

# User's Guide

## TMAG5328 Evaluation Module

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### ABSTRACT

This user's guide describes the characteristics, operation, and use of the TMAG5328 evaluation module (EVM). This EVM is designed to evaluate the performance of the TMAG5328. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the TMAG5328EVM. This document includes a schematic, reference printed circuit board (PCB) layouts, and a complete bill of materials (BOM).

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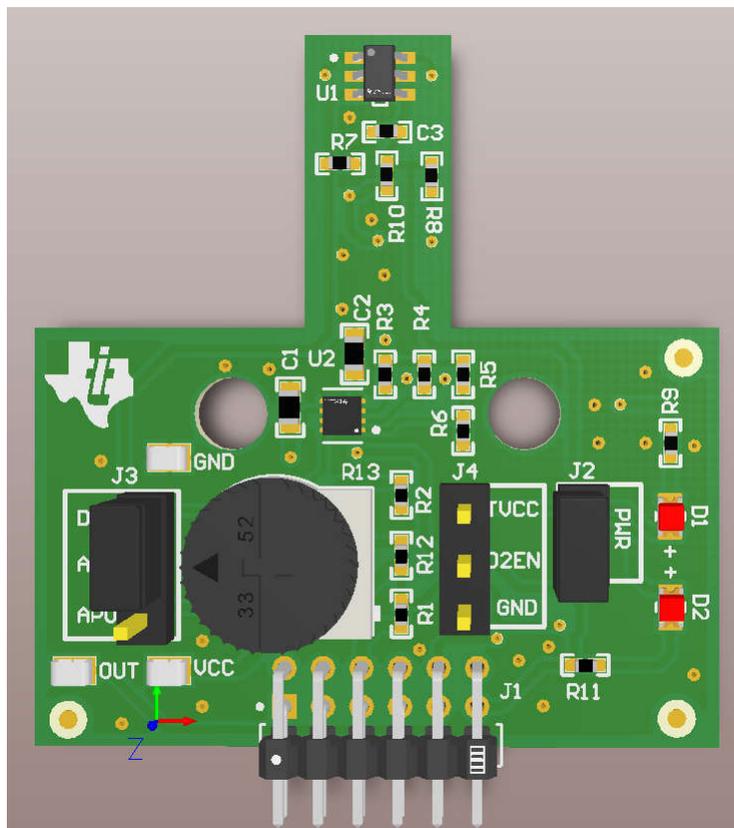
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## 1 Overview

The TMAG5328 is a resistor-adjustable device where the internal magnetic threshold sensitivity ( $B_{OP}$ ) varies with the value of the external resistor connected to the “ADJ” pin of the device. When the applied magnetic flux density exceeds the  $B_{OP}$  threshold, the device outputs a low voltage. The output stays low until the flux density decreases to less than the release point ( $B_{RP}$ ), then the output drives a high voltage. The  $B_{OP}$  is selectable to be anywhere between the 2-mT to 15-mT range. This device allows designing a platform of systems with multiple sensitivities with only one Hall sensor, thereby reducing device inventory management and facilitating prototyping by enabling  $B_{OP}$  adjustment after assembly. As an alternative to setting the  $B_{OP}$  directly with a resistor, the  $B_{OP}$  can also be set by directly applying a voltage on the ADJ pin, assuming that the voltage source can properly sink the current generated internally on the ADJ pin.

The TMAG5328EVM is an easy-to-use platform for evaluating the performance of the TMAG5328. This EVM supports adjusting the  $B_{OP}$  using four options: a fixed resistor, a potentiometer for creating an adjustable resistance, the DAC43701 DAC for creating an adjustable voltage, or an external voltage source. [Figure 1-1](#) shows the EVM. The [Sensor Controller Board \(SCB\)](#) interfaces the EVM to the PC GUI. Note that the SCB is sold separately from the TMAG5328EVM.



**Figure 1-1. TMAG5328 Evaluation Module**

The EVM is intended to provide basic functional evaluation of the devices. The layout is not intended to be a model for the target circuit, nor laid out for electromagnetic compatibility (EMC) testing.

## 1.1 Features

This EVM includes the following features:

- Supports multiple options for setting  $B_{OP}$ 
  - GUI-controlled DAC (requires Sensor Controller Board for initialization)
    - Sets voltage on TMAG5328 ADJ pin to create desired  $B_{OP}$
    - Enables dynamically changing  $B_{OP}$  by changing DAC output voltage
    - Nonvolatile memory on DAC can store DAC output voltage setting to support future operation without GUI or Sensor Controller Board
  - Potentiometer
    - Sets resistance on TMAG5328 ADJ pin to create desired  $B_{OP}$
    - Enables dynamically changing  $B_{OP}$  by adjusting potentiometer position
  - Resistor footprint for creating a static  $B_{OP}$
  - External voltage supply
- LED on TMAG5328 output for visual inspection of switch's output state
- Flexible TMAG5328 power supply options
  - 3.3-V rail from Sensor Controller Board: Enables evaluation without external power supply
  - External power supply: TMAG5328 powered independently from Sensor Controller Board, which enables testing the TMAG5328 at other voltages than 3.3 V
- 3D-printed magnetic attachment included in kit for facilitating magnetic testing

## 2 Kit Contents

Table 2-1 lists the contents of the EVM kit. Contact the nearest [Texas Instruments Product Information Center](#) if any component is missing.

**Table 2-1. Kit Contents**

ITEM	QUANTITY
TMAG5328EVM	1
Handheld magnet	1
<a href="#">Head-on Linear Displacement 3D print module</a>	1

## 3 Related Documentation From Texas Instruments

This user's guide is available from the TI website under literature number [SBAU376](#). Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions are available from [www.ti.com](http://www.ti.com) or the Texas Instruments' Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number. Table 3-1 lists documentation related to the EVM. Click the links in Table 3-1 for further information. The device name links to the product web folder on [www.ti.com](http://www.ti.com). The literature number links to the document PDF.

**Table 3-1. Related Documentation**

DOCUMENT TITLE	DOCUMENT LITERATURE NUMBER
TMAG5328 data sheet	<a href="#">SLYS044</a>

## 4 Hardware

Figure 4-1 shows a schematic snippet of the TMAG5328 portion of the TMAG5328EVM. The EVM supports adjusting  $B_{OP}$  with three on-board options: a GUI-controlled DAC, a potentiometer, or a fixed resistor. The different  $B_{OP}$  options are selected based on the configuration of resistor R7 and header J3 in Figure 4-1. The EVM also has other headers and test points for further configuring the EVM.

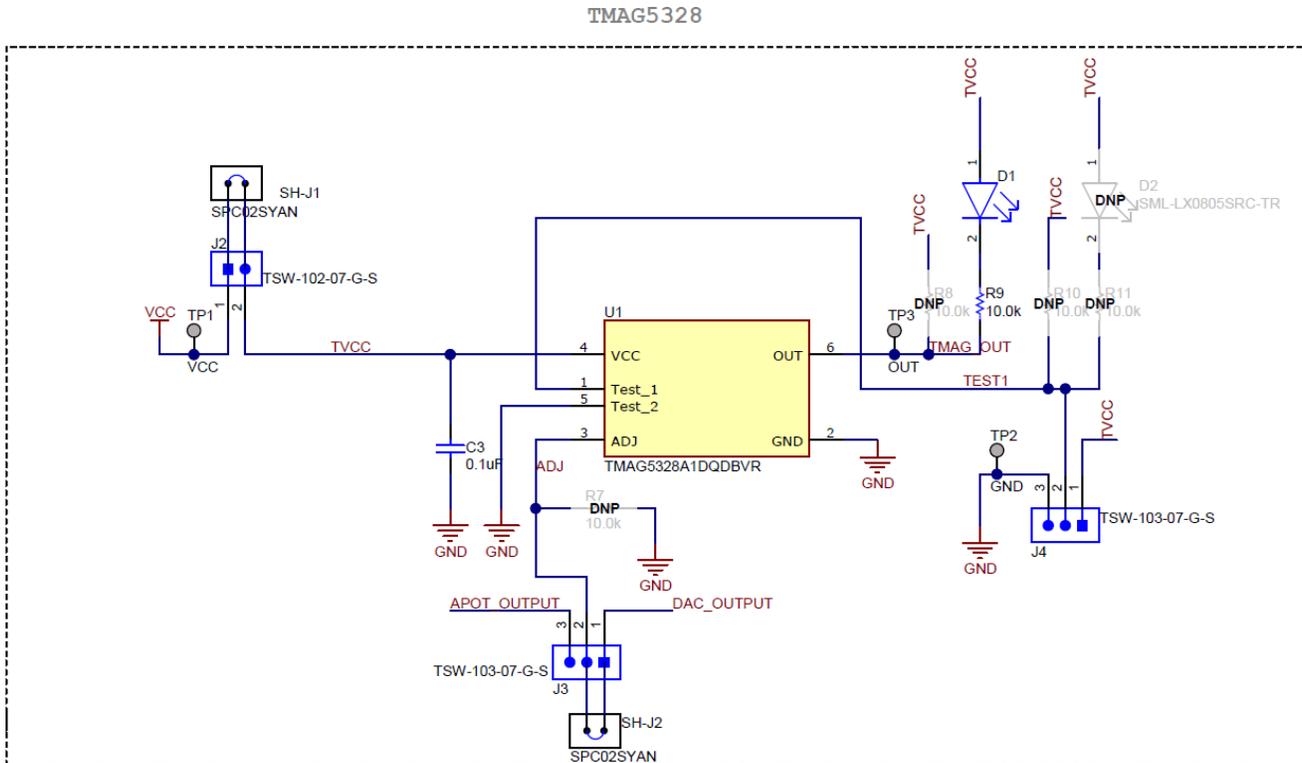


Figure 4-1. Schematic Snippet of TMAG5328 Portion of TMAG5328EVM

### 4.1 EVM Threshold Adjustment Options

#### 4.1.1 Adjusting Threshold With DAC

One option for setting the  $B_{OP}$  of the TMAG5328 is to use the onboard DAC43701 DAC to output a voltage on the TMAG5328 ADJ pin. The DAC43701 is an 8-bit voltage-output DAC with nonvolatile memory and I<sup>2</sup>C interface. The nonvolatile memory retains the set values in the absence of a power supply. As a result, if the DAC output settings are stored in the nonvolatile memory of the DAC, a microcontroller does not need to reconfigure the DAC after each reset. The DAC43701 can set the  $B_{OP}$  of the TMAG5328 without using the SCB afterward if the desired DAC output voltage was previously stored in the nonvolatile memory of the device. The SCB and GUI is only needed for the initial programming of the DAC voltage and the storing of this voltage into nonvolatile memory.

The DAC43701 also has an internal reference option feature that is used in the TMAG5328EVM. By using the internal reference, the output voltage of the DAC does not change drastically across power supply voltage as long as the power supply voltage for the DAC43701 is anywhere within the recommended 1.8V to 5.5V range.

Use Equation 1 to translate the voltage on the ADJ pin into the  $B_{OP}$  setting:

$$B_{OP} = 0.0125 \times \text{ADJ}_{\text{voltage}} \quad (1)$$

where:

- $B_{OP}$  is in units of mT

- ADJ<sub>voltage</sub> is in units of mV

As an example, if 680mV is applied to the ADJ pin, then the B<sub>OP</sub> is set to 8.5mT.

The TMAG5328 ADJ pin can accept a voltage from 0.16V to 1.2V. To stay within this voltage range, the GUI verifies that the DAC output voltage cannot be set outside of the 0.16V to 1.2V range.

The GUI allows setting the DAC voltage based on the following options:

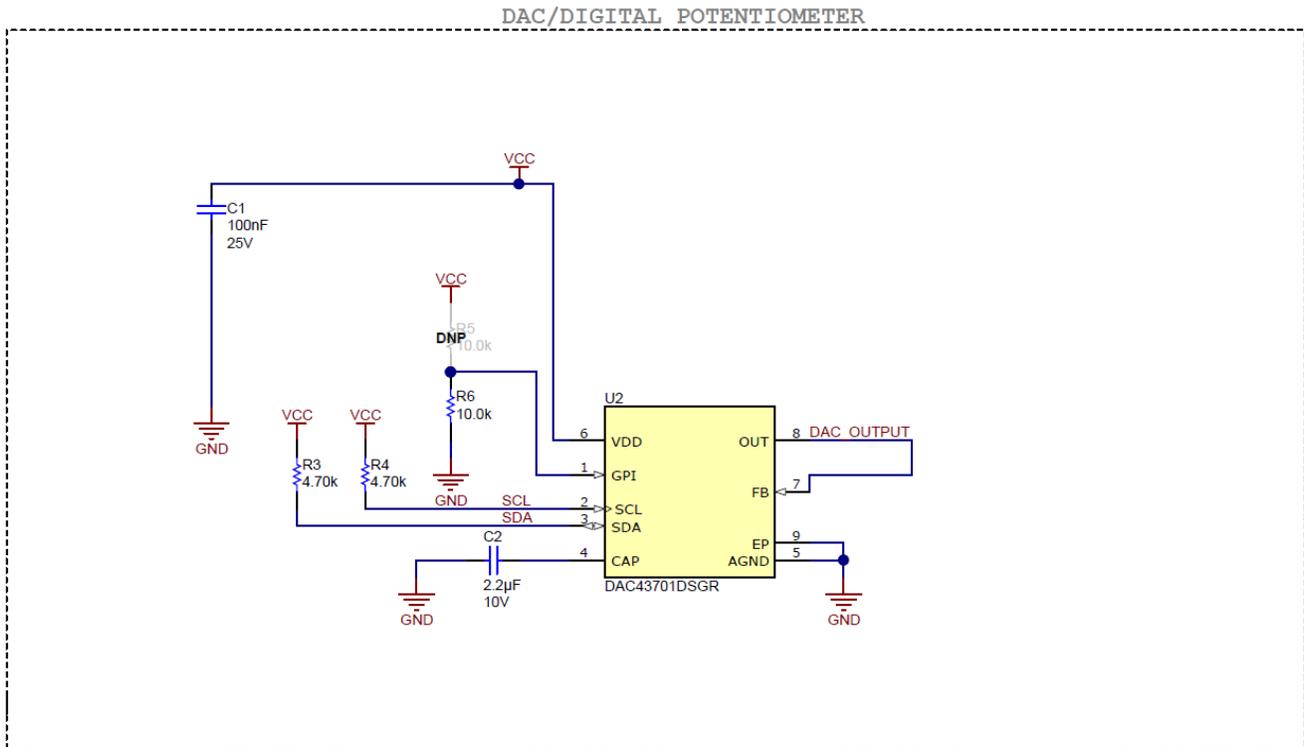
- **The magnetic flux density currently sensed by the TMAG5328:** For this option, the DAC determines the sensed magnetic flux density by sweeping the voltage on the ADJ pin from 1.2V (15mT) to 0.16V (2 mT) and then finding the first DAC code that causes the output of the TMAG5328 to assert low. This first DAC code is converted back into the corresponding DAC output voltage and then the corresponding B<sub>OP</sub> using the equation above. If the TMAG5328 is asserted low after applying 1.2V to the ADJ pin, then the sensed magnetic flux density is greater than the maximum 15-mT B<sub>OP</sub> supported by the device. If the TMAG5328 is still asserted high even after applying 0.16V to the ADJ pin, the sensed magnetic flux density is less than the minimum 2-mT B<sub>OP</sub> supported by the device.
- Manually inputting one of the parameters below (the GUI only enables one of these parameters at a time):
  - **Desired B<sub>OP</sub>**
  - **Desired voltage on the ADJ pin**
  - **ADJ equivalent resistance:** This setting simulates applying a resistor on the ADJ pin by applying a voltage that creates the same B<sub>OP</sub> as the input resistance.

The GUI also calculates an equivalent resistance value based on the DAC output voltage. The equivalent resistance value is the resistance value for the [fixed-resistor threshold adjustment option](#) that generates the same B<sub>OP</sub> as the currently set DAC output voltage. The equivalent resistance calculation allows the GUI to use the DAC to precisely determine the required ADJ resistance value that is needed in a final system that does not have a DAC.

[Figure 4-2](#) shows a schematic snippet of the DAC43701 portion of the TMAG5328EVM. The schematic snippet below is also compatible with the DAC43701, which is the 10-bit version of the DAC43701. In addition, the snippet is also compatible with the TPL1401, which is an 8-bit digital potentiometer device.

To select the DAC option for setting B<sub>OP</sub>, the DAC output must be connected to the ADJ pin, which is done by the following steps:

- Do not populate resistor R7.
- Connect a jumper between the "DAC" (pin 1) and "ADJ" (pin 2) pins of header J3.



**Figure 4-2. Schematic Snippet of DAC43701 Portion of TMAG5328EVM**

#### 4.1.2 Adjusting Threshold With Potentiometer

The  $B_{OP}$  of the TMAG5328 can also be set with the analog potentiometer that is on the EVM. To select the potentiometer option for setting  $B_{OP}$ , the potentiometer must be connected to the ADJ pin, which is done by the following steps:

- Do not populate resistor R7.
- Connect a jumper between the "APOT" (pin 3) and "ADJ" (pin 2) pins of header J3.

Use [Equation 2](#) to translate the resistance between the ADJ and GND pins into the  $B_{OP}$  setting:

$$B_{OP} = ADJ_{resistance} \quad (2)$$

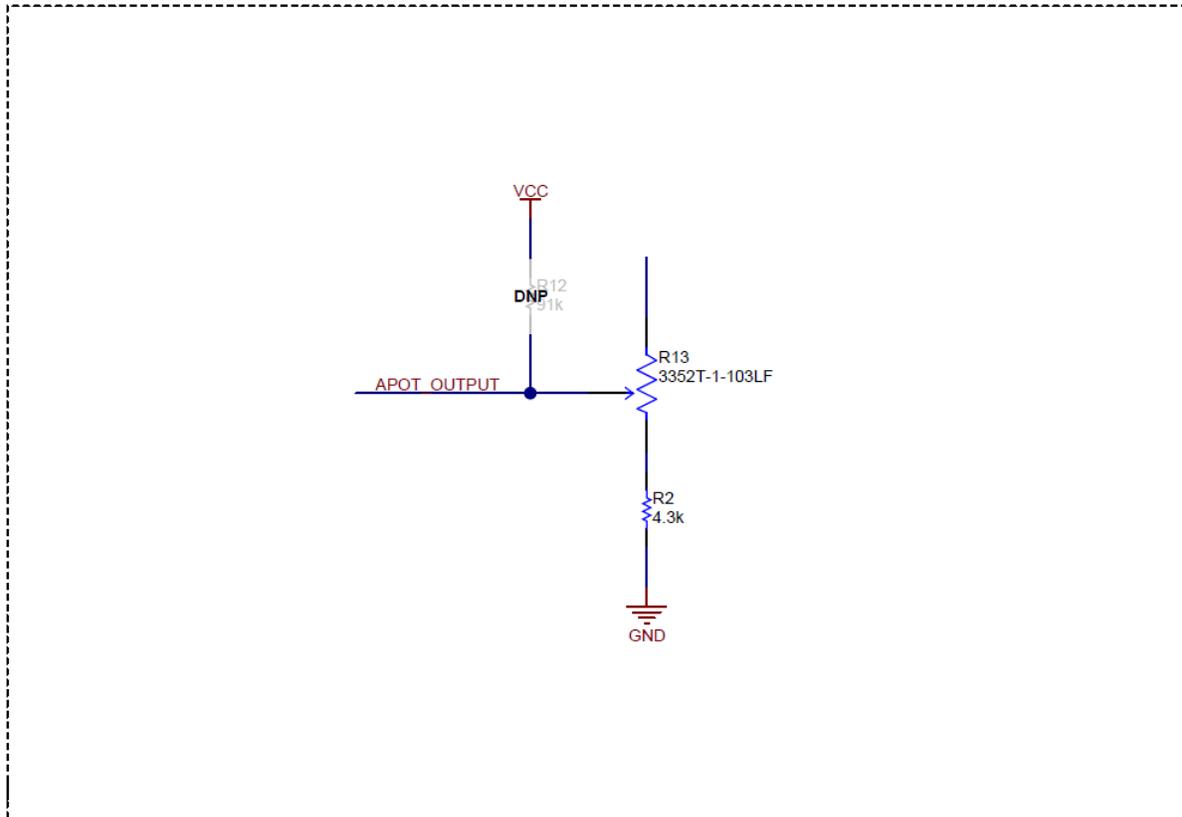
where:

- $B_{OP}$  is in units of mT
- $ADJ_{resistance}$  is in units of  $k\Omega$

As an example, if the resistance between ADJ and GND is 8.  $k\Omega$ , then the  $B_{OP}$  is set to 8.5mT.

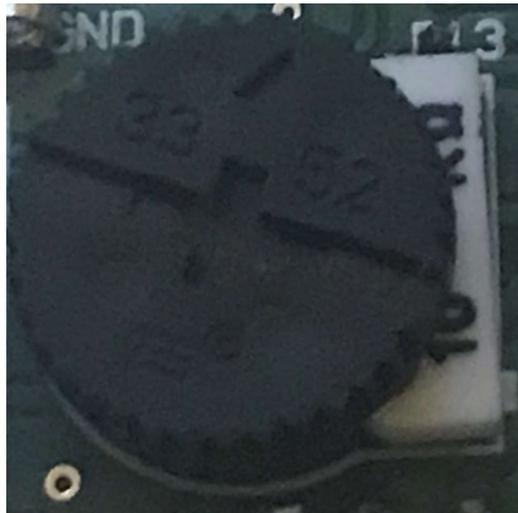
[Figure 4-3](#) shows the schematic snippet for the potentiometer portion of the EVM. This circuit consists of a 10k $\Omega$  potentiometer (R13) in series with a 4.3k $\Omega$  fixed resistor (R2). When the potentiometer is used for setting the  $B_{OP}$ , the ADJ pin sees a resistance equal to the sum of resistances R2 and R13. As a result, the ADJ pin can detect a resistance somewhere between 4.3k $\Omega$  to 14.3k $\Omega$ , depending on the position of the potentiometer. The 4.3k $\Omega$  to 14.3k $\Omega$  resistance range corresponds to a  $B_{OP}$  of 4.3 mT to 14.3mT. A 10-k $\Omega$  potentiometer is used, therefore the potentiometer only simultaneously covers a 10mT range of  $B_{OP}$  settings. The resistor R2 can be modified, however, to select which  $B_{OP}$  options are supported. As an example, if you want to support a 2mT to 12mT range, then the user can replace R2 with a 2k $\Omega$  resistor. Similarly, if the user wants to support a 5mT to 15mT range, then replace R2 with a 5k $\Omega$  resistor.

## ANALOG POTENTIOMETER

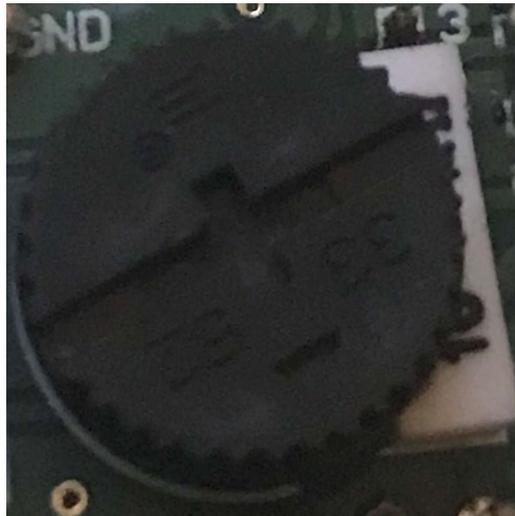


**Figure 4-3. Schematic Snippet of Potentiometer Portion of TMAG5328EVM**

Turning the potentiometer counterclockwise increases the resistance. [Figure 4-4](#) and [Figure 4-5](#) show the potentiometer positions that correspond to an ADJ resistance of 4.3k $\Omega$  and 14.3k $\Omega$ , respectively.



**Figure 4-4. Potentiometer Position for Creating 4.3k $\Omega$  ADJ Resistance**



**Figure 4-5. Potentiometer Position for Creating 14.3kΩ ADJ Resistance**

#### 4.1.2.1 Using the Potentiometer to Estimate the Magnetic Flux Density Sensed by the TMAG5328

Similar to sweeping the DAC output voltage to find the sensed magnetic flux density, an estimate of the sensed magnetic flux density can also be found by sweeping the potentiometer resistance by adjusting the position. In this approach, the potentiometer is placed to create the maximum resistance (Figure 4-5). If the output of the TMAG5328 is not asserted high (LED is OFF) for this potentiometer position, then replace R2 with a 5kΩ resistor. If the output is still not asserted high after replacing R2, then the sensed magnetic flux density is greater than the 15mT maximum magnetic flux density that can be sensed by the TMAG5328.

If the output of the TMAG5328 does in fact get asserted high when the maximum resistance is applied to the ADJ pin, then slowly turn the potentiometer clockwise until the output of the TMAG5328 first gets asserted low (LED is ON). As soon as the output gets asserted low, stop turning the potentiometer. The resistance between the ADJ pin and GND pin can then be measured and entered into the equation above to determine the TMAG5328's sensed magnetic flux density. If the potentiometer has been fully turned clockwise (Figure 4-4) and the output still does not get asserted low, replace R2 with a 2kΩ resistor. If the output is still not asserted low after replacing R2, then the sensed magnetic flux density is less than the 2mT minimum magnetic flux density that is able to be sensed by the TMAG5328.

Since the potentiometer is not affected by power resets, the potentiometer make sure that the same  $B_{OP}$  is used after a power reset, assuming that the position is not moved. As a result, the potentiometer option can be used regardless if the SCB board is connected or not. If the position of the potentiometer is accidentally changed, however, then  $B_{OP}$  changes. To make sure that the  $B_{OP}$  does not change, one option is to measure the resistance between the ADJ pin and GND pin and then use this resistor with the Section 4.1.3. When making these resistance measurements, make sure to do the resistance measurement when the system is not powered.

#### 4.1.3 Adjusting Threshold With Fixed Resistor

Another option for setting  $B_{OP}$  is to place a resistor on footprint R7 (see Figure 4-1). The R7 resistance is the resistance seen between the ADJ and GND pin of the TMAG5328. You must select a resistance within the 2kΩ to 15kΩ range.

If the user wants to select the fixed resistor option for setting  $B_{OP}$ , then remove the jumper on J3 so that the DAC, potentiometer or anything else that is not connected to the ADJ pin.

## 4.2 Power Supply Options and Jumper Settings

The TMAG5328 in this EVM can be powered from either the main power rail on the board, which is labeled as VCC on the board, or can be powered from an external power supply that is independent of the main power rail of the board. To power the TMAG5328 from the VCC rail, add a jumper on pins 1 and 2 of header J2. By adding the jumper to J2, the TMAG5328 is powered from the same power supply as the DAC43701. If the SCB is connected to the TMAG5328EVM, then the SCB provides 3.3V on VCC, so an external power supply must not

be connected to VCC in this scenario. If the SCB is not connected to the TMAG5328EVM, however, then VCC can be connected to an external power supply by connecting the external power supply between the VCC and GND test points. In this scenario, the external power supply voltage must be set to somewhere within 1.8V to 5.5V, which is within the normal power supply voltage range of both the DAC43701 and TMAG5328.

To power the TMAG5328 from an external power supply that is independent of the board's main power rail, remove the jumper on J2 and connect J4 Pin 1 (labeled TVCC on the board) to the positive terminal of a power supply and then connect the ground of the board to the negative terminal of the power supply. This configuration enables powering the TMAG5328 from a different power supply than the DAC and the SCB. The TMAG5328 power supply voltage must be set to be within 1.65V to 5.5V, which is the normal power supply voltage range of the TMAG5328.

Various jumper headers and jumper settings are present to add to the flexibility to the board. Some of these headers require that jumpers be placed appropriately for the board to correctly function. [Table 4-1](#) shows the functionality of each header on the board.

**Table 4-1. Header Names and Jumper Settings**

Header Name	Type	Main Functionality	Valid Use-Cases
J1	2 x 6 pin header	Connection to SCB	<p>To connect the TMAG5328EVM to the SCB, connect this male header to the female J1 header on the SCB. The pin mappings on this header include the following (even pins are on the top row and odd pins are on the bottom row):</p> <ul style="list-style-type: none"> <li>• Pin 4: GND</li> <li>• Pin 6: VCC (3.3V provided by SCB)</li> <li>• Pin 9: TMAG5328 Output</li> <li>• Pin 10: DAC43701 SCL I2C communication signal</li> <li>• Pin 11: Not used</li> <li>• Pin 12: DAC43701 SDA I2C communication signal</li> </ul>
J2	2-pin jumper header	PWR: TMAG5328 power select	<ul style="list-style-type: none"> <li>• Place a jumper here to power the TMAG5328's power rail, which is labeled on the EVM as TVCC, to the VCC rail on the board.</li> <li>• If the user needs to power the TMAG5328 from an external power supply that is independent of the DAC and SCB, then remove the jumper here and connect the external power supply between J4 Pin 1 and GND. This option allows testing the TMAG5328 at voltages other than the 3.3V provided by the SCB.</li> </ul>

**Table 4-1. Header Names and Jumper Settings (continued)**

Header Name	Type	Main Functionality	Valid Use-Cases
J3	3-pin jumper header	Threshold Adjustment Option Selection	<ul style="list-style-type: none"> <li>Place a jumper between the "ADJ" (pin 2) and "DAC" (pin 1) positions to use the DAC to set the <math>B_{OP}</math>. Make sure that resistor R7 is not populated. See <a href="#">Section 4.1.1</a> for more details.</li> <li>Place a jumper between the "ADJ" (pin 2) and "APOT" (pin 3) positions to use the potentiometer to set the <math>B_{OP}</math>. Make sure that resistor R7 is not populated. See <a href="#">Section 4.1.2</a> for more details.</li> <li>To set the <math>B_{OP}</math> using a fixed resistor, remove the jumper on this pin so that no jumper is populated. Add a resistor to R7 based on the desired <math>B_{OP}</math>. This resistor should be between 2 k<math>\Omega</math> to 15k<math>\Omega</math>. See <a href="#">Section 4.1.3</a> for more details.</li> <li>To set the <math>B_{OP}</math> using an external voltage source, remove the jumper on this pin so that no jumper is populated and also make sure that resistor R7 is not populated. The external power supply must be connected between the "ADJ" (pin 2) pin and GND. The applied voltage must be between 0.16V to 1.2V. In addition, the voltage source must be able to sink 80<math>\mu</math>A of current within 4<math>\mu</math>s for proper operation.</li> </ul>
J4	3-pin header	Probe here for TVCC and GND.	Probe here for TVCC (pin 1) and GND (pin 3). If a jumper is pressed on J2, TVCC is connected to VCC on the board. To power the TMAG5328 from an external power supply that is independent of VCC, remove the jumper header on J2 and connect the external bench power supply between TVCC and GND.

## 5 EVM Operation

The EVM can be evaluated using two options. The first option involves using the SCB and GUI. The second option involves using the TMAG5328EVM without the SCB and GUI so that the TMAG5328EVM operates as a stand-alone board. For both of these options, the Head-on module (Section 5.3) can be used to facilitate magnetic testing.

### 5.1 Evaluation With SCB and GUI

To use the EVM with the SCB, connect the EVM as shown in Figure 5-1.

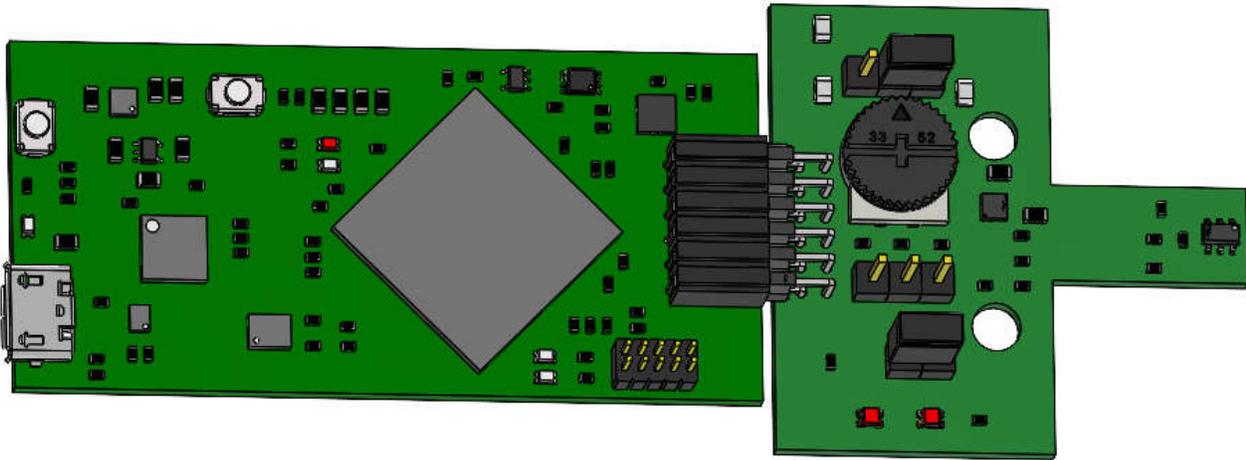


Figure 5-1. Sensor Control Board Connected to TMAG5328EVM

#### 5.1.1 Driver Installation

Before using the SCB, download and install this driver: <http://www.ti.com/lit/zip/sbac253>. This is a one-time step per computer. Unzip the folder and run the .exe file with administrator privileges.

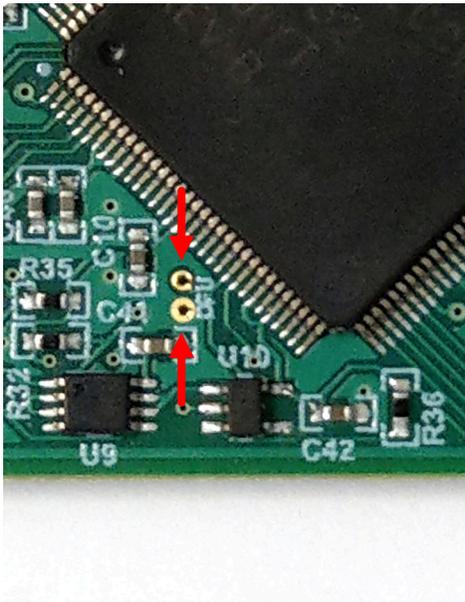
#### 5.1.2 Firmware

The firmware must be flashed onto the SCB to properly communicate to the TMAG5328EVM. After flashing the SCB with the TMAG5328EVM, the firmware does not have to be reflashed on the SCB as long as the firmware is not erased or replaced with the firmware for a different EVM. If the firmware is erased or replaced, the TMAG5328EVM firmware must be flashed onto the SCB again to communicate to the TMAG5328EVM. The latest version of the firmware can be downloaded from: <https://www.ti.com/lit/zip/sbac297>. It can also be downloaded onto the SCB from the GUI.

##### 5.1.2.1 Updating Firmware on SCB

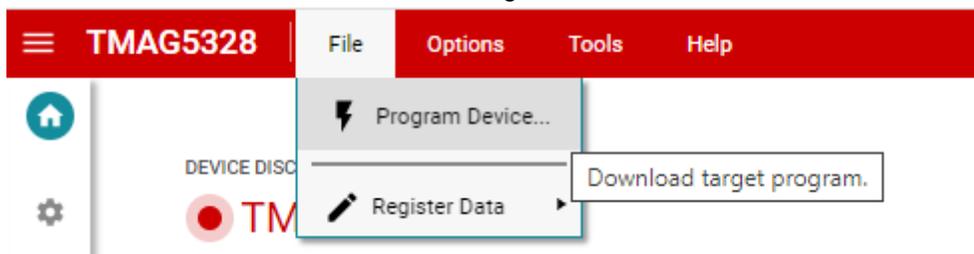
Follow these steps to install the firmware.

1. Configure the MCU on the SCB to be in Device Firmware Update (DFU) Mode. DFU mode can be entered manually through one of the following methods while the SCB is powered on:
  - a. Through software:
    - Send the command "bsl" on the SCB's USB Serial (COM) port.
  - b. Through hardware (with the EVM removed):
    - Short the two test points labeled *DFU* (see Figure 5-2) with a pair of tweezers (or wire) while pressing the RESET button. If this is done correctly, LED D1 on the SCB turns OFF while LED D5 (the power LED) is still ON. If LED D1 is still ON, then the GUI firmware is still active and the device has not entered DFU mode.



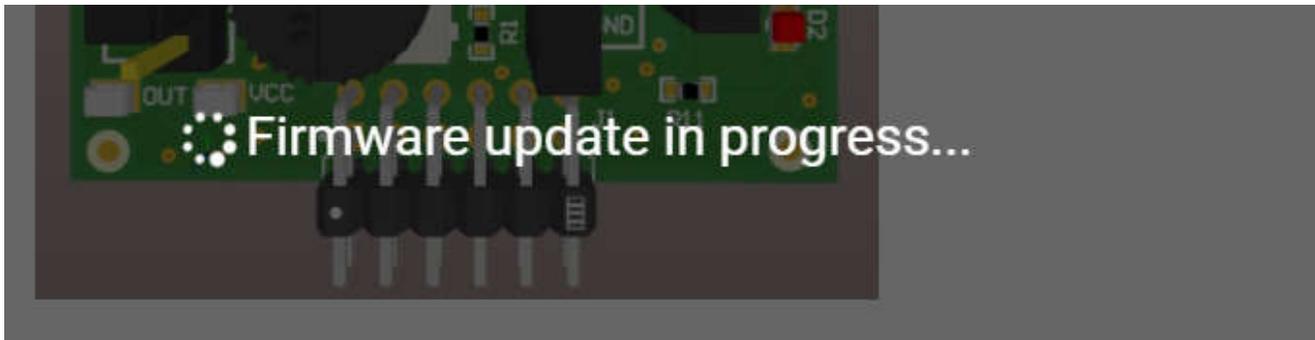
**Figure 5-2. Test Points Used to Enter DFU Mode Manually**

2. With the MCU in DFU mode, the firmware can now be uploaded through one of the following methods:
  - a. Bootstrap Loader (BSL) scripiter tool and batch file
    - i. Download the firmware package and BSL scripiter tool from the EVM page, or use the link: <https://www.ti.com/lit/zip/sbac297>
    - ii. Unzip the firmware folder and run the .bat file.
    - iii. Unplug the USB cable from the PC after the firmware is flashed, then plug the cable back in to reset the SCB.
  - b. TMAG5328GUI
    - i. Go to the GUI menu bar and click File → Program Device



**Figure 5-3. Program Device Option in Menu**

- ii. The screen below pops up while the firmware is updating.



**Figure 5-4. Firmware Update Screen**

- iii. After the firmware updates successfully, the GUI reloads automatically.

### 5.1.3 GUI Setup and Usage

Access the GUI in either the Google Chrome® or Firefox® browser by clicking the following link: <https://dev.ti.com/gallery/view/PositionSensing/TMAG5328GUI/>. Clicking the link takes you to the TMAG5328GUI home page tab. This page has links to the EVM block diagram, user's guide, data sheet, schematic, and the E2E forum for asking questions.

#### 5.1.3.1 Initial Setup

To set up the GUI the first time, follow these steps:

1. Make sure that the previously-mentioned driver was installed successfully to verify that everything works properly.
2. Plug the connected EVM and SCB unit to the PC and go to the [GUI link](#) provided earlier.
3. Click the GUI Composer application window to launch the GUI from the web browser.
  - For first-time GUI Composer setup, follow the prompts to download the *TI Cloud Agent* and browser extension shown in [Figure 5-5](#). These prompts appear after closing the README.md dialog.

### TI Cloud Agent Installation

Hardware interaction requires additional one time set up. Please perform the actions listed below and try your operation again. (What's this?)

- Step 1: **INSTALL** browser extension

- Step 2: **DOWNLOAD** and install the TI Cloud Agent Application

- Help. I already did this

**FINISH**

**Figure 5-5. TI Cloud Agent**

4. Click the  icon in the *GUI Composer* window to download the GUI offline (optional).

#### 5.1.3.2 GUI Operation

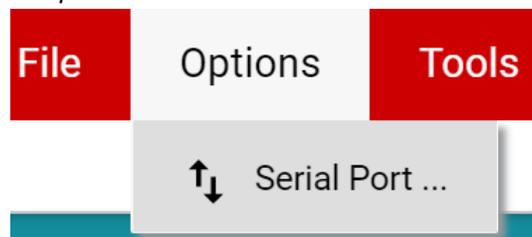
To operate the GUI, follow these steps:

1. Connect to and launch the GUI as described in [Section 5.1.3.1](#).
2. Close the README.md file page that pops up after the EVM connects to the GUI. The text near the bottom-left hand corner of the GUI reads *Hardware Connected*.



**Figure 5-6. Hardware Connected**

- a. If *Hardware Connected* does not show in the bottom-left hand corner of the GUI, then check different hardware COM ports under *Options* → *Serial Port*.



**Figure 5-7. Change Serial Port**

- b. If the hardware still does not connect, make sure you are using the correct GUI and EVM combination.

- Click the *Registers* icon to open the *Registers* page (also available on the left-side menu). Note that the *registers* listed are not registers on the TMAG5328 but are internal variables stored in the microcontroller that are not directly used for EVM evaluation. These variables cannot be modified from the *Registers* page and can be ignored.



## Registers

Low level register read and write operations

**Figure 5-8. Registers Page Icon**

- At the top of the *Registers* page, change *Auto Read* to *As fast as possible*.

Auto Read

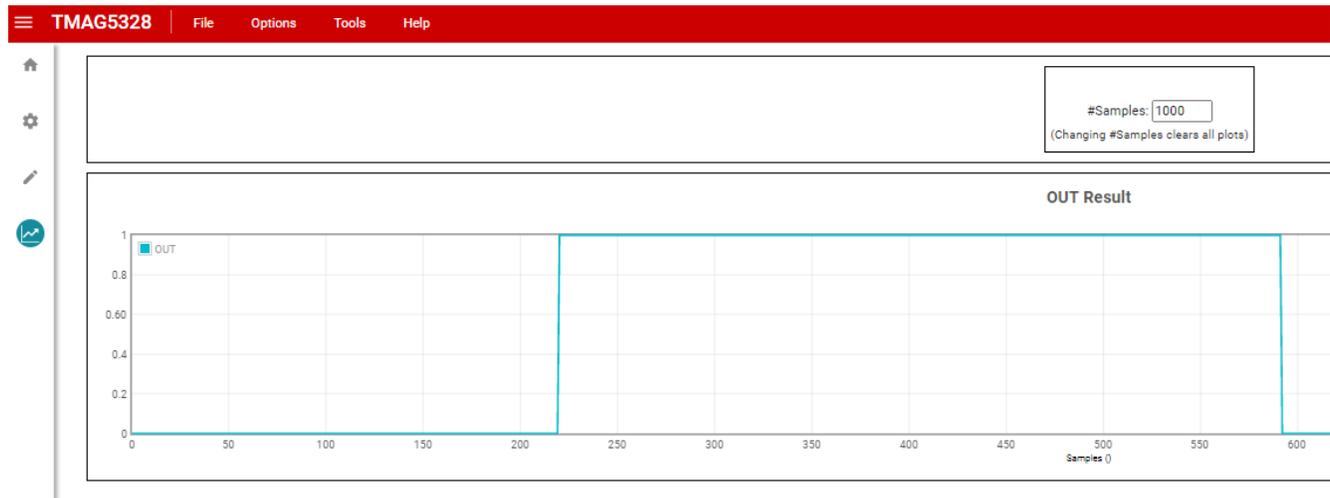
The TMAG5328 also has a *Results* page for viewing the state of the TMAG5328 OUT pin and a *DAC configuration* page for configuring the DAC. Both of these pages are described in the sections below.

### 5.1.3.2.1 GUI Results Page



Click the *Results Data* icon to view the *Results* page. This screen shows the state of the TMAG5328 OUT pin. Remember to set the *Auto Read* option on the *Registers* page to *As fast as possible* to view the results on this pin (see [Section 5.1.3.2](#)).

[Figure 5-9](#) shows an example plot of the OUT waveform. If the TMAG5328 OUT pin is at a high state (LED is OFF), a "1" is displayed on the graph. If the pin is at a low state (LED is ON), a "0" is displayed on the graph. The number of samples stored in the plot can be modified by adjusting the "1000" at the top of the screen with the desired number of samples then clicking enter. In addition, the plot can be exported by clicking the *SAVE PLOT* button.



**Figure 5-9. TMAG5328 GUI Results Page**

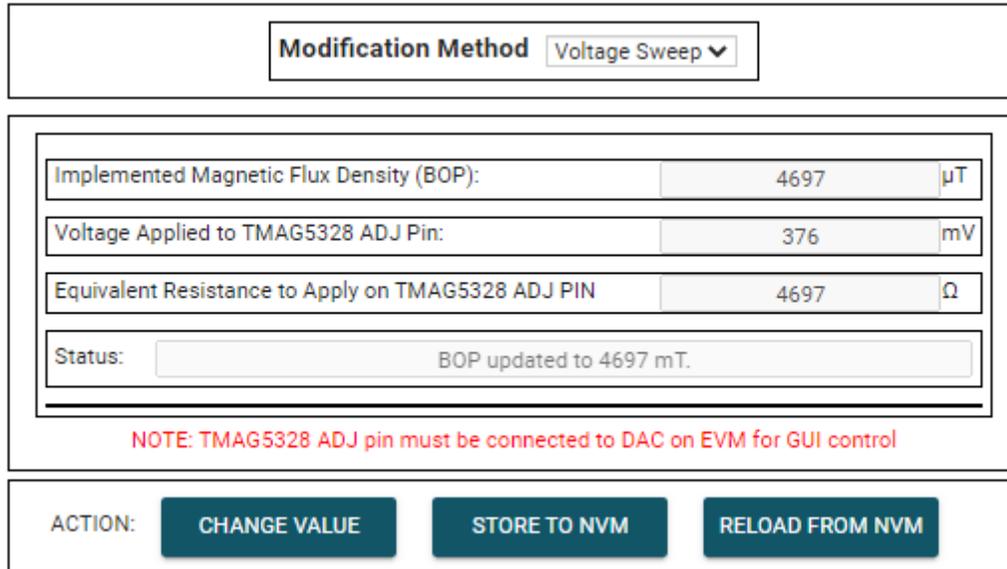
### 5.1.3.2.2 GUI DAC Configuration Page

The DAC on the EVM is configured using the DAC configuration page on the GUI. When configuring the DAC using the EVM, make sure that the EVM is configured to set the  $B_{OP}$  using the DAC (see [Section 4.1.1](#)). To go

to the DAC configuration page on the GUI, click the *DAC configuration* icon

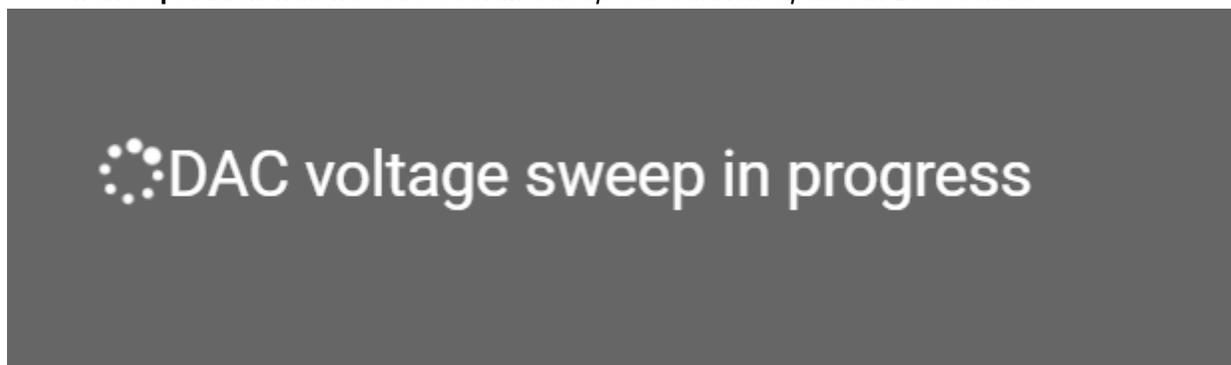


. Figure 5-10 shows the DAC configuration page.



**Figure 5-10. TMAG5328 GUI DAC Configuration Page**

- **Modification Method Drop-Down Box:** This drop-down box selects which method is used for setting the DAC voltage after you click the *CHANGE VALUE* button. There are four modification methods offered in this drop-down box:
  - **Voltage sweep Drop-Down Box Option:** This method sweeps the DAC output voltage to find the sensed magnetic flux density and then sets the  $B_{OP}$  to this sensed magnetic flux density. Completing the voltage sweep operation takes 20 seconds. During this time, the screen in Figure 5-11 is shown. After 20 seconds has passed, the screen in Figure 5-11 disappears and the status text box states one of the following:
    - **If the operation is successful:** "BOP updated to" followed by the sensed magnetic flux density value (see Figure 5-10).
    - **If the operation was successful but the sensed magnetic flux density was greater than the maximum 15-mT  $B_{OP}$  supported by the device:** "Magnetic Flux Density > 15 mT device maximum Bop."
    - **If the operation was successful but the sensed magnetic flux density was less than the minimum 2-mT  $B_{OP}$  supported by the device:** *Magnetic Flux Density < 2 mT device minimum Bop.*
    - **If the operation was not successful:** *Sweep started. Next update in 20 seconds.*



**Figure 5-11. DAC Sweep in Progress Screen**

- **Manual B Drop-Down Box Option:** This allows the user to enter a magnetic flux density into the "Implemented Magnetic Flux Density (BOP)" textbox. When you click the *CHANGE VALUE* button, the

- DAC is configured to output the voltage needed to generate the  $B_{OP}$  that was input into the "Implemented Magnetic Flux Density (BOP)" textbox.
- **Manual V Drop-Down Box Option:** This allows the user to enter a DAC output voltage into the "Voltage Applied to TMAG5328 ADJ Pin" textbox. When you click the *CHANGE VALUE* button, the DAC's output voltage is set to the output voltage that was entered into the "Voltage Applied to TMAG5328 ADJ Pin" textbox.
  - **Manual R Drop-Down Box Option:** This setting simulates applying a resistor on the ADJ pin by applying an equivalent DAC voltage that creates the same  $B_{OP}$  as the input provided into the "Equivalent Resistance to Apply on TMAG5328 ADJ Pin" textbox. Any resistors entered into this textbox are not programmed into the DAC until you click the *CHANGE VALUE* button.
- Textboxes
    - **Implemented Magnetic Flux Density (BOP) Textbox:** Displays the TMAG5328  $B_{OP}$  value based on the DAC settings. If the Modification Method drop-down box has the "Manual B" option selected, this textbox is also used to enter the desired  $B_{OP}$  to change to.
    - **Voltage Applied to TMAG5328 ADJ Pin Textbox:** Displays the DAC output voltage. If the Modification Method drop-down box has the "Manual V" option selected, this textbox is also used to enter the desired DAC output voltage to change to.
    - **Equivalent Resistance to Apply on TMAG5328 ADJ Pin Textbox:** Displays the resistor that can be applied to the ADJ pin to produce the same  $B_{OP}$  produced by the currently set DAC output voltage. If the Modification Method drop-down box has the "Manual R" option selected, this textbox is also used to enter the desired equivalent resistance value to change to.
    - **Status Textbox:** This displays the status associated with pressing different action buttons.
  - Action Buttons
    - **CHANGE VALUE button:** When you click this button, the DAC output voltage is changed according to the selected option in the "Modification Method" Drop-Down Box.
    - **STORE TO NVM button:** Pressing this button stores the current DAC output voltage to nonvolatile memory. If the EVM is power cycled, then the DAC is automatically set to the last output voltage stored in nonvolatile memory without requiring the microcontroller performing any reconfigurations steps on the DAC. As a result, the  $B_{OP}$  is also retained after the power cycle.
    - **RELOAD FROM NVM button:** Sets the current DAC output voltage to the DAC output voltage that is stored in nonvolatile memory.

#### 5.1.4 Direct EVM Serial Communication

If desired, the SCB can communicate directly with the EVM without the use of the GUI through the USB serial (COM) port. Simply send the desired command string over the serial port and receive the results. This is useful for interfacing the EVM with custom setups/scripts/GUIs. Note that the TMAG5328EVM has to be connected to the SCB to receive any command responses from the SCB.

The following commands are supported:

- Results Read command format: **rreg 0**
  - This command reads the state of the TMAG5328 OUT pin. If the pin is asserted high (the LED is OFF), the value returned is 1. If the pin is asserted low (the LED is ON), the value returned is 0.
  - [Figure 5-12](#) is an example response to the command. In this response, the TMAG5328 OUT pin is at a logic high since the returned value is 1 and not 0.

```

{"acknowledge": "rreg 0"}

{"register": {"address": 0, "value": 1}}

{"evm_state": "idle"}

```

**Figure 5-12. Example Result Read Command Response**

- DAC Sweep command format: **dacsweep**
  - This command initiates a DAC voltage sweep. This is the same command executed by the GUI whenever you click the *CHANGE VALUE* button while the "Modification Method" drop-down box is set to the "Voltage Sweep" option.

- **Figure 5-13** an example response to this command, where the first two lines are sent immediately while the third line is sent sometime within 20 seconds after the command was received. The number on the third line represents the new  $B_{OP}$  setting in units of  $\mu T$ .

```

{"acknowledge":"dacsweep"}

{"evm_state":"idle"}

{"DACSWEEP":5052}

```

**Figure 5-13. Example DAC Sweep Command Response**

- Set  $B_{OP}$  command format: **wreg 2 VAL**
  - This command allows you to enter a desired  $B_{OP}$ . This is the same command executed by the GUI whenever you click the *CHANGE VALUE* button while the "Modification Method" drop-down box is set to the "Manual B" option.
  - VAL is the desired  $B_{OP}$  in units of  $\mu T$ .
  - VAL is in hex, and wreg is always lower case
  - VAL can be in upper or lower case and does not need to be led by "0x". 0 padding VAL is also optional. For example, to write a BOP of 8000  $\mu T$ , some valid commands include:
    - wreg 2 1F40
    - wreg 2 0x1F40
      - When "0x" is used, the "x" must be lower case.
  - **Figure 5-14** is an example response to this command

```

{"acknowledge":"wreg 2 1F40"}

{"console":"Writing 0x1f40 to APPLIED_BOP register"}

{"evm_state":"idle"}

```

**Figure 5-14. Example Set  $B_{OP}$  Command Response**

- Set DAC Output Voltage command format: **wreg 1 VAL**
  - This command allows you to enter a desired output voltage to set the DAC to. This is the same command executed by the GUI whenever you click the *CHANGE VALUE* button while the *Modification Method* drop-down box is set to the *Manual V* option.
  - VAL is the desired DAC output voltage in units of mV.
  - VAL is in hex, and wreg is always lower case
  - VAL can be in uppercase or lowercase and does not need to be led by "0x". 0 padding VAL is also optional. For example, to set a DAC output voltage of 397mV, some valid commands include:
    - wreg 1 190
    - wreg 1 0x190
      - When "0x" is used, the "x" must be lower case.
  - **Figure 5-15** is an example response to this command

```

{"acknowledge":"wreg 1 190"}

{"console":"Writing 0x0190 to APPLIED_DAC_VOLTAGE register"}

{"evm_state":"idle"}

```

**Figure 5-15. Example Set DAC Output Voltage Command Response**

- Set Equivalent Resistance command format: **wreg 3 VAL**
  - This command allows you to configure the DAC output to create the same BOP that is generated by the input resistance. This is the same command executed by the GUI whenever the *CHANGE VALUE* button is clicked while the *Modification Method* drop-down box is set to the *Manual R* option.

- VAL is the desired equivalent resistance value in units of  $\Omega$ .
- VAL is in hex, and wreg is always lower case.
- VAL can be in upper or lower case and does not need to be led by "0x". 0 padding VAL is also optional. For example, to configure the DAC output to produce the same  $B_{OP}$  that is created if a 9000 $\Omega$  resistor was connected to the ADJ pin instead of the DAC, some valid commands include:
  - wreg 2 2328
  - wreg 1 0x2328
    - When "0x" is used, the "x" must be lower case.
- [Figure 5-16](#) is an example response to this command

```

{"acknowledge":"wreg 3 2328"}

{"console":"Writing 0x2328 to APPLIED_DAC_EQ_RESISTOR register"}

{"evm_state":"idle"}

```

**Figure 5-16. Example Set Equivalent Resistance Command Response**

- Store to Nonvolatile Memory command: **storenvm**
  - This command stores the current DAC output into nonvolatile memory. After power cycling the EVM, the DAC output voltage automatically initiates to the value stored in nonvolatile memory, thereby verifying the same  $B_{OP}$  value is used after power cycling the EVM. This is the same command executed by the GUI whenever you click the *STORE TO NVM* button.
  - [Figure 5-17](#) is an example response to this command:

```

{"acknowledge":"storenvm"}

{"evm_state":"idle"}

```

**Figure 5-17. Example Store to Nonvolatile Memory Command Response**

- Restore from Nonvolatile Memory command: **reloadnvm**
  - This command sets the currently applied DAC output voltage to the voltage that is stored in nonvolatile memory. This is the same command executed by the GUI whenever you click the *RELOAD FROM NVM* button.
  - [Figure 5-18](#) is an example response to this command:

```

{"acknowledge":"reloadnvm"}

{"evm_state":"idle"}

```

**Figure 5-18. Example Restore from Nonvolatile Memory Command Response**

- Firmware revision command format: **id**
  - This command prints the EVM the SCB is configured for (TMAG5328EVM in this case) and the date associated with the version of the firmware loaded on the SCB.
  - [Figure 5-19](#) is an example response to this command:

```

{"acknowledge":"id"}

{"id":{"name":"TMAG5328EVM","version":"1.1.0.0","date":"Jan 21 2022","time":"12:40:12"}}

{"evm_state":"idle"}

```

**Figure 5-19. Example Firmware Revision Command Response**

- BSL command format: **bsl**

- This command puts the device in BSL mode, which is necessary before reflashing the SCB firmware. An alternative to entering BSL mode is to run the mode in hardware as described in step 1b of [Section 5.1.2.1](#). Before BSL is entered, LED D1 is ON. If BSL mode is successfully entered, LED D1 is turned OFF so that only the Power LED (LED D5) is on. After entering BSL mode, the device does not accept any of the above commands.
- [Figure 5-20](#) shows an example response to this command:

```

{"acknowledge": "bsl"}
    
```

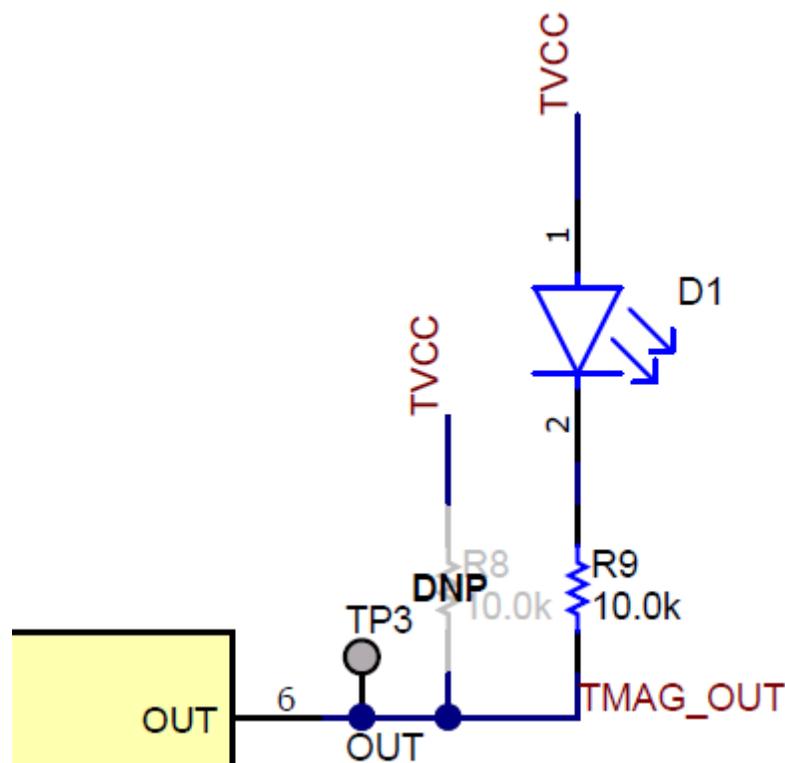
**Figure 5-20. BSL Command Response**

## 5.2 Evaluation Without SCB and GUI (EVM Stand-Alone Mode)

The TMAG5328EVM can operate in a stand-alone mode that does not require the SCB or GUI. To operate in stand-alone mode, an external power supply must be connected to the TMAG5328EVM (see [Section 4.2](#)).

When in standby mode,  $B_{OP}$  can be set using either the DAC, potentiometer, or fixed resistor options. Remember that the DAC output voltage cannot be changed without the SCB. The DAC output voltage will only be set to the value that was previously stored in its nonvolatile memory by the GUI. As a result, the DAC cannot be swept to find the sensed magnetic flux density of the TMAG5328 unless the SCB is connected. The potentiometer, however, does not require the SCB to estimate the sensed magnetic flux density TMAG5328 (see [Section 4.1.2.1](#)).

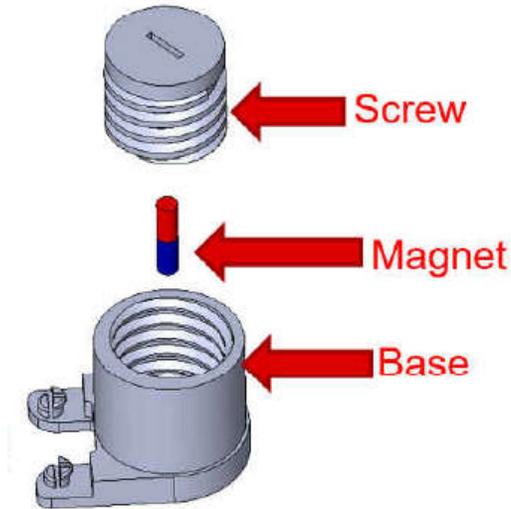
When in stand-alone mode, the TMAG5328 OUT pin can be probed at the test point that is labeled "OUT" on the board or on pin 9 of header J1. In addition, LED D1 can be used to visually observe the state of the TMAG5328 OUT pin. [Figure 5-21](#) shows the LED circuit connected to the OUT pin on the TMAG5328. If OUT is asserted high, the LED is OFF. If OUT is asserted low, the LED is ON.



**Figure 5-21. OUT LED Circuit**

### 5.3 Head-On Linear Displacement Demo

The TMAG5328EVM kit comes with a 3D-printed head-on linear displacement module with an embedded magnet. When connected to the TMAG5328EVM, the module creates a magnetic field that is sensed by the TMAG5328. The module has two portions: a screw and a base. The base is connected to the EVM and the screw is placed inside the base. A magnet is embedded within the screw, which produces the magnetic field sensed by the TMAG5328. [Figure 5-22](#) shows an exploded view of the different components within the module.

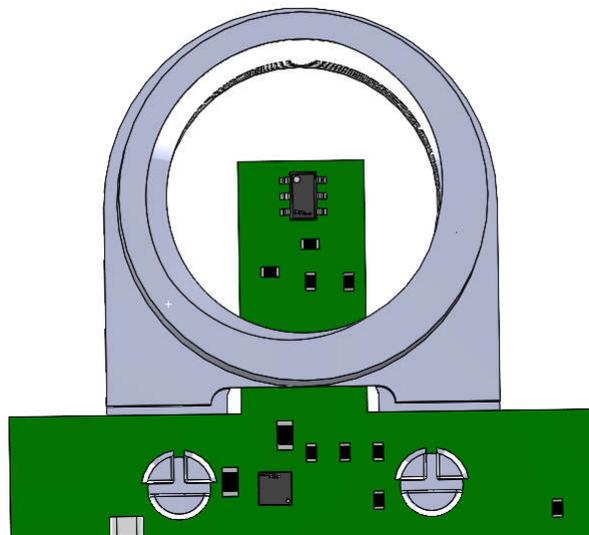


**Figure 5-22. Exploded View of the Head-On Linear Displacement Attachment**

When the screw is rotated clockwise inside the base, the magnet gets closer to the TMAG5328, thereby increasing the sensed magnetic flux density. If the screw is turned counterclockwise within the base, the screw increases its distance with respect to the TMAG5328, which decreases the sensed magnetic flux density.

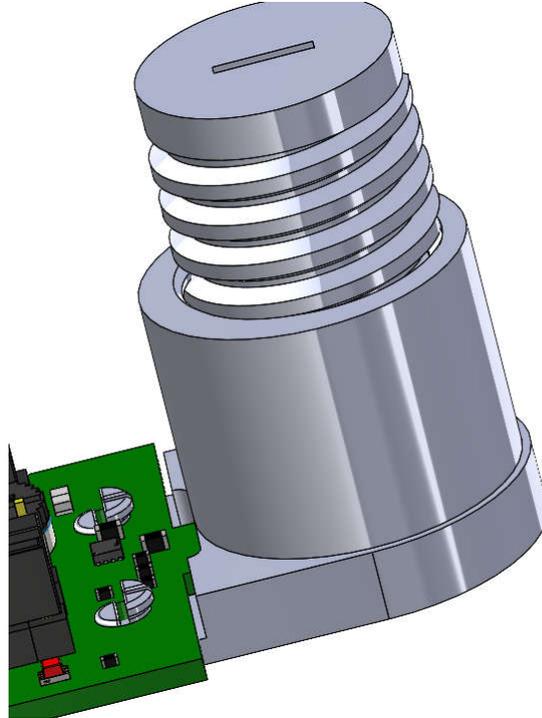
To use this module with the TMAG5328EVM, perform the following steps:

1. Connect the base of the module to the TMAG5328EVM (see [Figure 5-23](#)).



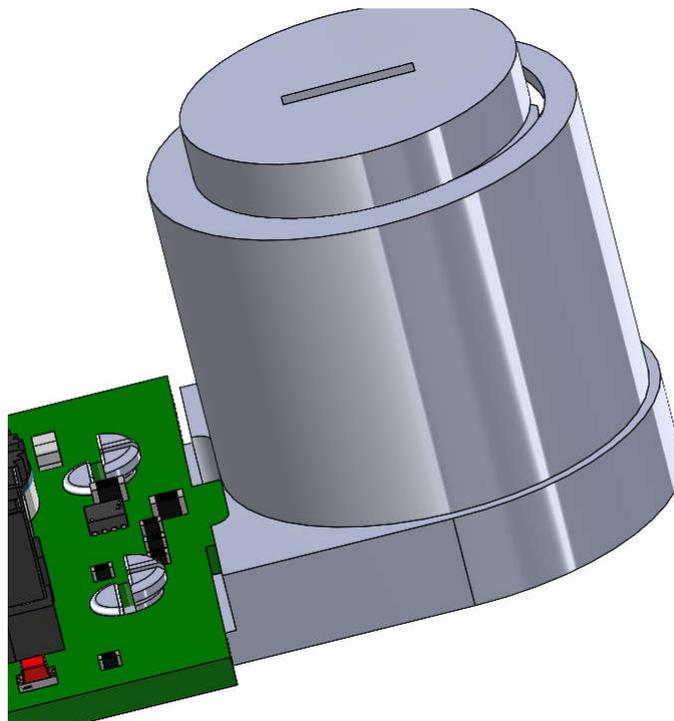
**Figure 5-23. Base Connected to TMAG5328EVM**

2. Place the screw at the top of the base (see [Figure 5-24](#)). As the screw is brought near the top of the base, the sensed magnetic flux density will approach around 2 mT.



**Figure 5-24. Screw Placed at Top of Base**

3. When the screw is at the top of the base, turn the screw clockwise to bring screw and its embedded magnet closer to the TMAG5328. After the screw is turned clockwise, the TMAG5328 OUT pin will be asserted low when the sensed magnetic flux density becomes greater than the set  $B_{OP}$ . After the screw is fully secured into the base (see [Figure 5-25](#)), the sensed magnetic flux density will be larger than the 15-mT  $B_{OP}$  maximum that is supported by the TMAG5328, so the TMAG5328 OUT pin will be asserted low and LED D1 will be ON.



**Figure 5-25. Screw Fully Fastened Into Base**

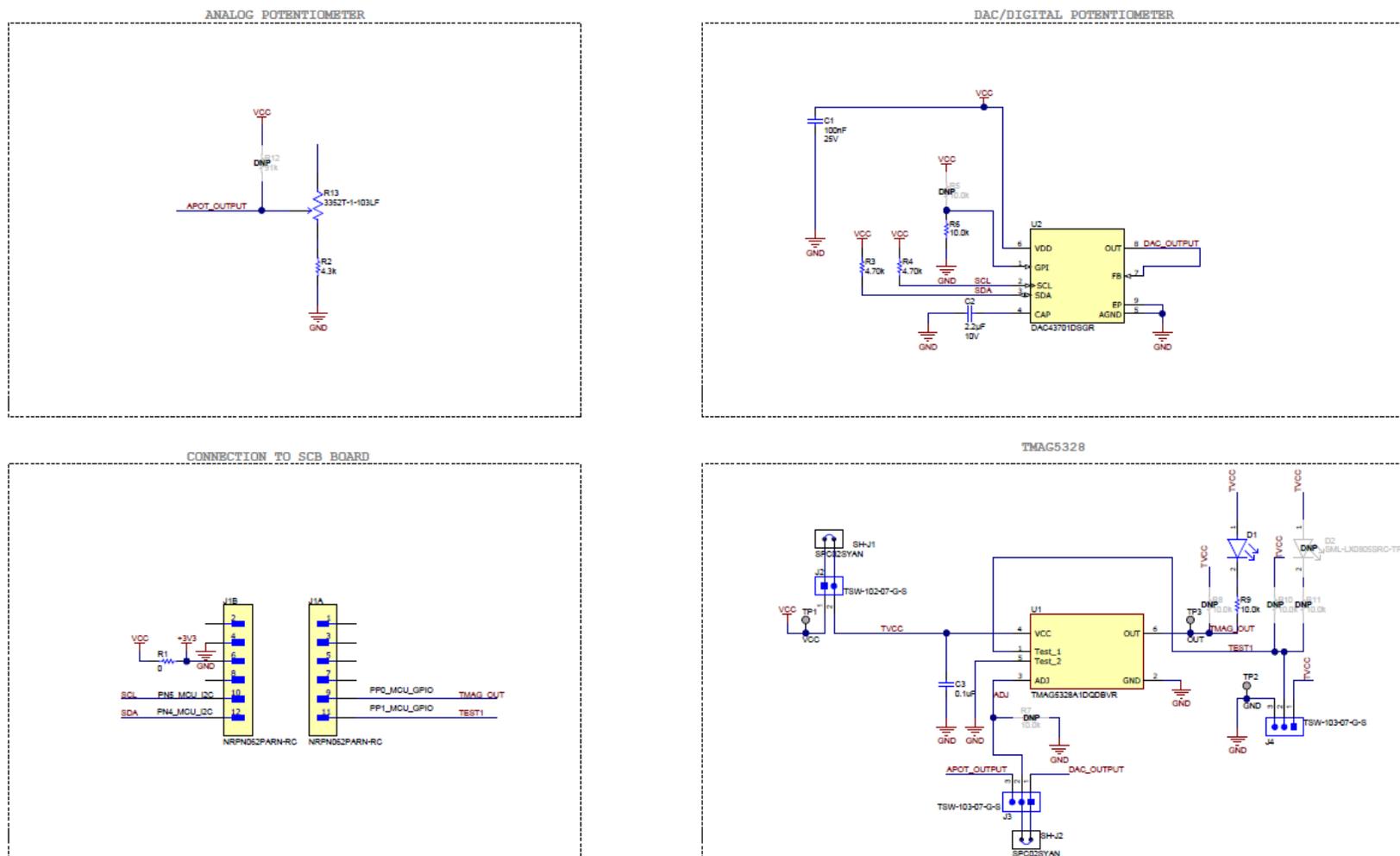
For more information on the Head-On Linear Displacement attachment, refer to the [Head-on Linear Displacement 3D Attachment user's guide](#).

## **6 Schematics, PCB Layout, and Bill of Materials**

The following sections list the schematics, PCB layouts, and bill of materials for the TMAG5328.

## 6.1 Schematics

Figure 6-1 shows the EVM schematic.



## 6.2 PCB Layout

Figure 6-2 through Figure 6-5 show the PCB layers of the EVM.

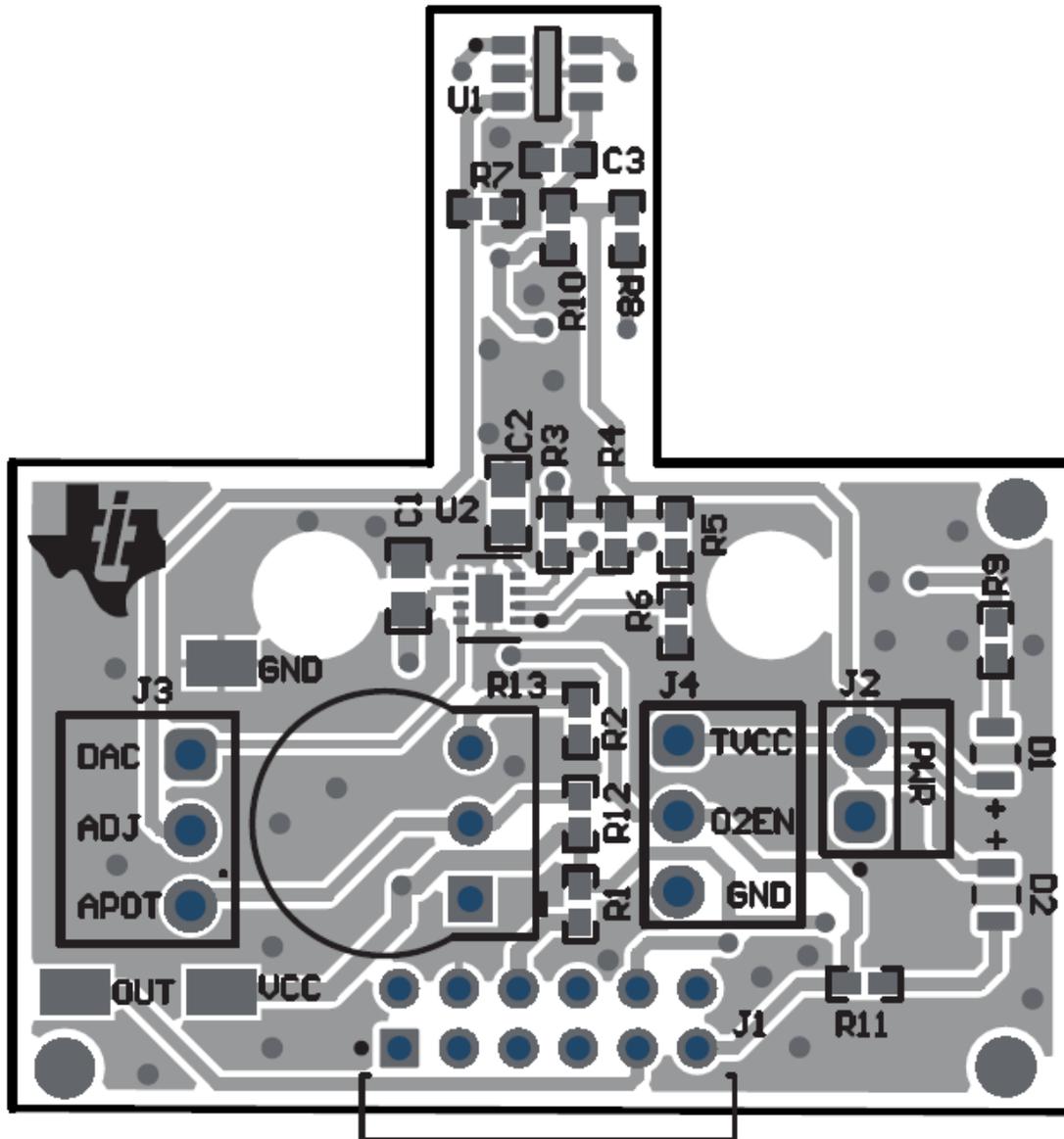


Figure 6-2. Top View

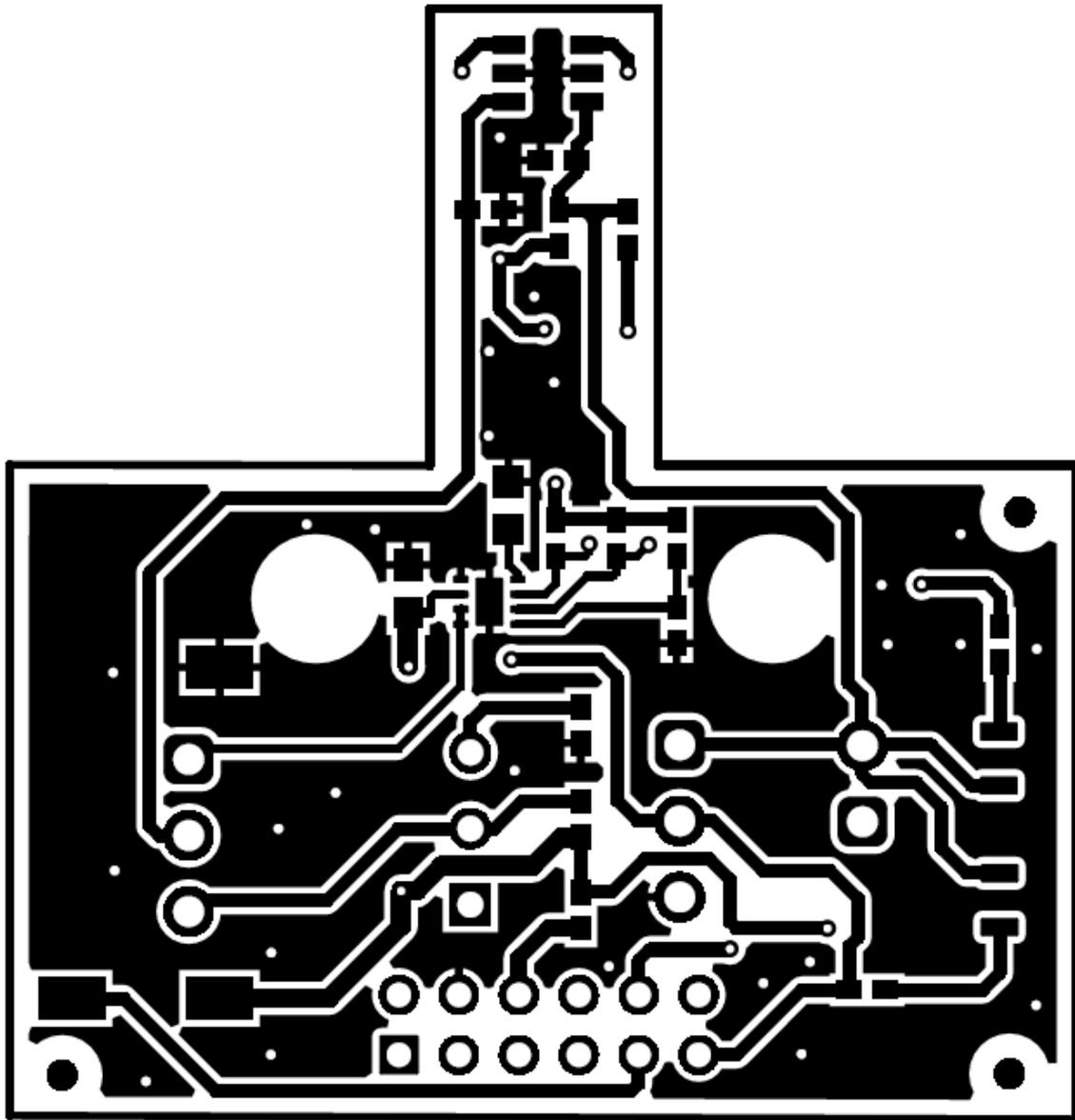


Figure 6-3. Top Layer

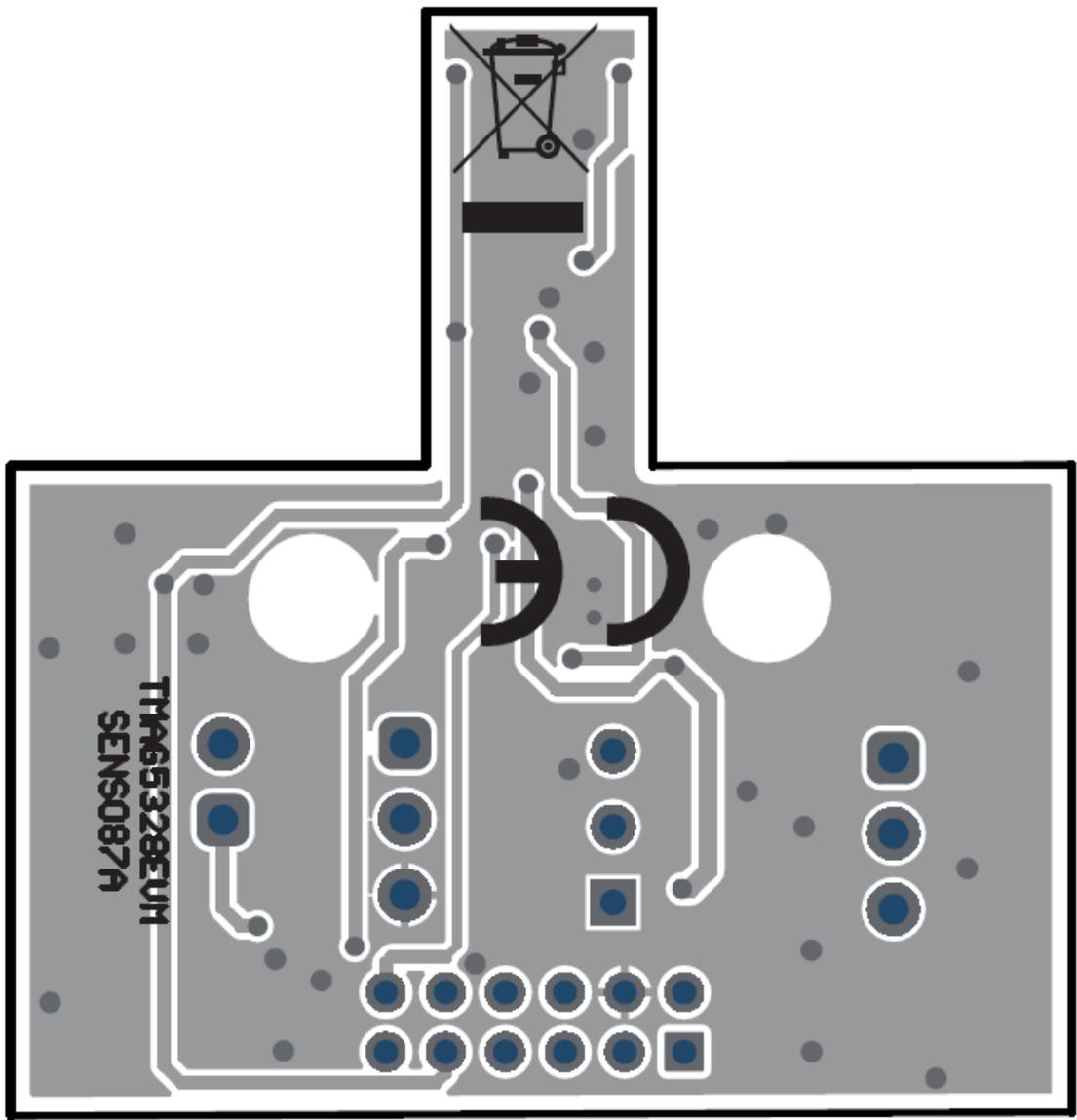


Figure 6-4. Bottom View

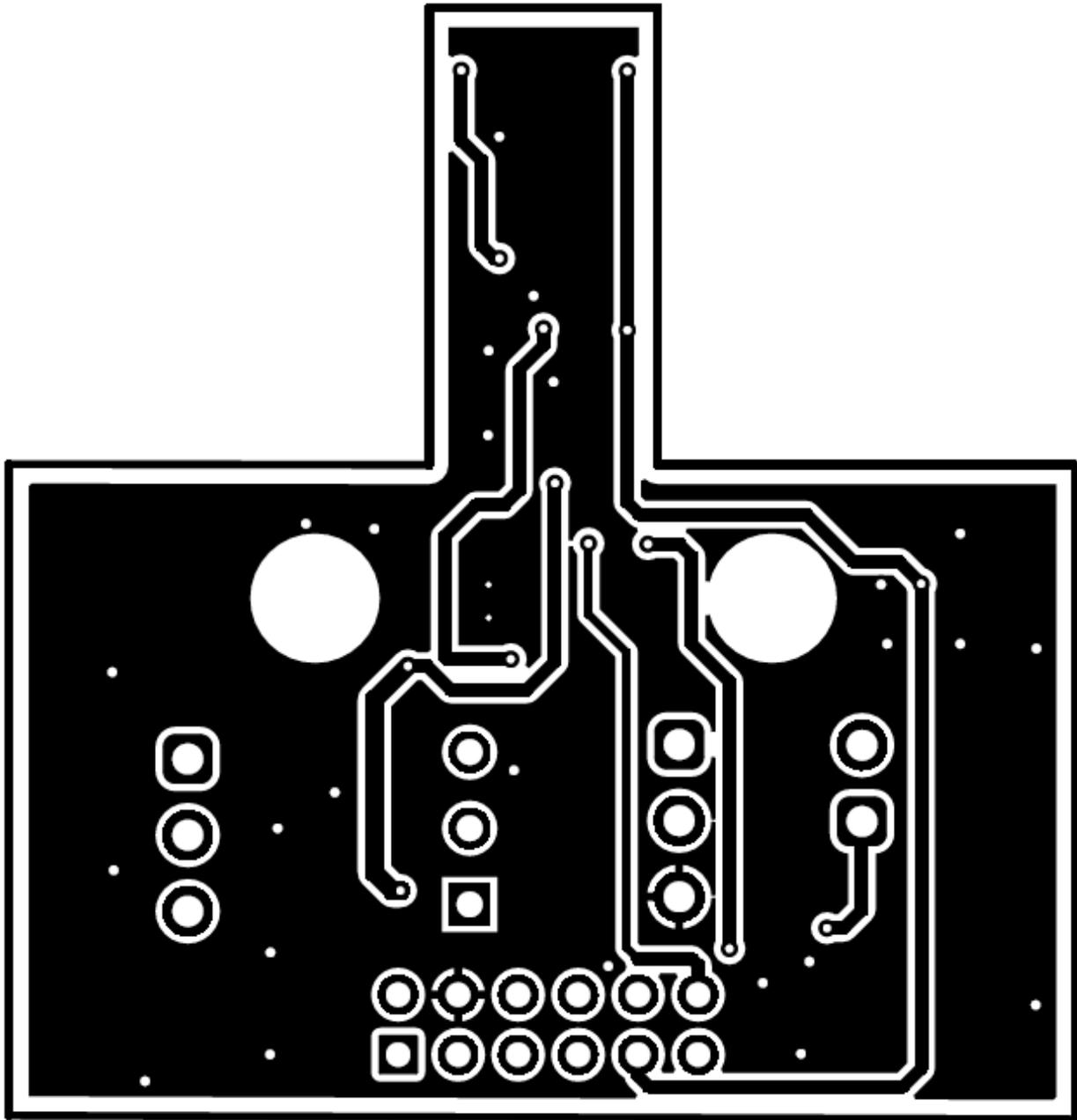


Figure 6-5. Bottom Layer

### 6.3 Bill of Materials

Table 6-1 provides the parts list for the EVM.

**Table 6-1. Bill of Materials**

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
!PCB1	1		Printed Circuit Board		SENS087	Any
C1	1	0.1uF	CAP, CERM, 0.1 uF, 25 V, +/- 10%, X7R, 0603	0603	C1608X7R1E104K080 AA	TDK
C2	1	2.2uF	CAP, CERM, 2.2 uF, 10 V, +/- 10%, X7R, 0603	0603	GRM188R71A225KE15 D	MuRata
C3	1	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 20%, X7R, 0402	0402	GRM155R71H104ME1 4D	MuRata
D1	1		Red LED Indication - Discrete 1.7V 0805 (2012 Metric)	0805	SML-LX0805SRC-TR	Lumex
FID1, FID2, FID3	3		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
H1	1		Kitting Item: TI SCB Controller		SENS077	Texas Instruments
H2	1		Kitting Item: 3025010-03; Cable, USB A MALE to Micro B MALE 3'; CDDS 6612041		6612041	Qualtek
H3	1		Kitting Item: D2X0, 1/8" dia. x 1" thick, N42 magnet		D2X0	K&J Magnetics
H4	1		Kitting Item: D28-N52 1/8" dia. x 1/2" thick, N52 magnet		D28-N52	K&J Magnetics
H5	1		Kitting Item: Plastic module with magnet. This module is 3D printed from two STL files that are assembled together.		Head-OnModule	Stratasys
J1	1		CONN HEADER R/A 12POS 2MM	HDR12	NRPN062PARN-RC	Sullins Connector Solutions
J2	1		Header, 100mil, 2x1, Gold, TH	2x1 Header	TSW-102-07-G-S	Samtec
J3, J4	2		Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec
R1	1	0	RES, 0, 5%, 0.063 W, 0402	0402	RC0402JR-070RL	Yageo America
R2	1	4.3k	RES, 4.3 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04024K30JNED	Vishay-Dale

**Table 6-1. Bill of Materials (continued)**

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
R3, R4	2	4.70k	RES, 4.70 k, 1%, 0.063 W, 0402	0402	CRG0402F4K7	TE Connectivity
R6, R9	2	10.0k	RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	RMCF0402FT10K0	Stackpole Electronics Inc
R13	1	10kΩ	10 kOhms 0.5W, 1/2W Through Hole Thumbwheel Potentiometer Top Adjustment	PTM_PTH_8MM9_9MM53	3352T-1-103LF	Bourns
SH-J1, SH-J2	2	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions
TP1, TP2, TP3	3		Test Point, SMT	Test Point, SMT	S2751-46R	Harwin
U1	1		PTMAG5328QDBVR	SOT23-6	PTMAG5328QDBVR	Texas Instruments
U2	1		8-bit, single-channel, voltage-output, smart DAC with GPIO trigger 8-WSON -40 to 125	WSON8	DAC43701DSGR	Texas Instruments
D2	0		Red LED Indication - Discrete 1.7V 0805 (2012 Metric)	0805	SML-LX0805SRC-TR	Lumex
R5, R7, R8, R10, R11	0	10.0k	RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	RMCF0402FT10K0	Stackpole Electronics Inc
R12	0	91k	RES, 91 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040291K0JNED	Vishay-Dale

## 7 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

<b>Changes from Revision * (December 2021) to Revision A (March 2022)</b>	<b>Page</b>
• Changed the <i>Overview</i> section.....	2
• Removed the sensor controller board (SCB) and USB cable from the EVM kit contents.....	4
• Changed <a href="#">Figure 4-1</a> .....	5
• Changed <a href="#">Figure 4-2</a> .....	5
• Changed the <i>Firmware</i> sections.....	12
• Changed the <i>GUI DAC Configuration Page</i> section.....	15
• Changed <a href="#">Figure 5-13</a> .....	17
• Changed <a href="#">Figure 6-1</a> .....	24
• Changed <a href="#">Table 6-1</a> .....	29

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