

Dual Auto-Zeroed Operational Amplifiers

Features

- First Monolithic Dual Auto-Zeroed Operational Amplifier
- Chopper Amplifier Performance Without External Capacitors
 - V_{OS} : 15 μ V Max
 - V_{OS} : Drift; 0.15 μ V/ $^{\circ}$ C Max
 - Saves Cost of External Capacitors
- SOIC Packages Available
- High DC Gain; 120dB
- Low Supply Current; 650 μ A
- Low Input Voltage Noise
 - 0.65 μ V_{P-P} (0.1Hz to 10Hz)
- Wide Common Mode Voltage Range
 - V_{SS} to V_{DD} - 2V
- High Common Mode Rejection; 116dB
- Dual or Single Supply Operation:
 - \pm 3.3V to \pm 8.3V
 - +6.5V to +16V
- Excellent AC Operating Characteristics
 - Slew Rate; 2.5V/ μ sec
 - Unity-Gain Bandwidth; 1.5MHz
- Pin Compatible with LM358, OP-14, MC1458, ICL7621, TL082, TLC322

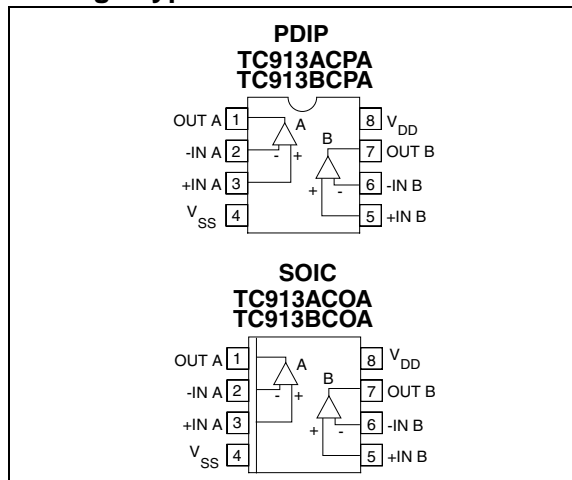
Applications

- Instrumentation
- Medical Instrumentation
- Embedded Control
- Temperature Sensor Amplifier
- Strain Gage Amplifier

Device Selection Table

Part Number	Package	Temp. Range	Offset Voltage
TC913ACOA	8-Pin SOIC	0 $^{\circ}$ C to +70 $^{\circ}$ C	15 μ V
TC913ACPA	8-Pin PDIP	0 $^{\circ}$ C to +70 $^{\circ}$ C	15 μ V
TC913BCOA	8-Pin SOIC	0 $^{\circ}$ C to +70 $^{\circ}$ C	30 μ V
TC913BCPA	8-Pin PDIP	0 $^{\circ}$ C to +70 $^{\circ}$ C	30 μ V

Package Type



General Description

The TC913 is the world's first complete monolithic, dual auto-zeroed operational amplifier. The TC913 sets a new standard for low power, precision dual-operational amplifiers. Chopper-stabilized or auto-zeroed amplifiers offer low offset voltage errors by periodically sampling offset error, and storing correction voltages on capacitors. Previous single amplifier designs required two user-supplied, external 0.1 μ F error storage correction capacitors — much too large for on-chip integration. The unique TC913 architecture requires smaller capacitors, making on-chip integration possible. Microvolt offset levels are achieved and **external capacitors are not required**.

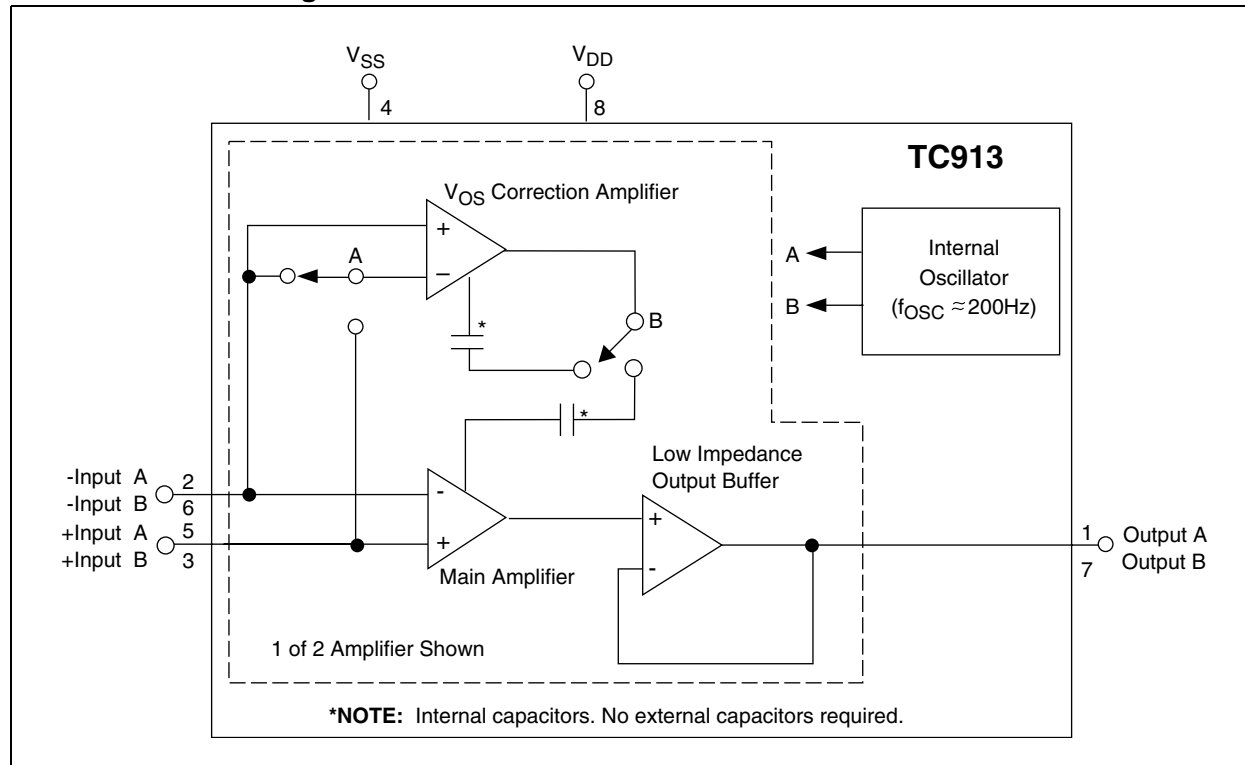
The TC913 system benefits are apparent when contrasted with a TC7650 chopper amplifier circuit implementation. A single TC913 replaces two TC7650's and four capacitors. Five components and assembly steps are eliminated.

The TC913 pinout matches many popular dual-operational amplifiers: OP-04, TLC322, LM358, and ICL7621 are typical examples. In many applications, operating from dual 5V power supplies or single supplies, the TC913 offers superior electrical performance, and can be a functional drop-in replacement; printed circuit board rework is not necessary. The TC913's low offset voltage error eliminates offset voltage trim potentiometers often needed with bipolar and low accuracy CMOS operational amplifiers.

The TC913 takes full advantage of Microchip's proprietary CMOS technology. Unity gain bandwidth is 1.5MHz and slew rate is 2.5V/ μ sec.

TC913A/TC913B

Functional Block Diagram



TC913A/TC913B

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings*

Total Supply Voltage (V_{DD} to V_{SS})	+18V
Input Voltage	($V_{DD} + 0.3V$) to ($V_{SS} - 0.3V$)
Current Into Any Pin	10mA
While Operating	100 μ A
Package Power Dissipation ($T_A = 70^\circ C$)	
Plastic DIP	730mW
Plastic SOIC	470mW
Operating Temperature Range	
C Device	0 $^\circ C$ to +70 $^\circ C$
Storage Temperature Range	-65 $^\circ C$ to +150 $^\circ C$

*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.

TC913A AND TC913B ELECTRICAL SPECIFICATIONS

Electrical Characteristics: $V_S = \pm 5V$, $T_A = +25^\circ C$, unless otherwise indicated.										
Symbol	Parameter	Min	TC913A			TC913B			Unit	Test Conditions
			Typ	Max	Min	Typ	Max			
V_{OS}	Input Offset Voltage	—	5	15	—	15	30	μV	$T_A = +25^\circ C$	
TCV_{OS}	Average Temp. Coefficient of Input Offset Voltage	—	0.05	0.15	—	0.1	0.25	$\mu V/^\circ C$	$0^\circ C \leq T_A \leq +70^\circ C$ $-25^\circ C \leq T_A \leq +85^\circ C$ (Note 1)	
I_B	Average Input Bias Current	—	—	90	—	—	120	pA	$T_A = +25^\circ C$	
		—	—	3	—	—	4	nA	$0^\circ C \leq T_A \leq +70^\circ C$	
		—	—	4	—	—	6	nA	$-25^\circ C \leq T_A \leq +85^\circ C$	
I_{OS}	Average Input Offset Current	—	5	20	—	10	40	pA	$T_A = +25^\circ C$	
		—	—	1	—	—	1	nA	$T_A = +85^\circ C$	
e_N	Input Voltage Noise	—	0.6	—	—	0.6	—	μV_{P-P}	0.1 to 1 Hz, $R_S \leq 100\Omega$	
		—	11	—	—	11	—	μV_{P-P}	0.1 to 10 Hz, $R_S \leq 100\Omega$	
CMRR	Common Mode Rejection Ratio	110	116	—	100	110	—	dB	$V_{SS} \leq V_{CM} \leq V_{DD} - 2.2$	
CMVR	Common Mode Voltage Range	V_{SS}	—	$V_{DD} - 2$	V_{SS}	—	$V_{DD} - 2$	V		
A_{OL}	Open-Loop Voltage Gain	115	120	—	110	120	—	dB	$R_L = 10 k\Omega$, $V_{OUT} = \pm 4V$	
V_{OUT}	Output Voltage Swing	$V_{SS} + 0.3$	—	$V_{DD} - 0.9$	$V_{SS} + 0.3$	—	$V_{DD} - 0.9$	V	$R_L = 10 k\Omega$	
BW	Closed Loop Bandwidth	—	1.5	—	—	1.5	—	MHz	Closed Loop Gain = +1	
SR	Slew Rate	—	2.5	—	—	2.5	—	V/ μ sec	$R_L = 10 k\Omega$, $C_L = 50 pF$	
PSRR	Power Supply Rejection Ratio	110	—	—	100	—	—	dB	$\pm 3.3V$ to $\pm 5.5V$	
V_S	Operating Supply Voltage Range	± 3.3 6.5	—	± 8.3 16	± 3.3 6.5	—	± 8.3 16	V	Split Supply Single Supply	
I_S	Quiescent Supply Current	—	0.65	0.85	—	—	1.1	mA	$V_S = \pm 5V$	

Note 1: Characterized; not 100% tested.

TC913A/TC913B

2.0 PIN DESCRIPTIONS

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

TABLE 2-1: PIN FUNCTION TABLE

Pin No. (8-Pin PDIP) (8-Pin SOIC)	Symbol	Description
1	OUT A	Output
2	-IN A	Inverting Input
3	+IN A	Non-inverting Input
4	V_{SS}	Negative Power Supply
5	+IN B	Non-inverting Input
6	-IN B	Inverting Input
7	OUT B	Output
8	V_{DD}	Positive Power Supply

3.0 DETAILED DESCRIPTION

3.1 Theory of Operation

Each of the TC913's two Op Amps actually consists of two amplifiers. A main amplifier is always connected from the input to the output. A separate nulling amplifier alternately nulls its own offset and then the offset of the amplifier. Since each amplifier is continuously being nulled, offset voltage drift with time, temperature and power supply variations is greatly reduced.

All nulling circuitry is internal and the nulling operation is transparent to the user. Offset nulling voltages are stored on two internal capacitors. An internal oscillator and control logic, shared by the TC913's two amplifiers, control the nulling process.

3.2 Pin Compatibility

The TC913 pinout is compatible with OP-14, LM358, MC1458, LT1013, TLC322, and similar dual Op Amps. In many circuits operating from single or $\pm 5V$ supplies, the TC913 is a drop-in replacement offering DC performance rivaling that of the best single Op Amps.

The TC913's amplifiers include a low-impedance class AB output buffer. Some previous CMOS chopper amplifiers used a high impedance output stage which made open-loop gain dependent on load resistance. The TC913's open-loop gain is not dependent on load resistance.

3.3 Overload Recovery

The TC913 recovers quickly from output saturation. Typical recovery time from positive output saturation is 20 msec. Negative output saturation recovery time is typically 5 msec.

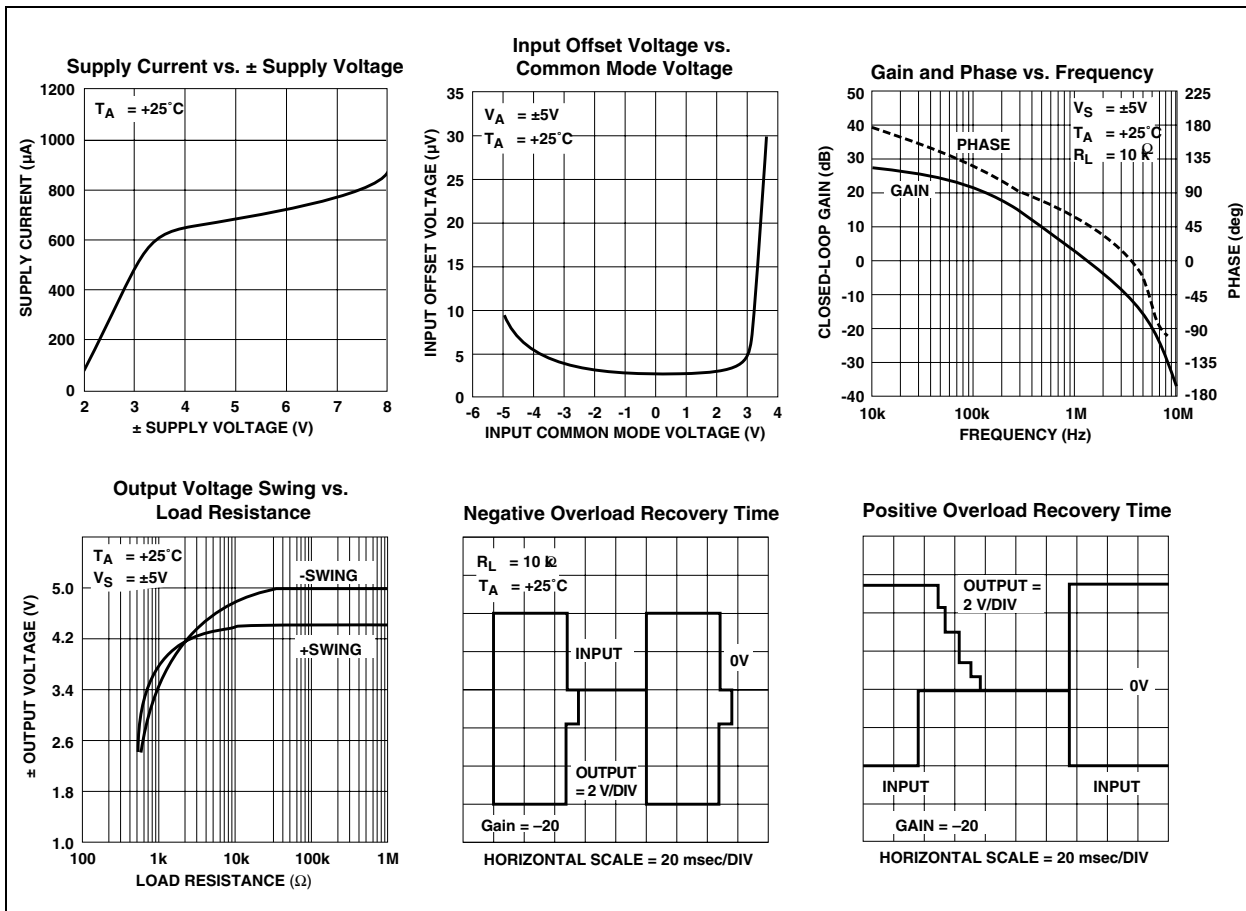
3.4 Avoiding Latchup

Junction-isolated CMOS circuits inherently contain a parasitic p-n-p-n transistor circuit. Voltages exceeding the supplies by 0.3V should not be applied to the device pins. Larger voltages can turn the p-n-p-n device on, causing excessive device power supply current and power dissipation. The TC913's power supplies should be established at the same time or before input signals are applied. If this is not possible, input current should be limited to 0.1mA to avoid triggering the p-n-p-n structure.

TC913A/TC913B

4.0 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.

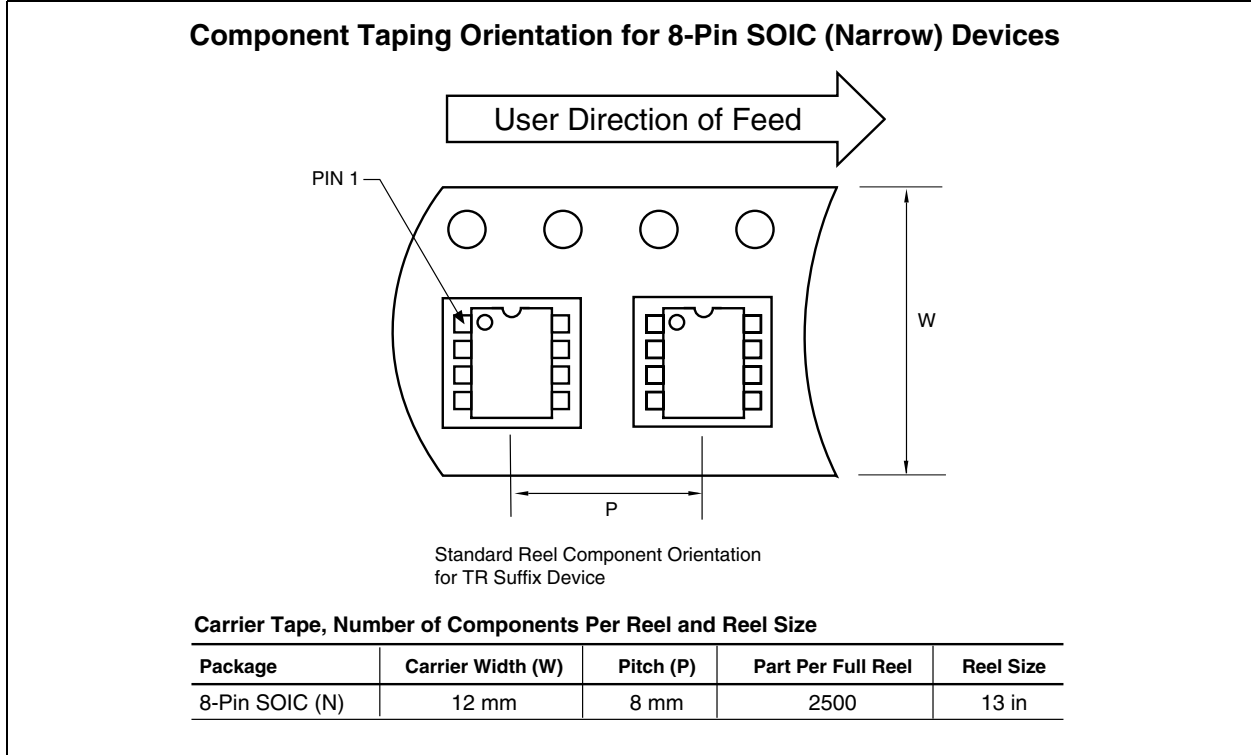


5.0 PACKAGING INFORMATION

5.1 Package Marking Information

Package marking data not available at this time.

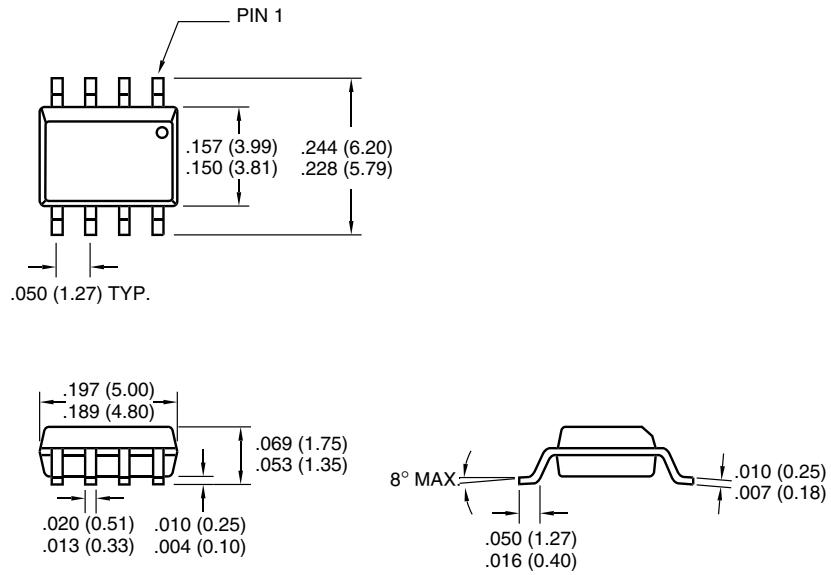
5.2 Taping Form



TC913A/TC913B

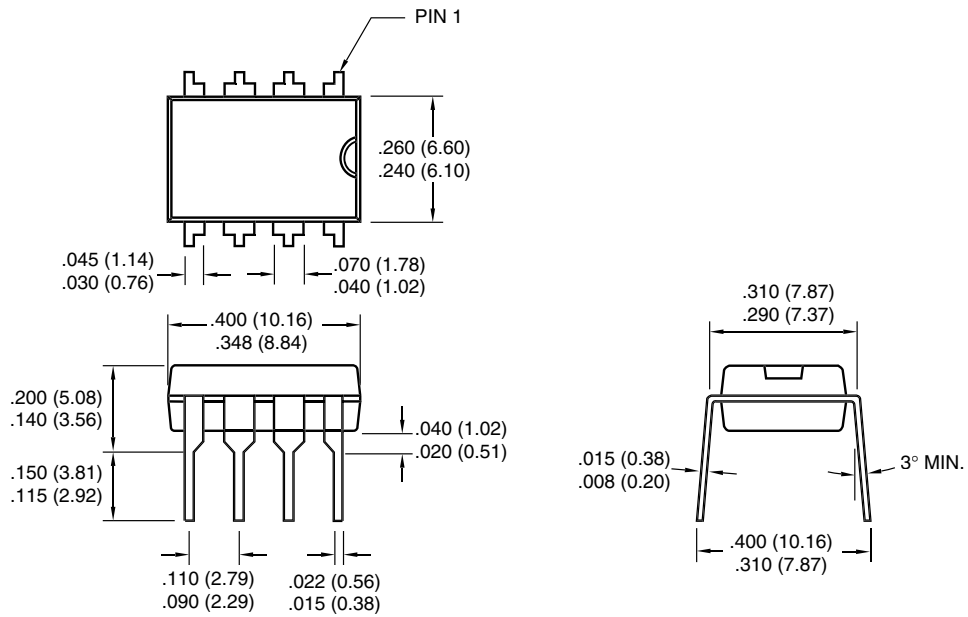
5.3 Package Dimensions

8-Pin SOIC



Dimensions: inches (mm)

8-Pin Plastic DIP



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)

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.

TC913A/TC913B

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.

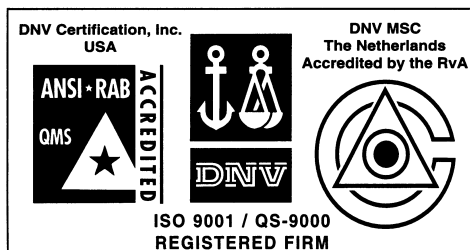
dsPIC, ECONOMONITOR, FanSense, FlexROM, fuzzyLAB, In-Circuit Serial Programming, ICSP, ICEPIC, microPort, Migratable Memory, MPASM, MPLIB, MPLINK, MPSIM, MXDEV, PICC, PICDEM, PICDEM.net, rfPIC, Select Mode and Total Endurance are trademarks of Microchip Technology Incorporated in the U.S.A.

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: 86-28-86766200 Fax: 86-28-86766599

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

China - Hong Kong SAR

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

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

04/20/02

