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# **MCP6XXX Amplifier Evaluation Board 1 User's Guide**

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# MCP6XXX AMPLIFIER EVALUATION BOARD 1 USER'S GUIDE

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## Preface

### NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site ([www.microchip.com](http://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 MCP6XXX Amplifier Evaluation Board 1. 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 MCP6XXX Amplifier Evaluation Board 1. The manual layout is as follows:

- **Chapter 1. “Product Overview”** - Provides all important information about the MCP6XXX Amplifier Evaluation Board 1.
- **Chapter 2. “Installation and Operation”** – Covers the installation and operation of the MCP6XXX Amplifier Evaluation Board 1. It lists the required tools, shows how to set up the board, and demonstrates how to verify the operation.
- **Appendix A. “Schematic and Layouts”** – Shows the schematic and board layouts for the MCP6XXX Amplifier Evaluation Board 1.
- **Appendix B. “Bill Of Materials (BOM)”** – Lists the parts used to build the MCP6XXX Amplifier Evaluation Board 1.

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## CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

### DOCUMENTATION CONVENTIONS

| Description                                      | Represents  | Examples  |
|--|---|---|
| <b>Arial font:</b>                               |   |   |
| Italic characters                                | Referenced books  | <i>MPLAB<sup>®</sup> IDE User's Guide</i>                   |
|  | Emphasized text   | ...is the <i>only</i> 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   | <u><i>File&gt;Save</i></u>                                  |
| Bold characters                                  | A dialog button   | Click <b>OK</b>   |
|  | A tab   | Click the <b>Power</b> 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>   |
| <b>Courier New font:</b>                         |   |   |
| 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   | <i>file.o</i> , where <i>file</i> can be any valid filename |
| Square brackets [ ]                              | Optional arguments  | mcc18 [options] <i>file</i> [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)<br>{ ...<br>}                              |

## RECOMMENDED READING

This user's guide describes how to use MCP6XXX Amplifier Evaluation Board 1. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

### **MCP6021 Data Sheet “Rail-to-Rail Input/Output, 10 MHz Op Amps” (DS21685)**

This data sheet provides detailed information regarding the MCP6021 product family.

## THE MICROCHIP WEB SITE

Microchip provides online support via our web site at [www.microchip.com](http://www.microchip.com). This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **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

## CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- 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 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 (July 2007)**

- Initial Release of this Document.



# MCP6XXX Amplifier Evaluation Board 1 User's Guide

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## Chapter 1. Product Overview

### 1.1 INTRODUCTION

The MCP6XXX Amplifier Evaluation Board 1 is described by the following:

- Assembly # : 114-00147
- Order # : MCP6XXXEV-AMP1
- Name: MCP6XXX Amplifier Evaluation Board 1

Items discussed in this chapter include:

- **Section 1.2 “MCP6XXX Amplifier Evaluation Board 1 Kit Contents”**
- **Section 1.3 “Microchip’s Web-Based Mindi™ Analog Simulator”**
- **Section 1.4 “MCP6XXX Amplifier Evaluation Board 1 Description”**

### 1.2 MCP6XXX AMPLIFIER EVALUATION BOARD 1 KIT CONTENTS

- MCP6XXX Amplifier Evaluation Board 1 - One partially assembled board
- Important Information “Read First”
- Accessory Bag - Contains loose parts for populating sockets on board
- Analog and Interface Products Demonstration Boards CD-ROM (DS21912)
  - MCP6XXX Amplifier Evaluation Board 1 User’s Guide (DS51667)



**FIGURE 1-1:** MCP6XXX Amplifier Evaluation Board 1 Kit.

# MCP6XXX Amplifier Evaluation Board 1 User's Guide

## 1.3 MICROCHIP'S WEB-BASED MINDI™ ANALOG SIMULATOR

The Mindi™ Analog Simulator tool is an innovative software tool that simplifies analog circuit design. The Mindi™ Analog Simulator tool supports the following application circuits: 1) Active Filters, 2) Amplifiers, 3) Battery Chargers, and 4) DC-to-DC Converters. The Mindi™ Amplifier Designer provides full schematic diagrams of the amplifier application circuit with recommended component values and displays the responses in frequency and time domains.

The Mindi™ Analog Simulator tool is a free web-based design tool available on the Microchip web site at <http://www.microchip.com> under “Online Simulation Tools” or by going directly to the Mindi™ web site at <http://www.microchip.com/mindi>.

The circuit simulator within the Mindi™ Analog Simulator tool can be downloaded and installed on a personal computer (PC) for more convenient simulations. Modified circuit files can also be downloaded to the PC.

## 1.4 MCP6XXX AMPLIFIER EVALUATION BOARD 1 DESCRIPTION

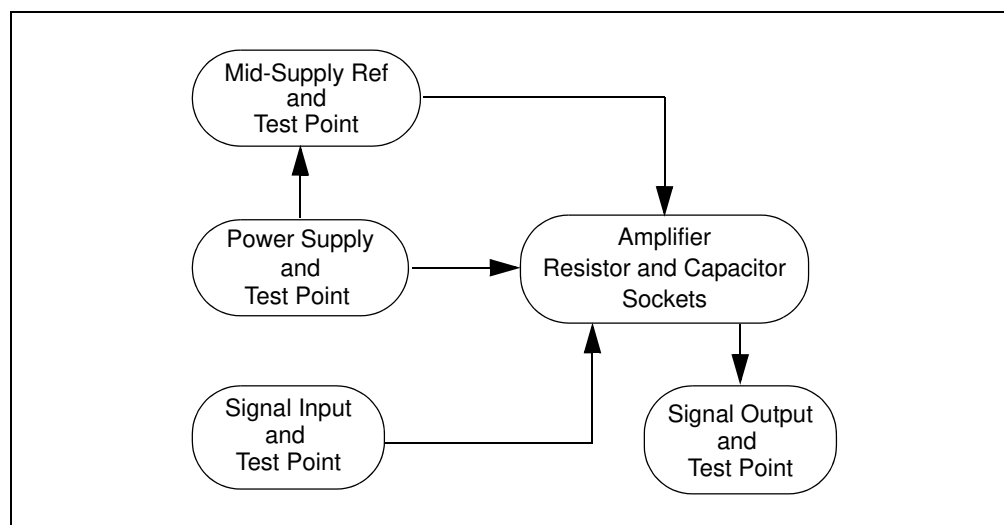
The MCP6XXX Amplifier Evaluation Board 1 is designed to support inverting/non-inverting amplifiers, voltage follower, inverting/non-inverting comparators, inverting/non-inverting differentiators.

However, at this time, the Mindi™ Amplifier Designer does not support the non-inverting comparator or the non-inverting differentiator.

MCP6XXX Amplifier Evaluation Board 1 has the following features:

- All amplifier resistors and capacitors are socketed
- All of the component labels on board keep consistent with those on schematic generated in the Mindi™ Amplifier Designer
- Supports all Microchip single op amps
  - PDIP-8 package (e.g., MCP6021) are socketed
  - SOIC-8 package can be accommodated; see **Section 2.4.3 “Amplifier Modification: Using 8-Pin SOIC Op Amps”**
- Test points for connecting lab equipment
- Single supply configuration

Figure 1-2 shows the block diagram of the MCP6XXX Amplifier Evaluation Board 1. Lab equipment can be attached (via test points) to measure the amplifier response.



**FIGURE 1-2:** MCP6XXX Amplifier Evaluation Board 1 Block Diagram.

## Chapter 2. Installation and Operation

### 2.1 INTRODUCTION

This chapter shows how to set up the MCP6XXX Amplifier Evaluation Board 1 and verify its operation. This chapter includes the following topics:

- Required Tools
- MCP6XXX Amplifier Evaluation Board 1 Set-Up
- MCP6XXX Amplifier Evaluation Board 1 Operation

### 2.2 REQUIRED TOOLS

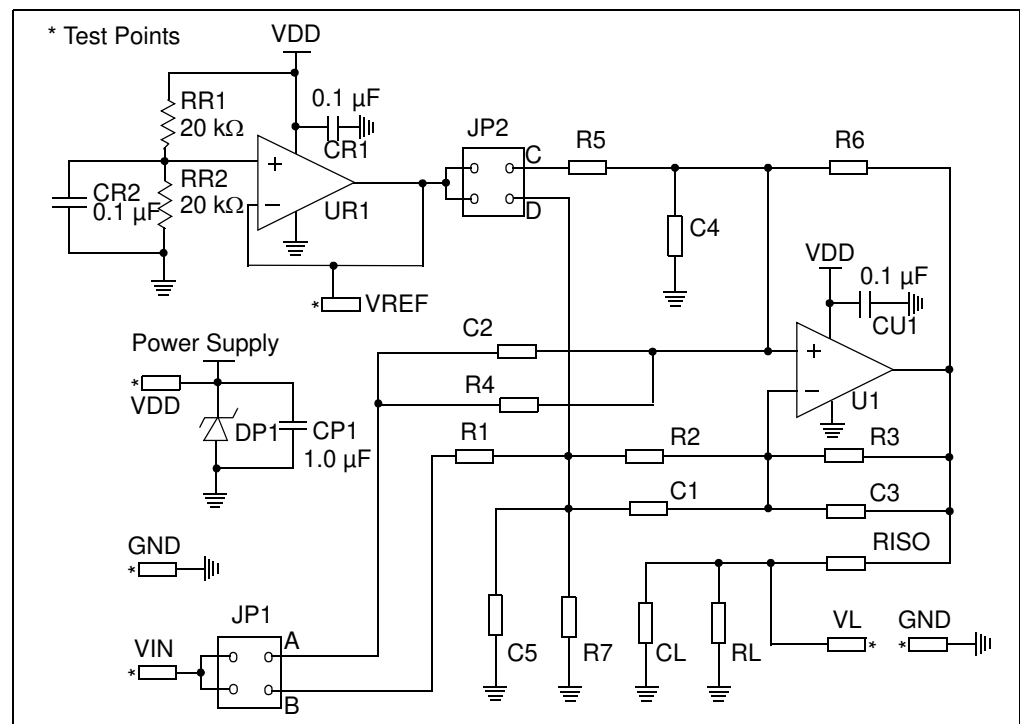
- Lab power supply
- Lab signal source (e.g., function generator)
- Lab measurement equipment (e.g., oscilloscope)

### 2.3 MCP6XXX AMPLIFIER EVALUATION BOARD 1 SET-UP

The MCP6XXX Amplifier Evaluation Board 1 is designed to support inverting/non-inverting amplifiers, voltage follower, inverting/non-inverting comparators, inverting/non-inverting differentiators

At this time, the Mindi™ Amplifier Designer does not support the non-inverting comparator or the non-inverting differentiator.

This section details the conversion of these topologies to the MCP6XXX Amplifier Evaluation Board 1. Figure 2-1 shows the circuit diagram for the board.



**FIGURE 2-1:** MCP6XXX Amplifier Evaluation Board 1 Circuit Diagram.

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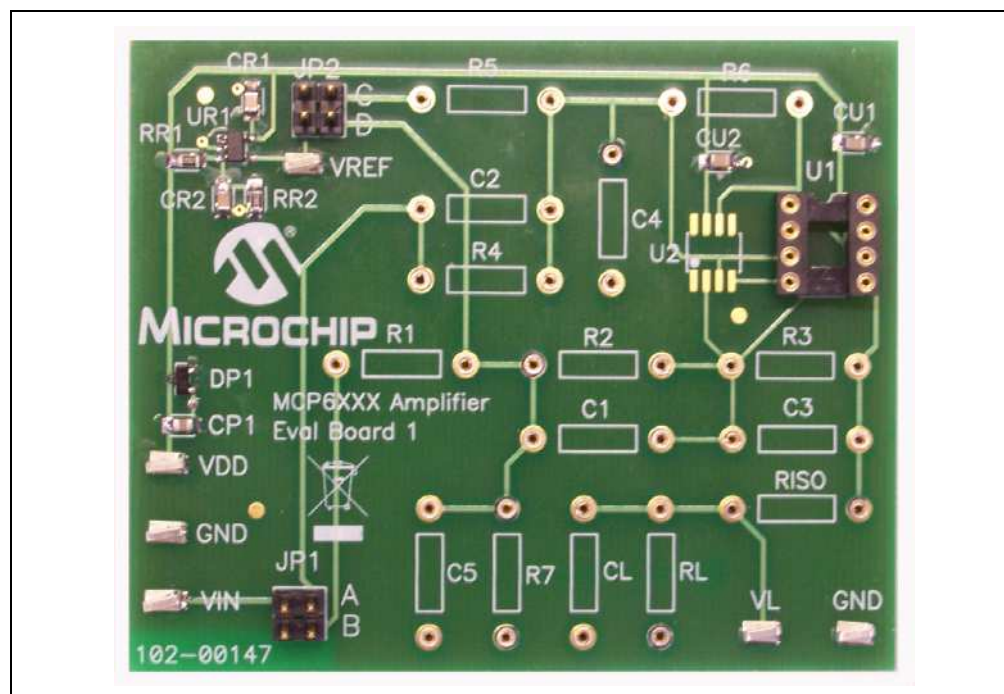
The power supply voltage should be in the allowed range for the installed op amps. Any of Microchip's op amps that operate below 5.5V can be used. Moreover, power supply is protected by a zener diode with nominal voltage 6.2V and bypassed by a 1.0  $\mu$ F capacitor. (See **Figure 2-3: "Power Supply Block."**)

The mid-supply reference consists of a voltage divider and a buffer amplifier. (See **Figure 2-4: "Mid-Supply Reference Block."**)

The resistors and capacitors that are part of an amplifier are placed in pin sockets which are labeled. All of the component labels on board keep consistent with those on schematic generated in the Mindi™ Amplifier Designer. The op amps are bypassed by 0.1  $\mu$ F capacitors and the single op amp U1 can have either a PDIP-8 or SOIC-8 package.

- PDIP-8 packages are inserted into the DIP-8 socket to the right of the U1 label
- SOIC-8 packages can be accommodated; see **Section 2.4.3 "Amplifier Modification: Using 8-Pin SOIC Op Amps"**

The (surface mount) test points for power supply, ground, input signal and output signal allow lab equipment to be connected to the board. The MCP6XXX Amplifier Evaluation Board 1 top view is shown in Figure 2-2.

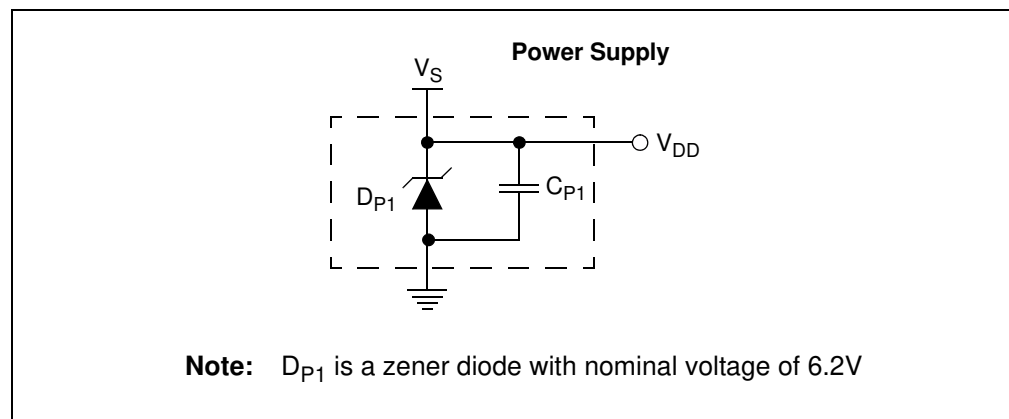


**FIGURE 2-2:** MCP6XXX Amplifier Evaluation Board 1 Top View.

## 2.3.1 Top Level Amplifier Circuit Diagrams

### 2.3.1.1 POWER SUPPLY BLOCK

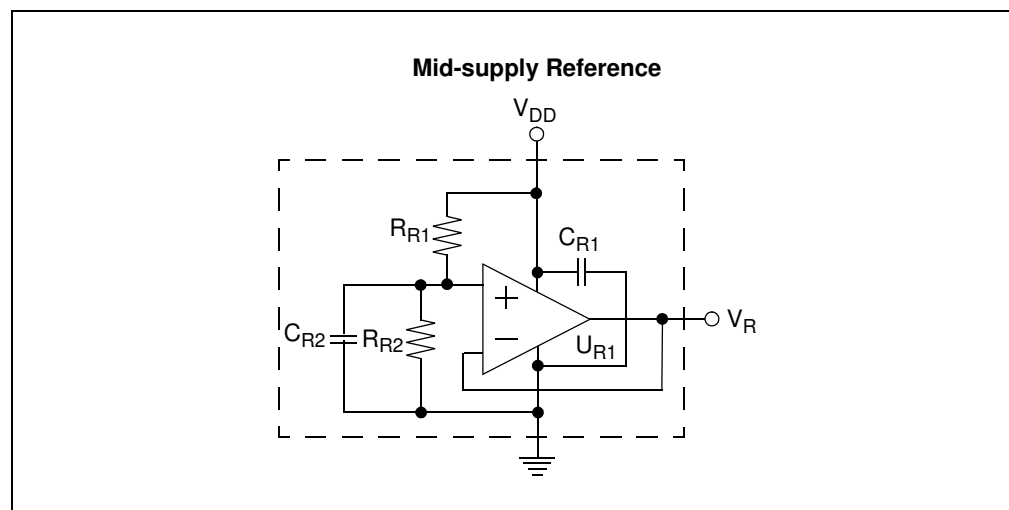
The power supply is protected by a zener diode and bypassed by a capacitor. Figure 2-3 shows the circuit diagram for the power supply.  $C_{P1} = 1.0 \mu\text{F}$ .



**FIGURE 2-3:** Power Supply Block.

### 2.3.1.2 MID-SUPPLY REFERENCE BLOCK

The mid-supply reference consists of a voltage divider and a buffer amplifier. Figure 2-4 shows the circuit diagram for the mid-supply reference.  $C_{R1} = C_{R2} = 0.1 \mu\text{F}$ ,  $R_{R1} = R_{R2} = 20.0 \text{ k}\Omega$ .

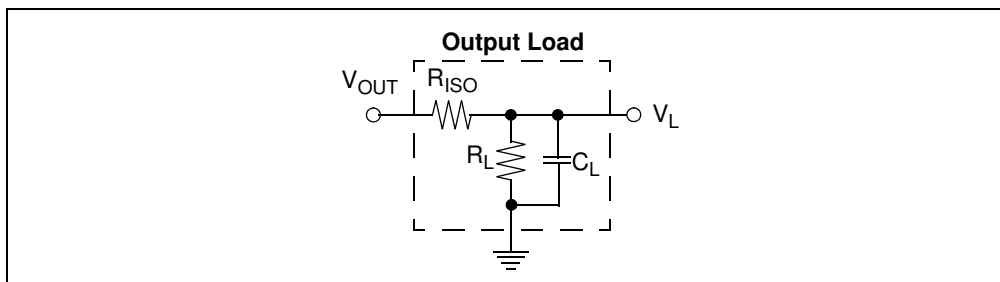


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## 2.3.1.3 OUTPUT LOAD BLOCK

The output load consists of a capacitor and two resistors. Figure 2-5 shows the circuit diagram for the output load.  $R_{ISO}$  is used to stabilize the amplifier when it drives a large capacitive load.  $R_{ISO}$  is a short circuit ( $0\Omega$ ) when  $C_L$  is small.

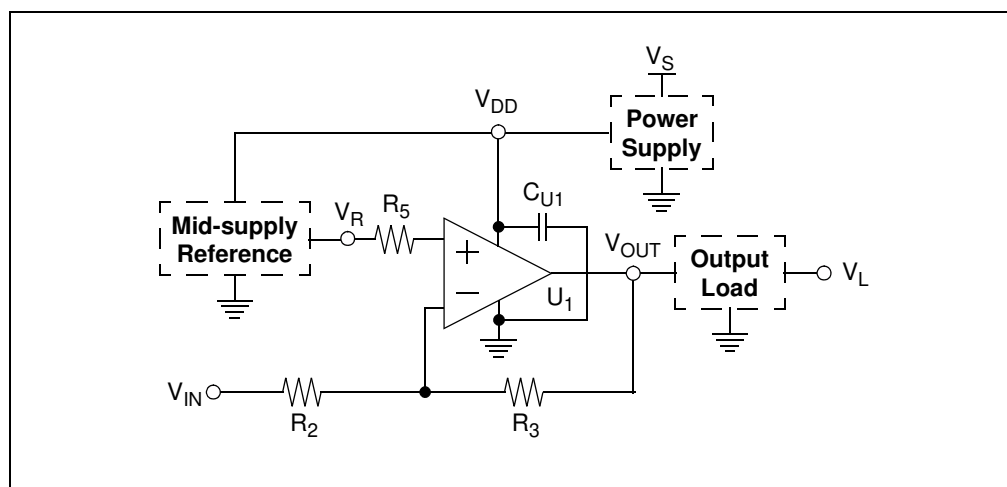


**FIGURE 2-5:** Output Load Block.

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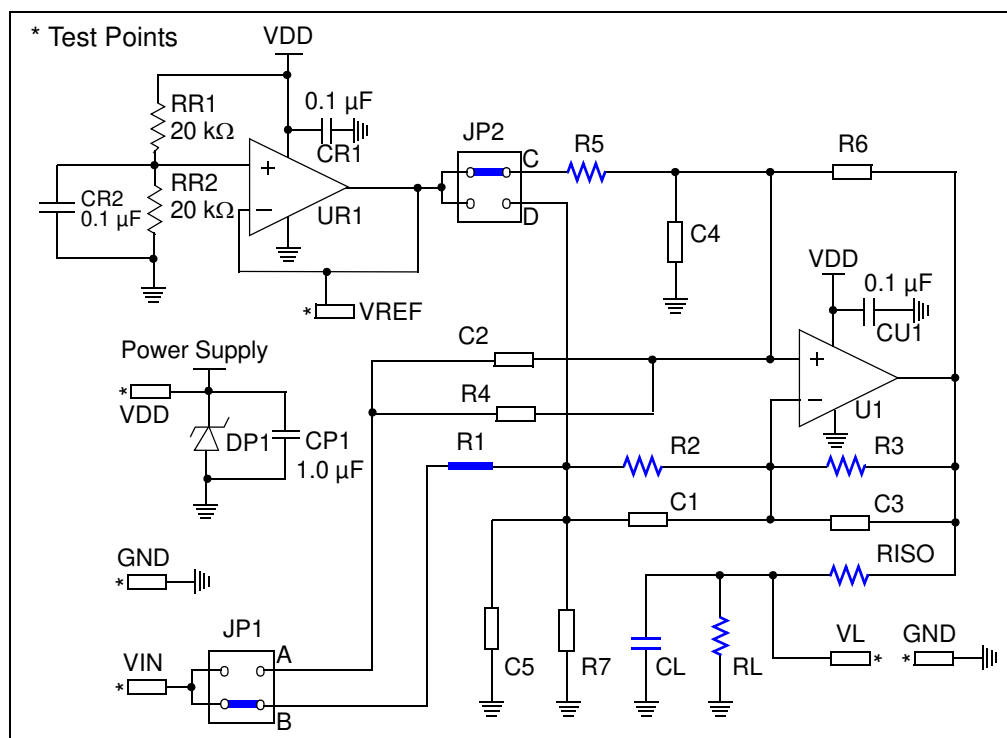
#### 2.3.1.4 INVERTING AMPLIFIER

- Amplifies a voltage with an inverting gain. Input and output voltages are shifted by a reference voltage for single supply.
- The Mindi™ Amplifier Designer gives design recommendations for an inverting amplifier circuit; see the circuit diagram shown in Figure 2-6
  - Fill the sockets with the recommended resistors and capacitors
  - Set JP1 and JP2 in the correct positions  
(for the given example, JP1: Position B, JP2: Position C)



**FIGURE 2-6:** *Inverting Amplifier Circuit Diagram.*

Figure 2-7 shows an example of the inverting amplifier circuit diagram supported by MCP6XXX Amplifier Evaluation Board 1.



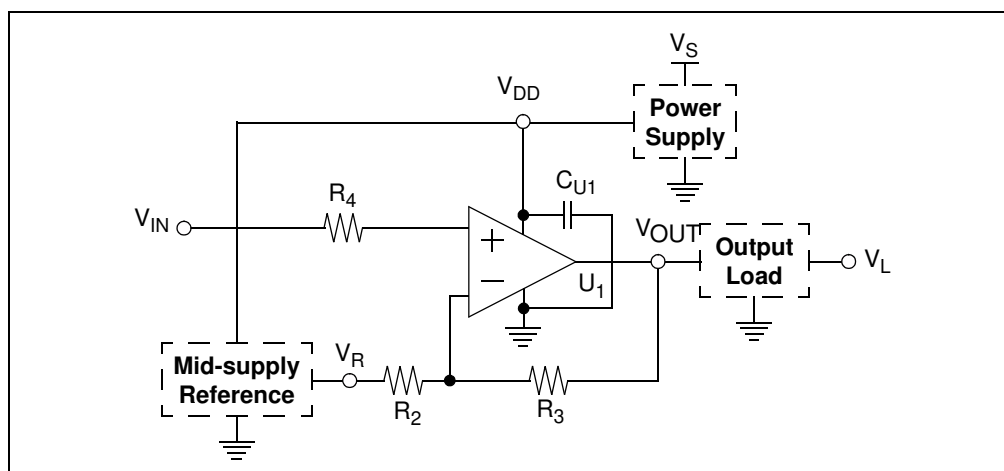
**FIGURE 2-7:** *Inverting Amplifier Example Supported by the MCP6XXX Amplifier Evaluation Board 1.*



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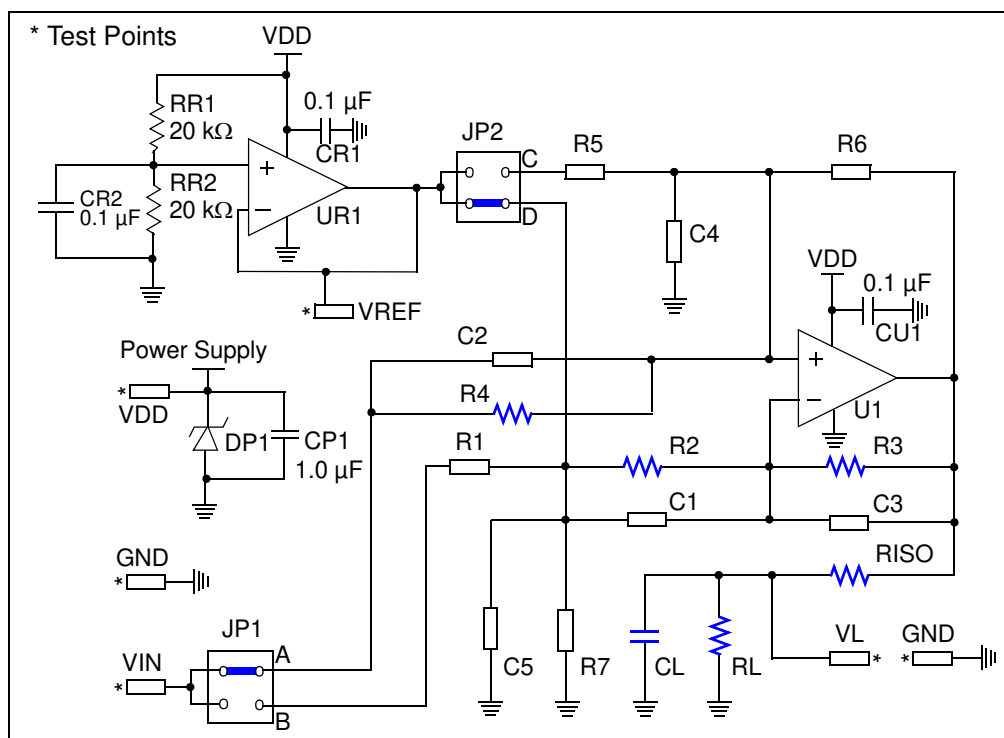
## 2.3.1.5 NON-INVERTING AMPLIFIER

- Amplifies a voltage with a non-inverting gain  $> +1$  V/V. Input and output voltages are shifted by a reference voltage for single supply
- The Mindi™ Amplifier Designer gives design recommendations for the non-inverting amplifier circuit; see the circuit diagram shown in Figure 2-8
  - Fill the sockets with the recommended resistors and capacitors
  - Set JP1 and JP2 in the correct positions (for the given example, JP1: Position A, JP2: Position D)



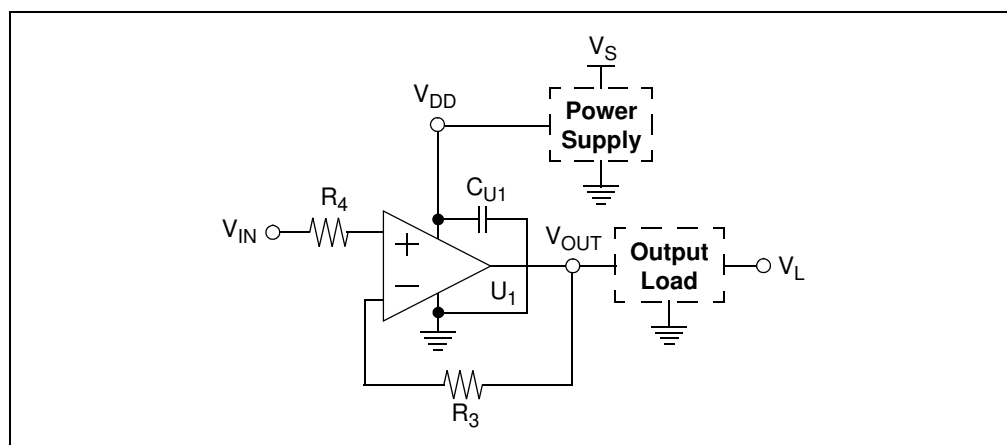
**FIGURE 2-8:** Non-Inverting Amplifier Circuit Diagram.

Figure 2-9 shows an example of the inverting amplifier circuit diagram supported by MCP6XXX Amplifier Evaluation Board 1.



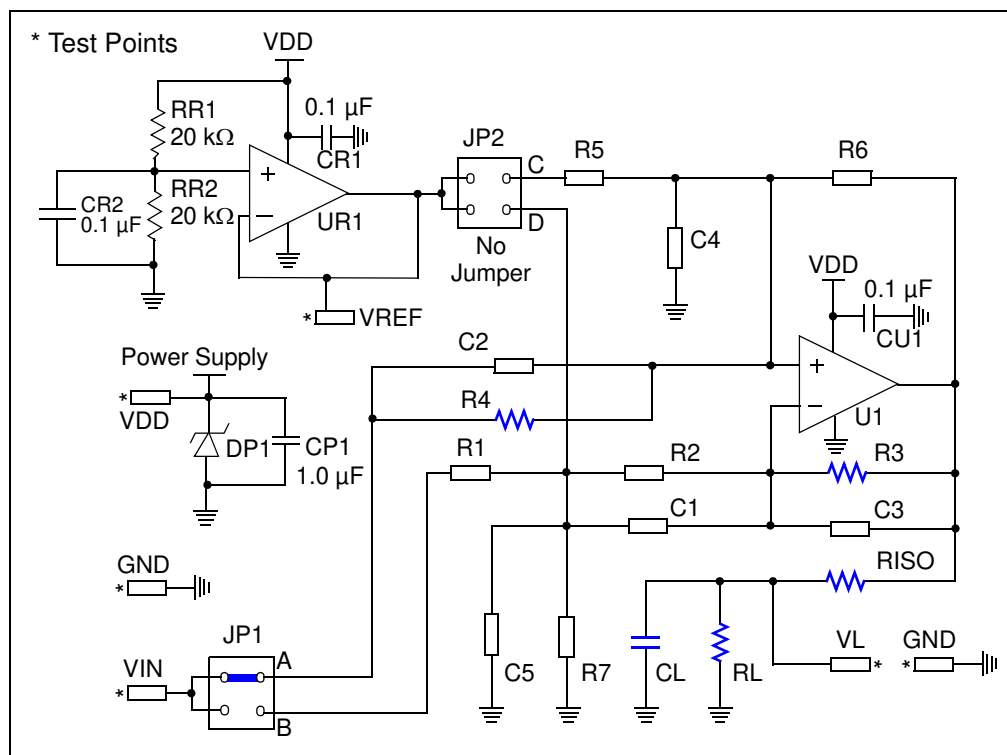
## 2.3.1.6 VOLTAGE FOLLOWER

- Known as a Unity Gain Buffer and as a Voltage Follower. Amplifies a voltage with a gain of 1 V/V
- The Mindi™ Amplifier Designer gives design recommendations for the voltage follower circuit; see the circuit diagram shown in Figure 2-10
  - Fill the sockets with the recommended resistors and capacitors
  - Set JP1 and JP2 in the correct positions  
(for the given example, JP1: Position A, JP2: Position N/A)



**FIGURE 2-10:** Voltage Follower Circuit Diagram.

Figure 2-11 shows an example of the voltage amplifier circuit diagram supported by MCP6XXX Amplifier Evaluation Board 1.



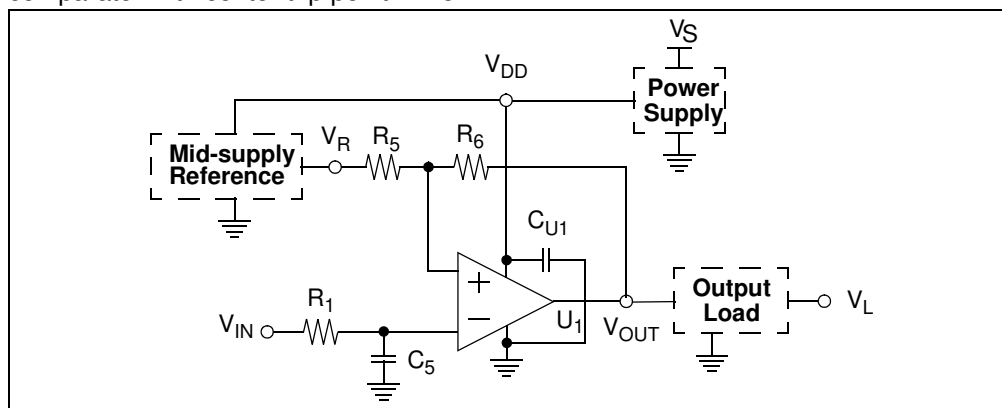
**FIGURE 2-11:** Voltage Amplifier Example Supported by the MCP6XXX Amplifier Evaluation Board 1.

# MCP6XXX Amplifier Evaluation Board 1 User's Guide

## 2.3.1.7 INVERTING COMPARATOR

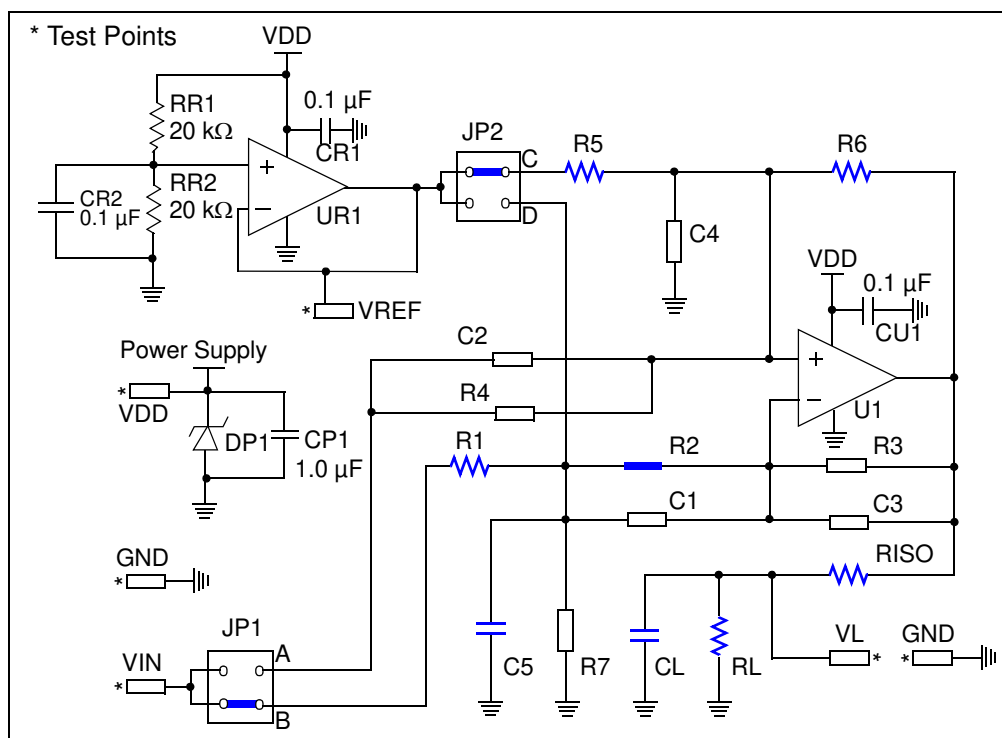
- Compares the input voltage to another (reference) voltage and forces the output to one of two digital states. Input signal is applied to the inverting input. The comparison includes a user selected amount of hysteresis. Input and output voltages are shifted by a reference for single supply
- The Mindi™ Amplifier Designer gives design recommendations for the inverting comparator circuit; see the circuit diagram shown in Figure 2-12
  - Fill the sockets with the recommended resistors and capacitors
  - Set JP1 and JP2 in the correct positions  
(for the given example, JP1: Position B, JP2: Position C)

**Note:** The MCP6XXX Amplifier Evaluation Board 1 currently only supports the inverting comparator with center trip point = 2.5V.



**FIGURE 2-12:** Inverting Comparator Circuit Diagram.

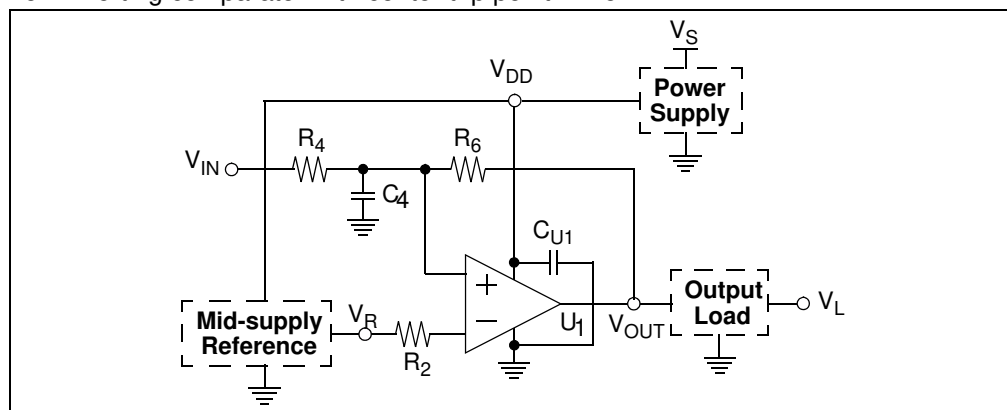
Figure 2-13 shows an example of the inverting comparator circuit diagram supported by MCP6XXX Amplifier Evaluation Board 1.



## 2.3.1.8 NON-INVERTING COMPARATOR (NOT CURRENTLY SUPPORTED)

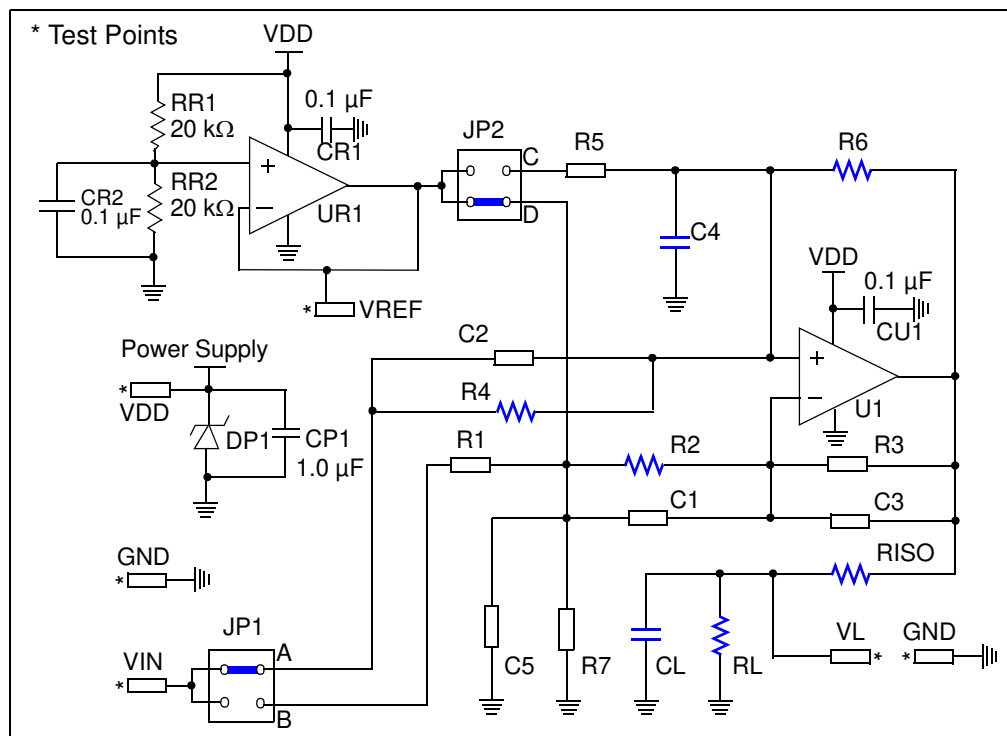
- Compares the input voltage to another (reference) voltage and forces the output to one of two digital states. Input signal is applied to the non-inverting input. The comparison includes a user selected amount of hysteresis. Input and output voltages are shifted by a reference for single supply
- The Mindi™ Amplifier Designer gives design recommendations for the non-inverting comparator circuit; see the circuit diagram shown in Figure 2-14
  - Fill the sockets with the recommended resistors and capacitors
  - Set JP1 and JP2 in the correct positions  
(for the given example, JP1: Position A, JP2: Position D)

**Note:** The MCP6XXX Amplifier Evaluation Board 1 currently only supports the non-inverting comparator with center trip point = 2.5V.



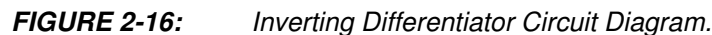
**FIGURE 2-14:** Non-Inverting Comparator Circuit Diagram.

Figure 2-15 shows an example of the non-inverting comparator circuit diagram supported by the MCP6XXX Amplifier Evaluation Board 1.



\_\_\_\_\_

- Differentiates and inverts a voltage with a differentiating frequency. Additional components ( $R_1$ ,  $C_3$ ) achieve stabilization and noise. Input and output voltages are shifted by a reference for single supply
- The Mindi™ Amplifier Designer gives design recommendations for the inverting differentiator circuit; see the circuit diagram shown in Figure 2-16
  - Fill the sockets with the recommended resistors and capacitors
  - Set JP1 and JP2 in the correct positions  
(for the given example, JP1: Position B, JP2: Position C)

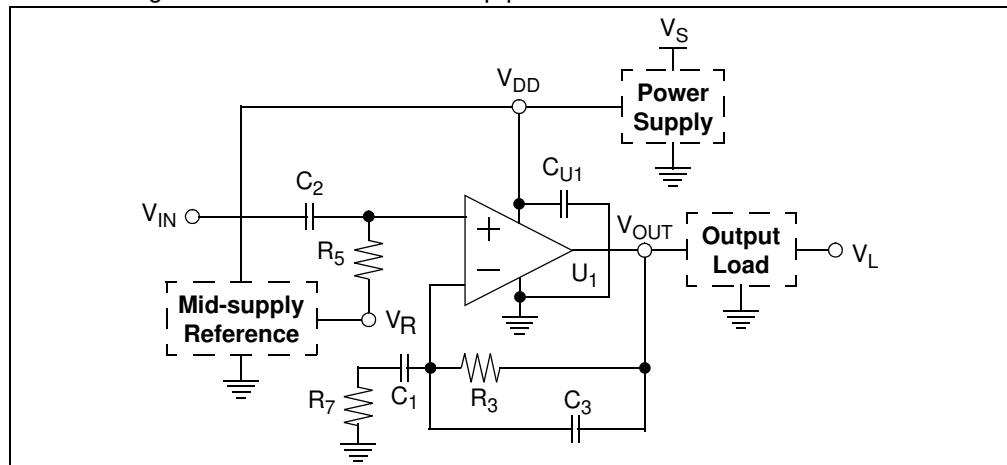
[illegible]

**FIGURE 2-17:** *Inverting Differentiator Example Supported by the MCP6XXX Amplifier Evaluation Board 1.*

## 2.3.1.10 NON-INVERTING DIFFERENTIATOR (NOT CURRENTLY SUPPORTED)

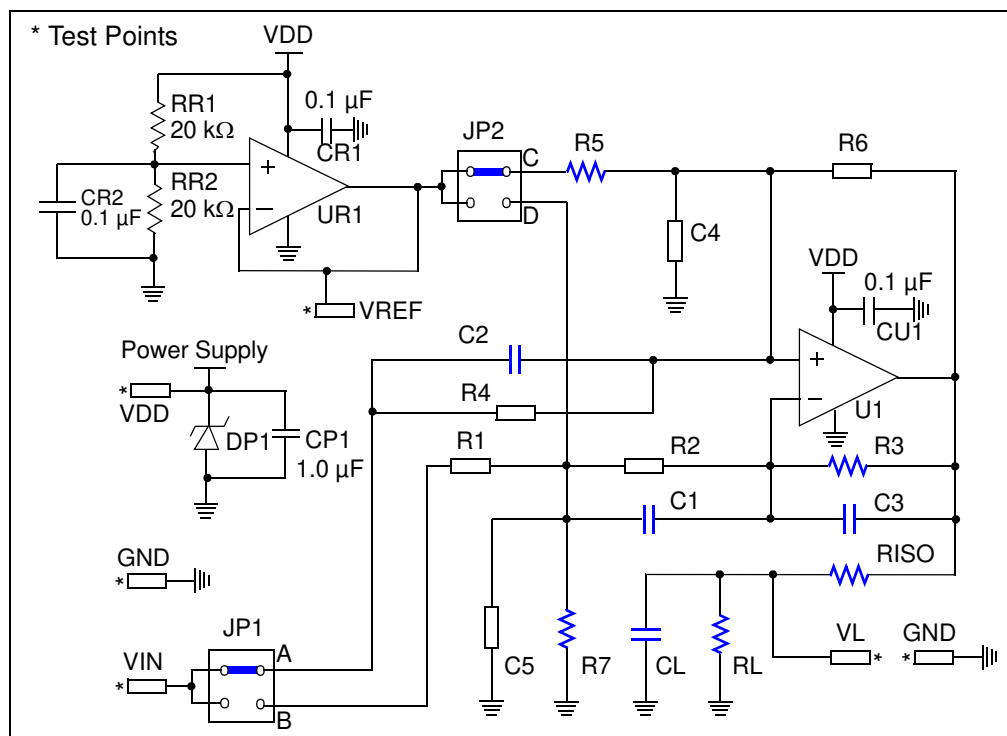
- Differentiates and inverts a voltage with a differentiating frequency. Additional components ( $R_7$ ,  $C_3$ ) achieve stabilization and noise. Input and output voltages are shifted by a reference for single supply
- The Mindi™ Amplifier Designer gives design recommendations for the non-inverting differentiator circuit; see the circuit diagram shown in Figure 2-18
  - Fill the sockets with the recommended resistors and capacitors
  - Set JP1 and JP2 in the correct positions  
(for the given example, JP1: Position A, JP2: Position C)

**Note:** The MCP6XXX Amplifier Evaluation Board 1 currently only supports the non-inverting differentiator with center trip point = 2.5V.



**FIGURE 2-18:** Non-Inverting Differentiator Circuit Diagram.

Figure 2-19 shows an example of the non-inverting differentiator circuit diagram supported by MCP6XXX Amplifier Evaluation Board 1.



**FIGURE 2-19:** Non-Inverting Differentiator Example Supported by the MCP6XXX Amplifier Evaluation Board 1.

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## 2.4 MCP6XXX AMPLIFIER EVALUATION BOARD 1 OPERATION

Items discussed in this section include:

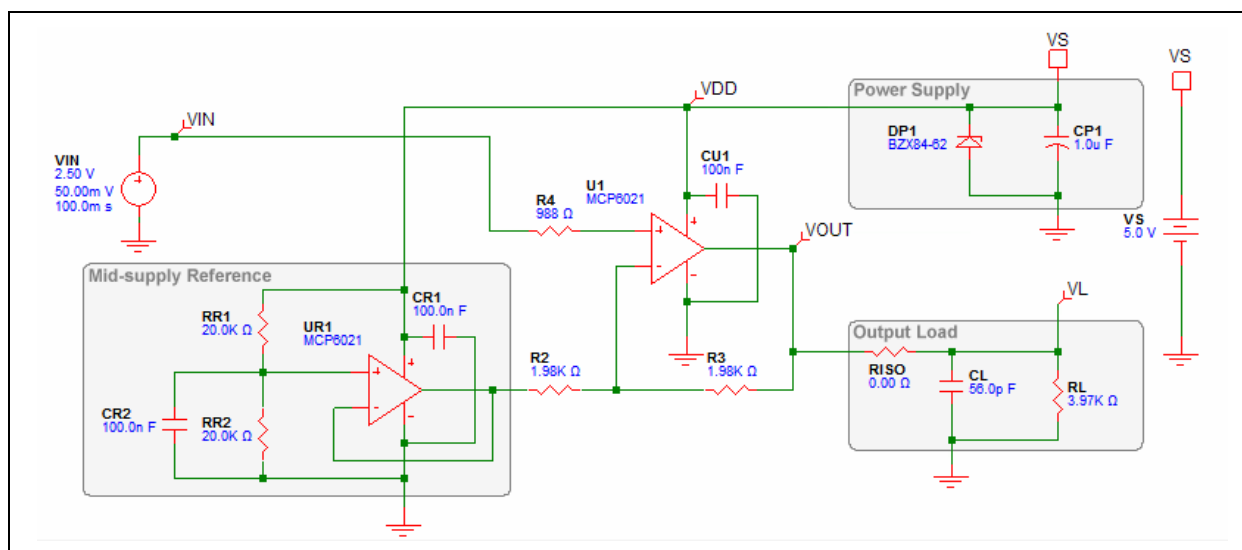
- Building the Amplifier
- Testing the Amplifier
- Amplifier Modification: Using 8-Pin SOIC Op Amps

### 2.4.1 Building the Amplifier

The accessory bag that comes with this kit makes it quick and easy to evaluate the amplifier described below; it was designed in Mindi™ Amplifier Designer.

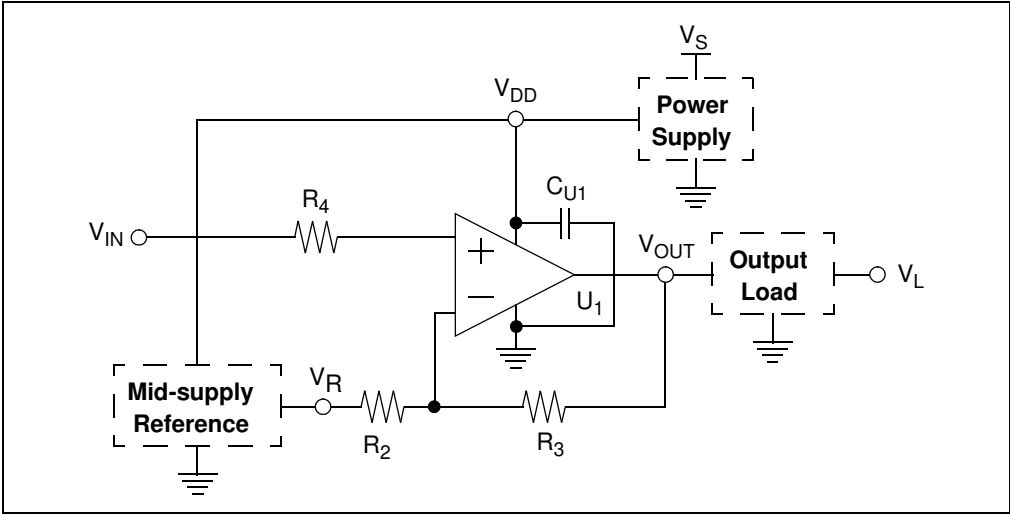
This amplifier is described as follows:

- Non-Inverting Amplifier (Single Supply Configuration)
- Power Supply Voltage is 5.0V
- Desired Closed Loop Gain is 2 V/V
- Load Capacitance is 56 pF



**FIGURE 2-20:** Non-Inverting Amplifier Designed In Mindi™ Amplifier Designer.

Figure 2-21 shows the same circuit redrawn to emphasize the non-inverting amplifier.



**FIGURE 2-21:** Non-Inverting Amplifier Circuit Diagram Supported by the MCP6XXX Amplifier Evaluation Board 1 Kit.

Each of the components in Figure 2-21 that needs to be inserted in a socket on the MCP6XXX Amplifier Evaluation Board 1 is listed in Table 2-1 and Table 2-2.

**TABLE 2-1: AMPLIFIER COMPONENTS LIST**

| PCB Labels | Component Values        |
|------------|-------------------------|
| R2         | 1.98 kΩ                 |
| R3         | 1.98 kΩ                 |
| R4         | 988Ω                    |
| RISO       | 0Ω                      |
| RL         | 3.97 kΩ                 |
| CL         | 56 pF                   |
| U1         | MCP6021, PDIP-8, 10 MHz |

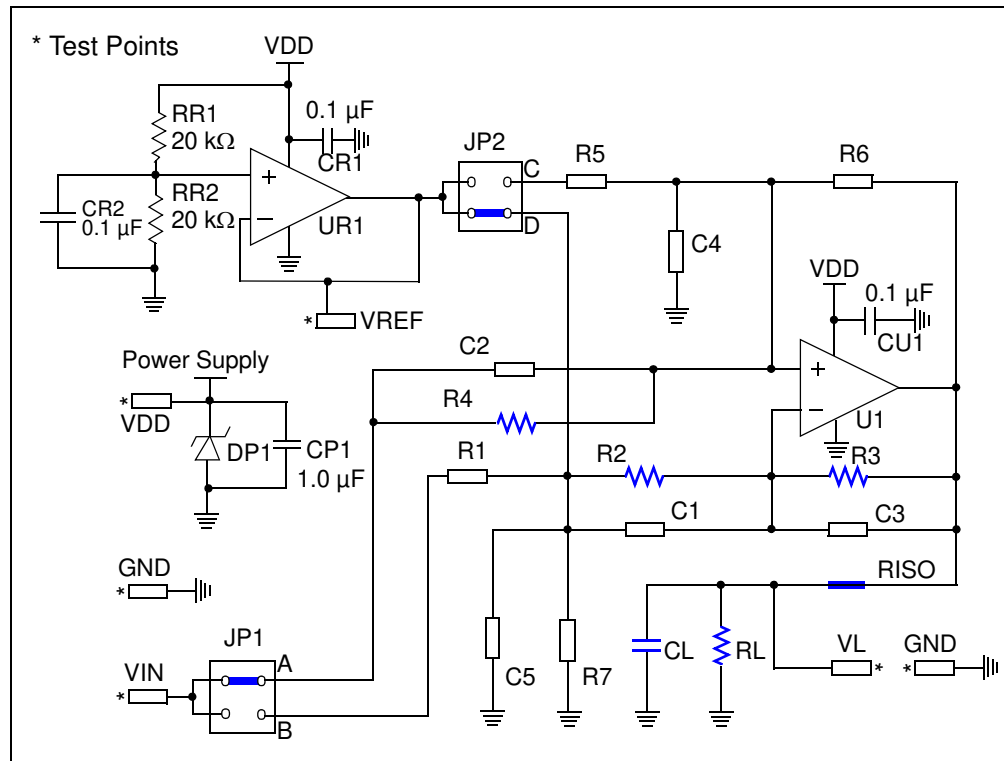
**TABLE 2-2: JUMPER POSITIONS**

| Jumper | Position |
|--------|----------|
| JP1    | A        |
| JP2    | D        |



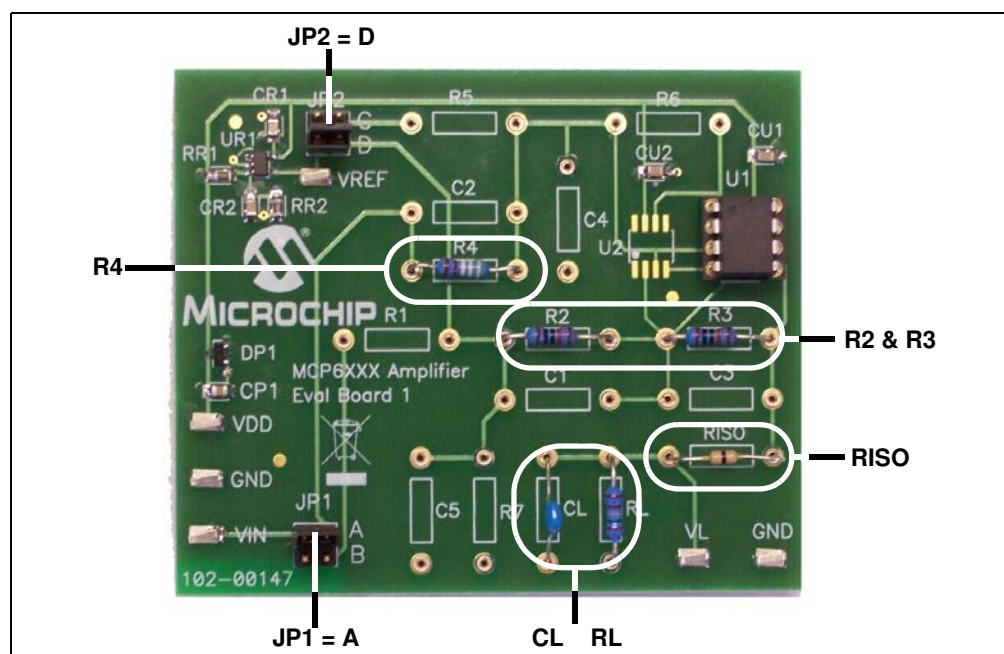
# MCP6XXX Amplifier Evaluation Board 1 User's Guide

Figure 2-22 shows the fully assembled MCP6XXX Amplifier Evaluation Board 1 for the non-inverting amplifier.



**FIGURE 2-22:** Fully Assembled Non-Inverting Amplifier Supported by the MCP6XXX Amplifier Evaluation Board 1.

The fully assembled MCP6XXX Amplifier Evaluation Board 1 top view is shown in Figure 2-23.

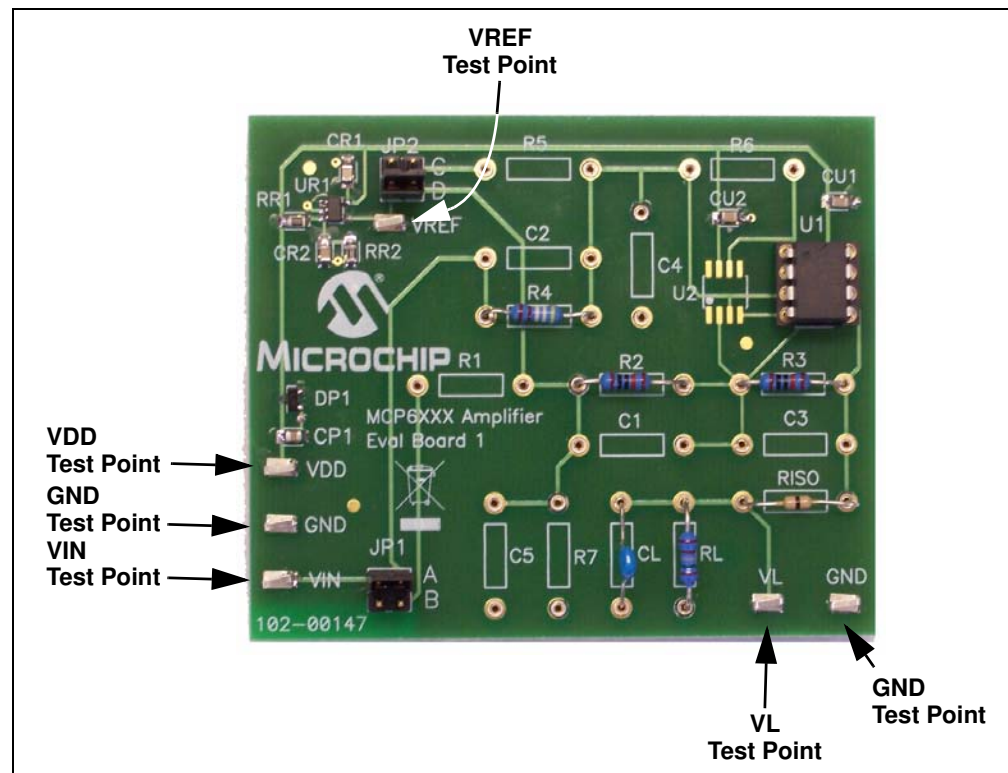


**FIGURE 2-23:** Picture of the Non-Inverting Amplifier Supported by the MCP6XXX Amplifier Evaluation Board 1.

## 2.4.2 Testing the Amplifier

### 2.4.2.1 CHECKING THE TEST POINTS

The (surface mount) test points for power supply, ground, input signal and output signal allow lab equipment to be connected to the board. Figure 2-24 shows the test points to check.



**FIGURE 2-24:** Checking the Test Points.