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**PICDEM™ MSC1**  
**USER'S GUIDE**

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**Note the following details of the code protection feature on PICmicro® MCUs.**

- The PICmicro family meets the specifications contained in the Microchip Data Sheet.
- Microchip believes that its family of PICmicro microcontrollers is one of the most secure products of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the PICmicro microcontroller in a manner outside the operating specifications contained in the data sheet. The person doing so may be engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable”.
- Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our product.

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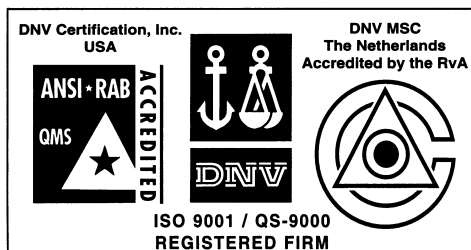
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**Table of Contents**

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**Preface****Chapter 1. Overview and Installation**

1.1	Introduction .....	5
1.2	Highlights .....	5
1.3	Unpacking Your PICDEM™ MSC1 .....	5
1.4	Installing the Hardware .....	6
1.5	Installing the GUI Software .....	7
1.6	What the PICDEM™ MSC1 Is .....	7

**Chapter 2. Basic Functions**

2.1	Starting Communications with the Evaluation Tool .....	9
-----	--	---

**Chapter 3. Tutorial/Demo**

3.1	Digital-to-Analog (DAC) Module Configuration .....	23
-----	--	----

**Appendix A. PICDEM™ MSC1 Schematics**

A.1	Introduction .....	35
A.2	Highlights .....	35
A.3	Schematics .....	36

<b>Index</b> .....	<b>39</b>
--------------------	-----------

<b>Worldwide Sales and Service</b> .....	<b>40</b>
--	-----------

# PICDEM™ MSC1 USER'S GUIDE

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NOTES:

## Preface

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### Introduction

This chapter contains general information about this manual and contacting customer support.

### Highlights

Topics covered in this chapter:

- About this Guide
- Warranty Registration
- Recommended Reading
- The Microchip Internet Web Site
- Development Systems Customer Notification Service
- Customer Support

### About This Guide

#### Document Layout

This document describes how to install a PICDEM™ MSC1 (Mixed Signal Controller1) on a PC and load the GUI software as a development tool for creating the initialization assembly code for your PIC16C781/782 application. The PICDEM™ MSC1 is the tradename for the PIC16C781/782 Microcontroller Evaluation Tool described in this manual. The manual layout is as follows:

- **Chapter 1: Overview and Installation** – What the PICDEM™ MSC1 is and how to install it.
- **Chapter 2: Basic Functions** – Describes how to get started using the PICDEM™ MSC1 and how to access the basic functions using the GUI software.
- **Chapter 3: Tutorial/Demo** - Provides an example of how you can configure a typical peripheral using the PICDEM™ MSC1 and create the initialization assembly code corresponding to your configuration.
- **Appendix A: Schematics** – Provides the schematics and board layout for the PICDEM™ MSC1.
- **PICDEM™ MSC1 Worldwide Sales and Service** – Lists Microchip sales and service locations and telephone numbers worldwide.

# PICDEM™ MSC1 User's Guide

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## Updates

All documentation becomes dated, and this user's guide is no exception. Since the PICDEM™ MSC1 and other Microchip tools are constantly evolving to meet customer needs, please refer to our web site at <http://www.microchip.com> to obtain the latest documentation available.

## Warranty Registration

Please complete the enclosed Warranty Registration Card and mail it promptly. Sending in your Warranty Registration Card entitles you to receive new product updates. Interim software releases are available at the Microchip web site.

## Recommended Reading

This user's guide describes how to use the PICDEM™ MSC1. The data sheets contain current information on programming the specific microcontroller devices.

### **README.TXT**

For the latest information on using PICDEM™ MSC1, read the README.txt file (ASCII text file) included with the PICDEM™ MSC1 software. The README.txt file contains update information that may not be included in this document.

### **MPLAB® IDE User's Guide (DS51025)**

Comprehensive guide that describes installation and features of Microchip's MPLAB Integrated Development Environment (IDE), as well as the editor and simulator functions in the MPLAB environment.

### **MPASM™ User's Guide with MPLINK™ & MPLIB™ (DS33014)**

Describes how to use Microchip Universal PICmicro® Microcontroller Assembler (MPASM), Linker (MPLINK), and Librarian (MPLIB).

### **Technical Library CD-ROM (DS00161)**

This CD-ROM contains comprehensive data sheets for Microchip PICmicro® MCU devices available at the time of print. To obtain this CD-ROM, contact the nearest Microchip Sales and Service location (see back page) or download individual data sheet files from the Microchip web site (<http://www.microchip.com>).

### **PICmicro Mid-Range MCU Family Reference Manual (DS33023)**

This manual explains the general details and operation of the MCU family architecture and peripheral modules. It is designed to complement the device data sheets.

## **Microsoft® Windows® Manuals**

This manual assumes that users are familiar with Microsoft Windows operating system. Many excellent references exist for this software program, and should be consulted for general operation of Windows.

## **PIC16C781/782 Data Sheet (DS41171)**

This book contains details about the PIC16C781/782 Microcontroller and more.

## **The Microchip Internet Web Site**

Microchip provides online support on the Microchip World Wide Web (WWW) site.

The web site is used by Microchip as a means to make files and information easily available to customers. To view the site, the user must have access to the Internet and a web browser, such as Netscape® Communicator or Microsoft® Internet Explorer®. Files are also available for FTP download from our FTP site.

### **Connecting to the Microchip Internet Website**

The Microchip web site is available by using your favorite Internet browser. Visit:

**<http://www.microchip.com>**

The file transfer site is available by using an FTP program/client to connect to:

**<ftp://ftp.microchip.com>**

## **Development Systems Customer Notification Service**

Microchip started the customer notification service to help our customers keep current on Microchip products with the least amount of effort. Once you subscribe to one of our list servers, you will receive e-mail notification whenever we change, update, revise or have errata related to that product family or development tool. See the Microchip web page at <http://www.microchip.com> for other Microchip list servers.

The Development Systems list names are:

- Compilers
- Emulators
- Programmers
- MPLAB
- Otools (other tools)



# PICDEM™ MSC1 User's Guide

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Once you have determined the names of the lists that you are interested in, you can subscribe by sending a message to:

```
listserv@mail.microchip.com
```

with the following as the body:

```
subscribe <listname> yourname
```

Here is an example:

```
subscribe programmers John Doe
```

To UNSUBSCRIBE from these lists, send a message to:

```
listserv@mail.microchip.com
```

with the following as the body:

```
unsubscribe <listname> yourname
```

Here is an example:

```
unsubscribe programmers John Doe
```

The following sections provide descriptions of the available Development Systems lists.

## Customer Support

Users of Microchip products can receive assistance through several channels:

- Distributor
- Local Sales Office
- Field Application Engineer (FAE)
- Corporate Applications Engineer (CAE)
- Systems Information Upgrade Hotline

Technical Support can be obtained through your local FAE or CAE. CAEs may be contacted at (480) 792-7627. Contact the Sales office for prices and literature requests. Sales offices are listed on the back cover of this User Guide.

In addition, there is a Systems Information and Upgrade Line. This line provides system users a listing of the latest versions of all of Microchip's development systems software products. Plus, this line provides information on how customers can receive any currently available upgrade kits.

The Hotline Numbers are:

1-800-755-2345 for U.S. and most of Canada, and

1-480-792-7302 for the rest of the world.

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## Chapter 1. Overview and Installation

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### 1.1 Introduction

The PICDEM™ MSC1 with its PC-based Graphical User Interface (GUI) software serves as a stand-alone development and evaluation tool for the PIC16C781/782 Microcontrollers, or as a user interface to the peripherals.

### 1.2 Highlights

The topics covered in this chapter are:

- Unpacking your PICDEM™ MSC1 hardware and software
- Installing the hardware
- Installing the GUI software
- What the PICDEM™ MSC1 is
- How the PICDEM™ MSC1 helps the Developer

### 1.3 Unpacking Your PICDEM™ MSC1

#### 1.3.1 Supplied Items

The items contained in your PICmicro box are:

- PICDEM™ MSC1 Circuit Board with a programmed PIC16C782 installed
- PIC16C781/782 Data Sheet (DS41171)
- CD-ROM containing: GUI software, User's Guide, Board Schematics, Monitor Firmware, Example Arbitrary Waveform
- Assorted jumpers

#### 1.3.2 Required Items

The items required are:

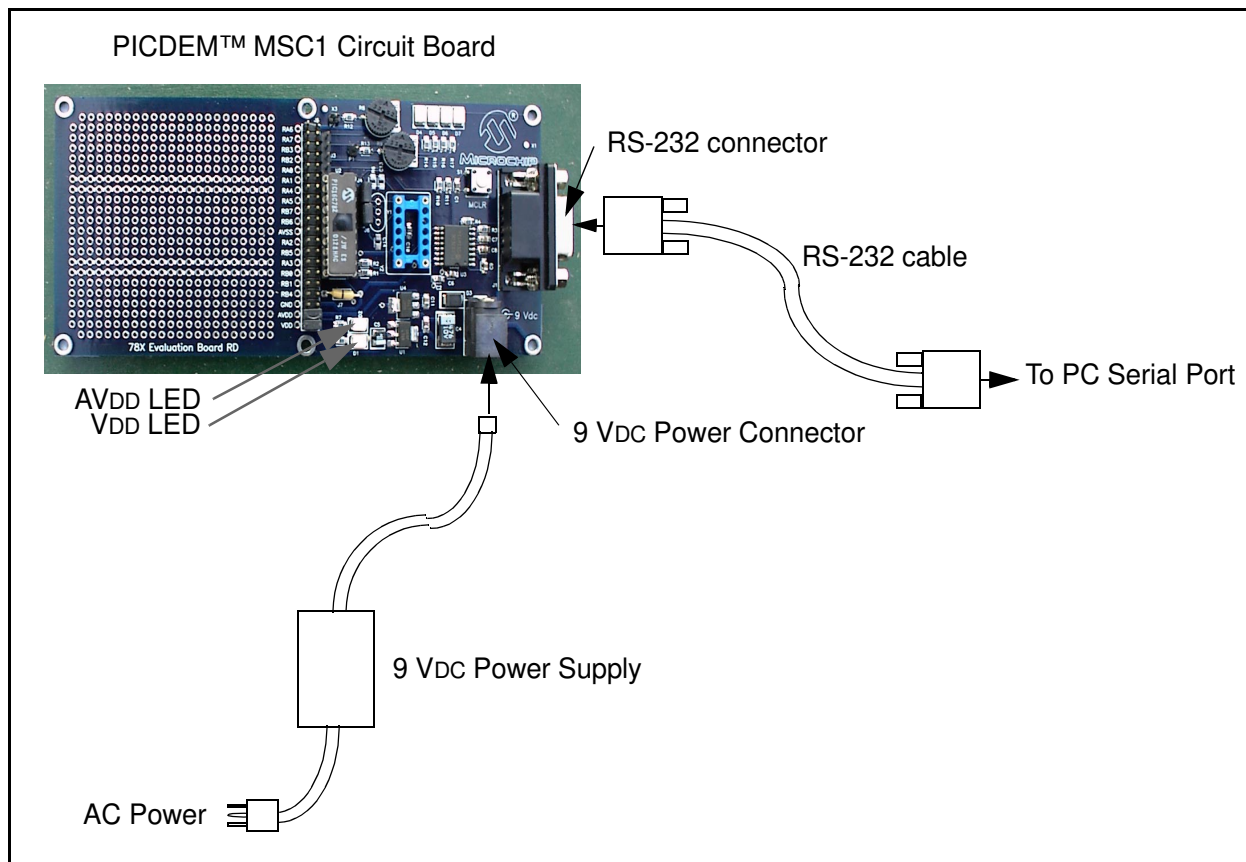
- PC running Windows 95 or newer operating system
- 9 VDC Power Supply
- 9-pin RS-232 Cable

# PICDEM™ MSC1 User's Guide

## 1.4 Installing the Hardware

Perform the following procedure to install the PICDEM™ MSC1 hardware:

1. Connect the PICDEM™ MSC1 circuit board to the 9 Vdc Power Supply as shown in the Figure 1.1 and plug in the AC connector for the 9 Vdc Power Supply.



**Figure 1.1: Installing the Hardware**

2. Connect one end of the RS-232 cable to the Serial Port of your PC.
3. Connect the other end of the RS-232 cable to the PICDEM™ MSC1 circuit board as shown in Figure 1.1. This completes the hardware installation.

**Note:** The AVDD LED and the VDD LED should be lit, indicating the Analog and Digital Power Supplies are operating.

## 1.5 Installing the GUI Software

The GUI software adheres to standard Windows® conventions and should be easy to install for anyone familiar with other Windows applications.

Perform the following procedure to install the GUI software:

1. Insert the CD containing the GUI software into your PC. Locate and double-click on the `setup.exe` file in the CD Root Directory. An Installation Wizard will guide you through the installation process.
2. Follow the instructions in the Installation Wizard. The installation creates an entry in the Start → Programs group. The Wizard will also create a PICDEM™ MSC1 icon for your desktop.
3. You can start the GUI software by using the Start → Programs → PICDEM™ MCS1 sequence.

## 1.6 What the PICDEM™ MSC1 Is

The Evaluation Tool is comprised of:

- Printed circuit board
- PC based GUI
- UV erasable PIC16C782 with monitor firmware
- 9V power supply (IEC)
- RS-232C cable (9-pin)
- General purpose jumper wires

In stand-alone mode, the GUI is useful for discovering the features of all the PIC16C781/782 peripherals and identifying which registers are affected by the different configurations. When used in conjunction with the evaluation board, the GUI gives instant access to the PIC16C781/782 peripherals allowing on-the-fly configuration changes by means of an RS-232 link between a PC and the evaluation board.

The GUI includes a Code Generator that can build the initialization assembly code that corresponds to the selected configuration. Developers can use the Code Generator to perform an entire configuration using the Evaluation Tool and save it as a disk file.

The firmware of the PICDEM™ MSC1 allows you to:

- Configure the inputs and outputs of each peripheral module using your application parameters
- Configure the operation of each peripheral module
- Load and view the contents of the Special Purpose Registers needed to run your application
- Operate a dynamic conversion loop for scoping the Output of the DAC Module
- Save the configuration file that you have created and insert it into your application software.

# PICDEM™ MSC1 User's Guide

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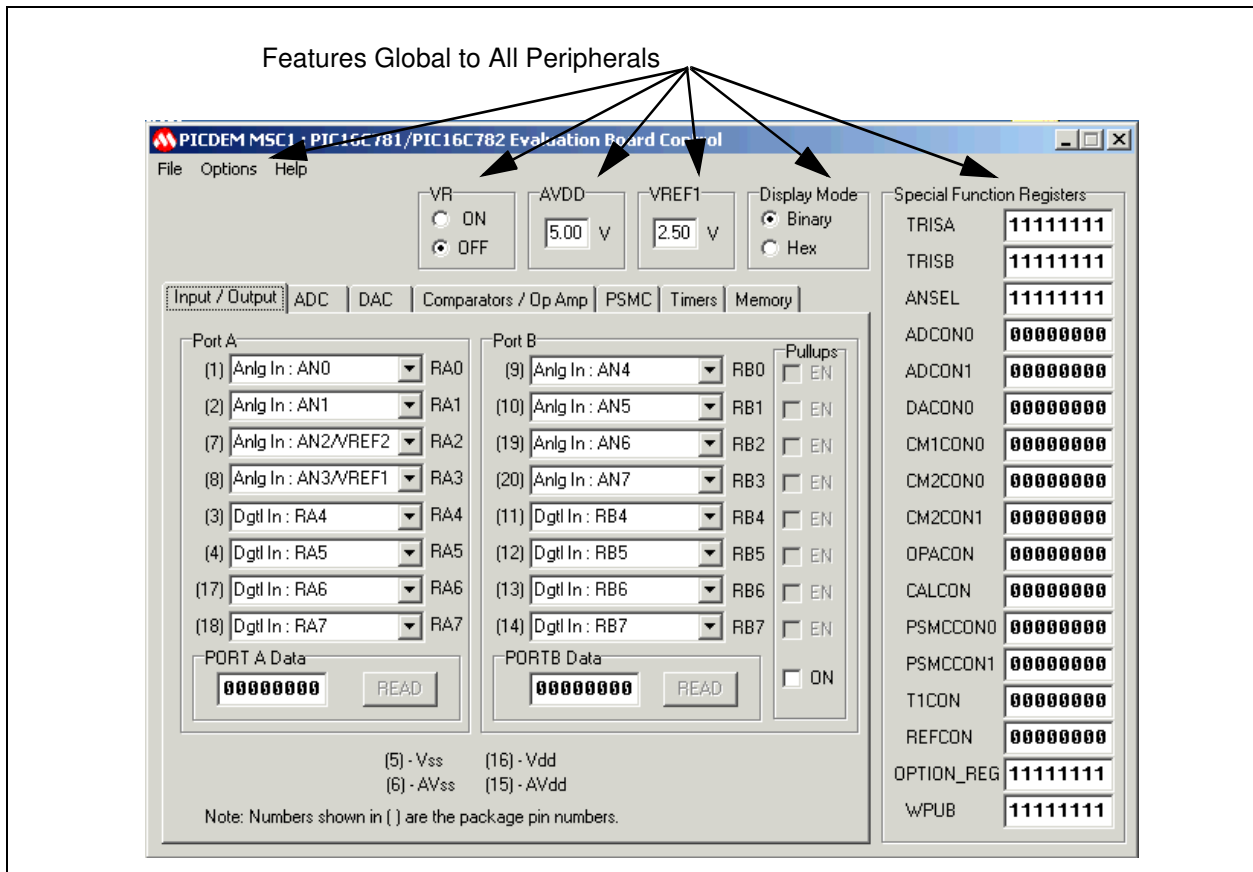
**Chapter 2. Basic Functions**

**2.1 Starting Communications with the Evaluation Tool**

**2.1.1 Introduction**

Start the GUI software by selecting Start→Programs→PICDEM MSC1, or you can double-click the PICDEM MSC1 program icon on your desktop. The GUI Control Panel displays, as shown in Figure 2.1.

**2.1.2 Using the GUI Control Panel**



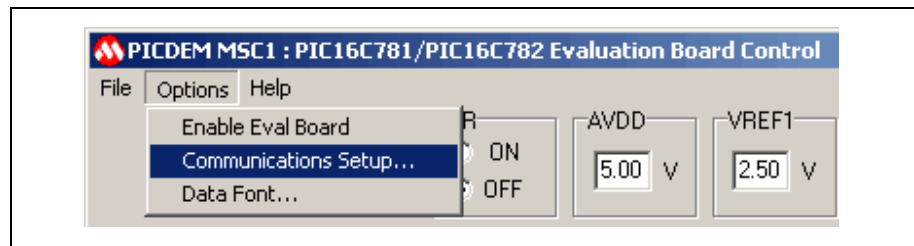
**Figure 2.1: PICDEM™ MSC1 Control Panel**

# PICDEM™ MSC1 User's Guide

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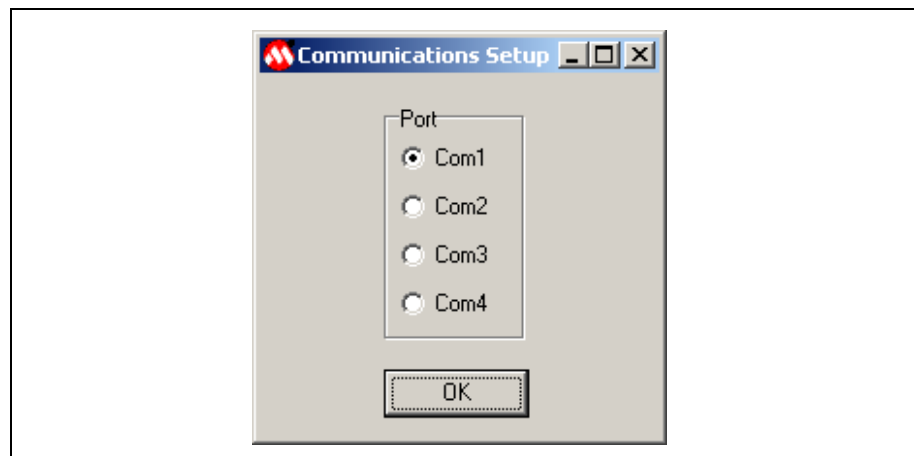
## Port Selection

Communications port selection is not automatic, so you need to make the communications port selection with the Options→Communications Setup pull-down menu option (see Figure 2.2) before attempting to connect to the Evaluation Board.



**Figure 2.2: Communications Setup**

Select the Communications Port that matches the one you are using for the serial communications with the Evaluation Board, as shown in Figure 2.3.

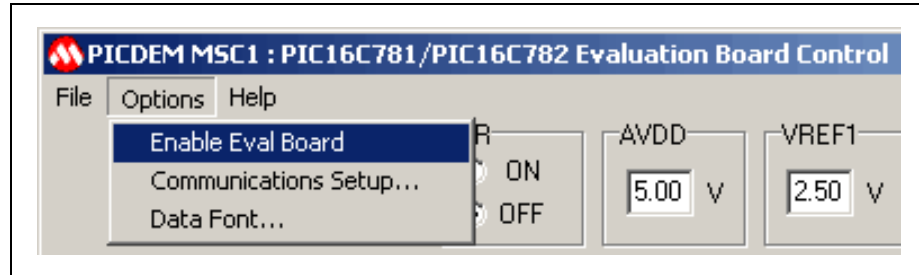


**Figure 2.3: Communications Port Selection Menu**

# Basic Functions

## Starting Communications

Select the Pull-down menu Options→Enable Eval Board to begin communications between the GUI Control Panel and the PICDEM™ MSC1, as shown in Figure 2.4.



**Figure 2.4: Enable Evaluation Board**

Select the Input/Output tab and note the Port A and Port B functions to verify that the GUI is communicating with the Evaluation Board.

**Note:** The MCLR function in Port A and the Dgtl Out: RB4 and Dgtl In: RB5 functions are shown in gray when the GUI software is initially communicating with the Evaluation Board.

## Serial Communications with the PICDEM™ MSC1 Evaluation Board

Since the PIC16C781/782 does not have a UART peripheral, serial communications are "bit-banded" with software timing loops. Timing calibration is performed automatically each time the board is enabled. The Evaluation Board clock is the internal RC oscillator.

One characteristic of this oscillator is that it may drift slightly in frequency with changes in temperature. If you expect to use the Evaluation Board over a wide temperature variation, you will need to recalibrate the communication timing at each new operating temperature.

You can recalibrate at any time by de-selecting the PICDEM MSC1 board by selecting Options→Enable Eval Board, then selecting Options→Enable Eval Board a second time to recalibrate and re-establish communications. When the connection is made, all registers will be initialized to the values set in the GUI. This procedure of disconnecting, then reconnecting, is also useful if you accidentally RESET the PIC16C781/782 with a stray probe or ground strap.

## PERIPHERAL ORGANIZATION

The PIC16C781/782 peripherals are organized as tabbed pages (see Figure 2.1), one for each major peripheral function. These include:

- Input/Output
- Analog-to-Digital Converter (ADC)
- Digital-to-Analog Converter (DAC)
- Comparators and Operational Amplifier
- Programmable Switch Mode Controller (PSMC)



# PICDEM™ MSC1 User's Guide

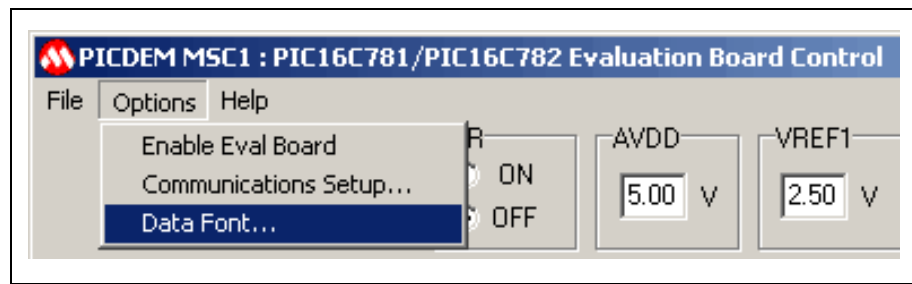
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- Timers
- Memory Access

When a configuration change is made, the register(s) affected by the change will turn red, calling attention to where the changes occurred. Register values cannot be entered directly. However, when the Evaluation Board is active, register values may be retrieved from the Evaluation Board by double-clicking on the register name. The register font color changes to blue in response.

## Changing the Default Font

In some cases, the default font will not fit in the Register Display boxes. You can change the font selection and size with the Options->Data Font menu option, as shown in Figure 2.5.



**Figure 2.5: Data Font Selection**

The best results will be obtained by choosing a scalable fixed-spacing font such as Courier New.

Some controls of the GUI are interlocked so that a change to one selection automatically selects other controls necessary for the proper operation of the selected item. For example, selecting PORTA RA0 as the non-inverting Op Amp input automatically selects RA1 as the inverting input and RB3 as the Op Amp output.

## Special Conventions

A special convention pertains to the following edit boxes:

- PORTA
- PORTB
- Timer0
- Timer1
- Memory Address
- Memory Data

When typing in one of these boxes, the font color changes to red, indicating that the entry is local only to that box. When the <Enter> key is pressed, the entry in the box is sent to the corresponding register and the font color reverts to black. If focus (i.e., clicking outside the box) is moved outside of the edit box before the <Enter> key is pressed, the box is restored to its original con-

# Basic Functions

tents and no action is taken. When the GUI is actively connected to the Evaluation Board, entries are instantly and automatically sent to the PIC16C782.

## GLOBAL ITEMS

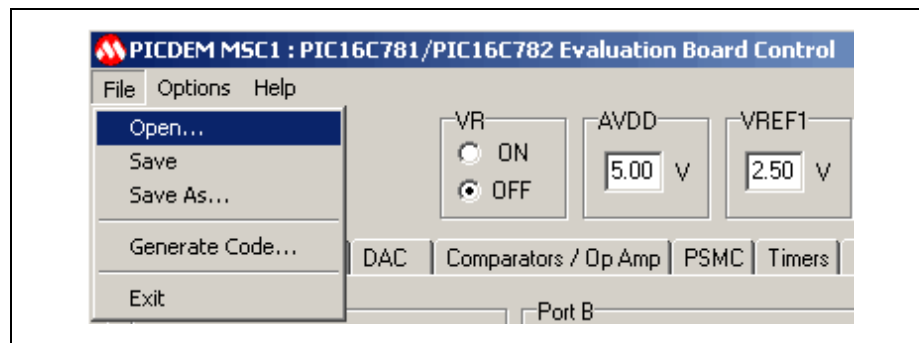
Items that are global to all the peripherals are located in the GUI outside of the tabbed pages (see Figure 2.1). Global items include:

- Special Function Registers
- Internal Voltage Reference Control (VR)
- Display Mode Selection (Binary or HEX)
- Pull-Down Menus
- Edit Boxes for the AVDD and VREF1 voltages

**Note:** The AVDD and VREF1 entries are used to compute some of the display values for the ADC and DAC peripherals, and have no other effects. If these inputs are known to be different than the values shown, enter the correct values.

## File Menu Functions

Click on the File menu to view the options, as shown in Figure 2.6.



**Figure 2.6: File Menu Options**

Except for the Generate Code option, the options on the File Menu are standard Microsoft Windows functions:

- **Open...** - allows you to open a previously saved version of the PICDEM MSC1 GUI configuration with all the parameters and data to use as a starting point for a new configuration.
- **Save** - allows you to capture and save the GUI information and configuration data as a file.
- **Save As...** - same as Save, but allows you to change the name of the **file saved**.
- **Generate Code...** - Creates an Initialization assembly code file that corresponds to the selected configuration.
- **Exit** - Closes and terminates the program.

# PICDEM™ MSC1 User's Guide

## 2.1.2.1 Input/Output

Use the Input/Output tab to configure the Port A and B functions, as shown in Figure 2.7. Some of the Port pins can be mixed signal (i.e., they can be either digital or analog). I/O functions are fully described in Section 3.0 of the PIC16C781/782 Data Sheet (DS41171).

Use drop-down menu to configure Port bit functions.

Register values are Read Only. Double-click on register name to read value from PICDEM MSC1 board.

TRISA	11111111
TRISB	11111111
ANSEL	11111111
ADCON0	00000000
ADCON1	00000000
DACON0	00000000
CM1CON0	00000000
CM2CON0	00000000
OPACON	00000000
CALCON	00000000
PSMCCON0	00000000
PSMCCON1	00000000
T1CON	00000000
REFCON	00000000
OPTION_REG	11111111
WPUB	11111111

Figure 2.7: Input/Output Functions

## 2.1.2.2 Analog-to-Digital Converter (ADC)

Use the ADC tab to configure the 10 inputs (shown in the ADC Input Select area) to the Analog to Digital Converter, as shown in Figure 2.8. The ADC allows conversion of an analog input signal to a corresponding 8-bit digital value. ADC functions are fully described in Section 9.0 of the PIC16C781/782 Data Sheet (DS41171).

Names change to correspond with selected pin function

Read ADC Continuous Mode checkbox<sup>(1)</sup>

single ADC read button

ADC - Internal RC clock source - Required when performing ADC conversions during SLEEP Mode

**Note 1:** When the Read ADC Continuous Mode is checked, ADC readings are automatically updated about 10 times per second.

**Figure 2.8: Analog-to-Digital Converter Peripheral (ADC) Functions**

# PICDEM™ MSC1 User's Guide

## 2.1.2.3 Digital-to-Analog Converter (DAC)

Use the DAC tab to configure the Digital to Analog Converter (DAC) module, as shown in Figure 2.9. The DAC module generates an output voltage proportional to the value in the 8-bit DAC Register. DAC functions are fully described in Section 10.0 of the PIC16C781/782 Data Sheet (DS41171).

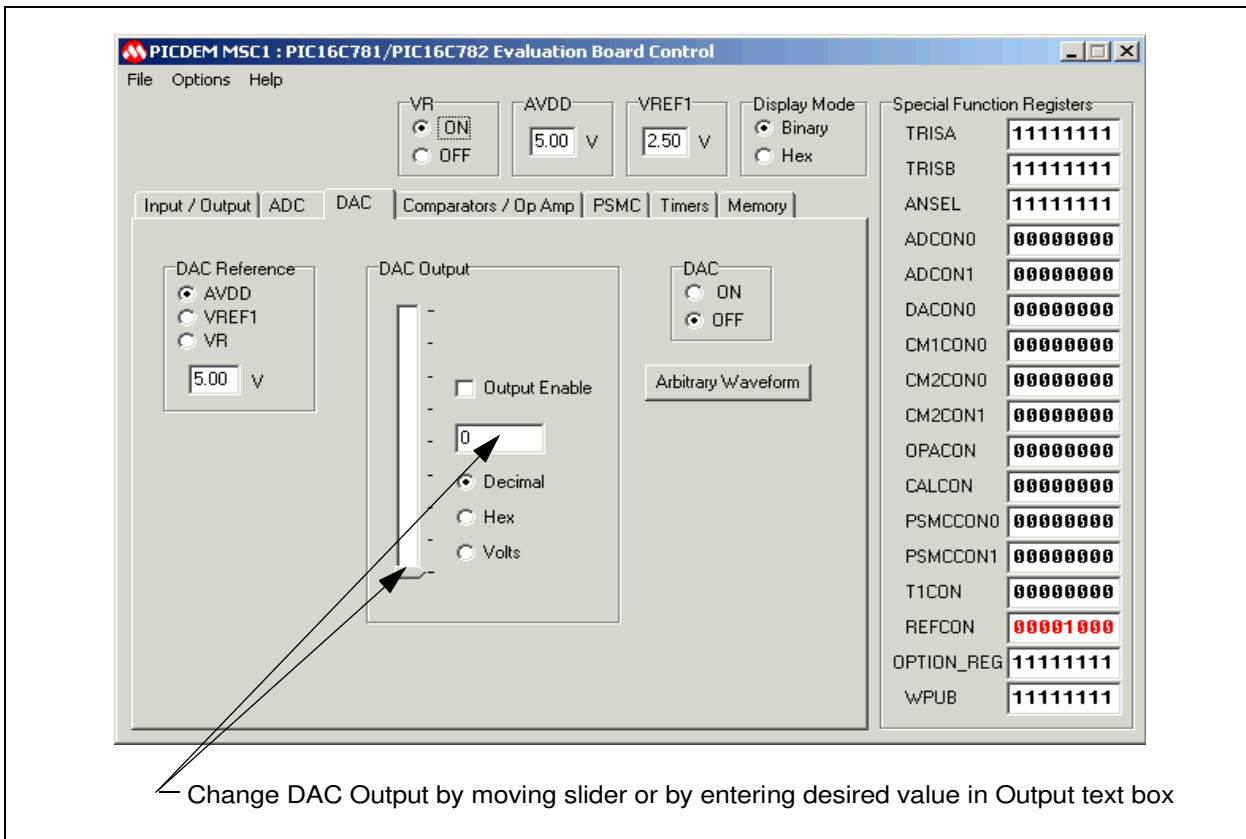


Figure 2.9: Digital-to-Analog (DAC) Peripheral Functions

## ARBITRARY WAVEFORM

The DAC Arbitrary Waveform function is a utility that provides for sending a set of user-defined data bytes to the DAC one byte at a time, with a user-defined dwell time between each byte. The data set must consist of 2 to 80 bytes. The dwell time is determined by waiting a user-defined number of timer0 count intervals. The utility computes dwell time as a function of :

- Timer0 clock
- Timer0 prescale
- Number of points in the waveform
- User-defined waveform period or frequency parameter.

Timer0 counts must be between 2 and 255. Adjust the parameters to ensure the count is within these limits.

The period of the waveform is defined as the time required for all the waveform points to be output.

Two types of waveforms can be computed by the utility:

1. A sine wave (see Figure 2.10)
2. A triangle wave (see Figure 2.11)

An unlimited number of other waveforms can be generated external to the utility and saved as a text file, which the utility can retrieve. Each point of the waveform is represented as an integer between 0 and 255. The set of points is saved as a text file with one integer per line. If the waveform file contains more than 80 integers, the Arbitrary Waveform utility accepts only the first 80.

The DAC data is displayed in the preview window when the waveform is generated or loaded from a file. Two waveform periods are displayed, so that unexpected discontinuities between the last and first data bytes can be identified. The preview window displays the waveform in an unsmoothed format that represents the expected DAC output.

Figures 2.10 and 2.11 show examples of utility generated sine and triangle waveforms respectively.

# PICDEM™ MSC1 User's Guide

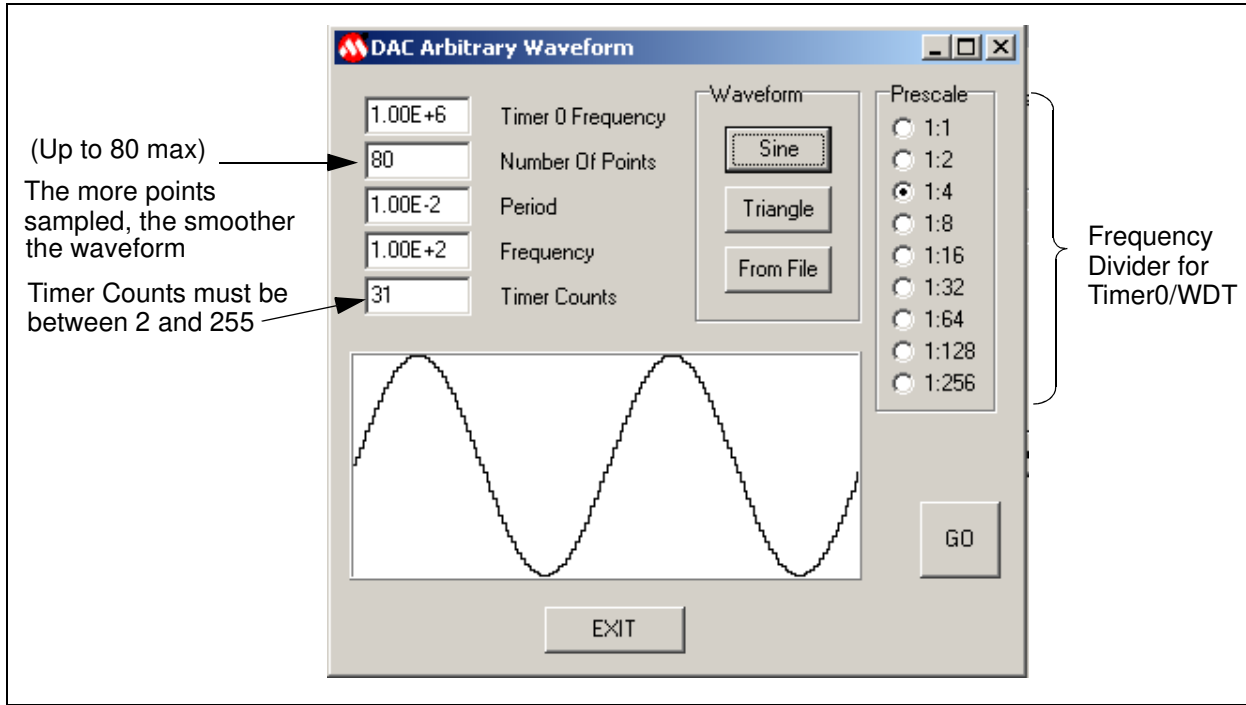


Figure 2.10: Sine Wave Example

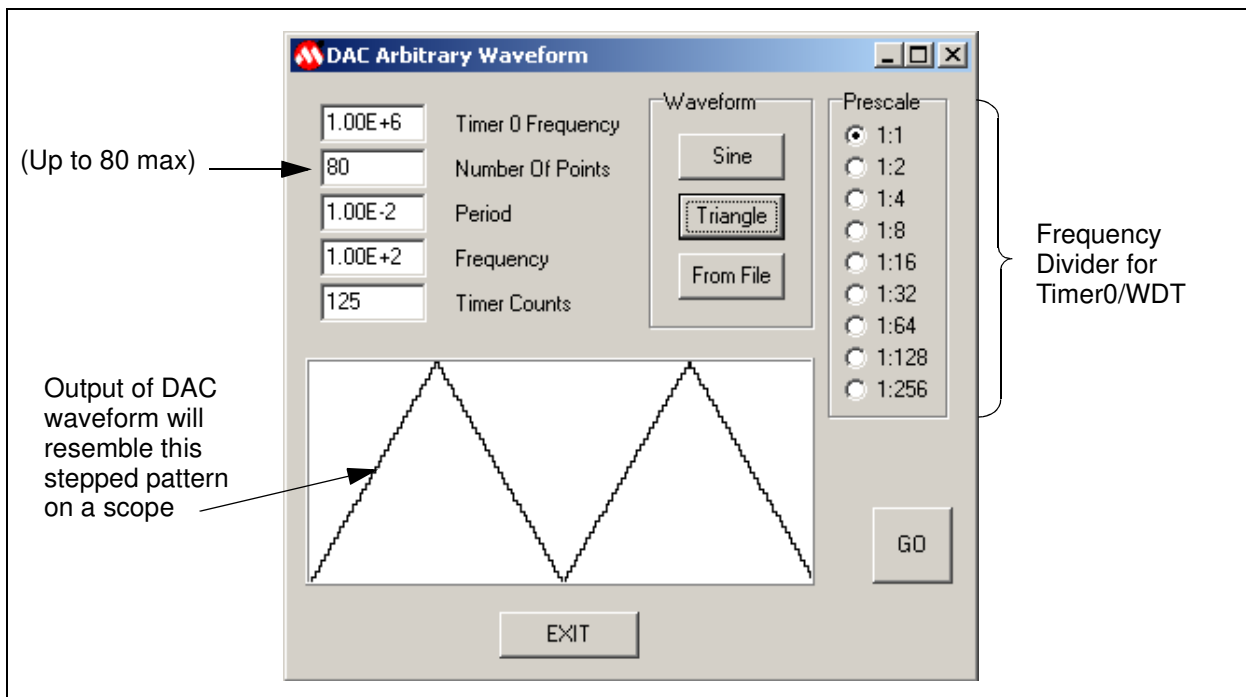


Figure 2.11: Triangle Waveform Example

## 2.1.2.4 Comparators/Op Amp

Use the Comparators/Op Amp tab to configure the two separate voltage comparators, C1 and C2, as shown in Figure 2.12. Internal voltage reference is provided by the VDAC option for both comparators. An external voltage reference can be supplied to C1 via the AN3/VREF1 input and the AN2/VREF2 input for C2. You can also use the same tab to configure the Operational Amplifier (OPA) module.

The Comparator Module functions are fully described in Section 12.0 of the PIC16C781/782 Data Sheet.

The Operational Amplifier (OPA) Module is fully described in Section 11.0 of the PIC16C781/782 Data Sheet (DS41171).

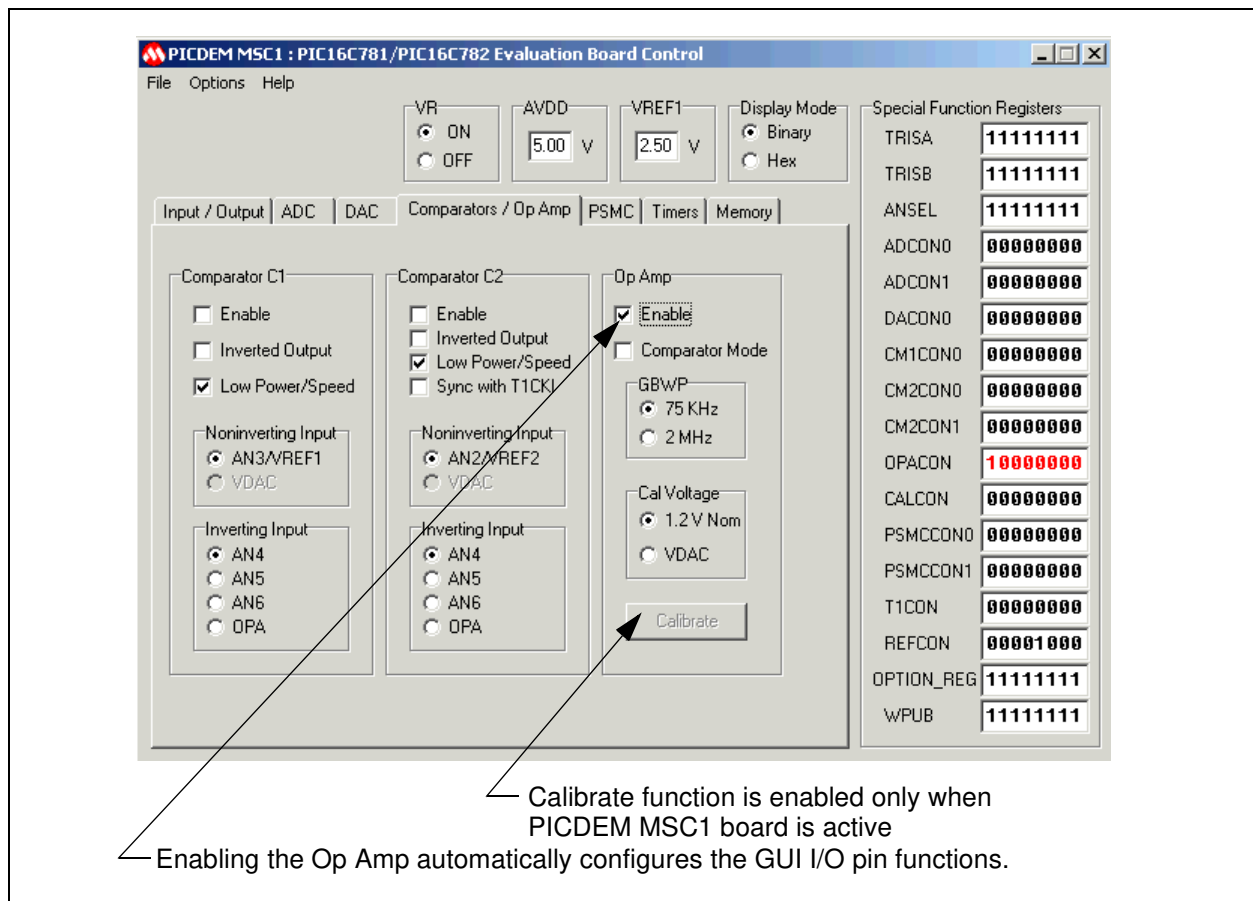


Figure 2.12: Comparators/Op Amp Peripheral Functions



# PICDEM™ MSC1 User's Guide

## 2.1.2.5 Programmable Switch Mode Controller (PSMC)

Use the PSMC tab to configure the PSMC module, as shown in Figure 2.13. This module provides all the necessary features to implement a pulsed feedback control system. The PSMC generates a pulsed output based on its analog feedback. The Programmable Switch Mode Controller (PSMC) is fully described in Section 13.0 of the PIC16C781/782 Data Sheet (DS41171).

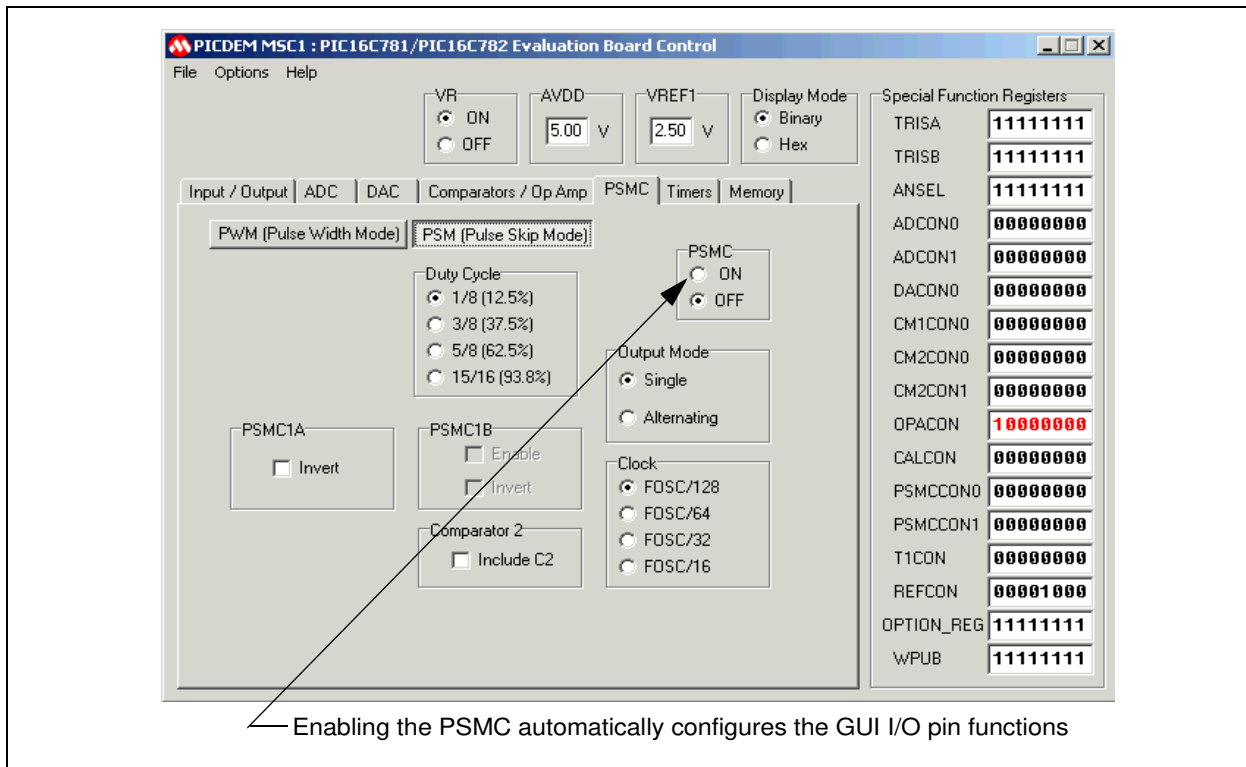


Figure 2.13: PSMC Peripheral Functions

## 2.1.2.6 Timers

Use the Timers tab to configure Timer0 and Timer1, as shown in Figure 2.14. Timer0 can operate as either a timer or a counter. The Timer0 Module is described in Section 5.0 of the PIC16C781/782 Data Sheet (DS41171). The Timer1 module is fully described in Section 6.0 of the PIC16C781/782 Data Sheet (DS41171).

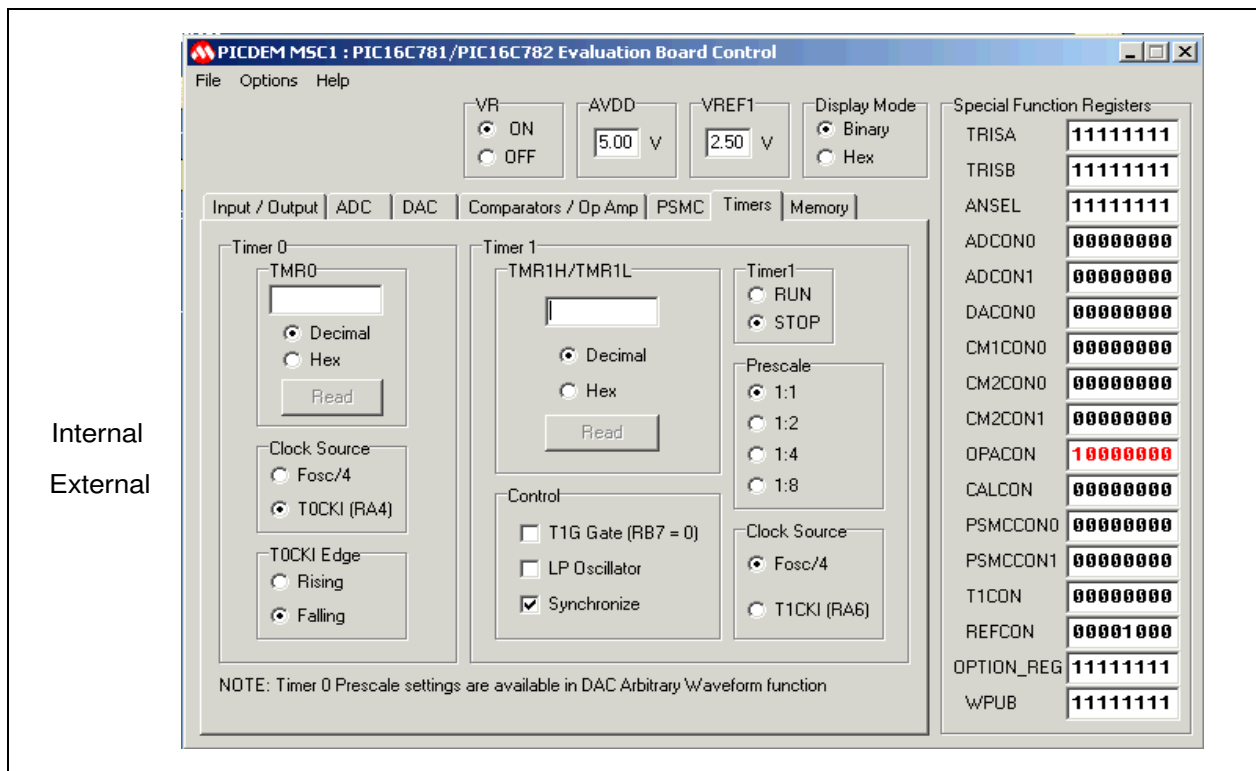


Figure 2.14: Timers / Peripheral Functions