

Application Circuits of the TC620/TC621 Solid-State Temperature Sensors

Author: Microchip Technology Inc.

INTRODUCTION

The TC620/TC621 are solid-state temperature sensors that are easy to program and interface with control equipment. The TC620 senses the temperature internally, while the TC621 uses an external thermistor. Figure 1 shows how the devices are connected.

The TC620/TC621 data sheet (DS21439) describes how to calculate the correct resistance value for any desired temperature. It also gives a graphical depiction of the outputs for varying temperatures.

Since the TC620 senses temperatures internally, its outputs must be limited to 1 mA. The device can source or sink higher currents, but internal self-heating may cause errors in the temperature sensing. The TC621 can source or sink 10 mA, since it uses an external

thermistor to sense a remote temperature. Internal heating will not affect the temperature sensing accuracy.

Figure 2 is a schematic of a heating and cooling controller using a single TC620 and a TC4469 Quad CMOS driver. In this example, the TC620 is programmed for maximum and minimum temperature set points with a hysteresis of 5°.

INPUT SECTION

Typically, a heating/cooling thermostat has a wide enough temperature range to allow heating and cooling from 45°F to 85°F (7°C to 29°C). The calculations that follow show how this range was incorporated into the design. The TC620 programming inputs have a resistance-to-temperature ratio of approximately 782Ω / °C.

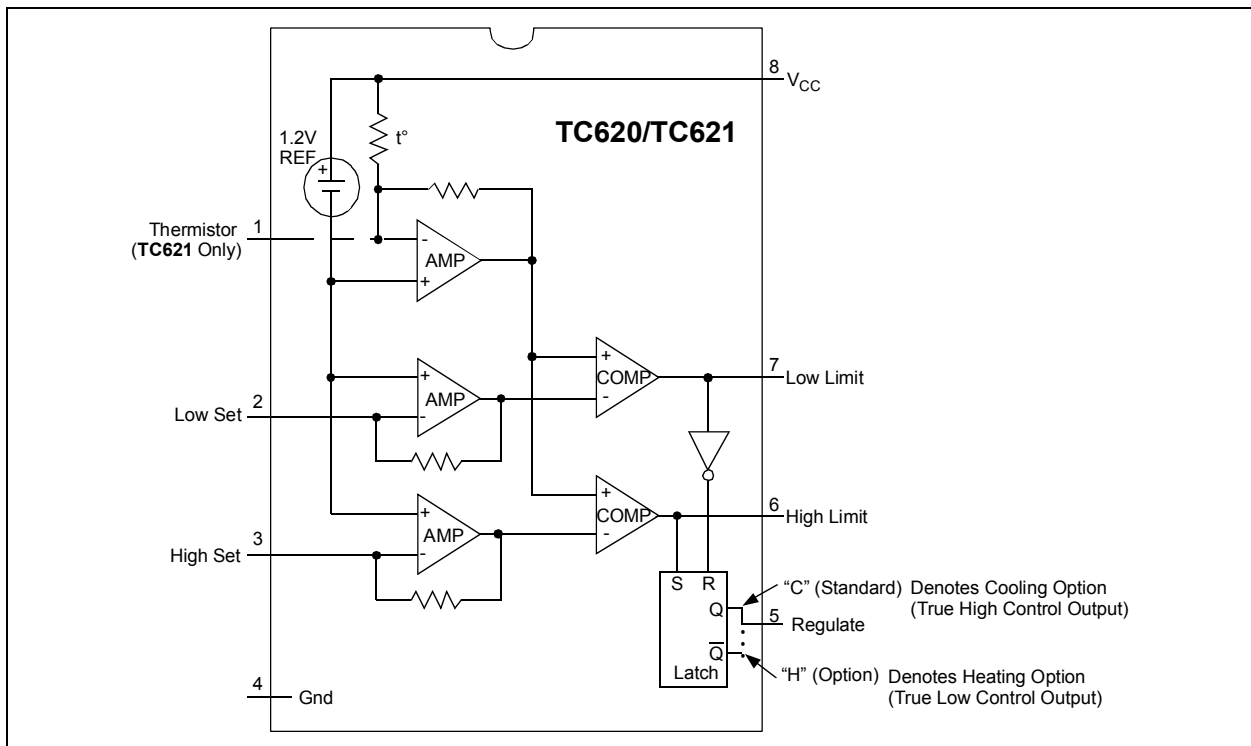


FIGURE 1: TC620/TC621 Block Diagram.

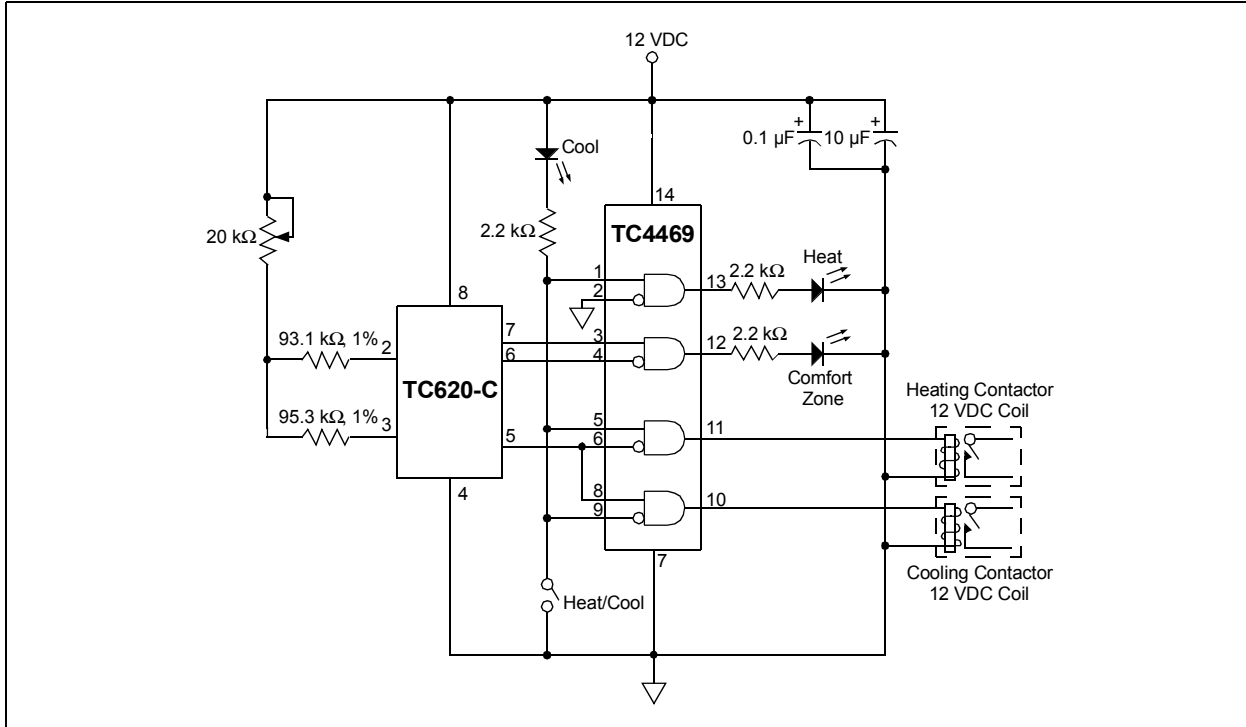


FIGURE 2: Heating/Cooling Thermostat Controller.

To get the desired range, we need a potentiometer that will provide a 22°C variation (29°C - 7°C = 22°C). Multiply this temperature range by the resistance versus temperature ratio to get the needed resistance for the potentiometer:

EQUATION

$$782 \times 22 = 17.2 \text{ k}\Omega$$

A 20 kΩ potentiometer will meet this requirement. Now each programming resistor can be calculated. For the low end of the window, the minimum programming resistor value should be:

EQUATION

$$R_{TRIP} = 0.783 \times T + 91 \dots R_{TRIP} = 96.5 \text{ k}\Omega$$

$$T = 7^\circ\text{C} (45^\circ\text{C})$$

By adding the 20 kΩ potentiometer value to this, we get:

EQUATION

$$96.5 \text{ k}\Omega + 20 \text{ k}\Omega = 116.5 \text{ k}\Omega \text{ total resistance}$$

Plugging this value back into the resistance calculation formula, we will verify that the maximum trip temperature is greater than the desired high end of the window:

EQUATION

$$T = \frac{(R_{TRIP} - 91)}{0.783} \quad T = 32^\circ\text{C} (89.6^\circ\text{C})$$

The previously calculated resistance values will span both ends of the desired heating and cooling window (45°F to 85°F).

To program an acceptable hysteresis for the thermostat, the Low Set resistor must be lower in value than the High Set resistor. A resistance versus temperature ratio of 782Ω / °C for temperatures below 70°C will give a good guideline for calculating the hysteresis. For a hysteresis of 5°, the difference in resistance is:

EQUATION

$$R_{DIFF} = 782 \times 5 \dots R_{DIFF} = 391 \text{ k}\Omega$$

Subtracting the 3.91 kΩ from the 96.5 kΩ will give the Low Set resistor value:

EQUATION

$$96.5 \text{ k}\Omega - 3.91 \text{ k}\Omega = 92.6 \text{ k}\Omega$$

Choosing standard 1% resistance values closest to the calculated values gives:

EQUATION

$$R_{HIGH\ Set} = 95.3\ k\Omega$$

$$R_{LOW\ Set} = 93.1\ k\Omega$$

With the 20 k Ω potentiometer connected to both programming resistors, the Low Set resistor's 5° hysteresis will track the High Set resistor, as the potentiometer is manually adjusted by the user for different temperatures.

OUTPUT SECTION

The Low Limit and High Limit outputs will go high when the device (or thermistor, TC621) reaches the programmed temperature for each corresponding input. The Regulate output is a latch that goes high when both programmed temperatures have been reached, and goes low when the device temperature decreases to below both set points. Figure 3 shows the outputs with respect to input set points and temperature changes.

The application in Figure 2 uses a TC4469 Quad CMOS Driver. This device has four independent drivers, each with a logic AND gate as an input. The AND gate has one non-inverting input and one inverting input. The first driver is used to drive an LED indicator. Depending on the position of the Heat/Cool selector switch, either the Heat or Cool LED indicator will be lit. The second driver is used to drive the "Comfort Zone" LED indicator. When the temperature is between the

two set points (our previously calculated 5° hysteresis), this indicator will be lit. The third driver controls the heating contactor. It is enabled when the Heat/Cool selector switch is open and the Regulate output is low. When the Heat/Cool selector switch is closed, the third driver is disabled and the fourth driver will be enabled to control the cooling contactor. This driver will turn on the cooling contactor when the Regulate output is high. The logic features of the TC4469 CMOS Driver are used to prevent the heating and cooling contactors from operating simultaneously.

The TC620/TC621 will operate with any supply between 4.5 VDC and 18 VDC. The TC4469 Quad CMOS Driver can source 300 mA continuously. The coils on the Heating and Cooling contactors must be of the appropriate type and voltage rating for the circuit.

24 VAC EQUIPMENT

Most heating and cooling equipment is designed to operate with a 24 VAC secondary voltage. The schematic in Figure 4 is an example of a 24 VAC system that drives 24 VAC relays and operates on an internally self-generated 15 VDC. Because the TC620 and the TC4469 are CMOS devices, their current requirements are extremely low. Using triac switches to energize the relays keeps the component costs to a minimum, while reliability stays high.

This design requires only four wires from the thermostat to the main control for a heating/cooling system. An additional fifth wire for a manual fan switch would make it compatible with standard 5-wire residential and commercial heating/cooling systems.

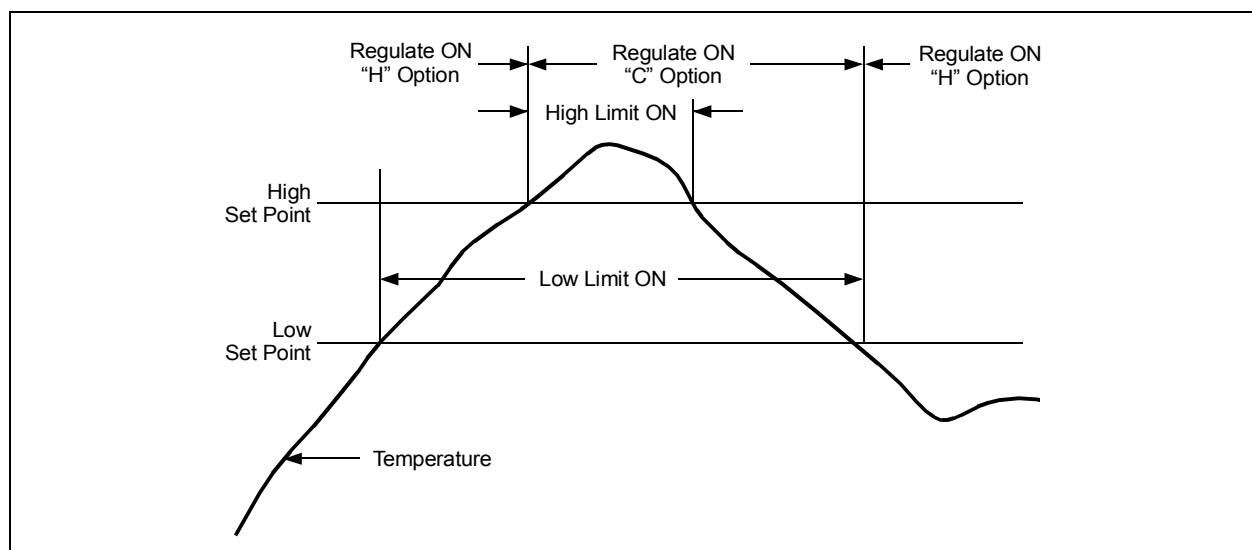


FIGURE 3: TC620/TC621 Input and Output Logic.

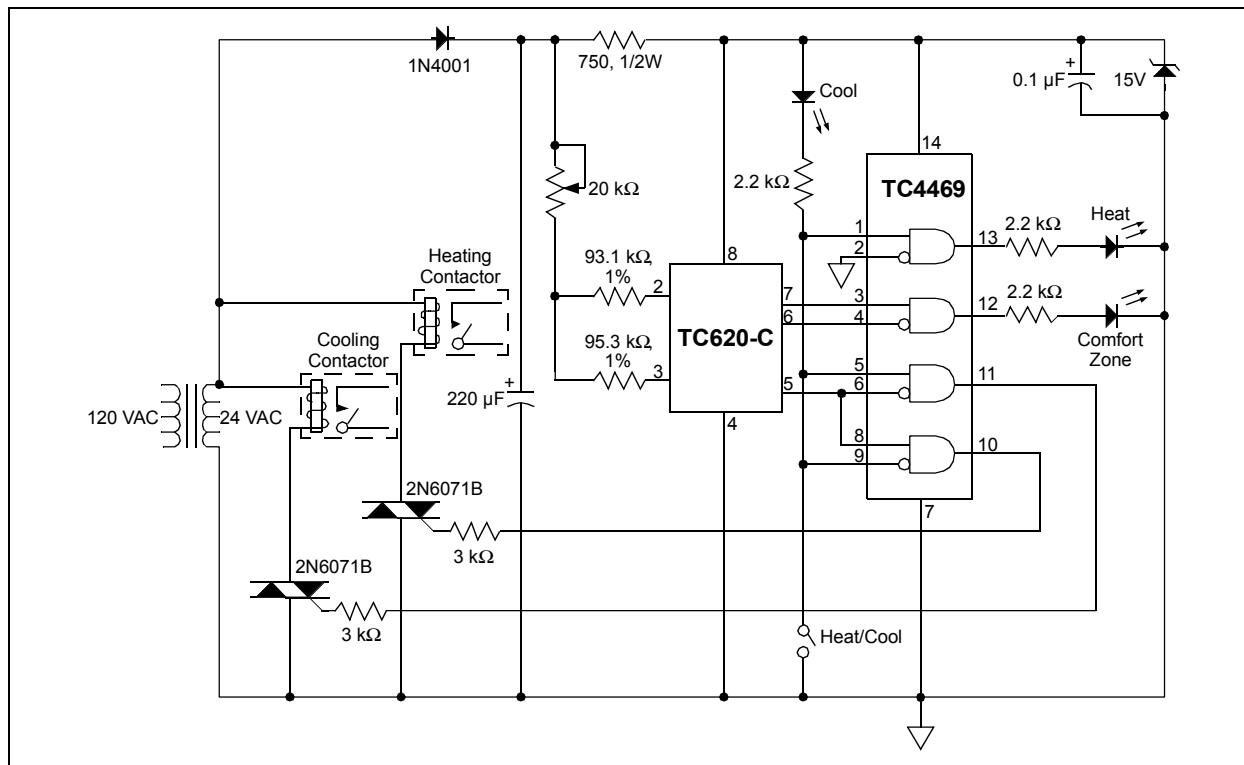


FIGURE 4: 24 VAC Heating/Cooling Thermostat Controller.

SOLAR HEAT CONTROLLER

Figure 5 shows an external temperature sensor for a pool solar heating panel control. The TC620 should be a part with the “H” option bonding. This inverts the Regulate output logic. This is necessary when using “NTC”-type thermistors because the internal logic is designed to function with a “PTC”-type thermistor. The external thermistor used in this design is an NTC (negative temperature coefficient) thermistor. One manufacturer is Keystone™ Carbon. Their part is RL1006-53.4K-140-D1, which has a resistance of 100 kΩ at 25°C. Another vendor is Thermometrics®. Their part is D200B104L. This thermistor assembly is attached to the solar panel in a manner that will allow it to sense heat generated by direct exposure to the sun.

This, then, energizes the pump when the sun is heating the panels, and turns off the pump when the sky becomes cloudy or the sun goes down. To prevent rapid cycling of the controller during partly-cloudy skies, the hysteresis is set for a wide (20°F) span.

The thermal time constant of the solar panel will also aid in the prevention of rapid pump cycling, if the thermal resistance between the thermistor assembly and the solar panel itself is low. The Low Set temperature is set for 26.7°C (80°F) and the High Set temperature is set for 37.8°C (100°F). The resistor values are calculated:

EQUATION

$$R_{TRIP} = 0.783 \times T + 91$$

$$R_{TRIP\ Low} = 111.9\ k\Omega \approx 113\ k\Omega\ 1\%$$

$$R_{TRIP\ High} = 120.6\ k\Omega \approx 121\ k\Omega\ 1\%$$

As the sun heats the thermistor assembly, the pump will turn on at 100°F and stay on until the thermistor assembly temperature decreases to 80°F. This ensures that the solar panel has time to heat up before the pump is energized, and that the pump will turn off before the solar panel has cooled below the pool temperature. The complete controller consists of nine low-cost components.

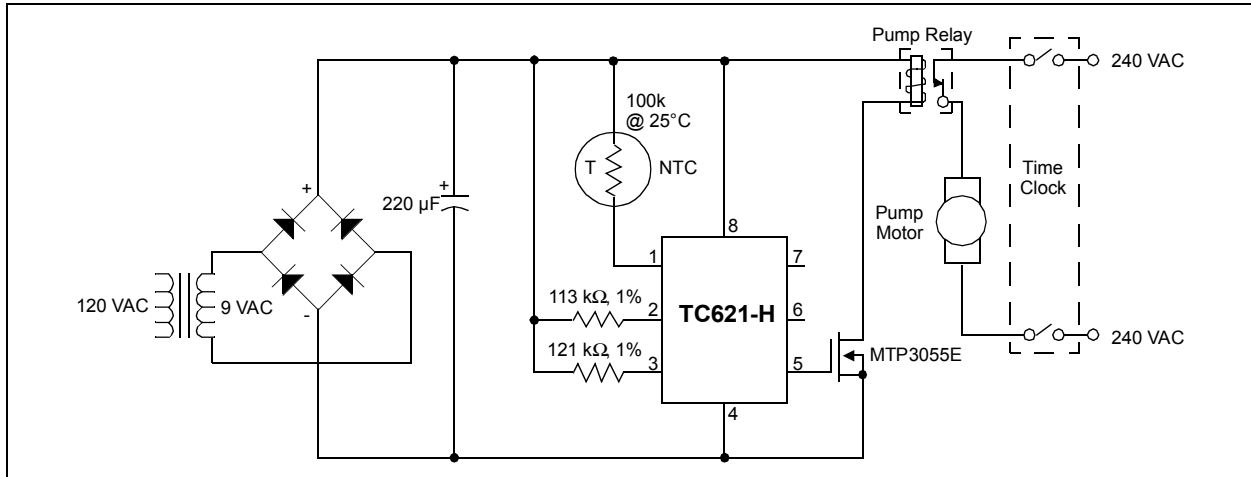


FIGURE 5: Pool Solar Heat Control.

SUMMARY

The TC620 and TC621 are programmable logic output temperature sensors. These sensors feature dual thermal interrupt outputs (high limit and low limit) which can be programmed with a single external resistor. The TC620 and TC621 can be used to provide simple on/off control for a wide range of applications, such as a cooling fan or heater.

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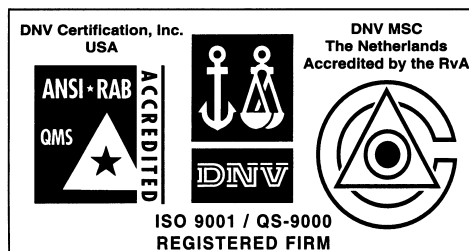
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2355 West Chandler Blvd.
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Web Address: <http://www.microchip.com>

Rocky Mountain

2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7966 Fax: 480-792-4338

Atlanta

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Tel: 770-640-0034 Fax: 770-640-0307

Boston

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Chicago

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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

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. 2401-2402, 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 - 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

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. 1812, 18/F, Building A, United Plaza
No. 5022 Binhe Road, Futian District
Shenzhen 518033, China
Tel: 86-755-82901380 Fax: 86-755-82966626

China - Qingdao

Rm. B503, Fullhope Plaza,
No. 12 Hong Kong Central Rd.
Qingdao 266071, China
Tel: 86-532-5027355 Fax: 86-532-5027205

India

Microchip Technology Inc.
India Liaison Office
Divyasree Chambers
1 Floor, Wing A (A3/A4)
No. 11, O'Shaughnessey 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 (Barbados) Inc.,
Taiwan Branch
11F-3, No. 207
Tung Hua North Road
Taipei, 105, Taiwan
Tel: 886-2-2717-7175 Fax: 886-2-2545-0139

EUROPE

Austria

Microchip Technology Austria GmbH
Durisolstrasse 2
A-4600 Wels
Austria
Tel: 43-7242-2244-399
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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
Steinheilstrasse 10
D-85737 Ismaning, 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
Winkersley Triangle
Wokingham
Berkshire, England RG41 5TU
Tel: 44 118 921 5869 Fax: 44-118 921-5820

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