

DRV110 and DRV120 Evaluation Modules (EVM)

This document describes the features and operation of the DRV110 and DRV120 Evaluation Modules (EVM). This EVM is a Texas Instruments HV EVM providing the key components necessary for evaluation of a DRV110 or a DRV120 integrated circuit (IC). This document shows how to power the DRV110 and DRV120 ICs with the EVM and contains the schematic, a printed circuit board (PCB), and a bill of materials.

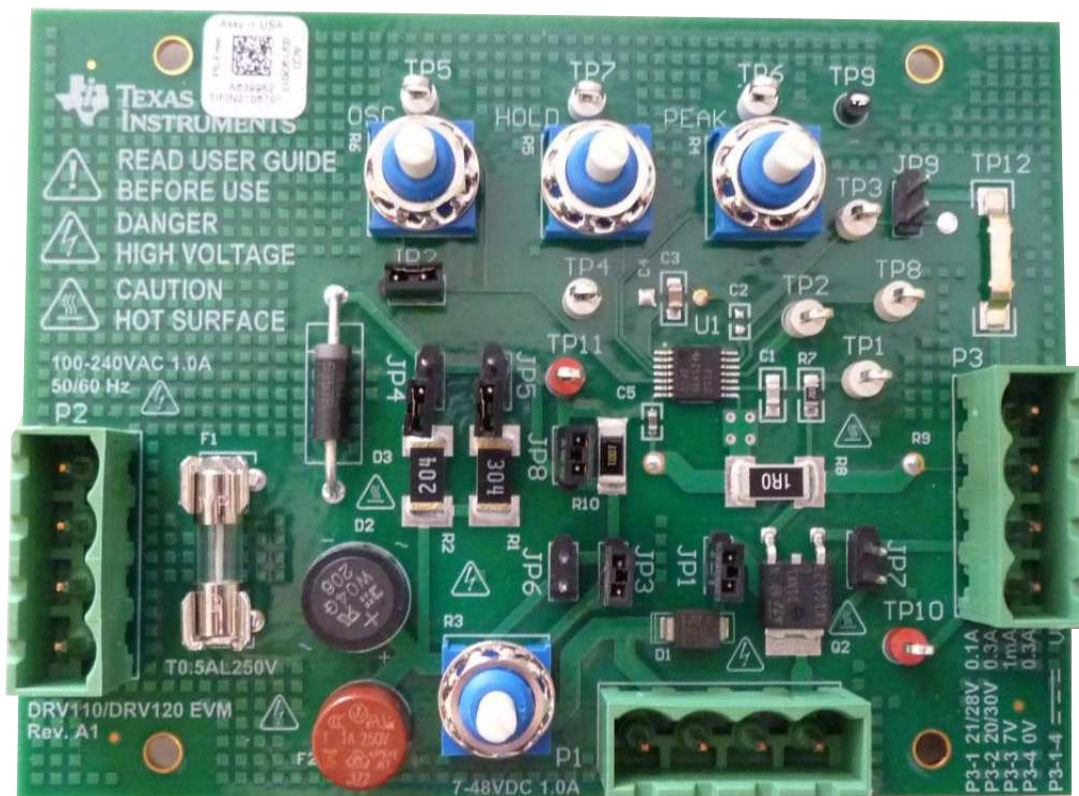


Figure 1. DRV110 and DRV120 EVM

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1 Background

The DRV110 IC is a power-saving pulse-width modulator (PWM) controller for solenoids with an internal supply regulator designed for a wide voltage range. The DRV120 IC provides similar load-current control with an integrated MOSFET switch output stage allowing a wide internal supply voltage range.

The 14-pin DRV110 and DRV120 IC are labeled on the board as U1. Peripheral components required to evaluate device features are also on the EVM. An external power supply and solenoid load (not provided with the EVM) must be wired to connectors on the EVM and the board must be configured before use. Various signals on the board can be accessed through test points and an output connector.

This EVM provides access to the features of the DRV110 or DRV120 ICs. Some modifications can be made to this module to test performance at different input and output voltages, currents and frequencies. Contact the TI Field Applications Group for more information.

2 Recommended Operating Conditions and Specifications

Never exceed operating conditions and ratings in [Table 1](#) and [Table 2](#).

Table 1. DRV110 and DRV120EVM Operating Conditions

Device	Parameter	Description	Connector	Min	Typ	Max	Unit	Notes
DRV110 DRV120	T_A	Operating ambient temperature	N/A	-40		35	°C	
DRV110	V_{DC}	DC supply voltage	P1: 1	7		48	V	
	I_{DC}	DC supply current	P1: 1		50	100 0	mA	
	V_{AC}	AC supply voltage	P2: 1,4	100		240	V_{rms}	50/60 Hz
	I_{AC}	AC supply current, P1: 1	P2: 1,4		50	500	mA_{rms}	Currents above 500 mA are only supported momentarily.
	V_{VLIMIT}	Intermediate supply node VLIMIT	P3: 1	7		18	V	Zener protected
DRV120	V_{DC}	DC supply voltage	P1: 1	7		28	V	
	I_{DC}	DC supply current	P1: 1		50	280	mA	
	V_{VLIMIT}	Intermediate supply node VLIMIT	P3: 1	7		28	V	Zener protected

Table 2. DRV110 and DRV120EVM Specification Summary

Device	Parameter	Operational Range
DRV110	I_{PEAK}	30–900 mA
	I_{HOLD}	30–150 mA
DRV120	I_{PEAK}	30–250 mA
	I_{HOLD}	30–100 mA
DRV110 DRV120	f_{PWM}	10–60 kHz
DRV110 DRV120	t_{KEEP}	Maximum 200 ms

3 Hardware Description

The EVM contains a switching transistor; Q2, a current sense resistor; R8, and a current recirculation diode; D1. Three 4-terminal connectors are provided for powering and measuring the EVM. The EVM is configured using jumpers. Test points are used to access signals on the board. Trimming potentiometers for external parameter settings to the DRV110 and DRV1120 ICs. See [Figure 2](#) for the EVM schematic.

3.1 Header Description

Descriptions of the 4-terminal connectors P1, P2 and P3 are shown in [Table 3](#).

Table 3. Header Description

Connector	Type	Label on the board	Description
P1: 1	Supply	VDC	Fuse protected DC supply voltage of the board
P1: 2	Load	COIL+	Terminal for inductive load, same potential as VDC terminal
P1: 3	Supply	GND	GND pin, ground node of the board
P1: 4	Load	COIL–	Terminal for inductive load
P2: 1-4	Supply ⁽¹⁾	AC, GND, GND, AC	Fuse protected AC supply voltage of the board
P3: 1	Output	VLIMIT	Intermediate supply voltage node with over voltage protection for DRV110 or DRV120 IC
P3: 2	Output	OUT	Connection to OUT pin of DRV110 or DRV120
P3: 3	Output	SENSE	Connection to SENSE pin of DRV110
P3: 4	Output	GND	GND pin, ground node of the board

⁽¹⁾ Only used with DRV110

3.2 Board Configuration and Jumper Description

The DRV110 and DRV120EVMs are designed for both the DRV110 and DRV120 ICs and can be operated from various types of power supplies. The jumper placement on the board must be correctly configured before power-up, as shown in [Table 4](#).

Table 4. Board Configuration

Device	Function	Jumper	Placement	Power Configuration	Comment
DRV110 DRV120	Board configuration	JP1	Insert jumper to close load-current recirculation path	N/A	Inserted by default
		JP2	Insert jumper to connect OSC to 1-M Ω trimmer		
DRV110 (leave open with DRV120)	Supply configuration	JP3	Insert jumper to select 10-k Ω series resistor R3	7-48 VDC, 1 A	Selection based on supply voltage and desired supply current.
		JP4	Insert jumper to select 200-k Ω series resistor R2	100-240 VAC, 1 A	
		JP5	Insert jumper to select 300-k Ω series resistor R1	100-240 VAC, 1 A	
DRV120 (leave open with DRV110)	Supply configuration	JP6	Insert jumper to bypass R1, R2, and R3 series resistors	7-28 VDC, 1 A	Inserted by default in DRV120
	Board configuration	JP7	Insert jumper to connect OUT to VCOIL	N/A	
		JP8	Insert jumper to bypass R10 series resistor		
DRV110 DRV120	Enable DRV110 and DRV120	JP9	Insert jumper to disable the device, leave open to enable	N/A	

3.3 Device Parameter Settings

The operating point and parameters of DRV110 and DRV120 are adjusted using components on the EVM as shown in [Table 5](#).

Table 5. Device Parameter Settings

Designator	Description	Comment
R3	10-k Ω trimmer, sets V_{IN} current of DRV110	Resistance value increases clockwise
R4	1-M Ω trimmer, sets I_{PEAK}	Resistance value increases clockwise
R5	1-M Ω trimmer, sets I_{HOLD}	Resistance value increases clockwise
R6	1-M Ω trimmer, sets f_{PWM}	Resistance value increases clockwise

3.4 Test Points

Test points of the board are show in [Table 6](#).

Table 6. Test Point Description

Designator	Description
TP1	Current SENSE pin of DRV110
TP2	OUT pin
TP3	EN pin
TP4	KEEP pin
TP5	OSC pin
TP6	PEAK pin
TP7	HOLD pin
TP8	STATUS pin
TP9	GND pin
TP10	VLIMIT net
TP11	V_{IN} pin
TP12	GND pin

3.5 Schematic

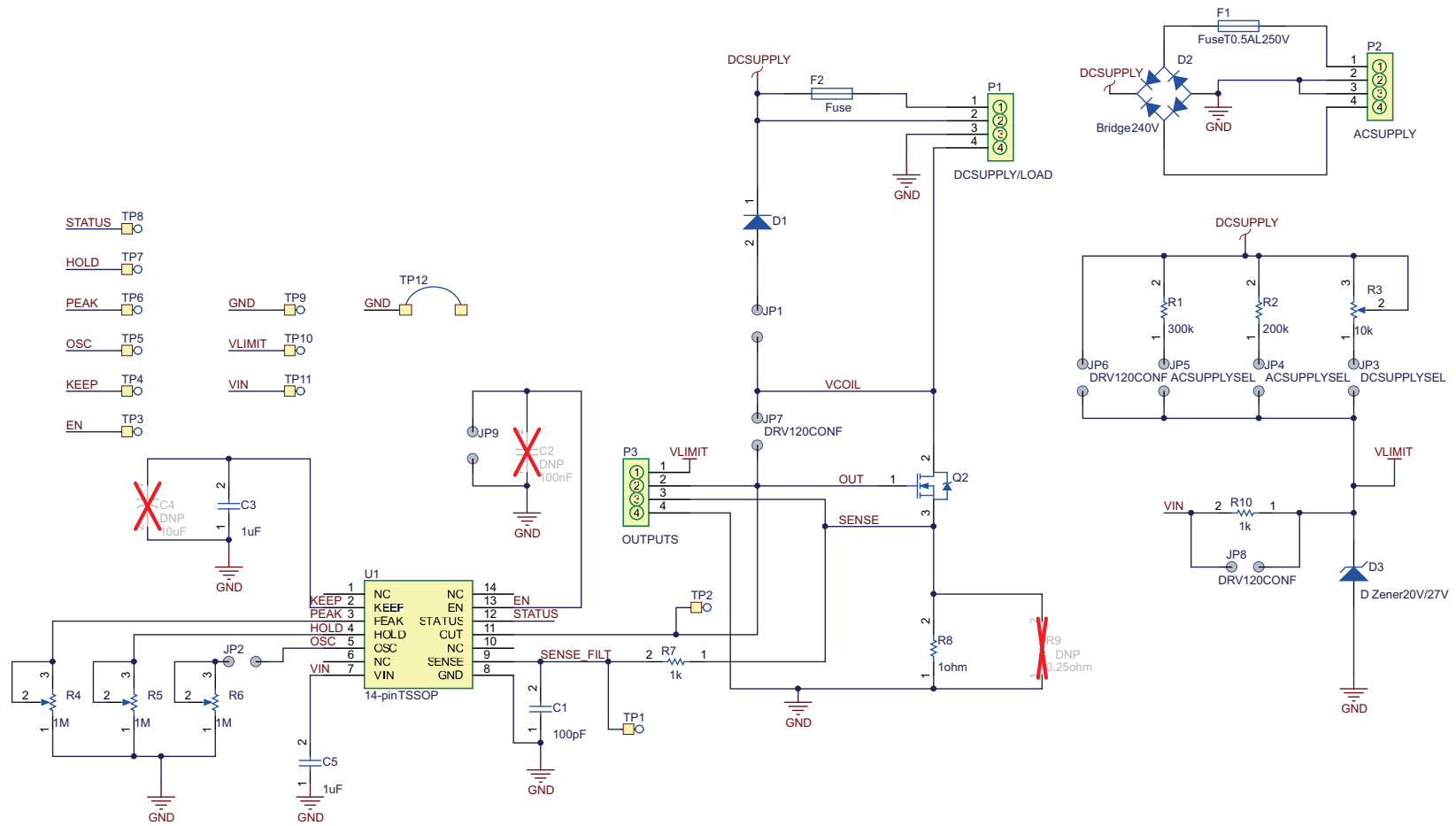


Figure 2. DRV110EVM Schematic

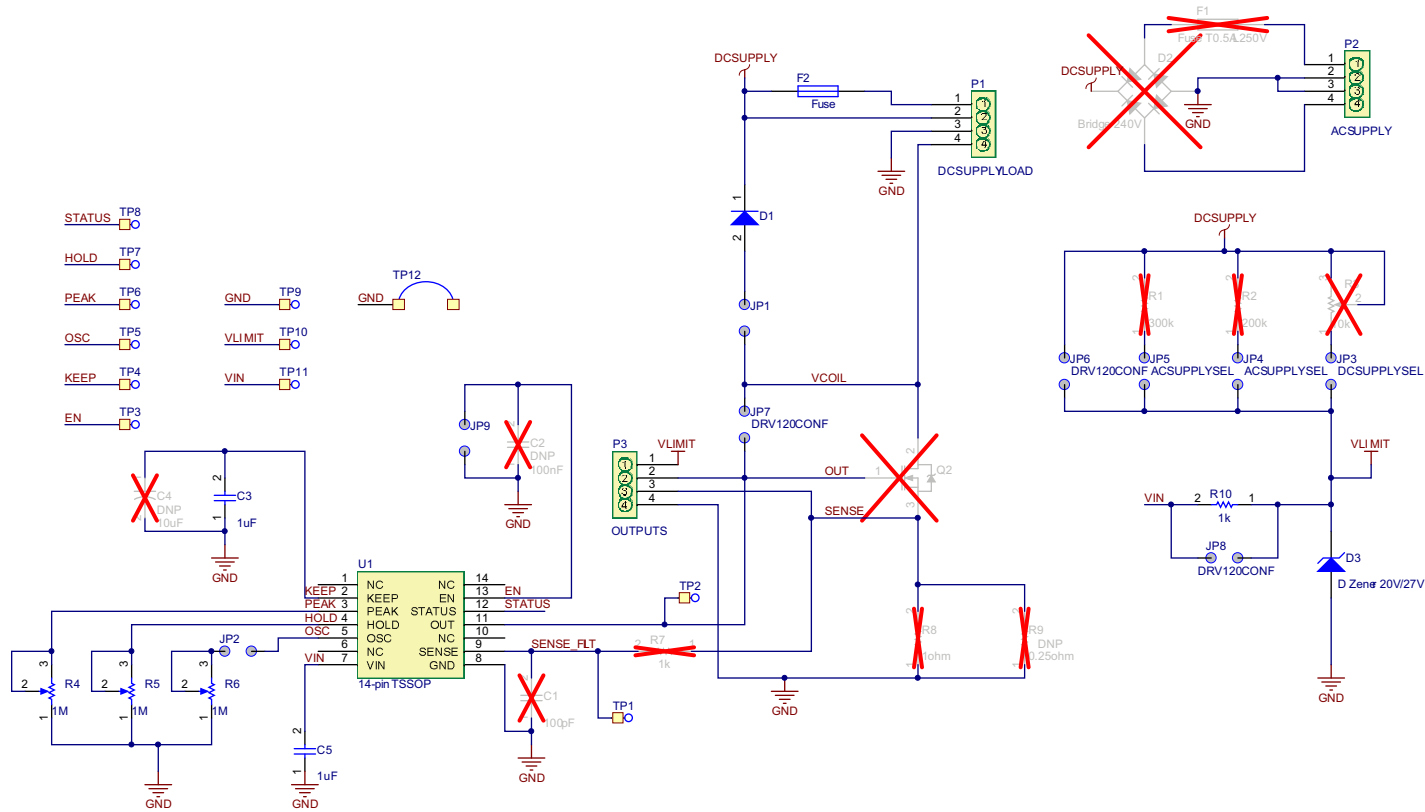


Figure 3. DRV120EVM Schematic

3.6 DRV110 and DRV120EVM Board Layouts

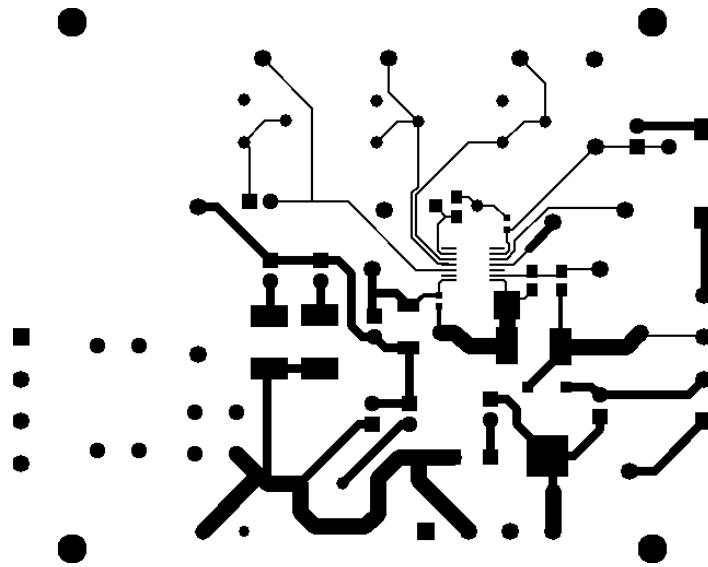


Figure 4. Top Layer Board Layout

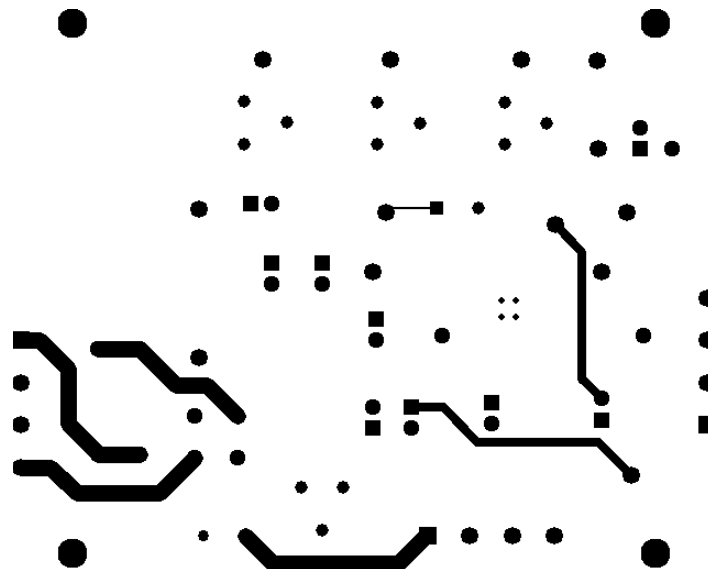


Figure 5. Bottom Layer Board Layout

4 Operation

4.1 Safety

WARNING

This EVM does not provide any kind of safety isolation, therefore, all voltages on the EVM are considered hazardous. Use isolated equipment when working with the EVM. Minimize the risk of fire hazard by replacing fuse F1 only with fuse T0.5AL250V.

Power supply connectors of the EVM, P1 and P2, are protected by fuses F1 and F2, respectively. The supply pin of the DRV110 or DRV120 IC is protected by Zener-diode; D3, allowing time for power supply overcurrent protection to trip. It is not intended to carry significant currents continuously.

Components on the EVM may become hot in normal use or because of abnormal configuration or violation of the operating conditions.

CAUTION

Do not leave the EVM powered when unattended.

4.2 Power-up Procedure

CAUTION

Always assume the entire EVM has fully-accessible and active high voltages.

When using the EVM to change measurement setup, access jumpers, wire test instruments, supplies or loads, use the following procedures:

1. De-energize the TI HV EVM and all its inputs, outputs and electrical loads before performing any electrical or diagnostic measurements. Revalidate that the TI HV EVM power has been safely de-energized.
2. Once the EVM is de-energized, proceed with the required electrical circuit configurations, wiring, measurement equipment connections, and other application needs. Continue to assume the EVM circuit and measuring instruments are electrically live.
3. Once EVM readiness is complete, energize the EVM.

Before connecting a load to the EVM it is recommended to test that board configuration and device power supply biasing is correctly set. The following procedure is recommended:

1. Ensure jumpers JP1 and JP2 are in place and that JP9 is left open.
2. Configure the board to test DRV110 or DRV120.
3. Configure the board to the power-supply type used.
4. Turn trimmers R4, R5, and R6 in a counter clockwise direction, as far as they go.
5. If a 14-V (V_{IN}) voltage is used for DRV110, ensure the V_{IN} pin current is limited by the series resistance. It is always a good practice, when applicable, to use too much resistance first and then to decrease the resistance and observe the effect on supply voltages.
6. During this procedure use a current limit in the EVM power supply. This current limit, along with Zener diode D3, protects device V_{IN} pin for over voltage.
7. Increase the power-supply voltage, if applicable, and observe supply voltages V_{IN} and VLIMIT on the board.

5 Bill of Materials
Table 7. DRV110 BOM

Designator	Digi-Key Part Number	Quantity	Description
C1	445-1329-1-ND	1	CAP CER 100PF 50V 5% NP0 0805
C3	399-5763-1-ND	1	CAP CER 1UF 10V 5% X8L 0805
C5	587-1437-1-ND	1	CAP CER 1UF 35V 10% X5R 0603
D1	497-3776-1-ND	1	DIODE FAST 600V 2A HE SMB
D2	W04GDI-ND	1	RECT BRIDGE GPP 400V 1.5A WOG
D3	1N5357BGOS-ND	1	DIODE ZENER 20V 5W AXIAL
F1	3521K-ND	2	CLIP FUSE 2AG/5MM THM W/LEGS 10A
F1 (mate)	MJS 500-R -ND	1	FUSE 500MA 250V SLOW 5X15 BULK
F2	507-1111-ND	1	FUSE SLOW 250VAC 1A RADIAL
JP1, JP2, ..., JP9	609-4434-ND	9	CONN HEADER 2POS VERT T/H
JP1, JP2, ..., JP9 (mate)	A26227-ND	9	SHUNT, ECON, PHBR 15 AU, BLACK
P1, P2, P3	A98232-ND	3	TERM BLOCK HEADER 4POS 5.08MM
P1, P2, P3 (mate)	A98225-ND	3	TERM BLOCK PLUG 4POS 5.08MM
Q2	497-2483-1-ND	1	MOSFET N-CH 600V 1A DPAK
R1	541-300KXCT-ND	1	RES 300K OHM 1W 5% 2512 SMD
R2	541-200KXCT-ND	1	RES 200K OHM 1W 5% 2512 SMD
R3	3310Y-001-103L-ND	1	POT 10K OHM 9MM SQ PLASTIC
R4, R5, R6	3310Y-001-105L-ND	3	POT 1.0M OHM 9MM SQ PLASTIC
R7	RMCF0805JT1K00CT-ND	1	RES 1K OHM 1/8W 5% 0805 SMD
R8	541-1.00AAFCT-ND	1	RES 1.00 OHM 1W 1% 2512 SMD
R10	RHM1.00KBFCT-ND	1	RES 1.00K OHM 1/2W 1% 2010 SMD
TP9	5001K-ND	1	TEST POINT PC MINI .040"D BLACK
TP10, TP11	5000K-ND	2	TEST POINT PC MINI .040"D RED
TP1, TP2, ..., TP8	5002K-ND	8	TEST POINT PC MINI .040"D WHITE
TP12	952-1474-1-ND	1	JUMPER TIN SMD
U1	n/a	1	DRV110
C2		1	NOT ASSEMBLED
C4		1	NOT ASSEMBLED
R9		1	NOT ASSEMBLED

Table 8. DRV120 BOM

Designator	Digi-Key Part Number	Quantity	Description
C3	399-5763-1-ND	1	CAP CER 1UF 10V 5% X8L 0805
C5	587-1437-1-ND	1	CAP CER 1UF 35V 10% X5R 0603
D1	497-3776-1-ND	1	DIODE FAST 600V 2A HE SMB
D3	1N5361BRLGOSCT-ND	1	DIODE ZENER 27V 5W AXIAL
F2	507-1111-ND	1	FUSE SLOW 250VAC 1A RADIAL
JP1, JP2,...., JP9	609-4434-ND	9	CONN HEADER 2POS VERT T/H
JP1, JP2,...., JP9 (mate)	A26227-ND	9	SHUNT, ECON, PHBR 15 AU,BLACK
P1, P2, P3	A98232-ND	3	TERM BLOCK HEADER 4POS 5.08MM
P1, P2, P3 (mate)	A98225-ND	3	TERM BLOCK PLUG 4POS 5.08MM
R4, R5, R6	3310Y-001-105L-ND	3	POT 1.0M OHM 9MM SQ PLASTIC
R10	RHM1.00KBFCT-ND	1	RES 1.00K OHM 1/2W 1% 2010 SMD
TP9	5001K-ND	1	TEST POINT PC MINI .040"D BLACK
TP10, TP11	5000K-ND	2	TEST POINT PC MINI .040"D RED
TP1, TP2,...., TP8	5002K-ND	8	TEST POINT PC MINI .040"D WHITE
TP12	952-1474-1-ND	1	JUMPER TIN SMD
U1	n/a	1	DRV120
C1		1	NOT ASSEMBLED
C2		1	NOT ASSEMBLED
C4		1	NOT ASSEMBLED
R9		1	NOT ASSEMBLED
Q2		1	NOT ASSEMBLED
F1		2	NOT ASSEMBLED
R7		1	NOT ASSEMBLED
R8		1	NOT ASSEMBLED
R1		1	NOT ASSEMBLED
R2		1	NOT ASSEMBLED
R3		1	NOT ASSEMBLED
D2		1	NOT ASSEMBLED

EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

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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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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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STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.
 - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductor products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software
 - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
2. *Limited Warranty and Related Remedies/Disclaimers:*
 - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
 - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.
 - 2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

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

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

NOTE:

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

3 Regulatory Notices:

3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

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

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

CAUTION

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

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

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

3.2 Canada

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

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lstds/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。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないものご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

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上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。日本テキサス・イ

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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lstds/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。 <https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

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.

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- 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.

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