EVALUATION KIT AVAILABLE

TC1040

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

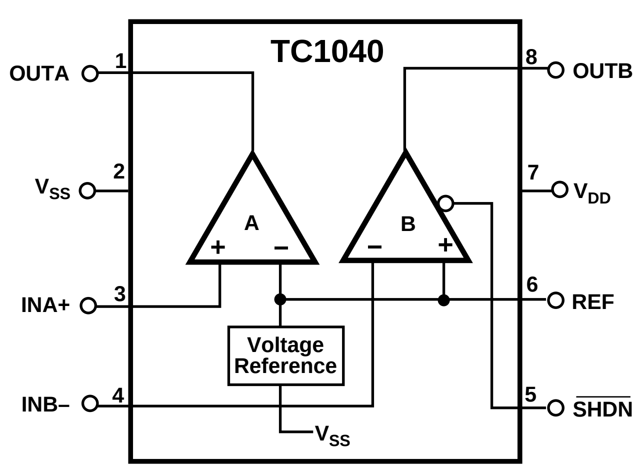
FEATURES

- **Combines Two Comparators and a Voltage Reference in a Single Package**
- **Optimized for Single-Supply Operation**
- **Small Package .... 8-Pin MSOP (Occupies Only Half the Area of an 8-Pin SOIC)**
- **Ultra Low Input Bias Current ..... Less than 100 pA**
- **Low Quiescent Current .... Operating 10μA (Typ.) Shutdown 6μA (Typ.)**
- **Rail-to-Rail Inputs and Outputs**
- **Operates Down to V_{DD} = 1.8V**
- **Reference and One Comparator Remain Active in Shutdown to Provide Supervisory Functions**

APPLICATIONS

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

PIN CONFIGURATION (MSOP)



8-Pin MSOP

GENERAL DESCRIPTION

The TC1040 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 TC1040 operates from two 1.5V alkaline cells down to V_{DD} = 1.8V. It requires only 10 μA, typical, of supply current, which significantly extends battery life. A low-power shutdown input ($\overline{SHDN}$) disables one of the comparators, placing its output in a high-impedance state. This mode saves battery power and allows comparator outputs to share common analog lines (multiplexing). Shutdown current is 6 μA (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 TC1040 is ideal for applications requiring low-power level detection.

ORDERING INFORMATION

Part No.	Package	Temp. Range
TC1040CEUA	8-Pin MSOP	– 40°C to +85°C
TC1043EV Evaluation Kit for Linear Building Block Family		

ABSOLUTE MAXIMUM RATINGS*

Supply Voltage 6.0V
Voltage on Any Pin:
(With Respect to Supplies) .. (V_{SS} – 0.3V) to (V_{DD} +0.3V)
Operating Temperature Range: .... – 40°C to + 85°C
Storage Temperature Range .... – 55°C to +150°C
Lead Temperature (Soldering, 10 sec) .... +260°C

* Static-sensitive device. Unused devices must be stored in conductive material. Protect devices from static discharge and static fields. 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 operational sections of the specifications is not implied. Exposure to Absolute Maximum Rating Conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS: Typical values apply at 25°C and V_{DD} = 3V. 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	Test Conditions	Min	Typ	Max	Unit
V_{DD}	Supply Voltage		1.8	—	5.5	V
I_Q	Supply Current, Operating	All outputs unloaded, $\overline{SHDN}$ = V_{DD}	—	10	15	µA
I_{SHDN}	Supply Current, Shutdown	COMPA and V_{REF} Outputs unloaded, $\overline{SHDN}$ = V_{SS}	—	6	10	µA
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}(SD)	Output Resistance in Shutdown	$\overline{SHDN}$ = $V_{SS,}$ COMPB only	20	—	—	MΩ
C_{OUT}(SD)	Output Capacitance in Shutdown	$\overline{SHDN}$ = $V_{SS,}$ COMPB only	—	—	5	pF
T_{SEL}	Select Time (For Valid Output)	($\overline{SHDN}$ = V_{IH} to V_{OUT}) R_L =10KΩ to $V_{SS,}$ COMPB only	—	20	—	µsec
T_{DESEL}	Deselect Time	($\overline{SHDN}$ = V_{IL} to V_{OUT}) R_L =10KΩ to $V_{SS,}$ COMPB only	—	500	—	nsec
V_{IR}	Input Voltage Range		V_{SS} – 0.2	—	V_{DD} +0.2	V
V_{OS}	Input Offset Voltage	V_{DD} = 3V, T_A = 25°C T_A = –40°C to 85°C	– 5 –5	—	+5 +5	mV
I_B	Input Bias Current	T_A = 25°C, INA+, INB– = V_{DD} to V_{SS}	—	—	±100	pA
V_{OH}	Output High Voltage	R_L = 10KΩ to V_{SS}	V_{DD} – 0.3	—	—	V
V_{OL}	Output Low Voltage	R_L = 10KΩ to V_{DD}	—	—	0.3	V
PSRR	Power Supply Rejection Ratio	T_A = 25°C, V_{DD} = 1.8V to 5V	60	—	—	dB
I_{SRC}	Output Source Current	INA+ = $V_{DD,}$ INB– = V_{SS} Output Shorted to V_{SS} V_{DD} = 1.8V	1	—	—	mA
I_{SINK}	Output Sink Current	INA+ = $V_{SS,}$ INB– = $V_{DD,}$ Output Shorted to V_{DD} V_{DD} = 1.8V	2	—	—	mA
t_{PD1}	Response Time	100 mV Overdrive,C_L = 100pF	—	4	—	µsec
t_{PD2}	Response Time	10 mV Overdrive, C_L = 100pF	—	6	—	µsec

ELECTRICAL CHARACTERISTICS: (CONT.) Typical values apply at 25°C and V_{DD} = 3V. 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	Test Conditions	Min	Typ	Max	Unit
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
N_{VREF}	Voltage Noise	100 Hz to 100 KHz	—	20	—	μV_{RMS}
	Noise Density	1 KHz	—	1.0	—	$\mu V/\sqrt{Hz}$

DETAILED DESCRIPTION

The TC1040 is one of a series of very low-power, linear building block products targeted at low-voltage, single-supply applications. The TC1040 minimum operating voltage is 1.8V and typical supply current is only 10 µA (fully enabled). It combines two comparators and a voltage reference in a single package. A shutdown mode is incorporated for easy adaptation to system power management schemes. During shutdown, one comparator is disabled (i.e. powered down with output at a high impedance). The "still awake" comparator and voltage reference can be used as a wake-up timer, power supply monitor, LDO controller, or other continuous duty circuit function.

Comparators

The TC1040 contains two comparators. The comparators' 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.

Comparator B is disabled during shutdown and has a high impedance output. Comparator COMPA remains active.

Voltage Reference

A 2.0 percent tolerance, internally biased, 1.20V bandgap voltage reference is included in the TC1040. It has a push-pull output capable of sourcing and sinking 50 µA. The voltage reference remains fully enabled during shutdown.

Shutdown Input

$\overline{SHDN}$ at V_{IL} disables one comparator. The $\overline{SHDN}$ input cannot be allowed to float; when not used, connect it to V_{DD}. The disabled comparator's output is in a high impedance state when shutdown is active. The disabled comparator's inputs and outputs can be driven from rail-to-rail by an external voltage when the TC1040 is in shutdown. No latchup will occur when the device is driven to its enabled state when $\overline{SHDN}$ is set to V_{IH}.

TYPICAL APPLICATIONS

The TC1040 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.

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 1 is a wake-up timer made from comparator A. (Comparator A is used because the wake-up timer must operate when $\overline{SHDN}$ is active.) Capacitor C1 charges through R1 until a voltage equal to V_R 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 8 µA and furnishes a nominal timer duration of 25 seconds.

Precision Battery Monitor

Figure 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 of Figure 2 uses a single TC1040, one-half of a TC1029, 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 $\overline{\text{BATT LOW}}$, while resistors R1 and R7 set the detection threshold for BATT FAIL. The component values shown assert $\overline{\text{BATT LOW}}$ at 2.2V (typical) and BATT FAIL at 2.0 (typical). Total current consumed by this circuit is typically 22 µA at 3V. Resistors R5 and R6 provide hysteresis for comparators COMPA and COMPB, respectively.

External Hysteresis

Hysteresis can be set externally with two resistors using positive feedback techniques (see Figure 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 100 pA, the current through R_C can be set to 100 nA (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 the stable reference voltage.

2. Determine the hysteresis voltage (V_{HY}) between the upper and lower thresholds.

3. Calculate R_A as follows.

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

Equation 1.

4. Choose the rising threshold voltage for V_{SRC} (V_{THR}).

5. Calculate R_B as follows:

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

Equation 2.

6. Verify the threshold voltages with these formulas:

V_{SRC} rising:

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

Equation 3.

V_{SRC} falling:

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

Equation 4.

EVALUATION KIT

The TC1043EV consists of a four-inch by six-inch pre-wired application circuit board. Pre-configured circuits include a pulse width modulator, wake-up timer, function generator, and others. On-board current meter terminals, voltage regulator, and a user-prototyping area speed circuit development. Please contact your local Microchip Technology representative for more information.

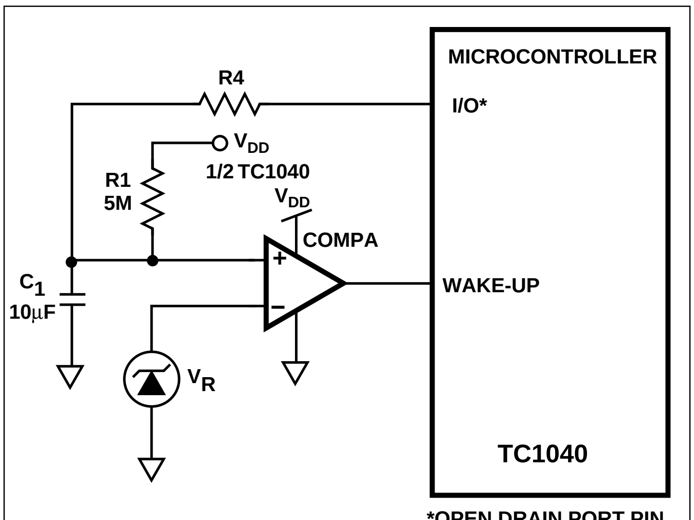


Figure 1. Wake-Up Timer

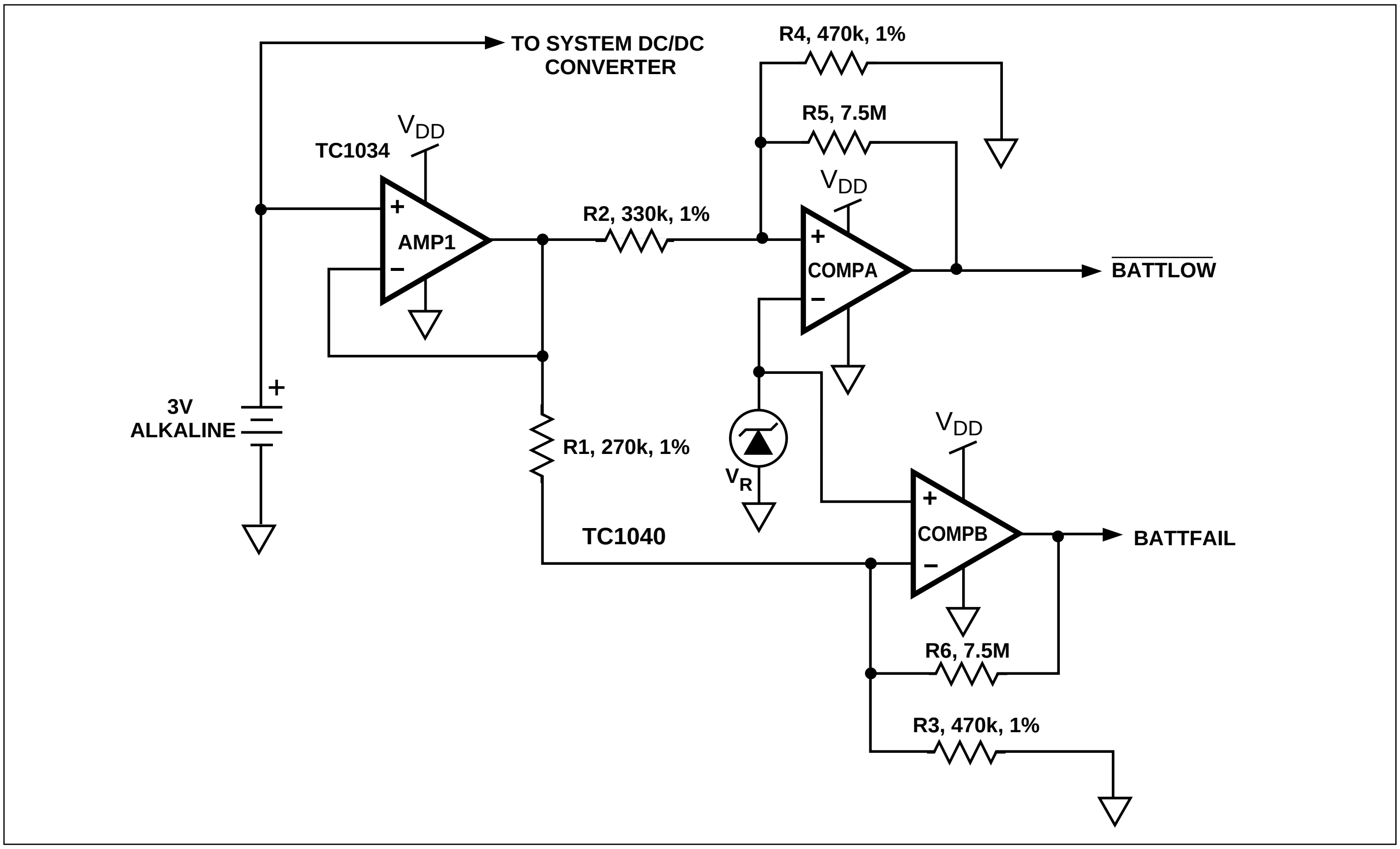


Figure 2. Precision Battery Monitor

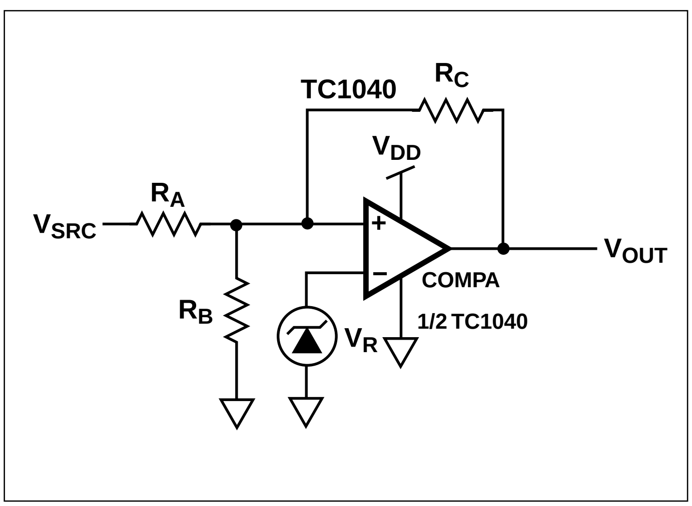
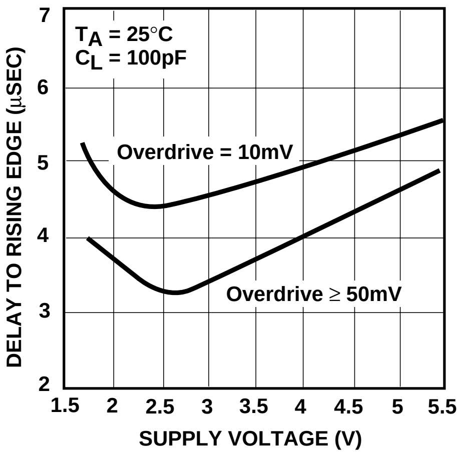


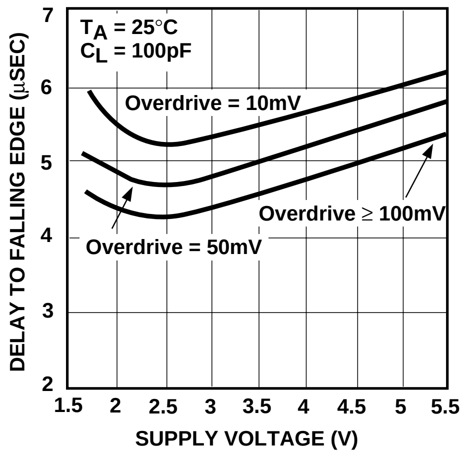
Figure 3.Comparator External Hysteresis Configuration

TYPICAL CHARACTERISTICS

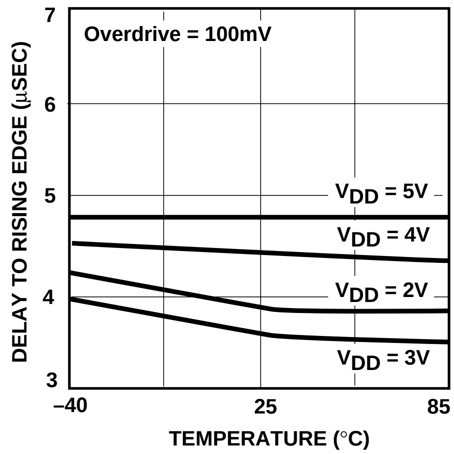
Comparator
Propagation Delay vs. Supply Voltage



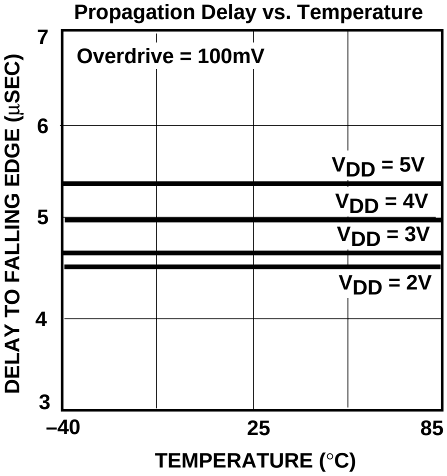
Comparator
Propagation Delay vs. Supply Voltage



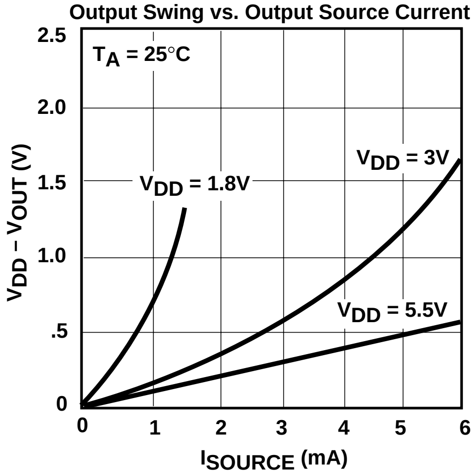
Comparator
Propagation Delay vs. Temperature



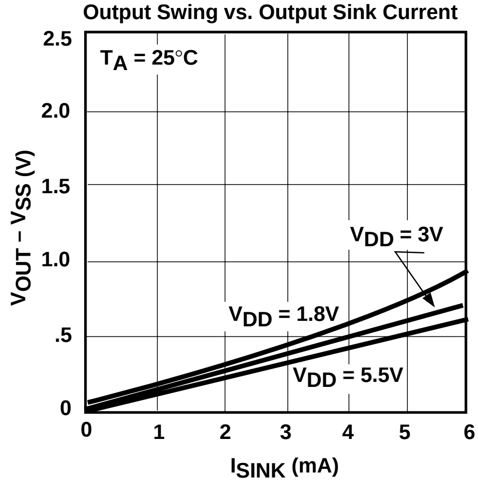
Comparator
Propagation Delay vs. Temperature



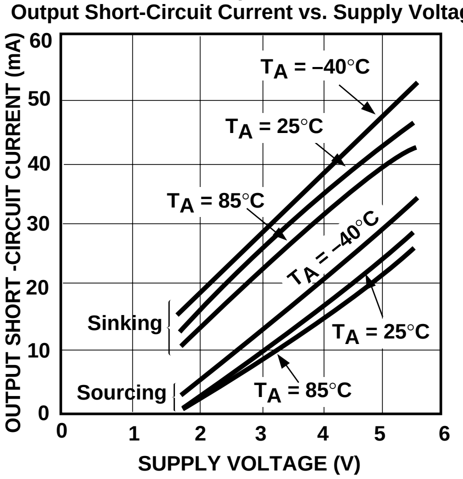
Comparator
Output Swing vs. Output Source Current



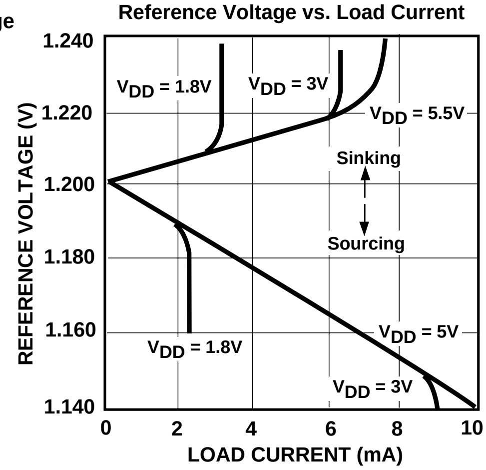
Comparator
Output Swing vs. Output Sink Current



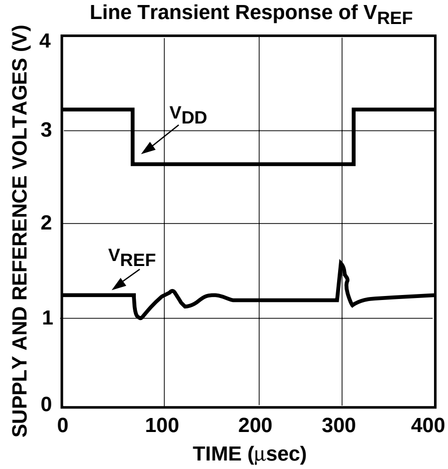
Comparator
Output Short-Circuit Current vs. Supply Voltage



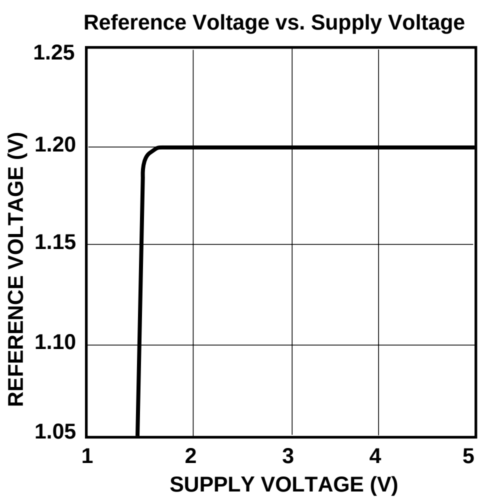
Reference Voltage vs. Load Current

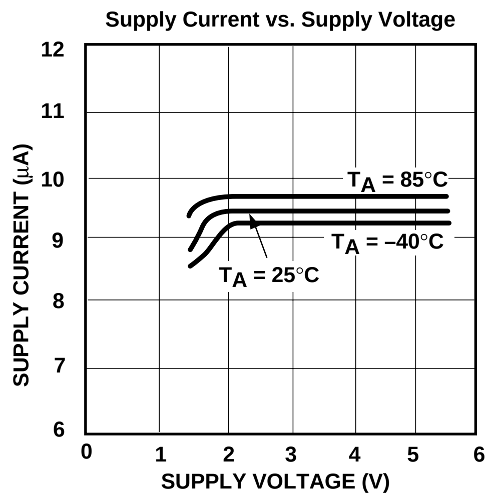


Line Transient Response of V_{REF}

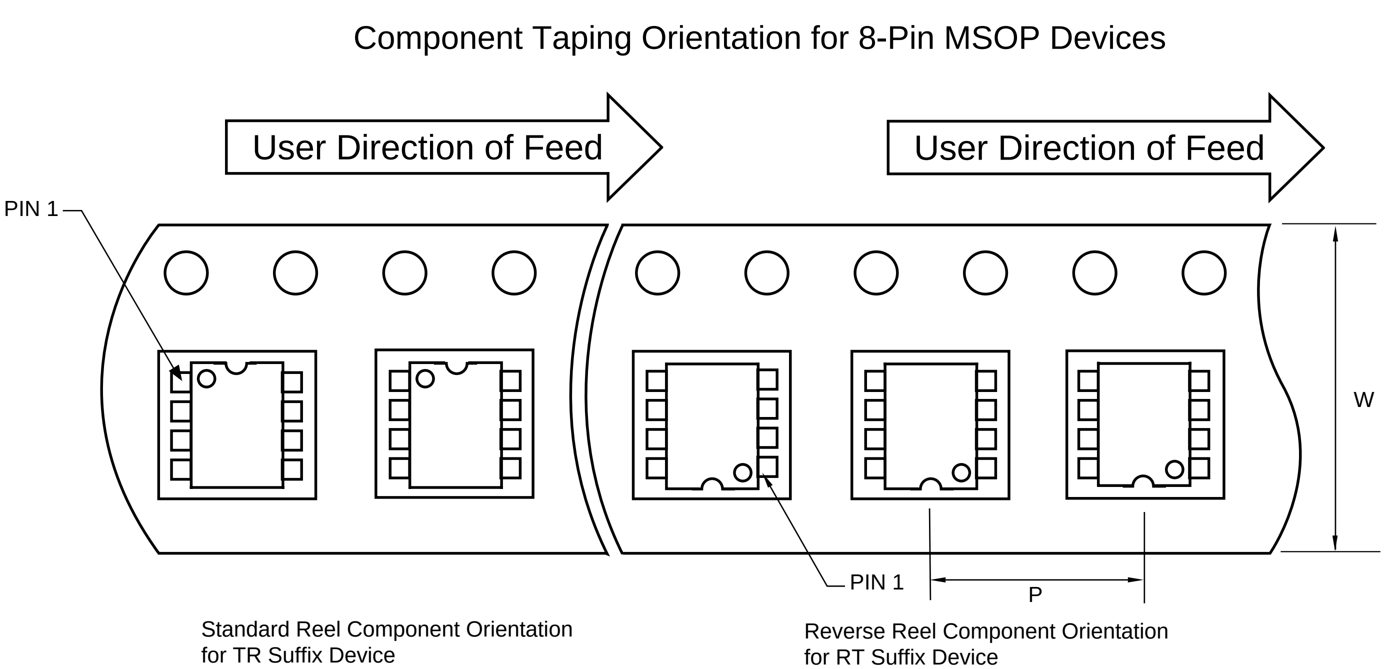


TYPICAL CHARACTERISTICS





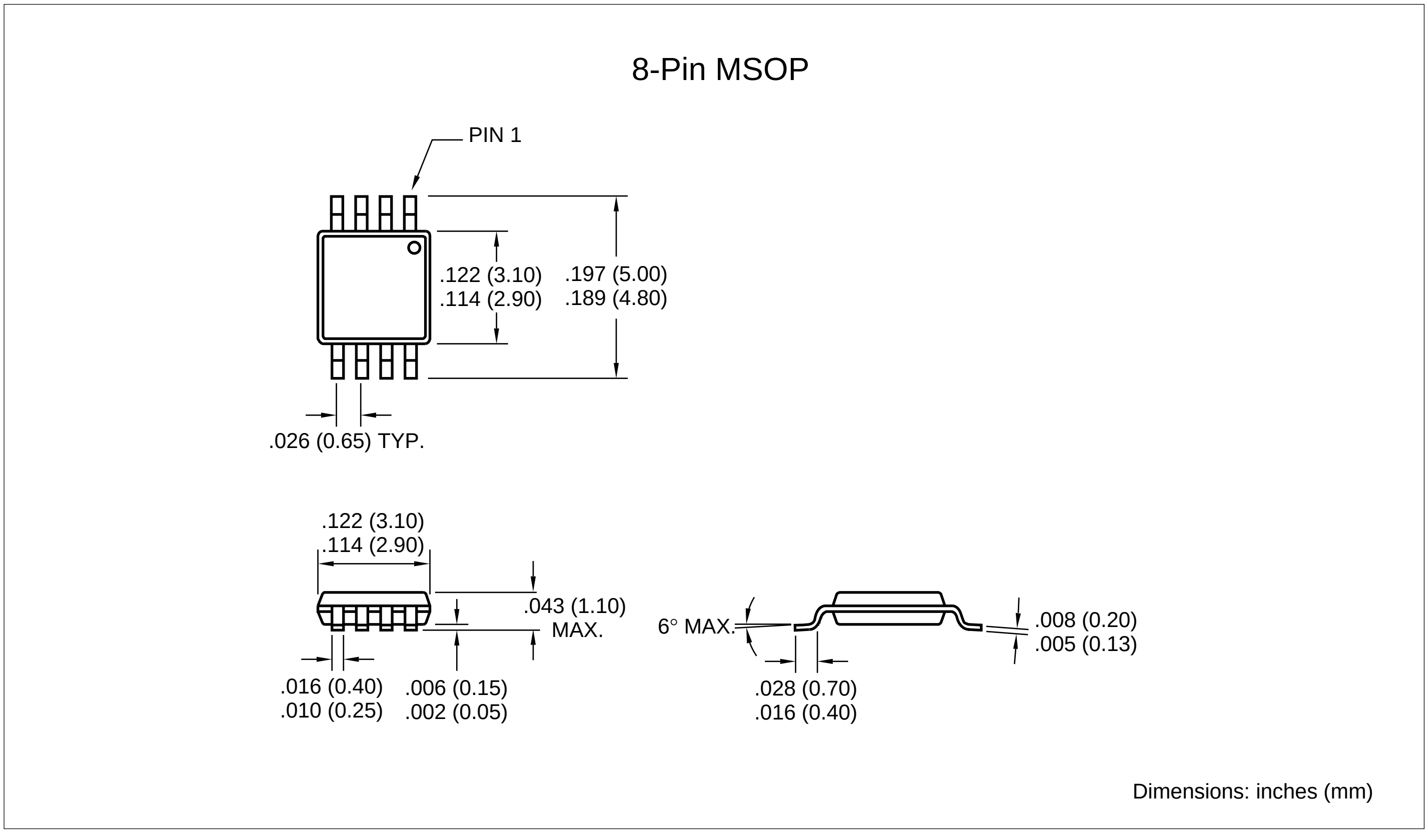
TAPING FORM



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

PACKAGE DIMENSIONS



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