MCP6V01 Input Offset Demo Board User's Guide

MCP6V01 INPUT OFFSET DEMO BOARD USER'S GUIDE

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NOTES:

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) 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 MCP6V01 Input Offset Demo 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 MCP6V01 Input Offset Demo Board. The manual layout is as follows:

- **Chapter 1. "Product Overview"** - Important information about the MCP6V01 Input Offset Demo Board.
- **Chapter 2. "Installation and Operation"** – Covers the initial set-up of the MCP6V01 Input Offset Demo Board. It lists the required tools and shows how to connect and set up the lab equipment. The basic theory on converting measurements to offset voltage, open-loop gain, CMRR, PSRR and input offset drift is given, along with a worked example. Hints are then given on reducing measurement noise.
- **Chapter 3. "Possible Modifications"** - Shows simple modifications to the MCP6V01 Input Offset Demo Board.
- **Appendix A. "Schematics and Layouts"** – Shows the schematic and board layouts for the MCP6V01 Input Offset Demo Board.
- **Appendix B. "Bill Of Materials (BOM)"** – Lists the parts used to build the sub-assemblies in the MCP6V01 Input Offset Demo Board.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

<table>
<tr><th>Description</th><th>Represents</th><th>Examples</th></tr>
<tr><td colspan="3">Arial font:</td></tr>
<tr><td rowspan="2">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></tr>
<tr><td rowspan="3">Initial caps</td><td>A window</td><td>the Output window</td></tr>
<tr><td>A dialog</td><td>the Settings dialog</td></tr>
<tr><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>“Save project before build”</td></tr>
<tr><td>Underlined, italic text with right angle bracket</td><td>A menu path</td><td><u>File>Save</u></td></tr>
<tr><td rowspan="2">Bold characters</td><td>A dialog button</td><td>Click OK</td></tr>
<tr><td>A tab</td><td>Click the Power tab</td></tr>
<tr><td>N‘Rnnnn</td><td>A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.</td><td>4‘b0010, 2‘hF1</td></tr>
<tr><td>Text in angle brackets < ></td><td>A key on the keyboard</td><td>Press <Enter>, <F1></td></tr>
<tr><td colspan="3">Courier New font:</td></tr>
<tr><td rowspan="7">Plain Courier New</td><td>Sample source code</td><td><code>#define START</code></td></tr>
<tr><td>Filenames</td><td><code>autoexec.bat</code></td></tr>
<tr><td>File paths</td><td><code>c:\mcc18\h</code></td></tr>
<tr><td>Keywords</td><td><code>_asm, _endasm, static</code></td></tr>
<tr><td>Command-line options</td><td><code>-Opa+, -Opa-</code></td></tr>
<tr><td>Bit values</td><td><code>0, 1</code></td></tr>
<tr><td>Constants</td><td><code>0xFF, ‘A’</code></td></tr>
<tr><td>Italic Courier New</td><td>A variable argument</td><td><code>file</code><code>.o</code>, where <code>file</code> can be any valid filename</td></tr>
<tr><td>Square brackets [ ]</td><td>Optional arguments</td><td><code>mcc18 [options] file [options]</code></td></tr>
<tr><td>Curly brackets and pipe character: { | }</td><td>Choice of mutually exclusive arguments; an OR selection</td><td><code>errorlevel {0|1}</code></td></tr>
<tr><td rowspan="2">Ellipses...</td><td>Replaces repeated text</td><td><code>var_name [, var_name...]</code></td></tr>
<tr><td>Represents code supplied by user</td><td><code>void main (void)
{ ...
}</code></td></tr>
</table>

RECOMMENDED READING

This user's guide describes how to use MCP6V01 Input Offset Demo Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

MCP6V01/2/3 Data Sheet, *"300 µA, Auto-Zeroed Op Amps"*, DS22058

Gives detailed information on one op amp family that is used on the MCP6V01 Input Offset Demo Board.

MCP6021/1R/2/3/4 Data Sheet, *"Rail-to-Rail Input/Output, 10 MHz Op Amps"*, DS21685

Gives detailed information on another op amp family that is used on the MCP6V01 Input Offset Demo Board.

AN1177 Application Note, *"Op Amp Precision Design: DC Errors"*, DS01177

Discusses how to achieve high DC accuracy in op amp circuits. Also discusses the relationship between an op amp's input offset voltage (V_{OS}), CMRR, PSRR, Open-Loop Gain and V_{OS} Drift over Temperature.

THE MICROCHIP WEB SITE

Microchip provides online support via our web site at 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
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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 (March 2009)

- Initial Release of this Document.

Chapter 1. Product Overview

1.1 INTRODUCTION

The MCP6V01 Input Offset Demo Board is described by the following:

- Assembly # : 102-00227-R3
- Order # : MCP6V01DM-VOS
- Name: MCP6V01 Input Offset Demo Board

Items discussed in this chapter include:

- Kit Contents
- Intended Use
- Description

1.2 KIT CONTENTS

This MCP6V01 Input Offset Demo Board Kit includes:

- Assembled Printed Circuit Board (PCB)
- Important Information “Read First”
- Analog and Interface Products Demonstration Boards CD-ROM (DS21912) Includes:
  - MCP6V01 Input Offset Demo Board User’s Guide, (DS51801)

FIGURE 1-1: *MCP6V01 Input Offset Demo Board Contents.*

1.3 INTENDED USE

The MCP6V01 Input Offset Demo Board is intended to provide a simple means to measure the MCP6V01/2/3 op amp's input offset voltage (V_{OS}) under a variety of bias conditions. This V_{OS} includes the specified input offset voltage value found in the data sheet plus changes due to power supply voltage (PSRR), common mode voltage (CMRR), output voltage (A_{OL}) and temperature ($\Delta V_{OS}/\Delta T_A$).

1.4 DESCRIPTION

Figure 1-2 shows the block diagram for the MCP6V01 Input Offset Demo Board.

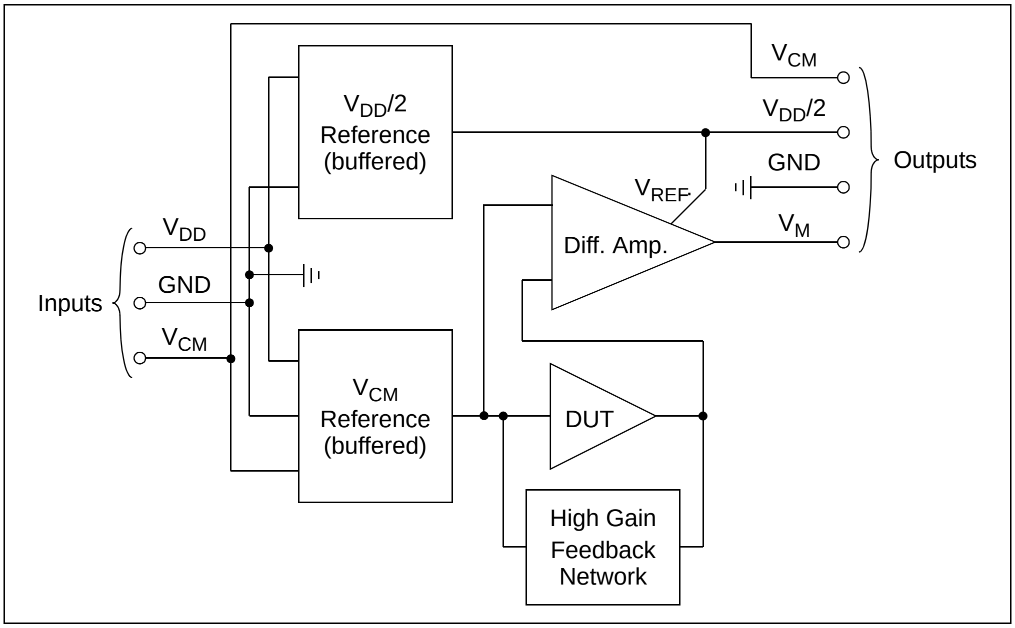


FIGURE 1-2: *Block Diagram.*

This circuit does the following:

- Supports Microchip's auto-zeroed, single op amps:
  - SOIC-8 package
  - Used as both Device Under Test (DUT) and in a difference amplifier
- Test points for connecting lab equipment
- Single supply configuration
- The bias inputs V_{DD}, V_{CM} and GND set the conditions for the DUT
- The $V_{DD}/2$ Reference uses a resistor ladder to divide V_{DD} in half, then buffers that voltage with an op amp in unity gain
- The V_{CM} Reference:
  - Has a resistor divider at the input that sets $V_{CM} = V_{DD}/2$ when that input is left open
  - When V_{CM} is driven by an external voltage source, the resistor divider has no effect on V_{CM}
  - V_{CM} is buffered
- The High Gain Feedback Network and DUT together:
  - Have a noise gain of $G_N \approx 10.0$ kV/V
  - Have a common mode gain of 1 V/V
  - Produce an output voltage of $G_N V_{OS} + V_{CM}$

- The Difference Amplifier (Diff. Amp.):
  - Rejects the DUT's common mode output (V_{CM})
  - Provides additional gain ($G_{DA} \approx 10.0$ V/V) to the term $G_N V_{OS}$ at the DUT's output
  - Shifts the output so it is centered on the reference $V_{REF} = V_{DD}/2$
  - Produce an output voltage of $G_{DA} G_N V_{OS} + V_{DD}/2$

The inputs:

- Allow the DUT to be biased at most valid bias points
- Allow V_{CM} to set by the circuit at $V_{DD}/2$, or set by the user

The outputs:

- Make it easy to measure the important bias voltages $V_{DD}/2$ and V_{CM}
- Make it easy to measure $V_M – V_{DD}/2 = G_{DA} G_N V_{OS}$

NOTES:

Chapter 2. Installation and Operation

2.1 INTRODUCTION

This chapter shows how to set up the MCP6V01 Input Offset Demo Board. Items discussed in this chapter include:

- Required Tools
- Connecting the Lab Equipment
- Operating Conditions
- Calculating the DUT's Input Offset Voltage (V_{OS})
- Converting Input Offset Voltage to Other Parameters
- Reducing the Measurement Noise

2.2 REQUIRED TOOLS

- Lab Power Supplies:
  - Two outputs
  - 0V to 5.5V minimum range
  - Adjustable
- One Voltmeter:
  - 1 mV resolution
  - -6V to +6V minimum range
  - Differential measurement (e.g., hand held meter)

2.3 CONNECTING THE LAB EQUIPMENT

Lab equipment is connected to this board as shown in Figure 2-1. The (surface mount) test points allow lab equipment to be connected to these boards. The power supplies are connected at the right. The voltmeter is connected at the four different points shown.

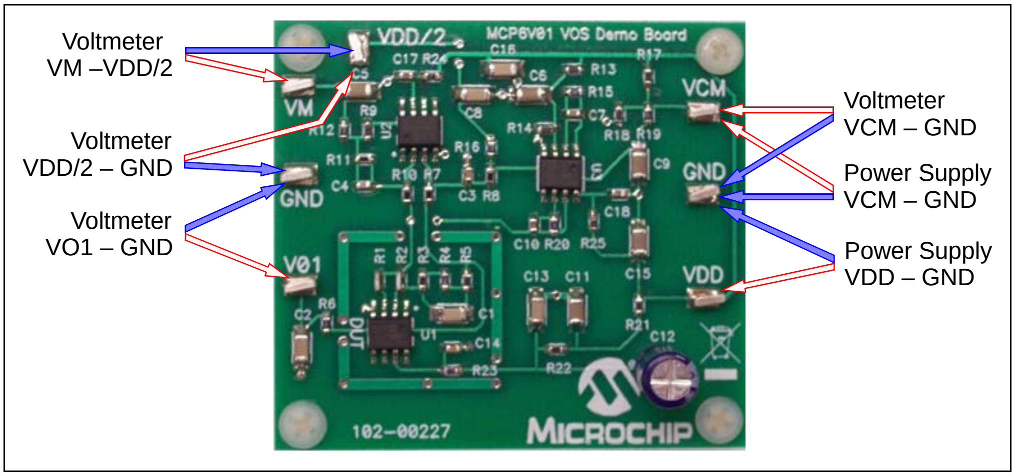


FIGURE 2-1: *Board Connections for the MCP6V01 Input Offset Demo Board.*

2.4 OPERATING CONDITIONS

This board works most effectively at room temperature (near +25°C). Measurements at other temperatures should be done in an oven where the air velocity is minimal.

The power supply (V_{DD}) should be between 1.8V and 5.5V.

The common mode voltage (V_{CM}) needs to be between 0.3V and V_{DD} – 0.3V for proper operation of this demo board.

2.5 CALCULATING THE DUT'S INPUT OFFSET VOLTAGE

The DUT's total input offset voltage (V_{OST}) can be calculated from a measurement as shown in Equation 2-1.

EQUATION 2-1:

$$V_{OST} = (V_M - V_{DD}/2) \cdot (1/(G_{DA}G_N))$$

Where:

$1/(G_{DA}G_N) \approx 10.0\ \mu V/V$

2.6 CONVERTING INPUT OFFSET VOLTAGE TO OTHER PARAMETERS

2.6.1 Theory

Changing the bias voltages changes the input offset voltage. Microchip's application note AN1177 discusses in detail how these changes in V_{OS} are related to specifications found in our data sheets. The following list summarizes the parameters that contribute to V_{OST}:

- Specified Input Offset Voltage:
  - V_{OS} = Input offset at the specified bias point
- DC Common Mode Rejection Ratio:
  - CMRR = $\Delta V_{CM}/\Delta V_{OS}$
- DC Power Supply Rejection Ratio:
  - PSRR = $(\Delta V_{DD} - \Delta V_{SS})/\Delta V_{OS}$
- DC Open-Loop Gain:
  - $A_{OL} = \Delta V_{OUT}/\Delta V_{OS}$
- Input Offset Drift over Temperature:
  - $\Delta V_{OS}/\Delta T_A$

Note: The data sheet Input Offset Voltage (V_{OS}) specification applies to one bias point and temperature only. The total input offset voltage (V_{OST}) includes V_{OS} and other changes in input offset as bias voltages and temperature change.

Example 2-1 gives an example of how V_{OST} changes with the common mode input voltage (V_{CM}).

EXAMPLE 2-1: COMMON MODE CHANGE EXAMPLE

Given:

V_{OST} = 0.5 µV, V_{CM} = 0V
V_{OST} = 1.0 µV, V_{CM} = 5V

Then:

ΔV_{OST} = 0.5 µV
ΔV_{CM} = 5.0V
CMRR = 5.0V / 0.5 µV
= 10 V/µV
= 140 dB

2.6.2 Application

When the common mode voltage (V_{CM}) is changed on this demo board, the output voltage (V_{OUT}) is forced to change by the same amount. There is no means provided to independently change V_{CM} and V_{OUT}. Thus, it is not possible to separate the Open-Loop Gain (A_{OL}) effect from the CMRR effect using this board.

Note: V_{OUT} cannot be changed independently of V_{CM}, so A_{OL} and CMRR cannot be distinguished using this circuit.

Since A_{OL} is usually much better than CMRR for the MCP6V0X op amps, we can attribute most of the change to CMRR and ignore A_{OL} in most cases. Table 2-1 shows one possible measurement matrix that will allow the user to estimate key parameters for the DUT.

TABLE 2-1: MEASUREMENT MATRIX

Operating Inputs (Note 1)			Measurement	
T_A (°C)	V_{DD} (V)	V_{CM} (V)	Symbol	Comments
+25	5.5	OFF	V_{M1}	Quick Check
		$V_{DD}/3$	V_{M2}	V_{OS} and PSRR
		0.5	V_{M3}	CMRR and A_{OL}
		5.0	V_{M4}	
	1.8	$V_{DD}/3$	V_{M5}	V_{OS} and PSRR
		0.3	V_{M6}	CMRR and A_{OL}
		1.5	V_{M7}	
-40	5.5	$V_{DD}/3$	V_{M8}	V_{OS} at temperature and $\Delta V_{OS}/\Delta T_A$
+85		$V_{DD}/3$	V_{M9}	
+125		$V_{DD}/3$	V_{M10}	

Note 1: V_{SS} = GND = 0V. V_{CM} = OFF means that the its power supply is off ($V_{CM} = V_{DD}/2$). $V_{OUT} \approx V_{CM}$.

Based on these measurements, we can make the following estimates, where the V_{OST_k} values are calculated from the measured V_{Mk} values (see Equation 2-1):

TABLE 2-2: ESTIMATES

Operating Inputs		Estimate	
V_{DD} (V)	**T_A (°C)**	**Equations** (Note 1)	**Units**
1.8 and 5.5	-40 to +125	$1/A_{OL}$ = 0, by assumption	µV/V
	+25	$1/PSRR$ = $(V_{OST\_2} – V_{OST\_5}) / (3.7V)$	µV/V
5.5	-40	V_{OS} = V_{OST_8}	µV
	+25	V_{OS} = V_{OST_2}	µV
	+85	V_{OS} = V_{OST_9}	µV
	+125	V_{OS} = V_{OST_10}	µV
	-40 to +125	$\Delta V_{OS}/\Delta T_A$ = $(V_{OST\_10} – V_{OST\_8}) / (165°C)$	µV/°C
	+25	$1/CMRR$ = $\{(V_{OST\_4} – V_{OST\_3}) / (4.5V)$	µV/V
1.8	+25	V_{OS} = V_{OST_5}	µV
		$1/CMRR$ = $(V_{OST\_7} – V_{OST\_6}) / (1.2V)$	µV/V

Note 1: V_{OST_k} is calculated from V_{Mk} using Equation 2-1.

Obviously, other values of T_A, V_{DD}, … can be used instead, with the proper adjustments to these equations.

2.7 REDUCING THE MEASUREMENT NOISE

The noise seen in the measurements is a result of the design choices made for the MCP6V01 Input Offset Demo Board. The components R12 and C5 set a lowpass pole at 0.16 Hz, which gives reasonable noise performance (±0.2 μV_{PK} referred to the input of the DUT) and settling time (1 to 2 seconds).

To achieve lower noise in your results, average many measurements together. For instance, measuring the output (V_M – $V_{DD}/2$) once a second for 16 seconds (16 samples) should produce an estimate with noise $\sqrt{16}$ = 4 times lower (i.e., ±0.05 μV_{PK}).

There is a practical limit on increasing the sample rate; the noise does not improve significantly after a certain point. The analog lowpass pole at 0.16 Hz causes closely spaced samples to be correlated. To avoid the overhead caused by sampling too fast, keep the sampling period near or above the pole's time constant (1.0s); this gives a minimum sample rate of 1 sample per second.

> **Note:** Sampling much faster than 1 SPS will not improve the averaged noise of this board's output significantly.

Chapter 3. Possible Modifications

3.1 INTRODUCTION

This chapter shows simple modifications to the MCP6V01 Input Offset Demo Board:

- Changing the DUT
- Connecting a Chip Select Pin to Ground

3.2 CHANGING THE DUT

Change the DUT (see Figure 3-1) to the MCP6V06 Op Amp as follows:

1. Remove U1 from the PCB, using a de-soldering tool.
2. Solder a MCP6V06 op amp in its place. Use a MCP6V06 in a SOIC-8 package. Pin 1 is next to the U1 reference designator on the PCB (not next to the DUT label)

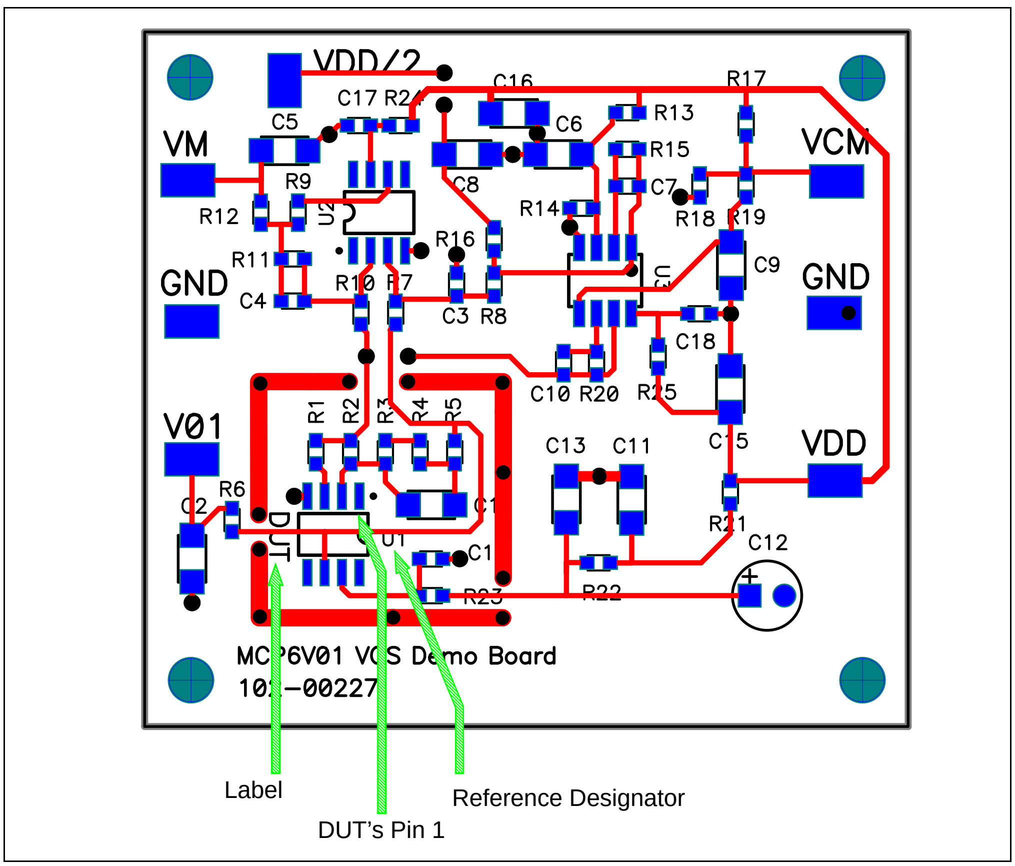


FIGURE 3-1: *Location and Orientation of DUT.*

3.3 CONNECTING A CHIP SELECT PIN TO GROUND

The DUT can be changed to the MCP6V03 or MCP6V08 op amps with chip select. If desired, their Chip Select pin (pin 8) can be forced to ground. This is done as follows (see Figure 3-2):

1. Solder one end of a wire to the DUT's pin 8. Pin 8 is next to the U1 reference designator on the PCB (not next to the DUT label)
2. Solder the other end of the wire the closest ground via on the PCB. The striped green arrow to the right in the figure shows the location. The solid green curve represents the wire.

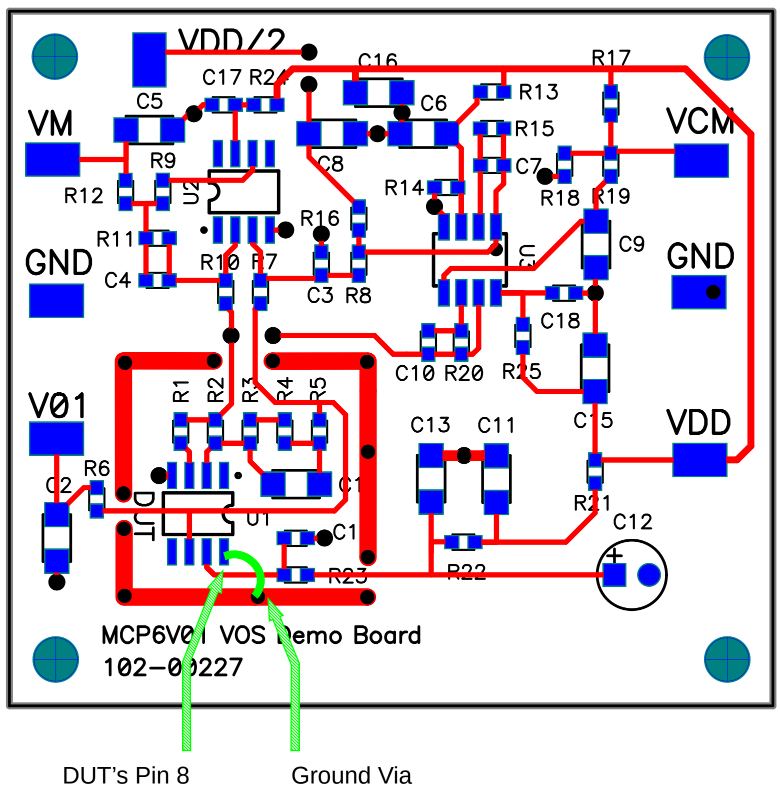


FIGURE 3-2: *Location and Orientation of DUT.*

Appendix A. Schematics and Layouts

A.1 INTRODUCTION

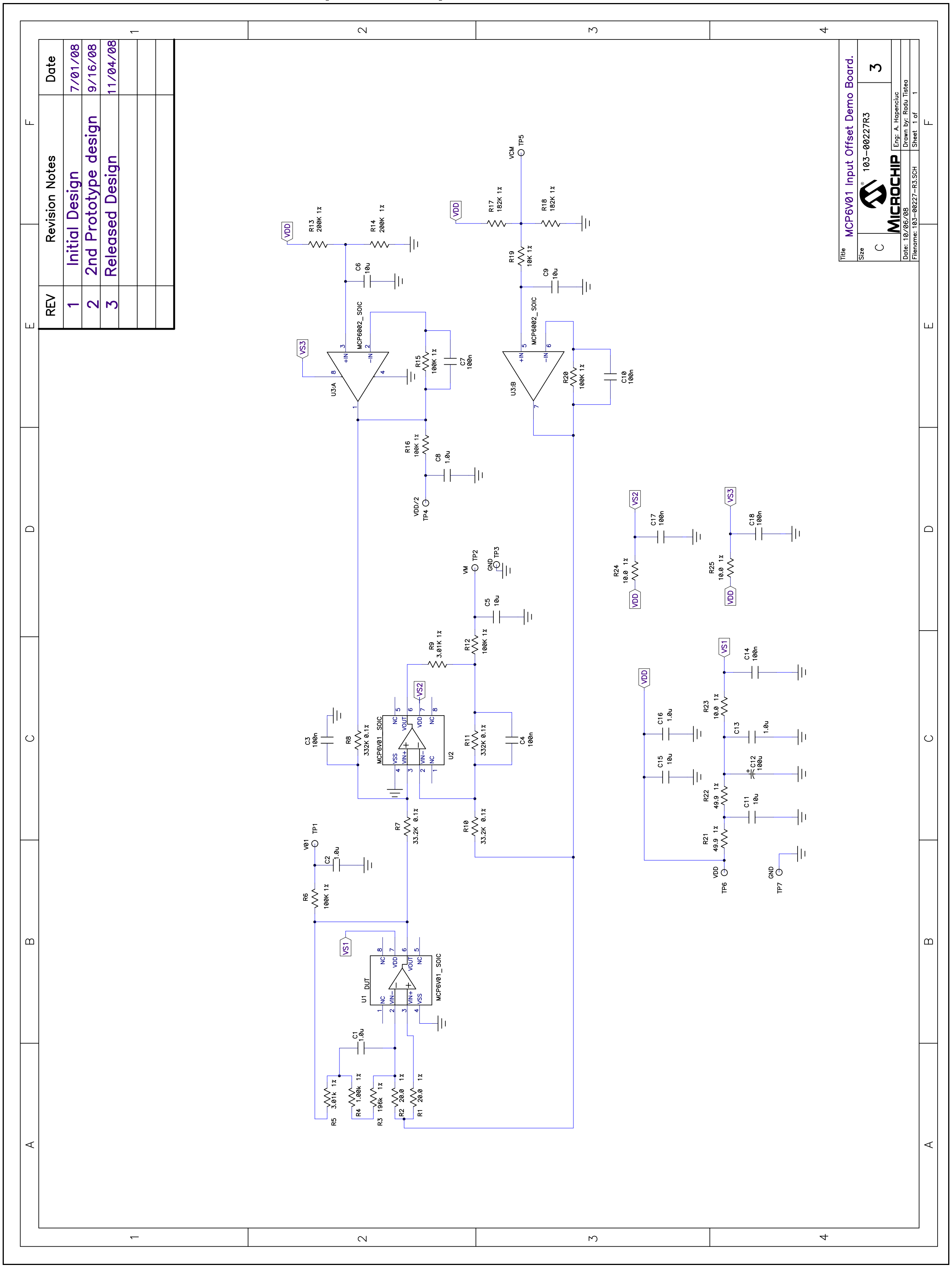
This appendix contains the schematics and layouts for the MCP6V01 Input Offset Demo Board.

The Gerber files for this board are available on the Microchip website (www.microchip.com) and are contained in the "`00227R3_Gerbers.zip`" zip file .

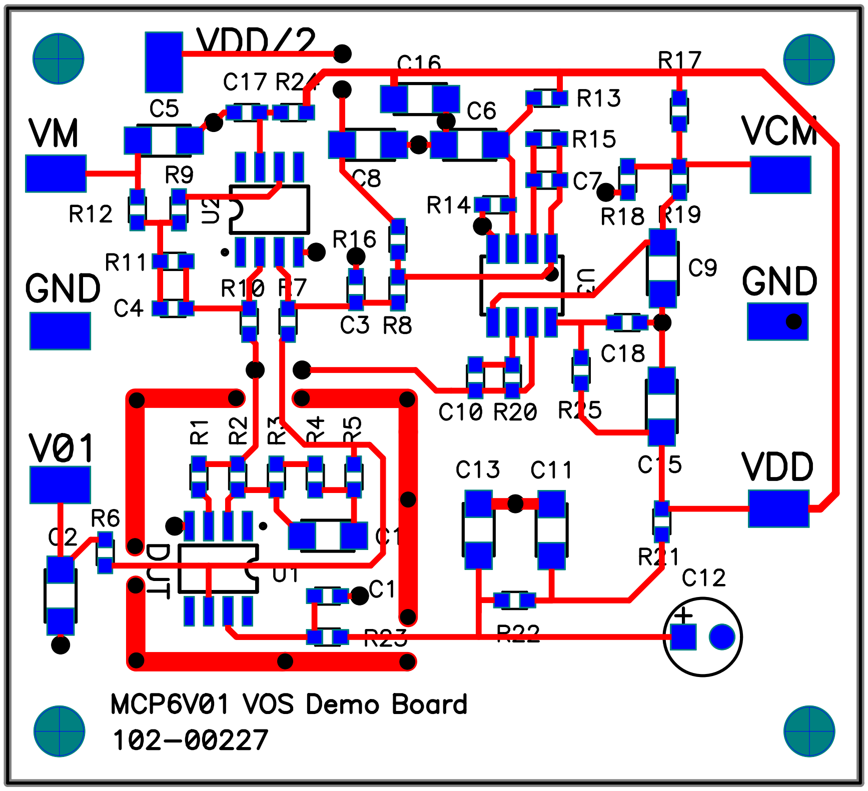
A.2 SCHEMATIC

See below the circuit diagram. On the left is the DUT (U1), which produces the common mode voltage plus the DUT's input offset (V_{OS}) times a gain. In the middle is the difference amplifier that amplifies and level shifts the DUT's output minus the mid-supply reference voltage. On the top right is the mid-supply reference (V_{DD}/2) and buffer. On the middle right is the common mode voltage reference (VCM) with buffer. On the bottom are the supply bypass capacitors and filter resistors.

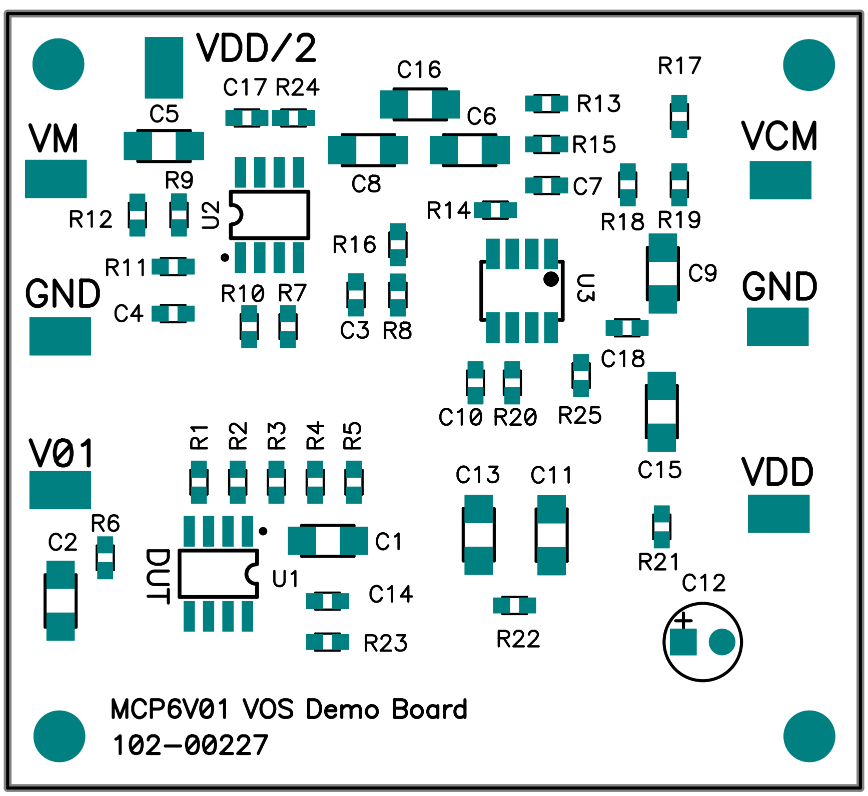
A.2 BOARD SCHEMATIC (Continued)



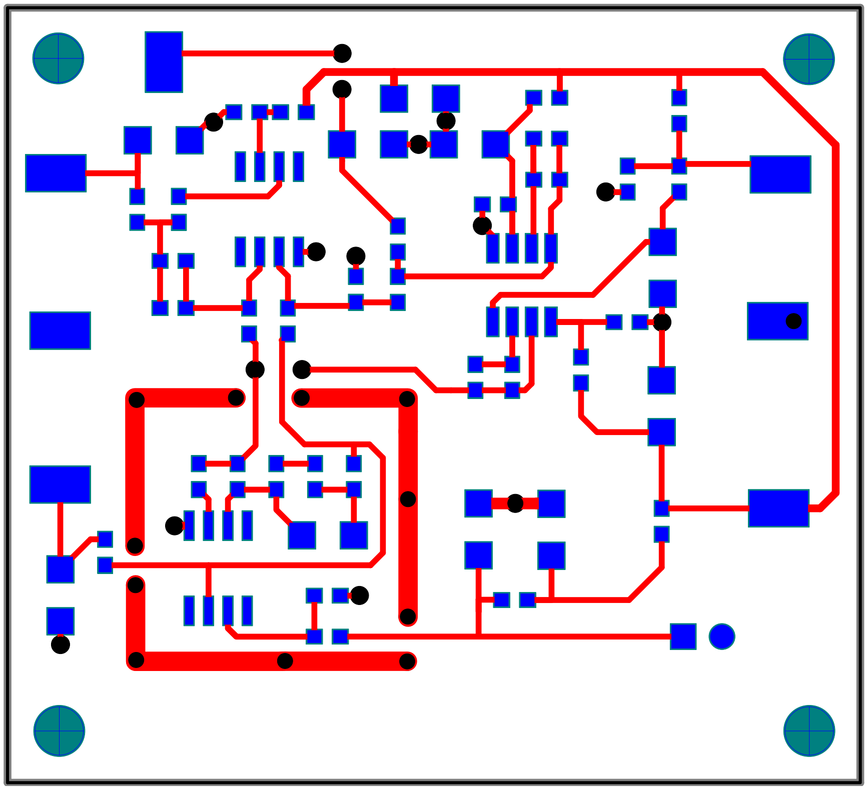
A.3 COMBINATION OF THE TOP SILK SCREEN AND TOP METAL LAYERS



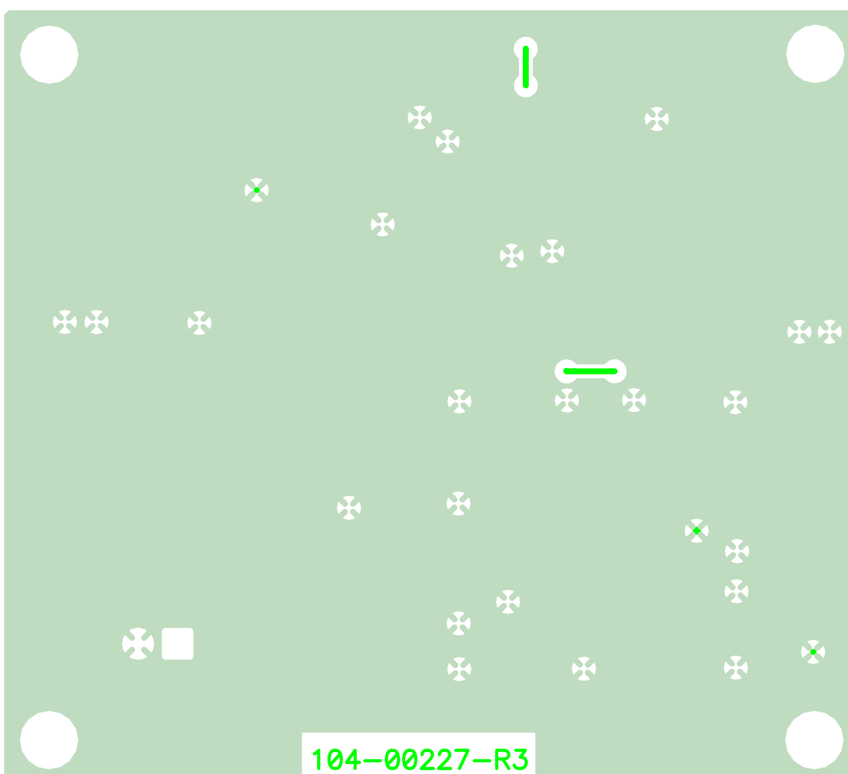
A.4 TOP SILK SCREEN



A.5 TOP METAL LAYER



A.6 BOTTOM METAL LAYER



Appendix B. Bill Of Materials (BOM)

B.1 MCP6V01 INPUT OFFSET DEMO BOARD BOM

The BOM in Table B-1 corresponds to Figure 2-1; it shows all of the components assembled on the PCB. Table B-2 shows additional parts that come in the ESD protection bag that the user, if needed, installs.

TABLE B-1: BILL OF MATERIALS FOR ASSEMBLED PCB

Qty	Reference	Description	Manufacturer	Part Number
7	C3, C4, C7, C10, C14, C17, C18	100 nF, 0603 SMD, X7R, 16V, 10%	Panasonic®-ECG	ECJ-1VB1C104K
5	C1, C2, C8, C13, C16	1.0 µF, 1206 SMD, X7R, 16V, 10%		ECJ-3YB1C105K
5	C5, C6, C9, C11, C15	10 µF, 1206 SMD, X7R, 16V, 10%		ECJ-3YX1C106K
1	C12	100 µF, Radial, Electrolytic, 10V, 20%		EEU-FC1A101S
1	PCB	2 layer PCB (2.20 in × 2.00 in)	n/a	n/a
2	R7, R10	33.2 kΩ, 0603 SMD, 0.1%, 25 ppm/°C, 1/10W	Susumu Co. Ltd.	RG1608P-3322-B-T5
2	R8, R11	332 kΩ, 0603 SMD, 0.1%, 25 ppm/°C, 1/10W		RG1608P-3323-B-T5
3	R23, R24, R25	10.0Ω, 0603 SMD, 1%, 1/10W	Panasonic-ECG	ERJ-3EKF10R0V
2	R1, R2	20.0Ω, 0603 SMD, 1%, 1/10W		ERJ-3EKF20R0V
2	R21, R22	49.9Ω, 0603 SMD, 1%, 1/10W		ERJ-3EKF49R9V
1	R4	1.00 kΩ, 0603 SMD, 1%, 1/10W		ERJ-3EKF1001V
2	R5, R9	3.01 kΩ, 0603 SMD, 1%, 1/10W		ERJ-3EKF3011V
1	R19	10.0 kΩ, 0603 SMD, 1%, 1/10W		ERJ-3EKF1002V
5	R6, R12, R15, R16, R20	100 kΩ, 0603 SMD, 1%, 1/10W		ERJ-3EKF1003V
2	R17, R18	182 kΩ, 0603 SMD, 1%, 1/10W		ERJ-3EKF1823V
1	R3	196 kΩ, 0603 SMD, 1%, 1/10W		ERJ-3EKF1963V
2	R13, R14	200 kΩ, 0603 SMD, 1%, 1/10W		ERJ-3EKF2003V
2	U1, U2	MCP6V01, SOIC-8, Single Op Amp	Microchip Technology Inc.	MCP6V01-E/SN
1	U3	MCP6002, SOIC-8, Dual Op Amp		MCP6002-E/SN
7	TP1 – TP7	SMD, Test Point	Keystone Electronics®	5016

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

TABLE B-2: BILL OF MATERIALS FOR LOOSE PARTS IN BAG

Qty.	Reference Designator	Description	Manufacturer	Part Number
4	(for PCB mounting)	Stand-off, Hex, 0.500", 4 × 40 Thread, Nylon, 0.285" max. O.D.	Keystone Electronics	1902C
4	(for PCB mounting)	Machine Screw, Phillips, 4 × 40 Thread, 1/4" long, Nylon	Building Fasteners	NY PMS 440 0025 PH

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Fax: 248-538-2260

Kokomo
Kokomo, IN
Tel: 765-864-8360
Fax: 765-864-8387

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