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Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a “DS” number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is “DSXXXXXA”, where “XXXXX” is the document number and “A” is the revision level of the document.

INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP9800 Temperature Data Logger Demo Board. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Web Site
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the MCP9800 Temperature Data Logger Demo Board. The manual layout is as follows:

- **Chapter 1. “Product Overview”** – Important information about the MCP9800 Temperature Data Logger Demo Board.
- **Chapter 2. “Installation and Operation”** – This chapter includes a detailed description of each function of the demo board and instructions for how to begin using the board.
- **Appendix A. “Schematic and Layouts”** – Shows the schematic and layout diagrams for the MCP9800 Temperature Data Logger Demo Board.
- **Appendix B. “Bill Of Materials (BOM)”** – Lists the parts used to build the MCP9800 Temperature Data Logger Demo Board.
CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

**DOCUMENTATION CONVENTIONS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Represents</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arial font:</td>
<td>Referenced books</td>
<td><em>MPLAB® IDE User’s Guide</em></td>
</tr>
<tr>
<td>Italic characters</td>
<td>Emphasized text</td>
<td><em>...is the only compiler...</em></td>
</tr>
<tr>
<td>Initial caps</td>
<td>A window</td>
<td>the Output window</td>
</tr>
<tr>
<td></td>
<td>A dialog</td>
<td>the Settings dialog</td>
</tr>
<tr>
<td></td>
<td>A menu selection</td>
<td>select Enable Programmer</td>
</tr>
<tr>
<td>Quotes</td>
<td>A field name in a window or dialog</td>
<td>“Save project before build”</td>
</tr>
<tr>
<td>Underlined, italic text with right angle bracket</td>
<td>A menu path</td>
<td><em>File&gt;Save</em></td>
</tr>
<tr>
<td>Bold characters</td>
<td>A dialog button</td>
<td>Click OK</td>
</tr>
<tr>
<td></td>
<td>A tab</td>
<td>Click the <em>Power</em> tab</td>
</tr>
<tr>
<td>N'Rnnnn</td>
<td>A number in Verilog® format, where N is the total number of digits, R is the radix and n is a digit.</td>
<td>4'b0010, 2'hF1</td>
</tr>
<tr>
<td>Text in angle brackets &lt; &gt;</td>
<td>A key on the keyboard</td>
<td>Press &lt;Enter&gt;, &lt;F1&gt;</td>
</tr>
</tbody>
</table>

**Courier New font:**

| Plain Courier New | Sample source code | #define START |
| Filenames | autoexec.bat |
| File paths | c:\mcc18\h |
| Keywords | _asm, _endasm, static |
| Command-line options | -Opa+, -Opa- |
| Bit values | 0, 1 |
| Constants | 0xFF, ‘A’ |
| Italic Courier New | A variable argument | file.o, where file can be any valid filename |
| Square brackets [ ] | Optional arguments | mcc18 [options] file [options] |
| Ellipses... | Replaces repeated text | var_name [, var_name... ] |
| | Represents code supplied by user | void main (void) { ... } |

**RECOMMENDED READING**

This user's guide describes how to use MCP9800 Temperature Data Logger Demo Board. The following Microchip documents are available and recommended as supplemental reference resources.

**MCP9800/1/2/3 Data Sheet, “2-Wire High-Accuracy Temperature Sensor” (DS21909)**

This data sheet provides detailed information regarding the MCP9800 device.

**AN1001 Application Note, “IC Temperature Sensor Accuracy Compensation with a PICmicro® Microcontroller” (DS01001)**

This application note provides detailed information regarding how to compensate the MCP9800 output for higher accuracy.
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• **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing

• **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

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• Local Sales Office
• Field Application Engineer (FAE)
• Technical Support
• Development Systems Information Line

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the web site at: http://support.microchip.com

DOCUMENT REVISION HISTORY

**Revision A (December 2005)**

• Initial Release of this Document.
Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MCP9800 Temperature Data Logger Demo Board and covers the following topics:

- What is the MCP9800 Temperature Data Logger Demo Board?
- What the MCP9800 Temperature Data Logger Demo Board Kit Includes

1.2 WHAT IS THE MCP9800 TEMPERATURE DATA LOGGER DEMO BOARD?

The MCP9800 Temperature Data Logger Demo Board demonstrates how to use the MCP9800 and an on-board EEPROM to log temperature data. A PIC16F684 14-pin Flash-based 8-bit CMOS PICmicro® microcontroller (MCU) device is used with the sensor and stores the temperature data in the EEPROM. The PICmicro microcontroller also communicates with the Personal Computer (PC) using the PICkit1™ Flash Starter Kit. The temperature data stored in the EEPROM can be transferred to a PC using the PICkit 1 software and saved in *.csv format. The data file can be opened using Microsoft® Excel® software.

The MCP9800 Temperature Data Logger Demo Board can also be used as a "stand-alone" module, powered with a lithium battery, to measure ambient temperature and store up to 4096 temperature samples over an extended period of time.

1.3 WHAT THE MCP9800 TEMPERATURE DATA LOGGER DEMO BOARD KIT INCLUDES

This MCP9800 Temperature Data Logger Demo Board Kit includes:

- The MCP9800 Temperature Data Logger Demo Board
- PIC16F684 Firmware
- "MCP9800 Temperature Data Logger Demo Board User’s Guide", (DS51593)
- MCP9800/1/2/3 Data Sheet, “2-Wire High-Accuracy Temperature Sensor”, (DS21909)
- 24XX1025 Data Sheet, “1024K i²C™ CMOS Serial EEPROM”, (DS21941)
- PIC16F684 Data Sheet, “14-Pin Flash-Based, 8-Bit CMOS Microcontrollers with nanoWatt Technology”, (DS40202)
Chapter 2. Installation and Operation

2.1 INTRODUCTION

The MCP9800 Temperature Data Logger Demo board allows the user to store up to 4096 temperature readings from the MCP9800 sensor to the 24LC1025, Microchip’s 1024 Kbit EEPROM. The PIC16F684 PICmicro microcontroller is used to communicate with the sensor and EEPROM. In addition, the PICmicro microcontroller interfaces to a PC using the PICkit™ 1 Flash Starter Kit and transfers the temperature readings from the EEPROM to the PC. The data can be viewed using Microsoft Excel software. The PICkit™ 1 Flash Starter Kit can also be used to reprogram the on-board PICmicro microcontroller. The user can specify the number of measurements and measurement duration. The MCP9800 Temperature Data Logger Demo board can be powered using an external supply, the PICkit™ 1 Flash Starter Kit, or a 24 mm Lithium cell. The battery allows stand-alone operations.

2.2 FEATURES

The MCP9800 Temperature Data Logger Demo board has the following features:

- The MCP9800 Sensor with 0.25°C/LSb resolution
- Store 4096 temperature samples to serial EEPROM
- Standard 100 mil 14-pin header (P1) for easy interface to the PICkit™ 1 Flash Starter Kit or custom application
- PIC16F6784 PICmicro Microcontroller
- Temperature Alert LED indicator and measurement progress LED Indicator

2.3 GETTING STARTED

This section describes how to quickly configure the MCP9800 Temperature Data Logger Demo board and PICkit™ 1 Flash Starter Kit. A simplified block diagram of the configuration is provided in Figure 2-1.

![FIGURE 2-1: MCP9800 Temperature Data Logger Demo Board Simplified Block Diagram.](image)
2.3.1 Hardware Setup

1. Connect the P1 header of the MCP9800 Temperature Data Logger Demo board to the J3 connector on the PICkit™ 1 Flash Starter Kit board. Refer to Figure 2-2 for proper orientation of the MCP9800 Temperature Data Logger Demo board and Figure 2-3 for a simplified board schematic.

2. Connect the PICkit™ 1 Flash Starter Kit USB cable from the USB port of the PC to the USB port (J1) on the PICkit™ 1 Flash Starter Kit board. +5V power is supplied to the PICkit 1 Flash Starter Kit board via the USB cable. The green POWER LED and the red BUSY LED will turn on, indicating that power is being supplied to the board.

FIGURE 2-2: MCP9800 PICtail™ Daughter Board and PICkit™1 FLASH Starter Kit.

FIGURE 2-3: Simplified MCP9800 PICtail™ Daughter Board Schematic.
2.3.2 Programming the PIC16F684

3. Download and install the PICkit™ 1 Flash Starter Kit software to your PC.
4. Copy the 00083R1.HEX file supplied on the CD that came with this kit to your PC.

Note: The PIC16F684 firmware is factory programmed with 00083R1.HEX, therefore, it is not necessary to program it out of the box.

5. When the PICkit™ 1 Flash Starter Kit is started, the main window will be displayed on the PC as indicated in Figure 2-4.

![PICkit™ 1 Flash Starter Kit GUI Window on the PC.](image)

6. Toggle device power to off by unchecking the Device Power box under Board Controls in the PICkit™ 1 Flash Starter Kit window (Figure 2-4). The BUSY LED on the PICkit™ 1 Flash Starter Kit board will turn off when the device power is turned off.
7. Click on the Erase button in the window to ensure that the PIC16F684 device has been erased.
8. From the File pull down menu, select Import HEX. A file window will appear. Select and Open 00083R1.HEX.
9. Click on the Write Device button in the PICkit™ 1 Flash Starter Kit window. The PIC16F684 device will be written to with the MCP9800 00083R1.HEX firmware. Once completed, the status bar at the bottom of the window will indicate Write Successful.
10. Toggle the device power on by checking the Device Power box under Board Controls in the PICkit™ 1 Flash Starter Kit window. The BUSY LED on the PICkit™ 1 Flash Starter Kit board will turn on when device power is turned on.
11. The PICmicro microcontroller starts measuring temperature and storing the data in the EEPROM.

Note: The J2 connector can be used to program the PICmicro microcontroller using PICkit™ 2 Microcontroller Programmer.
2.4 FUNCTIONAL DESCRIPTION

2.4.1 The MCP9800 Temperature Data Logger Demo board

The MCP9800 Temperature Data Logger Demo board uses the PIC16F684 to measure ambient temperature using the MCP9800 temperature sensor and store the temperature data to the 24LC1025 serial EEPROM. The number of samples and the sampling duration is specified by the user. Once the specified number of samples are stored, the controller waits for a command from the PICkit™ 1 Flash Starter Kit signal analysis tool to transmit the samples to the PC. The software tool can be used to save the data in *.csv format, which allows the user to view the data using Microsoft Excel software.

There are two LEDs on-board, D1 and D2. D1 indicates an overtemperature alert. It turns on when the ambient temperature rises above the user specified limit and it remains lit until the temperature falls below the user specified hysteresis limit. (see Section 2.4.2.3). D2 indicates that the PICmicro microcontroller is in the process of sampling temperature. During this time, it turns on momentarily every time temperature is sampled. Once all samples are acquired, D2 will remain off.

The RESET switch, S1, is used to reset the PICmicro microcontroller. Clicking GO in the signal analysis software also resets the PICmicro microcontroller.

There are three sources of power connections to the data logger. Power can be supplied by connecting the 14-pin header to the PICKit™ 1 Flash Starter Kit board. The user can also connect a +5V supply using the on-board test points. In addition, this board supports a 24 mm 3V Lithium cell for stand-alone operation. To use the battery, the "Battery On" jumper JP1 will need to be connected.

In order to prevent power contention between the power supply and on-board battery, a dual Schottky diode, U5, is used to limit the current path. The diode ensures normal operation if the board is connected to a +5V supply, while the Battery On jumper is connected. There is about a 100 mV (typical) drop across the Schottky diode. The output of the diode is referred to as \( V_{DD} \).

The MCP9800 Temperature Data Logger Demo board also uses Microchip's MCP101 supervisor to reset the controller if \( V_{DD} \) drifts below 2.5V.
2.4.2 User Selectable Features

There are several user selectable features, all require changing the code and recompiling the firmware. Steps 8, 9 and 10 of 2.3.2 "Programming the PIC16F684" will then have to be repeated to reprogram the PICmicro microcontroller.

The userVariables.inc file includes all variables.

2.4.2.1 STAND-ALONE

The MCP9800 Temperature Data Logger Demo board can be powered with a lithium cell and operate as a stand-alone temperature data logger. To enable this feature, set the stand-alone variable in the userVariable.inc file to "1", compile the code and program the PICmicro microcontroller. Set the variable to "0" to disable this feature.

In Stand-Alone mode, momentarily pressing the on-board reset push button switch will overwrite previously stored data.

In order to retrieve the logged data, refer to Section 2.4.2.4.

2.4.2.2 SETTING NUMBER OF SAMPLES AND SAMPLING TIME

The minimum number of samples that can be logged are 256 samples. The sample size can be increased by multiples of 256 up to 4096 samples. The data logger board can store up 128000 samples, however, currently the software tool does not support data transfer size greater than 4096 samples.

The minimum measurement duration is 60 ms. The duration can be increased by a multiple of 60 ms. Table 2-1 shows the user variable description as shown in the userVariable.inc file.

<table>
<thead>
<tr>
<th>Sample Size</th>
<th>Size</th>
<th>Sampling Time</th>
<th>Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>256</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>517</td>
<td>2</td>
<td>120</td>
</tr>
<tr>
<td>3</td>
<td>1024</td>
<td>10</td>
<td>600</td>
</tr>
<tr>
<td>4</td>
<td>2048</td>
<td>100</td>
<td>6,000</td>
</tr>
<tr>
<td>5</td>
<td>4096</td>
<td>6,000</td>
<td>360,000</td>
</tr>
</tbody>
</table>

Note 1: When downloading the data to the PC, select the corresponding sample size from the pull down menu provided in the signal analysis software.

2.4.2.3 SETTING TEMPERATURE ALERT LIMIT AND HYSTERESIS

The MCP9800 provides an open-drain temperature alert output. When the temperature rises above the user specified limit, the output toggles and it remains set until the temperature falls below the user specified hysteresis limit.

To set the limits, open the userVariables.inc file and select a decimal number that corresponds to the temperature of interest to the defined variables, MCP9800_Temperature.set and MCP9800_Temperature.hysteresis. For example, if the temperature limit is 30°C and the hysteresis limit is 27°C, define '.30' and '.27' for the variables, respectively.
2.4.2.4 LOADING SAMPLES TO THE PC

1. Connect the data logger to the PICkit™ 1 Flash Starter Kit J3 connector.
2. Select Acquisition mode as shown below and select the Oscilloscope display, as shown in Figure 2-5.
3. Click **GO** to start acquisition. When the acquisition is complete, the data in the EEPROM is transferred to the PC. In Stand-Alone mode, when clicking **GO**, the acquisition is bypassed and the data in the EEPROM is transferred to the PC.

The Samples pull-down list provided in the signal analysis software defines the number of temperature samples to be taken. In Stand-Alone mode, the samples need to match the user specified sample size (Table 2-1). The Speed pull-down list does not change the minimum temperature sampling speed of 60 ms.

![Figure 2-5: Loading the Data from the On-board EEPROM to the PC.](image)

The oscilloscope display shows the ambient temperature data from the MCP9800. This display does not support negative numbers. Therefore, the data is offset by 1024. In addition, the tool does not support 11-bit and 12-bit temperature data.

**Note:** The progress bar hangs for about 5-6 seconds for 256 temperature samples. This is due to timing differences between the PC and the PICmicro microcontroller. The delay increases as the number of samples increase. The GUI expects acquisition at 100 samples/sec, however, temperature is acquired at 16 samples/sec.

2.4.2.5 REAL-TIME DISPLAY ON PC

The stripchart tool available on the PICkit™ 1 Flash Starter kit software can be used to display real time temperature data. This is done by selecting the strip chart tool on the software and clicking **GO**.

![Figure 2-6: Selecting the Strip Chart Tool for Real-time Temperature Display.](image)

This display does not support negative numbers. Therefore, the data is offset by 1024. In addition, the tool does not support 11-bit and 12-bit data.

The real-time display does not operator in the Stand-Alone mode.
A.1 INTRODUCTION

This appendix contains the following schematics and layouts for the MCP9800 Temperature Data Logger Demo Board:

• Board Schematic
• Board - Top Layer
• Board - Silk-screen Layer
• Board - Bottom Layer
FIGURE A-1: Board Schematic.
FIGURE A-2:  Board - Silk-screen Layer.

FIGURE A-3:  Board - Bottom Layer
## Appendix B. Bill Of Materials (BOM)

### TABLE B-1: BILL OF MATERIALS

<table>
<thead>
<tr>
<th>Qty</th>
<th>Reference Designator</th>
<th>Description</th>
<th>Manufacturer</th>
<th>Manufacturer Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C1</td>
<td>CAP CER 10UF 10V Y5V 0805</td>
<td>Murata Electronics North America</td>
<td>GRM21BF51A106ZE15L</td>
</tr>
<tr>
<td>1</td>
<td>C2</td>
<td>CAP 1UF 16V CERAMIC Y5V 0805</td>
<td>Panasonic - ECG</td>
<td>ECJ-2VF1C105Z</td>
</tr>
<tr>
<td>1</td>
<td>C3</td>
<td>CAP .1UF 25V CERAMIC X7R 0805</td>
<td>Panasonic - ECG</td>
<td>ECJ-2V81E104K</td>
</tr>
<tr>
<td>2</td>
<td>D1,D2</td>
<td>LED RED CLEAR 0805 SMD</td>
<td>LITE-ON INC</td>
<td>LTST-C170CKT</td>
</tr>
<tr>
<td>5</td>
<td>R1-R5</td>
<td>RES 10.0K OHM 1/10W 1% 0805 SMD</td>
<td>Panasonic - ECG</td>
<td>ERJ-6ENF1002V</td>
</tr>
<tr>
<td>1</td>
<td>U1</td>
<td>14-Pin Flash-Based, 8-Bit CMOS Microcontrollers with nanoWatt Technology</td>
<td>Microchip Technology Inc.</td>
<td>PIC16F684_dip</td>
</tr>
<tr>
<td>1</td>
<td>U1 SOCKET</td>
<td>SOCKET,IC,14PIN,MACHINE TOOLED</td>
<td>JAMECO VALUEPRO</td>
<td>6100-14</td>
</tr>
<tr>
<td>1</td>
<td>U2</td>
<td>1024K I²C™ CMOS Serial EEPROM</td>
<td>Microchip Technology Inc.</td>
<td>24LC1025-I/P</td>
</tr>
<tr>
<td>1</td>
<td>U2 SOCKET</td>
<td>SOCKET,IC,08PIN,MACHINE TOOLED</td>
<td>JAMECO VALUEPRO</td>
<td>6100-8</td>
</tr>
<tr>
<td>1</td>
<td>U4</td>
<td>MCP101 Precision System Supervisors</td>
<td>Microchip Technology Inc.</td>
<td>MCP101T-270I/TT</td>
</tr>
<tr>
<td>1</td>
<td>U5</td>
<td>DIODE SCHOTTKY 30V 70MA MINI 3P</td>
<td>Panasonic - SSG</td>
<td>MA3X786E0L</td>
</tr>
<tr>
<td>1</td>
<td>U6</td>
<td>MCP9800 2-Wire High-Accuracy Temperature Sensor</td>
<td>Microchip Technology Inc.</td>
<td>MCP9800AOT-M/TOG</td>
</tr>
<tr>
<td>1</td>
<td>BAT1</td>
<td>HOLDER BATTERY COIN 24MM DIA SMD</td>
<td>Keystone Electronics</td>
<td>3006</td>
</tr>
<tr>
<td>1</td>
<td>Coin Battery</td>
<td>BATTERY LITHIUM COIN 3V CELL</td>
<td>Panasonic - BSG</td>
<td>CR2450</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>TEST POINT PC MULTI-PURPOSE BLK</td>
<td>Keystone Electronics</td>
<td>5011</td>
</tr>
<tr>
<td>2</td>
<td>VDD &amp; +5V</td>
<td>TEST POINT PC MULTI-PURPOSE RED</td>
<td>Keystone Electronics</td>
<td>5010</td>
</tr>
<tr>
<td>2</td>
<td>SDA &amp; SCK</td>
<td>TEST POINT PC MULTI-PURPOSE WHT</td>
<td>Keystone Electronics</td>
<td>5012</td>
</tr>
<tr>
<td>1</td>
<td>J1</td>
<td>Installation on Bottom Side HDR 1X14 CONN HEADER 14POS .100 VERT TIN</td>
<td>Molex/Waldom Electronics</td>
<td>22-28-4140</td>
</tr>
<tr>
<td>1</td>
<td>J2</td>
<td>Not Installed HDR 1X6 CONN HEADER 6 POS .100 VERT TIN</td>
<td>Molex/Waldom Electronics</td>
<td>22-28-4060</td>
</tr>
</tbody>
</table>
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Fax: 774-760-0088

### Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

### Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

### Detroit
Farmington Hills, MI
Tel: 248-538-2250
Fax: 248-538-2260

### Kokomo
Kokomo, IN
Tel: 765-864-8360
Fax: 765-864-8387

### Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608

### San Jose
Mountain View, CA
Tel: 650-215-1444
Fax: 650-961-0286

### Toronto
Mississauga, Ontario, Canada
Tel: 905-673-0699
Fax: 905-673-6509

## ASIA/PACIFIC

### Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

### China - Beijing
Tel: 86-10-8528-2100
Fax: 86-10-8528-2104

### China - Chengdu
Tel: 86-28-8676-6200
Fax: 86-28-8676-6599

### China - Fuzhou
Tel: 86-591-8750-3506
Fax: 86-591-8750-3521

### China - Hong Kong SAR
Tel: 852-2401-1200
Fax: 852-2401-3431

### China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

### China - Shanghai
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

### China - Shenzhen
Tel: 86-755-8203-2660
Fax: 86-755-8203-1760

### China - Shunde
Tel: 86-757-2839-5507
Fax: 86-757-2839-5571

### China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

### China - Xian
Tel: 86-29-8833-7250
Fax: 86-29-8833-7256

### India - Bangalore
Tel: 91-80-2229-0061
Fax: 91-80-2229-0062

### India - New Delhi
Tel: 91-11-5160-8631
Fax: 91-11-5160-8632

### India - Pune
Tel: 91-20-2566-1512
Fax: 91-20-2566-1513

### Japan - Yokohama
Tel: 81-45-471-6166
Fax: 81-45-471-6122

### Korea - Gumi
Tel: 82-54-473-4301
Fax: 82-54-473-4302

### Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or 82-2-558-5934

### Malaysia - Penang
Tel: 60-4-646-8870
Fax: 60-4-646-5086

### Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

### Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

### Taiwan - Hsin Chu
Tel: 886-3-572-9526
Fax: 886-3-572-6459

### Taiwan - Kaohsiung
Tel: 886-7-536-4818
Fax: 886-7-536-4803

### Taiwan - Taipei
Tel: 886-2-2500-6610
Fax: 886-2-2508-0102

### Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

### World Wide Sales and Service

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