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# MCP6S2X Evaluation Board (Rev. 4) User’s Guide

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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.

For the most up-to-date information on development tools, see the MPLAB IDE on-line help. Select the Help menu, and then Topics to open a list of available on-line help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP6S2X Evaluation Board (Rev. 4). Items discussed in this chapter include:

- About This Guide
- Warranty Registration
- Recommended Reading
- Troubleshooting
- The Microchip Web Site
- Development Systems Customer Change Notification Service
- Customer Support
ABOUT THIS GUIDE

Document Layout

This document describes how to use MCP6S2X Evaluation Board (Rev. 4) as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1: MCP6S2X Evaluation Board (Rev. 4)** - this section describes how to use the various features of the MCP6S2X Evaluation Board (Rev. 4).
- **Appendix A: Schematic** – shows the schematic and printed circuit board (PCB) layout diagrams for the MCP6S2X Evaluation Board (Rev. 4).
- **Appendix B: Bill of Materials (BOM)** – shows the parts used to build the MCP6S2X Evaluation Board (Rev. 4).
- **Appendix C: Evaluation Board Firmware** – shows the firmware for the PIC16C505 source code used on the MCP6S2X Evaluation Board (Rev. 4).
- **Appendix D: Setup Conditions** – shows configuration tables for the DIP switch settings and connections used for the MCP6S2X Evaluation Board (Rev. 4).
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>
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</thead>
<tbody>
<tr>
<td>Arial font:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italic characters</td>
<td>Referenced books</td>
<td>MPLAB IDE User's Guide</td>
</tr>
<tr>
<td>Emphasized text</td>
<td>...is the only compiler...</td>
<td></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>&quot;Save project before build&quot;</td>
</tr>
<tr>
<td>Underlined, italic text with right angle bracket</td>
<td>A menu path</td>
<td>File&gt;Save</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 Power tab</td>
</tr>
<tr>
<td>'bnnnnn'</td>
<td>A binary number where n is a digit</td>
<td>b00100, 'b10</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>
<tr>
<td>Courier font:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plain Courier</td>
<td>Sample source code</td>
<td>#define START</td>
</tr>
<tr>
<td></td>
<td>Filenames</td>
<td>autoexec.bat</td>
</tr>
<tr>
<td></td>
<td>File paths</td>
<td>c:\mcc18\h</td>
</tr>
<tr>
<td></td>
<td>Keywords</td>
<td>_asm, _endasm, static</td>
</tr>
<tr>
<td></td>
<td>Command-line options</td>
<td>-Opa+, -Opa-</td>
</tr>
<tr>
<td></td>
<td>Bit values</td>
<td>0, 1</td>
</tr>
<tr>
<td>Italic Courier</td>
<td>A variable argument</td>
<td>file.o, where file can be any valid filename</td>
</tr>
<tr>
<td>0xnnnnn</td>
<td>A hexadecimal number where n is a hexadecimal digit</td>
<td>0xFFFF, 0x007A</td>
</tr>
<tr>
<td>Square brackets [ ]</td>
<td>Optional arguments</td>
<td>mcc18 [options] file [options]</td>
</tr>
<tr>
<td>Curly brackets and pipe character: {</td>
<td>Choice of mutually exclusive arguments; an OR selection</td>
<td>errorlevel {0</td>
</tr>
<tr>
<td>Ellipses...</td>
<td>Replaces repeated text</td>
<td>var_name [, var_name...]</td>
</tr>
<tr>
<td></td>
<td>Represents code supplied by user</td>
<td>void main (void) { ... }</td>
</tr>
</tbody>
</table>

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RECOMMENDED READING

This user’s guide describes how to use MCP6S2X Evaluation Board (Rev. 4). Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

MCP6S2X PGA Data Sheet (DS21117)
This data sheet provides detailed information regarding the MCP6S21/2/6/8 family of PGAs.

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• General Technical Support – Frequently Asked Questions (FAQ), technical support requests, online discussion groups, Microchip consultant program member listing
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The Development Systems product group categories are:

• Compilers – The latest information on Microchip C compilers and other language tools. These include the MPLAB C17, MPLAB C18 and MPLAB C30 C compilers; MPASM™ and MPLAB ASM30 assemblers; MPLINK™ and MPLAB LINK30 object linkers; and MPLIB™ and MPLAB LIB30 object librarians.
• Emulators – The latest information on Microchip in-circuit emulators. This includes the MPLAB ICE 2000 and MPLAB ICE 4000.
• In-Circuit Debuggers – The latest information on the Microchip in-circuit debugger, MPLAB ICD 2.
• MPLAB IDE – The latest information on Microchip MPLAB IDE, the Windows® Integrated Development Environment for development systems tools. This list is focused on the MPLAB IDE, MPLAB SIM and MPLAB SIM30 simulators, MPLAB IDE Project Manager and general editing and debugging features.
• Programmers – The latest information on Microchip programmers. These include the MPLAB PM3 and PRO MATE® II device programmers and the PICSTART® Plus development programmer.
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• 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

In addition, there is a Development Systems Information Line which lists the latest versions of Microchip's development systems software products. This line also provides information on how customers can receive currently available upgrade kits.

The Development Systems Information Line numbers are:
1-800-755-2345 – United States and most of Canada
1-480-792-7302 – Other International Locations
Chapter 1. MCP6S2X Evaluation Board (Rev. 4)

1.1 INTRODUCTION

The MCP6S21/2/6/8 family of Programmable Gain Amplifiers (PGA) is available with one, two, six or eight signal input channels, respectively. The user can digitally select a specific input channel and set the gain. This family of PGAs can be evaluated using the MCP6S2X Evaluation Board (Rev. 4). The evaluation board schematic is shown in Figure 1-1. This board uses the MCP6S21 and MCP6S26 to allow the user to connect two signal sources to evaluate the PGAs. The 10 kΩ pull-up resistors provide noise immunity for the PGA digital input pins.

![MCP6S2X Evaluation Board schematic](image-url)
1.2 EVALUATION BOARD DESCRIPTION

The single-channel MCP6S21 and six-channel MCP6S26 have been selected for this evaluation board. The PIC16F676 microcontroller is used to program the PGAs according to the user inputs. User inputs are selected using the on-board DIP switch settings that are configured according to the table printed on the evaluation board. This allows the user to program the channel, gain and shutdown of each PGA. Either PGA or both PGAs can be shut down. The six channels of the MCP6S26 and the PGA gains of 1, 2, 4, 5, 8, 10, 16 and 32 V/V can be configured. Refer to Appendix D."Setup Conditions", for additional information.

When the momentary READ push button switch is pressed, the microcontroller reads the DIP switch configuration through the I/O ports. The controller determines the proper command and data bytes to be transmitted to the PGAs and the transmits a 16 or 32-bit word through the Serial Peripheral Interface (SPI™) port.

When the momentary MCLR push button switch is pressed, the microcontroller Master Clear is activated. This resets the microcontroller to a known initial state.

The ICSP connector provides the capability of programming the PIC16F676 from a PC. This requires additional hardware, such as MPLAB® ICD 2.

The two PGAs are cascaded, while the signal output of the MCP6S26 is directly connected to the analog input of the MCP6S21. This configuration outputs a maximum signal gain of 1024 V/V.

The digital lines of the PGA are daisy chained. The MCP6S26 has a Serial-Out (SO) line that can be used to serially program another device. Therefore, the SO line is connected to the Serial-In (SI) line of the MCP6S21. If the MCP6S26 is removed from the socket, the MCP6S21 cannot be programmed.

The MCP6S2X family of PGAs has a reference voltage input pin to offset the output signal. There are three reference voltage options on the board: 2.5V, adjustable reference voltage (0V to 5V) and ground. These options can be selected using the on-board jumper (JP1).

A prototype area is available for user circuit interface. The inputs, outputs and reference voltage traces of the PGAs conveniently pass near the prototype area for ease of connection. Test point connectors are available to interface with external circuits. The signals V_IN_0, V_IN_1, V_OUT_1 and V_OUT_2 can use SMA connectors that slide horizontally onto the board. 50Ω termination resistors can be added to V_IN_0 and V_IN_1. Refer to Appendix A."Schematic and Board Layouts" and Appendix D."Setup Conditions", for additional information.
1.3 HOW IT IS USED

1.3.1 Application Procedure - Stand-Alone Mode

1. Apply a 2.5V to 5.5V supply voltage to the $V_{DD}$ and ground (GND) terminals of J1. Place the $V_{DD}$ SELECT jumper (JP2) at the bottom (nearest J1).

**Note:** If jumper JP2 is incorrectly placed, there may be a conflict between power supplies.

For additional information on powering-up the MCP6S2X Evaluation Board (Rev. 4), refer to Section 1.4.2 “Applying Power”. During power-up, the MCP6S2X PGA’s default settings are Channel 0 (CH0) and gain = 1 V/V.

**Note:** Do NOT use the ICSP connector while in this mode (disconnect the cable). The results may be unpredictable and damage might occur due to conflicting voltage sources.

2. Connect a voltage-measuring device (such as an oscilloscope) to $V_{OUT_1}$ for the MCP6S26 and/or $V_{OUT_2}$ for the MCP6S21.

3. Select the desired reference voltage using JP1. If the adjustable reference voltage is selected, adjust this voltage using the potentiometer (ADJ_VREF). A test point is available to measure the reference voltage. Refer to Section 1.4.5 “Reference Voltage” for additional information.

**Note:** There are soldering pads available across each input terminal for termination resistors ($R_4$ and $R_5$). If these resistors (e.g., 50Ω) are needed for your application, solder them across the pads.

4. Apply the input signal source at $V_{IN_0}$ and/or $V_{IN_1}$. $V_{IN_0}$ is connected to Channel 0 and $V_{IN_1}$ is connected to Channel 1 of the MCP6S26 (refer to Section 1.4.4 “Analog Interface”). Make sure that the input signal range is at the proper level to avoid raling the amplifier output when the signal is gained. Refer to Section 1.4.5 “Reference Voltage” for additional information.

5. Refer to the Table 1-1 and select the desired gain, channel or shutdown using the on-board DIP switch. Press and release the READ push button switch to program the PGA and notice the change in the output voltage. Refer to Section 1.4.6 “Programming The PGA” for further explanation.

<table>
<thead>
<tr>
<th>TABLE 1-1: DIP SWITCH CONFIGURATION TABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Register</strong></td>
</tr>
<tr>
<td>Gain 1</td>
</tr>
<tr>
<td>Gain 2</td>
</tr>
<tr>
<td>Gain 4</td>
</tr>
<tr>
<td>Gain 5</td>
</tr>
<tr>
<td>Gain 8</td>
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<tr>
<td>Gain 10</td>
</tr>
<tr>
<td>Gain 16</td>
</tr>
<tr>
<td>Gain 32</td>
</tr>
<tr>
<td>Channel 0</td>
</tr>
<tr>
<td>Channel 1</td>
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<tr>
<td>Channel 2</td>
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<tr>
<td>Channel 3</td>
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<tr>
<td>Channel 4</td>
</tr>
<tr>
<td>Channel 5</td>
</tr>
<tr>
<td>SHDN</td>
</tr>
<tr>
<td>SHDN</td>
</tr>
<tr>
<td>SHDN</td>
</tr>
</tbody>
</table>
1.3.2 Application Procedure - Program Mode

1. Place the $V_{DD}$ SELECT jumper (JP2) at the top (away from J1). The MPLAB ICD 2 will provide 5V to the PGAs and to the microcontroller. Disconnect any external power supply from J1.

   **Note:** The ICSP™ connector can only be used to program the PIC16F676. In order to debug the firmware, use the MPLAB ICD 2 header. Refer to the MPLAB ICD 2 Header Installation Information (DS51292) for more information.

2. Configure the MPLAB ICD 2 to provide power to the evaluation board through the ICSP connector. This is accomplished by changing the MPLAB ICD 2 configuration in MPLAB IDE. The MPLAB ICD 2 needs to be powered by an external power source.

3. Connect the MPLAB ICD 2 to the ICSP connector and update the PIC16F676 firmware from a PC using MPLAB ICD 2.

   **Note:** Do not change either of the manual push button switches (MCLR and READ) while debugging the firmware. The results of this action would be unpredictable, and may cause damage due to conflicting voltage sources.

4. Follow steps 3 thru 5 in 1.3.1 “Application Procedure - Stand-Alone Mode”.

1.4 HOW IT WORKS

1.4.1 PGA Functions

The PGA has an internal precision operational amplifier in a non-inverting configuration. The gain of this operational amplifier is set using resistive ladders in the feedback loop. The resistor ratio is set using analog switches that are configured according to the instructions stored in the memory registers.

The MCP6S21/2/6/8 family of PGAs provide various input channel options: one, two, six or eight channel inputs, respectively. The non-inverting input of the internal precision operational amplifier is directly connected to the input channels through a multiplexer. The multiplexer is also configured according to the command stored in the memory registers. Figure 1-2 shows a block diagram of the MCP6S26 with six input channels. For the single-channel MCP6S21, the non-inverting input is directly connected to the input pin without a multiplexer.

**FIGURE 1-2:** The six-channel MCP6S26 PGA Block Diagram. The single-channel MCP6S21 does not have an input multiplexer.
1.4.2 Applying Power

The V\textsubscript{DD} SELECT jumper (JP2) connects the power plane (V\textsubscript{DD}) to either an external power supply (through J1) or to MPLAB ICD 2 (via the ICSP connector (J6)). It selects between two modes of operation:

1. **Stand-Alone Mode** - The MCP6S2X Evaluation Board (Rev. 4) is configured using the on-board switches. Power is brought in to connector J1 from an external supply and the V\textsubscript{DD} SELECT jumper selects J1. The external supply can be between 2.5V and 5.5V. When the PIC16F676 is in a valid operating voltage, the device will run the program stored in the device’s program memory (the firmware).

2. **Program Mode** - The MCP6S2X Evaluation Board (Rev. 4) is connected to the MPLAB ICD 2, which is connected to a PC. Power is brought in via the ICSP connector and the V\textsubscript{DD} SELECT jumper selects the ICSP source. V\textsubscript{DD} is 5.0V. The PIC16F676 firmware is reprogrammed by MPLAB IDE (application on PC).

1.4.3 Digital Interface

The memory registers are programmed using the SPI™ interface from a PIC16F676 microcontroller. The digital interface uses a standard 3-wire SPI protocol with Chip Select (CS), Serial Clock (SCK) and Serial In (SI) lines. These lines are directly connected to the MCP6S26 and have pull-up resistors. These pull-up resistors provide noise immunity for the PGA from the PICmicro® microcontroller’s I/O pins. The two PGAs are daisy chained with the SO pin from the MCP6S26 and connected to the SI pin of the MCP6S21. The SCK and CS lines are also connected to the MCP6S21.

In order to program the MCP6S21 through the daisy chain, the microcontroller pulls CS low and sends the 32-bit word through the SPI line. The first 16-bit word contains the command and data bytes for the MCP6S21, while the next 16-bit word contains the command and data bytes for the MCP6S26. The second 16-bit word can be zeros or a NOP command. At the end of the 32nd clock cycle, the first 16-bit word is pushed out of the MCP6S26 (through the SO line) and into the MCP6S21 (through the SI line). When CS toggles high, the bytes are latched in the registers. Instructions in the registers are then executed.

1.4.4 Analog Interface

The input channel 0 of the MCP6S26 is connected to V\textsubscript{IN\textsubscript{0}}. The input channels 1, 2 and 3 are connected to V\textsubscript{IN\textsubscript{1}}. Input channel 4 is connected to ground and input channel 5 is connected to the reference voltage. The user can connect two signal sources to channel 0 and channel 1 at V\textsubscript{IN\textsubscript{0}} and V\textsubscript{IN\textsubscript{1}}.

**Note:** There are soldering pads available across each input terminal for termination resistors (R4 and R5). If these resistors (e.g., 50Ω) are needed for your application, solder them across the pads.

The output pin of the MCP6S26 is connected to V\textsubscript{OUT\textsubscript{1}}. This pin is also connected to Channel 0 of the MCP6S21. The MCP6S21 can be used to gain the signal from the MCP6S26 by gains of 1, 2, 4, 5, 8, 10, 16 and 32 V/V. If both PGAs are configured for a gain of 32 V/V, the total signal gain is 1024 V/V. This illustrates the fact that the user can cascade several PGAs to get higher gains. The output pin of the MCP6S21 is connected to V\textsubscript{OUT\textsubscript{2}}. The outputs of both PGAs are loaded with 10 kΩ resistors and 56 pF capacitors in parallel. These loads can be changed by the user.

**Note:** The signals V\textsubscript{IN\textsubscript{0}}, V\textsubscript{IN\textsubscript{1}}, V\textsubscript{OUT\textsubscript{1}} and V\textsubscript{OUT\textsubscript{2}} can be setup for test points (surface-mount on top) or for SMA connectors (slide onto board horizontally). Refer to Appendix D, D.3 “SMA Connectors” for more information.
1.4.5 Reference Voltage

The MCP6S2X Evaluation Board (Rev. 4) has three reference-voltage settings, as shown in Figure 1-3. The MCP1525, a precision reference voltage device, is used to provide a 2.5V reference. The minimum supply voltage for this device is 2.7V. Therefore, this device will not operate when the evaluation board supply voltage (V_{DD}) is below 2.7V. An adjustable reference voltage (0V to 5V) is also available using a mechanical potentiometer. Since the reference voltage input of the PGA requires a low-impedance source, these reference voltages are buffered using the MCP6022, a 10 MHz operational amplifier. The PGA reference voltage input can also be connected to ground. All of these options can be selected using the on-board jumper connector JP1 (refer to Appendix D. "Setup Conditions" and D.5 "Reference Voltage Jumper Positions" for more information).

![Simplified Reference Voltage Schematic](image)

**FIGURE 1-3:** Simplified Reference Voltage Schematic.

The input and output of this PGA can swing rail-to-rail (V_{DD} and GND supply voltages). However, in order to keep linearity, the output voltage should not exceed the Maximum Output Voltage Swing, referred to in the electrical specifications of the MCP6S21/2/6/8 Data Sheet (DS21117). The reference voltage must be adjusted so that the maximum output would not exceed the specified limit.

The PGA output voltage, with respect to the input and reference voltages, can be determined using the following equation:

**EQUATION 1-1:**

\[ V_{OUT,1} = G_{MCP6S26}(V_{IN,X} - V_{REF}) + V_{REF} \]
\[ V_{OUT,2} = G_{MCP6S26} \times G_{MCP6S21}(V_{IN,X} - V_{REF}) + V_{REF} \]

Where:
- \( G_{MCP6S26} \) = gain of 1, 2, 4, 5, 8, 10, 16 or 32 V/V
- \( G_{MCP6S21} \) = gain of 1, 2, 4, 5, 8, 10, 16 or 32 V/V
- \( V_{IN,X} \) = signal at the MCP6S26’s selected channel
- \( V_{REF} \) = Reference Voltage at V_{REF} pin.
1.4.6  Programming The PGA

The DIP switch lines are connected to the five microcontroller I/O lines (RA5, RA2, RC0, RC1 and RC2) with pull-down resistors (Refer to Figure 1-1 and Appendix A. “Schematic and Board Layouts”). The extreme top switch is the Most Significant Bit (MSB) and the extreme bottom switch is the Least Significant Bit (LSB). Pushing the switches right corresponds to the ‘1’, as shown on Table 1-1. Once the DIP switch is configured to the desired setting, the READ push-button switch must be pressed and released. When the button is released, the microcontroller reads the DIP switch settings and transmits the corresponding command and data bytes to the PGAs. The microcontroller remains in a loop to continuously monitor the READ push button switch. Refer to Table 1-1 for the settings.
Appendix A. Schematic and Board Layouts

A.1 INTRODUCTION

This appendix contains the schematic and printed circuit board (PCB) layout diagrams for the MCP6S2X Evaluation Board (Rev. 4).

A.1.1 Highlights

The MCP6S2X Evaluation Board (Rev. 4) is constructed using a four-layer PCB. The top and bottom layers are for components and traces. The second layer is the ground plane and the third layer is \(V_{DD}\) the power plane.

Diagrams included in this appendix include:

- Schematic
- Top Silk Screen Layer
- Top Metal Layer
- Ground Plane Layer
- Power Plane Layer
- Bottom Metal Layer
- Bottom Silk Screen Layer

**Note:** The bottom metal layer (A.7) is missing a connection between pin 8 of the PIC16F676 (U2 in A.2) and pin 6 of the DIP switch (DSW1 in A.2) and with the pull-down resistor (R11). These traces have been corrected prior to shipping by making a solder bridge between these pins.
A.4 TOP METAL LAYER
A.5 GROUND PLANE LAYER
A.6 POWER PLANE LAYER
A.7 BOTTOM METAL LAYER
A.8 BOTTOM SILK SCREEN LAYER (TOP VIEW)
## B.1 INTRODUCTION

### TABLE B-1: BILL OF MATERIALS

<table>
<thead>
<tr>
<th>Reference Designator</th>
<th>Qty</th>
<th>Description</th>
<th>Manufacturer</th>
<th>Manufacturer Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1,C2</td>
<td>2</td>
<td>Capacitor, 56 pf, 0805</td>
<td>Digi-Key</td>
<td>PCC560CGCT</td>
</tr>
<tr>
<td>C3</td>
<td>1</td>
<td>Capacitor, 10 µF/16V, SMT</td>
<td>Jameco</td>
<td>192997</td>
</tr>
<tr>
<td>C4-C7,C9,C12-C14,C16, C18</td>
<td>10</td>
<td>Capacitor, 0.1 µF, 0805</td>
<td>Digi-Key</td>
<td>PCC1828CT-ND</td>
</tr>
<tr>
<td>C8</td>
<td>1</td>
<td>Capacitor, 1.0 µF, 0805</td>
<td>Digi-Key</td>
<td>PCC1849CT-ND</td>
</tr>
<tr>
<td>C10,C11</td>
<td>2</td>
<td>Capacitor, 2.2 µF, 0805</td>
<td>Digi-Key</td>
<td>PCC1851CT-ND</td>
</tr>
<tr>
<td>C15, C17</td>
<td></td>
<td>Note 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSW1</td>
<td>1</td>
<td>DIP Switch, DIP10</td>
<td>Digi-Key</td>
<td>CKN1289-ND</td>
</tr>
<tr>
<td>FB1</td>
<td>1</td>
<td>Ferrite Chip, 0805</td>
<td>Digi-Key</td>
<td>240-1018-1-ND</td>
</tr>
<tr>
<td>J1</td>
<td>1</td>
<td>2-pin Terminal Block, Connector</td>
<td>Digi-Key</td>
<td>ED1623-ND</td>
</tr>
<tr>
<td>J2-J5 (Note 1)</td>
<td>0</td>
<td>SMA Board Connectors, Female</td>
<td>Newark</td>
<td>SPC10611</td>
</tr>
<tr>
<td>J6</td>
<td>1</td>
<td>ICSP™ Connector, 6x6 Jack, R/A</td>
<td>Digi-Key</td>
<td>A9049-ND</td>
</tr>
<tr>
<td>JP1</td>
<td>1</td>
<td>Jumper, 3x2</td>
<td>Jameco</td>
<td>115035</td>
</tr>
<tr>
<td>JP2</td>
<td>1</td>
<td>Jumper, 1x3</td>
<td>Jameco</td>
<td>109575</td>
</tr>
<tr>
<td>R1-R3,R10-R19</td>
<td>13</td>
<td>Resistor, 10 kΩ, 0805</td>
<td>Digi-Key</td>
<td>P10.0KCCT-ND</td>
</tr>
<tr>
<td>R4,R5 (Note 2)</td>
<td>2</td>
<td>Resistor, 49.9 kΩ, 0805</td>
<td>Digi-Key</td>
<td>P49.9CCT-ND</td>
</tr>
<tr>
<td>R6</td>
<td>1</td>
<td>Resistor, 20 kΩ, 0805</td>
<td>Digi-Key</td>
<td>P20.0KCCT-ND</td>
</tr>
<tr>
<td>R7-R9</td>
<td>3</td>
<td>Resistor, 100 kΩ, 0805</td>
<td>Digi-Key</td>
<td>P100KCCT-ND</td>
</tr>
<tr>
<td>R20</td>
<td>1</td>
<td>Resistor, 470 kΩ, 0805</td>
<td>Digi-Key</td>
<td>P475CCT-ND</td>
</tr>
<tr>
<td>SW1,SW2</td>
<td>2</td>
<td>Momentary push button switch</td>
<td>Digi-Key</td>
<td>SW400-ND</td>
</tr>
<tr>
<td>TP5-TP7, TP11, TP12, TP18-TP20</td>
<td>8</td>
<td>Testpoint, SMT</td>
<td>Digi-Key</td>
<td>5016K-ND</td>
</tr>
<tr>
<td>TP14-TP17 (Note 3)</td>
<td>4</td>
<td>Testpoint, SMT</td>
<td>Digi-Key</td>
<td>5016K-ND</td>
</tr>
<tr>
<td>TP1-TP4, TP8-TP10, TP13</td>
<td>4</td>
<td>Testpoint, SMT</td>
<td>Digi-Key</td>
<td>5016K-ND</td>
</tr>
<tr>
<td>U1</td>
<td>1</td>
<td>MCP6S21, PDIP-8</td>
<td>Microchip Technology Inc.</td>
<td>MCP6S21</td>
</tr>
<tr>
<td>U2</td>
<td>1</td>
<td>PIC16F676, PDIP-14</td>
<td>Microchip Technology Inc.</td>
<td>PIC16F676</td>
</tr>
<tr>
<td>U3</td>
<td>1</td>
<td>MCP1525, SOT23-3</td>
<td>Microchip Technology Inc.</td>
<td>MCP1525</td>
</tr>
<tr>
<td>U4</td>
<td>1</td>
<td>MCP6022, SOIC-8</td>
<td>Microchip Technology Inc.</td>
<td>MC6022</td>
</tr>
<tr>
<td>U5</td>
<td>1</td>
<td>MCP6S26, PDIP-14</td>
<td>Microchip Technology Inc.</td>
<td>MCP6S26</td>
</tr>
<tr>
<td>VR1</td>
<td>1</td>
<td>10 kΩ Potentiometer</td>
<td>Digi-Key</td>
<td>3296W-103-ND</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>8-pin DIP socket (for U1)</td>
<td>Jameco</td>
<td>51625</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>14-pin DIP socket (for U2, U5)</td>
<td>Jameco</td>
<td>37196</td>
</tr>
</tbody>
</table>

### Notes

1: Optional; supplied by customer (use J2-J5 or TP14-TP17).
2: Optional; in kit of parts.
3: Optional; in kit of parts (use J2-J5 or TP14-TP17).
4: These capacitors and test points do not exist on the board; they are gaps in the numbering sequence.
Appendix C. Evaluation Board Firmware

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FILE: pga_demo.asm

; This firmware is developed for the MCP6S2X PGA demo board.
; The firmware reads the user interface dip and push-button switch settings and programs the PGA accordingly.

; File name: pga_demo.asm
; Date: 08/09/04
; File Version: 1.00
; Programmer: MPLAB ICE 2
; Demo Board:
; Name: MCP6S2X Eval. Bd.
; Number: 102-00018R4
; Rev.: R4
; PGAs: MCP6S21 (or MCP6S91), MCP6S26
; Author: Ezana Haile
; Company: Microchip Technology, Inc.

ERRORLEVEL -302
ERRORLEVEL -305

#INCLUDE <P16F676.INC>

; definitions

#define CS PORTC, 4 ; CHIP SELECT
#define SCK PORTC, 5 ; CLOCK
#define DO PORTC, 3 ; DATA OUT
#define PUSH PORTA, 0 ; READ PUSH BUTTON
#define SW1 PORTC, 2 ; SWITCH 1
#define SW2 PORTC, 1 ; SWITCH 2
#define SW3 PORTC, 0 ; SWITCH 3
#define SW4 PORTA, 2 ; SWITCH 4
#define SW5 PORTA, 5 ; SWITCH 5
#define PROG_GAIN B'01000000' ; PROGRAM GAIN
#define PROG_CHANNEL B'01000000' ; PROGRAM CHANNEL
#define PGA_SHDN B'00100000' ; SHUTDOWN PGA
; reserve memory byte
CBLOCK 0x20
COUNTER, BUFFER
ENDC

;============================================================================
;================= PROGRAM ==================================================
;============================================================================

PGA_DEMO                ; CODE NAME
ORG     0x00
GOTO    START

START ORG     0x05
BCF     STATUS, RP0   ; BANK 0
MOVLW   H'07'
MOVWF   CMCON         ; DIGITAL I/O
BCF     STATUS, RP0   ; BANK 1
CLRF    ANSEL         ; DIGITAL I/O
CLRF    WPUA
MOVLW   H'3F'
MOVWF   TRISA         ; SET PORT A AS INPUT
MOVLW   H'07'         ; SET RC<5,4,3> OUTPUT AND RC<2,1,0> INPUT
CLRF    TRISC         ; SET PORT C AS INPUT
BCF     STATUS, RP0   ; BANK 0
READ  BTFSC   PUSH          ; CHECK TO SEE IF THE READ BUTTON IS PRESSED
GOTO    READ
RDING BTFSS   PUSH          ; WAIT UNTIL THE BUTTON IS RELEASED
GOTO    RDING
LOOP
BSF     CS            ; UNSELECT THE DEVICES
BCF     DO            ; KEEP THE DATAOUT (DO) LOW
BCF     SCK           ; SET CLOCK
CLRF    BUFFER        ; CLEAR BUFFER
BTFSC   SW5
GOTO    CHANNEL_SHDN  ; DETERMINE IF IT’S FOR CHANNEL OR
; SHUTDOWN OTHERWISE PROGRAM GAIN
; PROGRAM THE GAIN OF PGA 1 (MCP6S26) OR PGA 2 (MCP6S21)

PGA_1_GAIN
BCF     CS            ; SELECT PGA
MOVLW   PRG_GAIN      ; PROGRAM GAIN CONFIGURATION
MOVF   BUFFER
CALL    BITBANG       ; SEND IT THROUGH SPI
CALL    READ_SWITCH   ; READ SWITCH SETTINGS
CALL    BITBANG       ; SEND IT THROUGH SPI AND PROGRAM PGA
BSF     CS            ; UNSELECT THE DEVICES
GOTO    READ

PGA_2_GAIN
BCF     CS            ; SELECT PGA
MOVLW   PRG_GAIN      ; PROGRAM GAIN CONFIGURATION
MOVF   BUFFER
CALL    BITBANG       ; SEND IT THROUGH SPI AND PROGRAM PGA
CALL    READ_SWITCH   ; READ SWITCH SETTINGS
CALL    BITBANG       ; SEND IT THROUGH SPI
CLRF    BUFFER        ; SEND ZEROS TO PUSH OUT THE DATA TO PGA 2
CALL    BITBANG       ; SEND 8 DUMMY BITS
CALL    BITBANG       ; SEND 8 DUMMY BITS
BSF    CS            ; UNSELECT THE DEVICES
GOTO   READ

; PROGRAM THE CHANNEL OR SHUTDOWN PGA 1 (MCP6S26) OR PGA 2 (MCP6S21)

CHANNEL_SHDN
BTFSC   SW4
GOTO    SHDN          ; GOTO SHUTDOWN

CHANNEL
BCF     CS            ; SELECT PGA
MOVLW   PRG_CHANNEL   ; PROGRAM CHANNEL CONFIGURATION
MOVF   BUFFER
CALL    BITBANG       ; SEND IT THROUGH SPI
CALL    READ_SWITCH   ; READ SWITCH SETTINGS
CALL    BITBANG       ; SEND IT THROUGH SPI AND PROGRAM PGA
BSF CS ; UNSELECT THE DEVICES
GOTO READ

SHDN
BTFSC SW3 ; IF THE 3RD SWITCH IS HIGH THEN DON’T SHUTDOWN
GOTO READ
BTFSC SW2 ; DETERMINE WHICH DEVICE
GOTO SHDN_BOTH ; SHUTDOWN BOTH PGAS
BTFSC SW1
GOTO SHDN_PGA_2 ; IF THE 1RD SWITCH IS HIGH THEN DON’T SHUTDOWN

SHDN_PGA_1 ; SHUTDOWN THE FIRST PGA
BCF CS ; SELECT PGA
MOVLW PGA_SHDN ; PROGRAM SHUTDOWN CONFIGURATION
MOVWF BUFFER
CALL BITBANG ; SEND IT THROUGH SPI AND PROGRAM PGA
CALL BITBANG ; SEND 8 DUMMY BITS
BSF CS ; UNSELECT THE DEVICES
GOTO READ

SHDN_PGA_2 ; SHUTDOWN THE SECOND PGA
BCF CS ; SELECT PGA
MOVLW PGA_SHDN ; PROGRAM SHUTDOWN CONFIGURATION
MOVWF BUFFER
CALL BITBANG ; SEND IT THROUGH SPI AND PROGRAM PGA
CALL BITBANG ; SEND 8 DUMMY BITS
CLRF BUFFER
CALL BITBANG ; SEND 8 DUMMY BITS
CALL BITBANG ; SEND 8 DUMMY BITS
BSF CS ; UNSELECT THE DEVICES
GOTO READ

SHDN_BOTH ; SHUTDOWN BOTH PGAs
BCF CS ; SELECT PGA
MOVLW PGA_SHDN ; PROGRAM SHUTDOWN CONFIGURATION
MOVWF BUFFER
CALL BITBANG ; SEND IT THRU SPI AND SHUTDOWN PGA
CALL BITBANG ; SEND 8 DUMMY BITS
CALL BITBANG ; SEND IT THRU SPI AND SHUTDOWN PGA
CALL BITBANG ; SEND 8 DUMMY BITS
BSF CS ; UNSELECT THE DEVICES
GOTO READ

;---------------------------------------------------------------------
;--- READ THE SWITCH SETTINGS
;---------------------------------------------------------------------
READ_SWITCH
CLRF BUFFER ; PROGRAM BUFFER FROM SWITCHES
BTFSC SW3 ; CHECK THE 3RD SWITCH
BSF BUFFER, 2
BTFSC SW2
BSF BUFFER, 1
BTFSC SW1
BSF BUFFER, 0
RETURN

;---------------------------------------------------------------------
;---- BIT BANG SPI COMMUNICATION
;---------------------------------------------------------------------
BITBANG
CLRC
MOVLW H’08’
MOVWF COUNTER ; SET THE BIT BANG COUNTER
SEND
BTFSC BUFFER, 7 ; SEE THE LAST BIT OF THE BUFFER
BSF DO ; THE SWITCH IS SET, THEN SET THE BUFFER HIGH
BSF SCK ; SET CLOCK
BCF SCK ; CLEAR CLOCK
BCF DO ; CLEAR THE DATA
RLF BUFFER, F ; ROLL THE BITS
DECFSZ COUNTER, F ; CHECK END OF COUNTER
GOTO SEND ; LOOP
RETURN

;---------------------------------------------------------------------

END
### Appendix D. Setup Conditions

#### D.1 DIP SWITCH CONFIGURATIONS (STAND-ALONE MODE)

**TABLE D-1: DIP SWITCH CONFIGURATION FOR MCP6S21 ONLY**

<table>
<thead>
<tr>
<th>Register</th>
<th>MCP6S21 MSB → LSB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain 1</td>
<td>01000</td>
</tr>
<tr>
<td>Gain 2</td>
<td>01001</td>
</tr>
<tr>
<td>Gain 4</td>
<td>01010</td>
</tr>
<tr>
<td>Gain 5</td>
<td>01011</td>
</tr>
<tr>
<td>Gain 8</td>
<td>01100</td>
</tr>
<tr>
<td>Gain 10</td>
<td>01101</td>
</tr>
<tr>
<td>Gain 16</td>
<td>01110</td>
</tr>
<tr>
<td>Gain 32</td>
<td>01111</td>
</tr>
<tr>
<td>SHDN (Shutdown)</td>
<td>11001</td>
</tr>
</tbody>
</table>

**TABLE D-2: DIP SWITCH CONFIGURATION FOR MCP6S26 ONLY**

<table>
<thead>
<tr>
<th>Register</th>
<th>MCP6S26 MSB → LSB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain 1</td>
<td>00000</td>
</tr>
<tr>
<td>Gain 2</td>
<td>00001</td>
</tr>
<tr>
<td>Gain 4</td>
<td>00010</td>
</tr>
<tr>
<td>Gain 5</td>
<td>00011</td>
</tr>
<tr>
<td>Gain 8</td>
<td>00100</td>
</tr>
<tr>
<td>Gain 10</td>
<td>00101</td>
</tr>
<tr>
<td>Gain 16</td>
<td>00110</td>
</tr>
<tr>
<td>Gain 32</td>
<td>00111</td>
</tr>
<tr>
<td>Channel 0</td>
<td>10000</td>
</tr>
<tr>
<td>Channel 1</td>
<td>10001</td>
</tr>
<tr>
<td>Channel 2</td>
<td>10010</td>
</tr>
<tr>
<td>Channel 3</td>
<td>10011</td>
</tr>
<tr>
<td>Channel 4</td>
<td>10100</td>
</tr>
<tr>
<td>Channel 5</td>
<td>10101</td>
</tr>
<tr>
<td>SHDN (Shutdown)</td>
<td>11000</td>
</tr>
</tbody>
</table>

**TABLE D-3: DIP SWITCH CONFIGURATION FOR MCP6S21 AND MCP6S26**

<table>
<thead>
<tr>
<th>Register</th>
<th>MCP6S21/MCP6S26 MSB → LSB</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHDN (Shutdown)</td>
<td>11010</td>
</tr>
</tbody>
</table>
D.2 MOMENTARY PUSH BUTTON SWITCH

D.2.1 Read Function

To change the PGA settings:

1. **Stand-alone Mode** - Configure the DIP Switch according to the tables in Appendix D.1. Press and release the **READ** switch; the microcontroller immediately updates the PGA’s configuration.

2. **Program Mode** - The change in PGA configuration needs to be provided in customer-supplied firmware.

D.2.2 Master Clear Function

To re-initialize the microcontroller:

1. **Stand-alone Mode** - Press and release the **MCLR** switch.

2. **Program Mode** - Do not use the **MCLR** switch. Disconnect from MPLAB ICD 2 and reconnect.

D.3 SMA CONNECTORS

The illustration below shows how the SMA connectors are slid onto the board at test points \(V_{IN_0}, V_{IN_1}, V_{OUT_1}, \) and \(V_{OUT_2}\). The round center conductor goes over the test pad and two of the square lugs go underneath the board on the unmasked ground fill (bottom metal). Solder the lugs and center conductor to the board.

**FIGURE D-1:** SMA Connectors.
D.4 TEST POINTS

TABLE D-4: TEST POINT CONNECTORS

<table>
<thead>
<tr>
<th>Name</th>
<th>Reference Designator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V\text{IN}_0</td>
<td>TP16</td>
<td>Input Voltage to Channel 0 (MCP6S26)</td>
</tr>
<tr>
<td>V\text{IN}_1</td>
<td>TP17</td>
<td>Input Voltage to Channel 1 (MCP6S26)</td>
</tr>
<tr>
<td>V\text{OUT}_1</td>
<td>TP15</td>
<td>Output Voltage from MCP6S26 (Input Voltage to MCP6S21)</td>
</tr>
<tr>
<td>V\text{OUT}_2</td>
<td>TP14</td>
<td>Output Voltage from MCP6S21</td>
</tr>
<tr>
<td>V\text{REF}</td>
<td>TP20</td>
<td>Reference Voltage (for MCP6S26 and MCP6S21)</td>
</tr>
<tr>
<td>V\text{DD}</td>
<td>TP6</td>
<td>Positive Supply Voltage</td>
</tr>
<tr>
<td>GND</td>
<td>TP5, TP7</td>
<td>Ground (Negative Supply Voltage)</td>
</tr>
<tr>
<td>CS</td>
<td>TP12</td>
<td>SPI\textsuperscript{TM} Chip Select</td>
</tr>
<tr>
<td>SCK</td>
<td>TP11</td>
<td>SPI Serial Clock</td>
</tr>
<tr>
<td>SI_1</td>
<td>TP19</td>
<td>SPI Serial Data In (MCP6S26)</td>
</tr>
<tr>
<td>SI_2</td>
<td>TP18</td>
<td>SPI Serial Data In (MCP6S21); SPI Serial Data Out (MCP6S26)</td>
</tr>
</tbody>
</table>

D.5 REFERENCE VOLTAGE JUMPER POSITIONS

TABLE D-5: JUMPER POSITIONS

<table>
<thead>
<tr>
<th>Jumper</th>
<th>Position</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>JP1</td>
<td>Top</td>
<td>2.5V</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>Adjustable Reference Voltage</td>
</tr>
<tr>
<td></td>
<td>Bottom</td>
<td>Ground</td>
</tr>
<tr>
<td>JP2</td>
<td>Top</td>
<td>V\text{DD} supplied by ICSP\textsuperscript{TM} Connector J6</td>
</tr>
<tr>
<td></td>
<td>Bottom</td>
<td>V\text{DD} supplied by Terminal Block J1</td>
</tr>
</tbody>
</table>
## Americas

**Corporate Office**  
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  Fax: 765-864-8387
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  Fax: 86-10-8528-2104
- **China - Chengdu**  
  Tel: 86-28-8676-6200  
  Fax: 86-28-8676-6599
- **China - Fuzhou**  
  Tel: 86-591-750-3506  
  Fax: 86-591-750-3521
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