MCP3564R microCurrent Monitor 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 (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 is useful to know before using the MCP3564R microCurrent Monitor Evaluation Board. Items discussed in this chapter include:

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

DOCUMENT LAYOUT

This document describes how to use the MCP3564R microCurrent Monitor Evaluation Board. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Provides key information about the MCP3564R microCurrent Monitor Evaluation Board
- **Chapter 2. "Hardware Description"** – Includes instructions and details about the hardware components used for MCP3564R microCurrent Monitor Evaluation Board
- **Chapter 3. "Software Solution"**– Describes the software solution for data acquisition, processing, and analysis of currents and voltages measurements
- **Chapter 4. "Installation and Operation"**– Includes step-by-step instructions for installing and starting the MCP3564R microCurrent Monitor Evaluation Board
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MCP3564R microCurrent Monitor Evaluation Board
- **Appendix B. "Bill of Materials (BOM)"** – Lists the components used to build the MCP3564R microCurrent Monitor Evaluation Board.

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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) { ... }`

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RECOMMENDED READING

This user's guide describes how to use the MCP3564R microCurrent Monitor Evaluation Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources:

Data Sheet – *"MCP3561/2/4R – Two/Four/Eight-Channel, 153.6 ksps, Low Noise 24-Bit Delta-Sigma ADCs with Internal Voltage Reference"* (20006391)

User's Guide – *"MCHP USB-to-TCP Bridge Service User's Guide"* (**50003749**)

User's Guide – *"EV64F02A Mixed Signal Data Capture Evaluation Board User's Guide"* (**50003745**)

THE MICROCHIP WEBSITE

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- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
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- 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.

Technical support is available at: microchip.com/support.

DOCUMENT REVISION HISTORY

Revision A (August 2025)

- Initial release of this document.

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Chapter 1. Product Overview

1.1 INTRODUCTION

The MCP3564R microCurrent Monitor Evaluation Board uses the wide dynamic range of MCP3564R 8-Channel, 24-bit Delta-Sigma ADC to measure both low (µA) and high (800+ mA) currents across a 0.05Ω shunt. To achieve this, it employs two high-side current sense amplifiers, MCP6C02 and MCP6C26, each with a fixed internal gain of 50.

The two different amplifiers were used for their complementary input voltage ranges, enabling current measurements from 0V up to 65V. Both are configured for bidirectional current sensing, with their outputs offset at half of the ADC's reference voltage (VREF).

Additionally, each current channel is paired with a buffered voltage divider that simultaneously measures the corresponding voltage levels.

The MCP3564R microCurrent Monitor is designed to be mikroBUS compatible, ensuring seamless interconnection with a wide variety of microcontroller boards from Microchip and MikroE.

For improved measurement precision at low currents and voltages, the MCP3564R microCurrent Monitor includes a 0.1% accuracy voltage reference (MCP1501 – 3V) and a 0.1% precision (300Ω) resistor for ADC calibration. An onboard EEPROM is also provided to save calibration parameters if needed.

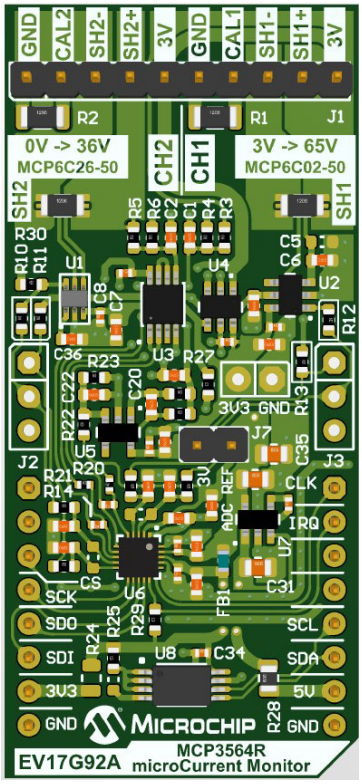

FIGURE 1-1: *MCP3564R microCurrent Monitor (EV17G92A).*

1.2 MCP3564R DELTA-SIGMA ANALOG-TO-DIGITAL CONVERTER FEATURES

The MCP3564R device is an 8-Channel, 24-Bit, Delta-Sigma Analog-to-Digital Converter (ADC) and its features include:

- The Oversampling Ratio (OSR) factor, adjustable from 32 to 98304, allows for high-speed/low-precision or low-speed/high-precision measurements. When measuring very small currents, a high OSR should be used for improved accuracy.
- The internal gain of 1 is used for measuring currents in the range of ±480 mA. For larger positive currents up to +840 mA, where the operational amplifier output voltage is larger than the internal 2.4V reference voltage of the ADC, the gain can be set to 1/3. For very low currents, increasing the internal gain will also amplify the external noise so there will not be a visible improvement in measurement accuracy. If higher or smaller currents need to be measured, the shunts can be replaced with another appropriate value and the internal gain can be used to complement the external operational amplifier gain. The external operational amplifier gain of 50 was chosen as a good compromise between signal gain and amplified input noise.
- The internal 2.4V voltage reference is used to also provide the operational amplifier reference for bidirectional current measurements.
- The offset and gain calibration registers allow automatic correction of ADC readings, reducing the processing load on the MCU by eliminating the need for manual compensation.
- The MCLK pin is routed to the mikroBUS PWM pin for a higher-frequency ADC clock input.
- The IRQ pin is routed to the mikroBUS INT pin for Scan Mode operation.
- Communication with the MCP3564R is performed using a standard 20 MHz SPI-compatible serial interface.

1.3 MCP3564R MICROCURRENT MONITOR FEATURES

The MCP3564R microCurrent Monitor has the following features:

- MCP3564R 8-Channel, 24-bit Delta-Sigma ADC
- High Side Zero-Drift Current Sense Amplifiers on 0.05Ω shunts:
  - MCP6C02 - range between 3V - 65V
  - MCP6C26 - range between 0V - 36V
- Buffered voltage dividers to measure bus voltages for both current channels
- On-board precision voltage reference (MCP1501) and 0.1% load resistors for calibrating the ADC measurements
- 10-pin Header for load connection and calibration
- mikroBUS compatibility
- Test Point on current sense amplifier outputs and power rails

1.4 EVALUATION PLATFORM SUPPORT

To simplify prototyping, a Python code example is available for the MCP3564R microCurrent Monitor, utilizing the PIC32MZ MXS Data Capture Board (EV64F02A) and associated MCHP USB to TCP Bridge Service. The code is designed to assist with board calibration and compute current and voltage measurements using an intuitive MCP3564R library. This example can also serve as a foundation for further data analysis.

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1.5 KIT CONTENTS

The MCP3564R microCurrent Monitor kit includes:

- MCP3564R microCurrent Monitor (EV17G92A)
- 2 jumpers (used for calibration).

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Chapter 2. Hardware Description

2.1 INTRODUCTION

This chapter details the hardware used to create the MCP3564R microCurrent Monitor and covers the following topics:

- MCP3564R microCurrent Monitor Hardware Overview
- Block Diagram
- Connection Diagram.

2.2 MCP3564R MICROCURRENT MONITOR HARDWARE OVERVIEW

Figure 2-1 shows a detailed view of the main components that are part of the MCP3564R microCurrent Monitor:

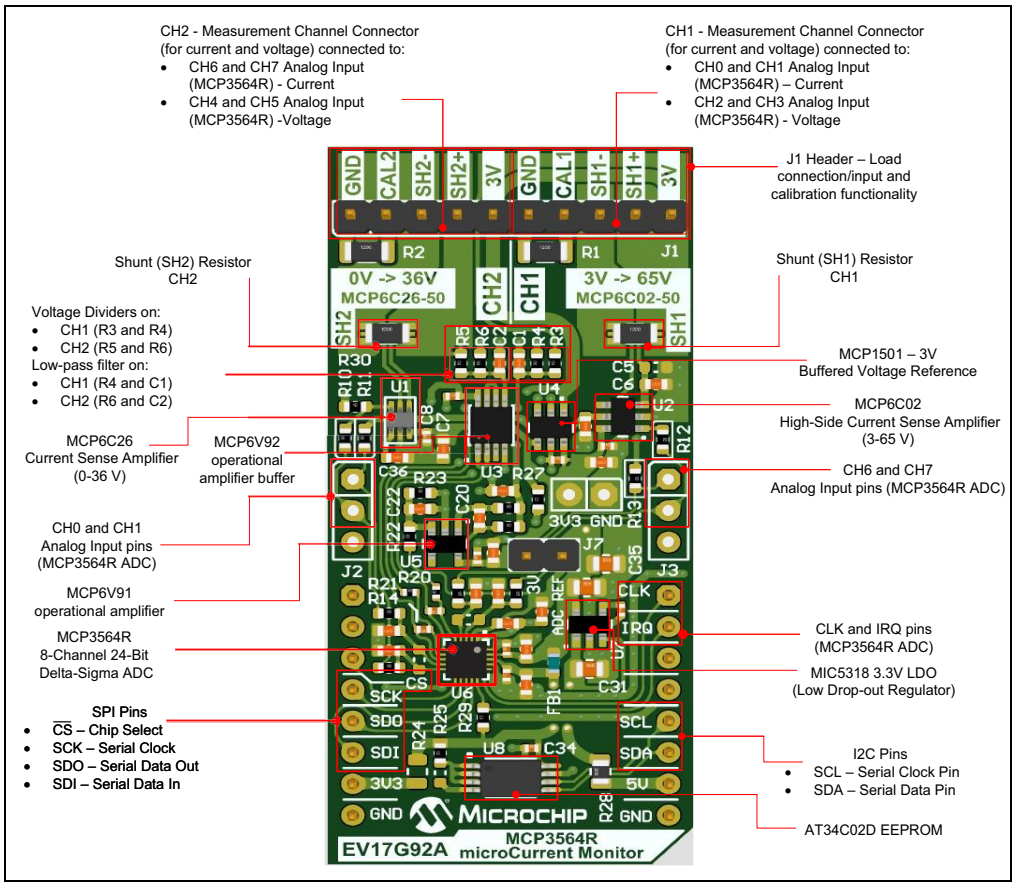

FIGURE 2-1: *MCP3564R microCurrent Monitor - Hardware Overview.*

2.3 MCP3564R MICROCURRENT - BLOCK DIAGRAM

The MCP3564RMCP3564R microCurrent Monitor consists of eight main component blocks:

1. Load Connection and Calibration Header
2. Current Amplifiers and Buffered Voltage Divider
3. Current Amplifier Voltage Reference
4. MCP3564R 24-Bit, 8-Ch Delta-Sigma ADC with internal Reference
5. Calibration Voltage Reference
6. LDO
7. EEPROM
8. MikroBUS Connector.

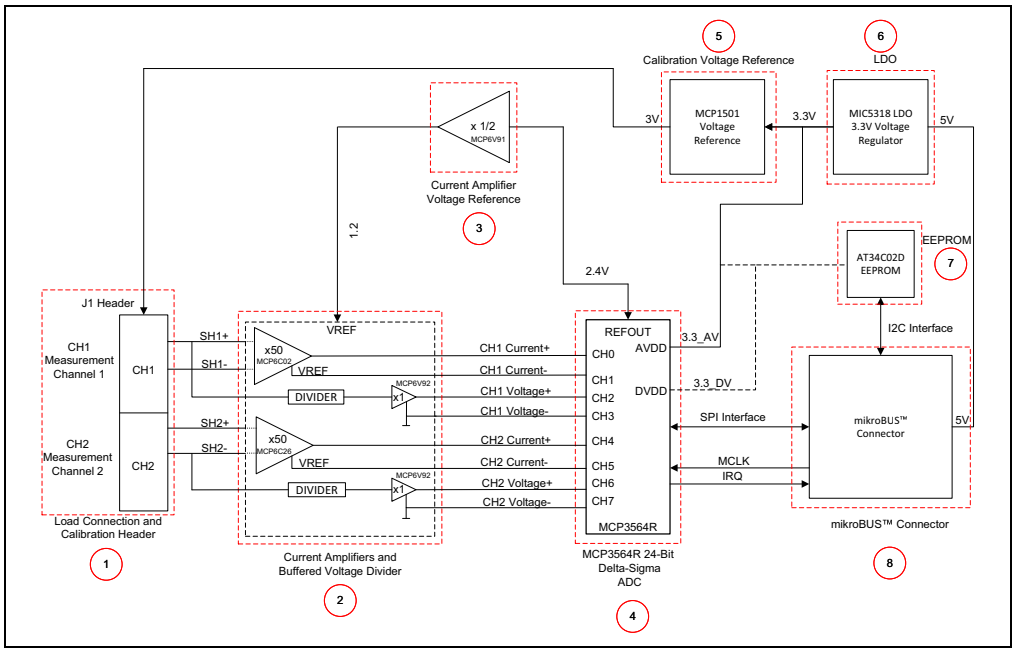

FIGURE 2-2: *MCP3564R microCurrent Monitor - Block Diagram.*

2.3.1 J1 HEADER - PIN DEFINITION

TABLE 2-1: J1 CONNECTOR PINS

Measurement Channel	J1 Connector Pins	Purpose
CH1	3V	3V Reference Voltage (jumper 3V to SH1+ for calibrating the voltage and current measurements)
	SH1+	SH1+ Terminal (connect external load power supply here, min. 3V, max. 65V)
	SH1-	SH1- Terminal (connect the positive end of the external load here and the negative end to the external power supply GND)
	CAL1	Calibration Resistor (jumper CAL1 to SH1- for calibrating the current measurement at 10mA)
	GND	Ground reference - connect external load power supply GND here (Note 1)

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TABLE 2-1: J1 CONNECTOR PINS (CONTINUED)

Measurement Channel	J1 Connector Pins	Purpose
CH2	3V	3V Reference Voltage (jumper 3V to SH1+ for calibrating the voltage and current measurements) (Note 2)
	SH2+	SH2+ Terminal (connect external load power supply here, max. 36V)
	SH2-	SH2- Terminal (connect the positive end of the external load here and the negative end to the external power supply GND)
	CAL2	Calibration Resistor (jumper CAL2 to SH2- for calibrating the current measurement at 10 mA)
	GND	Ground reference - connect external load power supply GND here (Note 1)

Note 1: Use a star connection to the external power supply GND output so that the load current does not generate a voltage drop on the reference ground voltage. This will yield better accuracy on the voltage measurements.

2: When calibrating the voltage on CH2 at 0V, place a jumper between SH2- and CAL2 to shunt the current coming from the operational amplifier reference voltage through MCP6C26 internal gain resistors. Failing to do so will generate a false voltage offset. When measuring a load, the SH2- is connected to the load GND reference which sinks the gain resistor current, thus eliminating the problem. For best accuracy, SH2- can be connected with a jumper wire to GND during calibration.

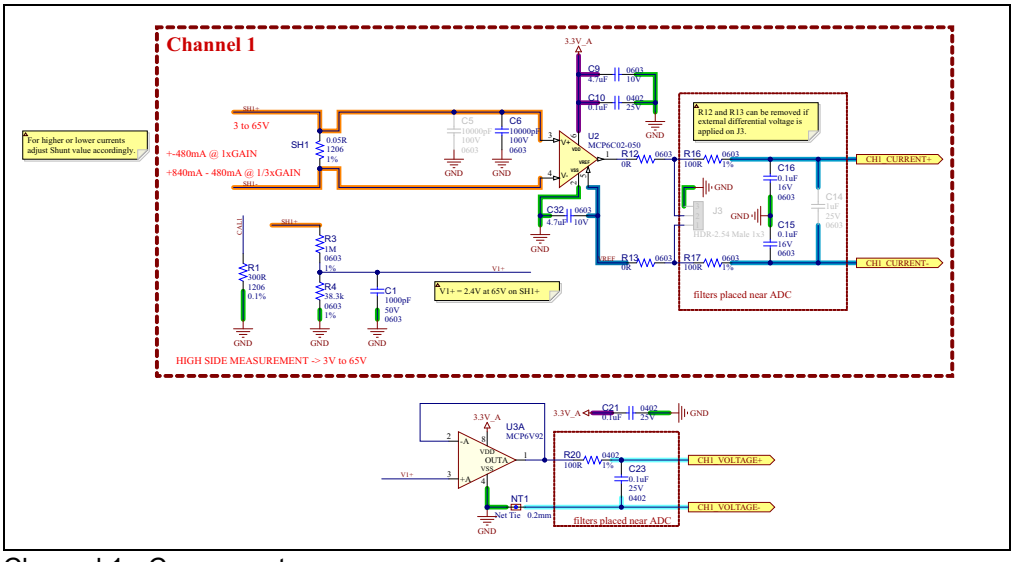
Each channel has a 0.1% precision voltage reference (3V) and a 0.1% precision 300 Ω load resistor (CALx) that are used for calibration. The calibration process eliminates the offsets introduced by the shunt solder pad parasitic resistance and other signal chain offset and gain errors.

Using the two jumpers provided in the kit, a 2-point calibration is done for each channel on both voltage and current:

- 0V - 3V
- 0A - 10 mA.

2.4 MEASUREMENT CHANNELS

2.4.1 CHANNEL 1



Channel 1 - Components.

2.5 MEASUREMENT CHANNELS

2.5.1 CHANNEL 1

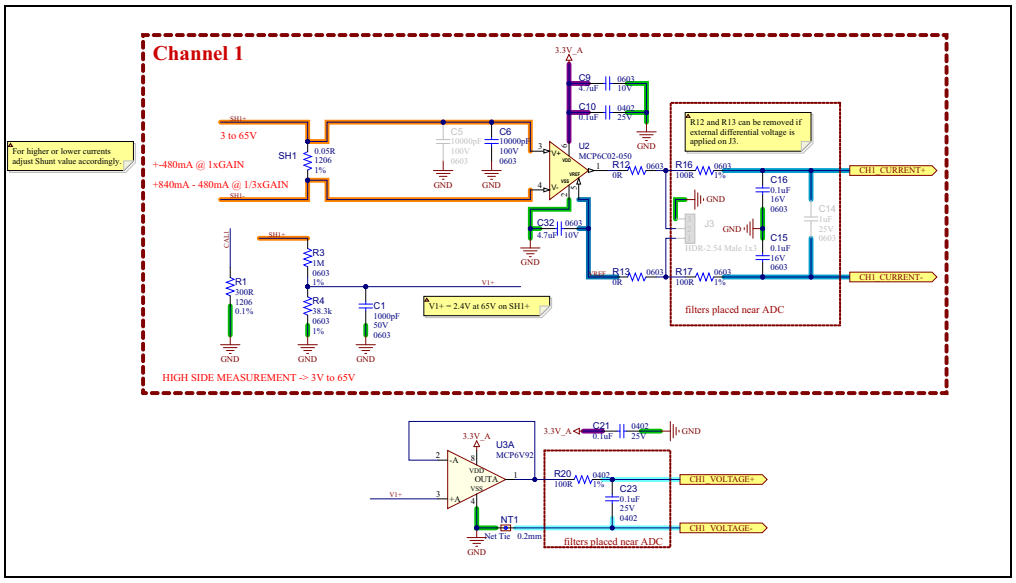


FIGURE 2-3: *Channel 1 - Components.*

The upper part of Figure 2-3 indicates the current measurement as the current passing through SH1 generates a voltage drop which is amplified 50 times by MCP6C02, offset by VREF (1.2V) and fed to the ADC through an anti-aliasing filter. MCP6C02 has to have at least 3V present on its positive input as this pin also powers the internal circuitry.

The J3 header is used as a test point to measure the amplifier output or to inject an external signal to the ADC when disconnecting the 0Ω resistors from the amplifier output and reference lines.

The lower part of the above figure indicates the voltage measurement as the voltage present on the positive end of the shunt is divided by R3 and R4, so that at 65V input voltage the ADC sees close to its reference voltage of 2.4V. Capacitor C1 creates a low pass filter with R3. This provides the highest resolution over the entire voltage span, with a minimum of amplified noise. The MCP6V92 buffer is used to prevent the ADC input current from altering the voltage drop on R4 during the measurements. The negative ADC input is connected to GND through Net Tie NT1 close to the operational amplifier ground pin to avoid measuring ground noise close to the ADC caused by the digital side of the board.

Current 2 Point Calibration:

- 0A: SH1+ is connected to 3V through a jumper, to enable the MCP6C02, while SH1- is left floating. As a result, the output of the amplifier will be slightly above 0V relative to the 1.2V reference voltage, considering that the input offset will also be amplified.
- 10 mA: a second jumper is added between SH1- and CAL1 to force a current draw through the 0.1% 300Ω resistor. The output of the amplifier will be slightly around 1.2V+0.025V, but since the ADC negative input is connected at 1.2V, the measured differential value will be 0.025V.

Voltage 2 Point Calibration:

- 0V: Leave SH1+ floating so the voltage divider does not see any voltage. The ADC will see the offset of the MCP6V92
- 3V: Jumper SH1+ to 3V so voltage divider sees the 3V 0.1% voltage reference.

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2.5.2 CHANNEL 2

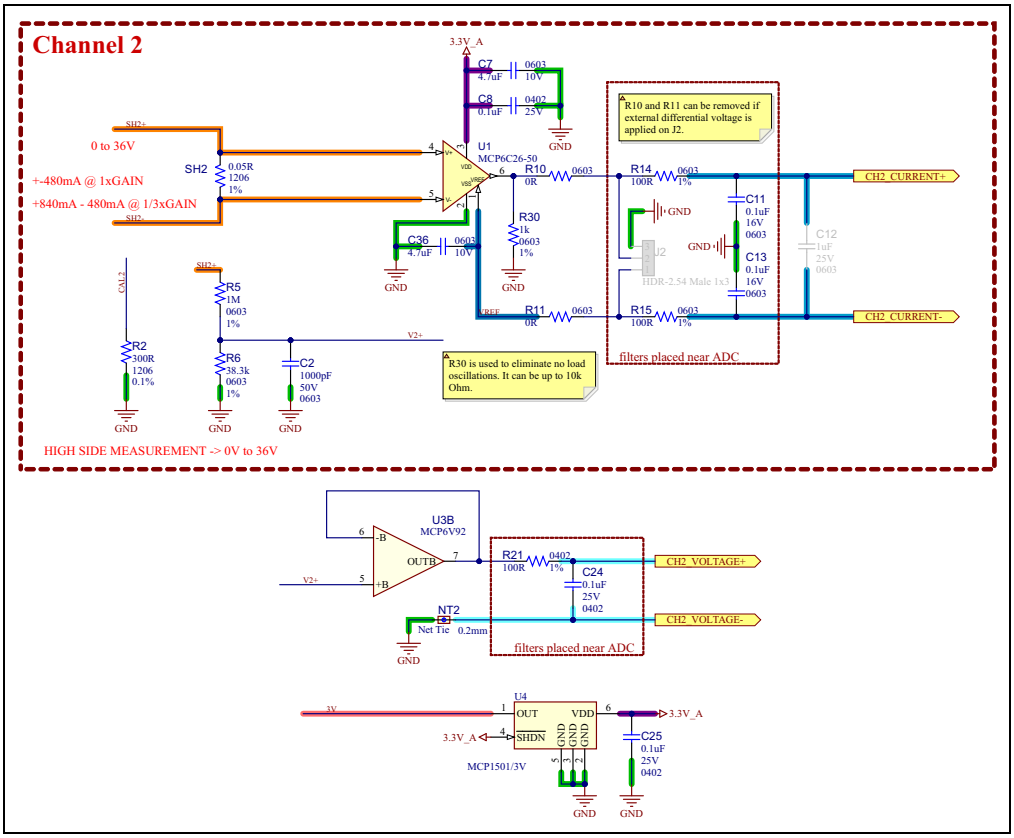

FIGURE 2-4: *Channel 2 - Components.*

The upper part of Figure 2-4 indicates the current measurement as the shunt value and MCP6C26 Current Amplifier gain are the same as for CH1, with the difference being that the MCP6C26 can measure power rails under 3V, but only up to 36V.

The J2 header is used as a test point to measure the amplifier output or to inject an external signal to the ADC when disconnecting the 0Ω resistors from the amplifier output and reference lines.

The lower part of Figure 2-4 indicates the voltage measurement for CH2 that uses the same voltage divider ratio and configuration as on CH1.

Current 2 Point Calibration:

- 0A: Leave SH2+ and SH2- pins floating or jumper SH2+ to 3V and leave SH2- floating. The output of the amplifier will be slightly higher than 0V above the 1.2V reference voltage, assuming the input offset gets also amplified.
- 10 mA: Jumper SH2+ to 3V and SH2- to CAL2 to force a current draw through the 0.1% 300Ω resistor. Similarly to CH1, the output of the amplifier will be around 1.2V/0.025V, but since the ADC negative input is connected at 1.2V, the measured differential value will be 0.025V.

Voltage 2 Point Calibration:

- 0V: Leave SH1+ floating so the voltage divider does not see any voltage and jumper SH2- to CAL2 so that most of the current coming from VREF through the internal gain resistors of the MCP6C26 out of the V+ pin gets shunted to GND and does not create a false offset.
- 3V: Jumper SH1+ to 3V so that the voltage divider registers the 3V 0.1% voltage reference.

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2.6 POWER SUPPLY

The MCP3564R microCurrent Monitor features a high performance, ultra-low-dropout (LDO) voltage regulator, MCP5318 that provides 3.3V supply voltage to power the components on the board. MCP5318 is powered with 5V from the microcontroller board through the mikroBus socket.

2.7 VOLTAGE REFERENCE

The MCP1501 buffered voltage reference provides on-board 3V, used to calibrate the ADC measurements.

2.8 MCP3564R DELTA-SIGMA ADC

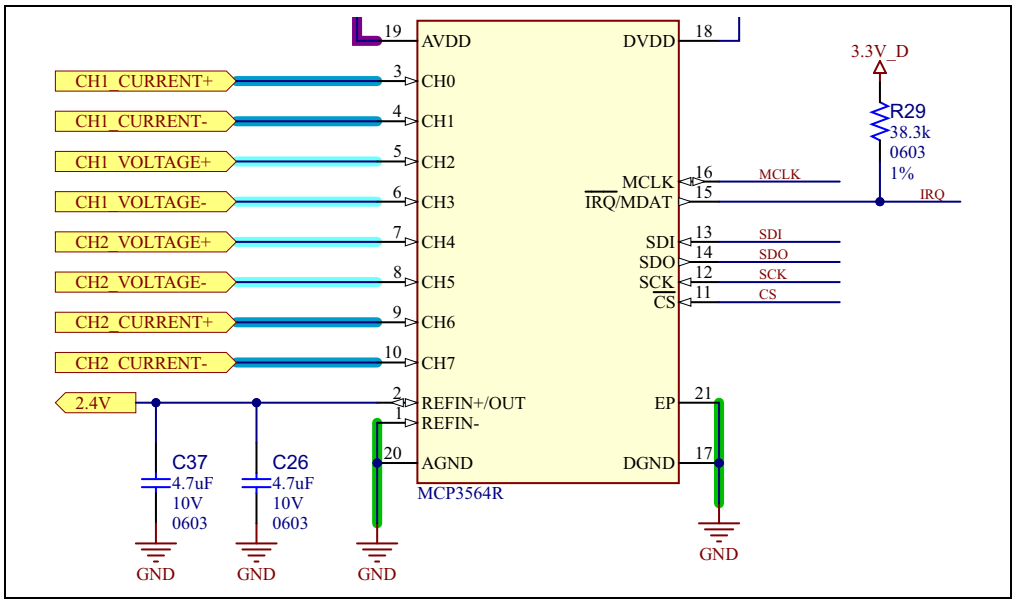

FIGURE 2-5: *MCP3564R DELTA-SIGMA ADC.*

The two measurement channels (CH1 and CH2), for current and voltage, are reaching the analog input channels of the MCP3564R 24-Bit, 8-Channel Delta-Sigma ADC as follows:

- CH1 Current: CH0 and CH1 (linked in differential mode)
- CH1 Voltage: CH2 and CH3 (linked in differential mode)
- CH2 Current: CH4 and CH5 (linked in differential mode)
- CH2 Voltage: CH6 and CH7 (linked in differential mode).

Communication between MCP3564R and the MCU Board is done through the SPI interface, using the $\overline{CS}$ (Chip Select), SCK (Serial Clock), SDI (Serial Data In) and SDO (Serial Data Out) pins on the MCP3564R microCurrent Monitor.

The current amplifiers are offsetting their outputs with VREF (1.2V) and the ADC is deducting automatically this reference voltage connected to the negative input from the positive input voltage. This eliminates any offsets introduced by the VREF driver (MCP6V91 and associated voltage divider tolerance).

2.9 CLICK BOARD/MIKROBUS CONNECTOR/INTERFACE

The mikroBUS connector provides an interface between the MCP3564R microCurrent Monitor and the microcontroller board. It uses the SPI interface for MCP3564R ADC and the I2C interface for AT34C02D EEPROM. This standard will allow the board to be used in conjunction with many other microcontroller platforms.

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2.10 DATA CAPTURE BOARD CONNECTION DIAGRAM

The project example presented in this document uses the MCP3564R microCurrent Monitor (EV17G92A) along with the PIC32MZ Mixed Signal Data Capture Board (EV64F02A).

The PIC32MZ Mixed Signal Data Capture Board (EV64F02A) containing PIC32MZ MCU is used to configure and read data from the MCP3564R ADC, through the embedded Generic SPI bridge firmware.

Note: The python script provided with MCP3564R microCurrent Monitor offers support only between the microCurrent Monitor Board (EV17G92A) and the PIC32MZ Mixed Signal Data Capture Board (EV64F02A). For further details, see **Chapter 3, "Software Solution"**.

Figure 2-6 shows the summarized connection between the MCP3564R microCurrent Monitor and PIC32MZ Mixed Signal Data Capture Board.

The MCP3564R microCurrent Monitor is connected to the PIC32MZ Data Capture Board using the mikroE click header. In this example, the first mikroBUS socket interface is used (the socket number 2 is defined by default in the python script), however the other socket can be chosen, if desired, with the specification to modify the software accordingly.

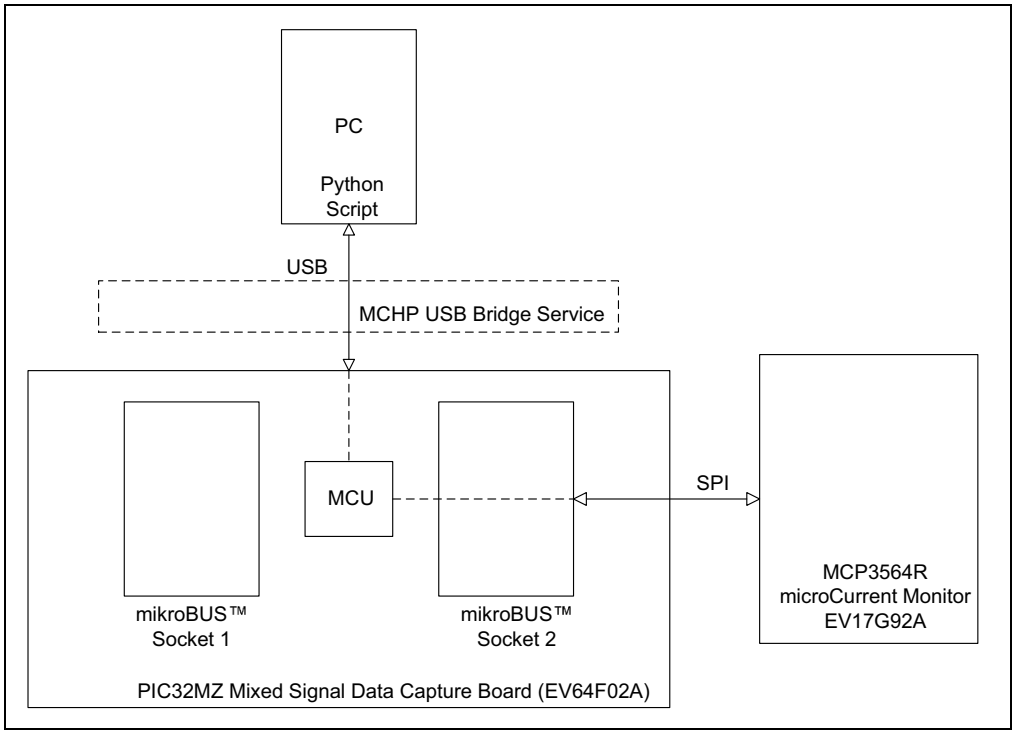

FIGURE 2-6: *Block Diagram Connection between PIC32MZ Mixed Signal Data Capture Board (EV64F02A), MCP3564R microCurrent Monitor (EV17G92A) and the PC.*

Chapter 3. Software Solution

3.1 INTRODUCTION

This chapter describes the proposed software solution for data acquisition, processing, and analysis of currents and voltages measurements using the MCP3564R microCurrent Monitor (EV17G92A) and PIC32MZ Mixed Signal Data Capture Board (EV64F02A) with existing firmware (with Generic SPI) and associated MCHP USB to TCP Bridge Service.

3.2 PYTHON SCRIPT

The proposed solution is a Python script developed to process and analyze current and voltage measurements with higher precision.

The script communicates with the MCP3564R microCurrent Monitor using the MCHP USB to TCP Bridge Service (MCHP USB Bridge Service) to facilitate data exchange between the USB-connected board (PIC32MZ Mixed Signal Data Capture Board) and TCP clients (Python Script). Through the USB connection the Python script can access the interface of PIC32MZ Mixed Signal Data Capture Board (specifically/called generic I2C, generic SPI). Data acquisition (currents and voltages measurements) is conducted through the SPI interface (generic SPI), which the MCP3564R ADC uses to communicate with the microcontroller board (MCU). An overview of this communication structure is illustrated in Figure 3-1.

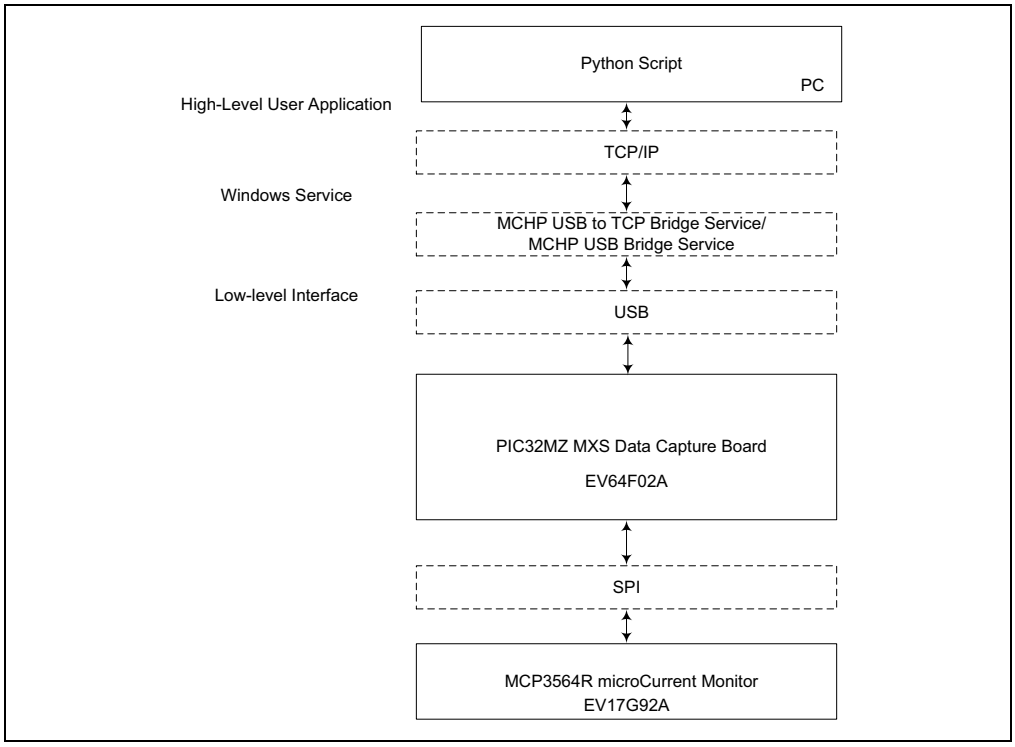

FIGURE 3-1: *Software Communication Structure.*

The Python script is designed to acquire a specified number of samples (defaulting to 50 samples) from each measurement channel – CH1 and CH2 – for both current and voltage, using the SPI interface (via TCP/IP through the MCHP USB Bridge Service through USB to SPI communication). Additionally, temperature measurement is requested from internal sensors of ADC. This results in a total of five measurements.

Once the values are acquired and processed, they are displayed in the terminal along with several calculated electrical performance parameters based on the measurements.

3.3 PROJECT STRUCTURE

The project structure includes four main components:

1. mchp_bridge_libs directory/files:

This directory contains the MCHP USB Bridge Service libraries.

2. MCP3564x_lib.py:

A Python library/API for the MCP356xR Delta-Sigma ADC's Family.

3. mcp3564r_data_acquisition.py:

The main Python Script to be executed.

4. Calib.json:

A JSON file that contains parameters and measurements used for the ADC's digital calibration method.

In the main Python script (mcp3564r_data_acquisition.py) exists a configuration structure that allows for easy board setup. The values of registers (for each measurement channel), board coefficients and parameters related to MCP3564R ADC can be changed.

A series of configurations have been set as follows:

- The board uses mikroBUS socket 2 for SPI communication.
- Data is acquired from all measurement channels (CH1 and CH2, voltage and current), and Internal Temperature Sensor.
- The MCP3564R Analog Input multiplexer (MUX) is configured to select the required inputs.
- ADC Oversampling Rate (OSR) is set to the maximum value (0b1111 corresponding to an OSR of 98,304).
- The ADC GAIN is set to 1 (no gain applied by default).
- The ADC uses the Internal Voltage Reference (2.4V) by default.
- A total of 50 samples are requested from each channel.

3.4 CALIBRATION PROCEDURE

The MCP3564R ADC includes a digital calibration feature to correct offset and gain errors. This calibration works by applying fixed offset and gain values to the ADC output code (stored in the ADCDATA register). For more details, see "*Two/Four/Eight-Channel, 153.6 ksps, Low Noise 24-Bit Delta-Sigma ADCs with Internal Voltage Reference*" (DS20006391C), sub-chapter 5.13 "Digital System Offset and Gain Calibrations".

To ensure accurate measurements, a calibration procedure has been implemented in Python. This procedure calculates the offset and gain errors, which are then used to determine the appropriate values for the OFFSETCAL and GAINCAL registers.

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The process requires the execution of two-point calibration measurements for each pair of channels (CH1 and CH2), specifically for voltage and current measurements at two points of 0V and 3000 mV, respectively 0A and 10 mA.

The script calculates the offset and gain errors by applying the equation of a straight line (y = mx + b) to two calibration points: the known (target) input values and the corresponding measured ADC output values. By comparing these pairs of values, the script determines the necessary corrections for both offset and gain.

The resulting calibration data is automatically saved in a JSON file for efficient record-keeping. After completing the calibration, the program calculates the appropriate values for the OFFSETCAL and GAINCAL registers of the MCP3564R ADC. These register values are essential for achieving precise measurements, as they are internally added to the ADCDATA register. With digital calibration enabled, the ADC uses these values to correct for gain and offset errors, ensuring accurate data acquisition, as determined in Equation 3-1.

EQUATION 3-1:

$$ADCDATA(\text{post-calibration}) = [ADCDATA(\text{pre-calibration}) + OFFSETCAL] \times GAINCAL$$

3.5 CONDITIONS

Both calibration and data acquisition measurements are based on the settings within the configuration data structure. If certain parameters are modified, both the calibration and data acquisition processes will follow the updated parameters in the structure.

To calibrate the MCP3564R ADC, it is recommended to maintain the initial settings. Specifically, a minimum of 50 samples should be acquired (for greater accuracy, acquiring 100 samples is advisable, although this will lengthen the procedure) at a maximum Oversampling Rate (OSR) of 98304 (0b1111), to ensure maximum resolution. When operating at the maximum OSR and with many samples, a longer conversion time is expected.

The required conversion time for data acquisition from the MCU is determined by the OSR, the internal clock of the ADC and the number of samples requested.

3.6 CONFIGURATION

The first step in the code is to establish a connection to the MCHP USB Bridge Service, then the board is connected to the service. Once the connection is successfully established, a confirmation message will appear in the terminal. Next, a read command is executed on the SPI interface to retrieve the values of the MCP3564R registers, which are then stored in a local object. Following this, a series of ADC registers are configured to perform the desired tasks. The digital calibration procedure is enabled by default and the corresponding ADC registers are set accordingly. Once all registers are configured, a write command is issued via SPI to update the registers with the specified values.

3.7 DATA ACQUISITION

After the configuration is complete, the `Start Conversion` command is executed, followed by a `Read Data` command on the SPI interface to collect data from all measurement channels through ADC. The acquired data is processed and displayed in the terminal. The data acquisition process runs continuously in a loop.

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Data acquisition is performed from all measurement channels (CH1 and CH2) for both voltage and current subsequential, as well as from internal temperature sensors. The measurements are processed and display the values in mV and mA. Additionally, electrical parameters are included to illustrate the board's performance.

The acquisition process is based on the configuration outlined in the data structure, specific OSR, ADC GAIN and other parameters are set as demonstrated in the Python code.

A series of transactions are executed by the MCU at precise time to provide the requested number of samples (using the communication structure: MCU <-> TCP/IP <-> Python Script).

Data acquisition can be conducted with calibration enabled, as is set by default, or disabled by modifying specific flag/variable in the configuration data structure.

Note: It is recommended to execute the calibration procedure first and use the digital calibration method for accurate measurements.

Chapter 4. Installation and Operation

4.1 INTRODUCTION

This chapter describes how to install the software solution to properly use the MCP3564R microCurrent Monitor.

4.2 HARDWARE REQUIREMENTS

Getting started requires the following components:

1. MCP3564R microCurrent Monitor (EV17G92A)
2. PIC32MZ Mixed Signal Data Capture Board (EV64F02A)
3. Additional:

- USB cable (provided with EV64F02A board)
- Jumpers (two are provided with MCP3564R microCurrent Monitor)

USB connectivity - physical requirement for the PC - standard type-A USB 2.0 port.

4.3 SOFTWARE REQUIREMENTS

A set of software packages requires installation before getting started:

1. PC with Microsoft® Windows® 10 or later
2. Windows Driver

- In case of manual installation: See "*MCHP USB to TCP Bridge Service User's Guide"* (50003749)

3. MCHP USB Bridge Service

- Tested with version v1.0.7
- To install the MCHP USB Bridge Service, download the installation package from http://www.microchip.com, under EV64F02A (PIC32MZ Mixed Signal Data Capture Board). Run the downloaded package and follow the instructions.
- See "*MCHP USB to TCP Bridge Service User's Guide*"

4. Additional information:

- Microsoft.NET Runtime 8.0 or later
  - Required by the MCHP USB Bridge Service (included in Service package if not present on system)

5. MCHP USB Bridge Bootloader Utility (integrated in MCHP USB Bridge Service)
   - Used to check or update the MCU firmware version through the bootloader
   - Tested with FW version 25.02.002
6. Python

- Tested with Python version 3.10.2

7. Project files from the Microchip product web page, under EV17G92A, MCP3564R microCurrent Monitor
8. Visual Studio Code or other compatible IDE (with Python language support)

Note: The user must follow the complete details presented in: "*MCHP USB to TCP Bridge Service User's Guide*" and *"EV64F02A Mixed Signal Data Capture Board User Guide*".

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4.4 SETUP

4.4.1 Hardware Setup

To set up the MCP3564R microCurrent Monitor with PIC32MZ Mixed Signal Data Capture Board, follow these steps:

1. Connect the MCP3564R microCurrent Monitor to mikroBUS socket 2, marked as number “2” on the PIC32MZ Mixed Signal Data Capture Board.
2. Place the jumpers over J1 connector from MCP3564R microCurrent Monitor as desired (it is not mandatory to select the jumper's position for this step).
3. Power on the PIC32MZ Mixed Signal Data Capture Board by plugging the micro-USB cable from the PC into connector J2 on the board.

Note: TheMCP3564R microCurrent Monitor can be connected to mikroBUS socket 1, which is labeled as “1” on the PIC32MZ Mixed Signal Data Capture Board. Socket 2 is used for the default software configuration, but the python script allows to change the socket number if needed.

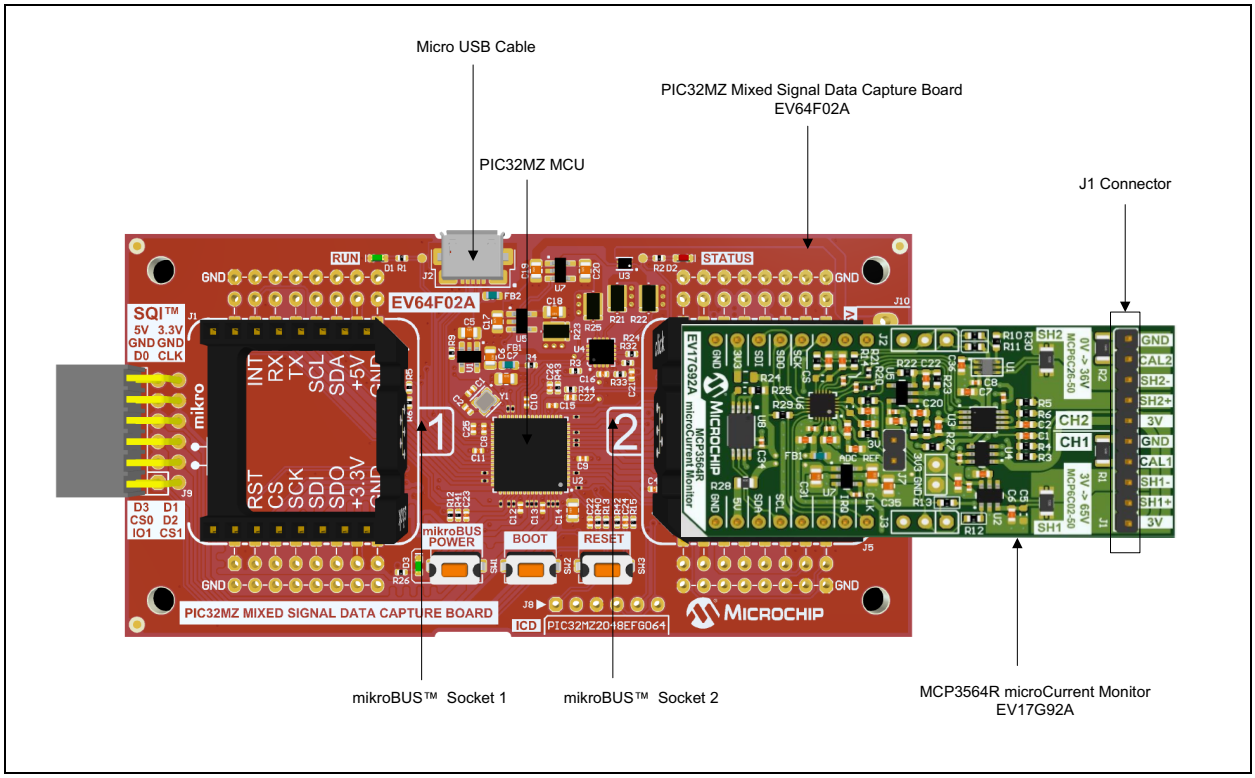

FIGURE 4-1: *Hardware Connection of the MCP3564R microCurrent Monitor to the PIC32MZ Mixed Signal Data Capture Board.*

4.4.2 Software Setup

After the hardware setup is done and the board is connected to PC, follow the next software requirements:

1. Start MCHP USB Bridge Service (in the Windows Service Management Tool)
   - go to Windows bar, open/write "Services", search for/click on "MCHP USB Bridge Service", then press "Start".

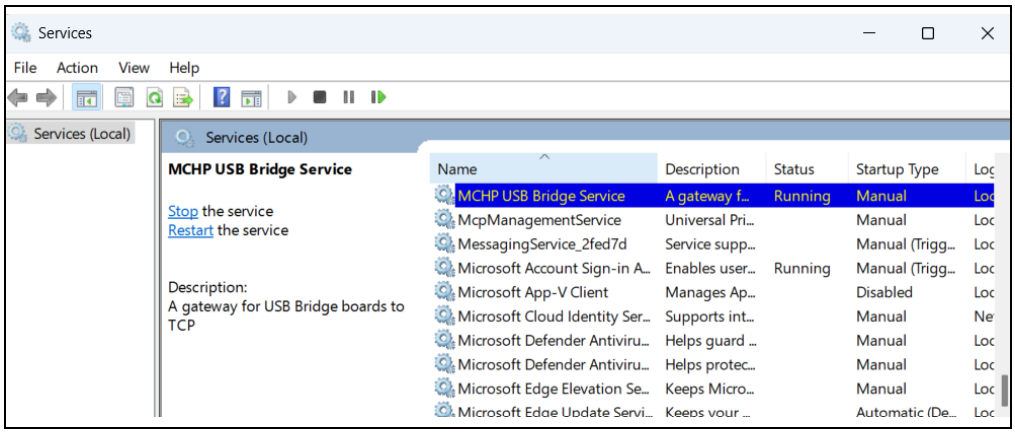

FIGURE 4-2: *MCHP USB Bridge Service Window - Running/Started.*

2. After the Service is started, check the status of the PIC32MZ Mixed Signal Data Capture Board.
3. Accessing the web interface:

- Open a web browser window and visit http://localhost:12110 to access the MCHP USB Bridge Bootloader Utility (the web interface of the MCHP USB Bridge Service).

4. Verifying board connection:

- When the PIC32MZ Mixed Signal Data Capture Board is connected to PC, the MCHP USB Bridge Bootloader Utility automatically detects the board and displays it in the: "Connected Board" or "Detected bootloaders" section.
- If the board is shown under "Connected Board":
  - Check the firmware version displayed on the web page under the "FW Version" section. If the firmware version is outdated (e.g., older than version 25.02.002), update it as described in **Section "Updating or uploading the firmware version (if required):"**. For more details, refer to the "*MCHP USB to TCP Bridge Service User's Guide*".
- If the board is shown under "Detected bootloaders":
  - A firmware upload is required - for more instructions, see **Section "Updating or uploading the firmware version (if required):"** or the "*MCHP USB to TCP Bridge Service User's Guide*".

5. Updating or uploading the firmware version (if required):

- Put the board into bootloader mode, if not already in that mode, by selecting the **Attempt DFU Reboot** button next to the board in the "Connected Boards" section of the utility. Once in DFU mode, the board will be removed from the "Connected Boards" section and added to the "Detected Bootloaders" section.
- In bootloader mode, the RUN and STATUS LEDs (red and green) on the PIC32MZ Mixed Signal Data Capture Board will blink. If the board is not in bootloader mode, these LEDs will not blink.
- The firmware is located in the directory where the MCHP USB Bridge Service was installed.For example: C:\Program Files\Microchip\usbBridgeService\firmware. The firmware is provided as a ZIP-compressed file, which is the required format

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for installation or updates.

- Click **Browse for firmware** in the utility, select the downloaded firmware file (located in the MCHP USB Bridge Service installation directory) and then press **Program** to update the firmware.
- After firmware update the board will appear under “Connected boards”.
- A restart of the service may be required after those steps.

6. Python script:

- After downloading the software files, open the project using the preferred integrated development environment (IDE).
- Navigate to the project directory, type `cmd` in the file explorer's address bar, and press <Enter> to open the Command Prompt. Once the Command Prompt is open, type `code`. and press <Enter>. This will launch Visual Studio Code with the project files loaded.

7. Setting up the development environment:

- Navigate to project directory in the terminal
- Use the following command to create a virtual environment:
  - `python -m venv env_name`, the last “`venv`” is the name of the environment and can have any name, for example `python -m venv myvenv`.

8. Activate the virtual environment:

– `env_name\Scripts\activate`

- The terminal prompt will usually indicate that the environment is active by prefixing the prompt with the environment name
- While the virtual environment is active, use pip to install necessary packages
- Create a requirements.txt file to list all project dependencies for easy installation later.

9. Run this command:

  - `pip freeze` - requirements.txt
  - `pip install` - r requirements.txt

- After installation is done, in the IDE bottom bar, click on python (Interpretar) and select the created virtual environment.

4.5 CALIBRATION PROCEDURE FOR MCP3564R ADC

Before running the script, the first step requires calibrating the MCP3564R ADC offset and gain errors. The calibration method is conducted at two measurement points:

- 0V and 3000 mV - for voltage
- 0A and 10 mA - for current

In the project file, there is a JSON file named Calib.json that contains the measured and calculated values for offset and gain.

The following set of measurements must be performed for each measurement channel, CH1 and CH2. The procedure involves the following steps:

1. Enter the calibration procedure.

- Check the MCHP USB Bridge Service to be started (in the Windows Service Management Tool), as described in **Section 4.4.2**.
- In the python project locate the Calib.json file.
  - in the first line: change the value of `calibrated: true` to `false`
  - `true` means the board is supposed to be calibrated and the parameters used for calibration are saved in the JSON file.
  - `false` means the board is not calibrated and the script will display the input

menu for calibration, instead of proceeding with data acquisition.

2. Next, run the main file (mcp3564r_data_acquisition.py) to initiate the calibration procedure.
3. The first message shows is the Service connection; the board is connected to the MCHP USB Bridge Service.
4. A calibration menu will then be displayed in the terminal and possible choices are displayed in Table . The system provides four selection options, numbered 0 to 3, each corresponding to a specific measurement channel. Once the desired channel is selected — for example, 1 for Voltage Channel CH1 — the system prompts for a calibration point, offering two options: 0 or 1. The appropriate calibration point is then selected, such as 0 to indicate 0V measurements.

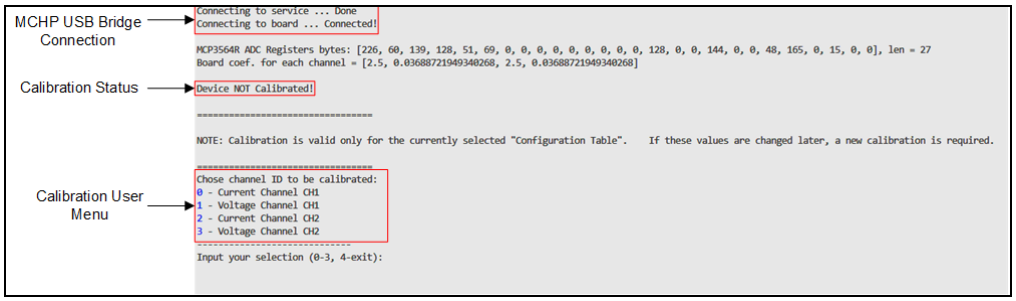

FIGURE 4-3: *Calibration User Menu.*

5. The jumper must be inserted in accordance with the selected measurement, as specified in Table , column "MCP3564R Board J1 Header Jumpers Positions".
6. The program measures the selected channel at selected measurement point.
7. Afterward, the system stores the obtained results in the JSON file under the appropriate "measured_val_x" section, based on the selected measurement channel. For example, if Channel 1 (Voltage CH1) is selected, the measured value is recorded under the group with "Channel name": "CH1 Voltage:" in the field "measured_val_1": 75.16313210772807. For details, refer to Figure 4-2.
8. Upon completion of the measurements on the selected channel, the value "4" must be entered to close the procedure. The process then resumes from Step 2 for each remaining channel, at both calibration points, until all measurements are completed and stored in the JSON file.

TABLE 4-1: INPUT CALIBRATION MENU - INPUT SELECTION AND HARDWARE JUMPERS ON J1 HEADER

Channel ID Selection	Corresponding Channel Name	Calibration Point Selection	Corresponding Calibration Value	MCP3564R Board J1 Connector Jumpers Positions
0	CH1 – Current	0	0 mA	SH1+ and 3V
		1	10 mA	SH1+ and 3V SH1+ and CAL1
1	CH1 – Voltage	0	0 mV	No jumpers
		1	3000 mV	SH1+ and 3V
2	CH2 – Current	0	0 mA	SH2+ and 3V
		1	10 mA	SH2+ and 3V SH2- and CAL2
3	CH2 – Voltage	0	0 mV	SH2- and CAL2
		1	3000 mV	SH2+ and 3V SH2- and CAL2
4*	Exit – Exit option/ Stop script execution			

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The calibration must be conducted using the following configuration: the oversampling ratio (OSR) is set to its maximum value, with the number of requested samples fixed at 50, as defined by default in the data structure table. Any modification to this table directly impacts the calibration procedure. Figure 4-2 illustrates a section of the Calib.json file, detailing the organization of data utilized during the calibration process.

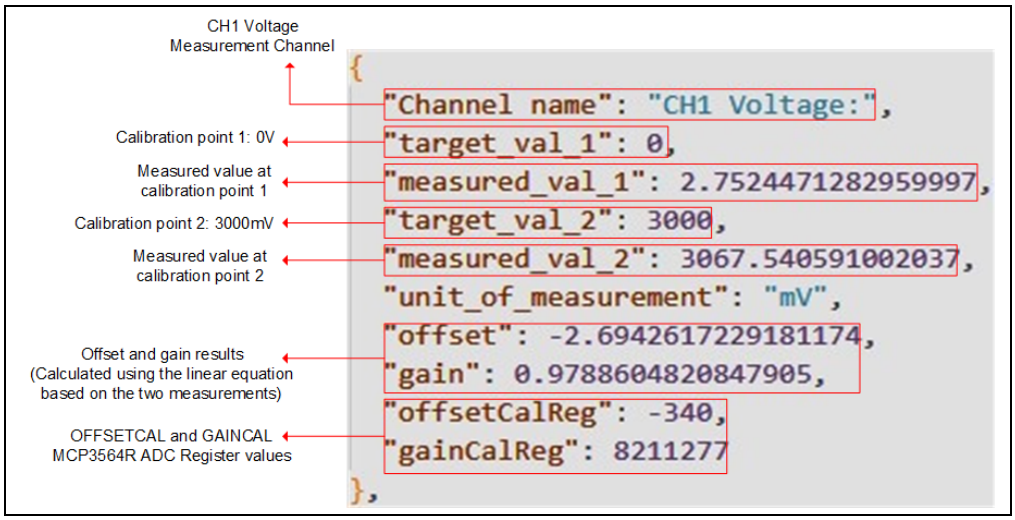

FIGURE 4-4: *Calib.json File - Structure.*

Note: If the calibration procedure is omitted, the system uses the already stored values in the Calib.json file. These values were obtained from a specific board and variations occur between boards due to component tolerance. Such practice is not recommended.

4.6 DATA ACQUISITION - CURRENT AND VOLTAGE MEASUREMENTS

After completing the calibration procedure, the data acquisition and measurement process using the board can begin by following these steps:

1. Exit the calibration procedure:

In the Python code, locate the Calib.json file and modify the first line by changing "calibrated": false to "calibrated": true.

2. Apply the input signal or configure onboard measurement:

Apply the desired voltage or current to the J1 header, ensuring compliance with the hardware range. Alternatively, place the jumper as specified in Table 4-1 to measure or test the available on-board options following calibration.

3. Prepare the acquisition script:

Open the mcp3564r_data_acquisition.py file and locate the data structure table. Parameters can be adjusted as necessary or left unchanged. The number of samples to be acquired from the ADC via SPI can also be modified; the default is set to 50. Increasing the sample count extends the acquisition time, particularly if the calibration settings remain unchanged.

4. Execute the acquisition script:

Run the mcp3564r_data_acquisition.py script to initiate the data acquisition process. The terminal first displays the connection status, followed by the real-time measurements and calculations.

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By completing these steps, the measurement process is successfully initiated and data is collected. Figure 4-3 presents a terminal output example showing measurements from all channels – CH1 and CH2 – for both voltage and current (e.g., 3000 mV and 10 mA), along with the internal ADC temperature.

```
CH1 Current : Mean for 30 samples = 9.97396 mA -> Peak to Peak = 43.373 uA -> Peaks from Mean Value = -23.21/+20.16 uA
    Standard Deviation = 12.4 uA | SNR (dB): 58.23 dB
CH1 Voltage : Mean for 30 samples = 2999.95374 mV -> Peak to Peak = 333.514 uV -> Peaks from Mean Value = -198.30/+135.22 uV
    Standard Deviation = 81.5 uV | SNR (dB): 91.47 dB
CH2 Curent : Mean for 30 samples = 10.05664 mA -> Peak to Peak = 43.030 uA -> Peaks from Mean Value = -15.71/+27.32 uA
    Standard Deviation = 9.3 uA | SNR (dB): 60.81 dB
CH2 Voltage : Mean for 30 samples = 2999.82732 mV -> Peak to Peak = 364.538 uV -> Peaks from Mean Value = -219.24/+145.30 uV
    Standard Deviation = 86.7 uV | SNR (dB): 90.93 dB
Internal Temperature : Temperature = 28.273 C
```

FIGURE 4-5: *Data Acquisition from CH1 and CH2 Measurements Channels.*

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Appendix A. Schematic and Layouts

A.1 INTRODUCTION

This appendix contains the following schematics and layouts for the MCP3564R microCurrent Monitor:

- Board Schematic - Connectivity
- Board - Top Silk Layer
- Board - Top Copper and Silk Layer
- Board - Top Copper Layer
- Board - Bottom Copper Layer
- Board - Bottom Copper And Silk Layer
- Board - Bottom Silk Layer

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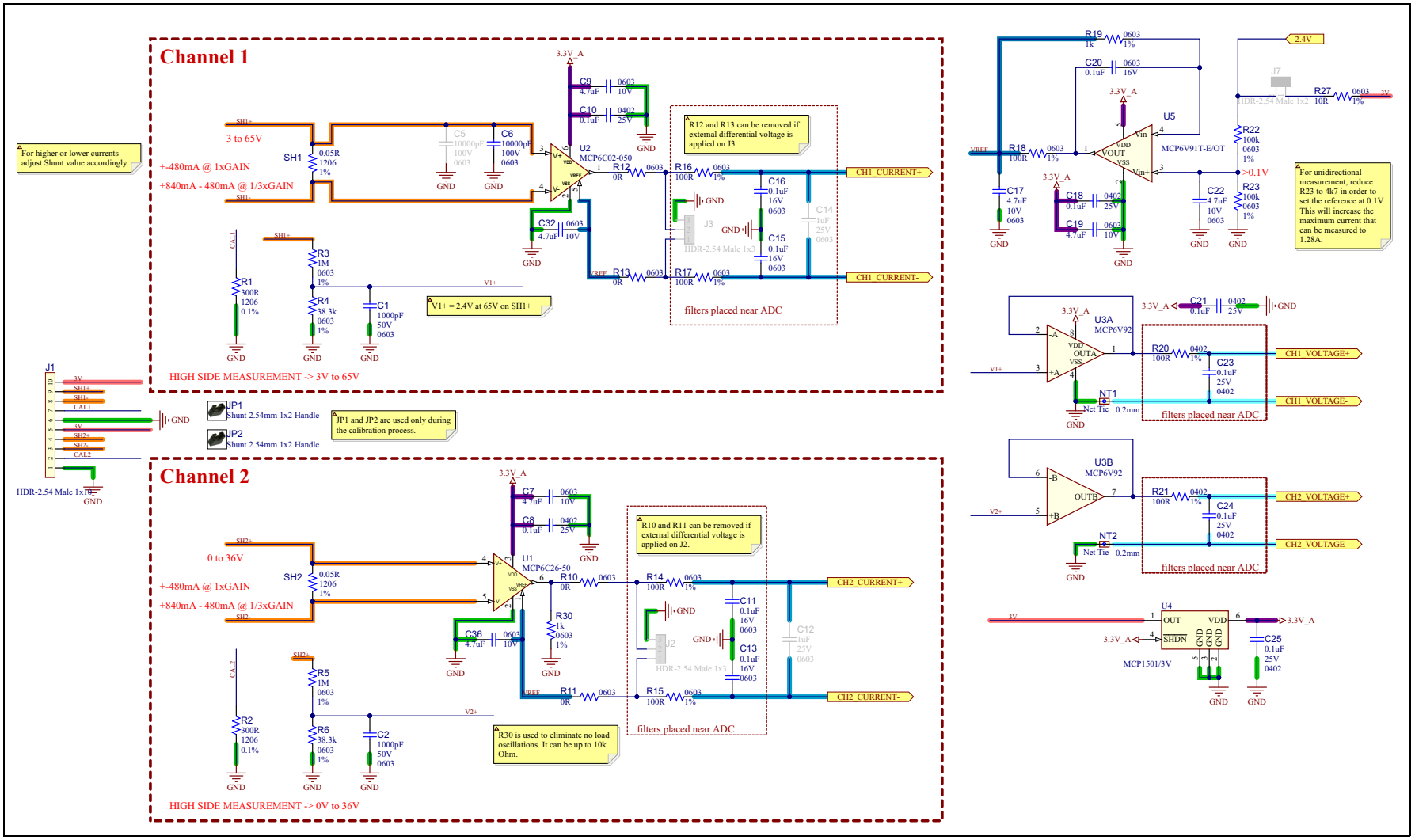
A.2 BOARD SCHEMATIC - CONNECTIVITY



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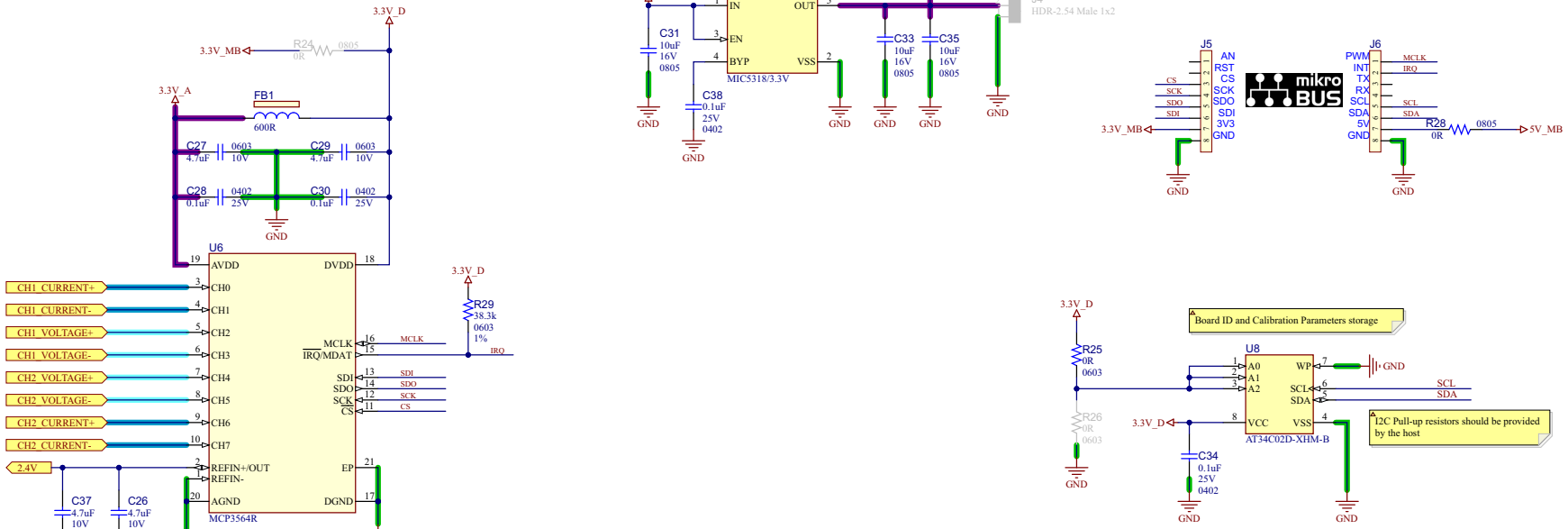
A.3 BOARD - TOP LAYER SILK



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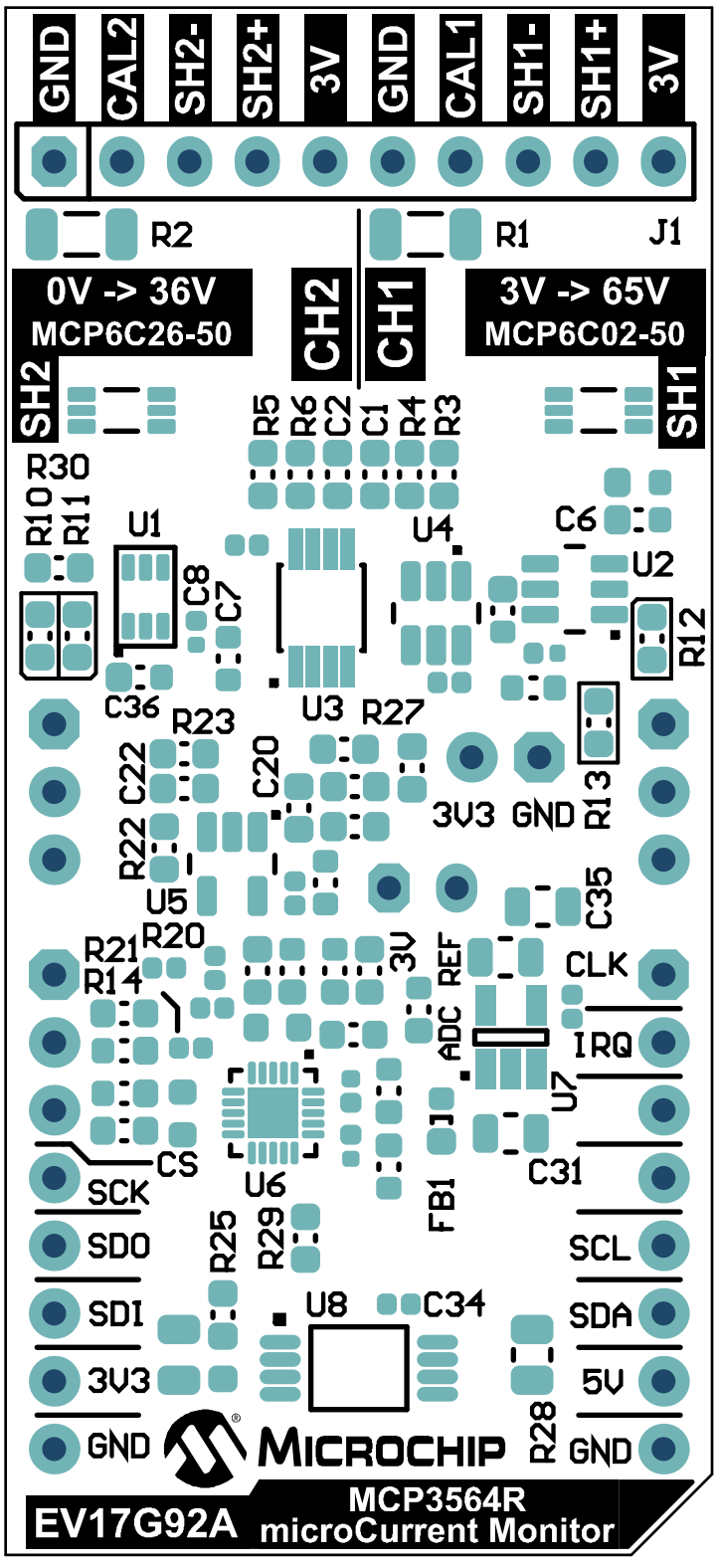
A.4 BOARD - TOP SILK LAYER



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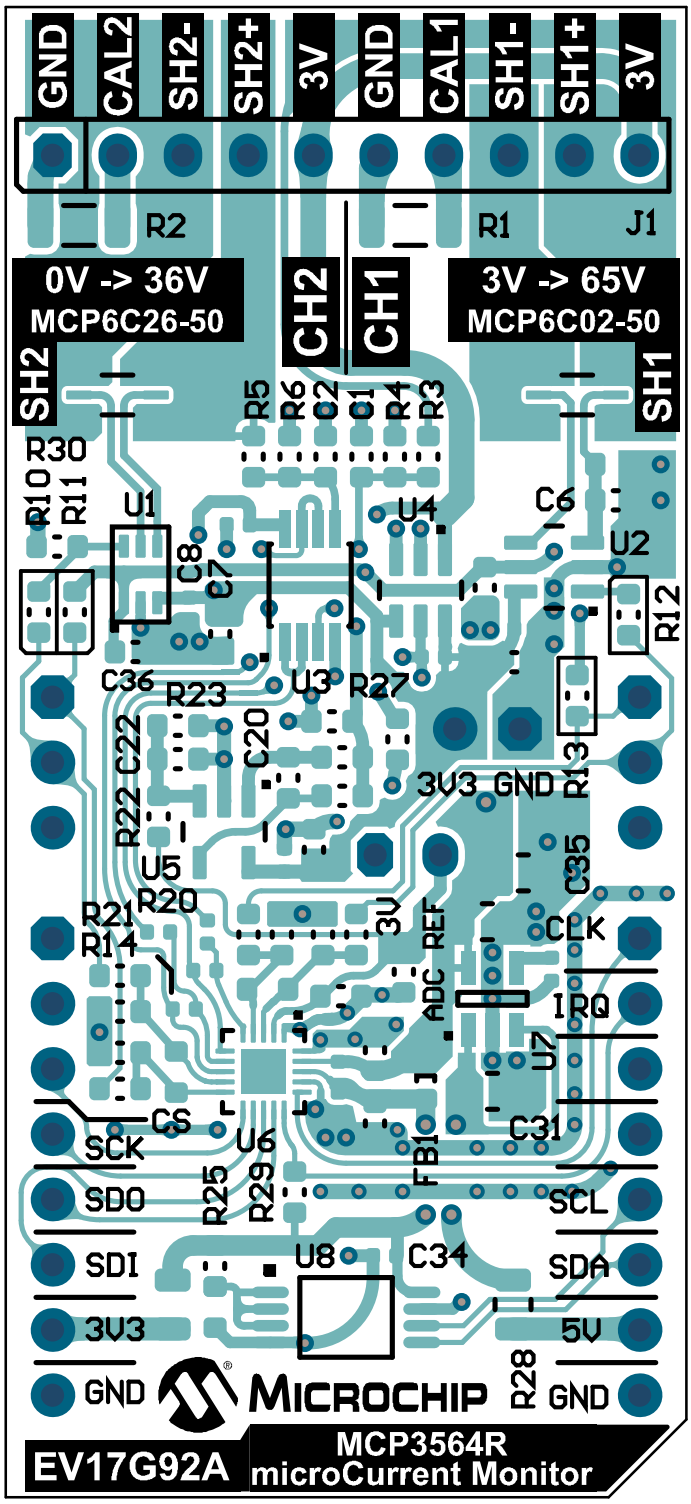
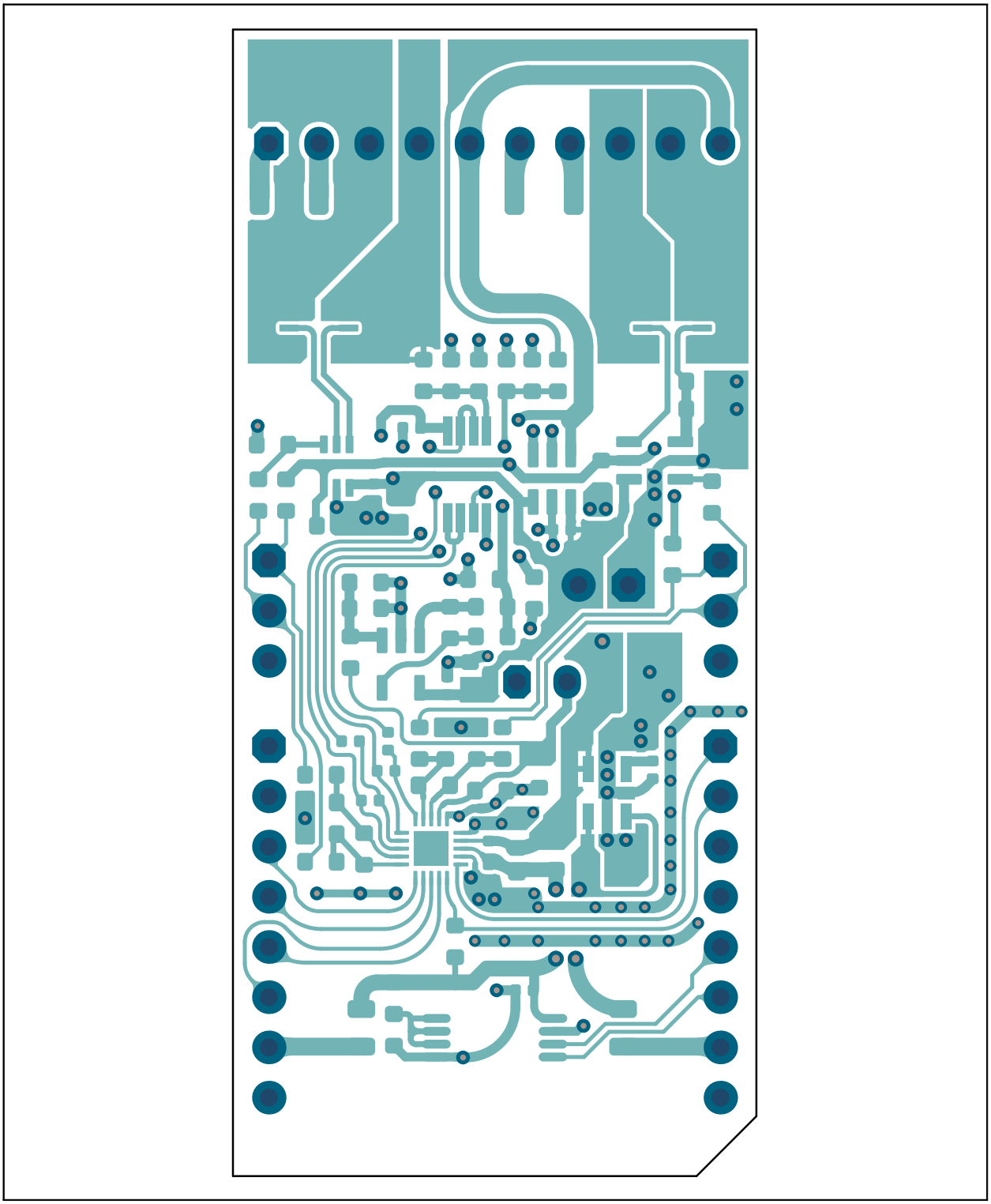
A.5 BOARD - TOP COPPER AND SILK LAYER



A.6 BOARD - TOP COPPER LAYER



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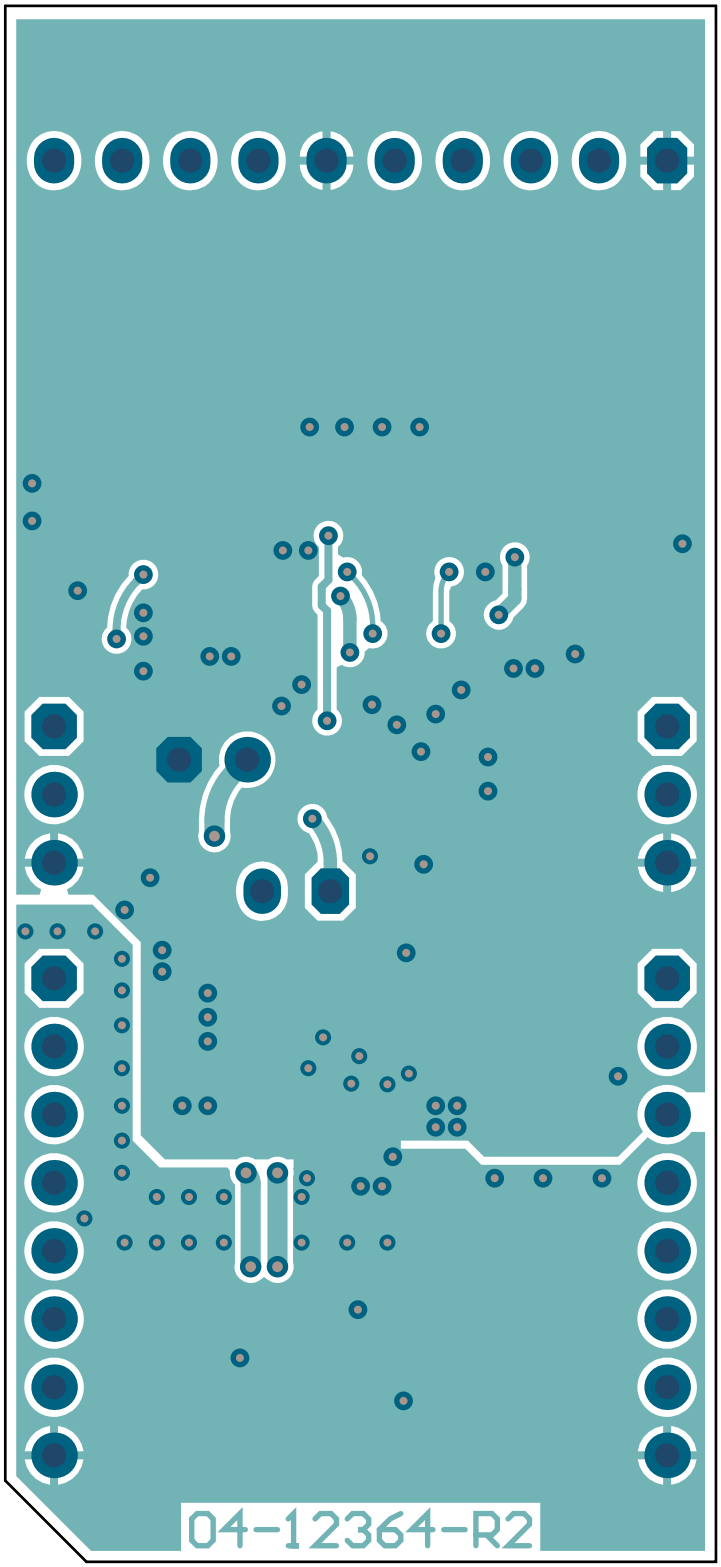
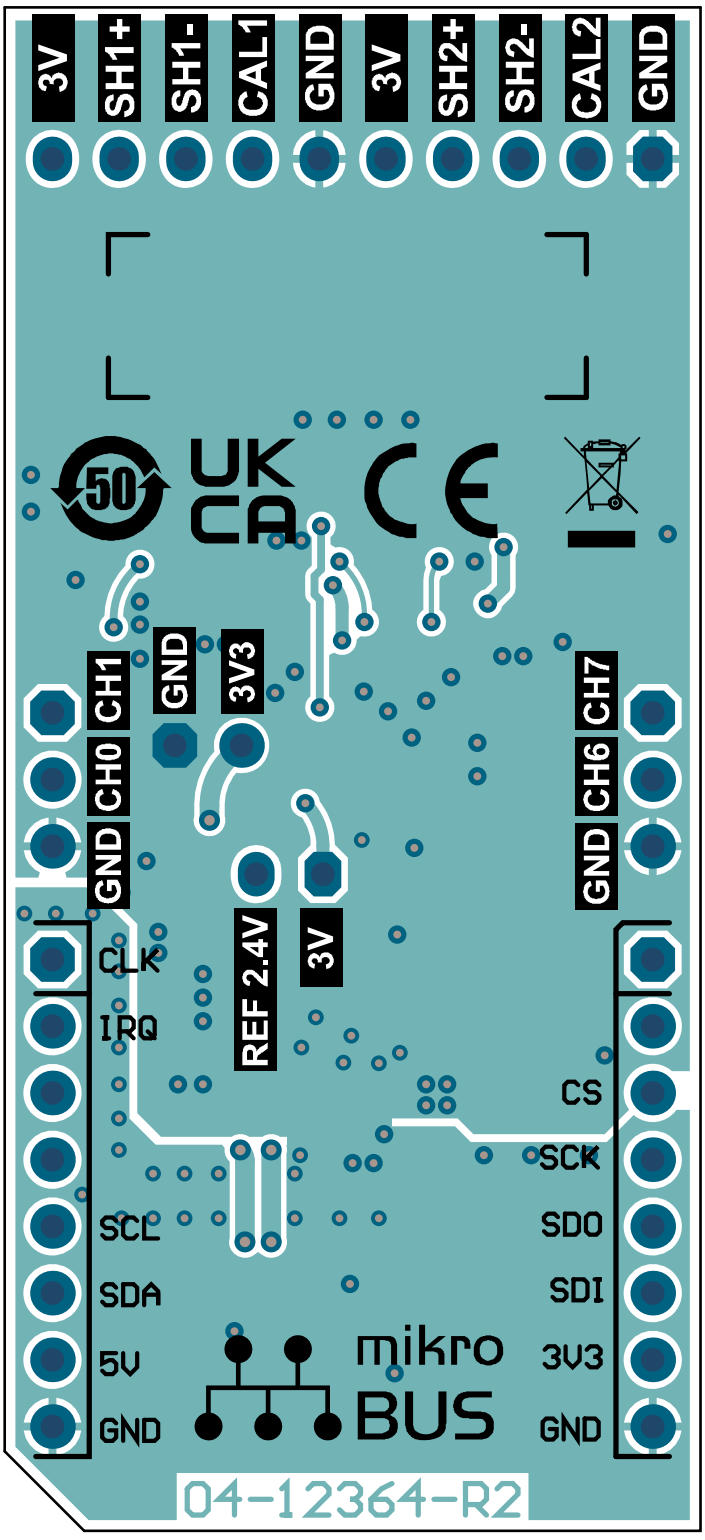
A.7 BOARD - BOTTOM COPPER LAYER



A.8 BOARD - BOTTOM COPPER AND SILK LAYER



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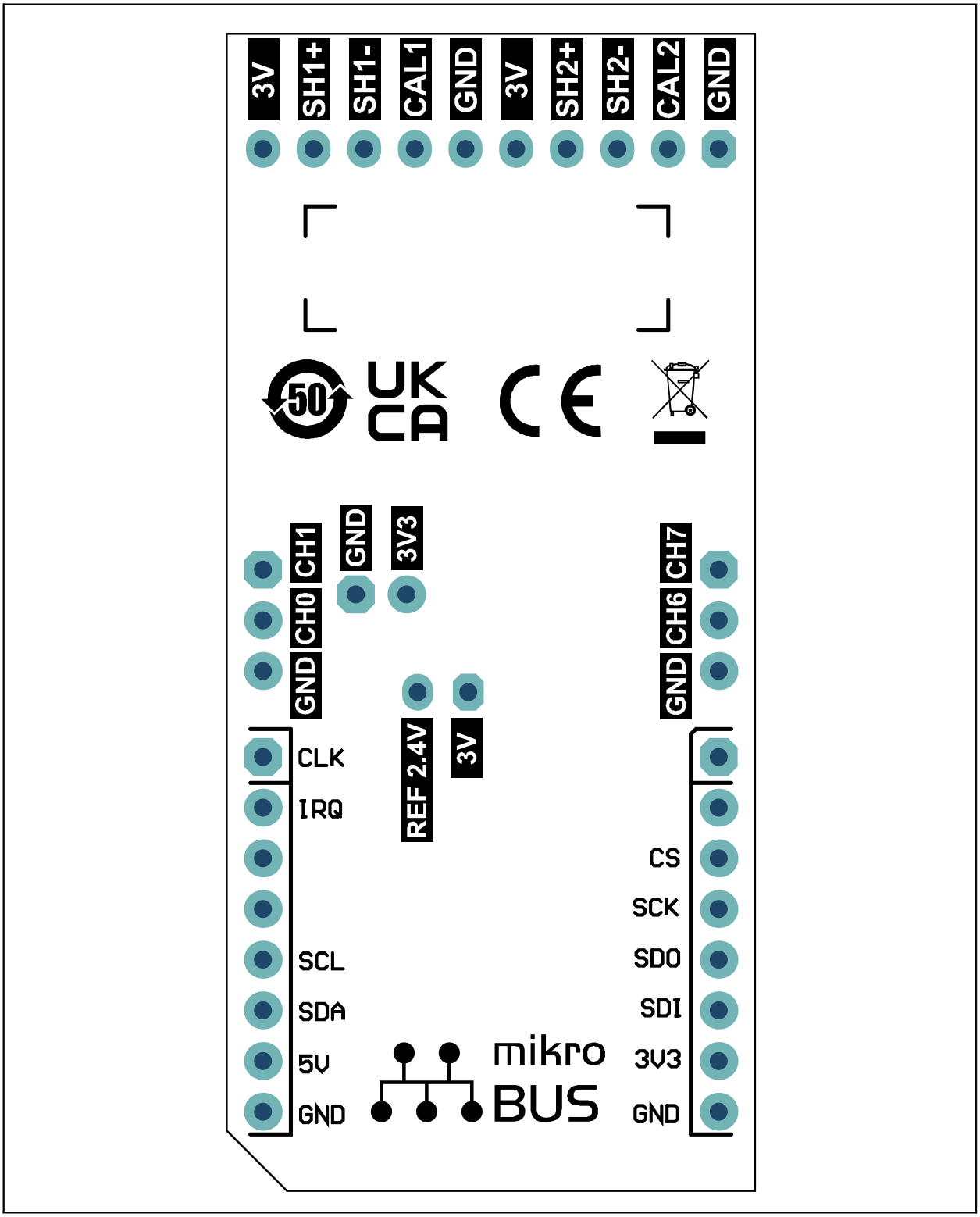
A.9 BOARD - BOTTOM SILK LAYER



Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS

Qty	Reference	Description	Manufacturer	Part Number
2	C1, C2	Ceramic capacitor, 1000 pF, 50V, ±10%, X7R, Surface Mount, 0603	Samsung Electro-Mechanics America, Inc.	CL10B102KB8NNNC
1	C6	Ceramic capacitor, 10000 pF, 100V, ±10%, X7R, Surface Mount, 0603	YAGEO Group	CC0603KRX7R0BB103
11	C7, C9, C17, C19, C22, C26, C27, C29, C32, C36, C37	Ceramic capacitor, 4.7 µf, 10V, ±20%, X7R, Surface Mount, 0603	Murata Electronics®	GRM188Z71A475ME15D
11	C8, C10, C18, C21, C23, C24, C25, C28, C30, C34, C38	Ceramic capacitor, 0.1 µF, 25V, ±10%, X7R, Surface Mount, 0402	Samsung Electro-Mechanics America, Inc.	CL05B104KA5NNNC
5	C11, C13, C15, C16, C20	Ceramic capacitor, 0.1 µF, 16V, ±10%, X7R, Surface Mount, 0603	YAGEO Group	CC0603KRX7R7BB104
3	C31, C33, C35	Ceramic capacitor, 10000 pF, 100V, ±10%, X7R, Surface Mount, 0603	Taiyo Yuden Co., Ltd.	EMK212BJ106KG-T
0	C5	Ceramic capacitor, 0.1 µF, 16V, ±10%, X7R, Surface Mount, 0603 – **Do not populate**	YAGEO Group	CC0603KRX7R0BB103
0	C12, C14	Ceramic capacitor, 1 µF, 25V, ±10%, X7R, Surface Mount, 0603 – **Do not populate**	Samsung Electro-Mechanics America, Inc.	CL10B105KA8NNNC
1	FB1	Ferrite bead, 600Ω, 100 MHz, 1A, Surface Mount,0603	Würth Elektronik	742792651
1	J1	Connector, header, 2.54 mm, male, 1x10, 5.84 mm mating length, Through Hole, vertical	Molex®, LLC	90120-0130
0	J2, J3	Connector, header, 2.54 mm, male, 1x2, gold, 5.84 mm mating length, Through Hole, Vertical – **Do not populate**	Amphenol Communications Solutions	68000-103HLF
2	J5, J6	Connector, header, 2.54 mm, male, 1x8, gold, 5.84 mm mating length, Through Hole	Amphenol ICC (FCI)	68001-108HLF
2	JP1, JP2	Headers and wires, mechanical, 2.54 mm, 1x2	Sullins Connector Solutions	STC02SYAN

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TABLE B-1: BILL OF MATERIALS (CONTINUED)

Qty	Reference	Description	Manufacturer	Part Number
0	J4, J7	Connector, header, 2.54 mm, male, 1x2, gold, 5.84 mm mating length, Through Hole, vertical – **Do not populate**	Würth Elektronik	
1	LABEL1	Label, PCBA, 18x6 mm, Datamatrix Assy# / Rev / Serial / Date	ACT Logimark AS	505462
1	PCB1	MCP3564R microCurrent Monitor Evaluation Board - Printed Circuit Board	Microchip Technology, Inc.	**04-12364-R2**
1	PCBA1	PCB Assembly	Microchip Technology, Inc.	**02-01301-R2**
2	R1, R2	Resistor, Thick Film, ±0.1%, 1/4W, Surface Mount, 1206	YAGEO Group	RT1206BRD07300RL
2	R3, R5	Resistor, Thick Film, 1 MΩ, ±1%, 1/10W, Surface Mount, 0603	Panasonic Industry Co., Ltd.	ERJ-3EKF1004V
3	R4, R6, R29	Resistor, Thick Film, 38.3 kΩ, ±1%, 1/10W, Surface Mount, 0603	Panasonic Industry Co., Ltd.	ERJ-3EKF3832V
5	R10, R11, R12, R13, R25	Resistor, Thick Film, 0Ω, ±1%, 1/10W, Surface Mount, 0603	Stackpole Electronics Inc.	RMCF0603ZT0R00
5	R14, R15, R16, R17, R18	Resistor, Thick Film, 100Ω, ±1%, 1/10W, Surface Mount, 0603, Automotive AEC-Q200	YAGEO Group	AC0603FR-07100RL
2	R19, R30	Resistor, Thick Film, 1 kΩ, ±1%, 1/10W, Surface Mount, 0603, Automotive AEC-Q200	YAGEO Group	RC0603FR-071KL
2	R20, R21	Resistor, Thick Film, 100Ω, ±1%, 1/10W, Surface Mount, 0402, Automotive AEC-Q200	KOA Speer Electronics, Inc.®	RK73H1ETTP1000F
2	R22, R23	Resistor, Thick Film, 100 kΩ, ±0.1%, 1/10W, Surface Mount, 0603	Panasonic Industry Co., Ltd.	ERA-3AEB104V
0	R24	Resistor, Thick Film, 0Ω, 1/8W, Surface Mount, 0805 – **Do not populate**	YAGEO Group	RC0805JR-070RL
0	R26	Resistor, Thick Film, 0Ω, 1/8W, Surface Mount, 0805 – **Do not populate**	Stackpole Electronics, Inc.	RMCF0603ZT0R00
1	R27	Resistor, Thick Film, 10Ω, ±1%, 1/10W, Surface Mount, 0603, Automotive AEC-Q200	Stackpole Electronics, Inc.	RMCF0603FT10R0
1	R28	Resistor, Thick Film, 0Ω, 1/8W, Surface Mount, 0805	YAGEO Group	RC0805JR-070RL
2	SH1, SH2	Resistor, Thick Film, 0.05Ω, 1%, 1W, Surface Mount, 1206	Vishay® Dale	WSLP1206R0500FEA
1	U1	Integrated Circuit, Current Sense Amplifier, Zero-Drift, SC-70-6	Microchip Technology, Inc.	**MCP6C26T-050E/LTY**
1	U2	High-Side Current Sense Amplifier, Analog, SOT-23-6	Microchip Technology, Inc.	**MCP6C02T-050E/CHY**
1	U3	Operational Amplifier, 2-Channel, 10 MHz, Analog, MSOP-8	Microchip Technology, Inc.	**MCP6V92-E/MS**

TABLE B-1: BILL OF MATERIALS (CONTINUED)

Qty	Reference	Description	Manufacturer	Part Number
1	U4	Voltage Reference, Integrated Circuit, 3V, ±0.1%, 20 mA, SOT-23-6	Microchip Technology, Inc.	**MCP1501T-30E/CHY**
1	U5	Operational Amplifier, 1-Channel, 10 MHz, Analog, SOT-23-5	Microchip Technology, Inc.	**MCP6V91T-E/OT**
1	U6	Analog-to-Digital Converter, 24-Bit, Delta-Sigma, 20-UQFN	Microchip Technology, Inc.	**MCP3564RT-E/NC**
1	U7	Linear Voltage Regulator, Low Drop Out, Integrated Circuit, 3.3V, 300 mA, TSOT-23-5	Microchip Technology, Inc.	**MIC5318-3.3YD5-TR**
1	U8	Electrically-Erasable and Programmable Read Only Memory, Integrated Circuit, I^2C, 1 MHz, TSSOP-8	Microchip Technology, Inc.	**AT34C02D-XHM-B**

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