

## Linear Building Block – Low Power Voltage Reference with Programmable Hysteresis Comparator and Shutdown

### 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: 6 $\mu$ A (Typ.), Shutdown Mode: 0.1 $\mu$ A (Typ.)
- Rail-to-Rail Inputs and Outputs
- Operates Down to  $V_{DD} = 1.8V$
- Programmable Hysteresis

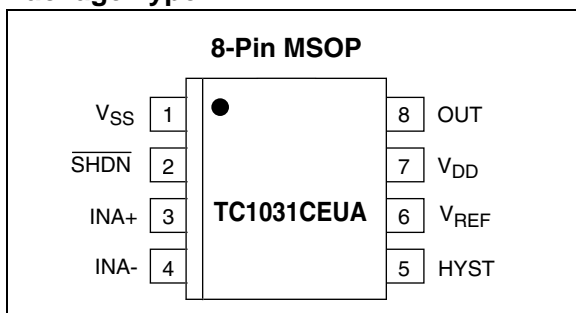
### Applications

- Power Management Circuits
- Battery Operated Equipment
- Consumer Products

### Device Selection Table

Part Number	Package	Temperature Range
TC1031CEUA	8-Pin MSOP	-40°C to +85°C

### Package Type



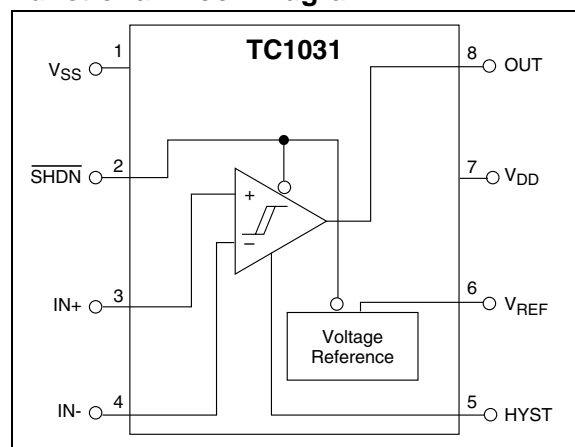
### General Description

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  $V_{DD} = 1.8V$ . Typical active supply current is 6 $\mu$ A. 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 0.1 $\mu$ A (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.

### Functional Block Diagram



# TC1031

## 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.

### TC1031 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
$V_{DD}$	Supply Voltage	1.8	—	5.5	V	
$I_Q$	Supply Current, Operating	—	6	10	$\mu A$	All Outputs Open, $\overline{SHDN} = V_{DD}$
$I_{SHDN}$	Supply Current, Shutdown	—	—	0.1	$\mu A$	$\overline{SHDN} = V_{SS}$
<b>Shutdown Input</b>						
$V_{IH}$	Input High Threshold	80% $V_{DD}$	—	—	V	
$V_{IL}$	Input Low Threshold	—	—	20% $V_{DD}$	V	
$I_{SI}$	Shutdown Input Current	—	—	$\pm 100$	nA	
<b>Comparator</b>						
$R_{OUT} (SD)$	Output Resistance in Shutdown	20	—	—	$M\Omega$	$\overline{SHDN} = V_{SS}$
$C_{OUT} (SD)$	Output Capacitance in Shutdown	—	—	5	pF	$\overline{SHDN} = V_{SS}$
$T_{SEL}$	Select Time	—	20	—	$\mu sec$	$V_{OUT}$ Valid from $\overline{SHDN} = V_{IH}$ $R_L = 10k\Omega$ to $V_{SS}$
$T_{DESEL}$	Deselect Time	—	500	—	nsec	$V_{OUT}$ Invalid from $\overline{SHDN} = V_{IL}$ $R_L = 10k\Omega$ to $V_{SS}$
$V_{ICMR}$	Common-Mode Input Voltage Range	$V_{SS} - 0.2$	—	$V_{DD} + 0.2$	V	
$V_{OS}$	Input Offset Voltage ( <b>Note 1</b> )	-5	—	+5	mV	$V_{DD} = 3V$ , $V_{CM} = 1.5V$
$I_B$	Input Bias Current	—	—	$\pm 100$	pA	$T_A = 25^\circ C$ $IN+, IN- = V_{DD}$ to $V_{SS}$
$V_{OH}$	Output High Voltage	$V_{DD} - 0.3$	—	—	V	$R_L = 10k\Omega$ to $V_{SS}$
$V_{OL}$	Output Low Voltage	—	—	0.3	V	$R_L = 10k\Omega$ to $V_{DD}$
CMRR	Common Mode Rejection Ratio	66	—	—	dB	$T_A = 25^\circ C$ , $V_{DD} = 5V$ $V_{CM} = V_{DD}$ to $V_{SS}$
PSRR	Power Supply Rejection Ratio	60	—	—	dB	$T_A = 25^\circ C$ , $V_{DD} = 1.8V$ to $5V$ $V_{CM} = 1.2V$
$I_{SRC}$	Output Source Current	1	—	—	mA	$IN+ = V_{DD}$ , $IN- = V_{SS}$ $V_{DD} = 1.8V$ , Output Shorted to $V_{SS}$
$I_{SINK}$	Output Sink Current	2	—	—	mA	$IN+ = V_{SS}$ , $IN- = V_{DD}$ , $V_{DD} = 1.8V$ , Output Shorted to $V_{DD}$
$V_{HYST}$	Voltage Range at HYST Pin	$V_{REF} - 0.08$	—	$V_{REF}$	V	
$I_{HYST}$	Hysteresis Input Current	—	—	$\pm 100$	nA	
$t_{PD1}$	Response Time	—	4	—	$\mu sec$	100mV Overdrive; $C_L = 100pF$
$t_{PD2}$	Response Time	—	6	—	$\mu sec$	100mV Overdrive; $C_L = 100pF$

**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  $V_{REF}$

## TC1031 ELECTRICAL SPECIFICATIONS (CONTINUED)

**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
<b>Voltage Reference</b>						
$V_{REF}$	Reference Voltage	1.176	1.200	1.224	V	
$I_{REF(SOURCE)}$	Source Current	50	—	—	$\mu A$	
$I_{REF(SINK)}$	Sink Current	50	—	—	$\mu A$	
$R_{OUT(SD)}$	Output Resistance in Shutdown	20	—	—	$M\Omega$	$\overline{SHDN} = V_{SS}$
$C_{OUT(SD)}$	Output Capacitance in Shutdown	—	—	5	pF	$\overline{SHDN} = V_{SS}$
$T_{SEL}$	Select Time	—	200	—	$\mu sec$	REF Valid from $\overline{SHDN} = V_{IH}$ $R_L = 100k\Omega$ to $V_{SS}$
$T_{DESEL}$	Deselect Time	—	10	—	$\mu sec$	REF Invalid from $\overline{SHDN} = V_{IL}$ $R_L = 100k\Omega$
$C_{L(REF)}$	Load Capacitance	—	—	100	pF	
$E_{VREF}$	Voltage Noise	—	20	—	$\mu V_{RMS}$	100Hz to 100kHz
$e_{VREF}$	Noise Density	—	10	—	$\mu V/\sqrt{Hz}$	1kHz

**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  $V_{REF}$

# TC1031

---

---

## 2.0 PIN DESCRIPTIONS

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	$V_{SS}$	Negative power supply.
2	$\overline{SHDN}$	Shutdown input.
3	IN+	Comparator non-inverting input.
4	IN-	Comparator inverting input.
5	HYST	Adjustable hysteresis input.
6	$V_{REF}$	Voltage reference output.
7	$V_{DD}$	Positive power supply.
8	OUT	Comparator output.

## 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

$\overline{\text{SHDN}}$  at  $V_{IL}$  disables both the comparator and voltage reference and reduces the supply current to less than 0.1µA. The  $\overline{\text{SHDN}}$  input cannot be allowed to float; when not used, connect it to  $V_{DD}$ . 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 latching will occur when the device is driven to its enabled state when  $\overline{\text{SHDN}}$  is set to  $V_{IH}$ .

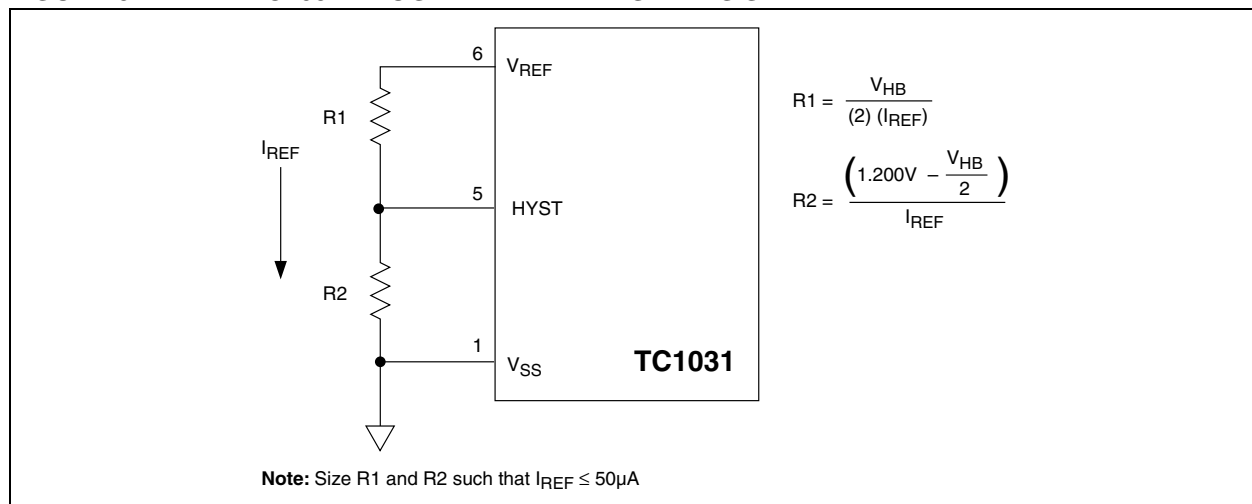
### 3.4 Programmable Hysteresis

Hysteresis is added to the comparators by connecting a resistor R1 between the  $V_{REF}$  and HYST pins and another resistor R2 between the HYST pin and  $V_{SS}$ . For no hysteresis  $V_{REF}$  should be directly connected to HYST. The hysteresis,  $V_{HB}$ , is equal to twice the voltage difference between the  $V_{REF}$  and HYST pins, where:

$$V_{HB} = 2 * V_{REF} * R1 / (R1 + R2) \quad (\text{See Figure 3-1})$$

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

**FIGURE 3-1: TC1031 PROGRAMMABLE HYSTERESIS**

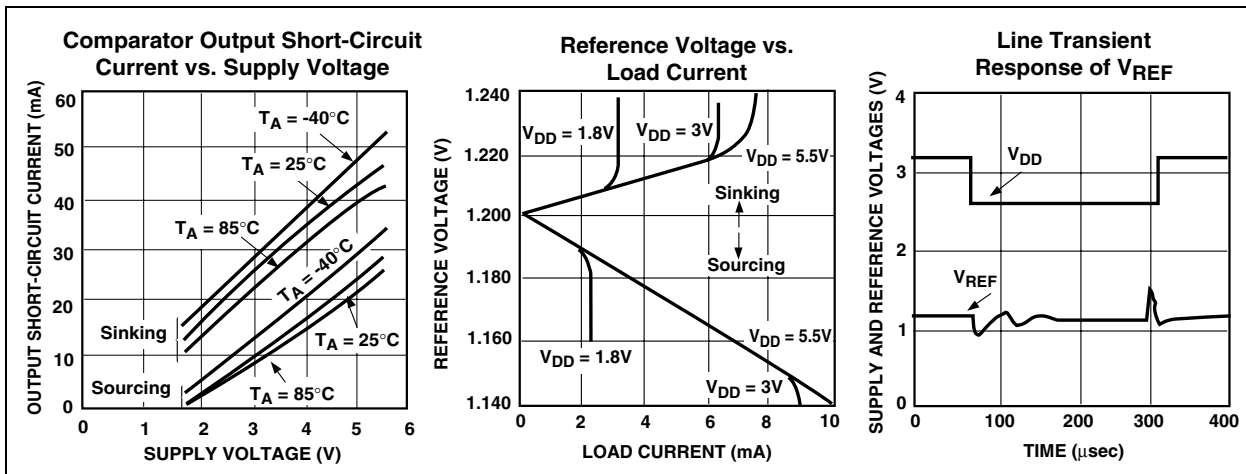
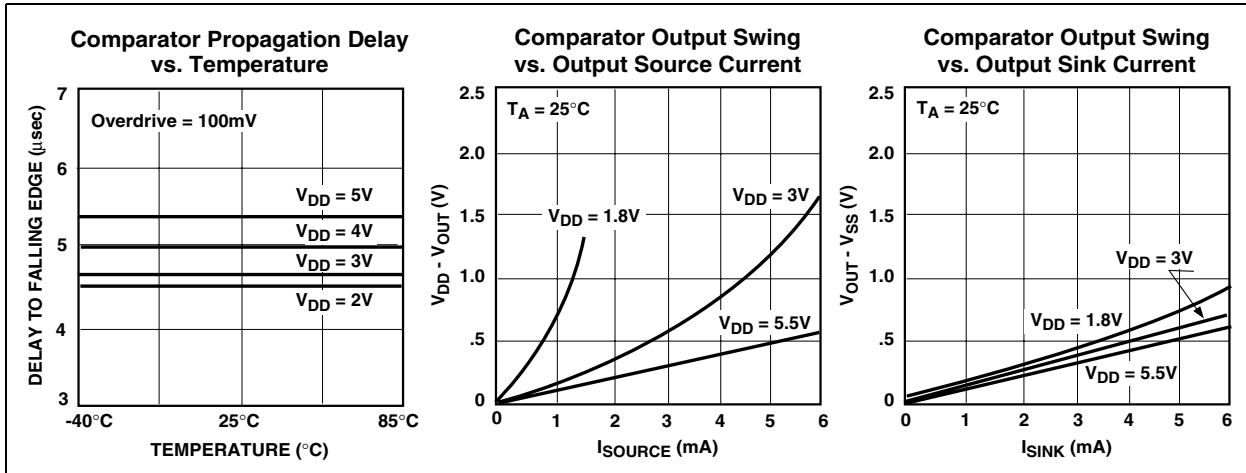
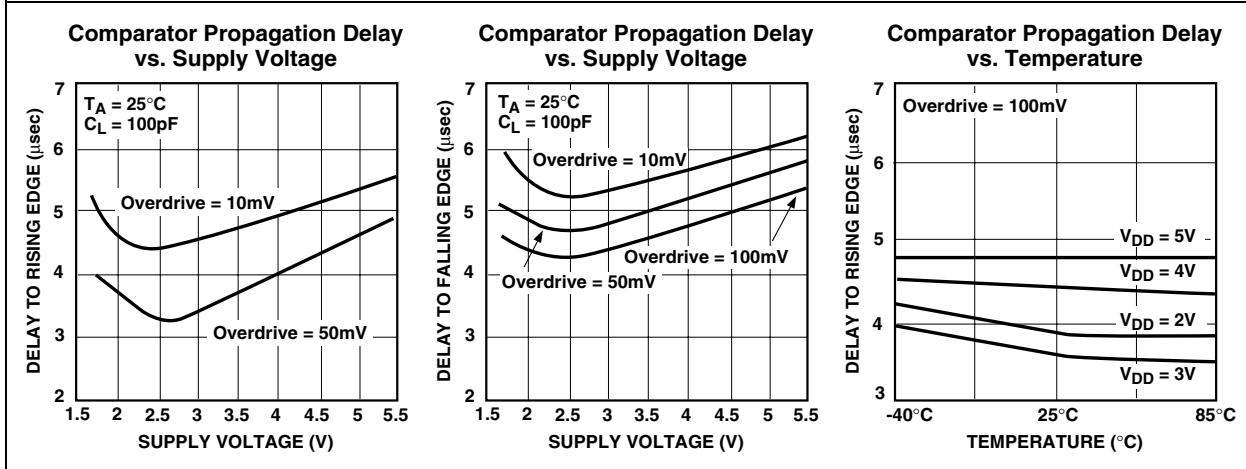


## 4.0 TYPICAL APPLICATIONS

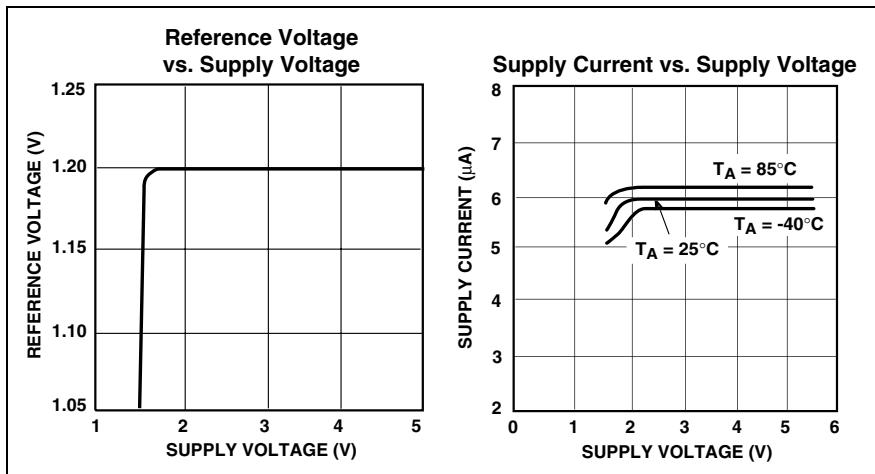
The TC1031 lends itself to a wide variety of applications, particularly in battery-powered systems. It typically finds application in power management, processor supervisory and interface circuitry.

## 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)



# TC1031

## 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

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)**



## **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](http://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](http://www.microchip.com/cn)) to receive the most current information on our products.

# TC1031

---

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.

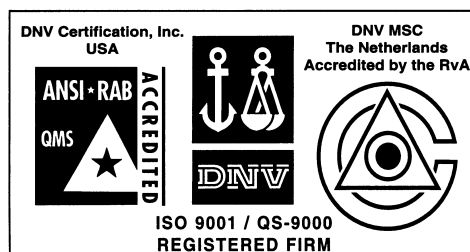
dsPIC, ECONOMONITOR, FanSense, FlexROM, fuzzyLAB, In-Circuit Serial Programming, ICSP, ICEPIC, microPort, Migratable Memory, MPASM, MPLIB, MPLINK, MPSIM, MXDEV, PICC, PICDEM, PICDEM.net, rfPIC, Select Mode and Total Endurance are trademarks of Microchip Technology Incorporated in the U.S.A.

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

