



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

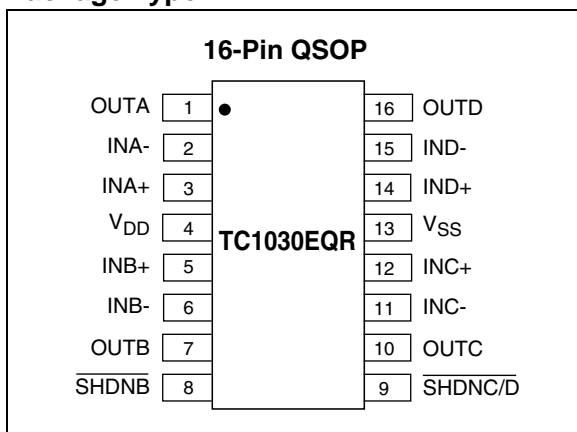
Applications

- 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

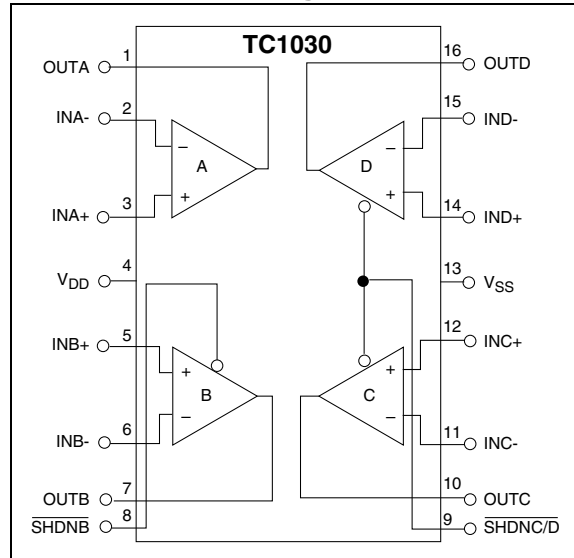
The TC1030 is a quad CMOS operational amplifier designed for low power applications. It has a typical operating supply current of 20µA which is constant over the supply voltage range of 1.8V to 5.5V.

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



TC1030

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 $V_{DD} = 3.0V$; $T_A = -40^\circ$ 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	$R_L = 10k\Omega$ to V_{SS}
T_{DESEL}	Deselect Time (V_{OUT} from \overline{SHDNB} , $\overline{SHDNC/D}$) = V_{IL}	—	20	—	nsec	$R_L = 10k\Omega$ to V_{SS}
A_{VOL}	Large Signal Voltage Gain	—	100	—	V/mV	$R_L = 10k\Omega$, $V_{DD} = 5V$
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	$V_{DD} = 3V$, $V_{CM} = 1.5V$, $T_A = 25^\circ C$, $T_A = -40^\circ C$ to 85°C
I_B	Input Bias Current	-100	50	100	pA	$T_A = 25^\circ C$; $V_{CM} = V_{DD}$ 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	$C_L = 100pF$; $R_L = 1 M\Omega$ 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	$R_L = 10k\Omega$
CMRR	Common Mode Rejection Ratio	70	—	—	dB	$T_A = 25^\circ C$; $V_{DD} = 5V$; $V_{CM} = V_{DD}$ to V_{SS}
PSRR	Power Supply Rejection Ratio	80	—	—	dB	$T_A = 25^\circ C$; $V_{CM} = V_{SS}$; $V_{DD} = 1.8V$ to 5V

TC1030 ELECTRICAL SPECIFICATIONS

Electrical Characteristics: Typical values apply at 25°C and $V_{DD} = 3.0V$; $T_A = -40^\circ$ to $+85^\circ C$, 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	—	μV_{pp}	0.1Hz to 10Hz
e_n	Input Noise Voltage Density	—	125	—	nV/\sqrt{Hz}	1kHz

TC1030

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	$\overline{\text{SHDNB}}$	Shutdown op amp B.
9	$\overline{\text{SHDNC/D}}$	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 32 μ A (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 **SHDNB** can be used to disable op amp B and pin **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 6 μ A, typical.

Input offset voltage is 500 μ V 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	10 μ A
V _{IL}	V _{IH}	A,B	C,D	16 μ A
V _{IH}	V _{IL}	A,C,D	B	24 μ A
V _{IH}	V _{IH}	A,B,C,D	None	32 μ A

TC1030

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

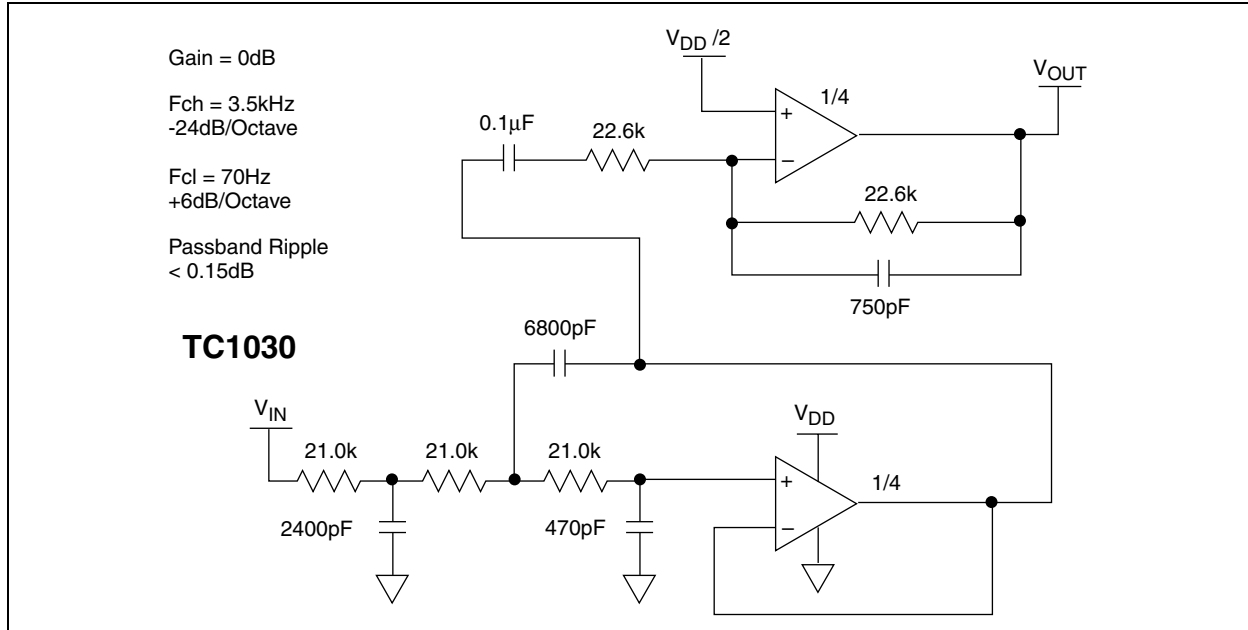
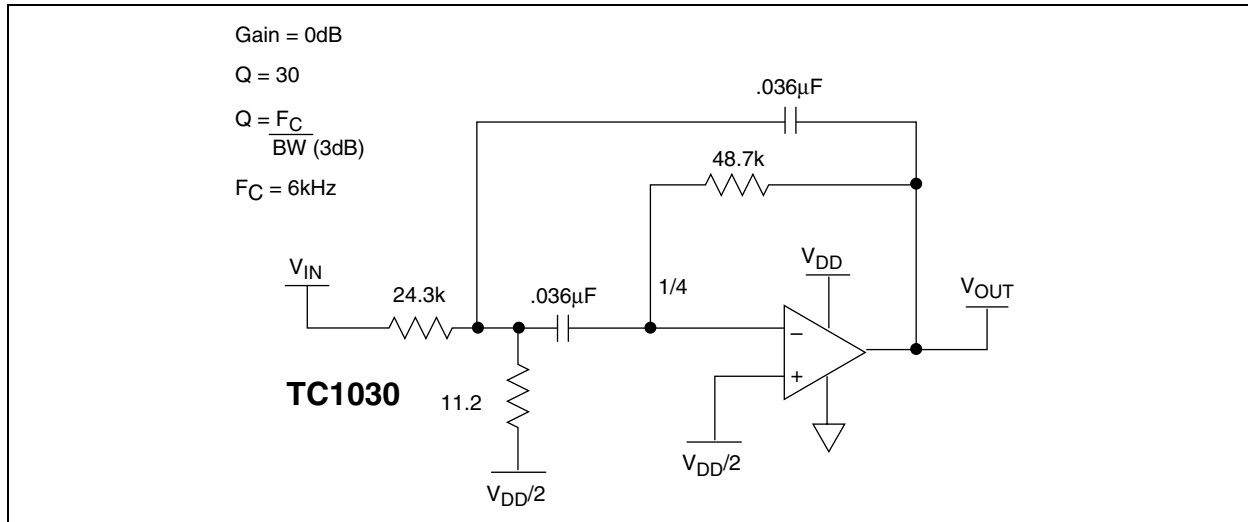
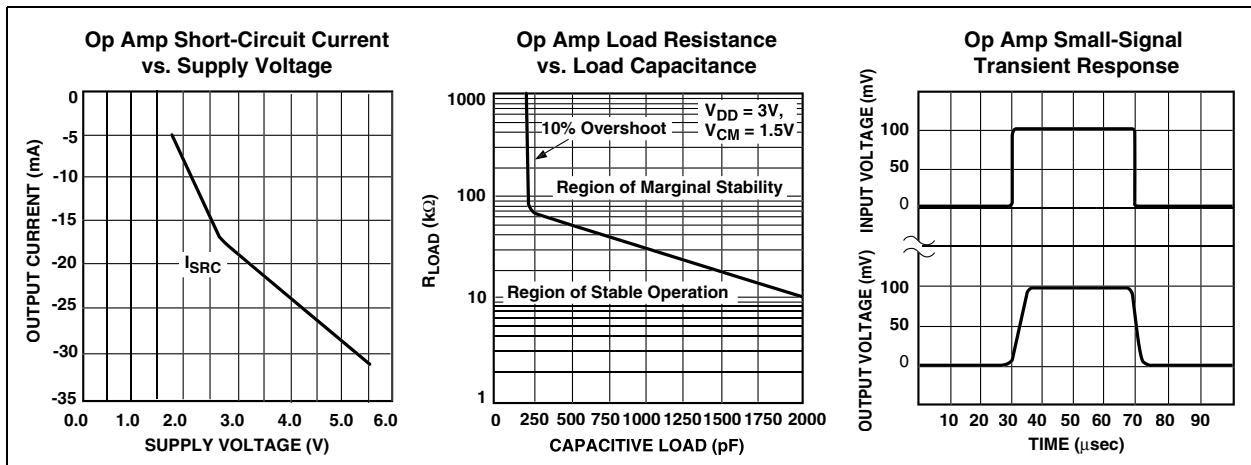
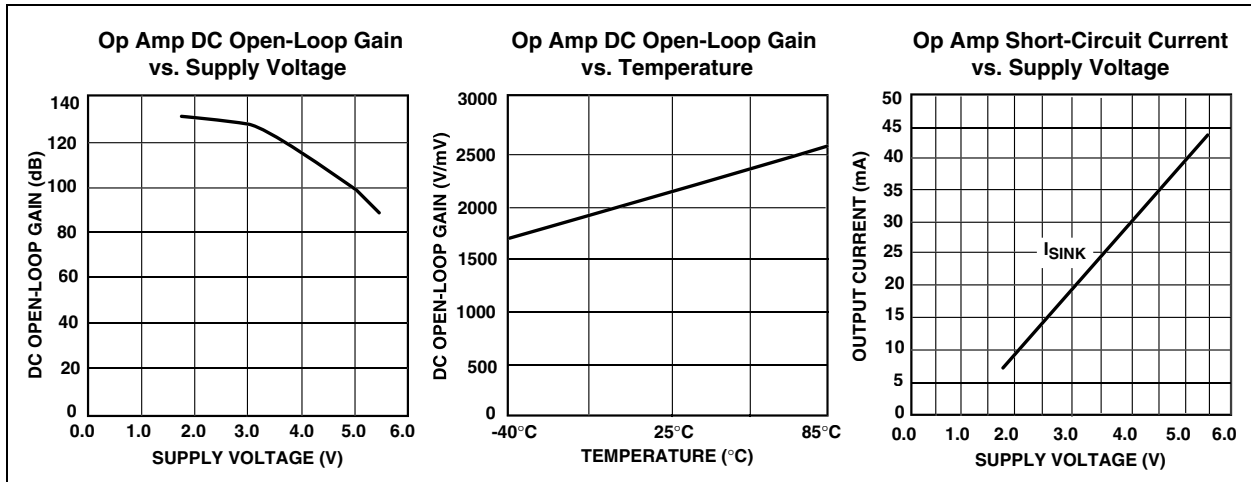
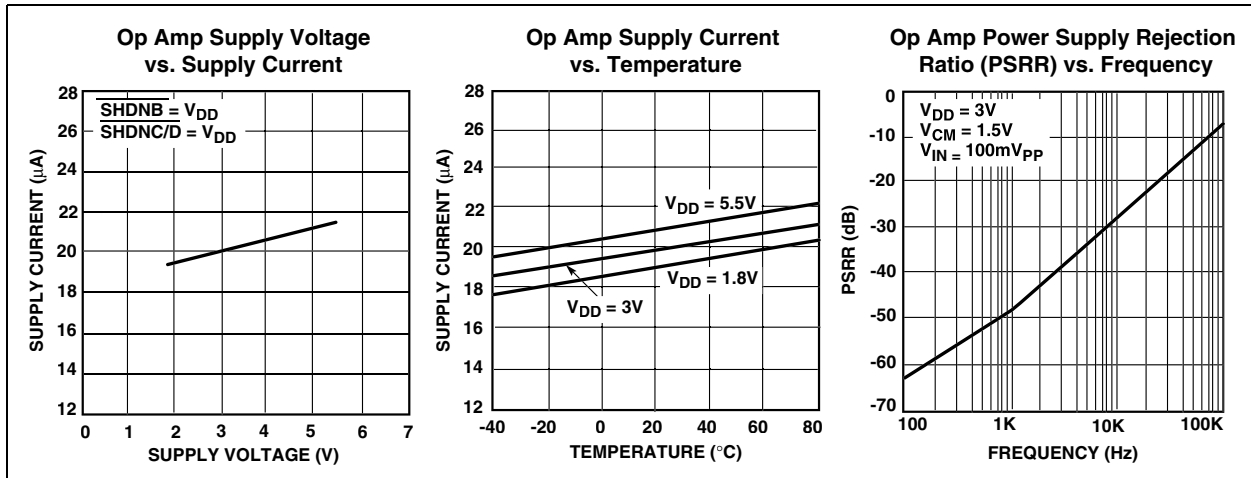


FIGURE 4-2: SECOND ORDER SAT BANDPASS FILTER

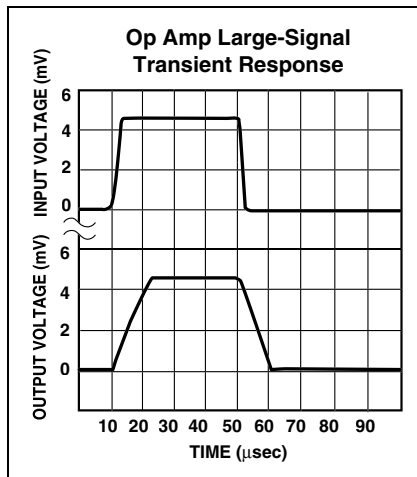


5.0 TYPICAL CHARACTERISTICS

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.



5.0 TYPICAL CHARACTERISTICS (CONTINUED)

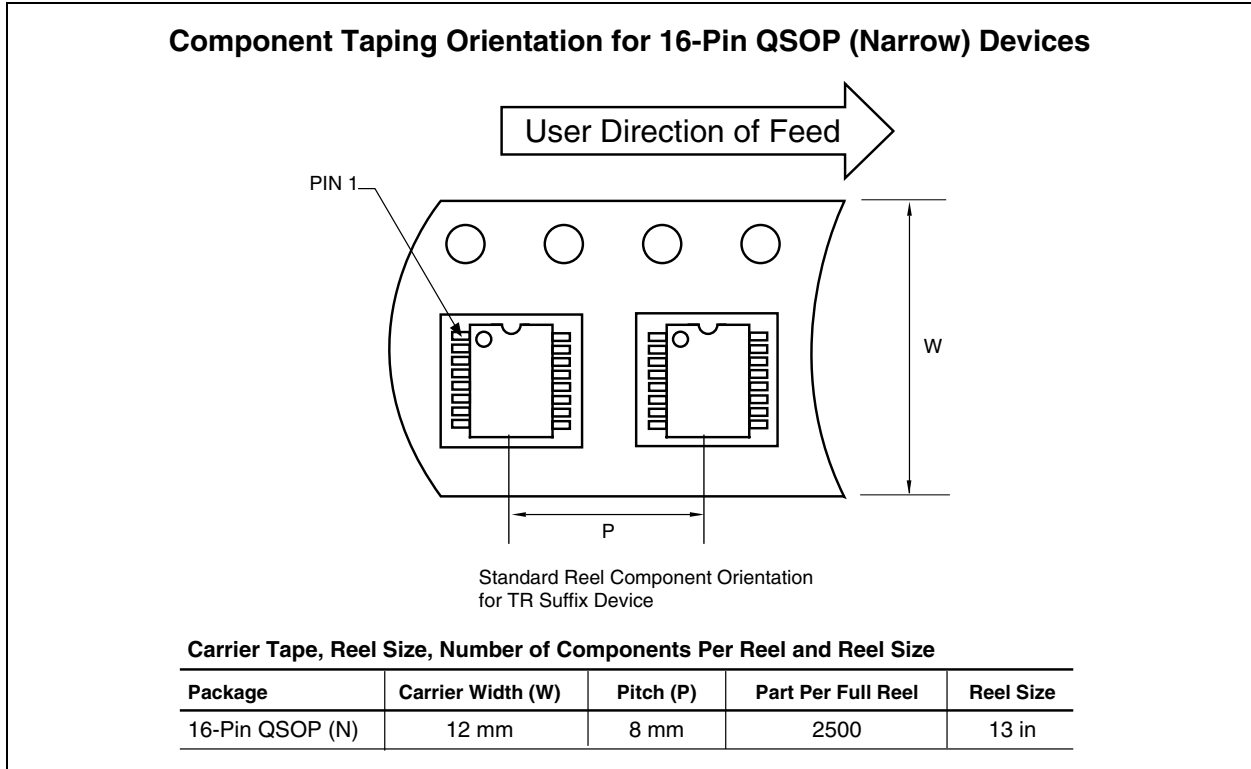


6.0 PACKAGING INFORMATION

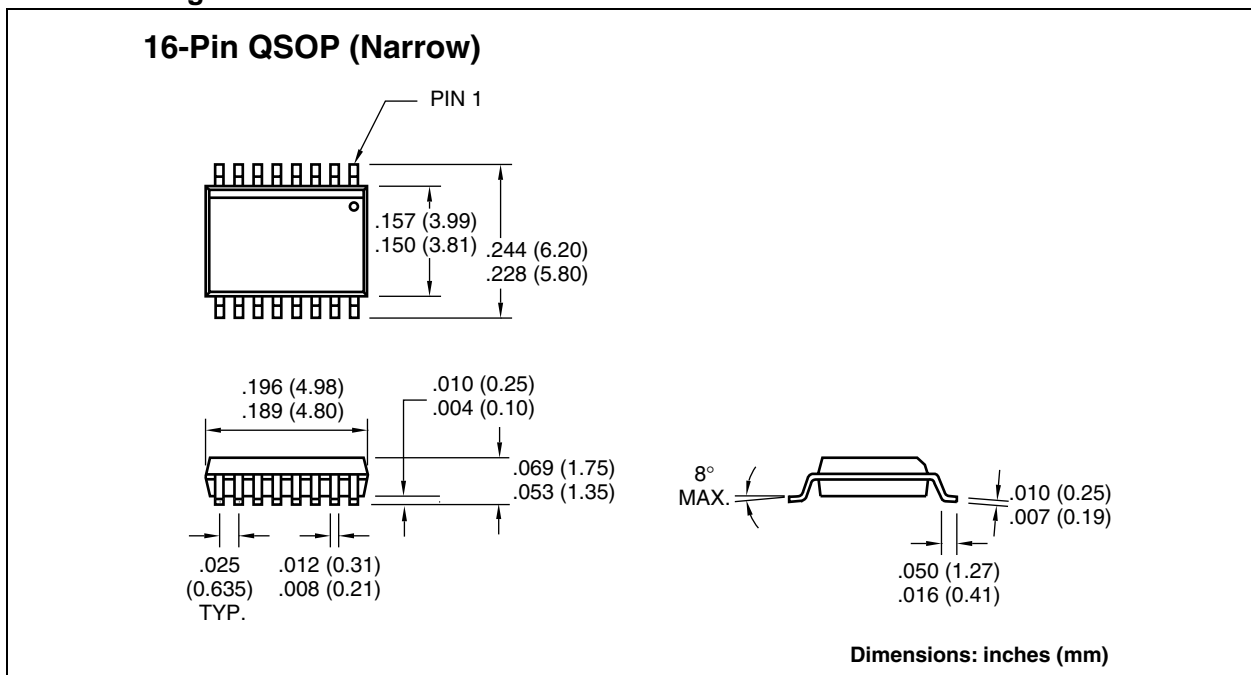
6.1 Package Marking Information

Package marking data not available at this time.

6.2 Taping Form



6.3 Package Dimensions



TC1030

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:

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.

New Customer Notification System

Register on our web site (www.microchip.com/cn) to receive the most current information on our products.

TC1030

NOTES:

Information contained in this publication regarding device applications and the like is intended through suggestion only and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. No representation or warranty is given and no liability is assumed by Microchip Technology Incorporated with respect to the accuracy or use of such information, or infringement of patents or other intellectual property rights arising from such use or otherwise. Use of Microchip's products as critical components in life support systems is not authorized except with express written approval by Microchip. No licenses are conveyed, implicitly or otherwise, under any intellectual property rights.

Trademarks


The Microchip name and logo, the Microchip logo, FilterLab, KEELOQ, microID, MPLAB, PIC, PICmicro, PICMASTER, PICSTART, PRO MATE, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

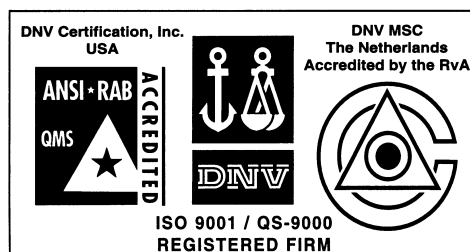
dsPIC, ECONOMONITOR, FanSense, FlexROM, fuzzyLAB, In-Circuit Serial Programming, ICSP, ICEPIC, microPort, Migratable Memory, MPASM, MPLIB, MPLINK, MPSIM, MXDEV, PICC, PICDEM, PICDEM.net, rfPIC, Select Mode and Total Endurance are trademarks of Microchip Technology Incorporated in the U.S.A.

Serialized Quick Turn Programming (SQTP) is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

© 2002, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

 Printed on recycled paper.



Microchip received QS-9000 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona in July 1999 and Mountain View, California in March 2002. The Company's quality system processes and procedures are QS-9000 compliant for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, non-volatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001 certified.



MICROCHIP

WORLDWIDE SALES AND SERVICE

AMERICAS

Corporate Office

2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200 Fax: 480-792-7277
Technical Support: 480-792-7627
Web Address: <http://www.microchip.com>

Rocky Mountain

2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7966 Fax: 480-792-7456

Atlanta

500 Sugar Mill Road, Suite 200B
Atlanta, GA 30350
Tel: 770-640-0034 Fax: 770-640-0307

Boston

2 Lan Drive, Suite 120
Westford, MA 01886
Tel: 978-692-3848 Fax: 978-692-3821

Chicago

333 Pierce Road, Suite 180
Itasca, IL 60143
Tel: 630-285-0071 Fax: 630-285-0075

Dallas

4570 Westgrove Drive, Suite 160
Addison, TX 75001
Tel: 972-818-7423 Fax: 972-818-2924

Detroit

Tri-Atria Office Building
32255 Northwestern Highway, Suite 190
Farmington Hills, MI 48334
Tel: 248-538-2250 Fax: 248-538-2260

Kokomo

2767 S. Albright Road
Kokomo, Indiana 46902
Tel: 765-864-8360 Fax: 765-864-8387

Los Angeles

18201 Von Karman, Suite 1090
Irvine, CA 92612
Tel: 949-263-1888 Fax: 949-263-1338

New York

150 Motor Parkway, Suite 202
Hauppauge, NY 11788
Tel: 631-273-5305 Fax: 631-273-5335

San Jose

Microchip Technology Inc.
2107 North First Street, Suite 590
San Jose, CA 95131
Tel: 408-436-7950 Fax: 408-436-7955

Toronto

6285 Northam Drive, Suite 108
Mississauga, Ontario L4V 1X5, Canada
Tel: 905-673-0699 Fax: 905-673-6509

ASIA/PACIFIC

Australia

Microchip Technology Australia Pty Ltd
Suite 22, 41 Rawson Street
Epping 2121, NSW
Australia
Tel: 61-2-9868-6733 Fax: 61-2-9868-6755

China - Beijing

Microchip Technology Consulting (Shanghai)
Co., Ltd., Beijing Liaison Office
Unit 915
Bei Hai Wan Tai Bldg.
No. 6 Chaoyangmen Beidajie
Beijing, 100027, No. China
Tel: 86-10-85282100 Fax: 86-10-85282104

China - Chengdu

Microchip Technology Consulting (Shanghai)
Co., Ltd., Chengdu Liaison Office
Rm. 2401, 24th Floor,
Ming Xing Financial Tower
No. 88 TIDU Street
Chengdu 610016, China
Tel: 86-28-6766200 Fax: 86-28-6766599

China - Fuzhou

Microchip Technology Consulting (Shanghai)
Co., Ltd., Fuzhou Liaison Office
Unit 28F, World Trade Plaza
No. 71 Wusi Road
Fuzhou 350001, China
Tel: 86-591-7503506 Fax: 86-591-7503521

China - Shanghai

Microchip Technology Consulting (Shanghai)
Co., Ltd.
Room 701, Bldg. B
Far East International Plaza
No. 317 Xian Xia Road
Shanghai, 200051
Tel: 86-21-6275-5700 Fax: 86-21-6275-5060

China - Shenzhen

Microchip Technology Consulting (Shanghai)
Co., Ltd., Shenzhen Liaison Office
Rm. 1315, 13/F, Shenzhen Kerry Centre,
Renminnan Lu
Shenzhen 518001, China
Tel: 86-755-2350361 Fax: 86-755-2366086

Hong Kong

Microchip Technology Hongkong Ltd.
Unit 901-6, Tower 2, Metroplaza
223 Hing Fong Road
Kwai Fong, N.T., Hong Kong
Tel: 852-2401-1200 Fax: 852-2401-3431

India

Microchip Technology Inc.
India Liaison Office
Divyasree Chambers
1 Floor, Wing A (A3/A4)
No. 11, O'Shaugnessey Road
Bangalore, 560 025, India
Tel: 91-80-2290061 Fax: 91-80-2290062

Japan

Microchip Technology Japan K.K.
Benex S-1 6F
3-18-20, Shinyokohama
Kohoku-Ku, Yokohama-shi
Kanagawa, 222-0033, Japan
Tel: 81-45-471-6166 Fax: 81-45-471-6122

Korea

Microchip Technology Korea
168-1, Youngbo Bldg. 3 Floor
Samsung-Dong, Kangnam-Ku
Seoul, Korea 135-882
Tel: 82-2-554-7200 Fax: 82-2-558-5934

Singapore

Microchip Technology Singapore Pte Ltd.
200 Middle Road
#07-02 Prime Centre
Singapore, 188980
Tel: 65-6334-8870 Fax: 65-6334-8850

Taiwan

Microchip Technology Taiwan
11F-3, No. 207
Tung Hua North Road
Taipei, 105, Taiwan
Tel: 886-2-2717-7175 Fax: 886-2-2545-0139

EUROPE

Denmark

Microchip Technology Nordic ApS
Regus Business Centre
Lautrup høj 1-3
Ballerup DK-2750 Denmark
Tel: 45 4420 9895 Fax: 45 4420 9910

France

Microchip Technology SARL
Parc d'Activite du Moulin de Massy
43 Rue du Saule Trapu
Batiment A - 1er Etage
91300 Massy, France
Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79

Germany

Microchip Technology GmbH
Gustav-Heinemann Ring 125
D-81739 Munich, Germany
Tel: 49-89-627-144 0 Fax: 49-89-627-144-44

Italy

Microchip Technology SRL
Centro Direzionale Colleoni
Palazzo Taurus 1 V. Le Colleoni 1
20041 Agrate Brianza
Milan, Italy
Tel: 39-039-65791-1 Fax: 39-039-6899883

United Kingdom

Arizona Microchip Technology Ltd.
505 Eskdale Road
Winnersh Triangle
Wokingham
Berkshire, England RG41 5TU
Tel: 44 118 921 5869 Fax: 44-118 921-5820

03/01/02

