

LOG114EVM User Guide

This user's guide describes the characteristics, operation, and use of the LOG114EVM evaluation board. It discusses how to set up and configure the board hardware, and reviews various methods of using the evaluation module (EVM). Throughout this document, the terms *evaluation board*, *evaluation module*, and *EVM* are synonymous with the LOG114EVM. This document also includes an electrical schematic, printed circuit board (PCB) layout drawings, and a parts list for the EVM.

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1 Overview

The [LOG114](#) is a single-supply, high-speed, precision logarithmic amplifier. This device computes the logarithm or log-ratio of an input current or voltage relative to a reference current or voltage. The LOG114EVM (shown in [Figure 1](#)) is a ready-to-use platform for evaluating the performance of the LOG114 in various configurations. This document gives a general overview of the LOG114EVM, and provides a general description of the features and functions to be considered while using this evaluation module.

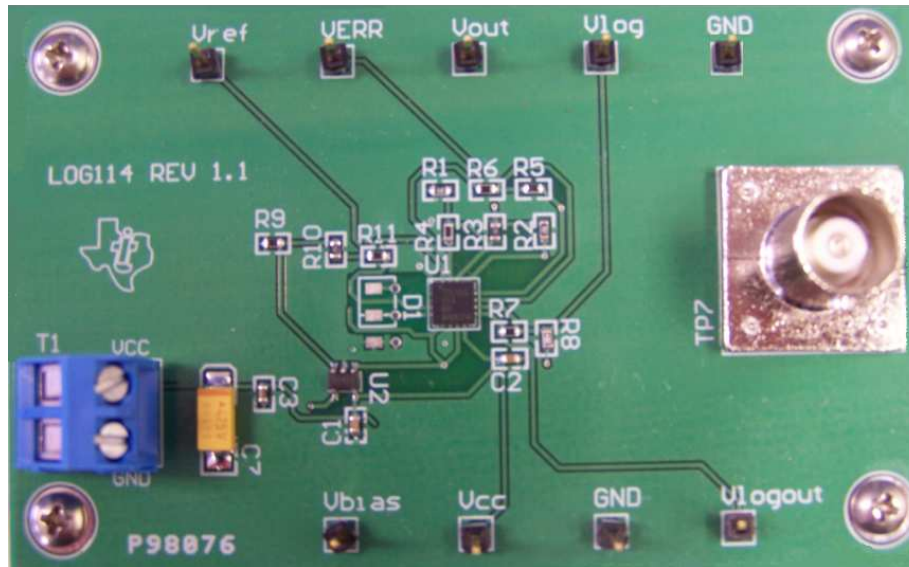


Figure 1. LOG114EVM

1.1 Getting Started

Tested at the factory over a wide range of input currents, the LOG114EVM comes ready to use and includes this Quick Start User's Guide. Use of the LOG114EVM requires a 5-V power source, an input source such as a photodiode or resistor, and a digital voltmeter or oscilloscope.

1.2 Related Documentation from Texas Instruments

The following documents provide information regarding Texas Instruments' integrated circuits and support tools for the LOG114EVM. This user's guide is available from the TI web site under literature number **SBOU110**. 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 may be available from the [TI web site](#), or call 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.

Related Documentation

Document	Literature Number
LOG114 Product Data Sheet	SBOS301
LOG114 TINA-TI Reference Design	SBOM384B
LOG114 TINA-TI Spice Model	SBOM385B

2 LOG114EVM

The LOG114EVM comes completely assembled and constructed to operate on a single 5-V power supply. The circuit used in the LOG114EVM is designed to operate over a wide range of input currents (10 nA to 10 mA) and scales the output voltage from 1.15 V to 2.75 V. There are three distinct sections to the LOG114EVM circuit: a precision level shifter, the signal path, and the high-current linearity correction section. Each section is described below to familiarize you with the circuit functionality and operation.

2.1 Level Shifter

A precision level shifter is required to operate the LOG114 on a single power supply. On the LOG114EVM, the level shifter circuit is constructed by deriving a bias voltage of 2 V from the 2.5-V voltage reference internal to the LOG114. This level shift of 2 V is required to keep the nodes internal to the LOG114 properly biased when operating from a single power supply. Resistors R9 and R10 form a voltage divider that is then buffered by the OPA365 amplifier. The output of the OPA365 is a fixed voltage of 2 V, independent of the power-supply voltage or input signal. C2 is used to bypass the power supply for the OPA365. The level shifter circuit is shown in Figure 2.

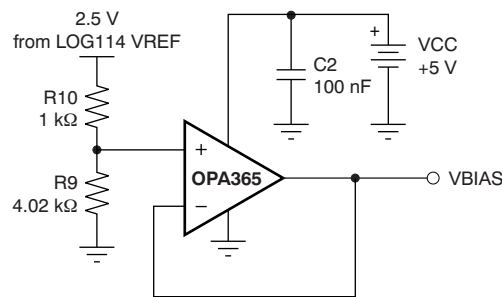


Figure 2. LOG114EVM Level Shifter

2.2 Signal Path

The LOG114 has two inputs, I_1 and I_2 . Input I_1 is used for the input signal (usually from a photodiode) and I_2 is a fixed-current reference signal. This fixed-current reference signal is derived from the 2.5-V voltage reference internal to the LOG114 and the 2-V output from the level shifter. The reference current into I_2 is given by Equation 1.

$$I_{\text{REF}} = \frac{(2.5 \text{ V} - 2 \text{ V})}{1 \text{ M}\Omega} = 500 \text{ nA} \quad (1)$$

The input current must flow into I_1 and comes directly from the anode of a photodiode. In non-optical applications, the input current could also be derived from a resistor, or a variety of other sources (see Section 3.4). For proper operation, each input to the LOG114 (I_1 and I_2) requires the current to flow into the LOG114.

The output from the LOG114 amplifier A3 is called V_{LOGOUT} . The relationship between V_{LOGOUT} , I_1 and I_2 , and the bias voltage generated by the level shifter is described by Equation 2.

$$V_{\text{LOGOUT}} = 0.375 \cdot \text{LOG}_{10} \left(\frac{I_2}{I_1} \right) + 2 \text{ V} \quad (2)$$

The V_{LOGOUT} output is then scaled by resistors R7 and R8. These resistors divide the signal before combining with the high-current linearity correction section. Combining the input signal and linearity correction signal is accomplished with amplifier A4 and resistors R5 and R6. Capacitor C1 is used to bypass the power supply for the LOG114. The signal path circuit is shown in Figure 3.

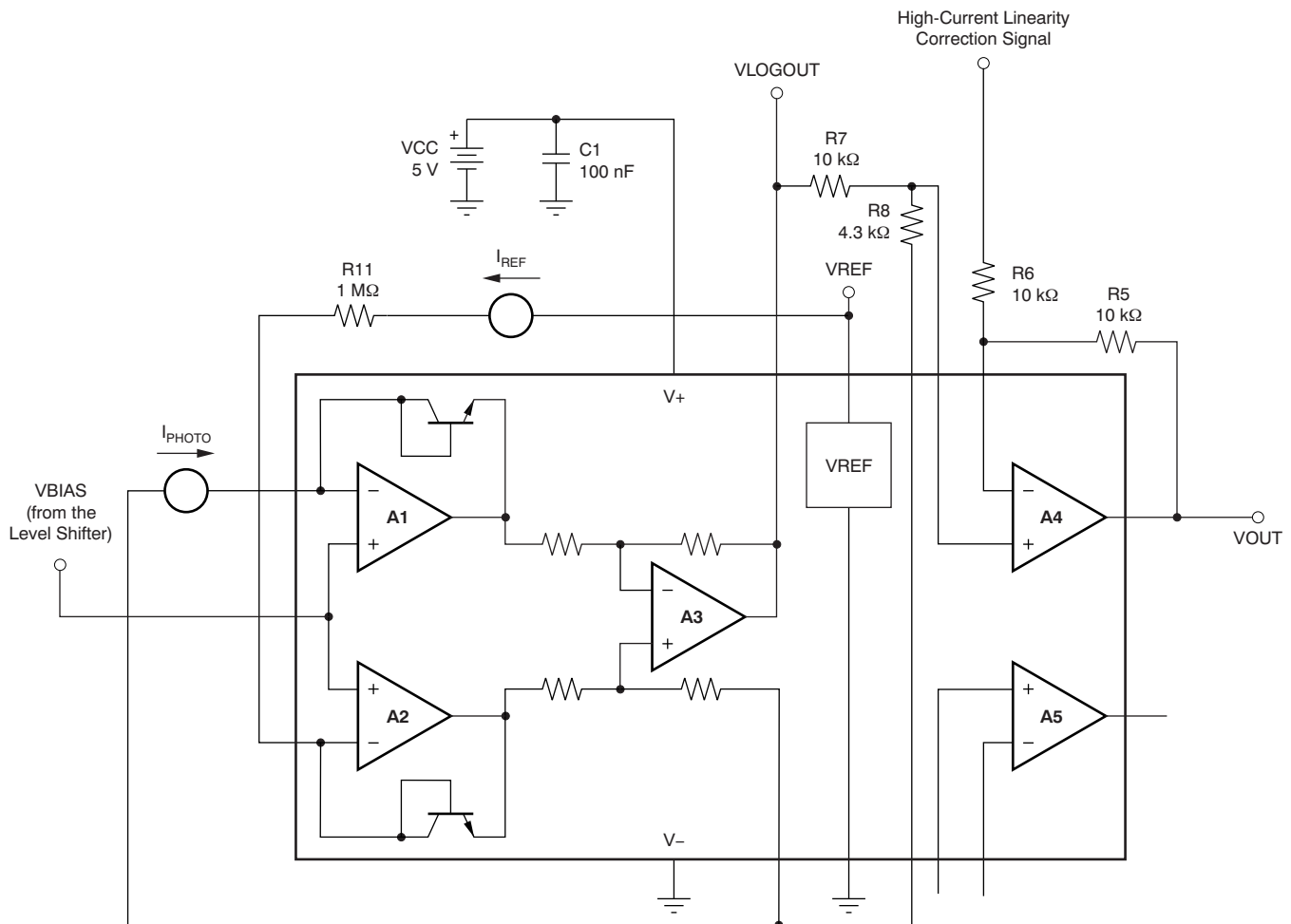


Figure 3. LOG114EVM Signal Path

2.3 High-Current Linearity Correction

The LOG114 is capable of handling a wide dynamic range of currents, from less than 100 pA in a carefully designed PCB to 10 mA in high-current applications. Because the LOG114 was designed for high speeds, the transistors that provide feedback around amplifiers A1 and A2 within the LOG114 have a small series resistance, R_S . This small series resistance causes a deviation from the ideal LOG114 transfer function at input currents that exceed approximately 1 mA. The modified equation for V_{LOGOUT} that shows this deviation from the ideal is given in Equation 3.

$$V_{\text{LOGOUT}} = 0.375 \cdot \text{LOG}_{10} \left(\frac{I_2}{I_1} \right) + 2 \text{ V} + I_1 \cdot R_S \quad (3)$$

The high-current linearity correction circuit (refer to Figure 4) creates an error signal that is proportional to input current I_1 by using R2, R3 and R4, and amplifier A5. Resistor R1 is used to properly level-shift the resulting output signal. The signal at the output from amplifier A5 is then coupled to the input of amplifier A4 in a manner that subtracts the error signal from the output of the EVM, V_{OUT} .

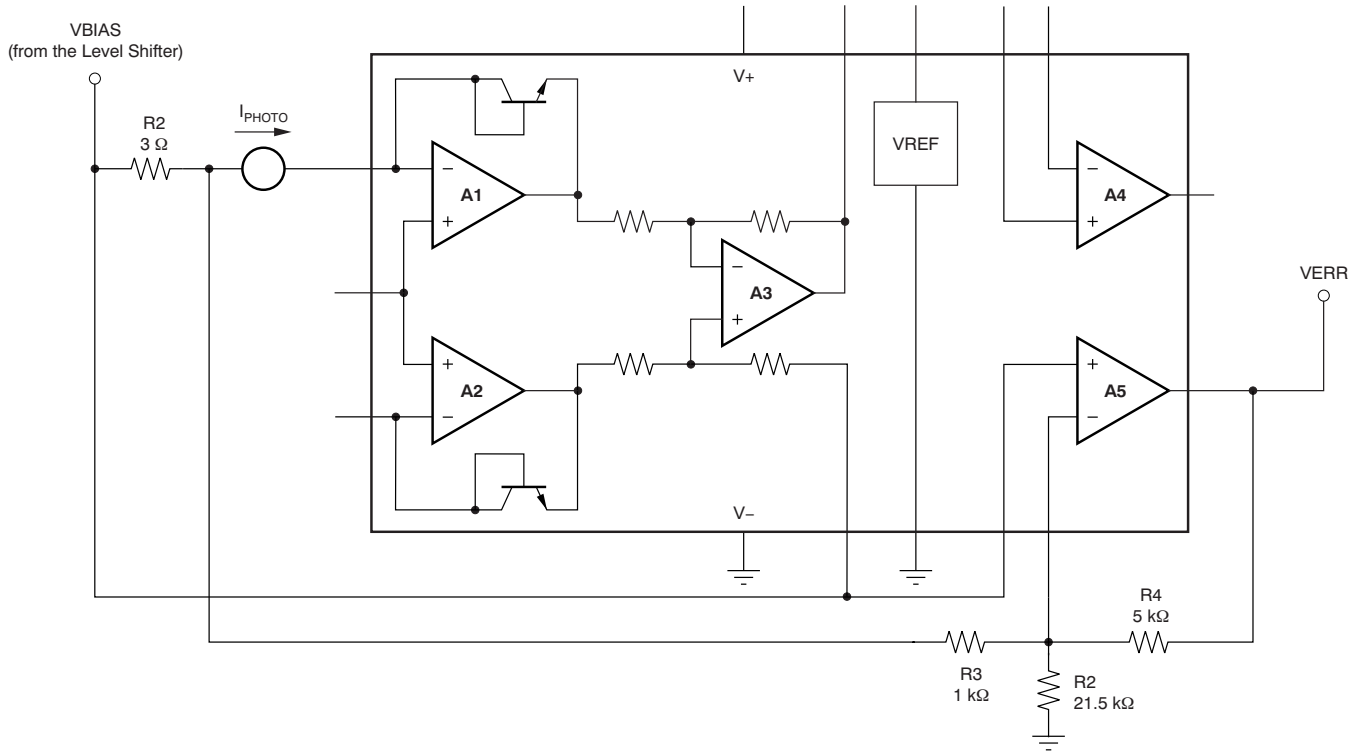


Figure 4. High-Current Linearity Correction Circuit

Figure 5 shows the entire circuit layout of the LOG114EVM.

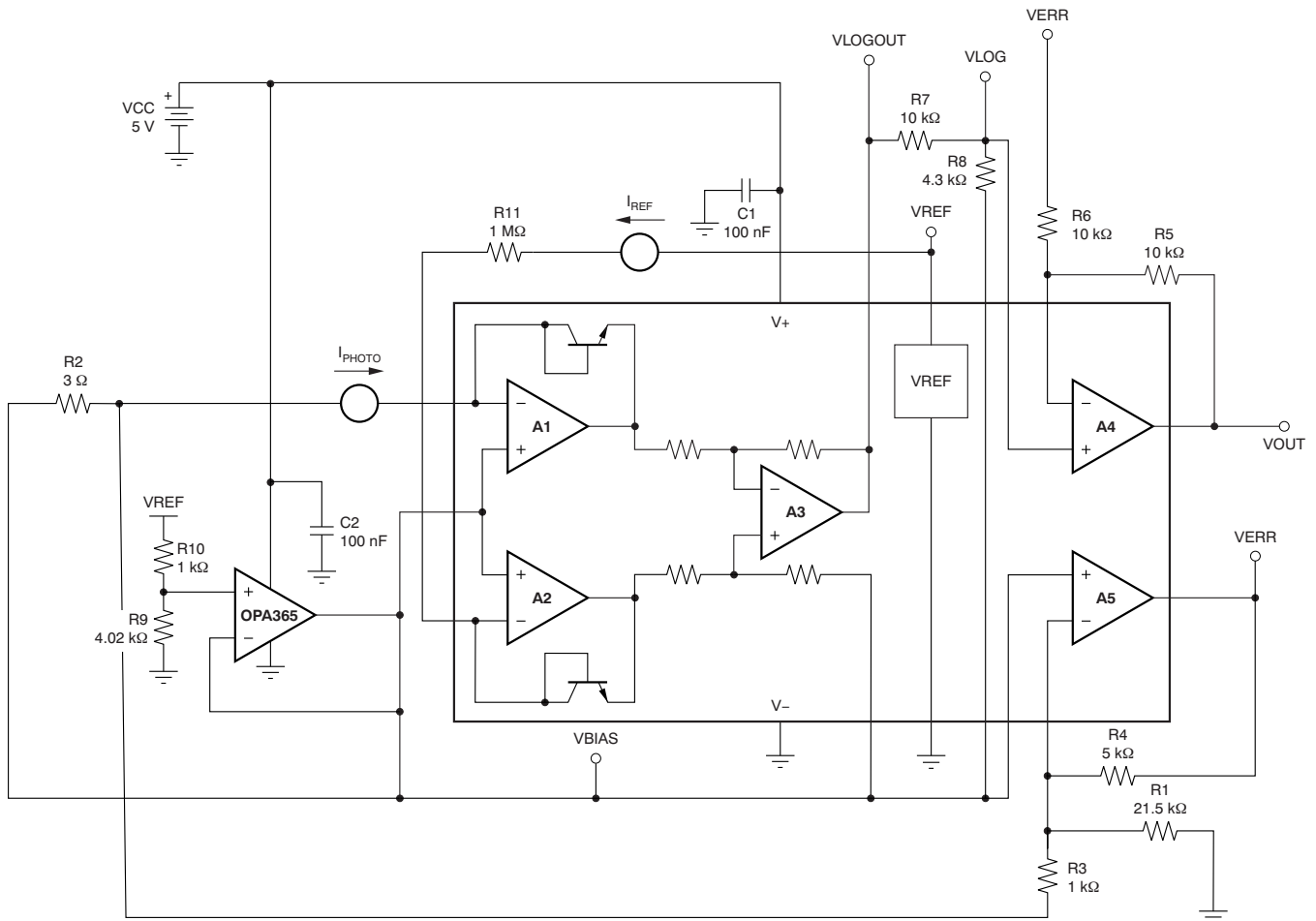


Figure 5. LOG114EVM Complete Circuit

3 Connecting to the LOG114EVM

The LOG114 requires only a few connections to operate: a 5-V power supply, an input source such as a photodiode or resistor, and a digital voltmeter or oscilloscope.

3.1 Electrostatic Discharge Warning

CAUTION

Many of the components on the LOG114EVM are susceptible to damage by electrostatic discharge (ESD). Customers are advised to observe proper ESD handling precautions when unpacking and handling the EVM, including the use of a grounded wrist strap at an approved ESD workstation.

3.2 Basic Connections

The connections for 5 V and ground are clearly marked on the LOG114EVM PCB. Figure 6 shows how to properly connect the power supply to the connector.

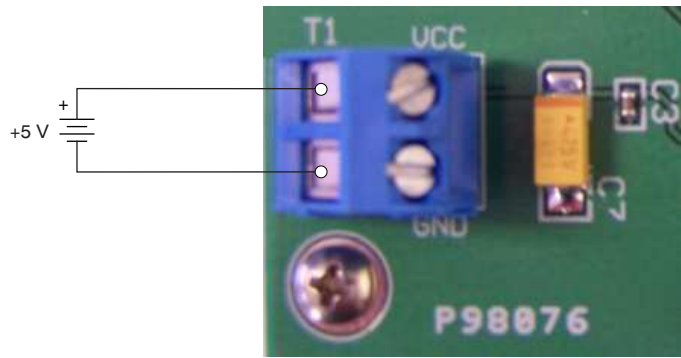


Figure 6. Connecting the 5V Power Supply

3.3 Using a Photodiode

An anode of a photodiode can be connected to the LOG114 by either using the pads or pin sockets on the LOG114EVM. To use the high-current linearity correction circuitry, connect the photodiode as illustrated in Figure 7.

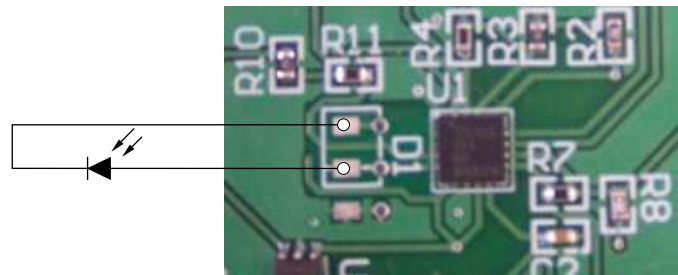


Figure 7. Using a Photodiode with the High-Current Linearity Correction Circuitry

Figure 8 shows the connections required to bypass the high-current linearity circuitry. This connection results in placing zero bias across the photodiode.

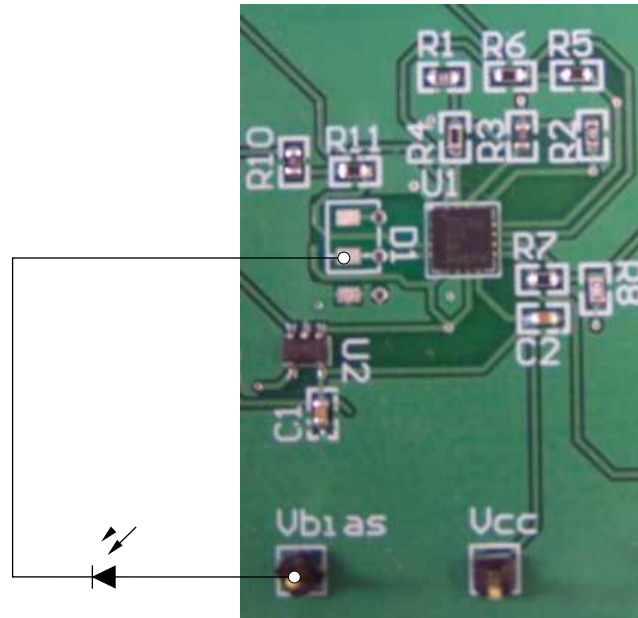


Figure 8. Using a Photodiode Without the High-Current Linearity Correction Circuitry

A 0.5-V reverse bias can be easily placed across the photodiode by connecting the photodiode as shown in Figure 9. When connecting the photodiode in this configuration, the high-current linearity correction circuitry is bypassed.

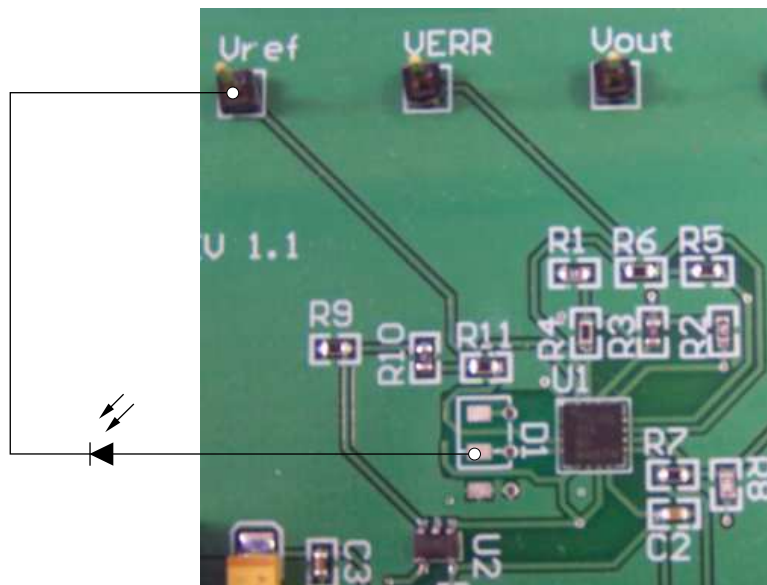


Figure 9. Applying a 0.5-V Reverse Bias to the Photodiode

3.4 Using a Resistor

Using a resistor instead of a photodiode to create an input current is quite simple. As Figure 10 shows, a 1-M Ω resistor is placed between V_{REF} and the input I₁. In this case, the input current I₁ is determined by Equation 4.

$$I_1 = \frac{(V_{REF} - V_{BIAS})}{R} \quad (4)$$

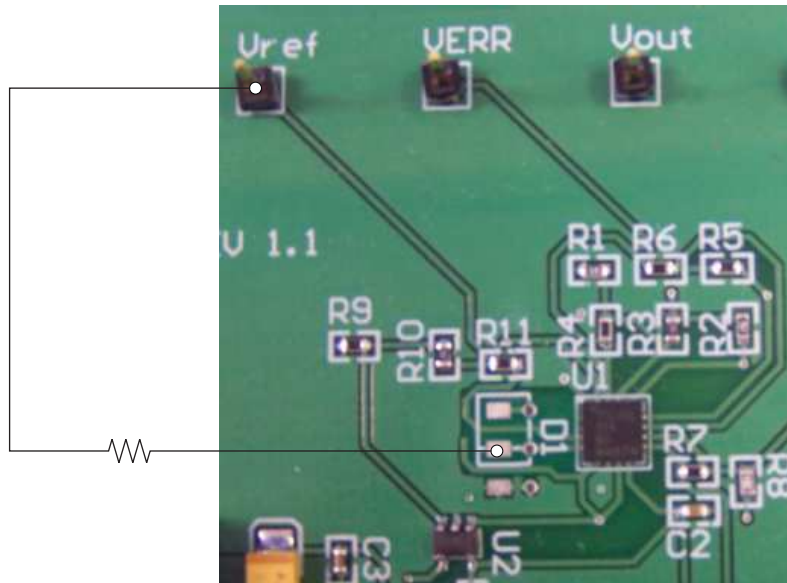


Figure 10. Using a Resistor to Create an Input Current

In the case where $I_1 = 500 \text{ nA} = I_{\text{REF}}$, the V_{LOGOUT} terminal is equal to the level shifting bias voltage of 2 V and the V_{OUT} terminal is equal to 1.5 V. The circuit in Figure 10, while convenient for creating an input current, does not take advantage of the high-current linearity correction circuitry. To use this circuitry, a second power supply must be used and configured as shown in Figure 11.

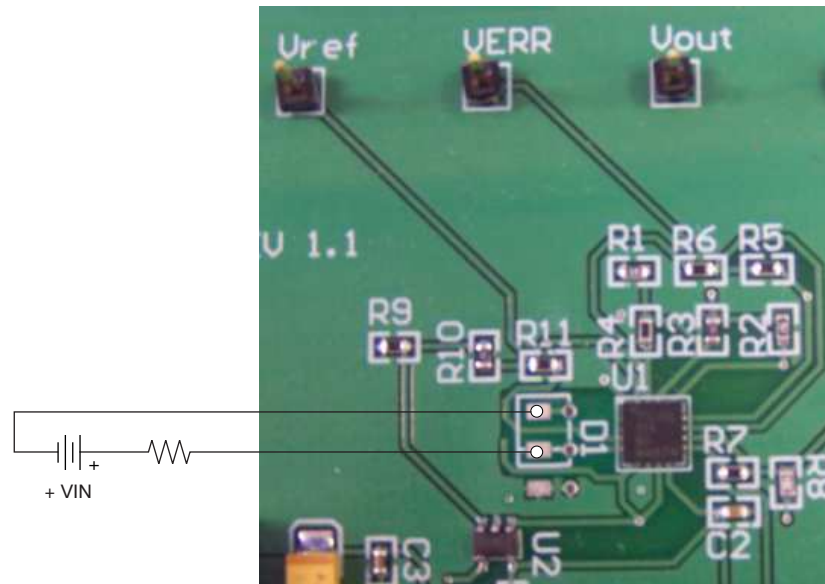


Figure 11. Using a Resistor and the High Current Linearity Correction Circuitry

Changing the input voltage or the resistor value changes the input current I_1 ($I_1 = V_{\text{IN}}/R$) and results in a change for the V_{LOGOUT} terminal voltage according to Equation 5.

$$V_{\text{LOGOUT}} = 0.375 \cdot \text{LOG}_{10}\left(\frac{I_2}{I_1}\right) + 2 \text{ V} + I_1 \cdot 50 \Omega \quad (5)$$

For input currents less than 1 mA, this equation simplifies to Equation 2.

The voltage at the V_{LOG} terminal is given by Equation 6:

$$V_{\text{LOG}} = \left[0.375 \cdot \text{LOG}_{10}\left(\frac{I_2}{I_1}\right) + I_1 \cdot 50 \Omega\right] \cdot 0.3 \text{ V/V} + 2 \text{ V} \quad (6)$$

The voltage at the V_{ERR} terminal is given by Equation 7:

$$V_{\text{ERR}} = 2 + \left[\frac{(I_1 \cdot 3)}{1 \text{ k}\Omega} + \frac{2}{21.5 \text{ k}\Omega}\right] \cdot 5 \text{ k}\Omega \quad (7)$$

The voltage at the V_{OUT} terminal is given by Equation 8:

$$V_{\text{OUT}} = 2 \cdot V_{\text{LOG}} - V_{\text{ERR}} \quad (8)$$

4 Using the LOG114EVM

Once the LOG114EVM has power applied and an input signal, easy access terminal pins allow for quickly evaluating the circuit performance. Connect a digital voltmeter or oscilloscope to any of the terminals to make the measurements. Figure 12 is a reference guide to the LOG114EVM and its related components.

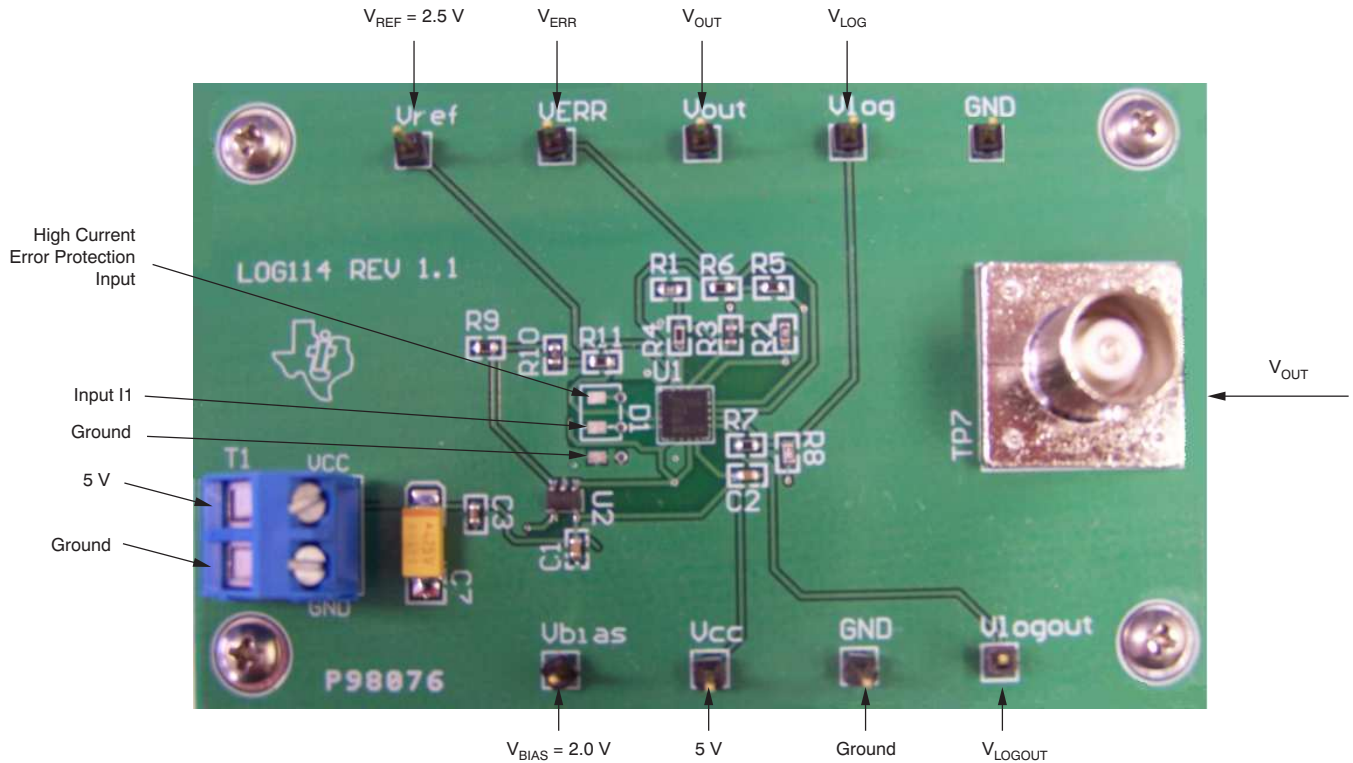


Figure 12. LOG114EVM Components

5 Verifying Results

Making measurements on the LOG114EVM is fast and easy. Connect a digital voltmeter or oscilloscope to the terminal of interest and record the results. Included with the graph of measured results is a table of results for common values of input currents. In [Figure 13](#), two curves are shown. Both curves use a resistor input and V_{OUT} is recorded as a function of input current. The compensated (red) curve connects the resistor as shown in [Figure 11](#) and uses the high-current linearity correction circuitry. The uncompensated curve (blue) uses the resistor connected to I_1 and V_{REF} as shown in [Figure 10](#).

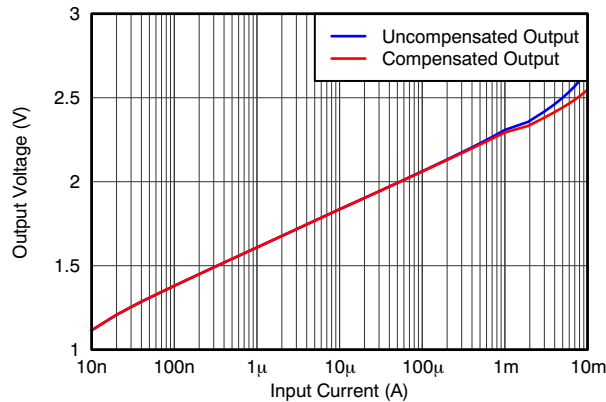


Figure 13. LOG114EVM Measured Results

[Table 1](#) lists several typical results obtained with various input voltages.

Table 1. LOG114EVM Typical Results

Input	Uncompensated		Compensated	
	V_{LOGOUT} (V)	V_{OUT} (V)	V_{LOGOUT} (V)	V_{OUT} (V)
10 nA	1.36	1.15	1.36	1.15
100 nA	1.74	1.38	1.74	1.38
1 μ A	2.11	1.60	2.11	1.60
10 μ A	2.49	1.83	2.49	1.83
100 μ A	2.87	2.06	2.87	2.06
1 mA	3.29	2.31	3.29	2.30
10 mA	4.11	2.82	4.11	2.67

6 LOG114EVM Documentation

This section contains the complete bill of materials and PCB layout for the LOG114EVM.

NOTE: These board layouts are not to scale. These image are intended to show how the board is laid out; they are not intended to be used for manufacturing LOG114EVM PCBs.

6.1 Schematic

Figure 14 shows the schematic for the LOG114EVM board

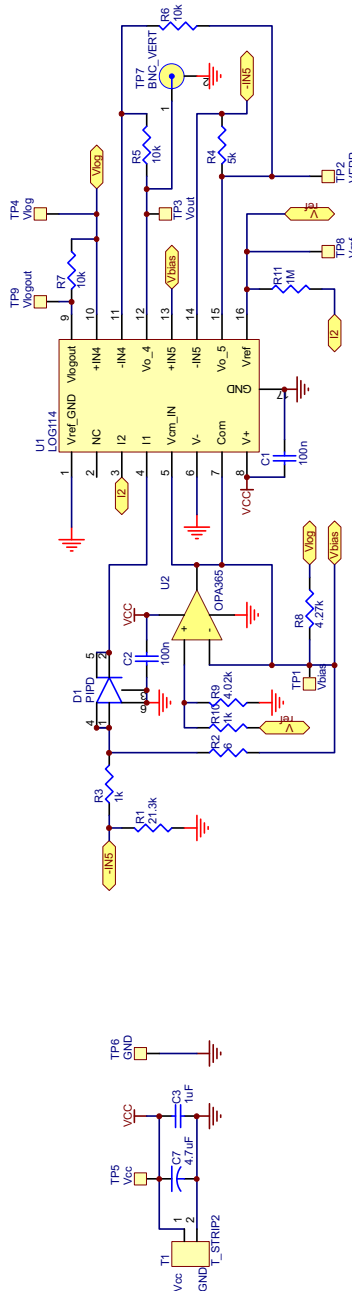


Figure 14. LOG114EVM Board Schematic

6.2 PCB Layout

Figure 15 through Figure 17 show the PCB layout of the LOG114EVM.

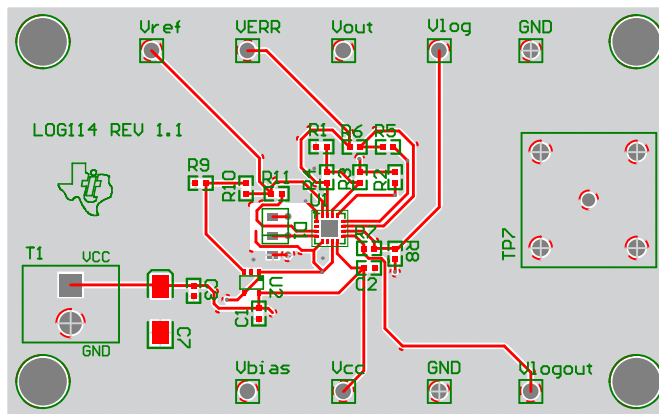


Figure 15. LOG114EVM: Top Side Composite Drawing

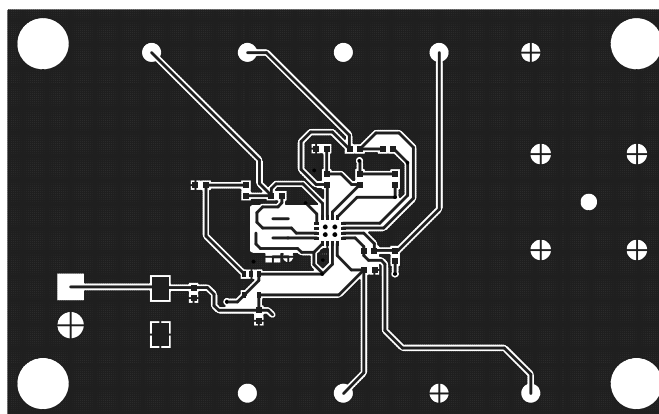


Figure 16. LOG114EVM: Top Copper Layer

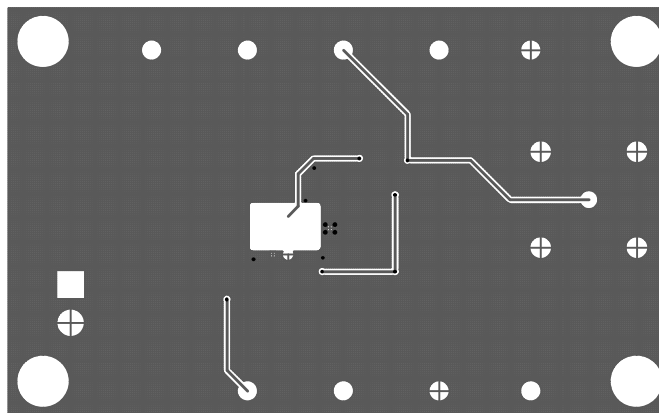


Figure 17. LOG114EVM: Bottom Copper Layer

6.3 Bill of Materials

Table 2 lists the bill of materials for the LOG114EVM

Table 2. LOG114 Bill of Materials

Item No	Count	Value	Ref Des	Description	MFR	Mfr Part Number
1	1	21.5 kΩ	R1	Resistor, 21.5 kΩ 1/10W 1% 0603 SMD	Yageo	RC0603FR-0721K5L
2	1	3 Ω	R2	Resistor, 3.0 Ω 1/10W 5% 0603	Panasonic - ECG	ERJ-3GEYJ3R0V
3	2	1 kΩ	R3, R10	Resistor, 1.0 kΩ .25W 5% 0603 SMD	Vishay/Dale	CRCW06031K00JNEAHP
4	1	4.99 kΩ	R4	Resistor, 4.99 kΩ 1/10W 1% 0603 SMD	Panasonic	ERJ-3EKF4991V
5	3	10 kΩ	R5, R6, R7	Resistor, 10.0 kΩ 1/10W 1% 0603 SMD	Panasonic	ERJ-3EKF1002VRES
6	1	4.3 kΩ	R8	Resistor, 4.3 kΩ 1/16W .5% 0603 SMD	Susumu	RR0816P-432-D
7	1	4.02 kΩ	R9	Resistor, 4.02 kΩ 1/10W 1% 0603 SMD	Panasonic	ERJ-3EKF4021V
8	1	1 MΩ	R11	Resistor, 1.00 MΩ 1/10W 1% 0603 SMD	Panasonic	ERJ-3EKF1004V
9	1	4.7 μF	C7	Capacitor, Tantalum 4.7 μF 35V 10% SM	AVX Corporation	TAJC475K035RNJ
10	1	0.1 μF	C3	Capacitor, Ceramic .100 μF 25V X7R 0603	Yageo	CC0603KRX7R8BB104
11	2	100 nF	C1, C2	Capacitor, Ceramic 1000 pF 25V Y5V 0603	Murata Electronics North America	GRM188F51E102ZA01D
12	1	—	U1	LOG114	Texas Instruments	LOG114AIRGVT
13	1	—	U2	OPA365	Texas Instruments	OPA365AIDBVR
14	1	BNC	TP7	Connector, Jack BNC Vert 50 Ω	Tyco Electronics	5227699-1
15	1	—	T1	PCB Terminal Block 5 MM 2-Pos	On-Shore Technology Inc	ED300/2
16	9	N/A	Test Points, All	Connector, Header 1-Pos .100" Sgl Gold	Samtec	TSW-101-07-G-S
17	4	Standoff	—	Standoffs, Hex , 4-40 Threaded, 0.500-in. length, 0.250-in OD, Aluminum Iridite Finish	Keystone	2203
18	4	Screw	—	Screw, Machine, Phillips 4-40x1/4 SS	B & F Fastener Supply	PMSSS 440 0025 PH
19	1	N/A	D1	Do not install	—	—

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of $\pm 2.4\text{V}$ to $\pm 5.5\text{V}$ and the output voltage range of $\pm 1.8\text{V}$ to $\pm 4.9\text{V}$.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's 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, some circuit components may have case temperatures greater than $+25^{\circ}\text{C}$. The EVM is designed to operate properly with certain components above $+25^{\circ}\text{C}$ as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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

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.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

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

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

【Important Notice for Users of this Product in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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