# MCP6C02 Evaluation Board User's Guide

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# MCP6C02 EVALUATION BOARD 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 website (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 "DSXXXXXXXXA", where "XXXXXXXX" 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 online help. Select the Help menu, and then Topics to open a list of available online help files.**

## INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP6C02 Evaluation Board. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Website
- Customer Support
- Document Revision History

## DOCUMENT LAYOUT

This document describes how to use the MCP6C02 Evaluation Board as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP6C02 Evaluation Board.
- **Chapter 2. "Installation and Operation"** – Includes instructions on installing and starting the board.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MCP6C02 Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MCP6C02 Evaluation Board.

## CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

**DOCUMENTATION CONVENTIONS**

| Description | Represents | Examples |
|---|---|---|
| **Arial font:** | | |
| Italic characters | Referenced books | *MPLAB® IDE User's Guide* |
| | Emphasized text | ...is the *only* compiler... |
| Initial caps | A window | the Output window |
| | A dialog | the Settings dialog |
| | A menu selection | select Enable Programmer |
| Quotes | A field name in a window or dialog | "Save project before build" |
| Underlined, italic text with right angle bracket | A menu path | *File>Save* |
| Bold characters | A dialog button | Click **OK** |
| | A tab | Click the **Power** tab |
| N'Rnnnn | A number in verilog format, where N is the total number of digits, R is the radix and n is a digit. | 4'b0010, 2'hF1 |
| Text in angle brackets < > | A key on the keyboard | Press <Enter>, <F1> |
| **Courier New font:** | | |
| Plain Courier New | Sample source code | `#define START` |
| | Filenames | `autoexec.bat` |
| | File paths | `c:\mcc18\h` |
| | Keywords | `_asm, _endasm, static` |
| | Command-line options | `-Opa+, -Opa-` |
| | Bit values | `0, 1` |
| | Constants | `0xFF, 'A'` |
| Italic Courier New | A variable argument | *`file`*`.o`, where *`file`* can be any valid filename |
| Square brackets [ ] | Optional arguments | `mcc18 [options]` *`file`* `[options]` |
| Curly brackets and pipe character: { \| } | Choice of mutually exclusive arguments; an OR selection | `errorlevel {0\|1}` |
| Ellipses... | Replaces repeated text | `var_name [, var_name...]` |
| | Represents code supplied by user | `void main (void) { ... }` |

## RECOMMENDED READING

This user's guide describes how to use the MCP6C02 Evaluation Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources:

- **MCP6C02 Data Sheet –** ***"Zero-Drift, 65V High-Side Current Sense Amplifier" (DS20006129)***
- **MCP6271 Data Sheet –** ***"170 µA, 2 MHz Rail-to-Rail Op Amp" (DS20001810)***
- **AN1258 Application Note –** ***"Op Amp Precision Design: PCB Layout Techniques" (DS01258)***

## THE MICROCHIP WEBSITE

Microchip provides online support via our website at www.microchip.com. This website is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the website 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

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

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the website at:
http://www.microchip.com/support

## DOCUMENT REVISION HISTORY

### Revision A (December 2020)

- Initial release of this document.

### Revision B (February 2021)

- Updated **Section 2.4.1 "Out-of-the-Box Setup"**.
- Updated the Board – Schematic.

**NOTES:**

# Chapter 1. Product Overview

## 1.1 INTRODUCTION

This chapter provides an overview of the MCP6C02 Evaluation Board and covers the following topics:

- **MCP6C02 Evaluation Board Short Overview**
- **MCP6C02 Evaluation Board Description**
- **Contents of the MCP6C02 Evaluation Board Kit**

## 1.2 MCP6C02 EVALUATION BOARD SHORT OVERVIEW

This board demonstrates the performance of the MCP6C02 high-side current sense amplifier. A load is supplied on the board for a convenient demonstration of the evaluation board. Supplying power and a load to the MCP6C02 Evaluation Board produces a small, measurable voltage drop across a shunt resistor on the evaluation board. This voltage drop is then amplified by the MCP6C02 on the board and outputted differentially at the test points $V_{OUT+}$ and $V_{OUT-}$ (TP1 and TP2). This voltage is proportional to the load current ($I_L$), as seen in Equation 1-1.

**EQUATION 1-1:**

$$V_{OUT} = R_{SHUNT} \times I_L \times Gain$$

## 1.3 MCP6C02 EVALUATION BOARD DESCRIPTION

Figure 1-1 shows the functionality of this demo board when using an external load. Detailed information is available in **Appendix A. "Schematic and Layouts"** and **Appendix B. "Bill of Materials (BOM)"**.

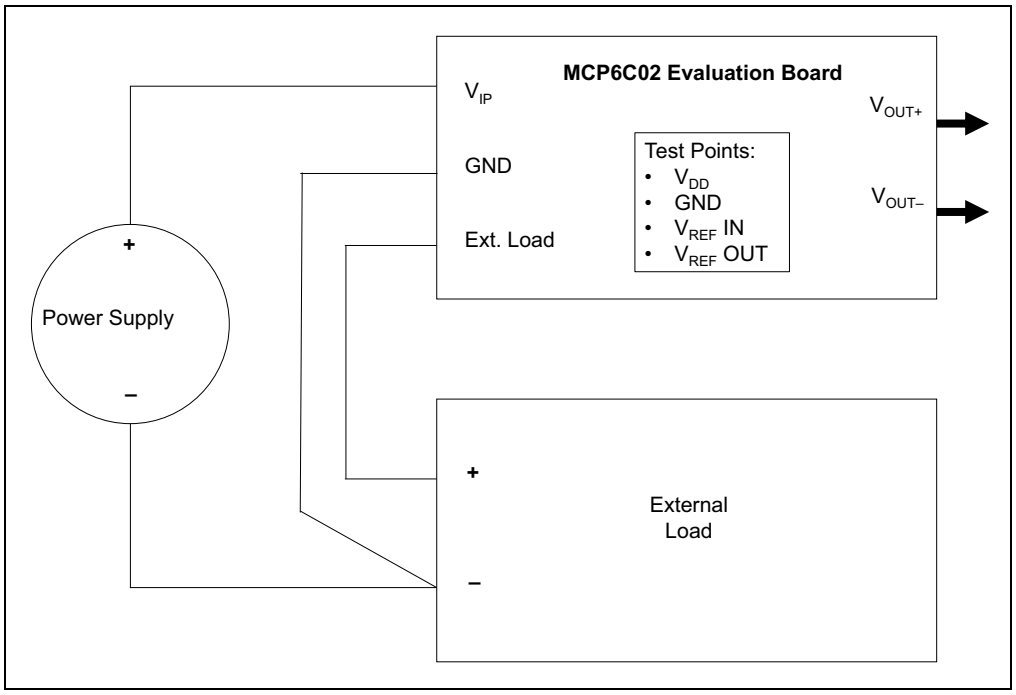
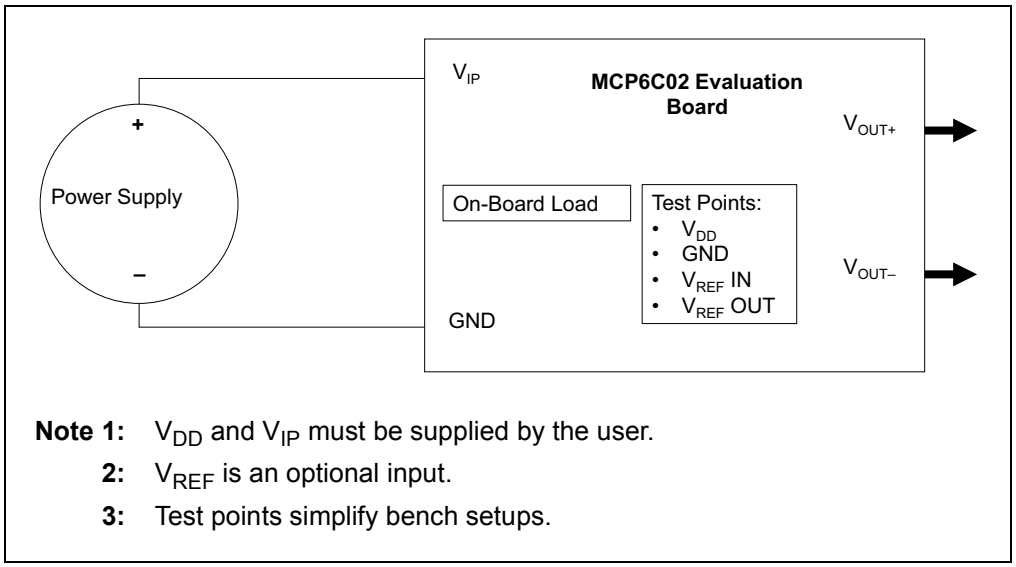



***FIGURE 1-1:*** *Using an External Load Block Diagram.*

Figure 1-2 shows the functionality of the evaluation board when using the on-board load.




**Note 1:** $V_{DD}$ and $V_{IP}$ must be supplied by the user.

**2:** $V_{REF}$ is an optional input.

**3:** Test points simplify bench setups.

***FIGURE 1-2:*** *Using the On-Board Load Block Diagram.*

## 1.4 CONTENTS OF THE MCP6C02 EVALUATION BOARD KIT

The MCP6C02 Evaluation Board kit includes:

- MCP6C02 Evaluation Board (ADM01104)

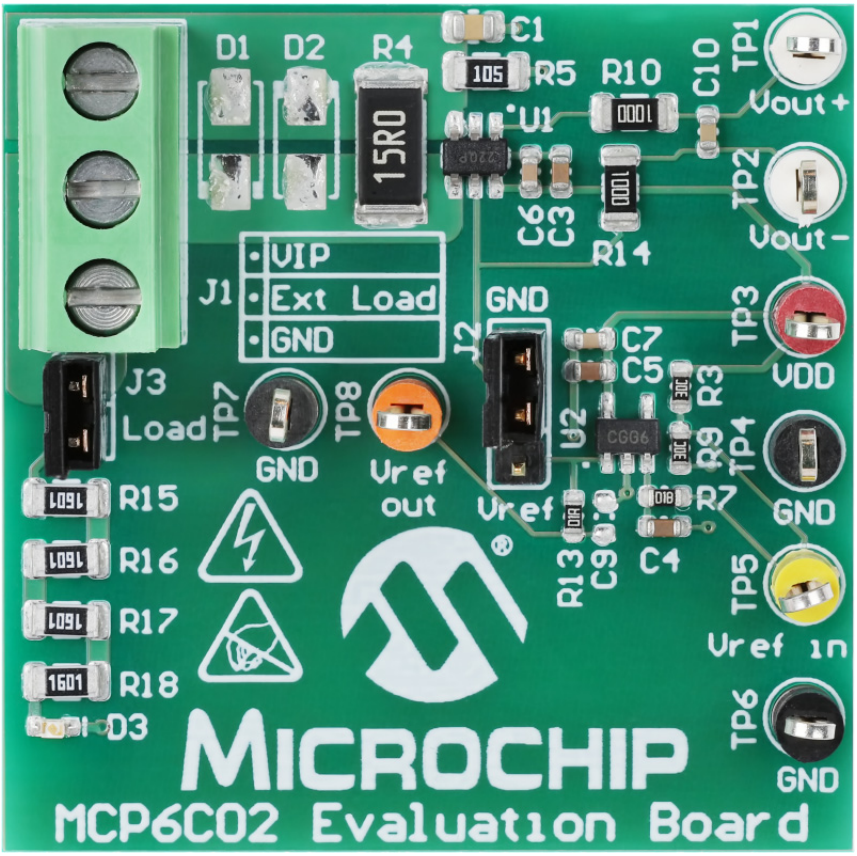



***FIGURE 1-3:*** *MCP6C02 Evaluation Board Kit Contents.*

**NOTES:**

# Chapter 2. Installation and Operation

## 2.1 INTRODUCTION

This chapter shows how to set up and operate the MCP6C02 Evaluation Board. Items discussed in this chapter include:

- Required Tools
- Basic Configurations
- Configurations with Modifications
- Configuring the PCB

## 2.2 SAFETY PRECAUTIONS

**WARNING**

**Care must be taken when using the MCP6C02 Evaluation Board at high voltages. Figure 2-1 and Figure 2-2 represent warning labels on the MCP6C02 Evaluation Board.**

***FIGURE 2-1:*** *WARNING: High Voltage on Board.*

***FIGURE 2-2:*** *WARNING: Do Not Touch Board.*

## 2.3 REQUIRED TOOLS

### 2.3.1 Bench Setup

Measurements on the bench focus on the analog performance:

- MCP6C02 Evaluation Board
- Lab Power Supply – generates up to +65.0V ($V_{IP}$), between 2V and 5.5V ($V_{DD}$), and ground (GND).
- Multimeter

## 2.4 BASIC CONFIGURATIONS

The following sections discuss various configurations supported by this board.

### 2.4.1 Out-of-the-Box Setup

The setup for the evaluation board is as follows (see Figure 2-3):

1. The MCP6C02 comes populated on the board.
2. The shunt resistor R4 (15Ω, 1%, 2512, SMD resistor) is mounted on the PCB.
3. The jumper at J2 is populated to connect $V_{REF}$ to ground. See **Section 2.4.2 "VREF"** for more $V_{REF}$ options.
4. The jumper at J3 is populated to connect the on-board resistive load (R15-R18 and D3).
5. Connect the power source at J1 to $V_{IP}$.
6. Connect power to $V_{DD}$ and GND.
7. When using the on-board resistive load, the LED (D3) turns on when $V_{IP}$ is about +3.0V and becomes brighter as $V_{IP}$ increases.
8. *Always* measure the output voltage differentially at $V_{OUT+}$ and $V_{OUT-}$ (TP1 and TP2).

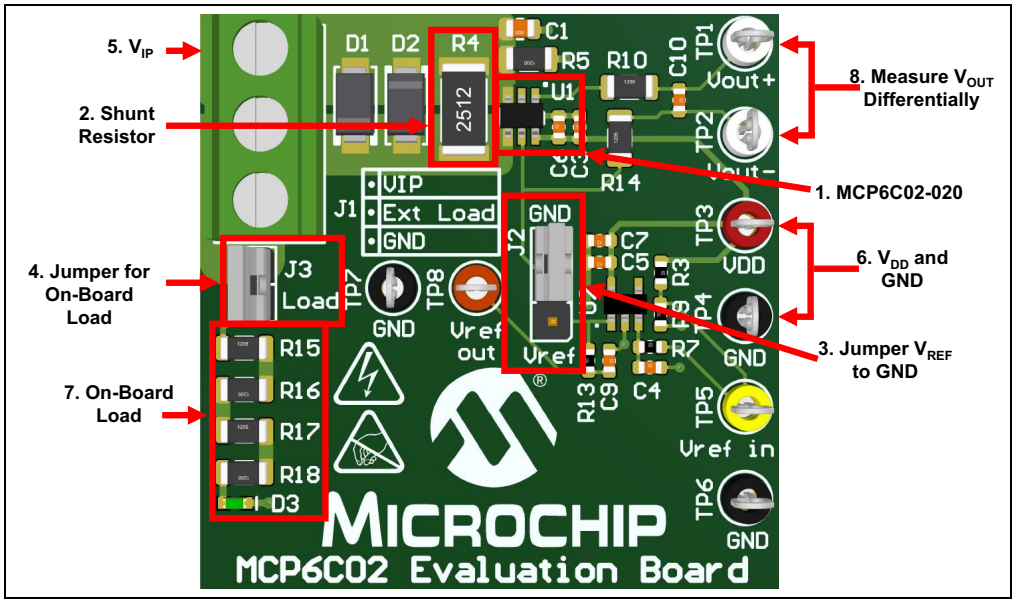



***FIGURE 2-3:*** *Out-of-the-Box Setup.*

Alternative shunt resistors may be used with the MCP6C02 Evaluation Board. To determine which $R_{SHUNT}$ resistor to use, see **Section 2.4.5 "Choosing Shunt Resistors"**.

### 2.4.2 $V_{REF}$

The MCP6C02 Evaluation Board has an optional, user-supplied reference voltage. The MCP6271 is used to supply a steady reference voltage to the MCP6C02. The J2 header provides the option of a reference voltage other than ground:

- Connecting a jumper at J2 to the $V_{REF}$ pin, as seen in Figure 2-4, selects the reference voltage supplied by the user.
- Connecting a jumper at J2 to the GND pin selects ground as the reference voltage. See Figure 2-4.

When using a reference voltage other than GND, follow the instructions below:

1. Connect the jumper at J2.
2. $V_{REF}$ must be supplied by the user at the TP2 test point.
3. $V_{REF}$ must remain within limitations defined by the MCP6C02 data sheet.
4. To yield reliable results, maintain $V_{REF}$ between 0V and $V_{DD}$ – 1.25V.

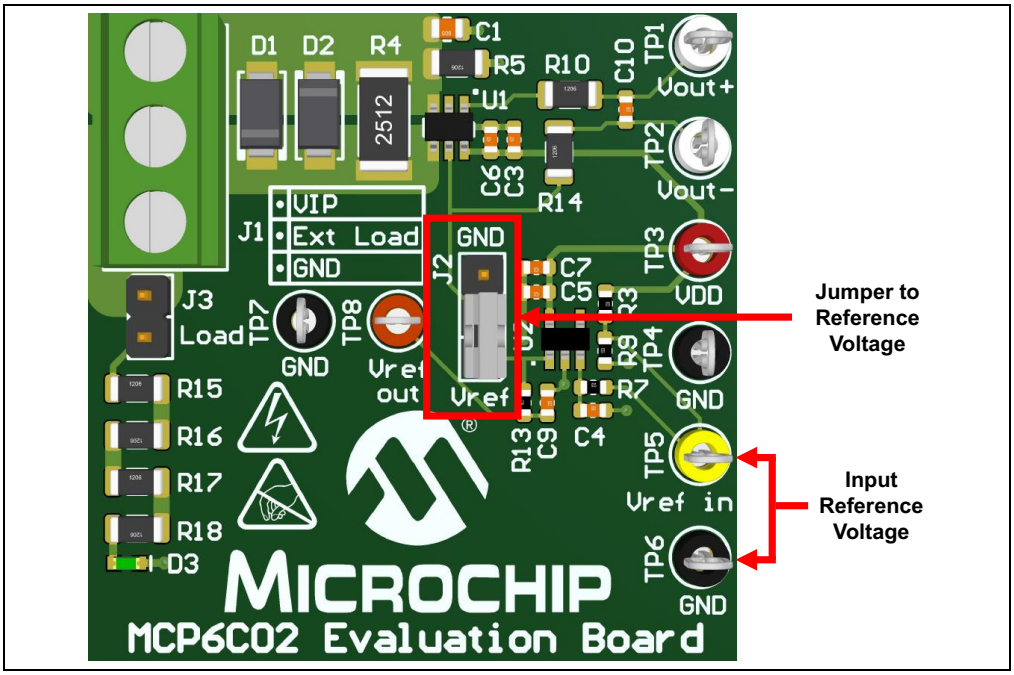



***FIGURE 2-4:*** *Using $V_{REF}$.*

### 2.4.3 Using the On-Board Load

The on-board load consists of four 1.6 kΩ, 1206 resistors (R15, R16, R17, and R18) and a green LED (D3). When the supplied voltage to $V_{IP}$ is about +3.0V (the specified minimum of $V_{IP}$), the LED turns on and gets brighter as $V_{IP}$ increases. The J3 jumper must be populated to enable the on-board load (see Figure 2-5).

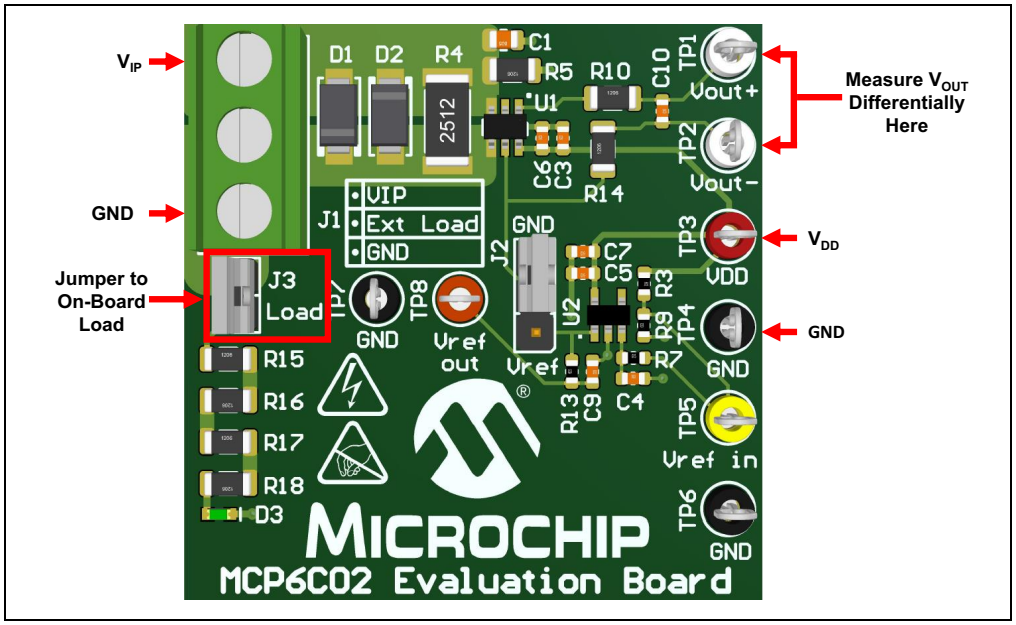



***FIGURE 2-5:*** *Using the On-Board Load.*

### 2.4.4 Using an External Load

When using an external load, follow the instructions below:

1. Remove the jumper at J3.
2. Supply the power source to the $V_{IP}$ terminal.
3. Connect the positive terminal of the external load to the external load terminal (middle terminal of J1, "Ext. Load") on the MCP6C02 Evaluation Board (see Figure 2-6).
4. Connect the grounds of your power source, the external load, and the MCP6C02 Evaluation Board.
5. Measure the output of the MCP6C02 Evaluation Board differentially at test points $V_{OUT-}$ and $V_{OUT+}$.

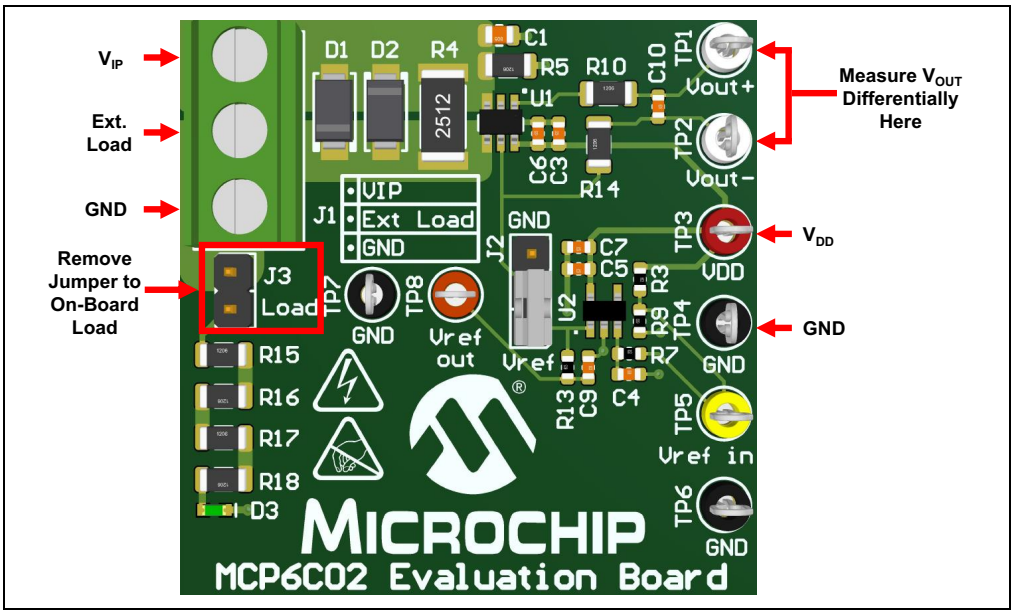



***FIGURE 2-6:*** *Using the External Load.*

### 2.4.5 Choosing Shunt Resistors

Here are some tips for choosing what value to use for the shunt resistor:

- When choosing a value for the shunt resistor (R4), there are two main things to consider: the minimum required accuracy of the device and the maximum power dissipation.
- High values of $R_{SHUNT}$ have high accuracy, but a high power dissipation.
- Low values of $R_{SHUNT}$ have low accuracy, but a low power dissipation.
- The offset voltage is fixed and is the main source of error. The typical offset voltage for the MCP6C02 Evaluation Board is between ±1.5 µV and ±1.9 µV.
- The value for the shunt resistor (R4) must be 15Ω in order to achieve less than 1% error when using the on-board resistive load (R12), which has a maximum load current of 9.7 mA.
- Refer to Equation 2-1 when determining the appropriate specifications for the shunt resistor.

**EQUATION 2-1:**

$$R_{SHUNT} > \frac{V_{OL}}{I_{MIN} \times G_{DM}}$$

$$R_{SHUNT} \geq \frac{MAX(V_{OS})}{I_{MAX} \times rel\_err}$$

$$R_{SHUNT} < \frac{P_{MAX}}{I_{MAX}^2}$$

$$R_{SHUNT} < \frac{V_{OH}}{I_{MAX} \times G_{DM}}$$

Where:

| | | |
|---|---|---|
| $I_{MIN}$ $I_{MAX}$ | = | the minimum and maximum of the absolute value of the currents the MCP6C02 will measure: ($I_{MIN}$ = MIN(\| I \|) and $I_{MAX}$ = MAX(\| I \|)) |
| $P_{MAX}$ | = | the desired maximum power rating of the shunt resistor |
| *rel_err* | = | the desired accuracy relative to the offset voltage ($V_{OS}$) and $I_{MAX}$ |

- When using the MCP6C02-050 and the MCP6C02-100, remember to adjust the value of the shunt resistor according to Equation 2-1.

## 2.5 CONFIGURATIONS AND MODIFICATIONS

### 2.5.1 Component Substitutions

Replace the MCP6C02 with another gain option when higher gain is needed. See **Appendix B. "Bill of Materials (BOM)"** for specific part numbers.

### 2.5.2 Optional Features

The following are optional features of the MCP6C02 Evaluation Board:

- Protective diodes (D1 and D2), in case the shunt resistor (R4) fails open. For the suggested diodes, see **Appendix B. "Bill of Materials (BOM)"**.
- R-C low-pass filter at the reference voltage output (TP8, $V_{REF}$ OUT). For the suggested capacitor value, see **Appendix B. "Bill of Materials (BOM)"**.

## 2.6 CONFIGURING THE PCB

### 2.6.1 Test Points

Table 2-1 lists the test points and describes their functionality.

**TABLE 2-1: TEST POINTS**

| Test Point | | Comments |
|---|---|---|
| Ref. Des. | Label | |
| TP1 | $V_{OUT+}$ | $V_{OUT+}$: Positive differential MCP6C02 Evaluation Board output |
| TP2 | $V_{OUT-}$ | $V_{OUT-}$: Negative differential MCP6C02 Evaluation Board output |
| TP3 | $V_{DD}$ | Power supply for both MCP6C02 and MCP6271 |
| TP4 | GND | Ground |
| TP5 | $V_{REF}$ IN | User-supplied reference voltage |
| TP6 | GND | Ground |
| TP7 | GND | Ground |
| TP8 | $V_{REF}$ OUT | Buffered reference voltage with added R-C low-pass filter |

### 2.6.2 Jumper and Switch Settings

Table 2-2 describes the jumper settings.

**TABLE 2-2: JUMPER SETTINGS**

| Jumper | | | Comments |
|---|---|---|---|
| Ref. Des. | No. | Label | |
| J2 | 1 | GND | Connects the MCP6C02 reference voltage to ground |
| | 2 | $V_{REF}$ | Connects the user-supplied reference voltage to the MCP6C02 Evaluation Board |
| J3 | 1 | J3 | When the jumper is in place, the on-board load is used (R15-R18 and D3) |

### 2.6.3 Schematic Connectors

Table 2-3 shows the connector labels used in the schematic.

**TABLE 2-3: TERMINAL BLOCK LABELS**

| External Signals | |
|---|---|
| **Label** | **Description** |
| $V_{IP}$ | Power supply for load |
| Ext. Load | Terminal to positive side of external load |
| GND | Ground (for $V_{IP}$ or Ext. Load) |

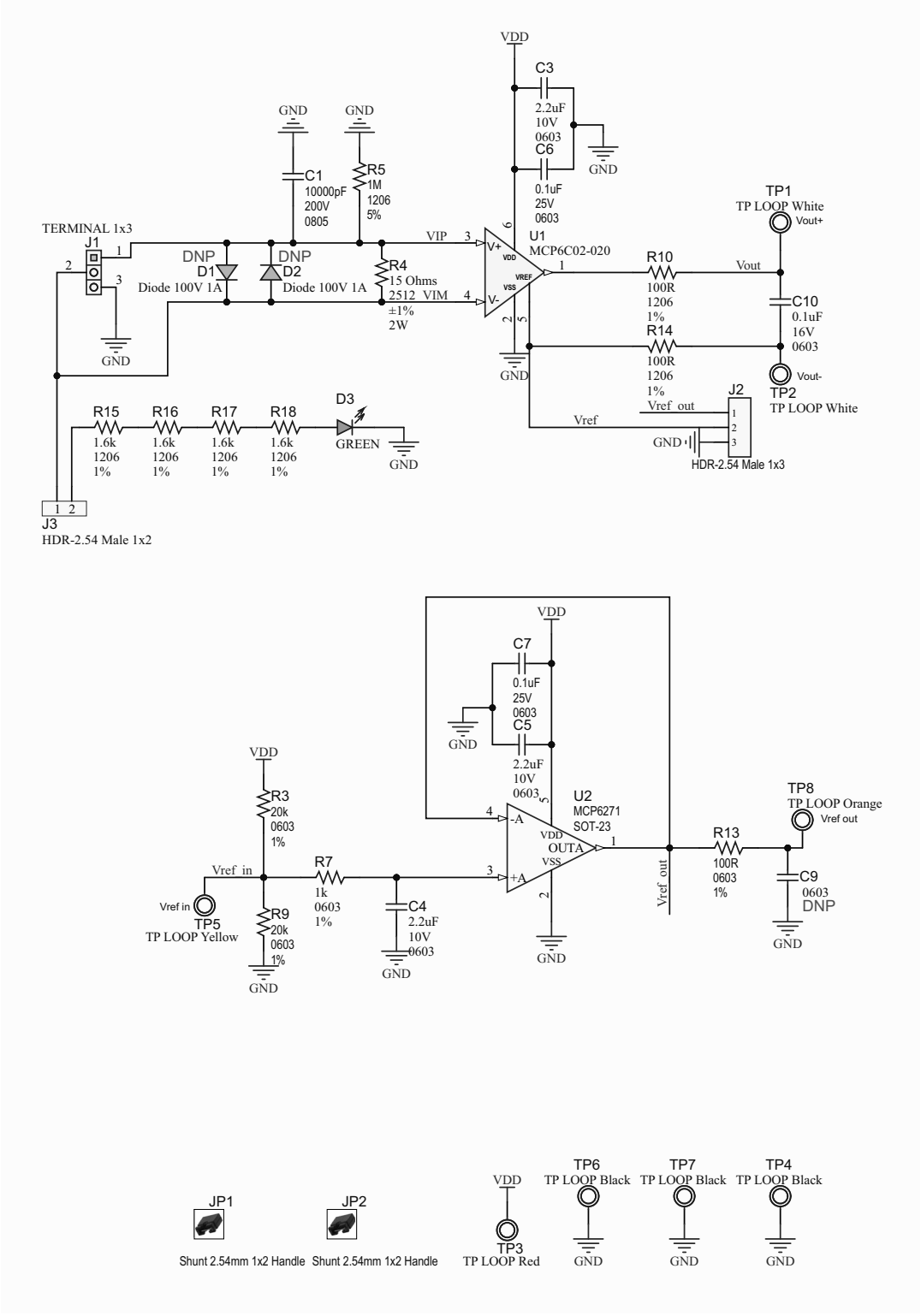
# Appendix A. Schematic and Layouts

## A.1 INTRODUCTION

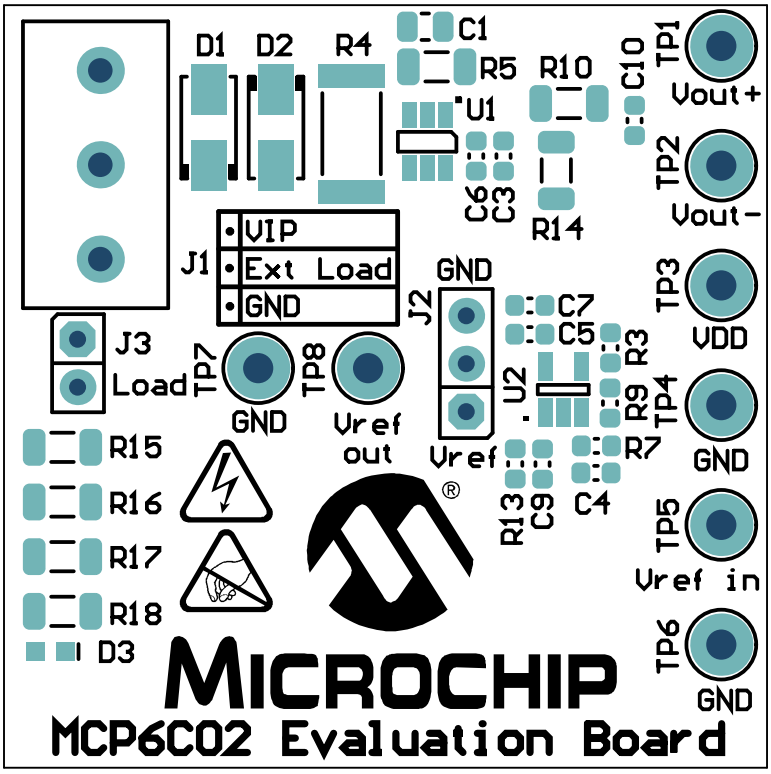
This appendix contains the following schematic and layouts for the MCP6C02 Evaluation Board:

- **Board – Schematic**
- **Board – Top Silk**
- **Board – Top Copper and Silk**
- **Board – Top Copper**
- **Board – Bottom Copper**
- **Board – Bottom Copper and Silk**
- **Board – Bottom Silk**

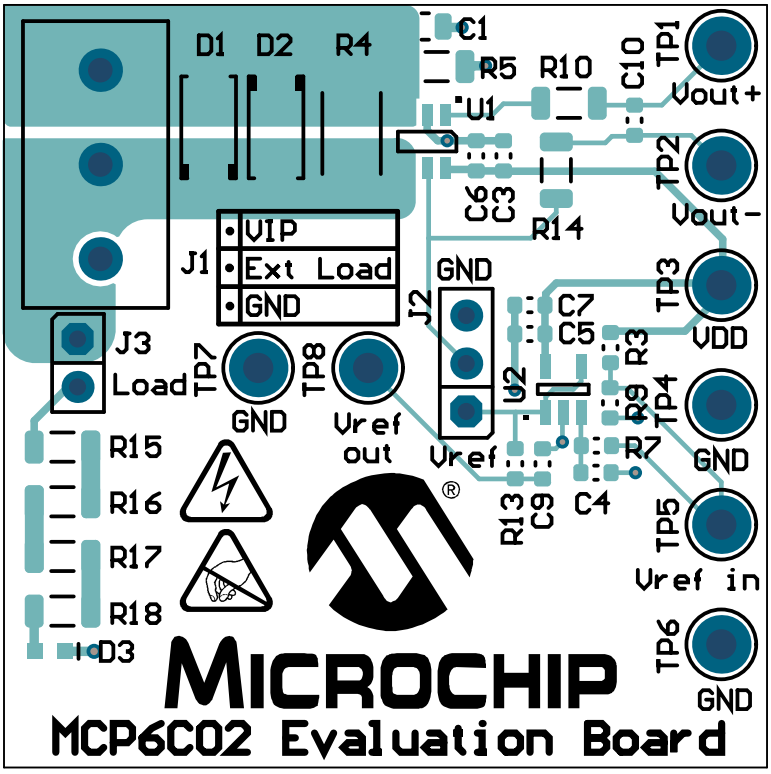
## A.2 BOARD – SCHEMATIC



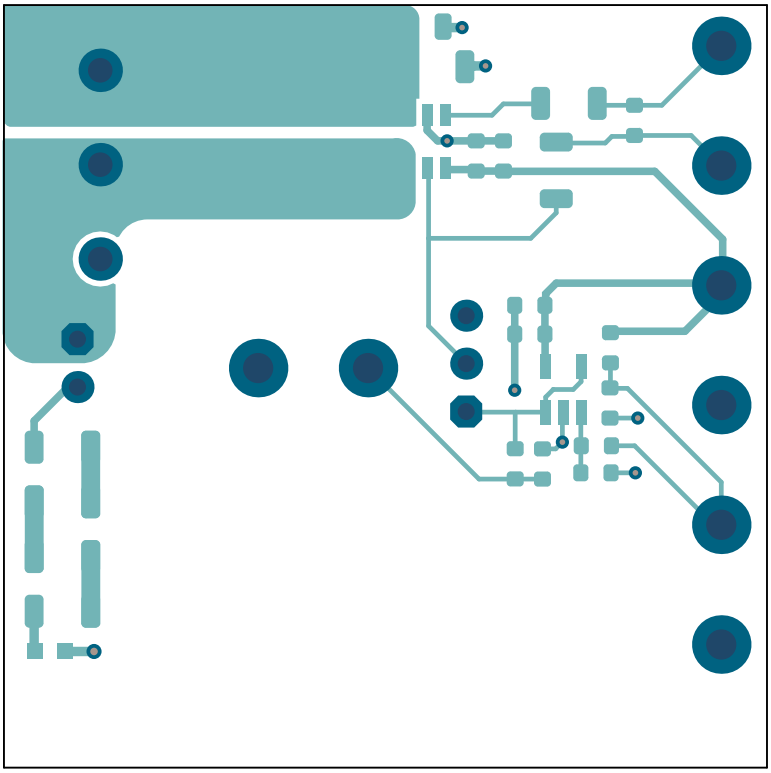
## A.3 BOARD – TOP SILK



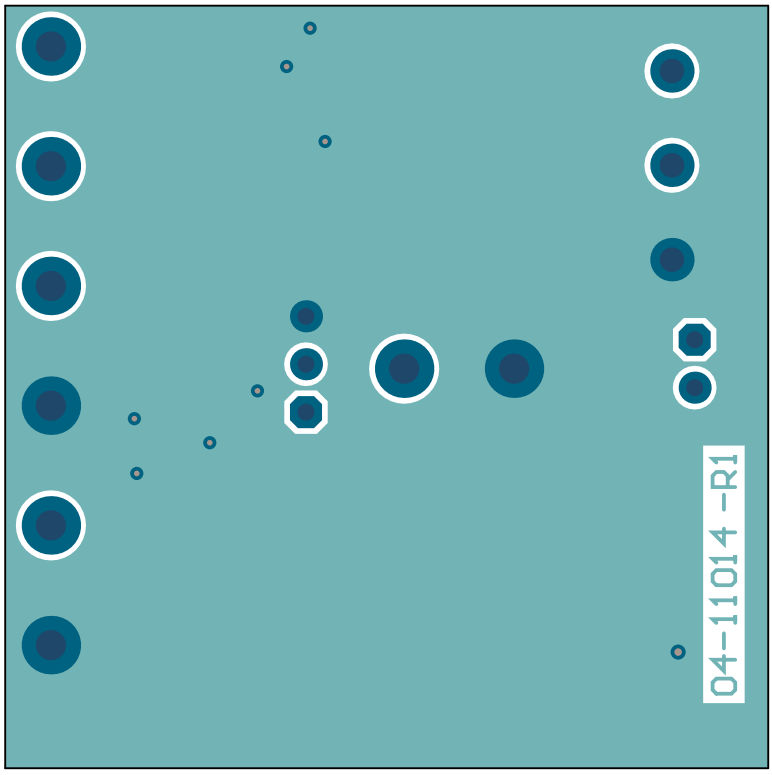

## A.4 BOARD – TOP COPPER AND SILK



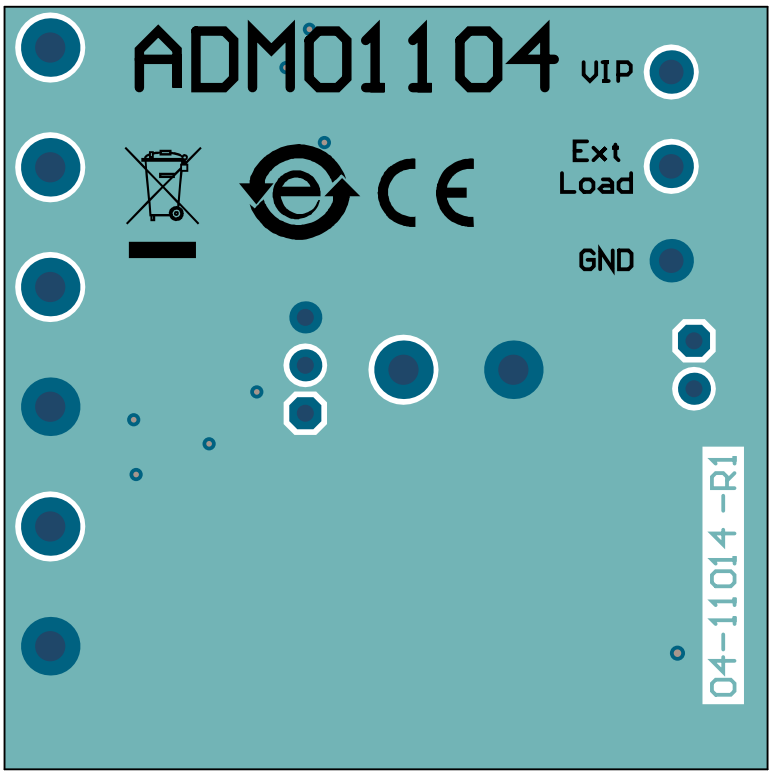
## A.5 BOARD – TOP COPPER



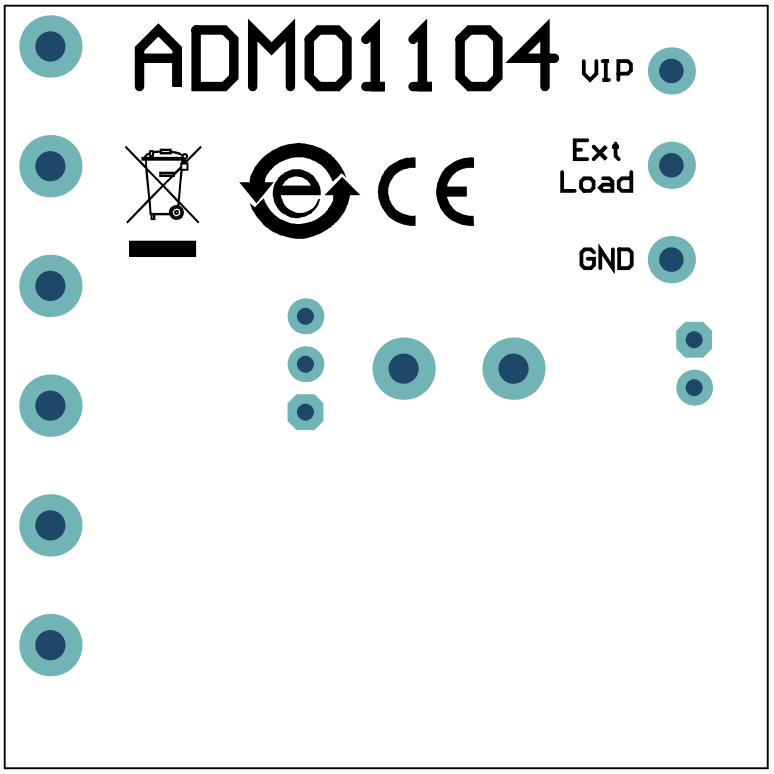
## A.6 BOARD – BOTTOM COPPER



## A.7 BOARD – BOTTOM COPPER AND SILK




## A.8 BOARD – BOTTOM SILK



**NOTES:**

# Appendix B. Bill of Materials (BOM)

**TABLE B-1: BILL OF MATERIALS (BOM)**

| Qty. | Reference | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 1 | C1 | Ceramic Capacitor, 10000 pF, 200V, X7R, 0805 | Samsung Electro-Mechanics America, Inc. | CL21B103KDCNNNC |
| 3 | C3, C4, C5 | Ceramic Capacitor, 2.2 µF, 10V, 10%, X7R, SMD, 0603 | Murata Manufacturing Co., Ltd. | GRM188R71A225KE15D |
| 2 | C6, C7 | Ceramic Capacitor, 0.1 µF, 25V, 5%, X7R, SMD, 0603 | Yageo Corporation | CC0603JRX7R8BB104 |
| 1 | C10 | Ceramic Capacitor, 0.1 µF, 16V, 10%, X7R, SMD, 0603 | Samsung Electro-Mechanics America, Inc. | CL10B104KO8NNNC |
| 1 | D3 | Diode, Green LED, 3.2V, 20 mA, 430 Mcd, Clear, SMD, 0603 | Wurth Elektronik | 150060GS75000 |
| 1 | J1 | Connector Terminal, 5 mm, 1x3, Female, 12-30AWG, 16A, Through-Hole, R/A | Wurth Elektronik | 691137710003 |
| 1 | J2 | Connector, Header-2.54, Male, 1x3, Gold, 5.84 MH, Through-Hole, Vertical | Amphenol Commercial | 68000-103HLF |
| 1 | J3 | Connector, Header-2.54, Male, 1x2, Gold, 5.84 MH, Through-Hole, Vertical | Wurth Elektronik | 61300211121 |
| 2 | JP1, JP2 | Mechanical Hardware Jumper, 2.54 mm, 1x2, Handle Gold | TE Connectivity, Ltd. | 881545-2 |
| 1 | PCB1 | MCP6C02 Evaluation Board – Printed Circuit Board | Microchip Technology Inc. | **04-11014-R1** |
| 2 | R3, R9 | Resistor, Thick Film, 20K, 1%, 1/10W, SMD, 0603 | Yageo Corporation | RC0603FR-0720KL |
| 1 | R4 | Resistor, SMD, 15Ω, 1%, 2W, 2512 | Bourns®, Inc. | CRM2512-FX-15R0ELF |
| 1 | R5 | Resistor, Thick Film, 1M 5% 1/4W SMD 1206 | Panasonic® - ECG | ERJ-8GEYJ105V |
| 1 | R7 | Resistor, Thick Film, 1K, 1%, 1/10W, SMD, 0603 | Yageo Corporation | RC0603FR-071KL |
| 2 | R10, R14 | Resistor, Thick Film, 100R, 1%, 1/4W, SMD, 1206 | Yageo Corporation | RC1206FR-07100RL |
| 1 | R13 | Resistor, Thick Film, 100R, 1%, 1/10W, SMD, 0603 | ROHM Semiconductor | MCR03EZPFX1000 |
| 4 | R15, R16, R17, R18 | Resistor, Thick Film, 1.6K, 1%, 1/4W, SMD, 1206 | Panasonic - ECG | ERJ-8ENF1601V |
| 2 | TP1, TP2 | Connector, Test Point, Loop, White, Through-Hole | Keystone Electronics Corp. | 5012 |

**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-1: BILL OF MATERIALS (BOM) (CONTINUED)**

| Qty. | Reference | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 1 | TP3 | Connector, Test Point, Loop, Red Through-Hole | Ohmite® Manufacturing | 5010 |
| 3 | TP4, TP6, TP7 | Connector, Test Point, Loop, Black 3.18x5.59, Through-Hole | Keystone Electronics Corp. | 5006 |
| 1 | TP5 | Connector, Test Point, Loop, Yellow, Through-Hole | Keystone Electronics Corp. | 5014 |
| 1 | TP8 | Connector, Test Point, Loop, Orange, Through-Hole | Keystone Electronics Corp. | 5013 |
| 1 | U1 | Microchip Analog Current Sense Amp, MCP6C02T-020E/CHY, SOT-23-6 | Microchip Technology Inc. | **MCP6C02T-020E/CHY** |
| 1 | U2 | Microchip Analog Op Amp, 1-Ch, 2 MHz, MCP6271T-E/OT, SOT-23-5 | Microchip Technology Inc. | **MCP6271T-E/OT** |

**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 (BOM) FOR ALTERNATE COMPONENTS**

| Qty. | Reference | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 1 | U1 | **NOT INCLUDED**, Microchip Analog Current Sense Amp, MCP6C02T-050E/CHY, SOT-23-6 | Microchip Technology Inc. | **MCP6C02T-050E/CHYCT-ND** |
| 1 | U1 | **NOT INCLUDED**, Microchip Analog Current Sense Amp, MCP6C02T-100E/CHY, SOT-23-6 | Microchip Technology Inc. | **MCP6C02T-100E/CHYCT-ND** |

**TABLE B-3: BILL OF MATERIALS (BOM) FOR OPTIONAL PARTS**

| Qty. | Reference | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 1 | C9 | **NOT INCLUDED**, Ceramic Capacitor, 2.2 µF, 16V, 10%, X5R, SMD, 0603 | TDK Corporation | C1608X5R1C225K080AB |
| 2 | D1, D2 | **NOT INCLUDED**, General Purpose Diode, 100V, 1A, SMA | ON Semiconductor® | SURA8110T3G |

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