TC1030

Linear Building Block – Quad Low Power Op Amp with Shutdown Modes

Features

- Optimized for Single Supply Operation
- Small Package: 16-Pin QSOP
- Ultra Low Input Bias Current: Less than 100pA
- Low Quiescent Current, Operating: 20µA (Typ.), Shutdown Mode: 6µA (Typ.)
- Rail-to-Rail Inputs and Outputs
- Operates Down to 1.8V
- Can Shut Down One, Two or Three Op Amps

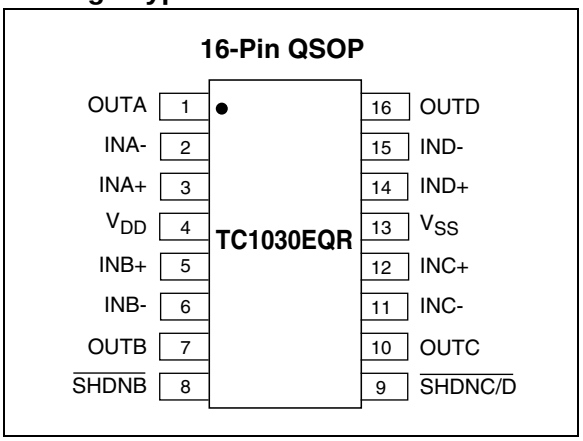
Applications

- Power Management Circuits
- Battery Operated Equipment
- Consumer Products

Device Selection Table

Part Number	Package	Temperature Range
TC1030EQR	16-Pin QSOP	-40°C to +85°C

Package Type



General Description

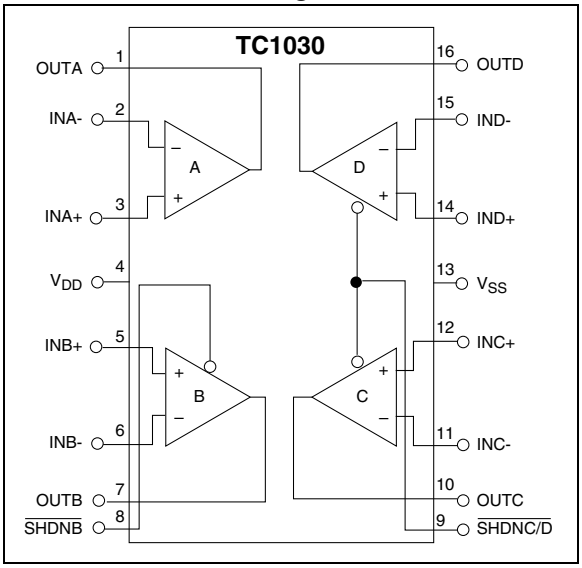
The TC1030 is a quad CMOS operational amplifier designed for low power applications. It has a typical operating supply current of 20µA which is constant over the supply voltage range of 1.8V to 5.5V.

Each op amp has rail-to-rail inputs and output which allow operation at low supply voltages with large input and output signal swings. Two active low shutdown pins are provided. One pin disables op amp B while the other disables op amps C and D. Op amp A is always active. When disabled, the outputs of op amps B, C and D are in a high impedance state.

Packaged in a 16-Pin QSOP, the TC1030 is ideal for battery operated applications.

The TC1030 is packaged in a 16-Pin QSOP, making it ideal for battery operated applications.

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.

TC1030 ELECTRICAL SPECIFICATIONS

Electrical Characteristics: Typical values apply at 25°C and V_{DD} = 3.0V; 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	
Shutdown Inputs						
V_{IH}	Input High Threshold	80% V_{DD}	—	—	V	
V_{IL}	Input Low Threshold	—	—	20% V_{DD}	V	
I_{SI}	Shutdown Input Current, $\overline{SHDNB}$ or $\overline{SHDNC/D}$	—	—	±100	nA	
Op Amps						
I_Q	Supply Current, Operating	—	20	32	µA	All Outputs Open, $\overline{SHDNB}$ = V_{DD}, $\overline{SHDNC/D}$ = V_{DD}
I_{SHDN}	Supply Current Shutdown Mode	—	6	10	µA	$\overline{SHDNB}$ = V_{SS}, $\overline{SHDNC/D}$ = V_{SS}
R_{OUT}(SD)	Output Resistance in Shutdown	20	—	—	MΩ	$\overline{SHDNB}$ = V_{SS}, $\overline{SHDNC/D}$ = V_{SS}
C_{OUT}(SD)	Out Capacitance in Shutdown	—	—	5	pF	$\overline{SHDNB}$ = V_{SS}, $\overline{SHDNC/D}$ = V_{SS}
T_{SEL}	Select Time (V_{OUT} from $\overline{SHDNB}$, $\overline{SHDNC/D}$) = V_{IL}	—	15	—	µsec	R_L = 10kΩ to V_{SS}
T_{DESEL}	Deselect Time (VOUT from $\overline{SHDNB}$, $\overline{SHDNC/D}$) = V_{IL}	—	20	—	nsec	R_L = 10kΩ to V_{SS}
A_{VOL}	Large Signal Voltage Gain	—	100	—	V/mV	R_L = 10kΩ, V_{DD} = 5V
GBWP	Gain-Bandwidth Product	—	90	—	kHz	V_{DD} = 1.8V to 5.5V; V_O = V_{DD} to V_{SS}
V_{ICMR}	Common Mode Input Voltage Range	V_{SS} – 0.2	—	V_{DD} + 0.2	V	
V_{OS}	Input Offset Voltage		±100 ±0.3	±500 ±1.5	µV mV	V_{DD} = 3V, V_{CM} = 1.5V, T_A = 25°C, T_A = –40°C to 85°C
I_B	Input Bias Current	-100	50	100	pA	T_A = 25°C; V_{CM} = V_{DD} to V_{SS}
$V_{OS(DRIFT)}$	Input Offset Voltage Drift	—	±4	—	µV/°C	V_{DD} = 3V; V_{CM} = 1.5V
SR	Slew Rate	—	35	—	mV/µsec	C_L = 100pF; R_L = 1 MΩ to GND, Gain = 1 V_{IN} = V_{SS} to V_{DD}
V_{OUT}	Output Signal Swing	V_{SS} + 0.05	—	V_{DD} – 0.05	V	R_L = 10kΩ
CMRR	Common Mode Rejection Ratio	70	—	—	dB	T_A = 25°C; V_{DD} = 5V; V_{CM} = V_{DD} to V_{SS}
PSRR	Power Supply Rejection Ratio	80	—	—	dB	T_A = 25°C; V_{CM} = V_{SS}; V_{DD} = 1.8V to 5V

TC1030 ELECTRICAL SPECIFICATIONS

Electrical Characteristics: Typical values apply at 25°C and V_{DD} = 3.0V; 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
I_{SRC}	Output Source Current	3	—	—	mA	$V_{IN}+ = V_{DD}$, $V_{IN}- = V_{SS}$ Output Shorted to V_{SS} V_{DD} = 1.8V; Gain = 1
I_{SINK}	DC Output Sink Current	4	—	—	mA	$V_{IN}+ = V_{SS}$, $V_{IN}- = V_{DD}$ Output Shorted to V_{DD} V_{DD} = 1.8V; Gain = 1
E_n	Input Noise Voltage	—	10	—	µVpp	0.1Hz to 10Hz
e_n	Input Noise Voltage Density	—	125	—	nV/$\sqrt{HZ}$	1kHz

2.0 PIN DESCRIPTION

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

TABLE 2-1: PIN FUNCTION TABLE

Pin No. (16-Pin QSOP)	Symbol	Description
1	OUTA	Op amp output.
2	INA-	Op amp inverting input.
3	INA+	Op amp non-inverting input.
4	V_{DD}	Positive supply voltage.
5	INB+	Op amp non-inverting input.
6	INB-	Op amp inverting input.
7	OUTB	Op amp output.
8	$\overline{SHDNB}$	Shutdown op amp B.
9	$\overline{SHDNC/D}$	Shutdown op amps C and D.
10	OUTC	Op amp output.
11	INC-	Op amp inverting input.
12	INC+	Op amp non-inverting input.
13	V_{SS}	Negative supply voltage.
14	IND+	Op amp non-inverting input.
15	IND-	Op amp inverting input.
16	OUTD	Op amp output.

3.0 DETAILED DESCRIPTION

The TC1030 is one of a series of very low power, linear building block products targeted at low voltage, single supply applications. The TC1030 minimum operating voltage is 1.8V, and maximum supply current is only 32µA (fully enabled). It combines four op amps in a single package.

Microchip's op amps are internally compensated to be unity-gain stable and have a typical gain bandwidth product of 90kHz with typical slew rates of 35V/msec.

The amplifier's input range extends beyond both supplies by 200mV and the outputs will swing to within several millivolts of the supplies depending on the load current being driven.

Two shutdown mode pins are incorporated for easy adaptation to system power management schemes. In this state, the shutdown pins allow the user to power on one, two, three, or all four op amps (see Table 4-1). Pin $\overline{\text{SHDNB}}$ can be used to disable op amp B and pin $\overline{\text{SHDNC/D}}$ to disable op amps C and D. Op amp A is always powered on regardless of the states of the shutdown pins. When both shutdown pins are low, the total quiescent current of the TC1030 is only 6µA, typical.

Input offset voltage is 500µV max at 25°C with an input bias current of less than 100pA. This makes the TC1030 extremely suitable for precision, low power applications.

4.0 TYPICAL APPLICATIONS

The TC1030 lends itself to a wide variety of applications, particularly in battery-powered systems. It typically finds application in power management, process supervisory and interface circuitry.

4.1 Voice Band Receive Filter

The majority of spectral energy for human voices is found to be in a 2.7kHz frequency band from 300Hz to 3kHz. To properly recover a voice signal in applications such as radios, cellular phones and voice pagers a low-power bandpass filter that is matched to the human voice spectrum can be implemented using Microchip's CMOS op amps. Figure 4-1 shows a unity gain multi-pole Butterworth filter with ripple less than 0.15dB in the human voice band. The lower 3dB cut-off frequency is 70Hz (single order response) while the upper cut-off frequency is 3.5kHz (fourth order response).

4.2 Supervisory Audio Tone (SAT) Filter for Cellular

Supervisory Audio Tones (SAT) provide a reliable transmission path between cellular subscriber units and base stations. The SAT tone functions much like the current/voltage used in land line telephone systems to indicate that a phone is off the hook. The SAT tone may be one of three frequencies: 5970, 6000 or 6030Hz. A loss of SAT implies that channel conditions are impaired and if SAT is interrupted for more than 5 seconds a cellular call is terminated.

Figure 4-2 shows a high Q (30) second order SAT detection bandpass filter using Microchip's CMOS op amp architecture. This circuit nulls all frequencies except the three SAT tones of interest.

TABLE 4-1: TC1030 SHUTDOWN POWER CONTROL LOGIC

SHDNC/D	SHDNB	OP AMPS ENABLED	OP AMPS DISABLED	MAX. DEVICE SUPPLY CURRENT
V_{IL}	V_{IL}	A	B,C,D	10µA
V_{IL}	V_{IH}	A,B	C,D	16µA
V_{IH}	V_{IL}	A,C,D	B	24µA
V_{IH}	V_{IH}	A,B,C,D	None	32µA

FIGURE 4-1: MULTI-POLE BUTTERWORTH VOICE BAND RECEIVE FILTER

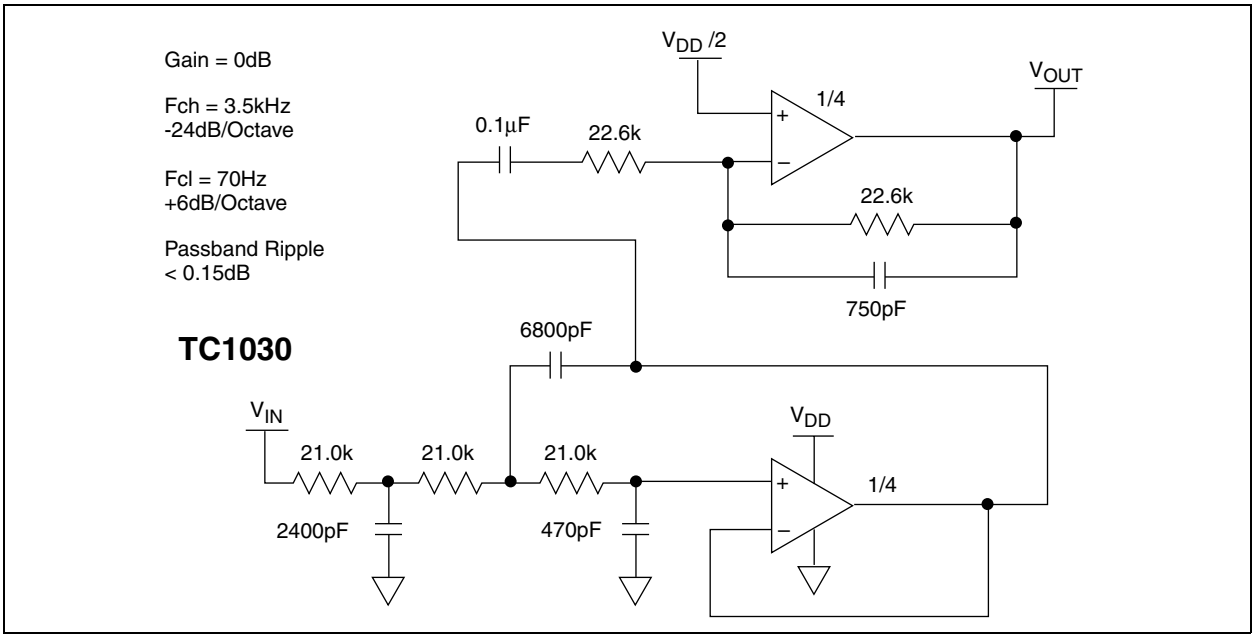
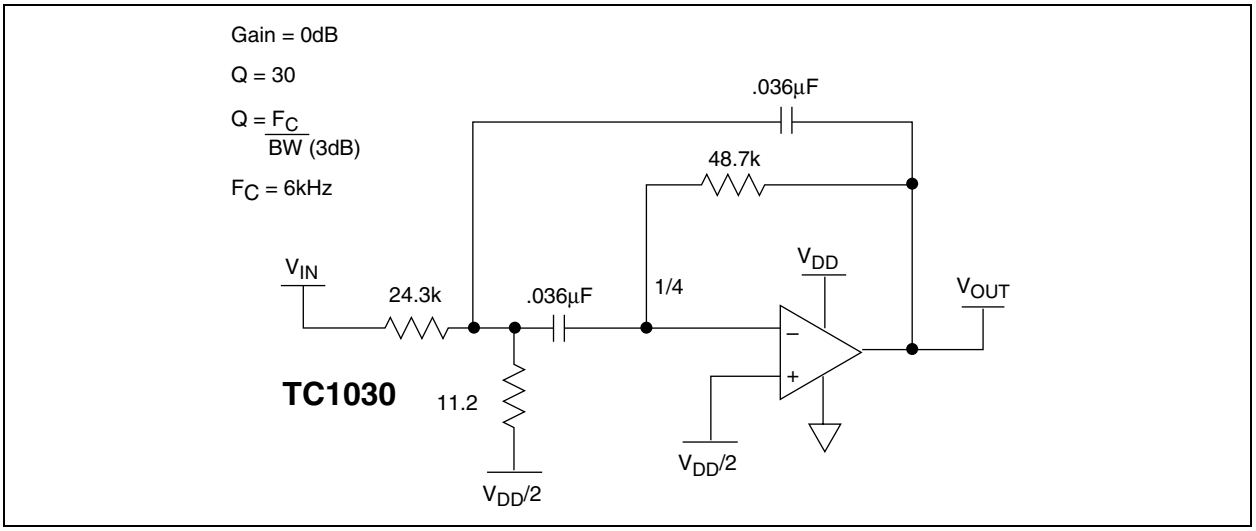


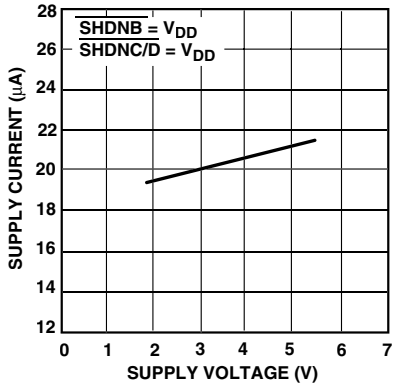
FIGURE 4-2: SECOND ORDER SAT BANDPASS FILTER



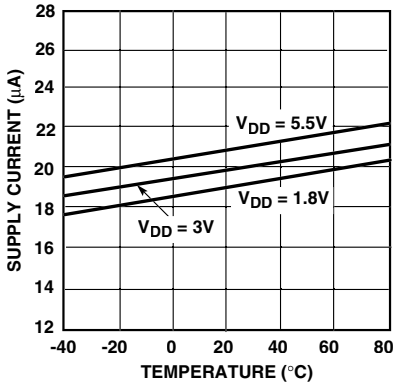
5.0 TYPICAL CHARACTERISTICS

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.

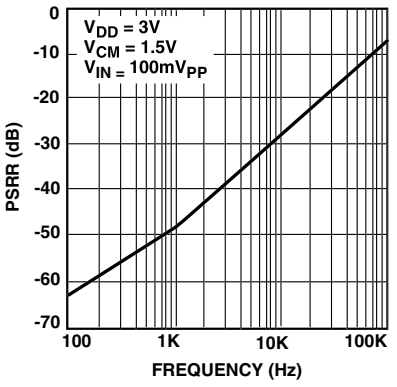
Op Amp Supply Voltage vs. Supply Current



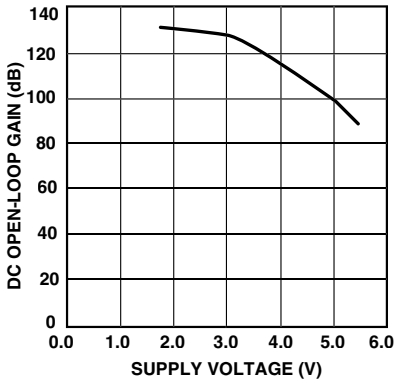
Op Amp Supply Current vs. Temperature



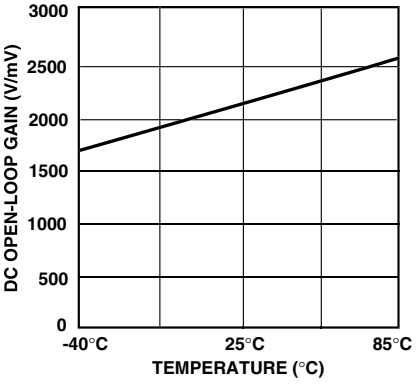
Op Amp Power Supply Rejection Ratio (PSRR) vs. Frequency



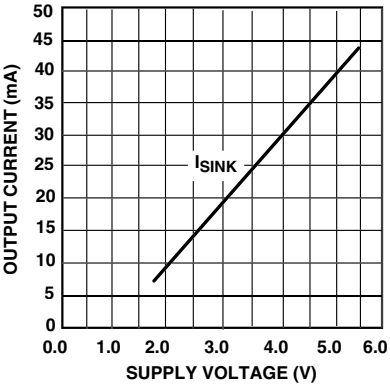
Op Amp DC Open-Loop Gain vs. Supply Voltage



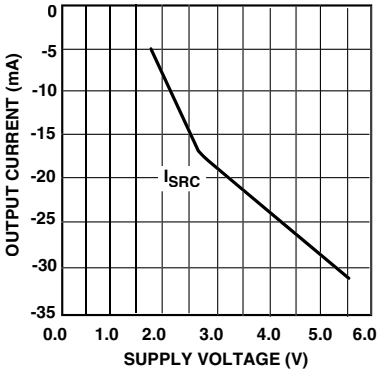
Op Amp DC Open-Loop Gain vs. Temperature



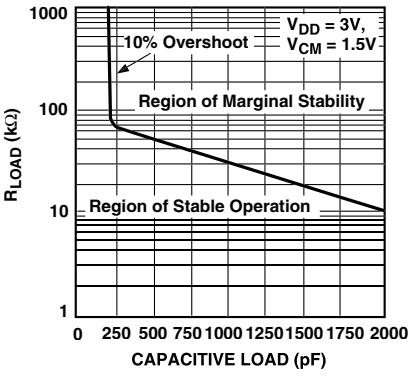
Op Amp Short-Circuit Current vs. Supply Voltage



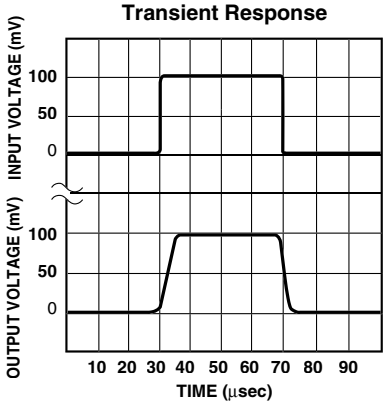
Op Amp Short-Circuit Current vs. Supply Voltage



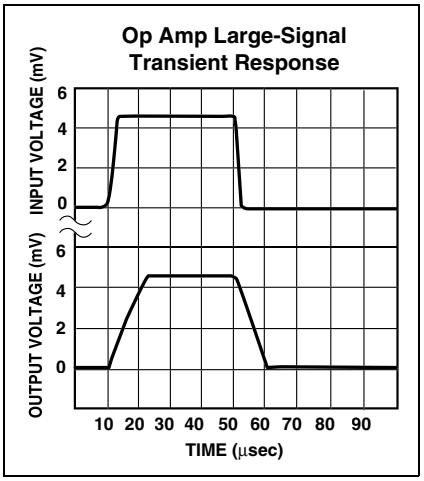
Op Amp Load Resistance vs. Load Capacitance



Op Amp Small-Signal Transient Response



5.0 TYPICAL CHARACTERISTICS (CONTINUED)



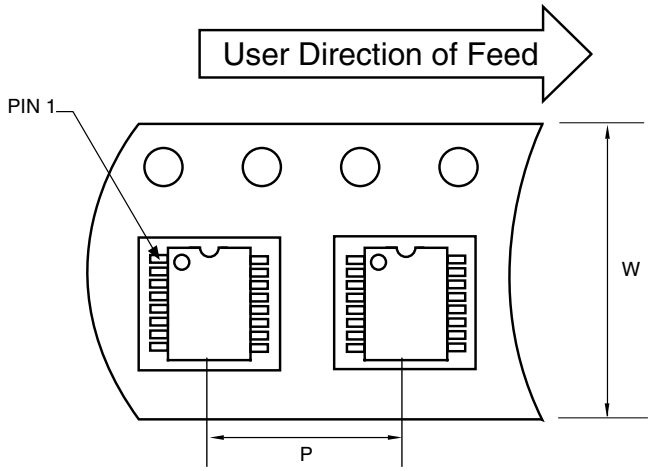
6.0 PACKAGING INFORMATION

6.1 Package Marking Information

Package marking data not available at this time.

6.2 Taping Form

Component Taping Orientation for 16-Pin QSOP (Narrow) Devices



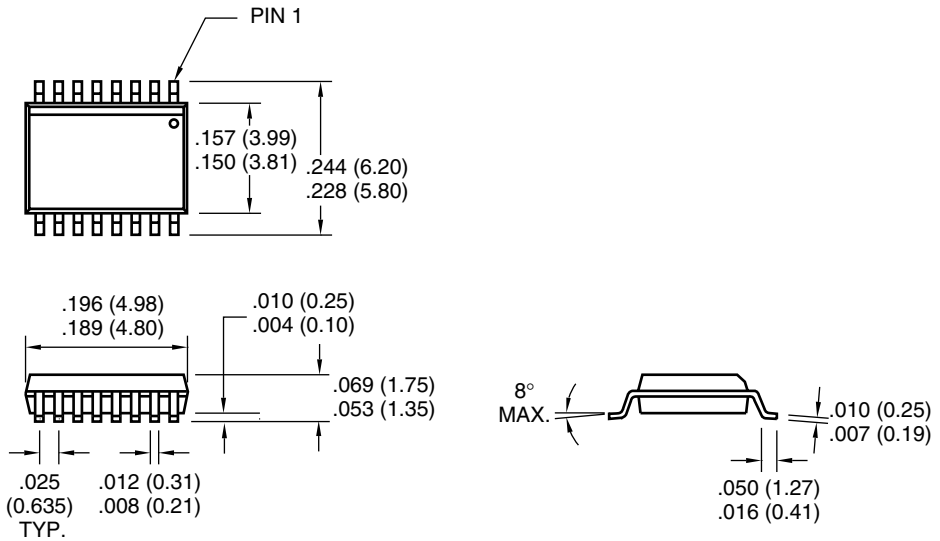
Standard Reel Component Orientation
for TR Suffix Device

Carrier Tape, Reel Size, Number of Components Per Reel and Reel Size

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

6.3 Package Dimensions

16-Pin QSOP (Narrow)



Dimensions: inches (mm)

NOTES:

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:

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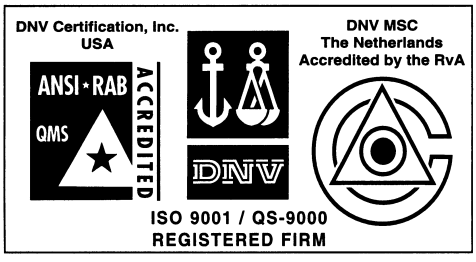

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