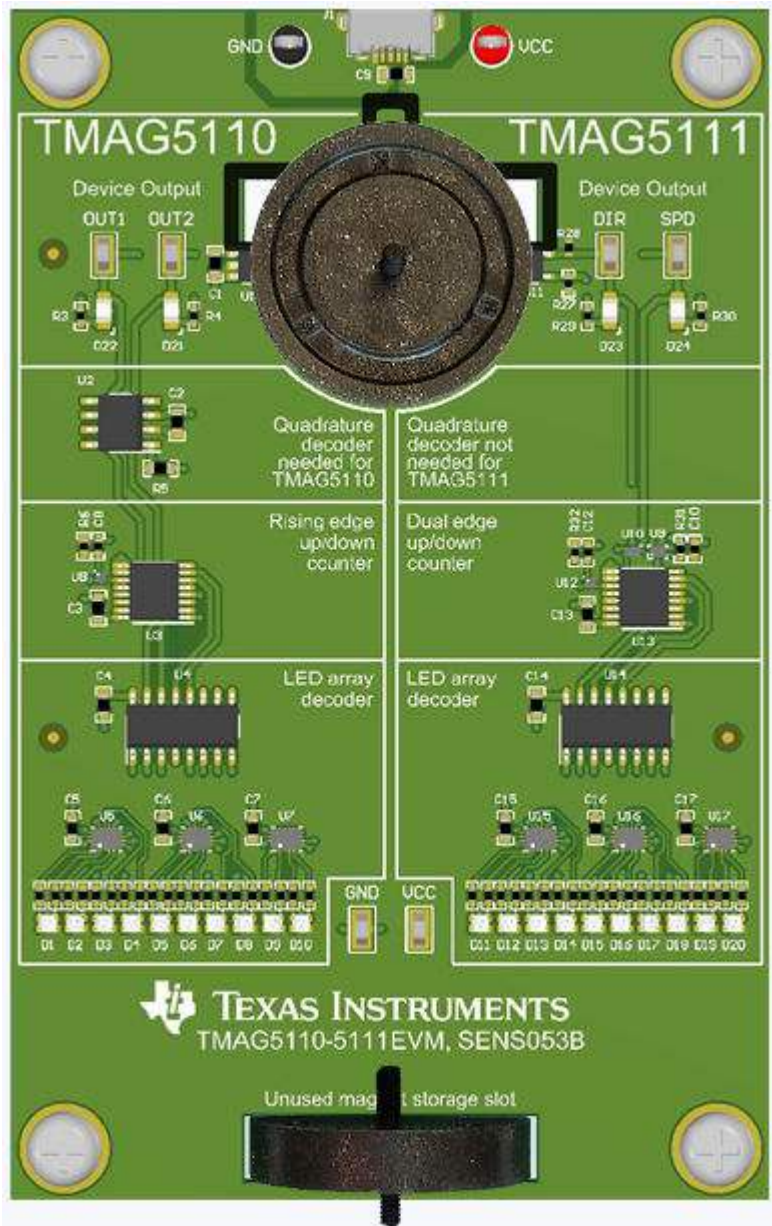


# TMAG5110-5111EVM Evaluation Module



## ABSTRACT



This user's guide describes the characteristics, operation, and use of the [TMAG5110](#) and [TMAG5111](#) evaluation module (EVM). This EVM is designed to evaluate the performance of the TMAG5110/1 dual latch, 2D Hall effect sensors. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the TMAG5110-5111EVM. This document includes a schematic, reference printed circuit board (PCB) layouts, and a complete bill of materials (BOM).

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## Trademarks

All trademarks are the property of their respective owners.

## 1 Overview

The TMAG5110 and TMAG5111 are 2-dimensional, dual digital-latch Hall effect sensors designed for high-speed and high-temperature motor applications. The devices are optimized for applications leveraging rotating ring magnets. Using the alternating magnetic flux density of the ring magnet, each device presents independent digital outputs based on the state of each of the onboard Hall effect latches to enable external or internal speed and direction decoding. Alternating north and south magnetic poles are required to toggle the output of each Hall effect latch, and integrated hysteresis provides robust switching.

The TMAG5110/1 are available in two sensitivity options, with  $B_{OPmax}$  and  $B_{RPmin}$  thresholds of  $\pm 1.4$  mT and  $\pm 3$  mT. Each sensitivity option is available with axes of sensitivity of XY, ZX, or ZY. These devices operate from a single 2.5-V to 38-V power supply, drawing a typical operating supply current of 6 mA across the operating temperature and power supply voltage ranges. These devices are currently available in a 5-pin SOT-23 package. This EVM uses a 5-V supply and both the TMAG5110B2 and TMAG5111B2, with sensitivity in the ZX axes and a maximum threshold of  $\pm 1.4$  mT. [Table 1-1](#) lists the axes of sensitivity and thresholds for each device.

**Table 1-1. TMAG5110/1 Device Summary**

Product	Axes of Sensitivity	$B_{OPmax}/B_{RPmin}$
TMAG5110A2	XY	$\pm 1.4$ mT
TMAG5110B2	ZX	$\pm 1.4$ mT
TMAG5110C2	ZY	$\pm 1.4$ mT
TMAG5110A4	XY	$\pm 3$ mT
TMAG5110B4	ZX	$\pm 3$ mT
TMAG5110C4	ZY	$\pm 3$ mT
TMAG5111A2	XY	$\pm 1.4$ mT
TMAG5111B2	ZX	$\pm 1.4$ mT
TMAG5111C2	ZY	$\pm 1.4$ mT
TMAG5111A4	XY	$\pm 3$ mT
TMAG5111B4	ZX	$\pm 3$ mT
TMAG5111C4	ZY	$\pm 3$ mT

### 1.1 Kit Contents

[Table 1-2](#) lists the contents of the TMAG5110-5111EVM kit. Contact the [Texas Instruments Customer Support Center](#) if any component is missing.

**Table 1-2. Kit Contents**

Item	Quantity
TMAG5110-5111EVM test board	1
10 pole ring magnet (packaged with PCB)	1
20 pole ring magnet (packaged with PCB)	1
Magnetic viewing film	1
Plastic module for position tests	1
USB cable	1

## 1.2 Related Documentation From Texas Instruments

This user's guide is available from the TI website under literature number SLYU050. 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 1-3](#) lists documentation related to the TMAG5110-5111EVM. Click the links in [Table 1-3](#) for further information on the TMAG5110/1. 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 1-3. Related Documentation**

Document Description	Document Literature Number
<a href="#">TMAG5110</a> data sheet	<a href="#">SBAS933</a>
<a href="#">TMAG5110-Q1</a> data sheet	<a href="#">SLYS029</a>
<a href="#">TMAG5111</a> data sheet	<a href="#">SBAS933</a>
<a href="#">TMAG5111-Q1</a> data sheet	<a href="#">SLYS029</a>
<a href="#">CD74HC190</a> data sheet	<a href="#">SCHS275</a>
<a href="#">CD74HC42</a> data sheet	<a href="#">SCHS133</a>
<a href="#">TMUX1574</a> data sheet	<a href="#">SCDS391</a>
<a href="#">SN74LVC2G14</a> data sheet	<a href="#">SCES200</a>
<a href="#">SN74LVC1G86</a> data sheet	<a href="#">SCES222</a>
<a href="#">SN74LVC1G17</a> data sheet	<a href="#">SCES351</a>

## 2 Hardware

The TMAG5110-5111EVM is an easy-to-use platform for evaluating the main features and performance of the TMAG5110 and TMAG5111. The EVM features two separate circuits showing different implementations of a rotary encoding application, with the TMAG5110 quadrature decoding circuit on the left and the TMAG5111 speed and direction circuit on the right. There are two different magnets and two magnet placement options to highlight the dual latch capabilities of pole pitch independence and magnet placement independence. There is also an extra plastic module in the EVM kit to help test and experiment with other magnet placement options.

The TMAG5110-5111EVM is intended to provide basic functional evaluation of the devices. The layout is not intended to be a model for the target circuit, nor is it laid out for electromagnetic compatibility (EMC) testing. The TMAG5110-5111EVM consists of one PCB with one TMAG5110 and one TMAG5111.

### 2.1 Features

- Includes both quadrature decoding and speed and direction implementations of a rotary encoding application
- Includes both a 10 pole and 20 pole ring magnet to show magnet pitch independence
- Each magnet can be placed in horizontal and vertical positions to show magnet placement independence
- Includes an additional position module which allows experimentation with further magnet placement options
- Conveniently powered from a common micro-USB connector

## 3 Operation

### 3.1 Quick Start Setup

The following instructions describe how to set up and use the TMAG5110-5111EVM:

1. Power up the EVM using either of the following methods:
  - a. USB power
    - i. Insert the micro USB cable into the EVM onboard USB receptacle J1.
    - ii. Plug the USB cable into any USB power source (for example: laptop, desktop, power bank, and so forth).
  - b. Variable power supply
    - i. Set the power supply voltage to 5 V. Do not turn on the power yet.
    - ii. Connect the power supply V- terminal to the black GND test point on the EVM.
    - iii. Connect the power supply V+ terminal to the red VCC test point on the EVM.
    - iv. Turn on the power supply.
2. Place either the 10 pole or the 20 pole ring magnet in one of the two positions indicated in [Figure 3-3](#).
3. Rotate the magnet in either direction and observe the various LED indicators.

### 3.2 EVM Operation

The TMAG5110-5111EVM features two functionally independent circuits, one for the TMAG5110 and one for the TMAG5111. Figure 3-1 shows an overview of the PCB layout. The circuit on the left features the TMAG5110 quadrature output device, and the circuit on the right features the TMAG5111 speed and direction output device. Section 4 goes over the different operational section blocks of the EVM and their functions and components.

For TMAG5110 each output is a logic high or low based on the latch state of the individual internal Hall sensors. So, for this case, OUT1 is for the Z-axis sensor and OUT2 is for the X-axis sensor.

For TMAG5111, as the magnet is rotated, OUT1 will indicate speed and OUT2 will indicate direction. Direction can be determined by observing whether this output is high or low, and Speed is indicated by the rate of output transitions.

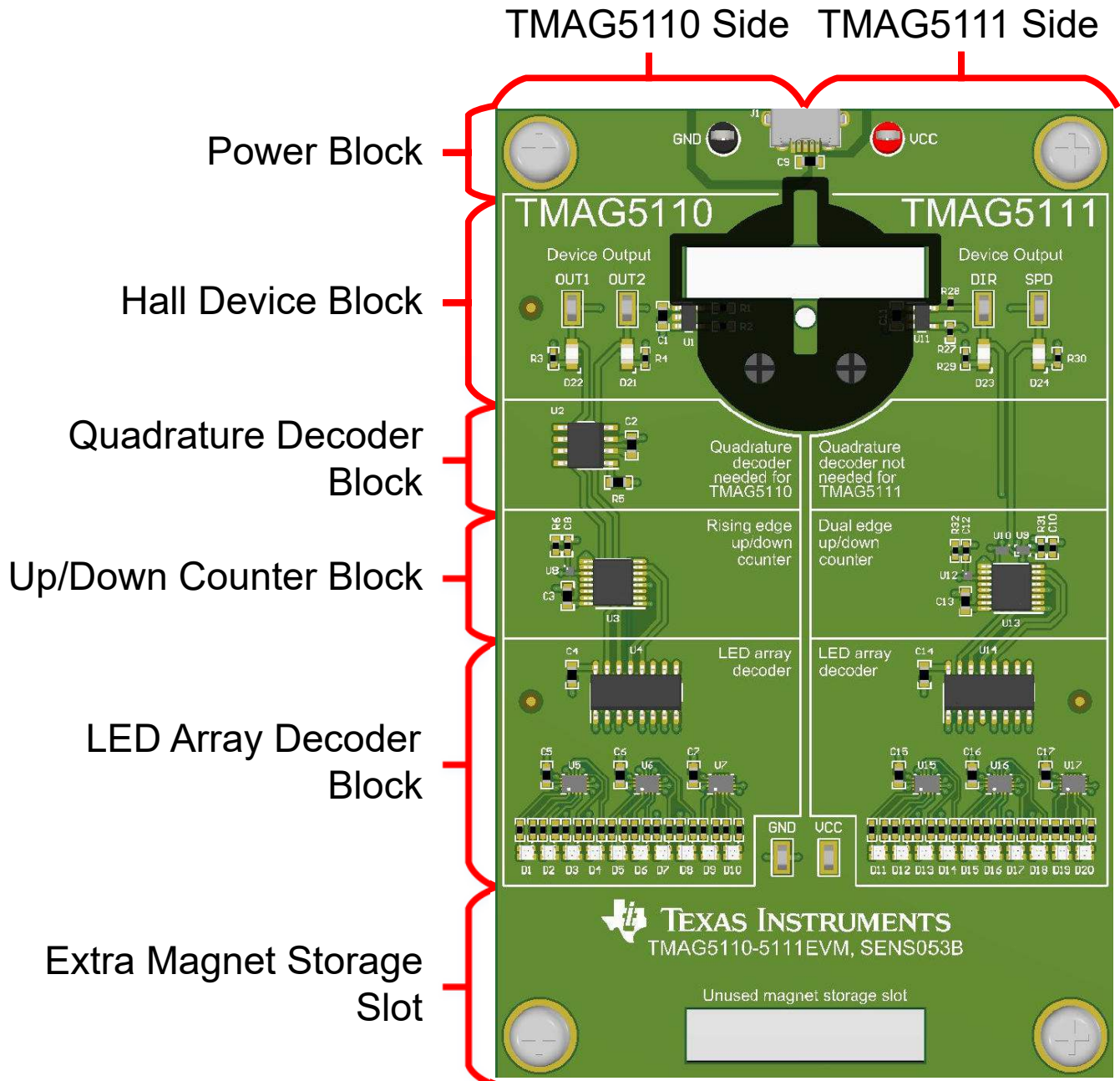
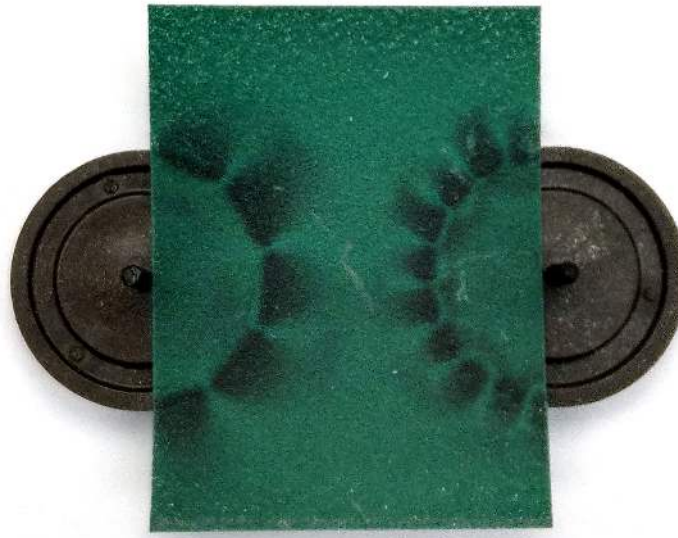


Figure 3-1. EVM Overview



Figure 3-2 shows how the magnetic viewing film included with the EVM kit can be used to tell the difference between the 10 pole and 20 pole magnets. In Figure 3-2, the 10 pole magnet is on the left and the 20 pole magnet is on the right.



**Figure 3-2. Magnetic Viewing Film**

The EVM features two convenient magnet placement orientation options for rotary encoding, shown in Figure 3-3. The magnets can easily be rotated while in these positions. The two LED arrays at the bottom (D1–D10 and D11–D20) will each have one LED lit up either green or blue that will move either right or left with the rotation of the magnet. The output LEDs near the sensors (D21–D24) show the state of the individual output pins of each device.





**Figure 3-3. EVM Magnet Placement Options**

Additional magnet placement options are possible when using the rotating position module included with this EVM kit, shown in [Figure 3-4](#) and [Figure 3-5](#). Note that this fixture swivels from side to side to show the design and alignment flexibility of the TMAG5110 and TMAG5111. To attach the module, insert the rod into the center hole of the EVM, and tighten the nut while holding the module in the desired position. To swivel the fixture, loosen the nut slightly.



Module Perpendicular

Module Diagonal

**Figure 3-4. Position Module Standard Placement**



Module Perpendicular Rotated

Module Diagonal Rotated

**Figure 3-5. Position Module Rotated Placement**

The included magnets should not be placed near stronger magnets, or the magnetic pole configuration may get altered. It is best practice not to touch the multipole ring magnets to any other magnet.

## 4 Circuitry

This section summarizes the EVM subsystems and their components. See [Figure 3-1](#) for the location of each subsystem on the PCB.

### 4.1 Power Block

This block is used to provide power to the PCB. J1 is a micro-USB connector used to conveniently power the EVM, but a supply may also be used with any of the GND or VCC test points (TP1-TP4). Note that there are also GND and VCC test points at the bottom of the PCB for convenience. C9 is a bypass capacitor used to help mitigate noise when powering the device from the micro-USB connector.

### 4.2 Hall Device Block

This block has the sensing devices, with any needed components, test points and LED indicators. The magnets are placed in this section to interact with the Hall sensors.

#### 4.2.1 TMAG5110 Side

U1 is the TMAG5110 which is a dual Hall latch with a quadrature output. C1 is a bypass capacitor that is placed near the sensor to help mitigate power supply noise and provide current quickly to the device when needed. R1 and R2 are pull up resistors since the device output is open drain. Note that a different resistance can be used for these resistors, based on the system speed and power requirements.

The TMAG5110 outputs can be directly monitored or used with the included test points TP5 and TP6 (for OUT2 and OUT1, respectively). D21 and D22 show the logic state of each output. R3 and R4 are current limiting resistors to control the brightness of the LEDs.

#### 4.2.2 TMAG5111 Side

U11, C11, R27, R28, TP7, TP8, D23, D24, R29, and R30 perform the same functions as the respective components from the TMAG5110, except that U11 is the TMAG5111 which is a dual Hall latch with speed and direction output.

### 4.3 Quadrature Decoder Block

This block is used to process data to prepare the signal for the up/down counter block.

#### 4.3.1 TMAG5110 Side

U2 is the LS7184N-S, which is a quadrature encoder to counter interface chip. This chip converts the outputs of the TMAG5110 to use directly with an up/down counter by outputting a speed pulse and a direction. Pin 6 is left floating to put the device in x4 mode, which gives a speed pulse for both rising and falling edges of each output from the TMAG5110. R5 is the RBIAS resistor which is used to adjust the output clock pulse width  $T_{OW}$ . In this case, 470 k $\Omega$  was used to set approximately 5.5- $\mu$ s  $T_{OW}$ . C2 is a bypass capacitor that is placed near the IC to help mitigate power supply noise and provide current quickly to the device when needed.

#### 4.3.2 TMAG5111 Side

Quadrature decoding is not needed for the TMAG5111.

### 4.4 Up/Down Counter Block

This block is used to convert direction and count data to a binary coded decimal (BCD) number from 0–9.

#### 4.4.1 TMAG5110 Side

U3 is the CD74HC190, which is a BCD up/down counter. This counter only counts on the rising edge of the pulse sent from the quadrature decoder (U2). The pre-settable pins are set to GND to give an initial value of 0. C3 is a bypass capacitor that is placed near the IC to help mitigate power supply noise and provide current quickly to the device when needed. C8 and R6 create an RC filter which are used with a single Schmitt-Trigger buffer (U8, SN74LVC1G17) to delay the LOAD signal for the up/down counter (U3). This is done so that the initial value of 0 is loaded to the counter after the device has been powered on.



#### 4.4.2 TMAG5111 Side

U13, C13, U12, C12, and R32 perform the same functions as the respective components from the TMAG5110 side but for the TMAG5111 signal path.

R31 and C10 create an RC filter which are combined with a dual Schmitt-Trigger buffer (U9, SN74LVC2G14) and a single 2-input Exclusive-OR gate (U10, SN74LVC1G86) to create an edge detection circuit. The edge detection circuit is used to convert the rising edge up/down counter (U13) to a dual edge up down counter to count every clock transition from the TMAG5111 (U11).

#### 4.5 LED Array Decoder Block

This block converts the BCD number of 0–9 to a position in an LED array that lights up in either green or blue based on the direction of magnet rotation.

##### 4.5.1 TMAG5110 Side

U4 is the CD74HC42, which is a BCD-to-decimal decoder. This device takes the BCD number and activates one of 10 outputs accordingly (active low). C4 is a bypass capacitor that is placed near the IC to help mitigate power supply noise and provide current quickly to the device when needed.

U5–U7 are each a TMUX1574, which are 2:1 (SPDT) 4-channel, powered-off protection switches that are used to split each output from U4 into two outputs. The direction line from U2 is used as an input to the switches to determine which of the two outputs should be active. C5–C7 are bypass capacitors that are placed near the ICs to help mitigate power supply noise and provide current quickly to the devices when needed.

Each output pair from U5–U7 connects to an individual RGB LED (in D1–D10), with one output going into the blue LED and the other output into the green LED. Because the switches U5–U7 are toggled from the direction line, the LEDs will show green or blue based on the direction the magnet is rotating. The specific LED lit up will be based on the BCD number 0–9 from the up/down counter (U3). R7–R27 are used as current-limiting resistors for the LEDs.

##### 4.5.2 TMAG5111 Side

U14, C4, U15–U17, C16–C17, D11–D20, R33–R52 perform the same functions as the respective components from the TMAG5110 side but for the TMAG5111 signal path, except that the direction line comes directly from the TMAG5111.

## 5 Schematics, PCB Layout, and Bill of Materials

### Note

Board layouts are not to scale. These figures are intended to show how the board is laid out. The figures are not intended to be used for manufacturing EVM PCBs.

### 5.1 Schematics

Figure 5-1 to Figure 5-3 show the schematic of the EVM. Figure 5-1 shows the circuitry for the TMAG5110 as well as the power connector and power test points. Figure 5-2 shows the circuitry for the TMAG5111. Figure 5-3 shows the mechanical components included with the EVM.

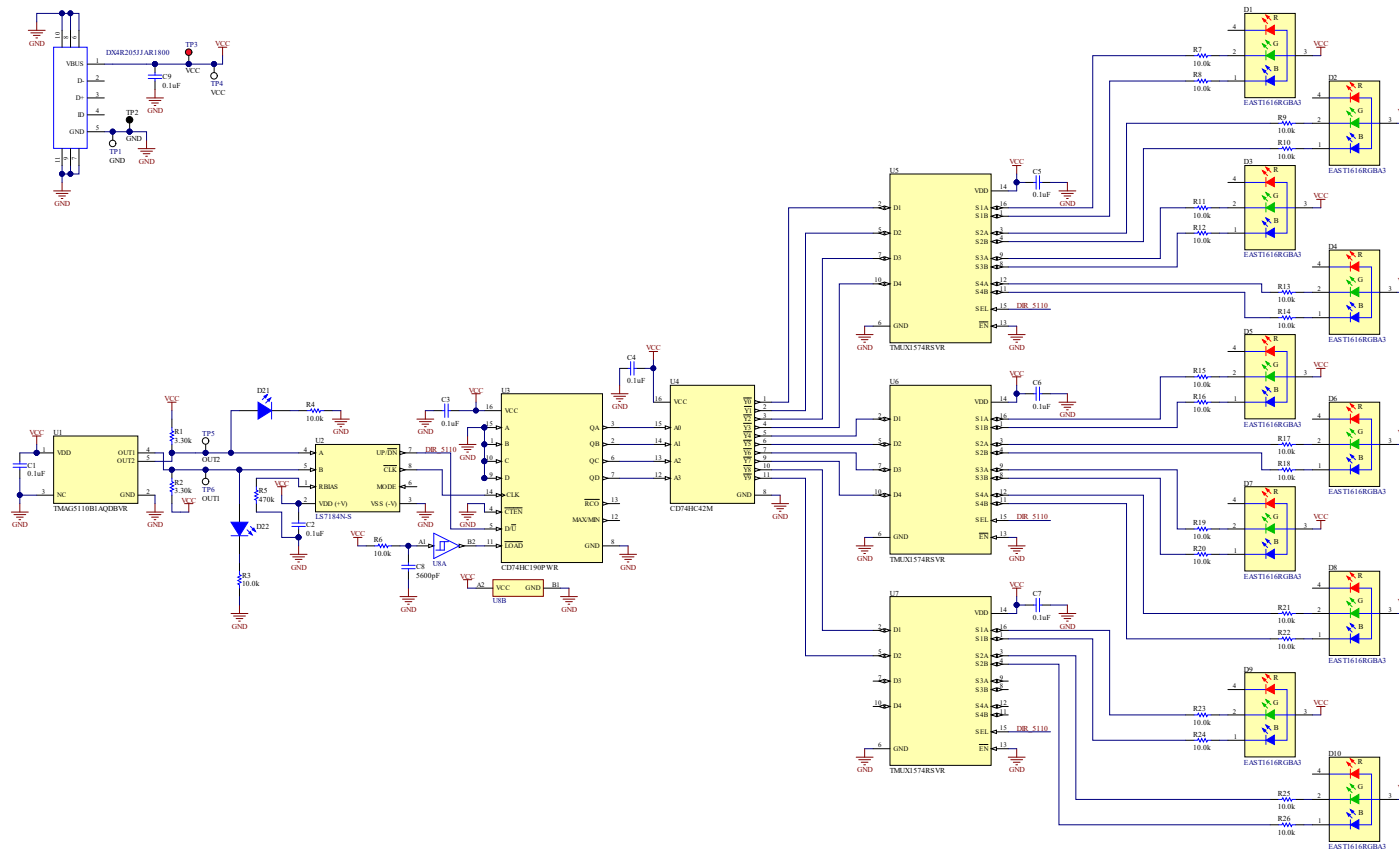


Figure 5-1. TMAG5110 Schematic

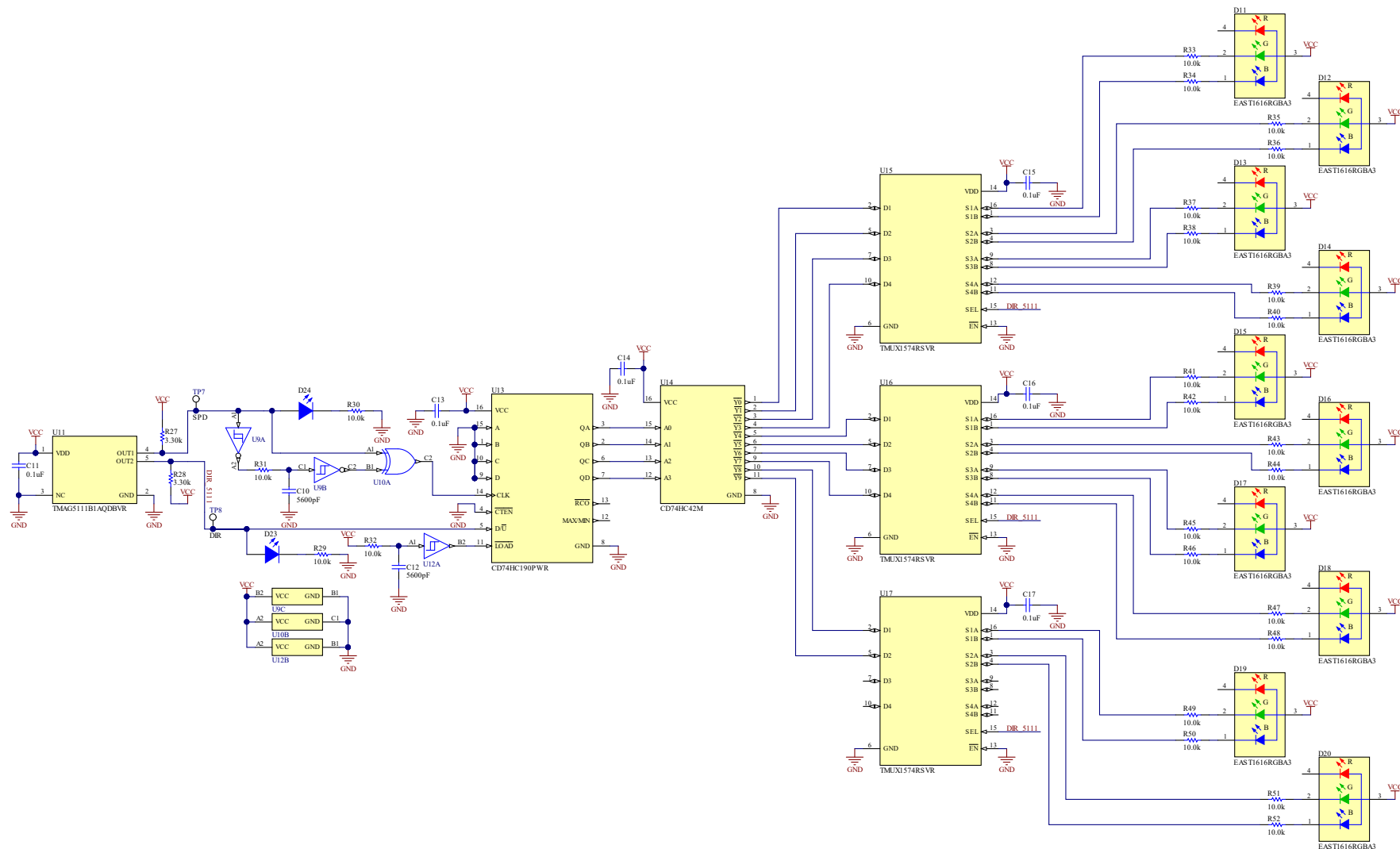
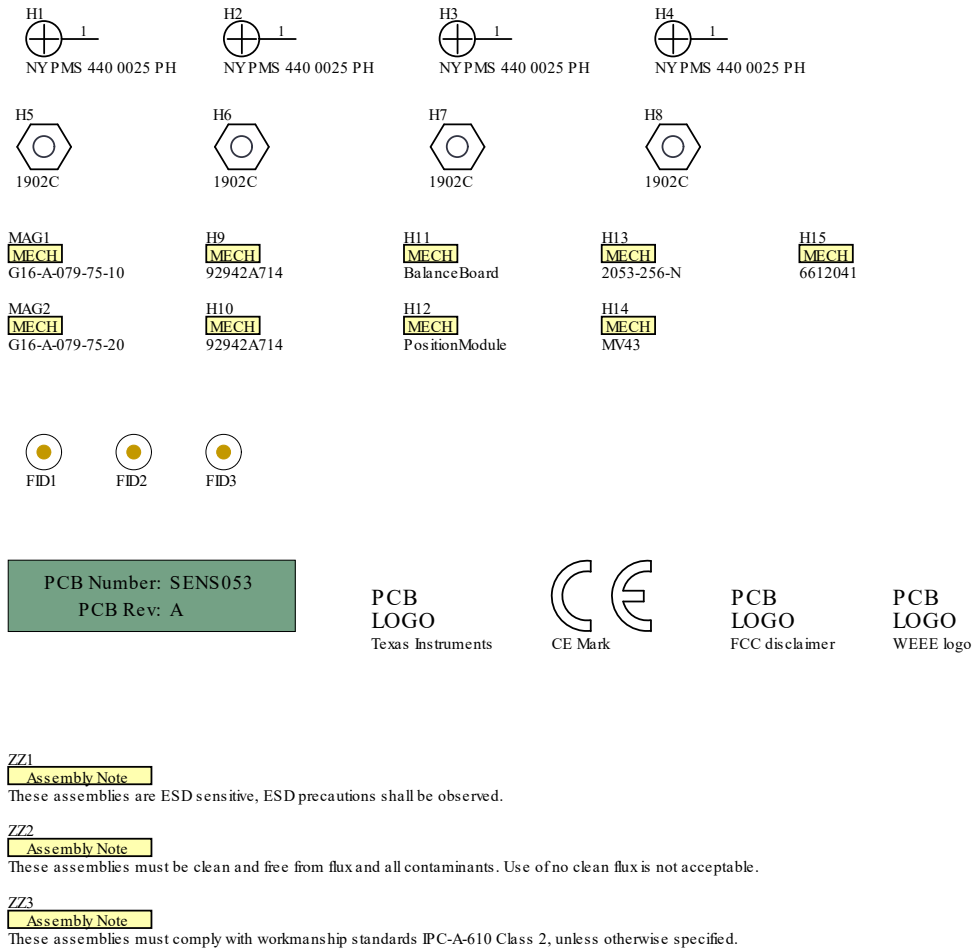


Figure 5-2. TMAG5111 Schematic



**Figure 5-3. Hardware Schematic**



## 5.2 PCB Layout

Figure 5-4 through Figure 5-7 illustrate the PCB layers of the EVM.

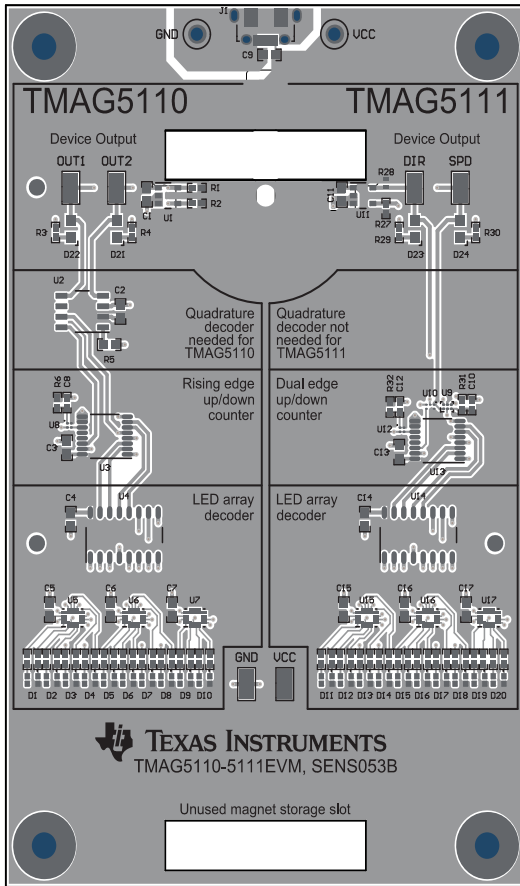


Figure 5-4. Top View

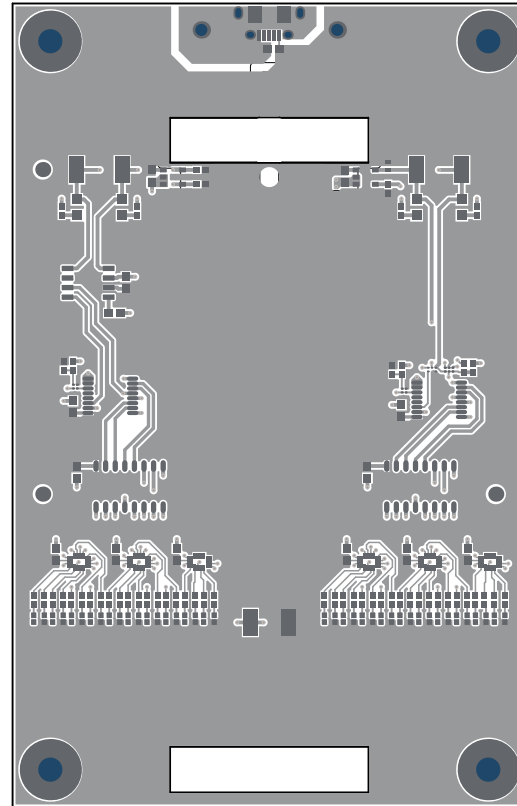
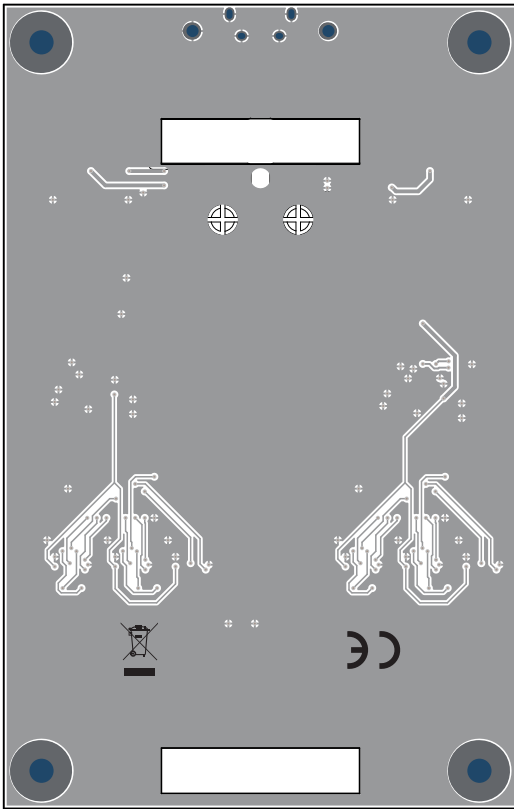
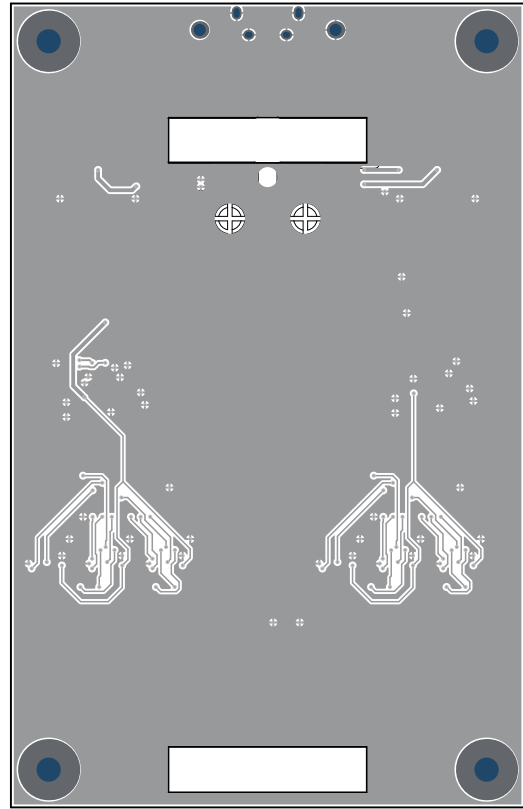


Figure 5-5. Top Layer



**Figure 5-6. Bottom View**



**Figure 5-7. Bottom Layer**

## 5.3 Bill of Materials

Table 5-1 provides the parts list for the EVM.

**Table 5-1. Bill of Materials**

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
IPCB1	1		Printed Circuit Board		SENS053	Any
C1, C2, C3, C4, C5, C6, C7, C9, C11, C13, C14, C15, C16, C17	14	0.1uF	CAP, CERM, 0.1 uF, 25 V, ±10%, X7R, 0603	0603	885012206071	Würth Elektronik
C8, C10, C12	3	5600pF	CAP, CERM, 5600 pF, 25 V, ±10%, X7R, 0402	0402	CL05B562KA5NNNC	Samsung Electro-Mechanics
D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, D14, D15, D16, D17, D18, D19, D20	20	RGB	LED, RGB, SMD	1.6x1.6mm	EAST1616RGBA3	Everlight
D21, D22, D23, D24	4	White	LED, White, SMD	0805	VAOL-S8WR4	Visual Communications Company, LLC
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Phillips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
H9, H10	2		Nylon Pan Head Slotted Screws, 2-56 Thread, 1" Long, Black		92942A714	McMASTER-CARR
H11	1		Plastic fixture to stabilize magnets		BalanceBoard	Stratasys
H12	1		Kitting Item: Plastic module to test magnet positions		PositionModule	Stratasys
H13	1		Kitting Item: Hex Standoff Threaded #2-56 Nylon 0.250" (6.35mm) 1/4"		2053-256-N	RAF Electronic Hardware
H14	1		Kitting Item: Magnetic Viewing Film. Purchase as needed		MV43	K&J Magnetics
H15	1		Kitting Item: 3025010-03; Cable, USB A MALE to Micro B MALE 3'; CDDS 6612041		6612041	Qualtek
J1	1		Connector, Receptacle, Micro-USB Type AB, R/A, Bottom Mount SMT	Connector, USB Micro AB	DX4R205JJAR1800	JAE Electronics
MAG1	1		Multipole Ring Magnet, 10 Poles, Neobond 30M, 2mm Bore Size, Molded		G16-A-079-75-10	Phoenix America
MAG2	1		Multipole Ring Magnet, 20 Poles, Neobond 30M, 2mm Bore Size, Molded		G16-A-079-75-20	Phoenix America
R1, R2, R27, R28	4	3.30k	RES, 3.30 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKF3301X	Panasonic
R3, R4, R6, R7, R8, R9, R10, R11, R12, R13, R14, R15, R16, R17, R18, R19, R20, R21, R22, R23, R24, R25, R26, R29, R30, R31, R32, R33, R34, R35, R36, R37, R38, R39, R40, R41, R42, R43, R44, R45, R46, R47, R48, R49, R50, R51, R52	47	10.0k	RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	RMCF0402FT10K0	Stackpole Electronics Inc
R5	1	470k	RES, 470 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603470KJNEA	Vishay-Dale
TP1, TP4, TP5, TP6, TP7, TP8	6		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
TP2	1		Test Point, Compact, Black, TH	Black Compact Testpoint	5006	Keystone
TP3	1		Test Point, Compact, Red, TH	Red Compact Testpoint	5005	Keystone

**Table 5-1. Bill of Materials (continued)**

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
U1	1		TMAG5110, DBV0005A (SOT-23-5)	DBV0005A	TMAG5110B1AQDBVR	Texas Instruments
U2	1		Quadrature Clock Converter, SOIC-8	SOIC-8	LS7184N-S	LSI Computer Systems, Inc.
U3, U13	2		High Speed CMOS Logic Presettable Synchronous BCD Decade Up/Down Counter, PW0016A (TSSOP-16)	PW0016A	CD74HC190PWR	Texas Instruments
U4, U14	2		High Speed CMOS Logic 1-of-10 BCD to Decimal Decoder, D0016A (SOIC-16)	D0016A	CD74HC42M	Texas Instruments
U5, U6, U7, U15, U16, U17	6		Low-capacitance, 2:1 (SPDT) 4-channel, powered-off protection switch with 1.8 V logic, RSV0016A (UQFN-16)	RSV0016A	TMUX1574RSVR	Texas Instruments
U8, U12	2		Single Schmitt-Trigger Buffer, YZV0004ADAD, LARGE T&R	YZV0004ADAD	SN74LVC1G17YZVR	Texas Instruments
U9	1		Dual Schmitt-Trigger Inverter, YZP0006ADAD, LARGE T&R	YZP0006ADAD	SN74LVC2G14YZPR	Texas Instruments
U10	1		Single 2-Input Exclusive-OR Gate, YZP0005AEAE, LARGE T&R	YZP0005AEAE	SN74LVC1G86YZPR	Texas Instruments
U11	1		TMAG5111, DBV0005A (SOT-23-5)	DBV0005A	TMAG5111B1AQDBVR	Texas Instruments
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A

## 6 Revision History

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

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### Changes from Revision A (April 2021) to Revision B (July 2021) Page

- Changed EVM board photo to high-resolution graphic..... 1
  - Changed PCB images to match online data sheet..... 16
- 

### Changes from Revision \* (June 2020) to Revision A (April 2021) Page

- Updated the numbering format for tables, figures, and cross-references throughout the document..... 1
  - Updated at product release to align to data sheet parameters..... 1
-

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