LMX8410LEVM User Guide

The Texas Instruments LMX8410LEVM evaluation module helps designers evaluate the operation and performance of the LMX8410L device (a high-performance, wideband demodulator with integrated synthesizer). The evaluation module routes the critical signals from the LMX8410L to SMA connectors at the board edges, which allows testing the full functionality of the device. Included with the EVM is a programming module that connects to the computer through USB. The LMX8410LEVM has an on-board TPS7A8801 device to help provide 5-V and 3.3-V rails from just one power source. An on-board 100-MHz oscillator is also running by default to allow users to quickly evaluate the internal synthesizer without needing to provide a reference input source.

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Trademarks

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1 Introduction

1.1 Evaluation Kit Contents

- LMX8410LEVM
- USB2ANY (contains 10-pin programming cable, programming module, USB cable)

1.2 Recommended Lab Test Equipment

- Signal Generator 1:
  - Used to generate RF input signal.
  - Able to provide 4 to 10 GHz output.
- Signal Generator 2 (optional):
  - Used to generate external LO signal.
  - Able to provide 4 to 10 GHz output.
- Spectrum Analyzer:
  - Used to detect IF output.
  - Able to detect up to 1.5GHz signal.
- Power Supply:
  - Default option (on board LDO): 5.3V supply voltage and up to 1A current.
  - Split supply option (bypass LDO): Two channels are required. The 5V channel draws about 0.14 A and the 3.3V channel draws up to 0.65A depending on mode options.

2 Hardware Setup

If you choose to evaluate the LMX8410LEVM with its internal synthesizer (internal LO mode), see Figure 1. If you choose to evaluate the LMX8410LEVM with an external LO signal (external LO mode), refer to Figure 2.

1. USB2ANY programmer:
   a. Connect the USB2ANY module through USB cable to computer.
   b. Then connect the 10-pin cable from USB2ANY module to LMX8410LEVM header (J13).
2. Power supply:
   a. Single supply option (default):
      - Set current limit to 1 A.
      - Set voltage to 5.3 V.
      - Connect the power supply output to SMA connector J1.
   b. Split supply option (bypassing LDO):
      - Bypass the LDO by moving R36 to the position of R37 (R36 is 0 Ohm resistor).
      - Remove R42 and R43 so the LDO outputs are disconnected.
      - Connect the 3.3 V power supply output to the SMA connector J2.
      - Connect the 5 V power supply output to the SMA connector J1.

3. RF input:

    a. Connect RF input signal to port J11.

    b. For two-tone measurements such as IP2 and IP3, it is recommended to use -10dBm RF input and 17MHz tone separation. IF the RF input level is too high, non-linearity may occur and results can be inaccurate; if RF level is too low, the spurs can easily be buried below noise floor. For the choice of tone separation, avoid using multiple of OSCin for internal LO mode because on-board coupling with OSCin may add flickering behaviors.

4. LO modes:

    1. Internal LO mode:

        • There is an on-board oscillator (Y1), which provides 100 MHz reference for the LMX8410L internal synthesizer.

        • To accurately measure the positions of spurs, bypass the on-board oscillator by moving R23 and R24 to the positions of R21 and R22 (R23 and R24 are 0 Ohm resistors) and removing R27. Then use 10 MHz reference output from Signal Generator as OSCin (reference for internal synthesizer). Inject the OSCin signal through ports OSCINP (J3) and OSCINM (J4). Synchronize the signal generator and spectrum analyzer.

    2. External LO mode:

        • Connect the LO signal input to connectors LO_M (J5) and LO_P (J6) through a balun.

        • Make sure that there are no pull-up resistors at the positions of R54 and R55. (If you never modified the board then don't worry about it.)

    3. To see the VCO output of internal LO:

        • In order to see the output of internal synthesizer, two 50 Ohm pull-up resistors are needed at the positions of R54 and R55.

        • The output can then be detected from connector J5 and J6.

5. IF output:

    a. J7 and J8 are I channel IF differential outputs; J9 and J10 are Q channel IF differential outputs. Keep in mind that it is critical to evaluate differential outputs using baluns. If you evaluate single-ended IF outputs, you won't get correct results. For example, the noise figure measured through single ended output will be higher because noise from IF_P and IF_M are not all uncorrelated.

    b. Note that IF gain bandwidth is DC to 1350MHz. Complex bandwidth is 2700MHz. The performances vary with IF frequency. Refer to typical performance plots in datasheet for more information.
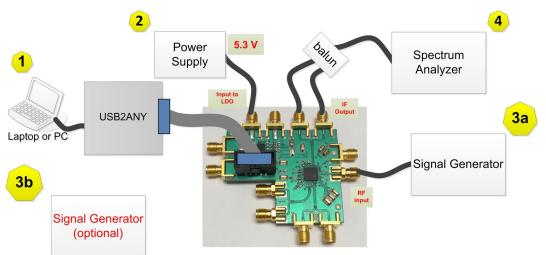

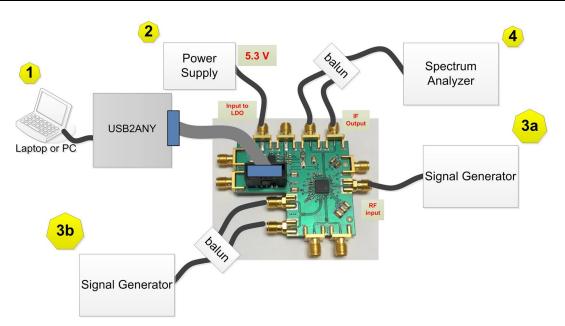**Figure 1. Setup Diagram for LMX8410L in Internal LO Mode**

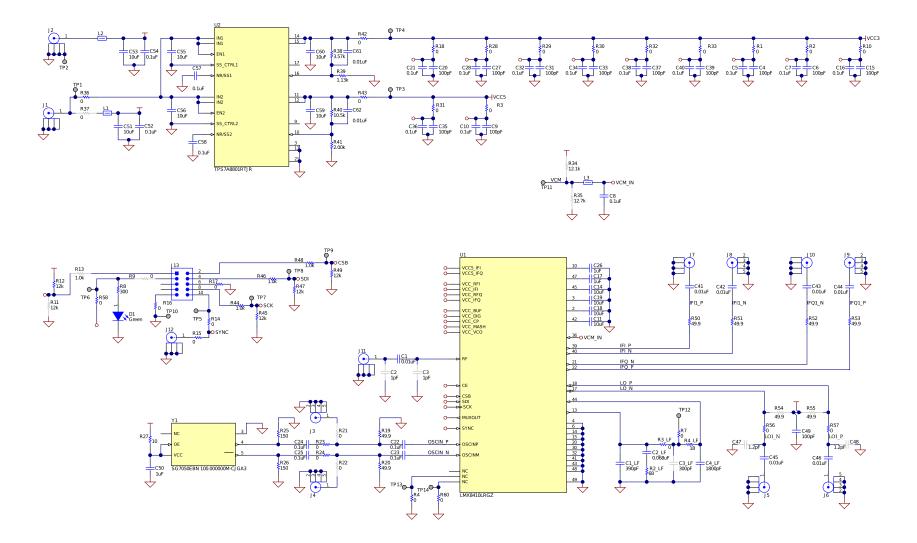**Figure 2. Setup Diagram for LMX8410L in External LO Mode**

3   Software Setup

1. Click Request and download the TICS Pro software from this link: http://www.ti.com/tool/ticspro-sw
2. Run the TICS Pro software.
3. From the top menu bar click "Select Device" → "Demodulator" → "LMX8410L"
4. From the top menu bar click "Default configuration" → Default mode.
5. Go to "LO" tab in the navigation pane on the upper left.
   - For internal LO mode, go to "Main Setup". In the drop-down box select either "Internal LO Poly to Mixer" or "Internal LO Div2 to Mixer". Go to "LO (MHz)", type in the LO frequency you want (4 to 10 GHz), then hit Enter. The correct internal LO configurations will automatically be set up. Note that the default reference frequency for integrated synthesizer is 100MHz. If you modified the board and use other OSCin frequency, say 10MHz, then put down the correct number below "Fosc (MHz)".
   - For external LO mode, inject your own LO signal then go to "Main Setup". Select "External LO to Mixer".
   - To view VCO output of internal synthesizer, follow the instructions in Section 2. Then go to "Main Setup". Select "internal LO only" and enter the desired LO frequency below "LO (MHz)"
6. Go to the "Mixer" tab in the navigation pane to configure the IF amplifier common mode voltage, DC offset correction, and IMRR calibration. For more instructions on these topics refer to the datasheet.

> **NOTE:** Check out the register descriptions in the bottom left pane of TicsPro.

4 Schematic

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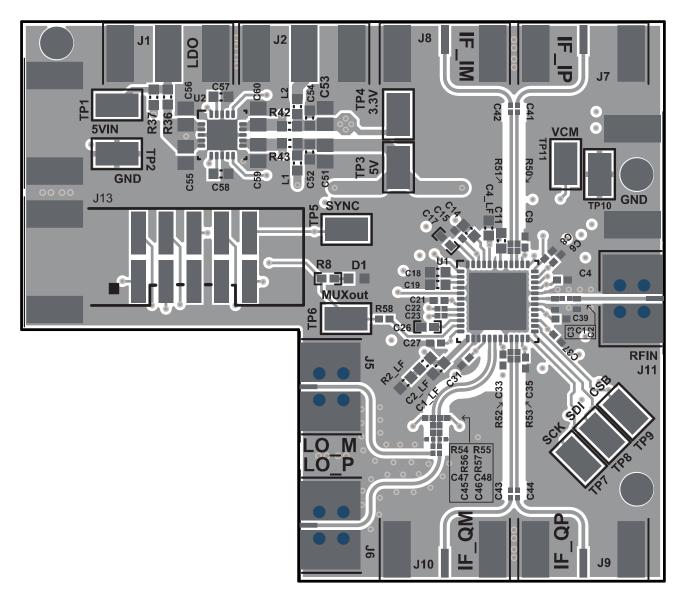
Figure 3. Board Schematic

5   Board Layout

Figure 4. Top Layer (Composite View)

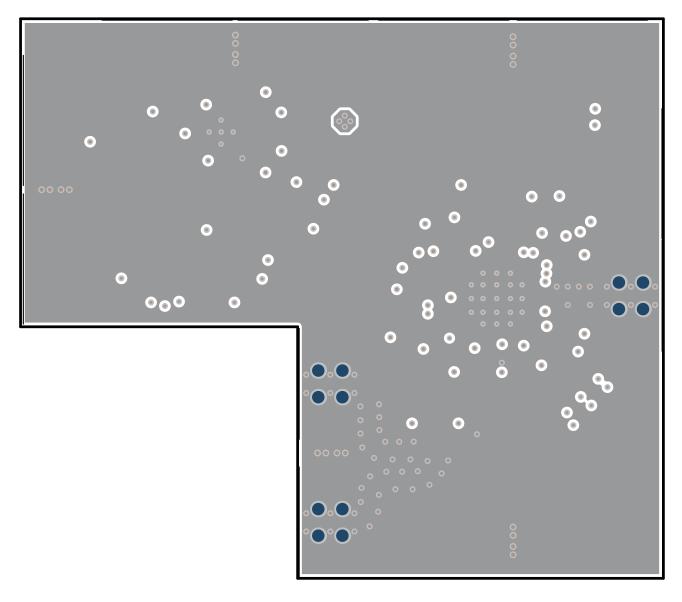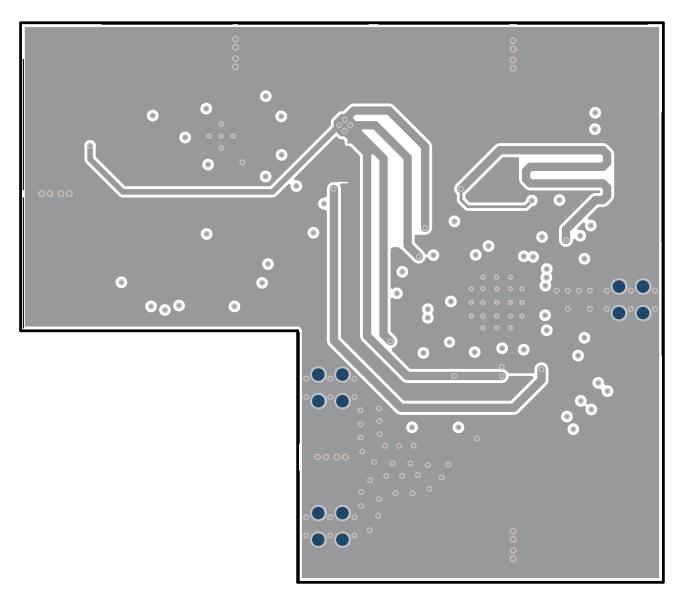**Figure 5. Ground (Mid Layer 1)**

Figure 6. Mid Layer 2
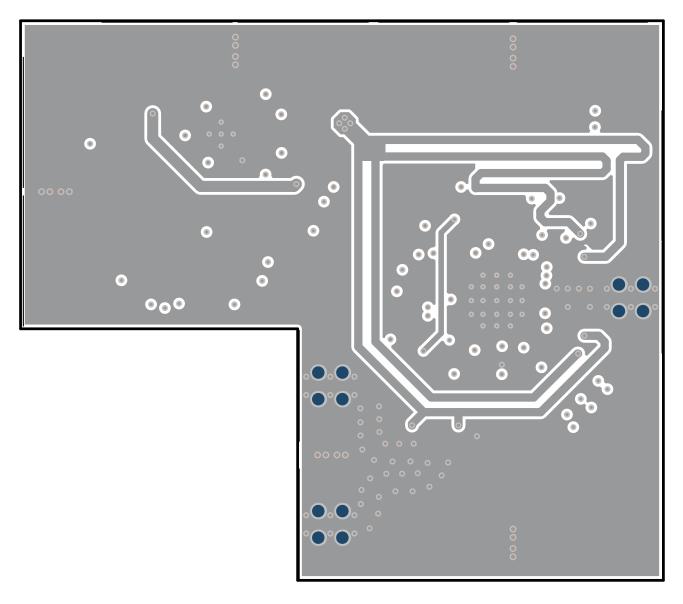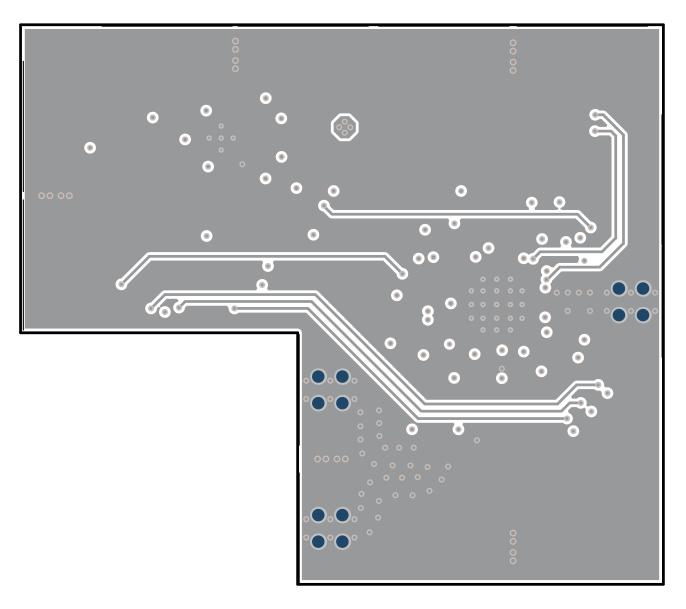
Figure 7. Mid Layer 3

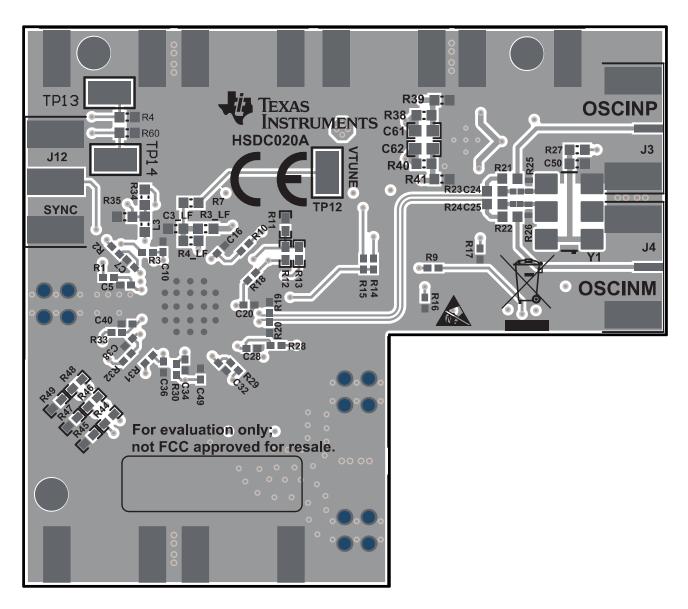**Figure 8. Mid Layer 4**

Figure 9. Bottom Layer (Composite View)

6   Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
!PCB	1		Printed Circuit Board		HSDC020	Any
C1, C41, C42, C43, C44, C45, C46	7	0.01uF	CAP, CERM, 0.01 uF, 6.3 V, +100/-0%, C0G/NP0, 0201	0201	550Z103PTT	AT Ceramics
C4, C6, C9, C15, C20, C27, C31, C33, C35, C37, C39	11	100pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0402	0402	GRM1555C1H101JA01D	MuRata
C5, C7, C8, C10, C16, C21, C28, C32, C34, C36, C38, C40	12	0.1uF	CAP, CERM, 0.1 uF, 16 V, +/- 10%, X7R, 0402	0402	GRM155R71C104KA88D	MuRata
C11, C14, C18, C19	4	10uF	CAP, CERM, 10 uF, 10 V, +/- 20%, X5R, 0603	0603	C1608X5R1A106M080AC	TDK
C12	1	1800pF	CAP, CERM, 1800 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C1H182JA01D	MuRata
C17, C26	2	1uF	CAP, CERM, 1 uF, 6.3 V, +/- 20%, X7R, 0402	0402	GRM155R70J105MA12D	MuRata
C22, C23, C24, C25	4	0.1uF	CAP, CERM, 0.1 uF, 16 V, +/- 10%, X5R, 0201	0201	GRM033R61C104KE84D	MuRata
C29	1	0.068uF	CAP, CERM, 0.068 uF, 16 V, +/- 10%, X7R, 0603	0603	GRM188R71C683KA01D	MuRata
C30	1	390pF	CAP, CERM, 390 pF, 50 V, +/- 1%, C0G/NP0, 0603	0603	CC0603FRNPO9BN391	Yageo America
C49	1	100pF	CAP, CERM, 100 pF, 25 V, +/- 5%, C0G/NP0, 0402	0402	C0402C101J3GACTU	Kemet
C50	1	1uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0603	0603	C1608X7R1C105K080AC	TDK
C51, C53, C55, C56, C59, C60	6	10uF	CAP, CERM, 10 uF, 10 V, +/- 10%, X5R, 0805	0805	C0805C106K8PACTU	Kemet
C52, C54, C57, C58	4	0.1uF	CAP, CERM, 0.1 uF, 16 V, +/- 5%, X7R, 0603	0603	0603YC104JAT2A	AVX
C61, C62	2	0.01uF	CAP, CERM, 0.01 uF, 50 V, +/- 10%, X7R, 0603	0603	CL10B103KB8NCNC	Samsung Electro-Mechanics
D1	1	Green	LED, Green, SMD	1.6x0.8x0.8 mm	LTST-C190GKT	Lite-On
J1, J2, J3, J4, J7, J8, J9, J10, J12	9		Connector, End launch SMA, 50 ohm, SMT	SMA End Launch	142-0701-851	Cinch Connectivity
J5, J6, J11	3		Connector, End launch SMA 50 ohm, TH	Connector, TH, End launch SMA	142-0761-881	Cinch Connectivity
J13	1		Header (shrouded), 100mil, 5x2, Gold, SMT	SMT Header	52601-S10-8LF	FCI
L1, L2, L3	3	1000 ohm	Ferrite Bead, 1000 ohm @ 100 MHz, 0.8 A, 0603	0603	MPZ1608S102ATA00	TDK
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
R1, R2, R3, R10, R14, R15, R16, R17, R18, R28, R29, R30, R31, R32, R33, R58	16	0	RES, 0, 5%, 0.063 W, 0402	0402	RC0402JR-070RL	Yageo America
R4, R6, R7, R23, R24, R36, R42, R43, R60	9	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R5	1	18.0	RES, 18.0, 1%, 0.1 W, 0603	0603	RC0603FR-0718RL	Yageo America
R8	1	300	RES, 300, 5%, 0.063 W, 0402	0402	CRCW0402300RJNED	Vishay-Dale

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
R12, R45, R47, R49	4	12k	RES, 12 k, 5%, 0.063 W, 0402	0402	CRCW040212K0JNED	Vishay-Dale
R19, R20	2	49.9	RES, 49.9, 1%, 0.063 W, 0402	0402	CRCW040249R9FKED	Vishay-Dale
R25, R26	2	150	RES, 150, 1%, 0.063 W, 0402	0402	CRCW0402150RFKED	Vishay-Dale
R27	1	10	RES, 10, 5%, 0.1 W, 0603	0603	CRCW060310R0JNEA	Vishay-Dale
R38	1	3.57k	RES, 3.57 k, 1%, 0.1 W, 0603	0603	RC0603FR-073K57L	Yageo America
R39	1	1.13k	RES, 1.13 k, 1%, 0.1 W, 0603	0603	RC0603FR-071K13L	Yageo America
R40	1	10.5k	RES, 10.5 k, 1%, 0.1 W, 0603	0603	RC0603FR-0710K5L	Yageo America
R41	1	2.00k	RES, 2.00 k, 1%, 0.1 W, 0603	0603	RC0603FR-072KL	Yageo America
R44, R46, R48	3	1.0k	RES, 1.0 k, 5%, 0.063 W, 0402	0402	CRCW04021K00JNED	Vishay-Dale
R50, R51, R52, R53	4	49.9	RES, 49.9, 0.5%, 0.05 W, 0201	0201	RC0201DR-0749R9L	Yageo America
R56, R57	2	0	RES, 0, 5%, 0.05 W, 0201	0201	CRCW02010000Z0ED	Vishay-Dale
R59	1	68.0	RES, 68.0, 1%, 0.1 W, 0603	0603	RC0603FR-0768RL	Yageo America
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14	14		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone
U1	1		5-10 GHz High Performance I/Q Demodulator with Integrated LO, RGZ0048A (VQFN-48)	RGZ0048A	LMX8410LRGZ	Texas Instruments
U2	1		Dual, 1-A, Low Noise (3.8-uVRMS), LDO Voltage Regulator, RTJ0020D (WQFN-20)	RTJ0020D	TPS7A8801RTJR	Texas Instruments
Y1	1		OSC, 100 MHz, LVPECLF, 3.3V, SMD	7x5mm	SG7050EBN 100.000000M-CJGA3	Epson
C2, C3	0	1pF	CAP, CERM, 1 pF, 50 V, +/-5%, C0G/NP0, 0402	0402	GRM1555C1H1R0CA01D	MuRata
C13	0	300pF	CAP, CERM, 3300pF, 100V, +/-5%, X7R, 0603	0603	GRM1885C2A301JA01D	MuRata
C47, C48	0	1.2pF	CAP, CERM, 1.2 pF, 50 V, +/- 20%, C0G/NP0, 0201	0201	GRM0335C1H1R2CA01D	MuRata
R9	0	0	RES, 0, 5%, 0.063 W, 0402	0402	RC0402JR-070RL	Yageo America
R11	0	12k	RES, 12 k, 5%, 0.063 W, 0402	0402	CRCW040212K0JNED	Vishay-Dale
R13	0	1.0k	RES, 1.0 k, 5%, 0.063 W, 0402	0402	CRCW04021K00JNED	Vishay-Dale
R21, R22, R37	0	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R34	0	12.1k	RES, 12.1 k, 1%, 0.1 W, 0603	0603	CRCW060312K1FKEA	Vishay-Dale
R35	0	12.7k	RES, 12.7 k, 1%, 0.1 W, 0603	0603	CRCW060312K7FKEA	Vishay-Dale
R54, R55	0	49.9	RES, 49.9, 1%, 0.05 W, 0201	0201	RC0201FR-7D49R9L	Yageo America

Revision History

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

Changes from Original (March 2018) to A Revision **Page**

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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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西新宿三井ビル

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

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://www.tij.co.jp/lsds/ti_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.

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.

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 CONFERRING 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.

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.