

Photodiode PGA PICtail™ Daughter Board User's Guide

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PHOTODIODE PGA PICTAIL™ DAUGHTER BOARD USER'S GUIDE

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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 Photodiode PGA PICtail™ Daughter Board. Items discussed in this chapter include:

- About this guide
- Recommended Reading
- The Microchip Web Site
- Customer Support

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ABOUT THIS GUIDE

This document describes how to use the Photodiode PGA PICtail Daughter Board. It also discusses the other available tools that are designed to work with it. The overall outline is as follows:

- **Chapter 1: Overview** – An introduction to the Photodiode PGA PICtail Daughter Board covering the kit contents, associated tools and how they work together.
- **Chapter 2: Set-Up Overview** – Covers the initial set-up of the Photodiode PGA PICtail Daughter Board, listing required tools, instructions on how to connect this board and demonstating how to verify the set-up
- **Chapter 3: Using the Photodiode-PGA PICtail Daughter Board** – Discusses different light sources, using the Signal Analysis PC Application and setting up the board to stand on its own.
- **Appendix A: Photodiode PGA PICtail Daughter Board Hardware** – Gives detailed information on the Photodiode PGA PICtail Daughter Board. Includes detailed circuit explanation, schematic, board layouts and Bill-of-Materials (BOM)

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Conventions Used In This Guide

This manual uses the following documentation conventions.

TABLE 1-1:

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
'bnnnn	A binary number where n is a digit	'b00100, 'b10
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier font:		
Plain Courier	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`
Italic Courier	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
`0x`*`nnnn`*	A hexadecimal number where *n* is a hexadecimal digit	`0xFFFF`, `0x007A`
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 the Photodiode PGA PICtail™ Daughter Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

PICkit™ 1 Flash Starter Kit User's Guide (DS40051)

Contains instructions on how to use the PICkit 1 Flash Starter Kit hardware and software.

Signal Analysis PICtail™ Daughter Board User's Guide (DS51476)

Contains instructions on how to use the Signal Analysis PICtail Daughter Board's hardware and software.

AN951, "Amplifying High-Impedance Sensors – Photodiode Example" (DS00951)

Explains the functionality and design of this board's circuit. Contains measurement results.

MCP6S21/2/6/8 Data Sheet (DS21117)

Gives detailed information on the MCP6S21/2/3/6/8 Programmable Gain Amplifiers (PGAs).

MCP6S91/2/3 Data Sheet (DS21908)

Gives detailed information on the MCP6S91/2/3 PGAs.

PIC16F684 Data Sheet (DS41202)

Gives detailed information on the PICmicro® microcontroller used on the Signal Analysis PICtail Daughter Board.

PIC16C745/765 Data Sheet (DS41124)

Gives detailed information on the PICmicro microcontroller used on the PICkit 1 Flash Starter Kit.

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- **General Technical Support** – Frequently Asked Questions (FAQ), 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
- 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

NOTES:

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Chapter 1. Overview

1.1 INTRODUCTION

The following name and assembly number are found on the Photodiode PGA PICtail™ Daughter Board's Printed Circuit Board (PCB):

- MCP6SX2DM-PICTLPD
- 102-00029

This PCB goes by the following titles:

- Photodiode PGA PICtail™ Daughter Board
- MCP6SX2 Photodiode-PGA Demo Board

This board supports the photodiode AN951, "Amplifying High-Impedance Sensors – Photodiode Example" (DS00951). It uses the PNZ334 photodiode as a light detector. Its output is conditioned by the MCP6001U op amp, which is set up as a transimpedance amplifier. The output is then amplified (and buffered) by either the MCP6S22 or the MCP6S92 Programmable Gain Amplifier (PGA).

Items discussed in this chapter include:

- Kit Contents
- Photodiode PGA PICtail™ Daughter Board
- Associated Tools
- Initial Set-up

1.2 KIT CONTENTS

- Photodiode PGA PICtail™ Daughter Board – An assembled and tested Printed Circuit Board (PCB)
- PICkit™ 1 CD-ROM (DS40049) – Contains the files and literature mentioned in this user's guide
- Additional PGA (MCP6S92) in an anti-static bag

1.3 PHOTODIODE PGA PICTAIL™ DAUGHTER BOARD

The Photodiode PGA PICtail™ Daughter Board contains the analog circuitry represented in Figure 1-1. Light incident to the photodiode is converted to current. The op amp converts current to voltage (transimpedance amplifier). This voltage is sent to the CH0 input of the PGA. The PGA gains and buffers this output, which is sent off-board (V_{OUT}). Board power is applied at the +5V and GND inputs. The SPI™ bus makes it possible to control the PGA; its gain and input channel can be set as desired from the software.

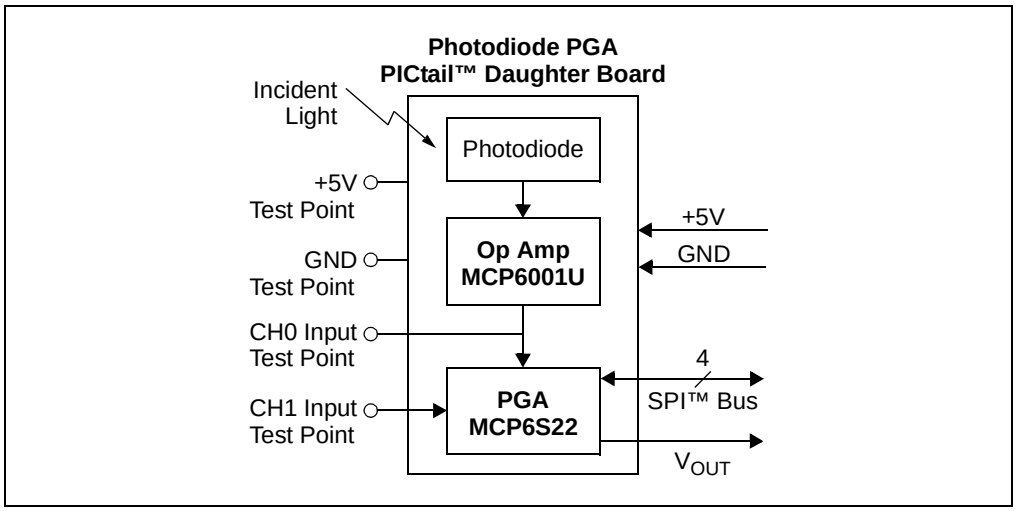


FIGURE 1-1: *Photodiode PGA PICtail™ Daughter Board Block Diagram.*

The test points make it easier to test key points in the circuit, change the input signals and to use this board as a stand-alone.

- GND Test Point – Connected to the ground plane and is a convenient ground point for any lab equipment
- +5V Test Point – Allows measurement of the positive supply voltage and provides a means to power this board with a laboratory power supply
- CH0 Test Point – The place to measure the transimpedance amplifier's output voltage (also the PGA's CH0 input)
- CH1 Test Point – Makes it possible to send any desired signal to the PGA

More details on the circuit and on its design can be found in **Appendix A. "Schematic and Layouts"** and in Application Note 951.

1.4 ASSOCIATED TOOLS

Figure 1-2 shows the block diagram of the hardware and software tools that the Photodiode PGA PICtail™ Daughter Board is designed to work with. More information on these tools can be found in the **"Recommended Reading"** section.

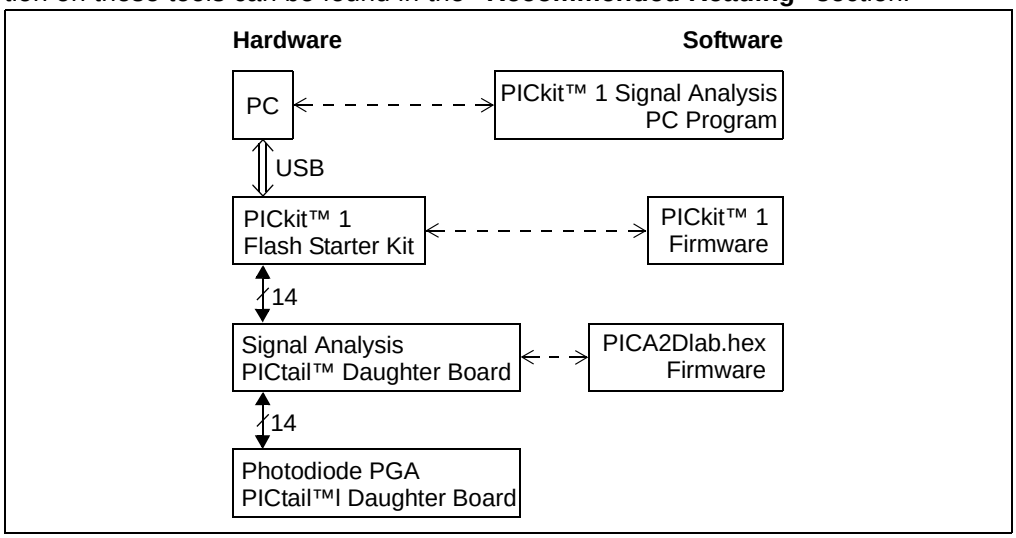


FIGURE 1-2: *Measurement Set-up Block Diagram.*

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1.4.1 PC Platform

The Personal Computer (PC) shown in Figure 1-2 needs to run on Windows® 98 SE or later. It provides a convenient interface for the user, communicates with the other boards and provides power through the USB connection.

1.4.2 PICkit™ 1 Signal Analysis PC Program

The PICkit™ 1 Signal Analysis PC Program configures and programs the PIC16F684 PICmicro® microcontroller on the Signal Analysis PICtail Daughter Board through the USB port on the PICkit 1 Flash Starter Kit. It also imports data through the same connection and displays the data in strip chart, histogram, FFT plot and oscilloscope plot formats. Data can be output in CSV format for importing into a spreadsheet program.

1.4.3 PICkit 1 Flash Starter Kit

The PICkit 1 Flash Starter Kit (DV164101) programs PICmicro® microcontrollers, using the PIC16C745's USB port to communicate with the PICkit 1 Signal Analysis PC Program. It connects to the Signal Analysis PICtail Daughter Board via a header (see Figure 2-1).

This board provides a single +5V supply voltage for the daughter boards. It can drive up to 5 µF on the supply; a larger capacitance may interfere with program timing.

1.4.4 PICkit 1 Firmware

This software resides on the PICkit 1 Flash Starter Kit's PIC16C745 microcontroller. Use version 2.0.2 or later.

1.4.5 Signal Analysis PICtail Daughter Board

This board is Microchip Development Tool AC164120. It connects to the PICkit 1 Flash Starter Kit, which it uses for power and a communications link to the PC. The on-board PIC16F684 has a 10-bit ADC that converts the Photodiode PGA PICtail™ Daughter Board's output voltage. The results are temporarily stored on the board's 25LC640 serial EEPROM chips.

The +5V single supply voltage from the PICkit 1 Flash Starter Kit board is bypassed with a bulk 1 µF capacitor and local 0.1 µF capacitors for each IC.

1.4.6 Firmware for the Signal Analysis PICtail Daughter Board

`PICA2Dlab.hex` is the standard file that supports the PICkit™ 1 Signal Analysis PC Program. The PGA and 10-bit ADC configuration are selected in the Signal Analysis PC Program and written to the PIC16F684. The PIC16F684 then sends the command(s) over the SPI bus to the PGA.

1.4.7 Interface Details

A more detailed look at how the Photodiode PGA PICtail™ Daughter Board interfaces with the other boards is shown in Figure 1-3.

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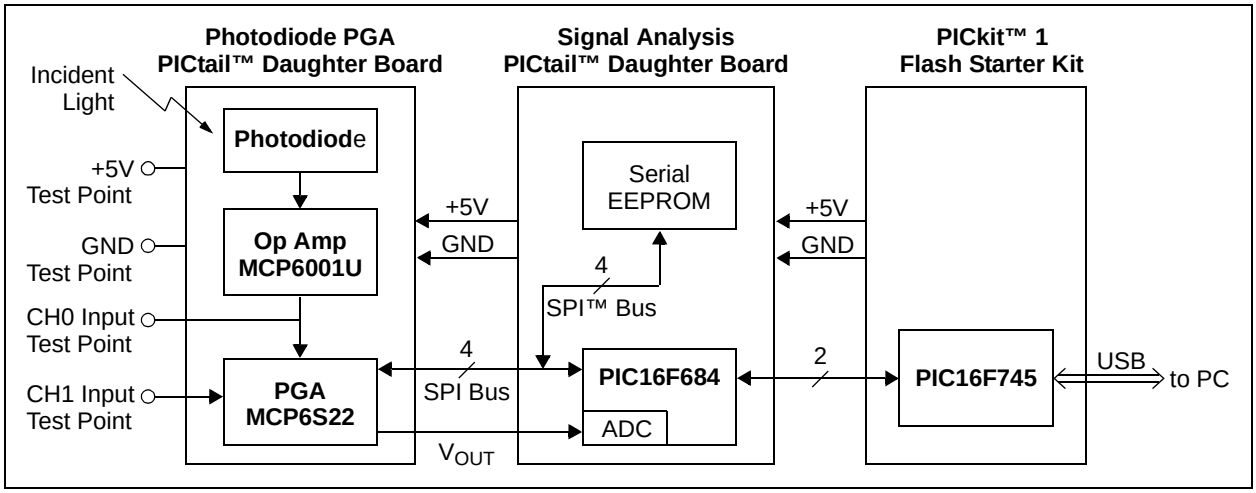


FIGURE 1-3: *Detailed Interface Diagram.*

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Chapter 2. Setup and Installation

2.1 INTRODUCTION

This chapter shows how to set up the Photodiode PGA PICtail™ Daughter Board. Items discussed in this chapter include:

This chapter discusses:

- Required Tools
- Connecting the Photodiode PGA PICtail™ Daughter Board
- Set-up Verification

2.2 REQUIRED TOOLS

The PICkit™ 1 Flash Starter Kit User's Guide explains how to set up the PC and the PICkit™ 1 Flash Starter Kit. Use firmware version 2.0.2 or later.

The Signal Analysis PICtail™ Daughter Board User's Guide shows how to install the PICkit 1 Signal Analysis PC Program on the PC and set up the Signal Analysis PICtail Daughter Board. It also covers the features of the PICkit 1 Signal Analysis PC Program.

The PICkit 1 CD-ROM (DS40049) contains many of the necessary files. Use version v2.0 or later.

2.3 CONNECTING THE PHOTODIODE PGA PICTAIL™ DAUGHTER BOARD

An exploded view of how the different boards connect is shown in Figure 2-1.

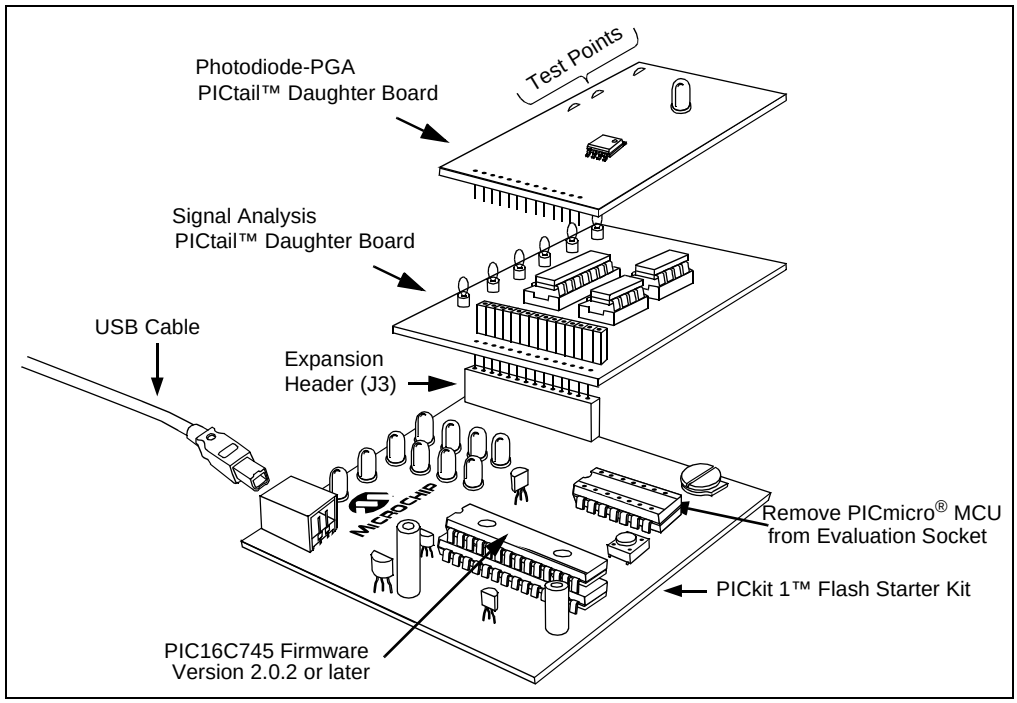


FIGURE 2-1: *Board Connections.*

2.3.1 PICkit 1 Flash Starter Kit

1. Remove any PICmicro microcontroller that may be in the evaluation socket.
2. Connect the USB cable to the PC and to the PICkit 1 Flash Starter Kit board. The status LEDs (green POWER and yellow BUSY in the LED array) should light up.

It is easiest to use this board when it lays directly on a bench top.

2.3.2 Signal Analysis PICtail Daughter Board

This board plugs into the PICkit 1 Flash Starter Kit's expansion header J3 (Figure 2-1), and must not cover the LED array. There should be no change in the status LEDs on the PICkit Flash Starter Kit board once it is plugged in.

2.3.3 Photodiode PGA PICtail™ Daughter Board

If you would rather use the MCP6S92 PGA, take it out of the anti-static bag and replace the already-installed MCP6S22 PGA.

1. Plug this board into, and directly above, the Signal Analysis PICtail Daughter Board (Figure 2-1). There should be no change in the status LEDs on the PICkit Flash Starter Kit board once it is plugged in.

2.1 Set-up Verification

1. Select the **Real Time Mode** radio button.
2. Click on the **Strip Chart** button.
3. Change the **sample speed** to 20 sample/secs.
4. Click on the green **GO** button; the strip-chart will show the measured output of the Photodiode PGA PICtail™ Daughter Board.
5. Move the photodiode close to a light source, such as a desk lamp, and verify that the strip-chart changes with light intensity (e.g., Figure 2-2).

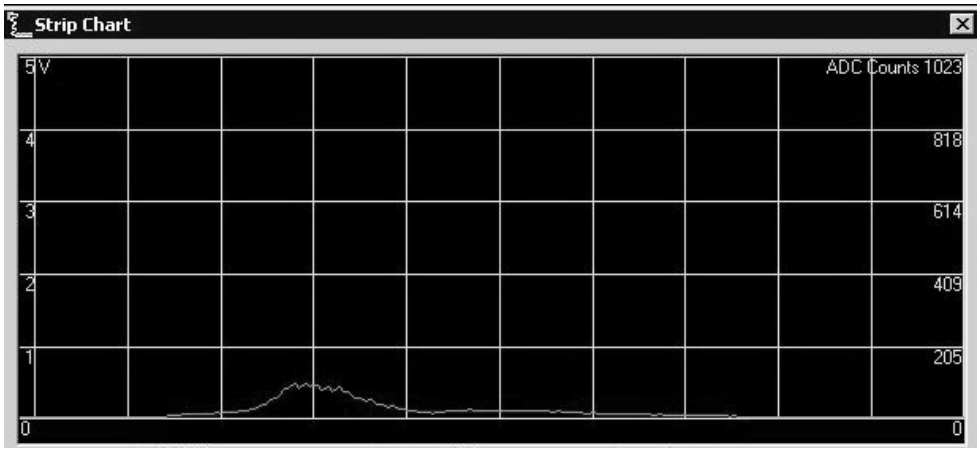


FIGURE 2-2: *Strip Chart.*

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Chapter 3. Operation

3.1 INTRODUCTION

This demonstration board makes it easy to explore the operation of a photodiode application. Items discussed in this chapter include:

- Light Sources
- Using the Signal Analysis PC Program for this Board
- Stand-Alone Board Set-up

3.2 LIGHT SOURCES

Different types of light sources have different characteristics. DC-powered light sources have a constant output intensity. AC-powered light sources have an output intensity that varies with time around an average value.

A battery power light source will have minimal fluctuations in light intensity. A battery-powered flashlight or LED array are good DC light sources.

Incandescent light bulbs and flourescent lights powered by the mains (e.g., 120 VAC at 60 Hz) are typical AC light sources.

When making light intensity measurements, other light sources in the environment may need to be blocked to achieve better measurement accuracy. Place a box over the light source, the demo board and on top of the bench to keep out ambient light; see Figure 3-1.

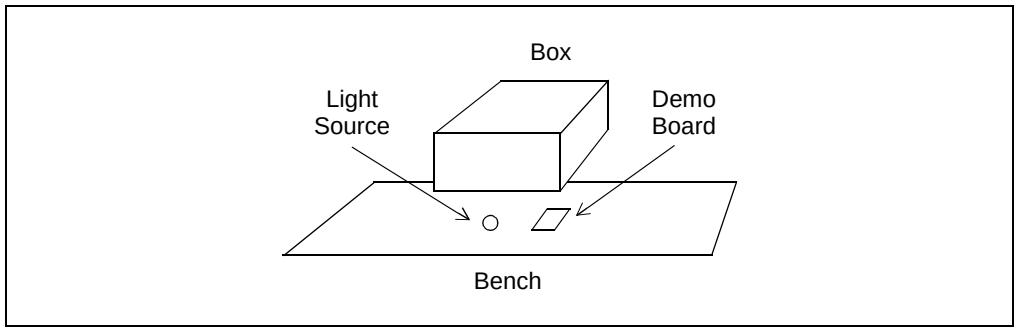


FIGURE 3-1: *Bench Set-up.*

3.2.1 Using the Signal Analysis PC Application for This Board

See **"Chapter 2. Using the PICkit™ Signal Analysis PC Application"** of the **"Signal Analysis PICtail Daughter Board User's Guide"** (DS51476) for details on displaying measured results. The possible formats include: oscilloscope, FFT, histogram and strip-chart.

The measured results can then be interpreted as illuminance; see **AN951, "Amplifying High Impedance Sensors – Photodiode Example"** (DS00951).

3.2.2 Configure the PGA

The PICkit 1 Signal Analysis PC Program can configure the PGA; see Figure 3-2. The MCP6S22 PGA defaults to Gain = 1 and to input CH0 when it powers up.

Note: The MCP6S92 PGA powers up to a random state; it must have its gain and input written to it before it will operate as expected.

1. Open the PGA window by clicking the **External Devices** button.
2. Select the correct PGA from the indicated pull-down list.
3. Select the desired PGA input. Usually the selection will be CH0 for the photodiode output, but it can be CH1 when another input source is provided at the CH1 test point (Figure 1-1).
   a. Select **Write to Register** from the indicated pull-down list. (Figure 3-2, #5)
   b. Set A0 = 1. (Figure 3-2, #6)
   c. Set C2:C0 to all zeros. (Figure 3-2, #7)
   d. Execute the command by clicking on the **Write to PGA** button. (Figure 3-2, #8)
4. Select the desired PGA gain.
   a. Select Write to Register from the indicated pull-down list. (Figure 3-5, #5)
   b. Set A0 = 0. (Figure 3-5, #6)
   c. Select PGA gain from the pull-down list. (Figure 3-5, #4)
   d. Execute the command by clicking on the **Write to PGA** button. (Figure 3-2, #8)

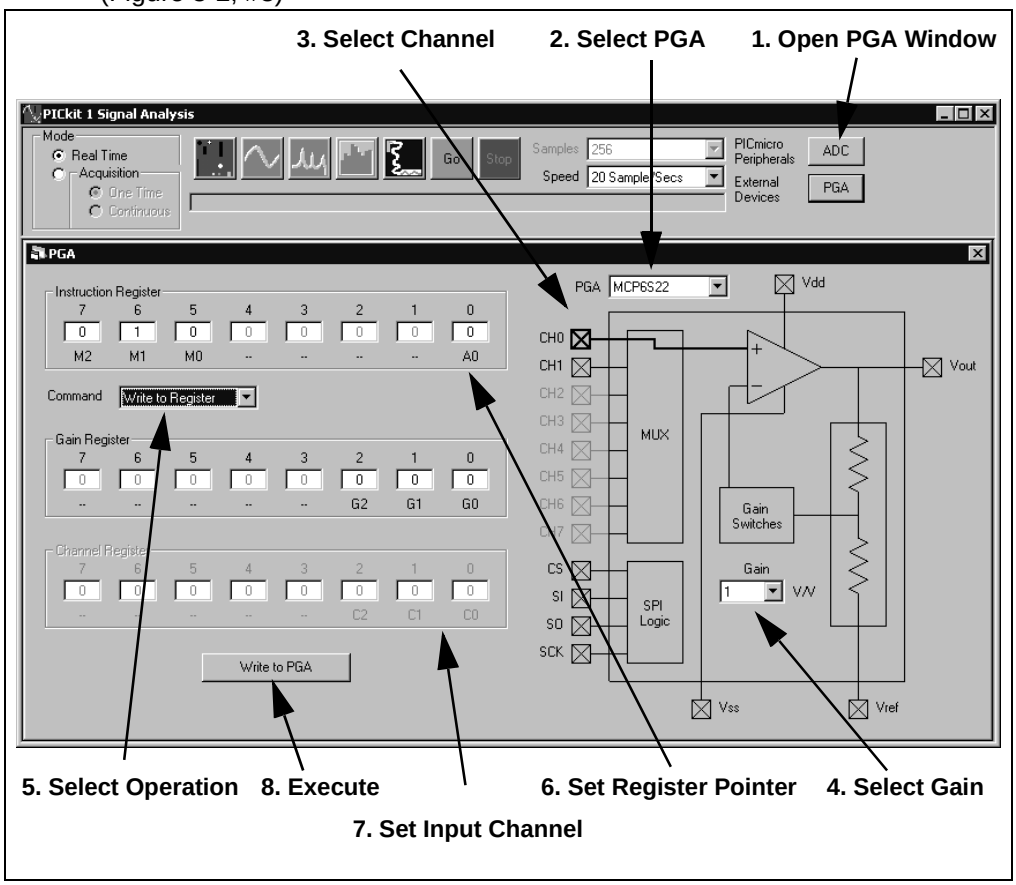


FIGURE 3-2: *PGA Configuration.*

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3.2.3 Configure the ADC

The ADC is automatically set up by the PICkit 1 Signal Analysis PC Program. The two possible inputs are shown in Figure 3-3.

1. If in the Real Time mode of operation (strip chart), select the **number of samples** from the first pull-down list.
2. Select the **sample rate** from the second pull-down list.

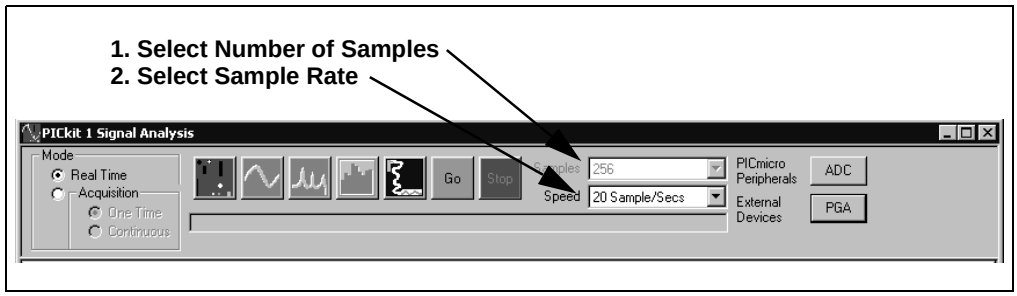


FIGURE 3-3: *Standard ADC Options.*

The PICkit 1 Signal Analysis PC Program allows the user to manually configure the ADC.

1. Clicking the ADC button (see Figure 3-4) opens the ADC configuration window. This window starts at the power-on default conditions for the ADC; therefore, it must be configured before use.

See the PIC16F684 data sheet (DS41202) for more information on configuring the registers.

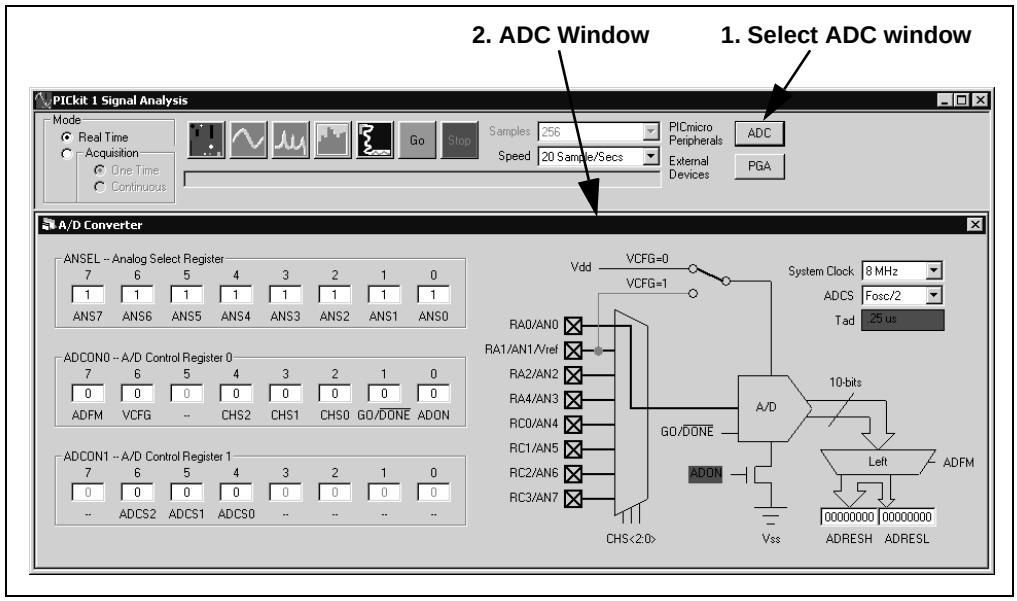


FIGURE 3-4: *Manual ADC Configuration.*

3.2.4 Measurement Example

The photodiode was placed next to a flourescent desk light. The gain was set to 16 V/V, the speed to 5000 samples/sec and the number of samples to 1024. The results are in Figure 3-5.

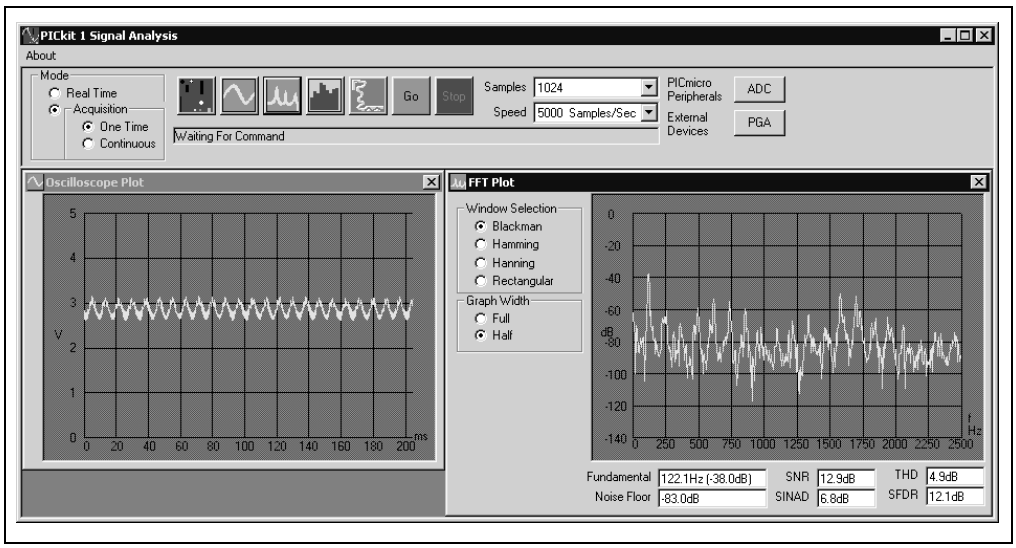


FIGURE 3-5: *Measurement Results.*

3.1 Stand-Alone Board Set-up

Figure 3-6 shows one possible method for using the Photodiode PGA PICtail™ Daughter Board by itself (without the accompanying tools shown in Figure 1-2). Most of the probes from the lab equipment (on the left) connect to the test points. The oscilloscope (O-Scope) probe to V_{OUT} connects to header J2's pin # 10 (labeled RC0).

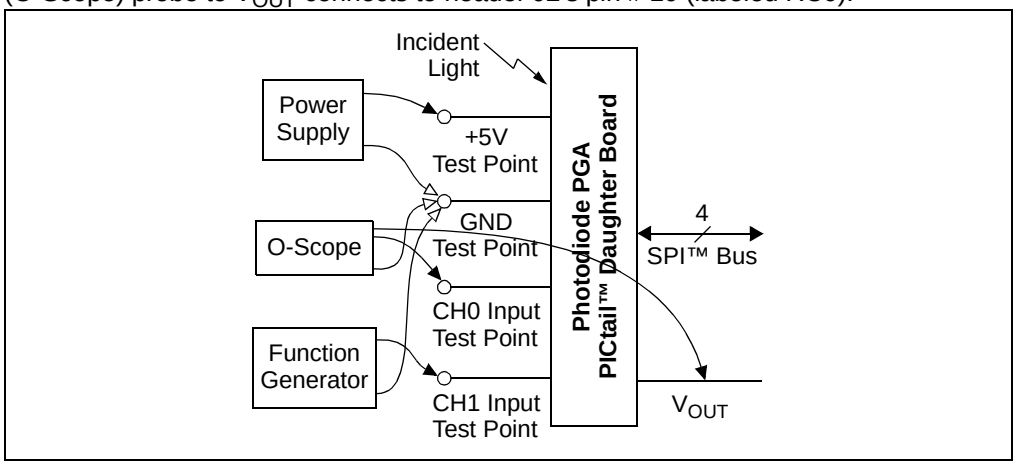


FIGURE 3-6: *Photodiode PGA PICtail™ Daughter Board Block Diagram.*

The PGAs' power supply range is between 2.5V and 5.5V. The MCP6001U op amp will also operate over this range.

The SPI bus needs to be connected to a microcontroller with the appropriate firmware. The MCP6S22 PGA powers up to input CH0 and 1 V/V gain. The MCP6S92 needs to be initialized after power-up.

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Appendix A. Schematic and Layouts

A.1 INTRODUCTION

This appendix contains the schematics and layouts for the Photodiode PGA PICtail™ Daughter Board.

The MCP6SX2-PICTLPD Demonstration Board is constructed using a two-layer Printed Circuit Board (PCB). The top layer is for components and traces. The bottom layer is the ground plane.

Information on this board includes:

- Board Schematic
- Board - Top Silk-Screen And Metal Layers
- Board - Top Metal Layer
- Board - Bottom Metal Layer

A.2 DEMONSTRATION BOARD DESCRIPTION

A simplified schematic is shown in Figure 1.3, with the complete schematic being presented in **A.4 "Board Schematic"**. D_1 is the photodiode that converts light into current. Op amp U_1 and resistor R_1 convert the current into a voltage; they form a transimpedance amplifier. Capacitor C_1 stabilizes the transimpedance amplifier.

R_2 and C_2 filter the transimpedance amplifier's output to reduce noise. They also act as an anti-aliasing filter for the ADC. The voltage V_{OUT} appears at this filter's output.

The MCP6SX2 Programmable Gain Amplifier (PGA) can be either the MCP6S22 or the MCP6S92. The PGA gains V_{OUT} up to produce the ADC's input voltage V_{PGA}. It also provides the capability to send another input to the ADC. It receives commands from the PIC16F684 via the SPI™ serial bus.

The PIC16F684 is on the Signal Analysis PICtail Daughter Board (PIC16F684) and provides an internal 10-bit ADC for measuring V_{OUT}. It also controls the PGA via the SPI serial interface.

The firmware on the PIC16F684 works with the PICkit 1 Signal Analysis PC program (see **Section 1.4.6 "Firmware for the Signal Analysis PICtail Daughter Board"**).

This is a two-layer board. It has a solid ground plane on the bottom layer to minimize EMC issues, and routes the traces in the top layer. The complete schematic is in **Sections A.4 "Board Schematic"**; the board layer plots in **A.5 "Board - Top Silk-Screen And Metal Layers"**, **A.6 "Board - Top Metal Layer"**, **A.7 "Board - Bottom Metal Layer"** and **Appendix B. Bill-Of-Materials (BOM)**. The Gerber files for this board are available on the Microchip web site (www.microchip.com) and are contained in the zip file `00951.zip`.

A.3 ADDITIONAL COMMENTS

The demonstration board includes test points for convenience on the bench. The "+5V" and "GND" test points connect to the board's supply voltages. The "CH0" test point connects to the PGA's CH0 input; it is also connected to the transimpedance amplifier's output (with filtering). The "CH1" test point allows the user to place any desired signal at the PGA's CH1 input.

The PIC16F684 (and 10-bit ADC) are not part of the demo board schematic; they are part of the Signal Analysis PICtail Daughter Board. (Figure 1-3).

The PICkit 1 Flash Starter Kit provides a +5V single supply-voltage. It can drive up to 5 µF on the supply; a larger capacitive load causes current loading and timing issues.

The PICkit 1 Flash Starter Kit Signal Analysis PICtail Daughter Board uses the +5V single-supply voltage. It has 0.1 µF local bypass capacitors for each IC, and a 1 µF bulk bypass capacitor for the entire board.

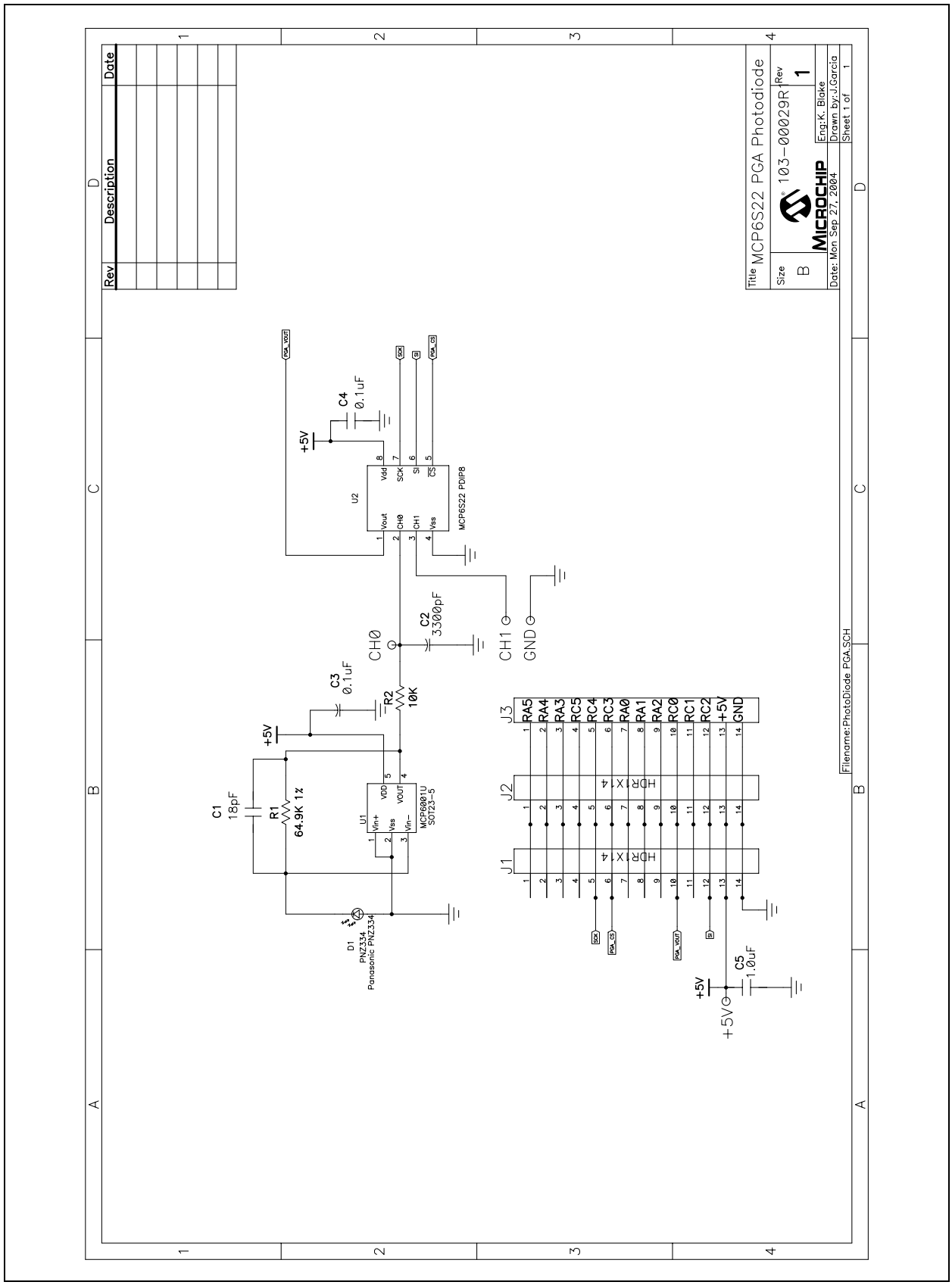
This demonstration board also uses the +5V single supply voltage. It has a 0.1 µF local bypass capacitor for the PGA and a 1 µF bulk bypass capacitor for the entire board. A solid ground plane provides a good ground for the PGA.

High-frequency design practices are used to minimize digital interference:

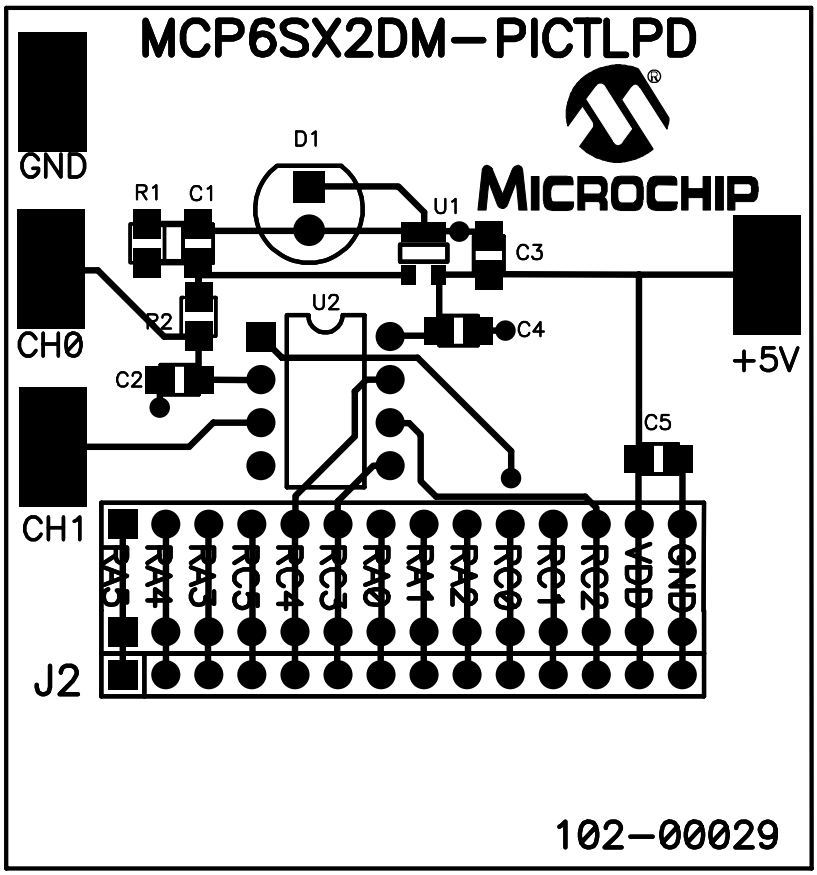
- Solid ground plane
- Surface-mount devices
- Separate digital and analog lines and sections
- Straight and short lines to the PGA

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A.4 BOARD SCHEMATIC

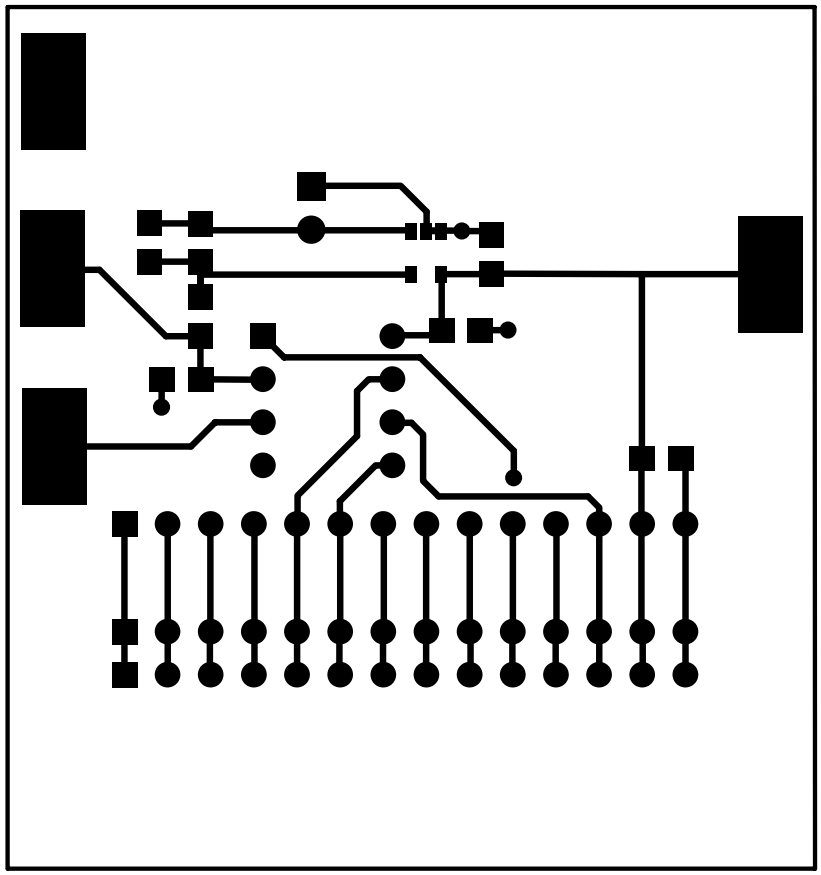


A.5 BOARD - TOP SILK-SCREEN AND METAL LAYERS

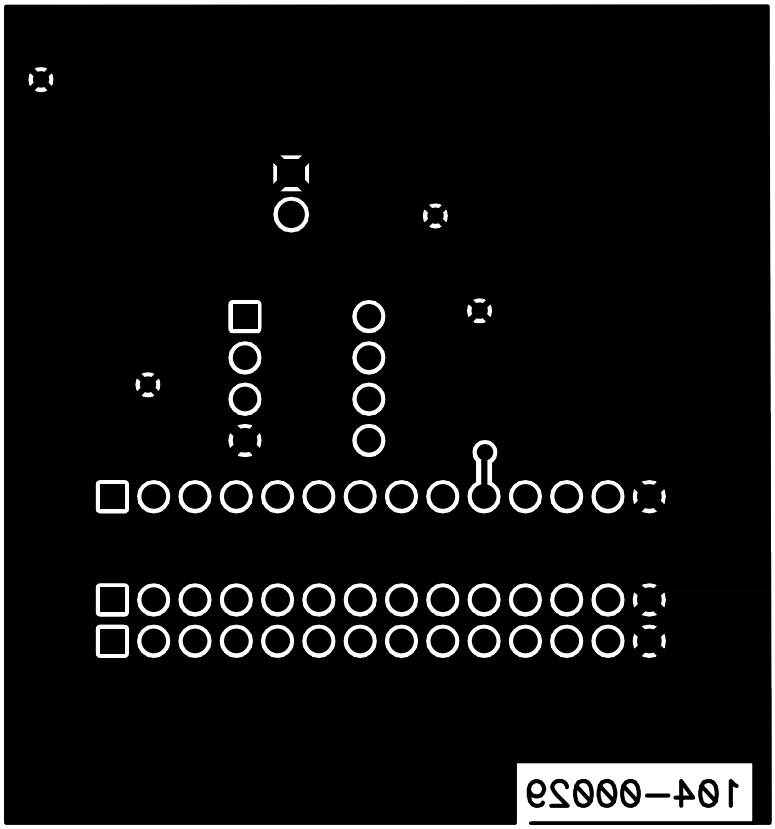


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A.6 BOARD - TOP METAL LAYER



A.7 BOARD - BOTTOM METAL LAYER



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Appendix B. Bill-Of-Materials (BOM)

TABLE B-1: BILL-OF-MATERIALS

Qty	Reference	Description	Manufacturer	Part Number
1	C1	Ceramic Capacitor, 18 pF, 50V, 5%, NP0, 0805 SMD	Panasonic® - ECG	ECJ-2VC1H180J
1	C2	Ceramic Capacitor, 33 nF, 50V, 10%, X7R, 0805 SMD	Panasonic - ECG	ECJ-2VB1H333K
2	C3,C4	Ceramic Capacitor, 0.1 µF, 25V, 10%, X7R, 0805 SMD	Panasonic - ECG	ECJ-2VB1E104K
1	C5	Ceramic Capacitor, 1.0µF, 16V, 10% X7R, 0805 SMD	Kemet®	C0805C105K4RACTU
1	D1	PIN Photodiode	Panasonic - SSG	PNZ334
1	J2	Header, 1X14, 0.100" Pitch, Vertical, Tin	Molex®/Waldom® Electronics Corp.	22-28-4140
1	R1	Chip Resistor, 64.9 kΩ, 1/10W, 1%, 0805 SMD	Panasonic - ECG	ERJ-6ENF6492V
1	R2	Chip Resistor, 10.0 kΩ, 1/10W, 1%, 0805 SMD	Panasonic - ECG	ERJ-6ENF1002V
4	GND,CH0, CH1,+5V	PC Test Point, Compact, SMT	Keystone Electronics®	5016
1	U1	MCP6001U, Op Amp, 1 MHz, SOT23-5	Microchip Technology Inc.	MCP6001U-I/OT
1	U2	MCP6S22, PGA, 10 MHz, 2 inputs, PDIP-8 **(Note 1)**	Microchip Technology Inc.	MCP6S22-I/P
1	U2	MCP6S92, PGA, 10 MHz, 2 inputs, PDIP-8 **(Note 1)**	Microchip Technology Inc.	MCP6S92-E/P
1	—	IC Socket, 8-pin, Gold Plated, 0.300" (for U2)	Mill-Max® Manufacturing Corp.	110-93-308-41-001
1	PCB	Bare Printed Circuit Board	—	—

Note 1: Either PGA will work in this application. The board comes with a MCP6S22 installed. A MCP6S92 comes in the anti-static parts bag.

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