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PICtail Plus Daughter Board
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MCP4725 PICtail™ Plus DAUGHTER BOARD USER'S GUIDE

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MCP4725 PICtail™ Plus DAUGHTER BOARD USER'S GUIDE

Preface

INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP4725 PICtail™ Plus Daughter 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 MCP4725 PICtail™ Plus Daughter Board as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

• **Chapter 1. "Quick Start Instructions"** – this chapter provides an overview of the MCP4725 PICtail™ Plus Daughter Board and instructions on how to program the DAC register and EEPROM of the MCP4725 device.
• **Appendix A. "Schematics and Board Layouts"** – shows the schematic and layout diagrams for the MCP4725 PICtail™ Plus Daughter Board.
• **Appendix B. "Bill Of Materials (BOM)"** – lists the parts used to build the MCP4725 PICtail™ Plus Daughter Board.

MCP4725 PICtail™ Plus Daughter Board User's Guide

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
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]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
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 MCP4725 PICtail™ Plus Daughter Board. The following Microchip documents are available and recommended as supplemental reference resources.

PICkit™ Serial Analyzer User's Guide (DS51647)

Consult this document for instructions on how to use the PICkit Serial Analyzer hardware and software.

MCP4725 Data Sheet, "12-Bit DAC with EEPROM Memory in SOT-23-6" (DS22039)

This data sheet provides detailed information regarding the MCP4725 product family.

MCP4725 SOT-23 Evaluation Board User's Guide (DS51669)

PIC24FJ128GA010 Family Data Sheet (DS39747)

Explore 16 Development Board User's Guide (DS51589)

AN1079, "Using the C3 Compiler and the I2C Peripheral to Interface Serial EEPROMs with dsPIC33F" (DS01079)

PICkit™ Serial Analyze User's Guide (DS51647)

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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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- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

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 (March 2008)

• Initial Release of this Document.

MCP4725 PICtail™ Plus DAUGHTER BOARD USER'S GUIDE

Chapter 1. Quick Start Instructions

1.1 INTRODUCTION

The following sections provide an overview of the MCP4725 PICtail™ Plus Daughter Board and demonstrate how to use (a) the MCP4725 device in a 16-bit MCU environment and (b) evaluate the MCP4725 device features using the PICkit™ Serial Analyzer (P/N: DV164122). The MCP4725 PICtail™ Plus Daughter Board is designed to work with both the Explorer 16 Development Board (P/N: DV164033) and the PICkit™ Serial Analyzer (P/N: DV164122).

The following topics are covered:

• Description of the MCP4725 PICtail™ Plus Daughter Board
• How to use the MCP4725 PICtail™ Plus Daughter Board with the Explorer 16 Starter Kit
• How to use MCP4725 PICtail™ Plus Daughter Board with the PICkit™ Serial Analyzer

1.2 DESCRIPTION OF THE MCP4725 PICtail™ Plus DAUGHTER BOARD

The MCP4725 PICtail™ Plus Daughter Board (P/N MCP4725DM-PTPLS) contains an MCP4725 12-bit Digital-to-Analog Converter (DAC). This daughter board has the following two interfaces:

• Explorer 16 Starter Kit (P/N: DV164033) for 16-bit MCU environment
• PICkit™ Serial Analyzer (P/N: DV164122) for reading and writing the DAC register and observing the DAC output

The user can connect this daughter board to one of the above tools and perform their own experiments.

The board has test points for SDL, SDA, and V_{OUT}. By connecting an oscilloscope to these test points (to SCL, SDA, V_{OUT}) or Digital Multimeter to V_{OUT}, the user can examine the data communications through the I^{2}C™ bus line and observe the resulting DAC output (V_{OUT}). Refer to **Appendix A. "Schematic and Layouts"**

1.2.1   I^{2}C Address Bits and A0 Address Bit Selection

The I^{2}C device code and address bits of the MCP4725 device are:

• Device Code: '1100'
• A2, A1, A0 Address Bits: '00X', where X is for the A0 bit which is determined by the logic state of the A0 pin

Note that the first two address bits (A2 and A1) are programmed at factory during device production and A0 bit is programmed by the user during applications. The A2 and A1 address bits of the MCP4725 device used for the MCP4725 PICtail™ Plus Daughter Board are programmed at the factory to '00'. The JMP1 connector on the MCP4725 PICtail™ Plus Daughter Board selects the A0 bit. The following conditions show the A0 bit selection:

• A0 bit = '1' if JMP1 is connected to V_{DD}
• A0 bit = '0' if JMP1 is connected to V_{SS} (Default setting)
• Address bits A2, A1 = '00'

Based on the above information, the combined device code and address bits for the I^2C Serial Communication are:

- 1100-001$\overline{W}$/R: if JMP1 is connected to V_{DD}
- 1100-000$\overline{W}$/R: if JMP1 is connected to V_{SS}
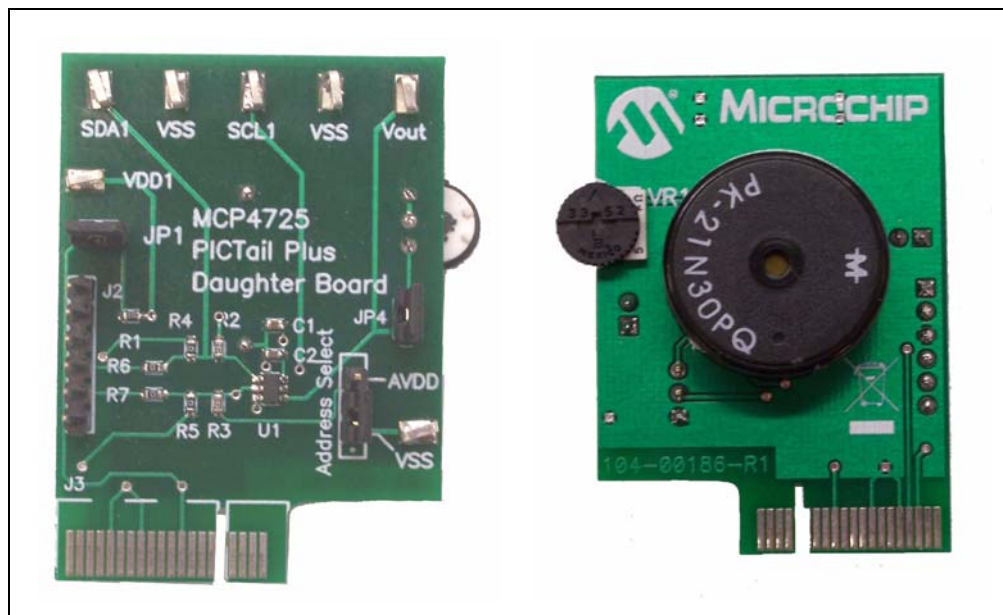- Where $\overline{W}$/R is write("0") or read ('1') bit.

FIGURE 1-1:   *Front and Back Views of the MCP4725 PICtail™ Plus Daughter Board.*

1.3   GETTING STARTED WITH EXPLORER 16 DEVELOPMENT BOARD

Figure 1-2 shows the MCP4725 PICtail™ Plus Daughter Board with the Explorer 16 Development Board. When they are connected, the user can program the 16-bit PIC24FJ128 MCU on the Explorer 16 Starter Kit. The Explorer 16 Development Board sends I^2C serial communication commands to the MCP4725 PICtail™ Plus Daughter Board for the MCP4725 DAC output. The Explorer 16 MCU firmware for this MCP4725 PICtail™ Plus Daughter Board writes to the DAC input register continuously in 1 LSB increments. The user can see the DAC output (V_{OUT}) changes using an oscilloscope. Also, a buzzer on the MCP4725 PICtail™ Plus Daughter Board makes sounds driven by the DAC output (V_{OUT}).

1.3.1   Connecting to the Explorer 16 Starter Kit

1. Connect the MCP4725 PICtail™ Plus Daughter Board to the J5 socket on the Explorer 16 Development Board as shown in Figure 1-2.
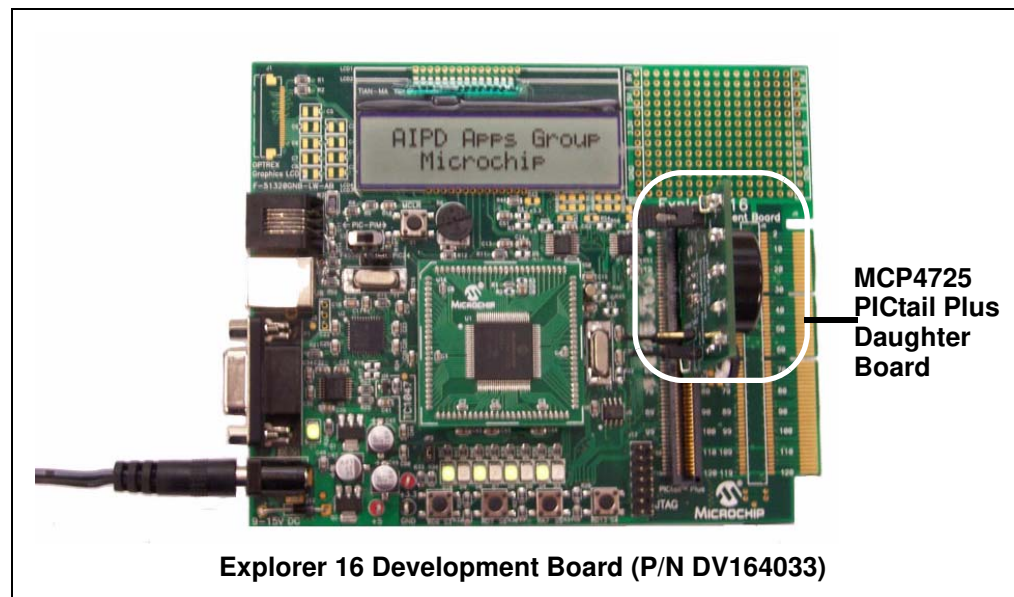

Explorer 16 Development Board (P/N DV164033)

MCP4725 PICtail Plus Daughter Board

FIGURE 1-2:   *Connecting the MCP4725 PICtail™ Plus Daughter Board to the Explorer 16 Development Board.*

1.3.2   Programming the PIC24FJ128 MCU

The Explorer 16 Development Board contains the PIC24FJ128 MCU. The user can download the firmware to the MCU using the MPLAB ICD2 programmer. Refer to Chapter 2 of the Explorer 16 Development Board User's Guide (DS51589) for details on the programming of the Explorer 16 Development Board.

1.3.2.1   THE PIC24FJ128 MCU FIRMWARE FOR THE MCP4725 PICtail™ Plus DAUGHTER BOARD

The original firmware for the Explorer 16 Development Board is modified for the MCP4725 PICtail™ Plus Daughter Board demonstration. The firmware uses most of the original codes for the Explorer 16 Development Board except the I^{2}C peripheral control routines for the PIC24FJ128 MCU.

The following four routines are added or modified from the original Explorer 16 Development Board firmware.

• PIC24ExplDemo_MCP4725_Main.c
• MCP4725_i2C_Func.c
• Banner_MCP4725.c
• i2C_MCP4725.h

The user can modify the above routines for their own application.

The source code is compiled by using Microchip's C30 Compiler and the hex code is programmed to the MCU using the MPLAB ICD 2. Figure 1-3 shows connection of the MPLAB ICD 2 and the Explorer 16 Development Board. Figure 1-4 shows the MPLAB IDE programming environment.

1.3.2.2   FIRMWARE FLOW CHART FOR THE MCP4725 DAUGHTER BOARD

Figure 1-5 shows the flow chart of the firmware. Once the MCU firmware is programmed, the user can observe the following events:

1. V_{OUT} changes as the MCU rewrites the DAC codes. See Figure 1-6 for the V_{OUT} waveform.
2. Audible sounds (Buzzer) if JP4 is connected.
3. I^2C data communication (SDA and SCL) waveform over the I^2C bus line. See Figure 1-6 and Figure 1-7.

1.3.3   DAC Output (V_{OUT})

The MCU sends write commands for EEPROM and DAC input register.

The MCU writes EEPROM only once, but writes continuously the DAC input register. The EEPROM is written for the $V_{OUT} = V_{DD}/2$, and the DAC input register is continuously written for the V_{OUT} to be ramp: The DAC input code is written from "000h" to "FFFh" with 1 LSB increment. When it reaches "FFFh", resets to "000h" and repeats the writing from "000h" to "FFFh" with 1 LSB again.

The user can observe the V_{OUT} at the V_{OUT} test pin using a digital voltmeter or oscilloscope. Figure 1-7 shows the I^2C clock (SCL) and data (SDA) signals, and DAC output waveform.

The DAC input register is written with fast mode write command which does not affect the EEPROM. The user can confirm the data written in EEPROM ($V_{OUT} = V_{DD}/2$) by disconnecting the MCP4725 PICtail™ Plus Daughter Board from the Explorer 16 Development Board. When the board is first powered, the MCP4725 device loads the EEPROM data to the DAC input register by itself and then outputs an analog voltage determined by the EEPROM data.

1.3.4   Audible Buzzer

The MCP4725 PICtail™ Plus Daughter Board includes a buzzer. This buzzer is directly connected to the V_{OUT}. The user can disable the buzzer by disconnecting JP4. The buzzer sounds also can be adjusted by VR1.
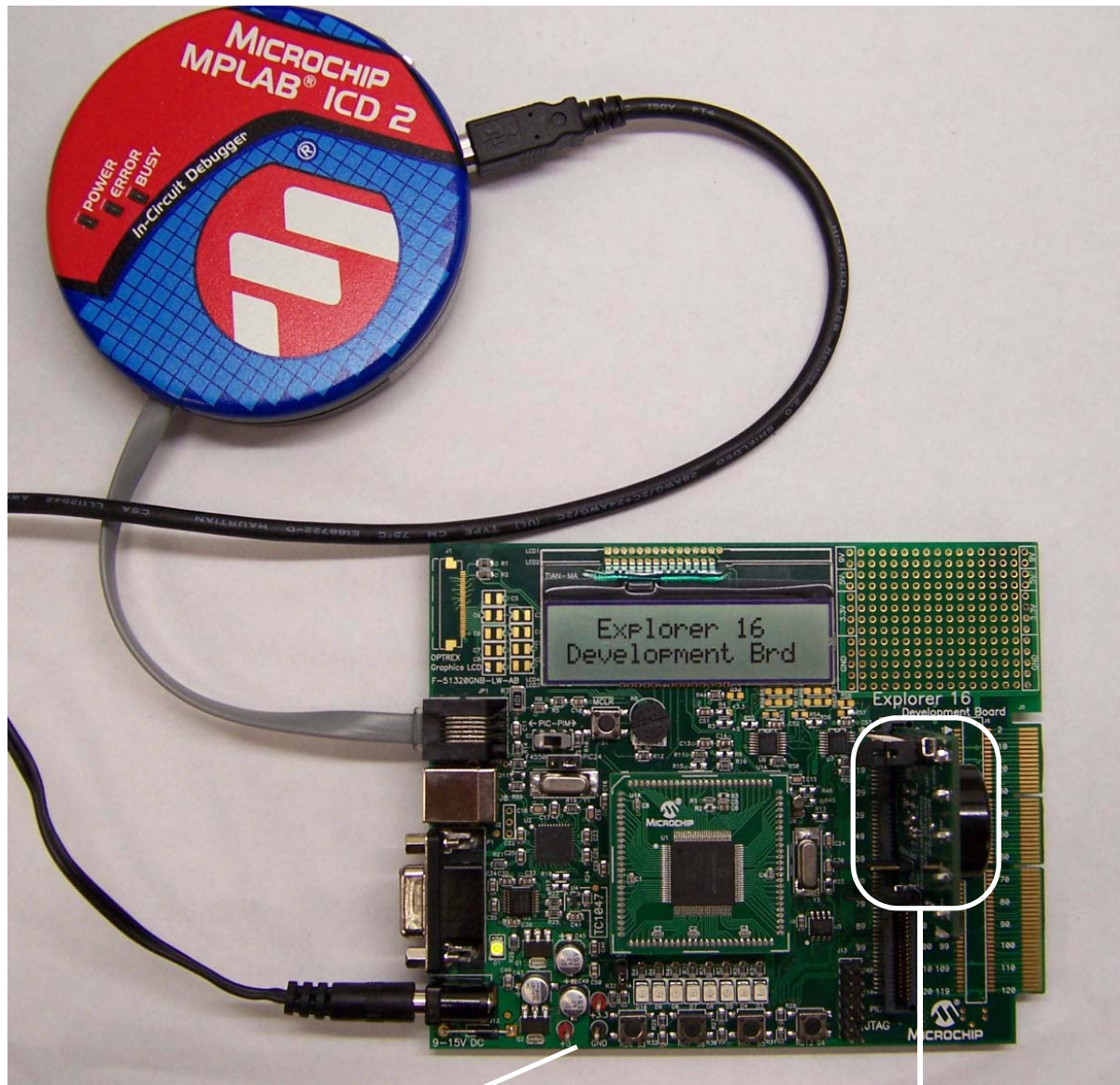
**Explorer 16 Development Board
(P/N DV164033)**

**MCP4725 PICtail Plus
Daughter Board
(P/N MCP4725DM-PTPLS)**

FIGURE 1-3: *MPLAB ICD2 connection to Explorer 16 Development Board with the MCP4725 PICtail™ Plus Daughter Board for programming.*

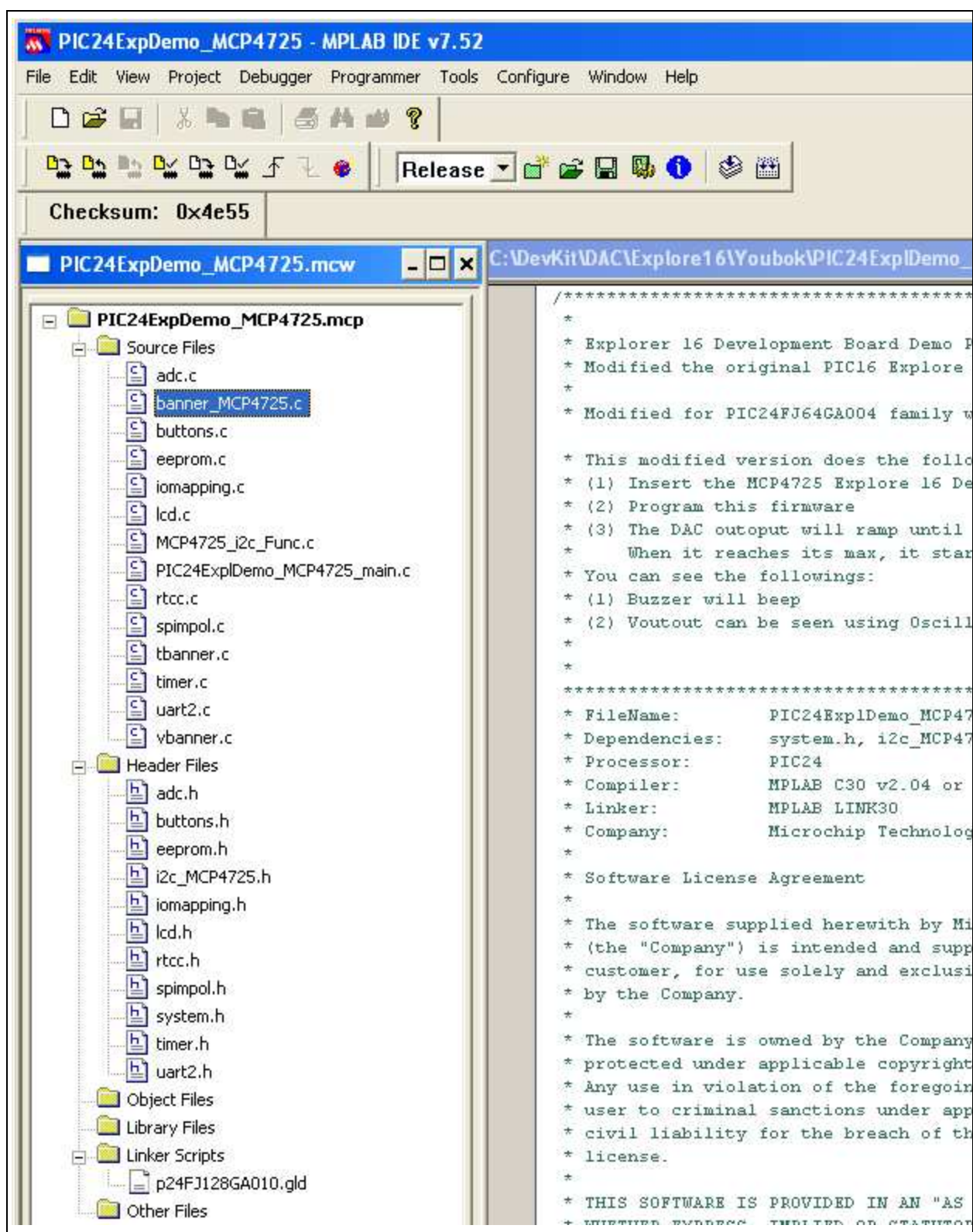# MCP4725 PICtail™ Plus Daughter Board User's Guide

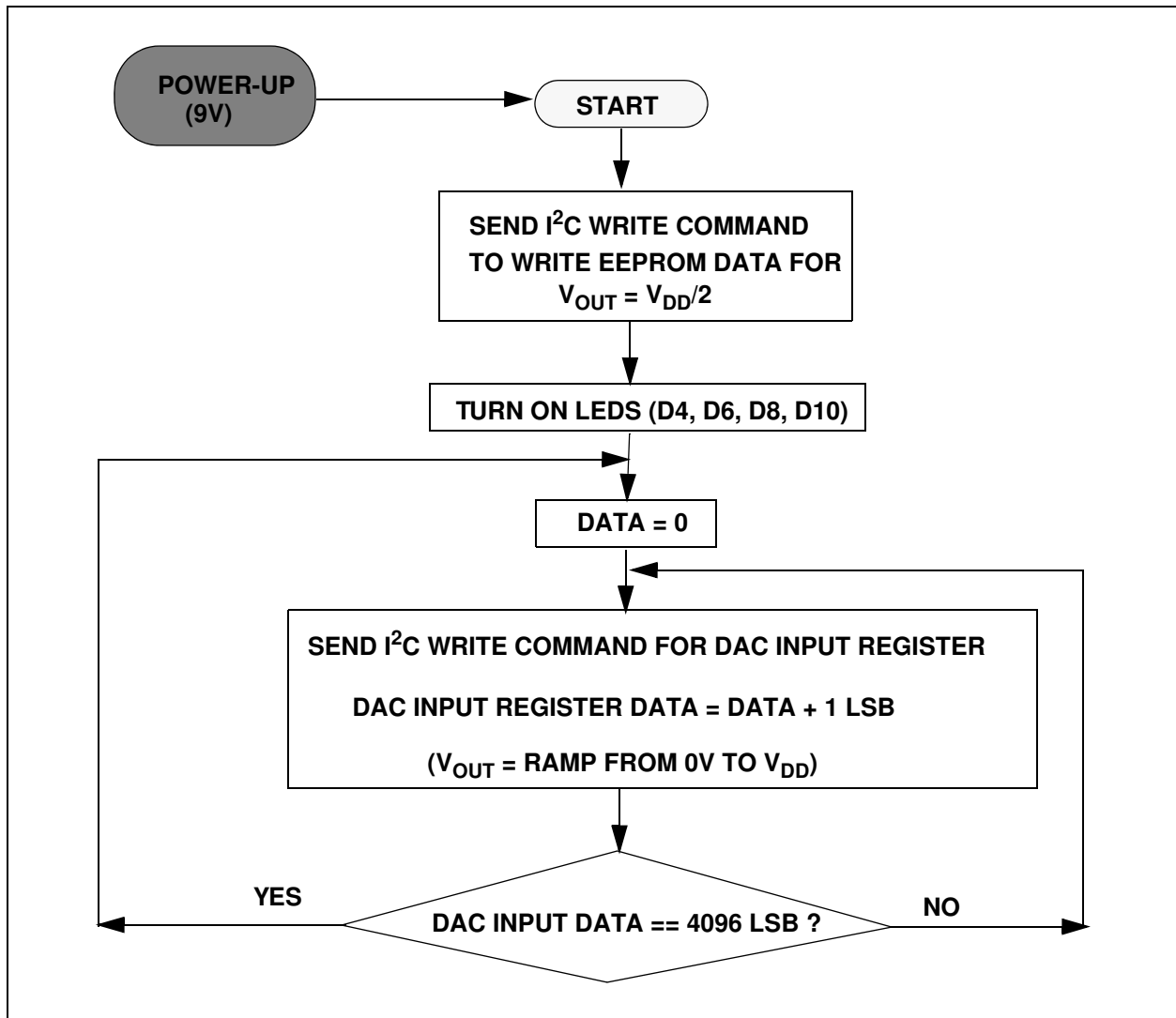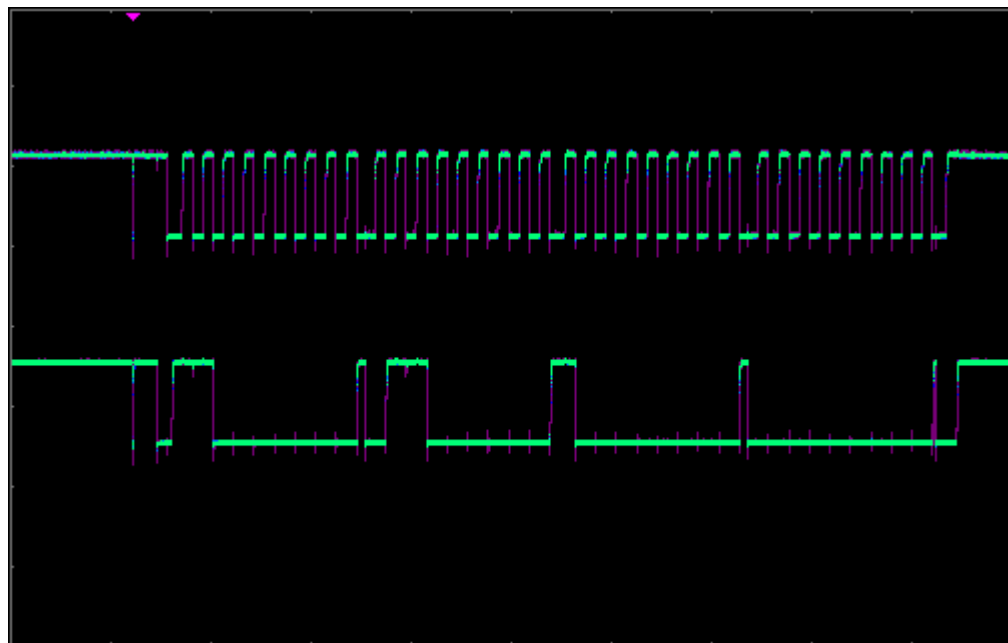*FIGURE 1-4:* MPLAB IDE Programming Environment.

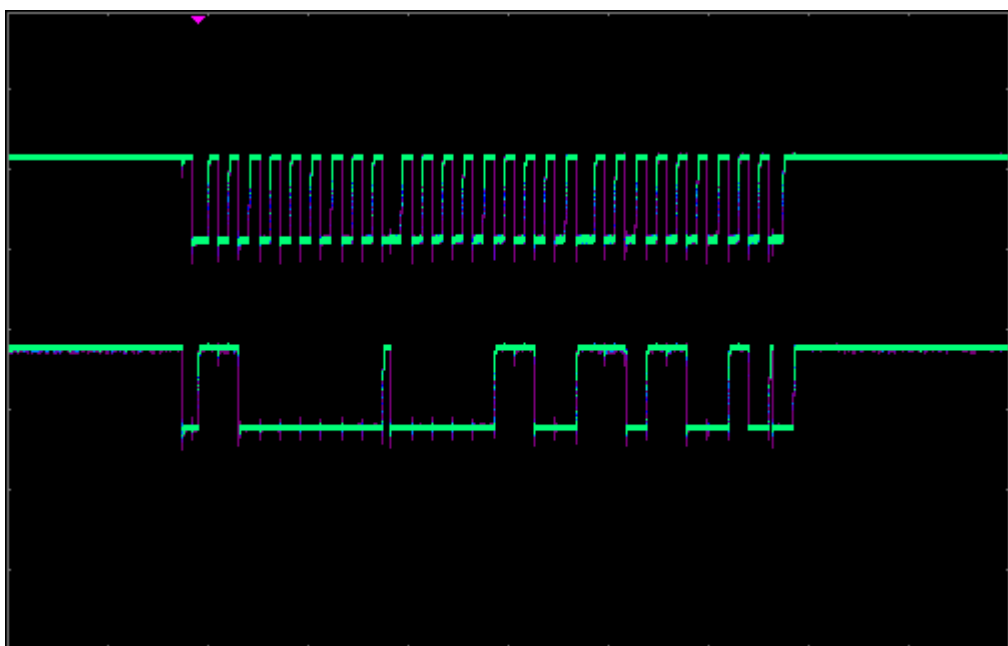*FIGURE 1-5:*   *Flow Chart for the MCP4725 PICtail™ Plus Daughter Board Firmware.*

(a) Write DAC Input Register and EEPROM
(DAC Code = 1000-0000-0000)

$$Expected\ DAC\ Output\ =\ \frac{V_{DD} \bullet Dn}{4096}\ =\ \frac{5 \bullet 800(hex)}{4096}\ =\ 2.5V$$

(b) Fast Write Command
(DAC Code = 0110-1101-1001)

$$Expected\ DAC\ Output\ =\ \frac{V_{DD} \bullet Dn}{4096}\ =\ \frac{5 \bullet 6D9(hex)}{4096}\ =\ 2.1398V$$

FIGURE 1-6: *I^2C Write Command Waveforms for the MCP4725.*
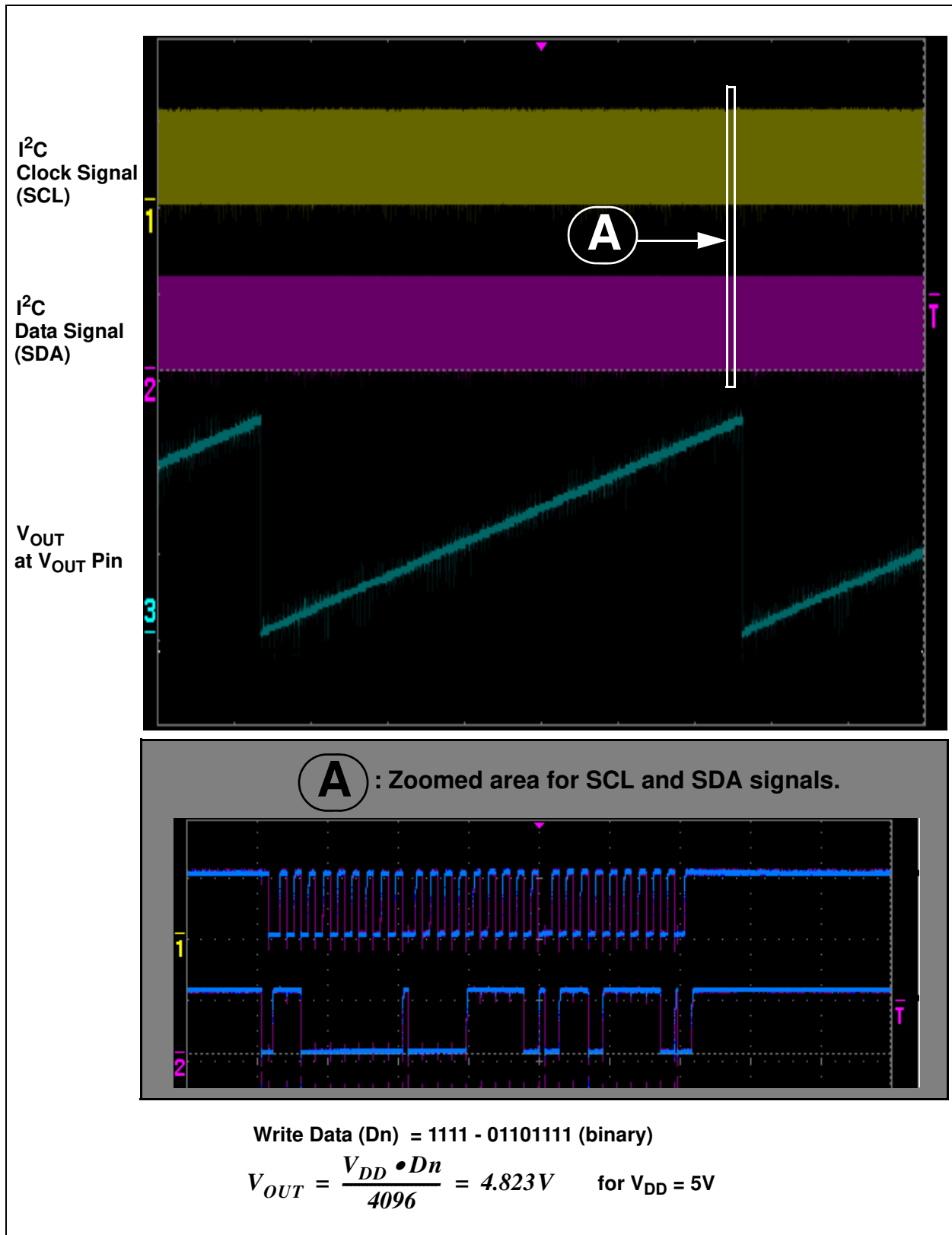
FIGURE 1-7: *I^2C SCL, SDA, and V_{OUT} Waveforms while incrementing the DAC code by 1 LSB.*

Within the figure:

A : Zoomed area for SCL and SDA signals.

Write Data (Dn) = 1111 - 01101111 (binary)

$$V_{OUT} = \frac{V_{DD} \bullet Dn}{4096} = 4.823V \quad \text{for } V_{DD} = 5V$$

Labels: I²C Clock Signal (SCL); I²C Data Signal (SDA); V_OUT at V_OUT Pin

1.4   GETTING STARTED WITH PICKIT™ SERIAL ANALYZER

The user can use the MCP4725 PICtail™ Plus Daughter Board with the PICkit™ Serial Analyzer by setting up as shown in Figure 1-8.

The following describes how to use them together:

1. Connect the MCP4725 PICtail™ Plus Daughter Board's J2 pin socket to the PICkit™ Serial Analyzer.
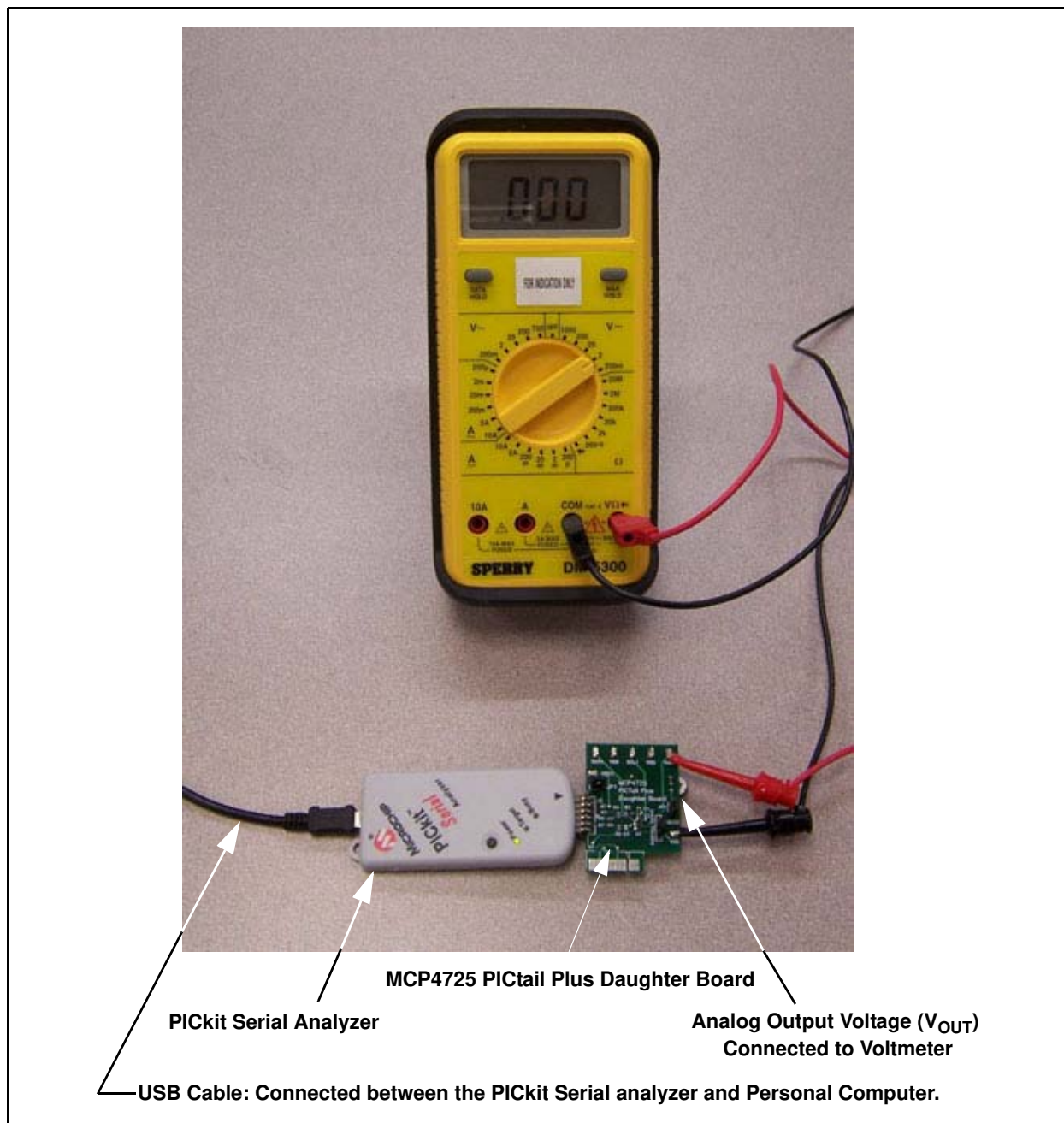2. Connect a Digital Voltmeter to V_{OUT} pin and V_{SS}.

MCP4725 PICtail Plus Daughter Board

PICkit Serial Analyzer

Analog Output Voltage (V_{OUT}) Connected to Voltmeter

USB Cable: Connected between the PICkit Serial analyzer and Personal Computer.

FIGURE 1-8:   *MCP4725 PICtail™ Plus Daughter Board with the PICkit™ Serial Analyzer.*

1.4.1 PICkit™ Serial Analyzer PC Software Set-Up for the MCP4725 Daughter Board

The following steps describe how to set and use the PICkit™ Serial Analyzer PC Graphic User Interface (GUI) to control the MCP4725 PICtail™ Plus Daughter Board.

1. Install the PICkit™ Serial Analyzer software onto your personal computer (PC).
2. Connect the USB cable between the PICkit™ Serial Analyzer and your PC.
3. Run the PICkit™ Serial PC Software: It will open up to the following graphic user interface (GUI). Click the **Next** button and follow the instructions:
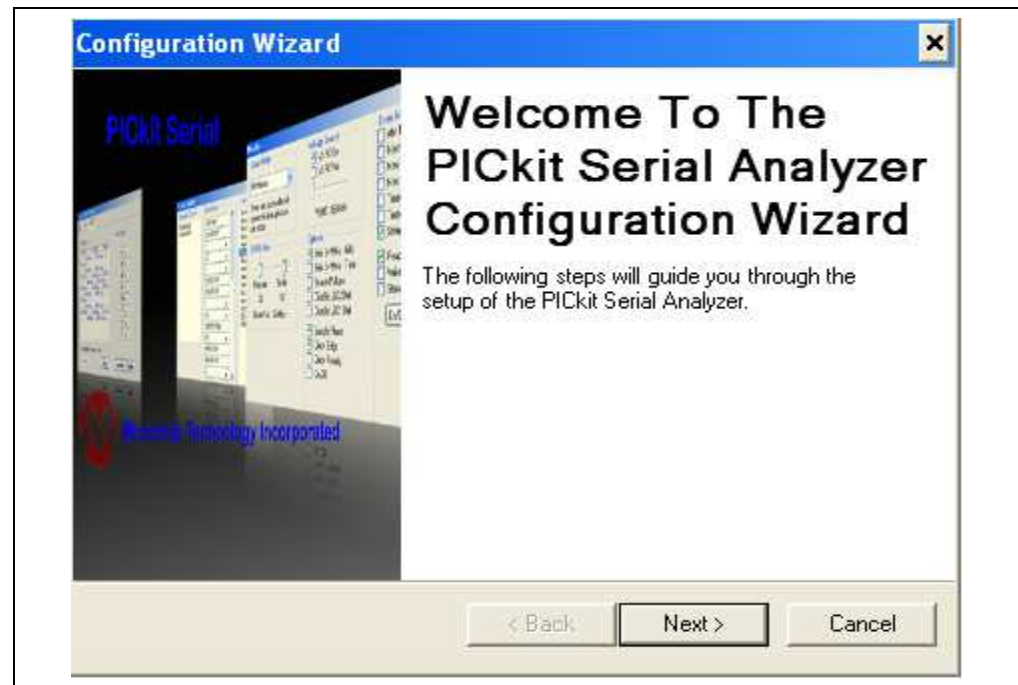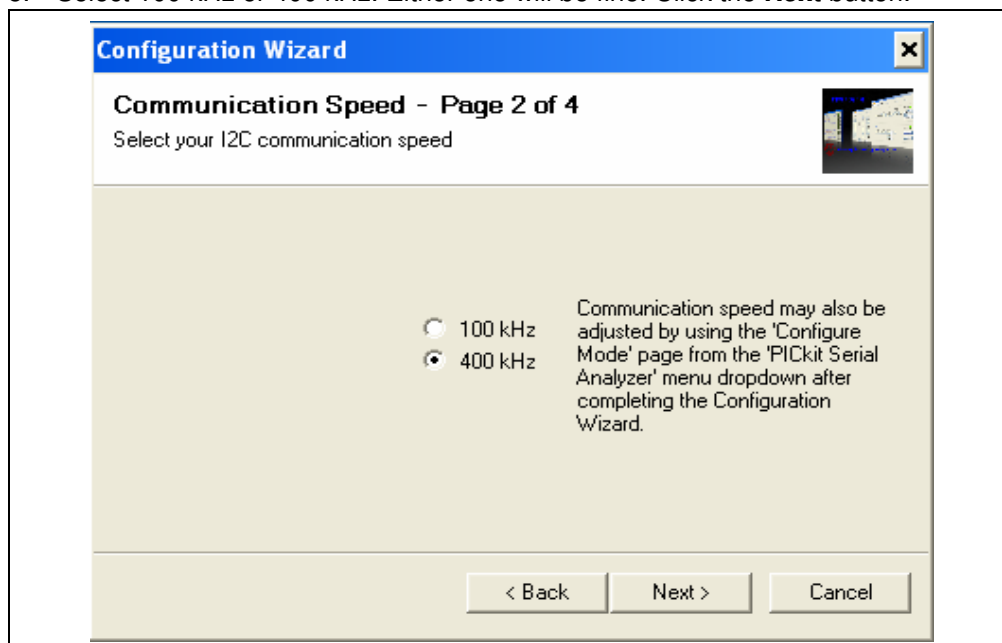

4. Select the Communication Mode type: I^{2}C Master, and click the **Next** button.
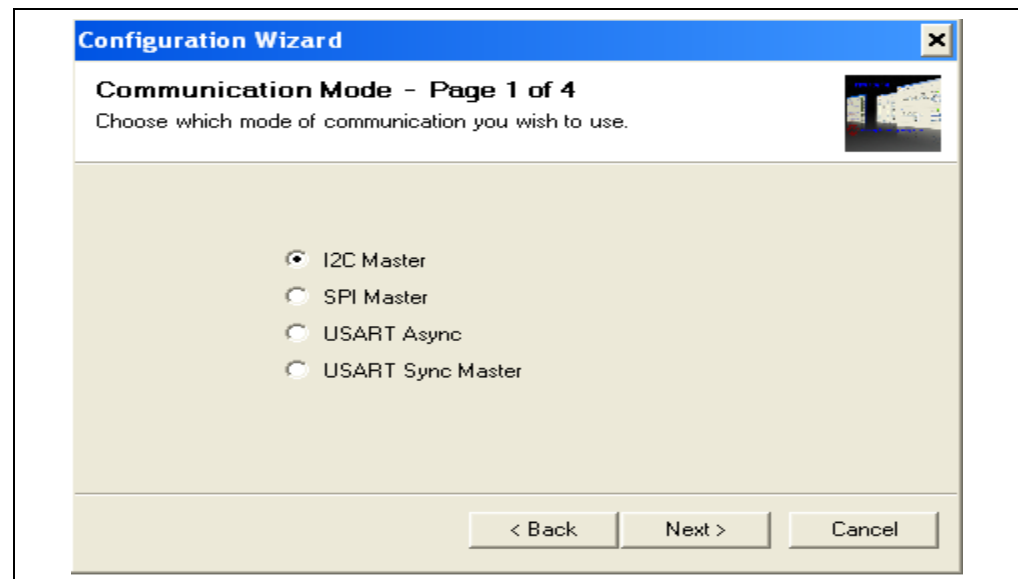
5. Select 100 kHz or 400 kHz. Either one will be fine. Click the **Next** button.

> **Note:** The MCP4725 device supports the I^{2}C bus data rate up to 3.4 MHz, but the current version of the PICkit™ Serial Analyzer supports the I^{2}C bus data rate up to 400 kHz only.

6. Select *No* on Enable Pull-ups, and click the **Next** button.

> **Note:** The MCP4725 PICtail™ Plus Daughter Board has its own pull-up resistors, therefore, you don't need additional pull-up resistors from the PICkit™ Serial Analyzer.
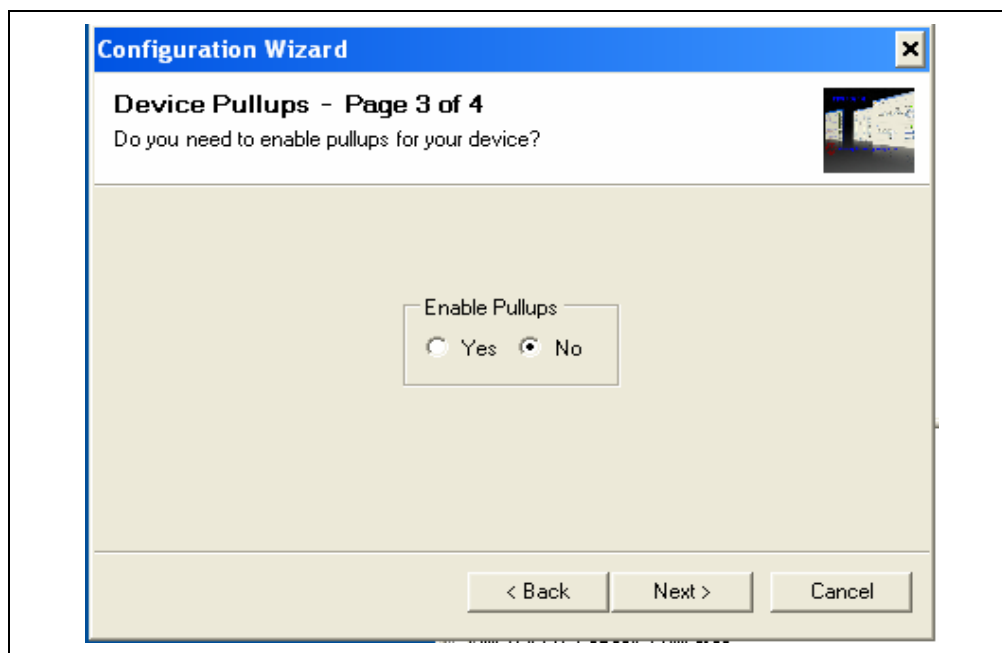
7. Select the V_{DD} voltage of the MCP4725 PICtail™ Plus Daughter Board and click the **Next** button.

Case 1: When you use V_{DD} from the PICkit™ Serial Analyzer:

If you choose **PICkit™ Serial will power my device** and **5 Volts** as shown below, the the MCP4725 PICtail™ Plus Daughter Board is powered by the 5V DC from the PICkit™ Serial Analyer through the JP1 jumper. In this case, make sure that the JP1 jumper on the MCP4725 PICtail™ Plus Daughter Board is connected.
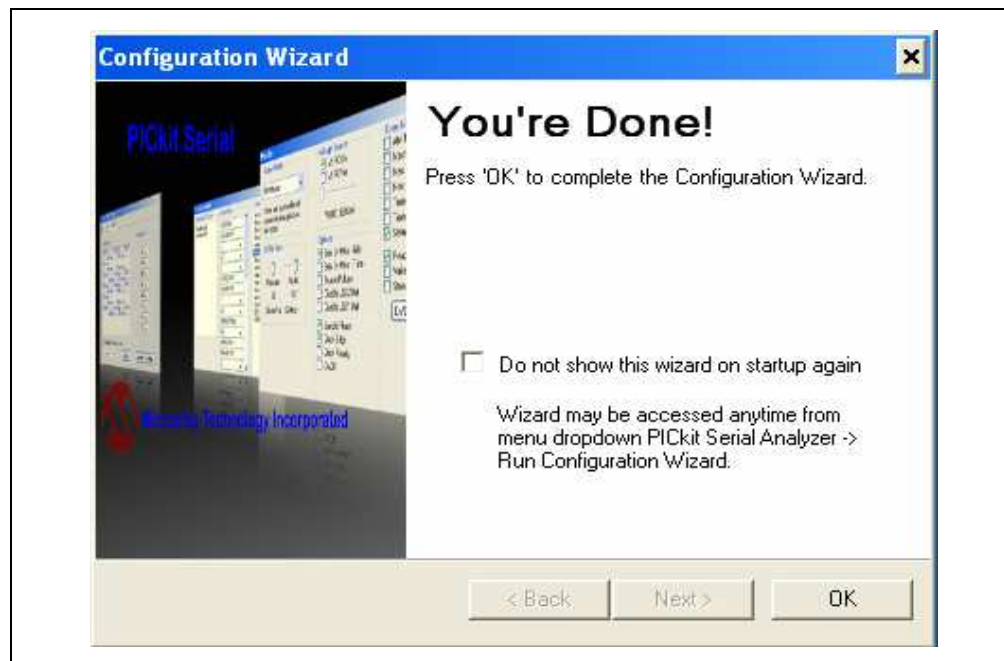
Case 2: When you use your own V_{DD}:

You can also provide your own V_{DD} voltage by applying a V_{DD} voltage at TP1. In this case, make sure that the JP1 jumper is disconnected.
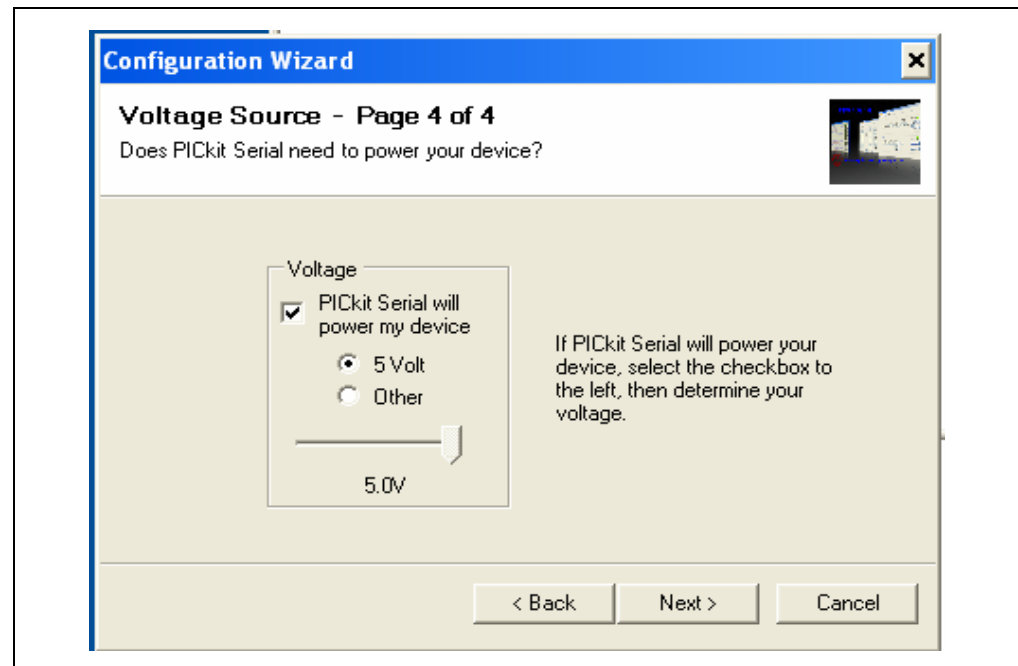
8. Click the **OK** button. You have made all of the PICkit™ Serial Analyzer Configu-
ration Set-ups. You are now ready to program the MCP4725 PICtail™ Plus
Daughter Board using the PICkit™ Serial Analyzer.

1.4.2   Creating Script Files

In order to make a communication between the PICkit™ Serial Analyzer and the MCP4725 PICtail™ Plus Daughter Board, it needs a script file. The following procedure shows how to create script files and how to use them.

1.   Select **Communication -----> Script ---> Script Builder.**
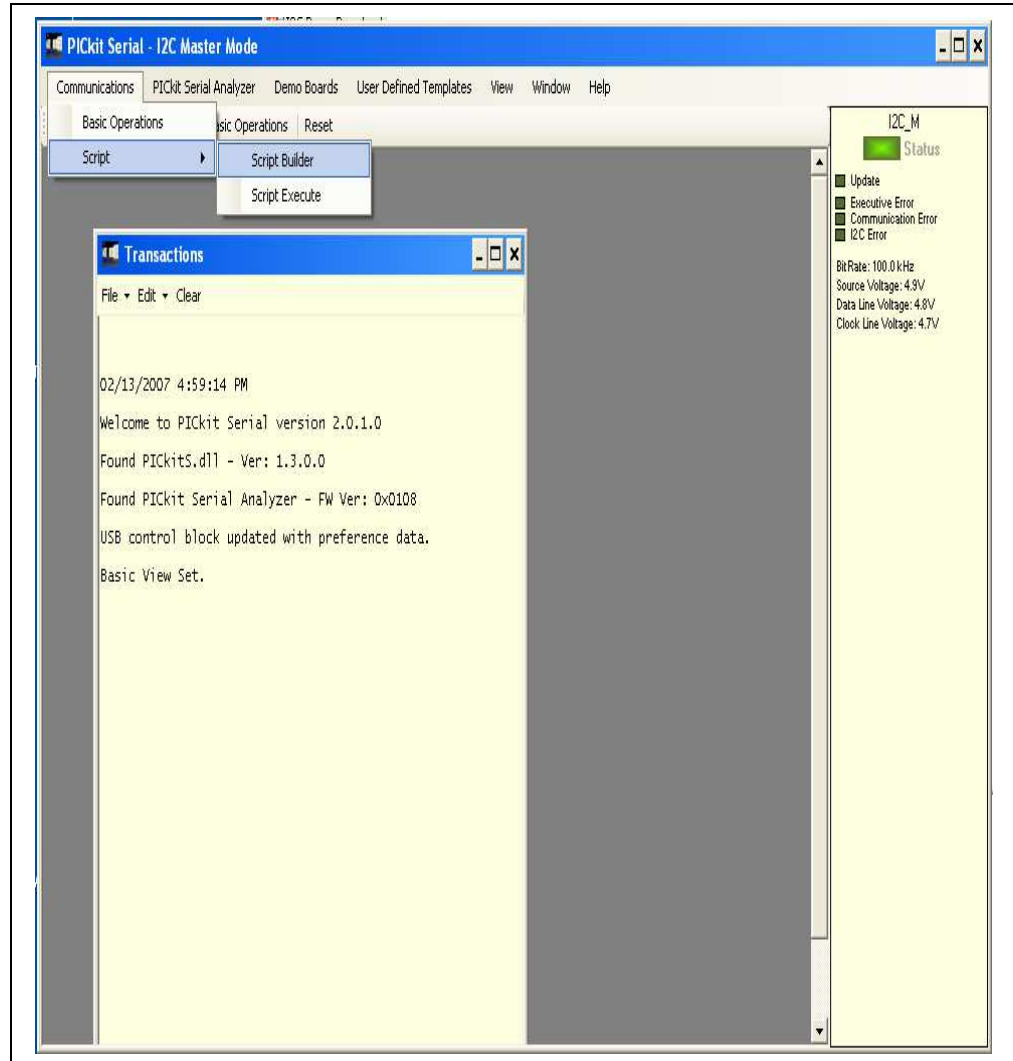
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1.4.2.1   CREATING SCRIPT FILES TO PROGRAM DAC REGISTER

1. Click on **WriteBlockAddrA8** in "Example I2C Scripts" column.

    This will fill in the spaces under **Script Detail** column.

Modifying the Script Details Parameters:

2. Under the Script Detail column, select the item in the parameter box.

3. Right click the mouse button and an option box appears to the right of your selection. This gives you the options that are available for the parameter selected.

4. Select the desired option.

5. Keep the parameters in the same order as shown below:
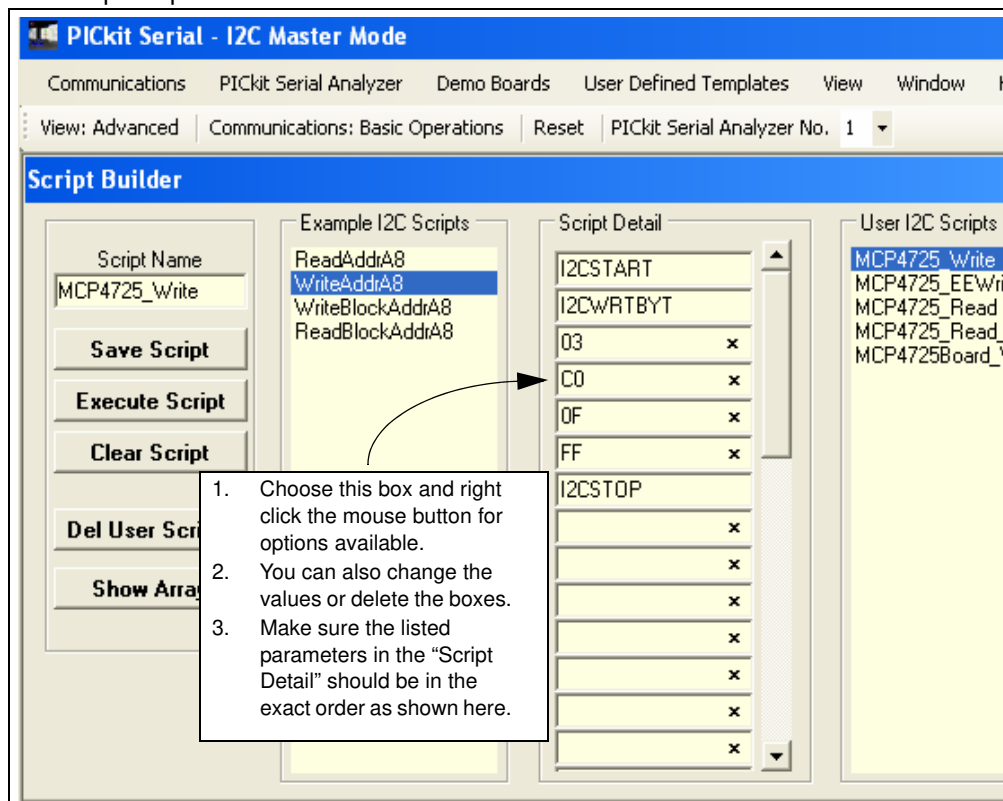
4. Change the parameter value.

Script Detail	
I2CSTART	*
I2CWRTBYT	*
03	----------> This means there are three bytes to send
C0	----------> 1st Write Byte: Address byte = 1100-0000
0F	----------> 2nd Write Byte: 0000-1111
FF	----------> 3rd Write Byte: 1111-1111
I2CSTOP	*

Note: All 7 parameters above must be listed in order. The parameters with * are not modifyable. Address bits A2, A1, A0 = 1, 1, 0 if both JMP2 and JMP3 are tied to V_{DD}. You can choose any data you want for the 2nd and 3rd write bytes. If you use the above write data, the MCP4725 device will output:

$$V_{OUT} = \frac{V_{DD} \cdot FFF(hex)(V)}{4096} = V_{DD}(V)$$
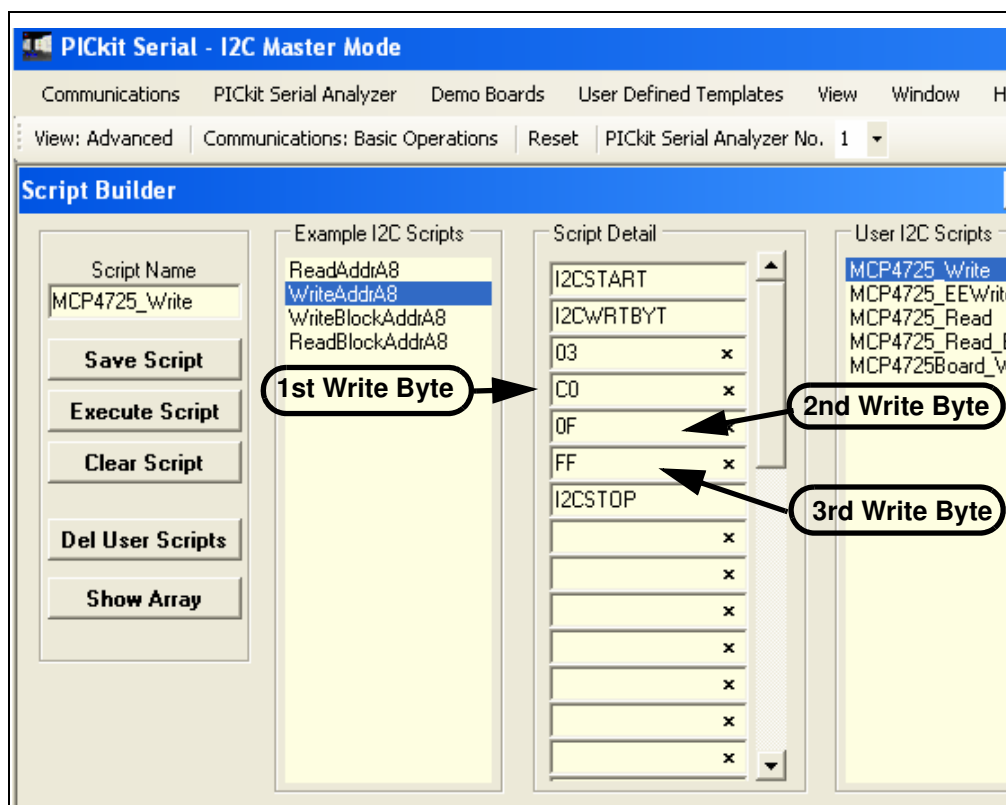
1.4.2.2 SAVING THE SCRIPT FILE AND PROGRAMMING DAC REGISTER (FAST MODE)

1. Change 2nd and 3rd data bytes you want in the Script Detail.
2. Type in any script name (i.e., MCP4725_Write) in the space below the **Script Name** menu.
3. Click **Save Script** button.
4. Click **Execute Script** button.

> **Note:** At this point, the PICkit™ Serial transmits the Fast Write Command to the MCP4725 device. The saved file name will appear in **Users I2C Scripts** column and can be reused any time by selecting the file name.

5. The device provides analog output voltage (V_{OUT}) at the V_{OUT} terminal on the MCP4725 PICtail™ Plus Daughter Board.
6. V_{OUT} can be monitored by using a voltmeter.

> **Note:** When you click on the "Execute Script" menu, the "Busy" LED on the PICkit Serial Analyzer will momentarily turn on and then turn off. If the LED remains ON, a communications problem has occurred. Remove the PICkit Serial Analyzer from the personal computer and recheck the parameter value in the order of the parameters under the **Script Detail** column. Try again until the "Busy" LED goes OFF after executing the write command.