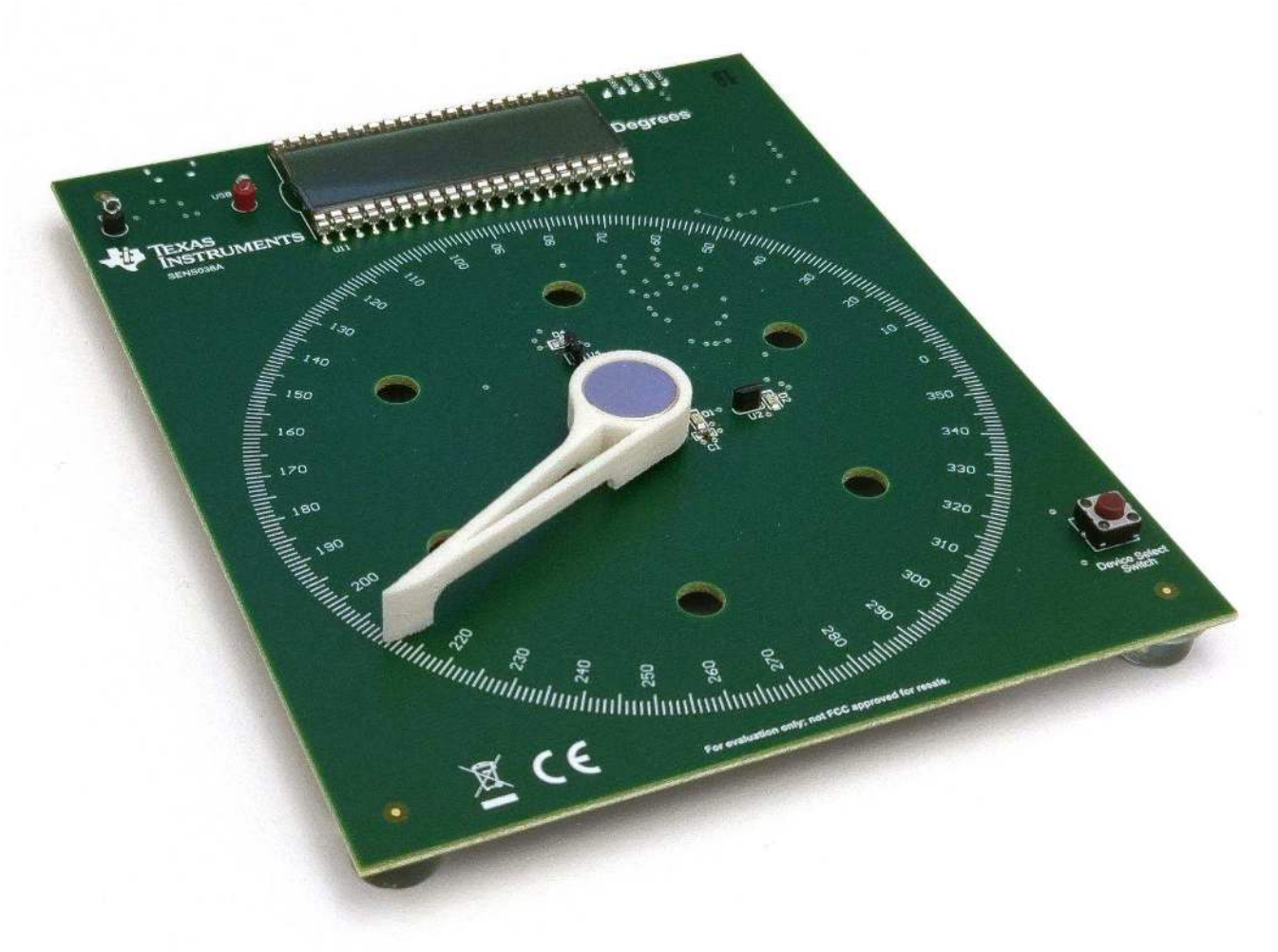
User's Guide
SLYU048–July 2018

DRV5055-ANGLE-EVM



This user's guide describes the characteristics, operation, and use of the DRV5055-ANGLE-EVM evaluation module (EVM). This EVM demonstrates the application of the DRV5055 linear Hall effect sensor for contactless angle measurement in rotary systems. The EVM implements both encoding and decoding of absolute angle information. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the DRV5055-ANGLE-EVM. 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 DRV5055 family of ratiometric, linear Hall effect sensors sense magnetic fields ranging from ±21 mT to ±176 mT, depending on device and supply voltage. These devices operate from a single 3.3-V or 5-V nominal power supply voltage, and draw a maximum of 10 mA of supply current. The linear output range is between 600 mV and V_{CC} – 200 mV. Table 1 summarizes the available options by input range for 3.3-V supply voltage. The DRV5055 is currently available in a 3-pin SOT-23 or 3-pin TO-92 package.

Table 1. DRV5055 Device Summary

Product	Linear Input Range (mT)
DRV5055A1	±22
DRV5055A2	±44
DRV5055A3	±88
DRV5055A4	±176

1.1 Kit Contents

Table 2 lists the contents of the DRV5055-ANGLE-EVM kit. Contact the nearest Texas Instruments Product Information Center if any component is missing.

Table 2. Kit Contents

Item	Quantity
Fully assembled PCB with magnet and plastic magnet holder	1
USB cable	1

1.2 EVM Features

The DRV5055-ANGLE-EVM includes the following features:

- Evaluation straight out of box with no additional instrumentation
- USB-powered for convenience, but includes option to connect external power source
- Silkscreen compass for angle setting
- Onboard LCD for measured angle display
- Onboard push-button switch that toggles through multiple sensor configurations and sets calibration points
- Supports single-sensor configurations for limited-range angle sensing, and dual-sensor configurations for full 360° sensing range
- Supports up to 36-point transfer function calibration for < 1° peak-to-peak estimation error
- PCB mounting holes

1.3 Related Documentation From Texas Instruments

This EVM user's guide provides information regarding TI's integrated circuits used in the assembly of the DRV5055-ANGLE-EVM. This user's guide is available from the TI website under literature number SLYU048. 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 3 lists documentation related to the DRV5055-ANGLE-EVM. The device name links to the product web folder on www.ti.com. The literature number links to the document PDF.

Table 3. Related Documentation

Document Title	Document Literature Number
DRV5055 data sheet	SBAS640
DRV5055-Q1 data sheet	SBAS639
TS3A24159 data sheet	SCDS238
OPA2314 data sheet	SBOS563
SN74LVC1G17 data sheet	SCES351
ADS7042 data sheet	SBAS608
TLV755P data sheet	SBVS320
MSP430FR4133 data sheet	SLAS865
Angle Measurements With Linear Hall Effect Sensors Application Report	SLYA036

2 Operation

Users interact with the EVM is entirely through controls and visual indicators on the front side of the PCB. The various components of the simple and intuitive user interface are shown in Figure 1.

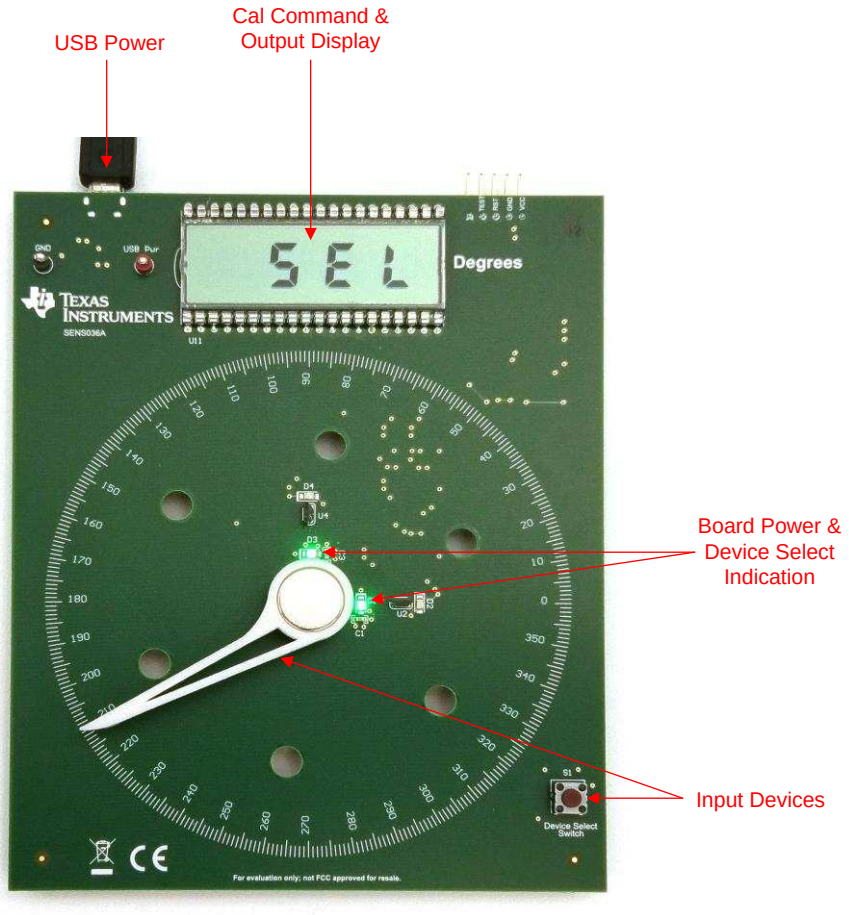

Figure 1. DRV5055-ANGLE-EVM User Interface

The silkscreen compass serves as the reference for setting the shaft angle. The main input devices of the EVM are the push-button switch and the plastic pointer that also holds the magnet. Both inputs are used to configure the board; whereas, only the pointer is used during normal operation.

The LCD is the main output device for displaying user commands during calibration, as well as angle measurements. Onboard LEDs identify the devices that are selected for measurement. The LEDs also serve as power-good indicators.

The operation of the DRV5055-ANGLE-EVM begins with a calibration procedure that must be executed immediately after power up. After calibration is complete, the value displayed on the LCD accurately tracks the position of the pointer. The following sections describe the calibration procedure and available operating modes in greater detail.

2.1 Calibration Procedure

The calibration procedure is invoked each time the EVM is powered on. The calibration procedure can also be started from the normal operating mode with a long-press (> 2 s) of the push-button switch. Figure 2 shows the bottom silkscreen layer of the PCB. The PCB includes a quick lookup guide to the calibration procedure, as detailed in the following steps.

1. With the board powered on, the instruction *SEL* is displayed on the LCD. Use the push-button switch to cycle through the various, supported dual- and single-sensor configurations. To select a particular configuration, hold down the push-button switch for at least two seconds (long-press).
2. Next, the instruction *SPIn* appears on the display. Spin the pointer around in any direction and complete at least two full revolutions. The system automatically transitions to the next step when the required information (that is, peak values of the sensor output voltages) has been stored.
3. If a single-sensor configuration was selected in Step 1, then at this point, the EVM enters the normal operating mode. Otherwise, the *CP.* instruction is displayed. *CP* stands for *Calibration Points* and represents the number of line segments used to approximate the nonlinear shaft angle-to-estimated-angle transfer function. Up to 36 points are supported. Rotate the pointer clockwise to increase the number of calibration points or counterclockwise to decrease the number of calibration points. A short press (< 1 s) of the push-button stores the desired value.
4. The last step of the calibration procedure is to identify the positions on the compass corresponding to the calibration points. For each calibration point that appears on the display, rotate the pointer to the corresponding position on the compass, and press the push-button to store.

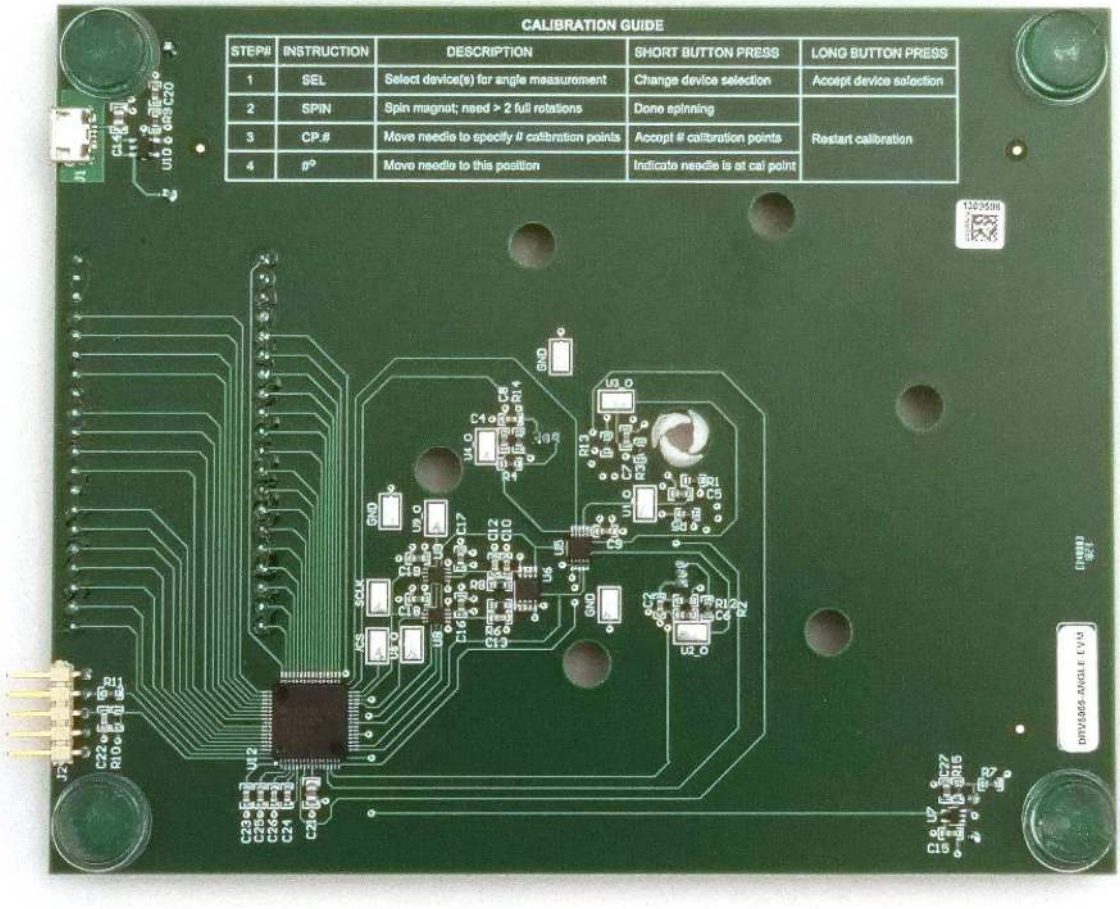

Figure 2. Calibration Guide on Bottom Silkscreen for Quick Lookup

2.2 Functional Modes

2.2.1 Power Supply Modes

A 3.3-V supply voltage is necessary for DRV5055-ANGLE-EVM operation. The power supply can be derived from either the USB bus of a charger or PC, or from an external dc power source connected between the test points labeled *USB Pwr* and *GND*.

CAUTION

To prevent damage to the onboard linear voltage regulator, the input supply voltage *must not* exceed 6 V.

2.2.2 Measurement Modes

As described in Section 2.1, this EVM supports both single-sensor and dual-sensor modes for evaluation. The dual-sensor mode offers absolute angle sensing over a full 360° range, and delivers the best performance. The single-sensor mode is more cost-effective, and sufficient in applications where the sensing range is less than 180°. However, the EVM does not support offset calibration in single-sensor mode. Consequently, setting the pointer to 0° on the compass almost always produces a value not equal to 0° on the display. To verify linear behavior between the shaft angle setting and the estimated angle, first locate the positions where the displayed angle becomes 0°. Then, observe changes in the displayed values as the pointer is moved around this reference point. See the *Angle Measurements With Linear Hall Effect Sensors Application Report* for a detailed discussion of the two measurement modes.

3 Hardware

Figure 3 shows the major blocks that make up the DRV5055-ANGLE-EVM hardware. The various blocks are broadly described in the following sections.

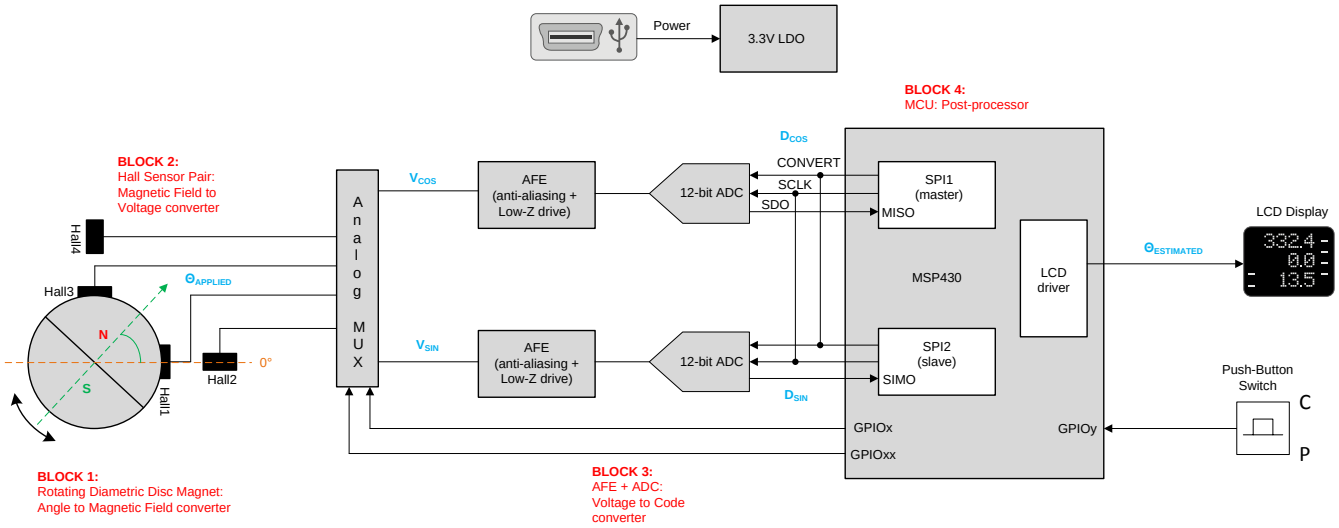

Figure 3. Block Diagram of the DRV5055-ANGLE-EVM

3.1 Permanent Magnet

For the DRV5055-ANGLE-EVM angle sensing algorithm to work, the shaft angle information must be encoded as sinusoidal magnetic flux density signals. The necessary encoding is achieved by using a diametric disc magnet that produces a circular magnetic field. As seen in Figure 1, the magnet is attached to a plastic pointer fixture mounted in the hole at the center of the compass. As the pointer (and magnet) rotate, the circular field of the magnet rotates, and the magnetic flux density at any point around the magnet changes sinusoidally over time. For example, Figure 4 depicts a finite-element model of a rotating diametric disc magnet. As the magnet rotates, the components of the magnetic flux density vector are measured at points P1 and P2, and are sinusoidal, as shown in the plot of Figure 4.

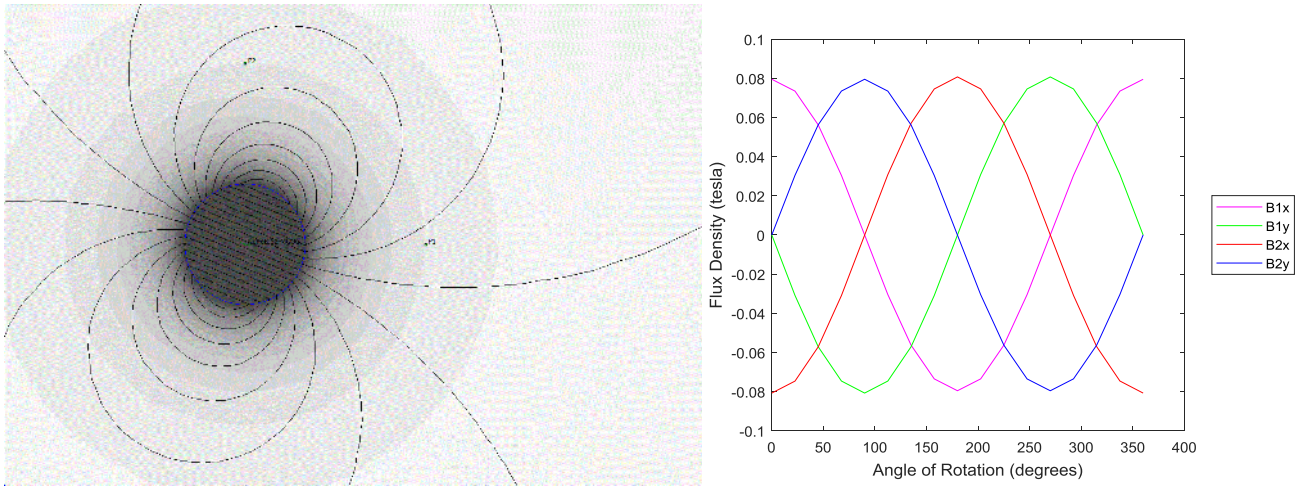

Figure 4. Generating Sinusoidal Magnetic Flux Density Signals

3.2 Hall Sensor(s) and Analog MUX

The magnetic flux density signals generated by the rotating magnet are measured at four locations around the magnet by the DRV5055 linear Hall effect sensors. The PCB includes both package variants of the DRV5055. Each sensor measures the flux density at the sensor location, and outputs a proportional voltage signal that swings between 600 mV and 3.1 V. The Hall effect sensor outputs are routed to a dual 2:1 low-distortion analog MUX (TS3A24159). The MUX that selects individual or pairs of sensors for single-sensor or dual-sensor modes of operation, respectively. Dual-sensor mode requires sin/cos encoding for angle sensing over the full 360° range. Select any pair of sensors located on the same circle or on the same radial line in order to generate the required sin/cos signal pairs.

3.3 Simultaneous Sampling ADCs

Data conversion of the Hall effect sensor outputs is accomplished by a pair of ADS7042 SAR ADCs configured for simultaneous sampling. Simultaneous sampling is important to prevent any additional phase errors caused by skewed sampling instants that disrupt the sin/cos relationship of the dual-sensor outputs. SAR ADCs generally have extremely low aperture delay (a few nanoseconds at most) because SAR ADCs are specifically designed to convert instantaneous samples of the input signal, rather than window-averaged values . As a result, SAR ADCs are an excellent choice for simultaneous-sampling applications. The ADS7042 normally supports a maximum throughput of 1 MSPS. However, the settling characteristics of the ADC input drive circuit used on this EVM limit the max throughput to approximately 300 kSPS. The maximum sampling rate is still sufficient for noise reduction through oversampling and averaging in most applications. The maximum sampling rate is also sufficient for acquiring relatively high-speed input signals of up to 20 kHz; the approximate bandwidth of the DRV5055.

3.4 MCU

The MCU captures the ADC outputs and post-processes the digital data (that is, applies calibration, normalization, and the decode function) to estimate the shaft angle. The EVM uses the MSP430FR4133, an ultra-low-power MCU. The MSP430FR4133 natively supports a 7-segment LCD drive, and includes two SPI interfaces to control the dual ADCs. The MPS430FR4133 also includes an optimized floating point math library (MSPMATHLIB) to efficiently evaluate inverse trigonometric functions. ASIN is used for single-sensor decoding, and ATAN2 is used for dual-sensor decoding. The MSP430 programming interface is also accessible for experimentation.

4 Schematics, PCB Layout, and Bill of Materials

4.1 Schematics

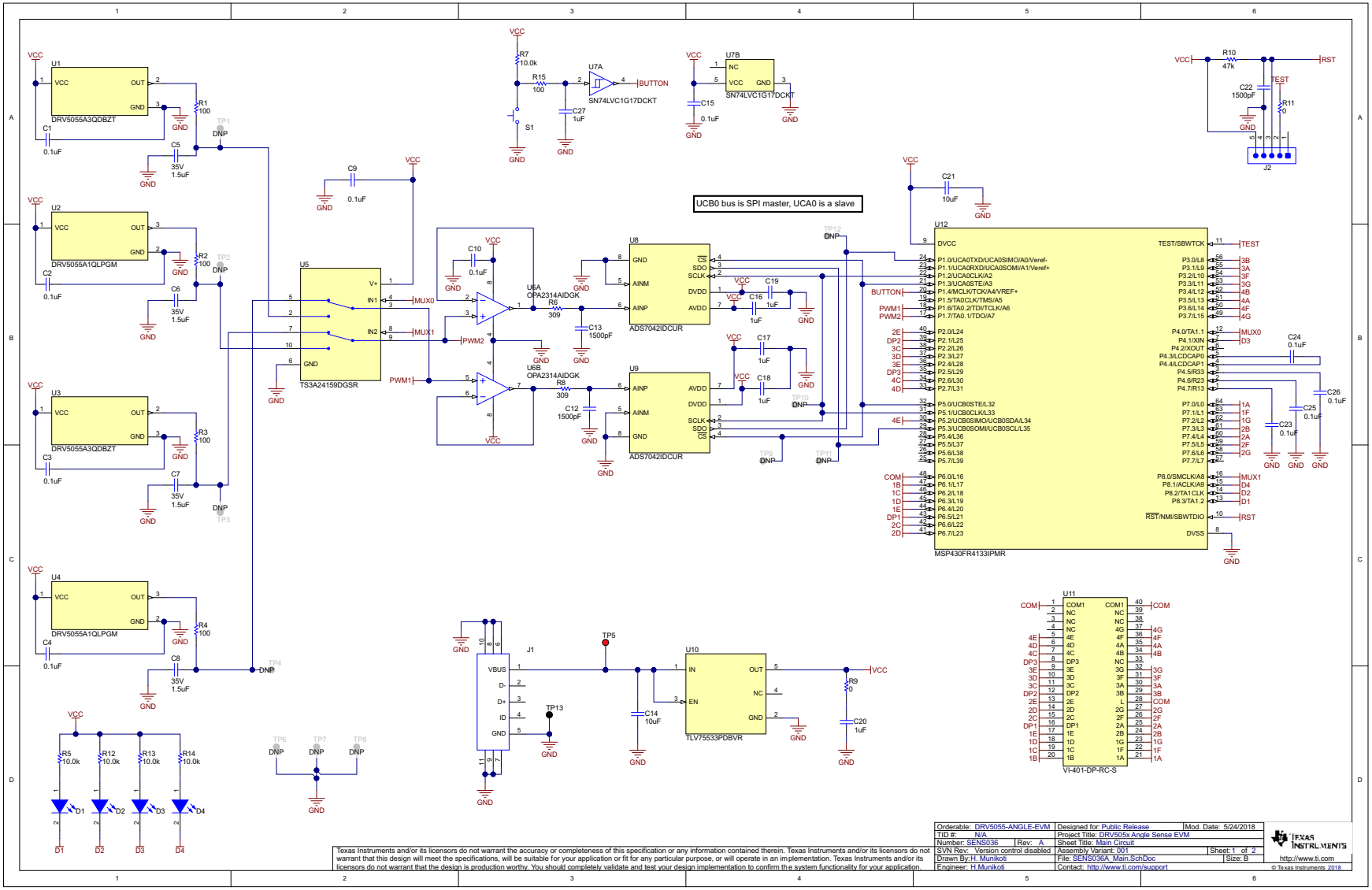

Figure 5. Schematic of DRV5055-ANGLE-EVM

4.2 PCB Layout

NOTE: PCB layout images are not to scale.

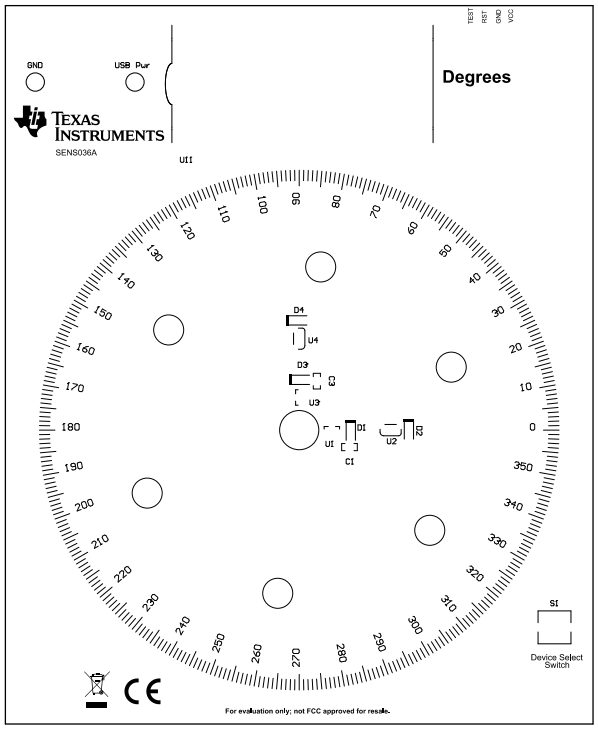

Figure 6. Top Overlay

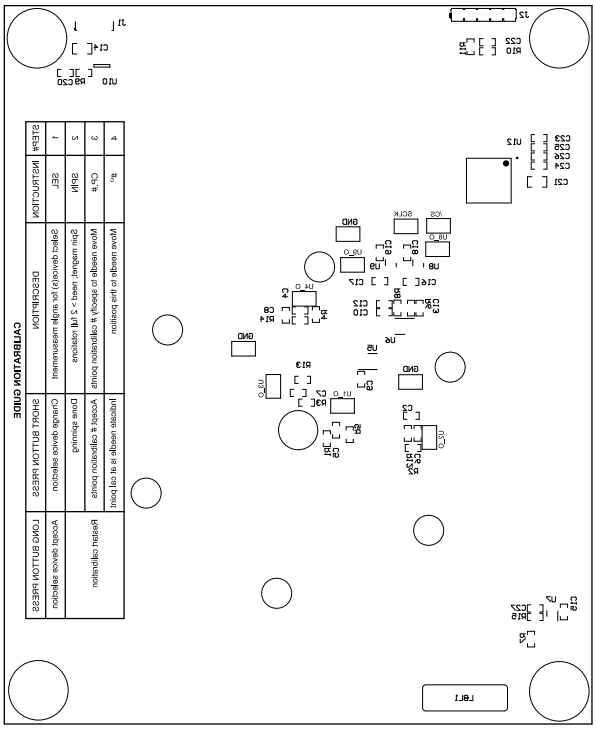

Figure 8. Bottom Overlay

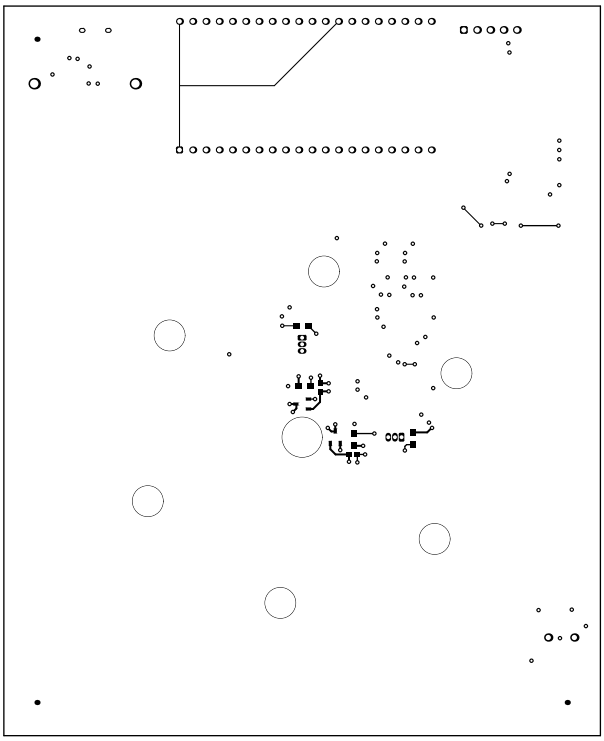

Figure 7. Top Layer

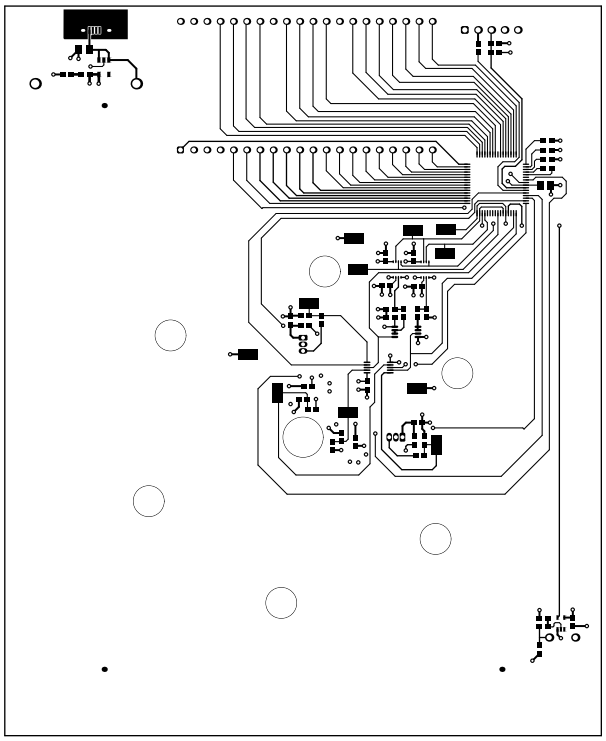

Figure 9. Bottom Layer

4.3 Bill of Materials

Table 4 provides the parts list for the DRV5055-ANGLE-EVM.

Table 4. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	PartNumber	Manufacturer
C1, C2, C3, C4, C9, C10, C15, C23, C24, C25, C26	11	0.1uF	CAP, CERM, 0.1 uF, 25 V, +/- 10%, X7R, 0603	0603	C0603X104K3RACTU	Kemet
C5, C6, C7, C8	4	1.5uF	CAP, CERM, 1.5 uF, 35 V, +/- 10%, X5R, 0603	0603	C1608X5R1V155K080AC	TDK
C12, C13, C22	3	1500pF	CAP, CERM, 1500 pF, 50 V,+/- 5%, C0G/NP0, 0603	0603	GRM1885C1H152JA01J	MuRata
C14, C21	2	10uF	CAP, CERM, 10 uF, 10 V, +/- 10%, X7R, 0805	0805	885012207026	Wurth Elektronik
C16, C17, C18, C19, C20, C27	6	1uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0603	0603	C1608X7R1C105K080AC	TDK
D1, D2, D3, D4	4	Green	LED, Green, SMD	LED_0805	APT2012LZGCK	Kingbright
H1, H2, H3, H4	4		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M
H5	1		Diametrically magnetized disc 0.5" dia x 0.125" th N42, 2.79lbs		D82DIA	K&J Magnetics
H6	1		3D printed magnet holder		Used in BOM report	Used in BOM report
H7	1		As Required: SUPER GLUE LIQUID 0.1 OZ		8333-3G	MG Chemicals
J1	1		Receptacle, USB 2.0, Micro-USB Type B, R/A, SMT	USB-micro B USB 2.0, 0.65mm, 5 Pos, R/A, SMT	10118194-0001LF	FCI
J2	1		Header, 2.54mm, 5x1, Gold, R/A, TH	Header, 2.54mm, 5x1, R/A, TH	PRPC005SBAN-M71RC	Sullins Connector Solutions
PCB1	1		Printed Circuit Board		SENS036	Any
R1, R2, R3, R4, R15	5	100	RES, 100, 1%, 0.1 W, 0603	0603	RC0603FR-07100RL	Yageo
R5, R7, R12, R13, R14	5	10.0k	RES, 10.0 k, 0.1%, 0.1 W, 0603	0603	RG1608P-103-B-T5	Susumu Co Ltd
R6, R8	2	309	RES, 309, 1%, 0.1 W, 0603	0603	RC0603FR-07309RL	Yageo
R9, R11	2	0	RES, 0, 5%, 0.1 W, 0603	0603	RC0603JR-070RL	Yageo
R10	1	47k	RES, 47 k, 5%, 0.1 W, 0603	0603	RC0603JR-0747KL	Yageo
S1	1		Switch, Tactile, SPST-NO, 0.02A, 15V, TH	6.0x5.0x6mm	EVQ-21505R	Panasonic
TP5	1		Test Point, Compact, Red, TH	Red Compact Testpoint	5005	Keystone
TP13	1		Test Point, Compact, Black, TH	Black Compact Testpoint	5006	Keystone
U1, U3	2		High Accuracy 3.3 V or 5 V Ratiometric Bipolar Hall Effect Sensor Family, DBZ0003A (SOT-23-3)	DBZ0003A	DRV5055A3QDBZT	Texas Instruments
U2, U4	2		High Accuracy 3.3 V or 5 V Ratiometric Bipolar Hall Effect Sensor Family, LPG0003A (TO-92-3)	LPG0003A	DRV5055A1QLPGM	Texas Instruments

Table 4. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	PartNumber	Manufacturer
U5	1		0.3-Ohm 2-Channel SPDT Bidirection Switch, DGS0010A (VSSOP-10)	DGS0010A	TS3A24159DGSR	Texas Instruments
U6	1		Dual, 3MHz, Low-Power, Low-Noise, RRI/O, 1.8V CMOS Operational Amplifier, DGK0008A (VSSOP-8)	DGK0008A	OPA2314AIDGK	Texas Instruments
U7	1		Single Schmitt-Trigger Buffer, DCK0005A, SMALL T&R	DCK0005A	SN74LVC1G17DCKT	Texas Instruments
U8, U9	2		12-Bit, 1-MSPS, Ultra-Low-Power and Ultra-Small-Size SAR ADC with SPI Interface, DCU0008A (VSSOP-8)	DCU0008A	ADS7042IDCUR	Texas Instruments
U10	1		500-mA, Low IQ, Small Size, Low Dropout Regulator, DBV0005A (SOT-23-5)	DBV0005A	TLV75533PDBVR	Texas Instruments
U11	1		LCD 7-Segment, TH	50.8x22.86mm	VI-401-DP-RC-S	Varitronix
U12	1		16 MHz Ultra-Low-Power Microcontroller with 16 KB FRAM, 2 KB SRAM, 60 IO, 10 ch ADC10, LCD, IR Logic, PM0064A (LQFP-64)	PM0064A	MSP430FR4133IPMR	Texas Instruments
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
LBL1	0			PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
TP1, TP2, TP3, TP4, TP6, TP7, TP8, TP9, TP10, TP11, TP12	0		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone

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 with 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.

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/lsds/ti_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/lsds/ti_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.

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2. 実験局の免許を取得後ご使用いただく。
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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page
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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.

4 *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 compliance in all respects with such laws and regulations. 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.

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