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 $B_{OP_{max}}$ and $B_{RP_{min}}$ thresholds of ±1.4 mT and ±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 ±1.4 mT. Table 1-1 lists the axes of sensitivity and thresholds for each device.

Table 1-1. TMAG5110/1 Device Summary

<table>
<thead>
<tr>
<th>Product</th>
<th>Axes of Sensitivity</th>
<th>$B_{OP_{max}}/B_{RP_{min}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMAG5110A2</td>
<td>XY</td>
<td>±1.4 mT</td>
</tr>
<tr>
<td>TMAG5110B2</td>
<td>ZY</td>
<td>±1.4 mT</td>
</tr>
<tr>
<td>TMAG5112C2</td>
<td>ZY</td>
<td>±1.4 mT</td>
</tr>
<tr>
<td>TMAG5110A4</td>
<td>XY</td>
<td>±3 mT</td>
</tr>
<tr>
<td>TMAG5110B4</td>
<td>ZY</td>
<td>±3 mT</td>
</tr>
<tr>
<td>TMAG5110C4</td>
<td>ZY</td>
<td>±3 mT</td>
</tr>
<tr>
<td>TMAG5111A2</td>
<td>XY</td>
<td>±1.4 mT</td>
</tr>
<tr>
<td>TMAG5111B2</td>
<td>ZY</td>
<td>±1.4 mT</td>
</tr>
<tr>
<td>TMAG5111C2</td>
<td>ZY</td>
<td>±1.4 mT</td>
</tr>
<tr>
<td>TMAG5111A4</td>
<td>XY</td>
<td>±3 mT</td>
</tr>
<tr>
<td>TMAG5111B4</td>
<td>ZY</td>
<td>±3 mT</td>
</tr>
<tr>
<td>TMAG5111C4</td>
<td>ZY</td>
<td>±3 mT</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMAG5110-5111EVM test board</td>
<td>1</td>
</tr>
<tr>
<td>10 pole ring magnet (packaged with PCB)</td>
<td>1</td>
</tr>
<tr>
<td>20 pole ring magnet (packaged with PCB)</td>
<td>1</td>
</tr>
<tr>
<td>Magnetic viewing film</td>
<td>1</td>
</tr>
<tr>
<td>Plastic module for position tests</td>
<td>1</td>
</tr>
<tr>
<td>USB cable</td>
<td>1</td>
</tr>
</tbody>
</table>
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 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. The literature number links to the document PDF.

### Table 1-3. Related Documentation

<table>
<thead>
<tr>
<th>Document Description</th>
<th>Document Literature Number</th>
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<tbody>
<tr>
<td>TMAG5110 data sheet</td>
<td>SBAS933</td>
</tr>
<tr>
<td>TMAG5110-Q1 data sheet</td>
<td>SLYS029</td>
</tr>
<tr>
<td>TMAG5111 data sheet</td>
<td>SBAS933</td>
</tr>
<tr>
<td>TMAG5111-Q1 data sheet</td>
<td>SLYS029</td>
</tr>
<tr>
<td>CD74HC190 data sheet</td>
<td>SCHS275</td>
</tr>
<tr>
<td>CD74HC42 data sheet</td>
<td>SCHS133</td>
</tr>
<tr>
<td>TMUX1574 data sheet</td>
<td>SCDS391</td>
</tr>
<tr>
<td>SN74LVC2G14 data sheet</td>
<td>SCES200</td>
</tr>
<tr>
<td>SN74LVC1G86 data sheet</td>
<td>SCES222</td>
</tr>
<tr>
<td>SN74LVC1G17 data sheet</td>
<td>SCES351</td>
</tr>
</tbody>
</table>
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 indicated 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 3-2** 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.
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.
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 kΩ was used to set approximately 5.5-µs $T_{OW}$. 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.

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Figure 5-1. TMAG5110 Schematic
Figure 5-2. TMAG5111 Schematic
**Figure 5-3. Hardware Schematic**

- **Assembly Note**: These assemblies are ESD sensitive, ESD precautions shall be observed.
- **Assembly Note**: These assemblies must be clean and free from flux and all contaminants. Use of no-clean flux is not acceptable.
- **Assembly Note**: These assemblies must comply with workmanship standards IPC-A-610 Class 2, unless otherwise specified.
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
### 5.3 Bill of Materials

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

<table>
<thead>
<tr>
<th>Designator</th>
<th>Quantity</th>
<th>Value</th>
<th>Description</th>
<th>Package Reference</th>
<th>Part Number</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPCB1</td>
<td>1</td>
<td></td>
<td>Printed Circuit Board</td>
<td>SENS053</td>
<td>Any</td>
<td></td>
</tr>
<tr>
<td>C1, C2, C3, C4, C5, C6, C7, C9, C11, C13, C14, C15, C16, C17</td>
<td>14</td>
<td>0.1μF</td>
<td>CAP, CERM, 0.1 μF, 25 V, ±10%, X7R, 0603</td>
<td>0603</td>
<td>885012206071</td>
<td>Wurth Elektronik</td>
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<tr>
<td>C8, C10, C12</td>
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<td>5600pF</td>
<td>CAP, CERM, 5600 pF, 25 V, ±10%, X7R, 0402</td>
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<td>CL05B562KA5NNNC</td>
<td>Samsung Electro-Mechanics</td>
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<td>D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D14, D15, D16, D17, D18, D19, D20</td>
<td>20</td>
<td>RGB</td>
<td>LED, RGB, SMD</td>
<td>1.6x1.6mm</td>
<td>EAST1616RGBA3</td>
<td>Everlight</td>
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<td>D21, D22, D23, D24</td>
<td>4</td>
<td>White</td>
<td>LED, White, SMD</td>
<td>0805</td>
<td>VAOL-S8WR4</td>
<td>Visual Communications Company, LLC</td>
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<tr>
<td>H1, H2, H3, H4</td>
<td>4</td>
<td></td>
<td>Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead</td>
<td>Screw</td>
<td>NY PMS 440 0025 PH</td>
<td>B&amp;F Fastener Supply</td>
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<tr>
<td>H5, H6, H7, H8</td>
<td>4</td>
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<td>Standoff, Hex, 0.5&quot;L #4-40 Nylon</td>
<td>Standoff</td>
<td>1902C</td>
<td>Keystone</td>
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<td>H9, H10</td>
<td>2</td>
<td></td>
<td>Nylon Pan Head Slotted Screws, 2-56 Thread, 1&quot; Long, Black</td>
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<td>McMaster-Carr</td>
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<td>H11</td>
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<td>Stratasys</td>
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<tr>
<td>H12</td>
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<td>Plastic module to test magnet positions</td>
<td>PositionModule</td>
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<td>H13</td>
<td>1</td>
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<td>H14</td>
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<tr>
<td>R1, R2, R27, R28</td>
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<td>3.30k</td>
<td>RES, 3.3 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0402</td>
<td>0402</td>
<td>ERJ-2RKF3301X</td>
<td>Panasonic</td>
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<tr>
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<td>47</td>
<td>10.0k</td>
<td>RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402</td>
<td>0402</td>
<td>RMCF0402FT10K0</td>
<td>Stackpole Electronics Inc</td>
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<td>R5</td>
<td>1</td>
<td>470k</td>
<td>RES, 470 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603</td>
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<td>CRCW0603470KJNEA</td>
<td>Vishay-Dale</td>
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<td>Keystone</td>
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<td>Black Compact Testpoint</td>
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<td>Keystone</td>
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<td>Value</td>
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<td>Manufacturer</td>
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<td>DBV0005A</td>
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<td>TMAG5110B1AQDBVR</td>
<td>Texas Instruments</td>
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<td>Quadrature Clock Converter, SOIC-8</td>
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<td>SOIC-8</td>
<td>LS7184N-S</td>
<td>LSI Computer Systems, Inc.</td>
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<td>U3, U13</td>
<td>2</td>
<td>High Speed CMOS Logic Presetable Synchronous BCD Decade Up/Down Counter, PW0016A (TSSOP-16)</td>
<td>PW0016A</td>
<td>PW0016A</td>
<td>CD74HC190PWR</td>
<td>Texas Instruments</td>
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<td>U4, U14</td>
<td>2</td>
<td>High Speed CMOS Logic 1-of-10 BCD to Decimal Decoder, D0016A (SOIC-16)</td>
<td>D0016A</td>
<td>D0016A</td>
<td>CD74HC42M</td>
<td>Texas Instruments</td>
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<tr>
<td>U5, U6, U7, U15, U16, U17</td>
<td>6</td>
<td>Low-capacitance, 2:1 (SPDT) 4-channel, powered-off protection switch with 1.8 V logic, RSV0016A (UQFN-16)</td>
<td>RSV0016A</td>
<td>RSV0016A</td>
<td>TMUX1574RSVR</td>
<td>Texas Instruments</td>
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<tr>
<td>U8, U12</td>
<td>2</td>
<td>Single Schmitt-Trigger Buffer, YZV0004ADAD, LARGE T&amp;R</td>
<td>YZV0004ADAD</td>
<td>YZV0004ADAD</td>
<td>SN74LVC1G17YZVR</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>U9</td>
<td>1</td>
<td>Dual Schmitt-Trigger Inverter, YZP0006ADAD, LARGE T&amp;R</td>
<td>YZP0006ADAD</td>
<td>YZP0006ADAD</td>
<td>SN74LVC2G14YZPR</td>
<td>Texas Instruments</td>
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<tr>
<td>U10</td>
<td>1</td>
<td>Single 2-Input Exclusive-OR Gate, YZP0005AEAE, LARGE T&amp;R</td>
<td>YZP0005AEAE</td>
<td>YZP0005AEAE</td>
<td>SN74LVC1G86YZPR</td>
<td>Texas Instruments</td>
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<tr>
<td>U11</td>
<td>1</td>
<td>TMAG5111, DBV0005A (SOT-23-5)</td>
<td>DBV0005A</td>
<td>DBV0005A</td>
<td>TMAG5111B1AQDBVR</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>FID1, FID2, FID3</td>
<td>0</td>
<td>Fiducial mark. There is nothing to buy or mount.</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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</tbody>
</table>
6 Revision History
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

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
STANDARD TERMS FOR EVALUATION MODULES

1. Delivery: TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User’s acceptance of the EVM is expressly subject to the following terms.

1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software.

1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 Limited Warranty and Related Remedies/Disclaimers:

2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User’s design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User’s claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects within ten (10) business days after the defect has been detected.

2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User’s account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:
EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.
3 Regulatory Notices:

3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:

CAUTION
This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices
NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices
NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

Concerning EVMs Including Radio Transmitters:
This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:
(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:
Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L’exploitation est autorisée aux deux conditions suivantes: (1) l’appareil ne doit pas produire de brouillage, et (2) l’utilisateur de l’appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d’en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:
Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.
Concernant les EVMs avec antennes détachables
Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et
d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage
radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope
rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le
présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le
manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne
non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de
l'émetteur

3.3 Japan

3.3.1 Notice for EVMs delivered in Japan: Please see http://www.tij.co.jp/l SDS/TL_ja/general/eStore/notice_01.page 日本国内に
輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/l SDS/TL_ja/general/eStore/notice_01.page

3.3.2 Notice for Users of EVMs Considered “Radio Frequency Products” in Japan: EVMs entering Japan may not be certified
by TI as conforming to Technical Regulations of Radio Law of Japan.
If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the
instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs
(which for the avoidance of doubt are stated strictly for convenience and should be verified by User):
1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal
Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry’s Rule for
Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to
EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan
with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note
that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けて
いないものがあります。技術基準適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの
措置を取っていただく必要があります。
1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用
いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。
なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。
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ンスツルメンツ株式会社
東京都新宿区西新宿6丁目24番1号
西新宿三井ビル

3.3.3 Notice for EVMs for Power Line Communication: Please see http://www.tij.co.jp/l SDS/TL_ja/general/eStore/notice_02.page
電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://
http://www.tij.co.jp/l SDS/TL_ja/general/eStore/notice_02.page

3.4 European Union

3.4.1 For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):
This is a class A product intended for use in environments other than domestic environments that are connected to a
low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this
product may cause radio interference in which case the user may be required to take adequate measures.
EVM Use Restrictions and Warnings:

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 Safety-Related Warnings and Restrictions:

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. Accuracy of Information: To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. Disclaimers:

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED “AS IS” AND “WITH ALL FAULTS.” TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFEERING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. User’s Indemnity Obligations and Representations. User will defend, indemnify and hold TI, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of or in connection with any handling or use of the EVM that is not in accordance with these terms. This obligation shall apply whether claims arise under statute, regulation, or the law of tort, contract or any other legal theory, and even if the EVM fails to perform as described or expected.

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8. **Limitations on Damages and Liability:**

8.1 **General Limitations.** In no event shall TI be liable for any special, collateral, indirect, punitive, incidental, consequential, or exemplary damages in connection with or arising out of these terms or the use of the EVMs, regardless of whether TI has been advised of the possibility of such damages. Excluded damages include, but are not limited to, cost of removal or reinstallation, ancillary costs to the procurement of substitute goods or services, retesting, outside computer time, labor costs, loss of goodwill, loss of profits, loss of savings, loss of use, loss of data, or business interruption. No claim, suit or action shall be brought against TI more than twelve (12) months after the event that gave rise to the cause of action has occurred.

8.2 **Specific Limitations.** In no event shall TI’s aggregate liability from any use of an EVM provided hereunder, including from any warranty, indemnity or other obligation arising out of or in connection with these terms, exceed the total amount paid to TI by User for the particular EVM(s) at issue during the prior twelve (12) months with respect to which losses or damages are claimed. The existence of more than one claim shall not enlarge or extend this limit.

9. **Return Policy.** Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. **Governing Law:** These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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