

Using the TLC5929, 16-Channel LED Driver with 7-Bit Global Brightness Control, Power-Save Mode, and Full Self-Diagnosis for LEDs

The Texas Instruments TLC5929 evaluation module (EVM) is a fully assembled and tested circuit for evaluating the TLC5929, a 16-channel, constant-current LED driver with 7-Bit Global Brightness Control, Power-Save Mode, and Full Self-Diagnosis for LEDs. The EVM is capable of driving up to 50 mA per channel when powered from a 5-V supply.

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1 Introduction

1.1 Description

The evaluation board is powered with external power supplies. An external device capable of providing clock, data, latch, and blank signals also controls the EVM. This is done with an SPI-compatible serial interface on a microcontroller or through a function generator. Connect different LEDs to the evaluation board through the output connector.

1.2 Applications

- Variable Message Signs
- Illumination
- LED Video Displays

1.3 Features

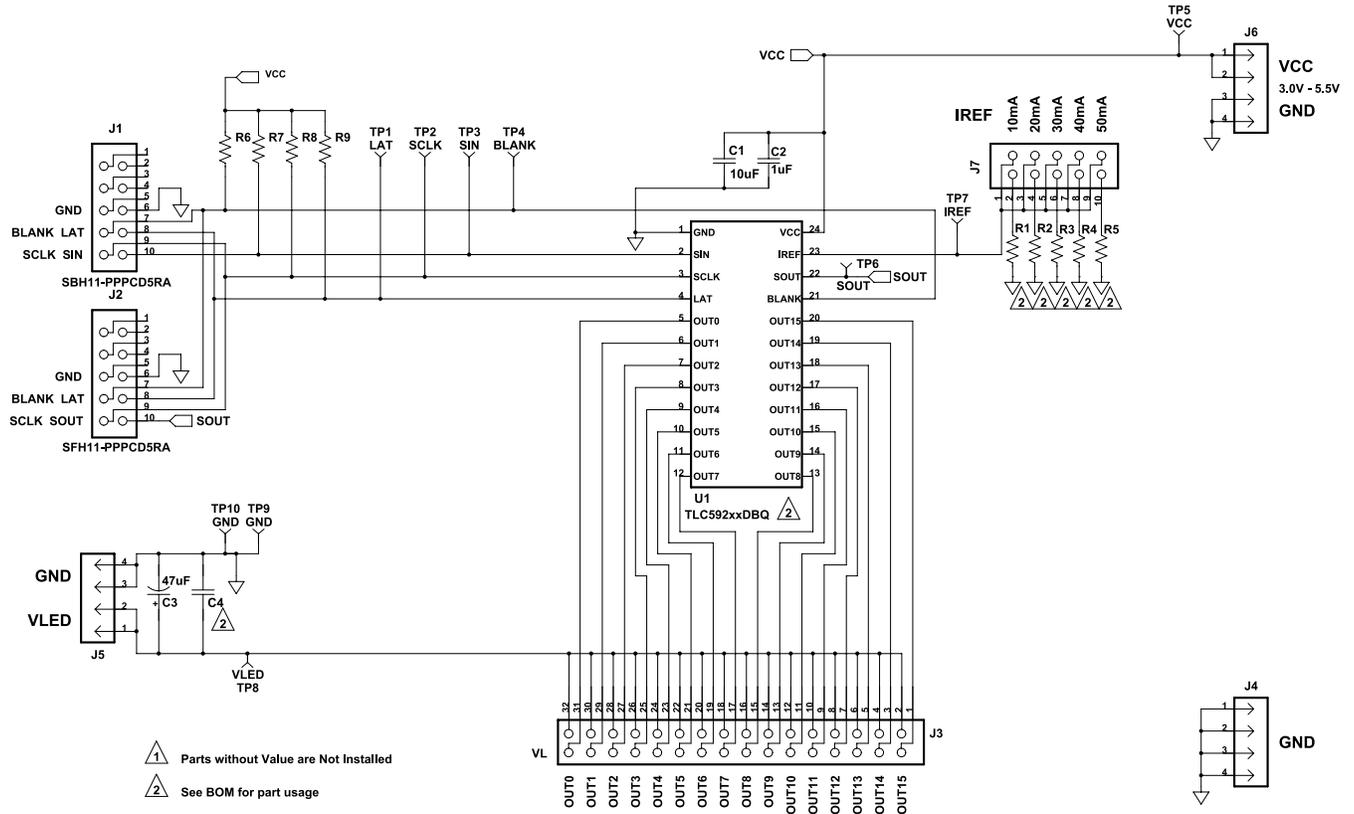
- EVM printed circuit board (PCB) assembled with the TLC5929 LED Driver
- I_{REF} (current reference) for operation of 10, 20, 30, 40, or 50 mA per channel (selectable through jumpers).
- 2 × 16 output header for connecting through-hole LEDs (LEDs not included) or the white LED board, WLEDEV-132 (not included)

2 TLC5929 EVM Electrical Performance Specifications

Table 1. TLC5929 EVM Electrical and Performance Specifications

		MIN	TYP	MAX	UNITS
Input Characteristics					
Voltage range	V_{CC}	3		5.5	V
	V_{LED}			10	V
Maximum input current	$V_{LED} = V_{CC} = 5\text{ V}$, $I_{REF} = 50\text{ mA}$		0.82	0.9	A
No load input current				20	mA
V_{IH}	SIN, SCLK, LAT, BLANK	$0.7 \times V_{CC}$		V_{CC}	V
V_{IL}		GND		$0.3 \times V_{CC}$	
Output Characteristics					
V_{OH}	$I_{OH} = -1\text{ mA}$ (SOUT)	$V_{CC} - 0.4$		V_{CC}	V
V_{OL}	$I_{OL} = 1\text{ mA}$ (SOUT)			0.4	V
Output load current, I_{OUTx}	I_{REF} set to 50 mA	50			mA
Systems Characteristics					
Clock frequency	SCLK			33	MHz
Operating temperature		-40		85	°C

3 TLC5929 EVM Schematic



NOTE: For Reference Only, See [Table 4](#) for Specific Values

Figure 1. TLC5929 EVM Schematic

4 Connector and Test Point Descriptions

4.1 Connectors

Table 2. Connector Description

Test Points	Type	Description
J1	Input	Serial interface connector
J2	Output	Serial interface connector to connect a second board
J3	Power	LED connector
J4	GND	GND connector for easy probe connection
J5	Power	V_{LED} power connector, 2 pins V_{LED} , and 2 GND pins
J6	Power	V_{CC} power connector, 2 pins V_{CC} , and 2 GND pins

4.1.1 Serial Interface Connector (J1)

Evaluate this EVM by preparing a signal pattern generator like an FPGA, CPLD, MCU or some equipment like the DG2020 for the input signals. J1 connects the signals BLANK (pin 7), SIN (pin 10), SCLK (pin 9), LAT (pin 8), and GND (pin 6).

4.1.2 Serial Connector (J2)

Evaluation of the series connection of several TLC5929 is possible with this EVM. Connect J1 of the second EVM with the serial connector, J2, of the first EVM. The signals BLANK (pin 7), SCLK (pin 9), LAT (pin 8), and GND (pin 6) of the first EVM are directly connected to the second EVM. The output signal SOUT (pin 10) of the first EVM is connected to the input signal SIN of the second EVM.

4.1.3 LED Connector (J3)

J3 can connect to the WLEDEVM-132 (not included), or single LEDs, or LED strings between V_{LED} and OUTx. WLEDEVM-132 contains 16 white LEDs connected with the anode to V_{LED} and the cathode to OUTx of TLC5929. J3 can also be connected to single LEDs or LED strings between V_{LED} and OUTx. The lower pins of J3 are connected to V_{LED} , the upper pins of J3 are connected to the OUTx pins of the TLC5929.

4.1.4 GND Connector (J4)

J4 connects to GND making the reference voltage available for measurement purposes.

4.1.5 V_{LED} Connector (J5)

J5 supplies the LEDs (not included) with the anode voltage. Connect V_{LED} between the positive node (pins 1 and 2, closer to J3) and the GND node (pins 3 and 4).

4.1.6 V_{CC} Connector (J6)

J6 supplies the TLC5929 with the supply voltage. Connect V_{CC} between the positive node (pins 1 and 2, closer to J2) and the GND node (pins 3 and 4).

4.2 I_{REF} Jumpers (J7)

The 2 × 5 header, J7, selects the desired maximum output current. The currents available for the TLC5929 are 10, 20, 30, 40, and 50 mA per channel.

NOTE: The LEDs connected to J3 do not turn on if there is no jumper set at J7.

$$R_{IREF} = \frac{V_{IREF}}{I_{OLCMax}} \times 54.8 \quad (1)$$

Where:

V_{IREF} = the internal reference voltage on the IREF pin (typically 1.205 V)

I_{OLCMax} = 1 mA to 40 mA for $V_{CC} \leq 3.6$ V, or 1 mA to 50 mA for $V_{CC} > 3.6$ V with BC = 7Fh

4.3 Test Point Descriptions

Table 3. Test Point Description

Test Points	Name	Type	Description
TP1	LAT	Input	Level-triggered latch. The data is held when LAT is low. The data is transferred to the on/off data latch when LAT is high.
TP2	SCLK	Input	Serial data shift clock input
TP3	SIN	Input	Serial data input for the shift register
TP4	BLANK	Input	Output enable for all channels. Outputs are disabled when BLANK is high.
TP5	VCC	Power	Supply for TLC5929 (3–5.5 V).
TP6	SOUT	Output	Serial data output
TP7	I_{REF}	I/O	Constant-current set resistor
TP8	V_{LED}	Power	Power supply for LED lamps (up to 17 V)
TP9, TP10	GND	Power	Power ground

4.3.1 Input Voltage Monitoring (TP5, TP8, TP9, TP10)

The TLC5929 EVM provides test points for measuring the voltage applied to the IC and the LEDs. This allows measurement of the actual supply voltages without losses from input cables and connectors.

The V_{CC} voltage measurements are made between TP5 and TP10. The V_{LED} voltage measurements are made between TP8 and TP9. Use these test points by connecting a voltmeter positive terminal to TP5/8 and negative terminal to TP9/10.

4.3.2 Serial Interface Connection (TP1, TP2, TP3, TP4, TP6)

Evaluate this EVM by preparing a signal pattern generator like an FPGA, CPLD, MCU or some equipment like DG2020 for the input signals BLANK (TP4), SIN (TP3), SCLK (TP2) and LAT (TP1).

Use TP6 for observing the signal SOUT sends to a second EVM (not included).

4.3.3 Constant Sink Current (TP7)

Measure the voltage present at the I_{REF} pin of the TLC5929 with TP7.

5 Test Set Up

5.1 Equipment

5.1.1 Voltage Source

V_{CC} supply (TLC5929 Driver): 3–5.5 V at 50 mA.

V_{LED} supply: 5 V at more than 16 times the set output current, I_{REF}

CAUTION

Do not operate without LED loads. The TLC5929 outputs are bipolar and can draw high I_{CC} current when no load is connected. In addition the fault protection will be triggered.

Connect V_{CC} to J6 and V_{LED} to J5 as shown in [Figure 2](#).

5.1.2 Serial Interface

Evaluate this EVM by preparing a signal pattern generator like an FPGA, CPLD, MCU or some equipment like DG2020 for the input signals. Connector J1 or TP1 to TP4 connect the signals BLANK (pin 7 or TP4), SIN (pin 10 or TP3), SCLK (pin 9 or TP2), LAT (pin 8 or TP1), and GND (pin 6 or TP10).

5.2 Equipment Setup

[Figure 2](#) shows the basic test set up recommended to evaluate the TLC5929 EVM. Note that although the return for J5 and J6 are the same system ground, the connections should remain separate as shown in [Figure 2](#).

5.2.1 Procedure

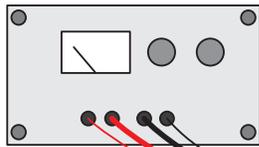
1. Working at an ESD workstation, make sure that any wrist straps, bootstraps, or mats are connected referencing the user to earth ground before power is applied to the EVM. Wear electrostatic smock and safety glasses.
2. Before connecting the DC input sources, V_{CC} and V_{LED} , limit the source currents. Set V_{CC} and V_{LED} to 0 V, initially, and connect as shown in [Figure 2](#).
3. Place a jumper on J7 to the desired forward current. R5 personalizes the needed current, according to Equation 1 in [Section 4.2](#).
4. Connect the DC power supplies, V_{CC} and V_{LED} , to the EVM as shown in [Figure 2](#).
5. Connect the pattern generator or MCU to the EVM as shown in [Figure 2](#).
6. Make sure the pattern generator or MCU is loaded with the EVM control software and the I/O levels are compatible with the TLC5929 V_{CC} supply. Example: if $V_{CC} = 3.3$ V, then interface 3.3-V I/O's to the EVM board.
7. Using the timing diagram ([Figure 9](#), TLC5929 ([SBVS159](#)) datasheet) as a guide, load the TLC5929 registers and control the outputs as desired.

5.2.2 Diagram

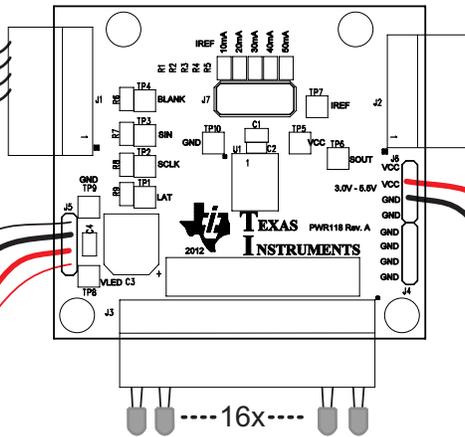
**Signal Pattern Generator
(FPGA, CPLD, MCU, Equipment)**



V_{OH} : e.g. 3.3V or 5V
 V_{OL} : GND



**LED Power Supply
e.g. 5V**



**LED Driver Power Supply
e.g. 3.3V or 5V**

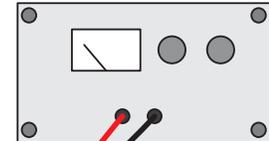


Figure 2. TLC5929 EVM Recommended Test Set-Up

6 TLC5929 EVM Assembly Drawings and Layout

Figure 3 through Figure 5 show the design of the TLC5929 EVM printed circuit board. The EVM has been designed using a 2-Layer, 1-oz copper-clad circuit board, 6.1 cm x 5.3 cm, with all components on the top side and all active traces to the top and bottom layers. This allows viewing, probing, and evaluation of the TLC5929 LED control IC in a practical double-sided application. Moving components to both sides of the PCB or using additional internal layers offers additional size reduction for space-constrained systems.

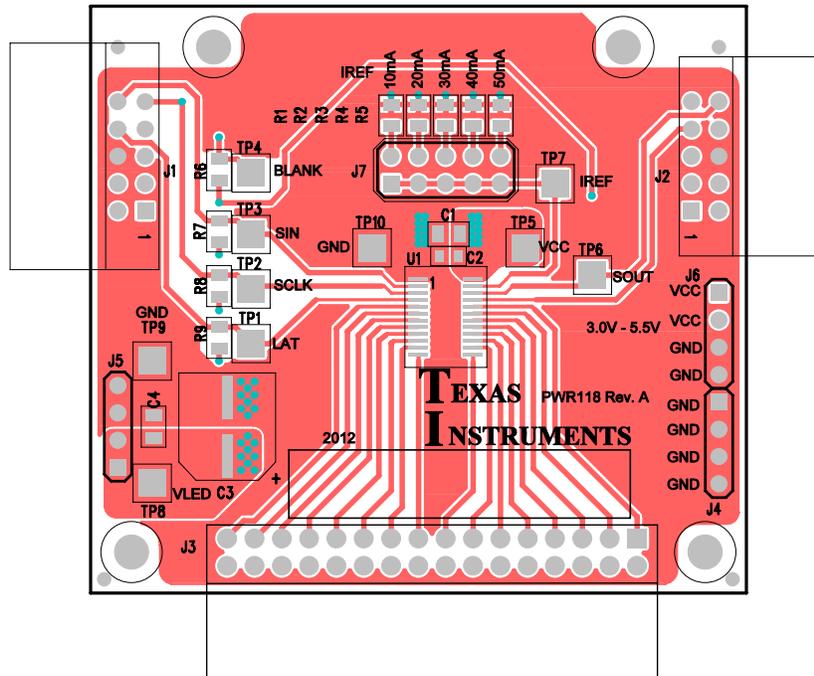


Figure 3. TLC5929 EVM Component Placement (Viewed From Top)

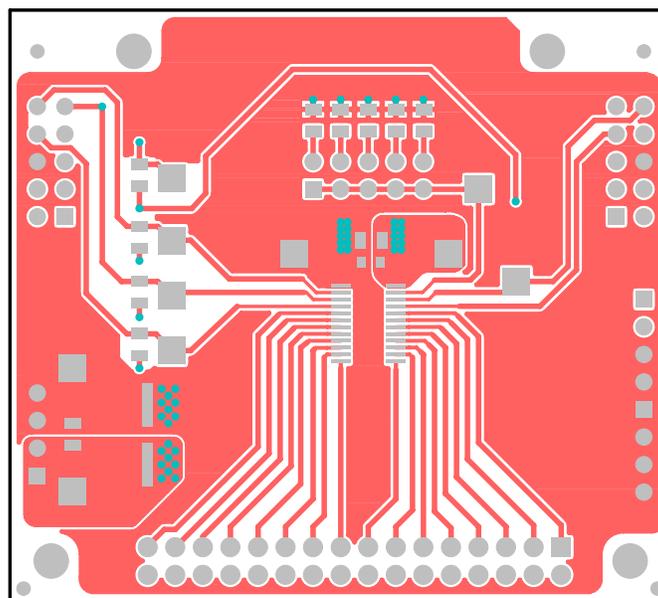


Figure 4. TLC5929 EVM Top Copper (Viewed From Top)

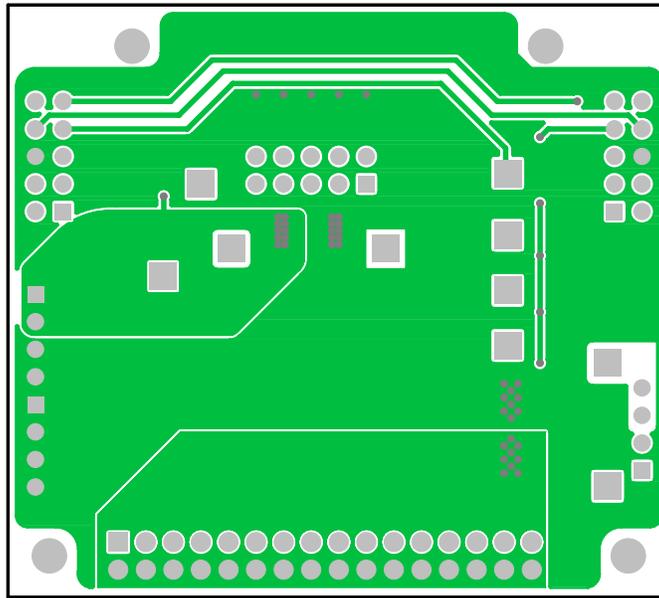


Figure 5. TLC5929 EVM Bottom Copper (Viewed From Bottom)

7 List of Materials

Table 4 lists the EVM components as configured according to the schematic shown in Figure 1.

Table 4. Bill of Materials

QTY	Reference	Value	Description	Size	Part Number	MFR
1	C2	1 μ F	Capacitor, ceramic, 10 V, B, 10% capacitor, ceramic, 10 V, X7R, 10%	0603	GRM185B31A105KE35 C1608X7R1A105K	Murata TDK
1	C4	open	Capacitor, ceramic, 25 V, X7R, 10%	0805	Std	STD
1	C1	10 μ F	Capacitor, ceramic chip, 10 V, \pm 10%	0805	GRM21BR71A106KE51	Murata
1	C3	47 μ F	Capacitor, electrolytic 25 V, -55 to $+105$ $^{\circ}$ C, \pm 20%	8 \times 6.2 mm	UWZ1E470MCL1G	Nichicon
1	R1	6.65 k Ω	Resistor, chip, 1/10W, 0.1%	0805	STD	STD
1	R2	3.32 k Ω	Resistor, chip, 1/10W, 0.1%	0805	STD	STD
1	R3	2.21 k Ω	Resistor, chip, 1/10W, 0.1%	0805	STD	STD
1	R4	1.65 k Ω	Resistor, chip, 1/10W, 0.1%	0805	STD	STD
1	R5	1.33 k Ω	Resistor, chip, 1/10W, 0.1%	0805	STD	STD
1	U1	TLC5929DBQ	IC, 16 Channel Constant-Current LED Driver with LED Open Detection	SSOP-24	TLC5929DBQ	TI

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As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

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.

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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.

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

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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.

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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.

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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.

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REGULATORY COMPLIANCE INFORMATION

As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

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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<http://www.tij.co.jp>

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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TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

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