0 TYPICAL CHARACTERISTICS

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.

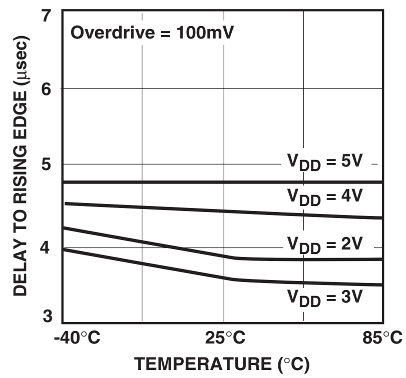
Comparator Propagation Delay vs. Supply Voltage



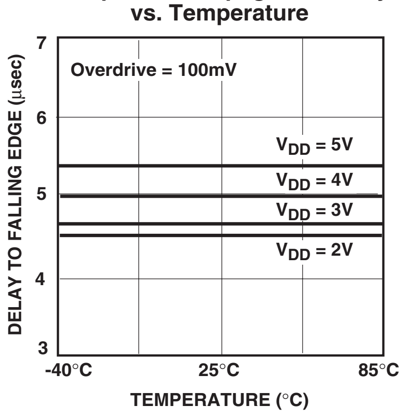
Comparator Propagation Delay vs. Supply Voltage



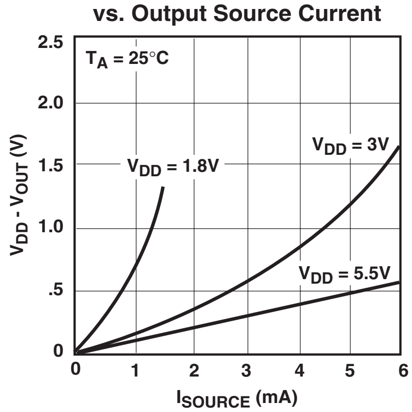
Comparator Propagation Delay vs. Temperature



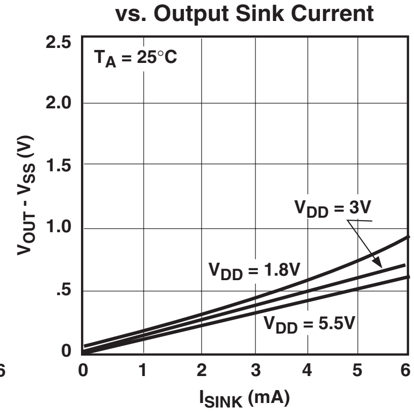
Comparator Propagation Delay vs. Temperature



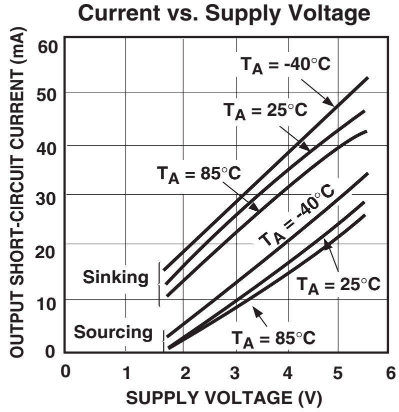
Comparator Output Swing vs. Output Source Current



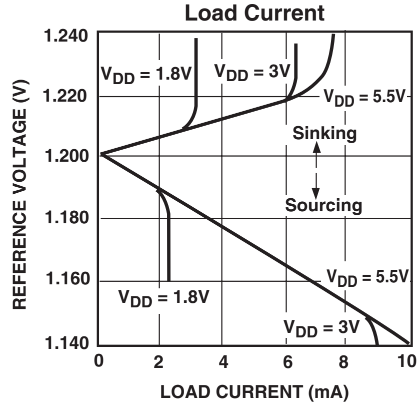
Comparator Output Swing vs. Output Sink Current



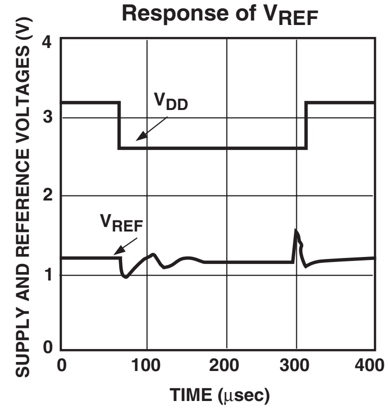
Comparator Output Short-Circuit Current vs. Supply Voltage



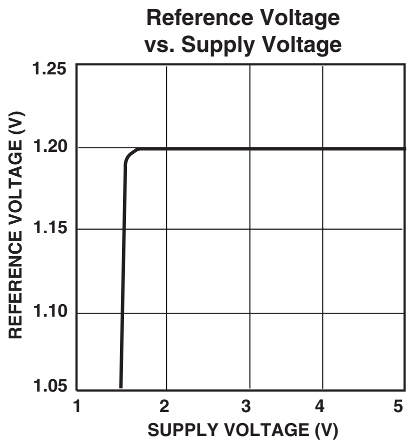
Reference Voltage vs. Load Current

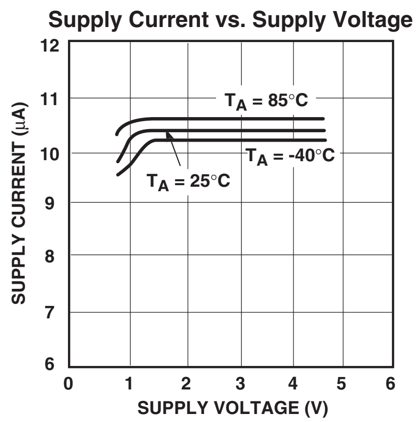


Line Transient Response of V_{REF}



5.0 TYPICAL CHARACTERISTICS (CONTINUED)





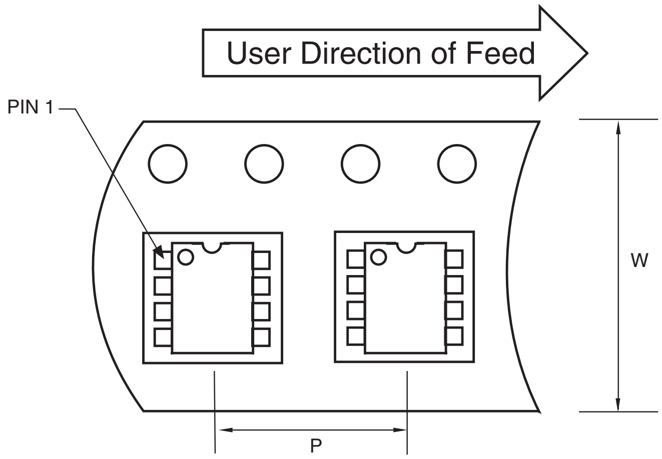
6.0 PACKAGING INFORMATION

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



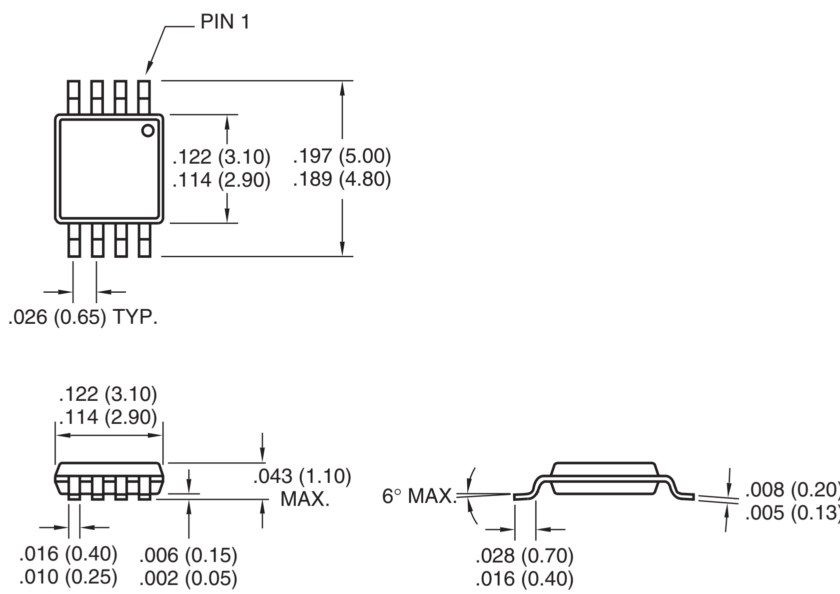
Standard Reel Component Orientation
for TR Suffix Device

Carrier Tape, Number of Components Per Reel and Reel Size

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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