EVM User's Guide: XTR300EVM

XTR300 Evaluation Module

Description

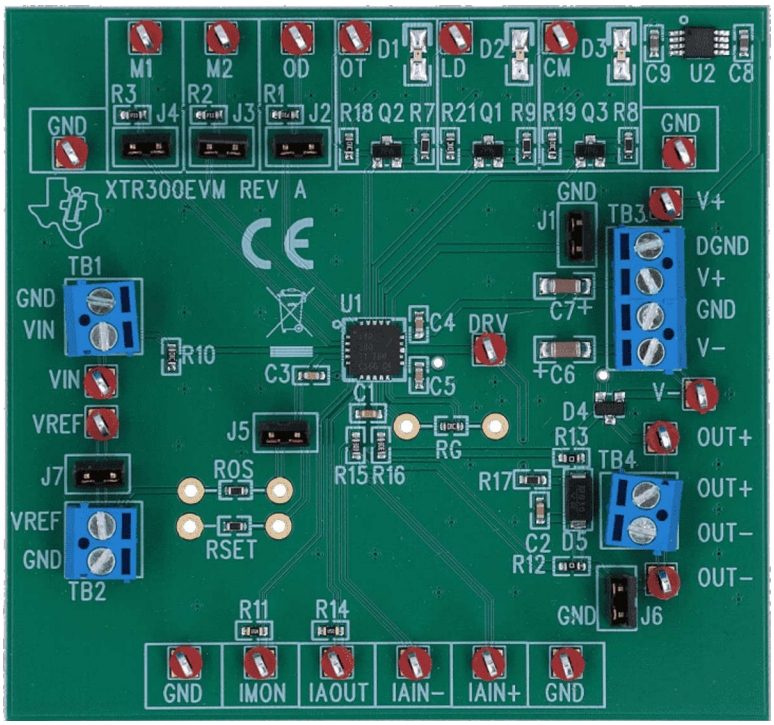
The XTR300 evaluation module (EVM) is a development platform for evaluating the XTR300, a precision output driver for three-wire current or voltage systems. No external shunt resistor is required. Only external gain-setting resistors and a loop compensation capacitor are required.

Features

- Easy handling of the small QFN package.
- Easy access to all pins of the device.
- Easily-configured mode-select pins to switch between voltage output and current output modes.
- LED indicators for the error flags.
- Optional use of a 5V regulated voltage.
- Output protection and filtering circuitry.

Applications

- Motor drives analog outputs: 4-20mA and ±10V
- PLC output programmable driver
- Industrial high-voltage I/O
- Three-wire sensor current or voltage output
- ±10V two- and four-wire voltage output



XTR300EVM

1 Evaluation Module Overview

1.1 Introduction

The XTR300 is a universal output driver for industrial and process-control applications. This device can be configured as a current or voltage output device without requiring an external shunt resistor. The XTR300 requires minimal external circuitry, including a few gain-setting resistors and a loop compensation capacitor. The XTR300 offers separate driver and receiver channels for improved flexibility. The internal instrumentation amplifier (IA) is normally connected for remote voltage sensing in voltage output mode. Alternatively, the IA can be used as a high-voltage, high-impedance measurement channel. In voltage output mode, a copy of the output current is provided to allow for easy testing of the load condition and eventual calculation of the load resistance. In current output mode, the load voltage can be monitored.

The XTR300 device provides configuration and notification functionality by using the error flag and digital control pins. The digital output selection capability, together with the error flags and monitor pins, makes remote configuration and troubleshooting possible. Fault conditions on the output and the IA input, as well as overtemperature conditions, are indicated by the error flags. The monitoring pins, IMON and IAOUT, provide continuous feedback regarding load power or impedance. For additional protection, the maximum output current is internally limited and thermal protection is provided.

The XTR300EVM highlights and demonstrates various configurations of the XTR300. The EVM allows the user to modify the inputs, configuration pins, and support circuitry to test and evaluate desired behavior.

This user’s guide describes the characteristics and operation of the XTR300 evaluation module (EVM) board. This document also describes how to set up and configure the hardware and reviews various aspects of the part's operation. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the XTR300EVM. This user’s guide also includes information regarding operating procedures, input or output connections, an electrical schematic, printed circuit board (PCB) layout, and a parts list for the EVM.

1.2 XTR300EVM Kit Contents

Table 1-1 details the contents of the XTR300EVM kit.

Table 1-1. Contents of XTR300EVM Kit

Item	Quantity
XTR300EVM PCB Evaluation Board	1

1.3 Specification

The XTR300EVM offers the following features:

- Selectable output mode
- Enable or disable output
- Easy visual of the following error events:
  - Over temperature
  - Load error
  - Input amplifier common mode over range

1.4 Device Information

The EVM is built with the XTR300 device in the 20-pin VQFN package with a thermal pad.

2 Hardware

2.1 Evaluation Setup

To setup the XTR300EVM...

1. Set jumpers according to output mode configuration, see Section 2.4 for details.
2. Connect power supply (V+, V-, and GND) to TB3 or the test points labeled V+, V-, and GND.
3. Connect the output load to TB4 or test points labeled OUT+ and OUT-.
4. Connect the input signal to TB1 or test point labeled VIN and one of the GND test points.
5. If needed, connect the reference voltage to TB2 or test point labeled VREF and one of the GND test points.
   a. By default, this reference is provided onboard.
6. Turn on the power supply.
7. If needed, turn on the reference voltage supply.
8. Turn on the input signal.
9. Measure the output.

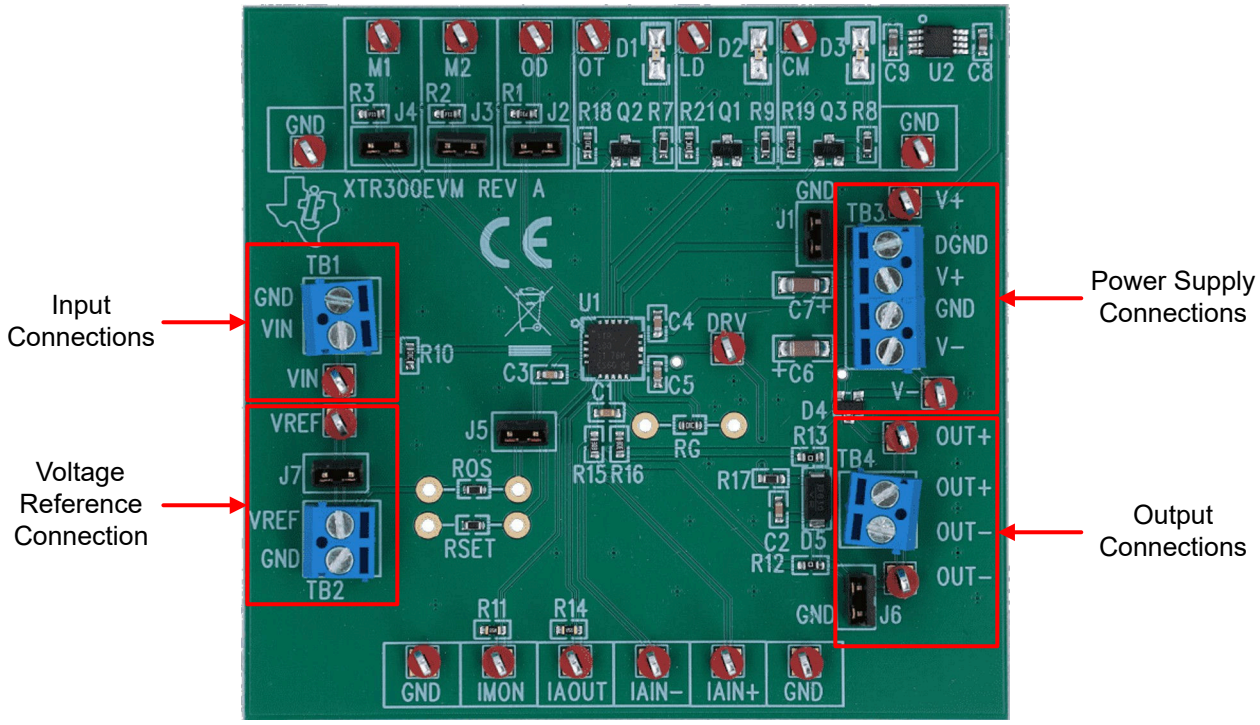


Figure 2-1. Locations of the Power Supply, Input, Output, and Voltage Reference Connections

2.2 Jumper Configuration Settings

There are seven jumpers located on the XTR300EVM. The functions are described in Table 2-1.

Table 2-1. Jumper Settings

Jumper	Function
J1	Connects the digital ground pin (DGND) to GND
J2	Pulls the output disable pin (OD) high, enabling the output
J3	Pulls the mode select pin (M2) high
J4	Pulls the mode select pin (M1) high
J5	Applies an offset to the VIN signal. Is used with VREF to create a bidirectional output with a single-ended input
J6	Connects OUT– to ground
J7	Connects an onboard 5V reference to VREF

2.3 Features

2.3.1 Input Signal

Terminal block TB1 is used for the non-inverting input signal, VIN. The valid range input is from –10V to +10V. However, the EVM is configured for a 0V to 5V or a ±5V input signal. A test point connected to VIN is located next to TB1.

2.3.2 Reference Voltage

A reference voltage is needed to produce a bidirectional output from a single-ended source. The XTR300EVM supports using either an external or onboard 5V reference voltage. To use the onboard reference voltage, shunt J7.

To use an external reference voltage, apply the voltage to terminal block TB2. Before applying the external reference voltage, make sure that shunt J7 is removed.

2.3.3 XTR300EVM Output

The output for the XTR300EVM is located at terminal block TB4. The output stage of the XTR300 consists of an Instrumentation Amplifier, IA, (IAIN– and IAIN+) and a unique op amp (DRV) that combine to form an analog output that can be digitally configured to provide either current or voltage output to TB4. OUT+ and OUT– are also connected to test points near TB4.

2.3.4 Error Flags

The XTR300 has three error flags to indicate when a specific error has occurred as described in Table 2-2.

Table 2-2. Error Flags

Error Flags	Description
EF_{CM}	Instrumentation Amplifier (IA) Common-Mode Over Range fault pin goes low as soon as the inputs of the IA reach the limits of the linear operation for the input voltage.
EF_{LD}	Load Error flag fault pin indicates fault conditions driving voltage or current into the load. In voltage output mode, the flag monitors the voltage limits of the output swing and the current limit condition caused from short or low load resistance. In current output mode, the flag indicates a saturation into the supply rails from a high load resistance or open load.
EF_{OT}	Overtemperature fault pin goes low if the chip temperature reaches a temperature of 140°C and resets as soon as the chip cools down to 125°C. The flag does not automatically shut down the output; the flag allows the user system to take action on the situation. If desired, this output can be connected to output disable (OD) which disables the output and therefore removes the source of power. This connection acts like an automatic shut down, but requires a 2.2kΩ external pullup resistor to safely override the internal current sources. The IA channel is not affected, which allows continuous observation of the voltage at the output.

The LEDs D1, D2, and D3 turn on when the XTR300 experiences an overtemperature fault, a load error fault, or an IA common-mode over range fault, respectively. Alternatively, the voltages at the error flags can be monitored at the LD, OT, and CM test points.

2.3.5 IMON: Current Monitor Output

When in voltage mode, the IMON pin produces a current mirror that generates an exact 1/10th copy of the output current as seen in Equation 1.

$$\mathrm{IMON} = \frac{\mathrm{I_{DRV}}}{10} \tag{1}$$

To convert IMON to a voltage, a resistor (R11) is used as seen in Equation 2. By default, R11 is 750Ω.

$$\mathrm{V_{IMON}} = \mathrm{IMON} \times \mathrm{R11} \tag{2}$$

The test point labeled IMON allows for easy to read monitoring of the IMON pin.

2.3.6 IAOUT: Voltage Monitor

The XTR300 has an internal instrumentation amplifier that can be used to monitor the output voltage when in current mode operation by looking at the IAOUT pin. The IAOUT pin has a transfer function as shown in Equation 3.

$$IA_{OUT} = 2 \times \frac{(I_{IN+} - I_{IN-})}{RG} \quad (3)$$

By default, the RG resistor is set to 10kΩ.

To convert IAOUT to a voltage, a resistor (R14) is used as seen in Equation 4. By default R14 is 750Ω.

$$V_{IAOUT} = IAOUT \times R14 \quad (4)$$

The test point labeled IAOUT allows for easy to read monitoring of the IAOUT pin.

2.3.7 Other Test Points

- M1 and M2 are connected to the M1 and M2 mode select pins of the XTR300.
- OD is connected to the output disable (OD) pin of the XTR300.
- IAIN– is the inverting input of the IA.
- IAIN+ is the noninverting input of the IA.

2.4 Output Mode Configurations

This section describes four configurations for the XTR300EVM that enable evaluation of the basic XTR300 functions.

2.4.1 Current Mode Configurations

2.4.1.1 Single-Ended Current Output

The first current-mode configuration creates a single-ended output from a single-ended input. The jumper settings for this configuration are listed in Table 2-3. The current output is calculated by the transfer function in Equation 5:

$$I_{OUT} = \frac{10}{RSET} \times VIN \quad (5)$$

The default EVM value for RSET is 2.5kΩ.

Table 2-3. Single-Ended Current Output Jumper Settings

Jumper	Function
J1	On
J2	On
J3	On
J4	Off
J5	Off
J6	Off
J7	Off

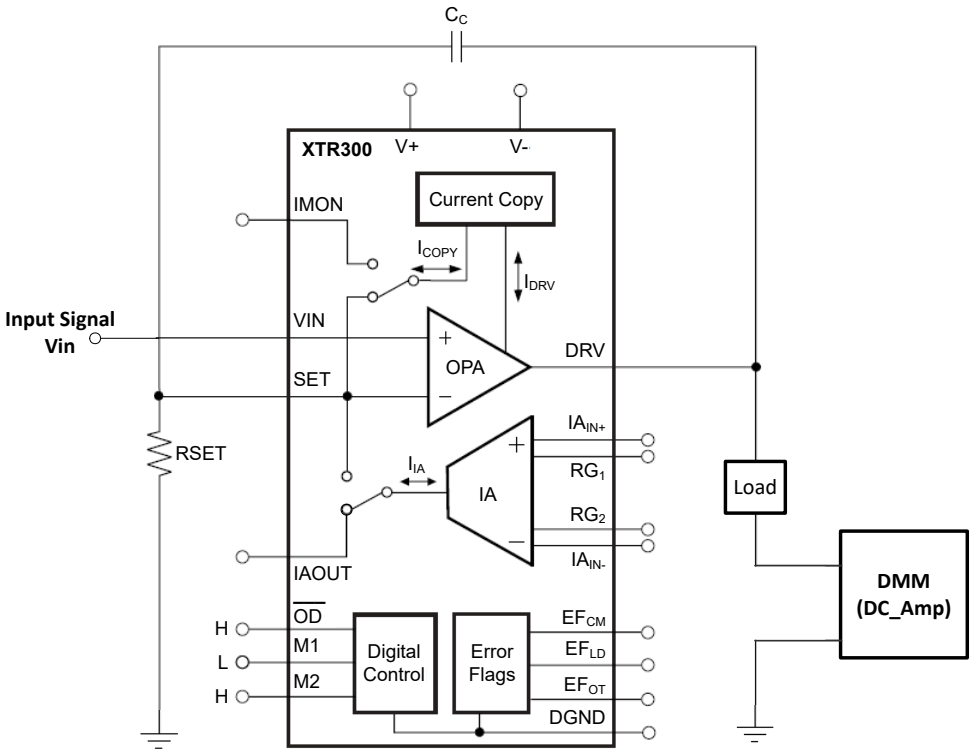


Figure 2-2. XTR300 Single-Ended Current Output Configuration Circuit Drawing

Figure 2-3 shows how to setup the XTR300EVM in single-ended current output mode. Connect your load to TB4 between OUT+ and GND. Apply ±15V to V+ and V–. Connect a 5V signal to VIN. Measure the current through the load by putting a digital multimeter (DMM) in series with the load. The current though the load is approximately 20mA with the default board values.

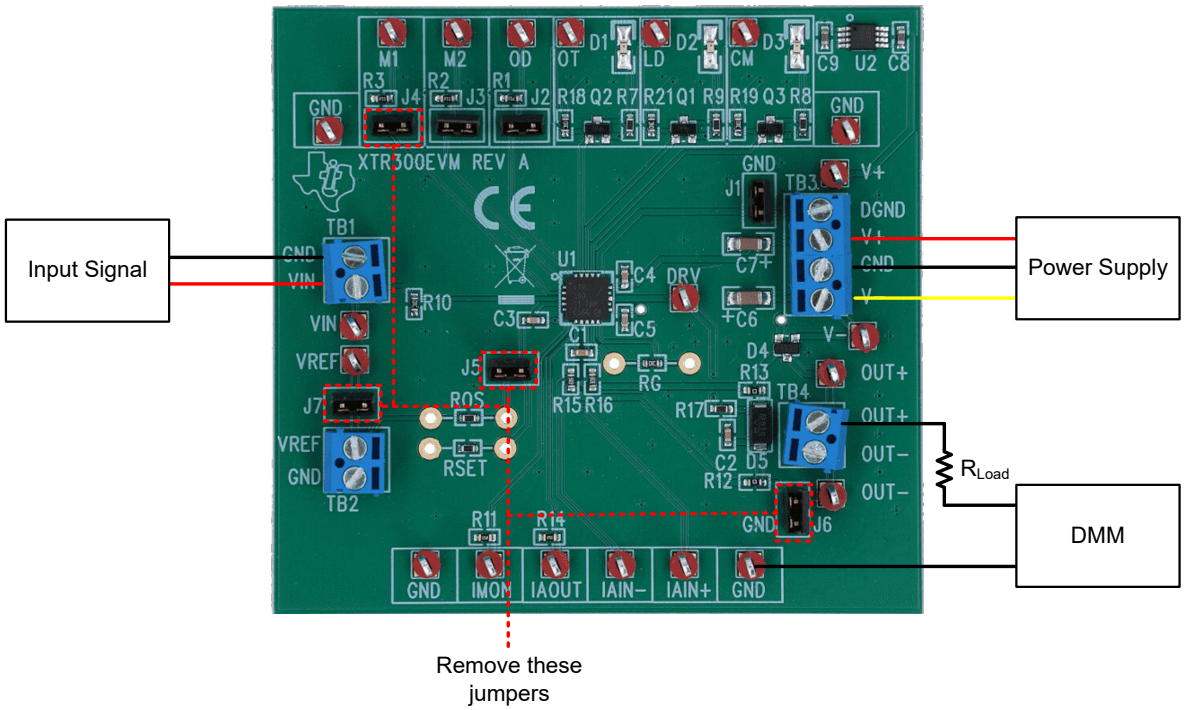


Figure 2-3. XTR300EVM Single-Ended Current Output Configuration Setup

2.4.1.2 Bidirectional Current Output

The second current output configuration creates a bidirectional output from a single-ended input. The jumper settings for this configuration are listed in Table 2-4. The output current is calculated by the transfer function in Equation 6:

$$I_{OUT} = 10 \times \left(\frac{VIN}{RSET} + \frac{VIN - VREF}{ROS} \right) \quad (6)$$

The default EVM configuration sets RSET to 2.5kΩ and ROS to 2.5kΩ.

Table 2-4. Bidirectional Current Output Jumper Settings

Jumper	Function
J1	On
J2	On
J3	On
J4	Off
J5	On
J6	Off
J7	Off or on(1)

(1) J7 must be off if an external reference is used and on if the internal reference is to be used.

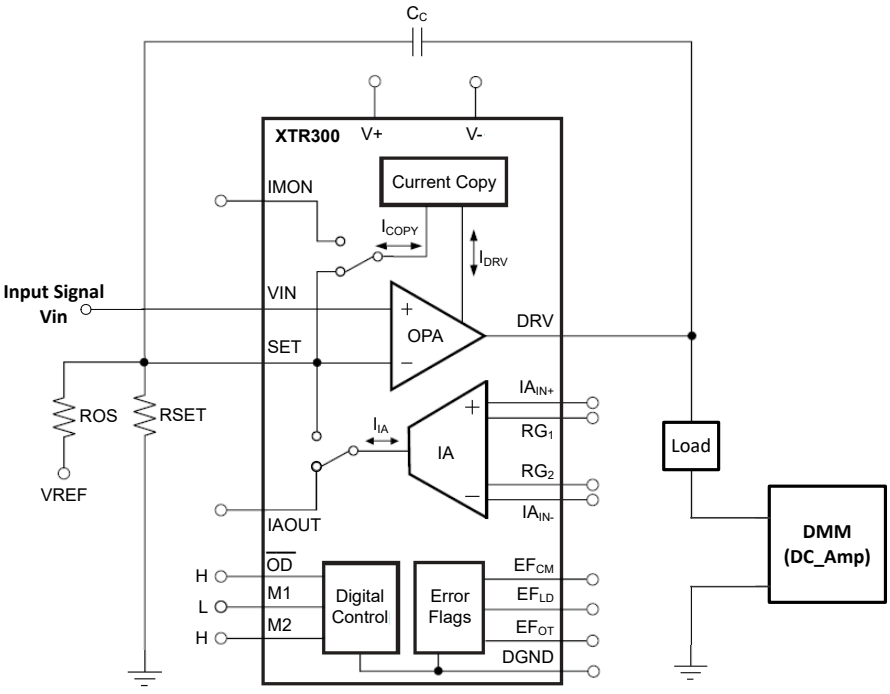


Figure 2-4. XTR300 Bidirectional Current Output Configuration Circuit Drawing

Figure 2-5 shows how to setup the XTR300EVM in a bidirectional current output mode. Connect your load to TB4 between OUT+ and GND. Apply ±15V to V+ and V–. Connect a 5V signal to VIN. Connect a 5V reference to VREF. If there is no external reference voltage, connect J7 to apply an onboard reference voltage of 5V. Measure the current through the load by putting a digital multimeter (DMM) in series with the load. The current through the load is approximately 20mA with the default board values. If you apply a 0V signal to VIN, the current through the load is approximately –20mA.

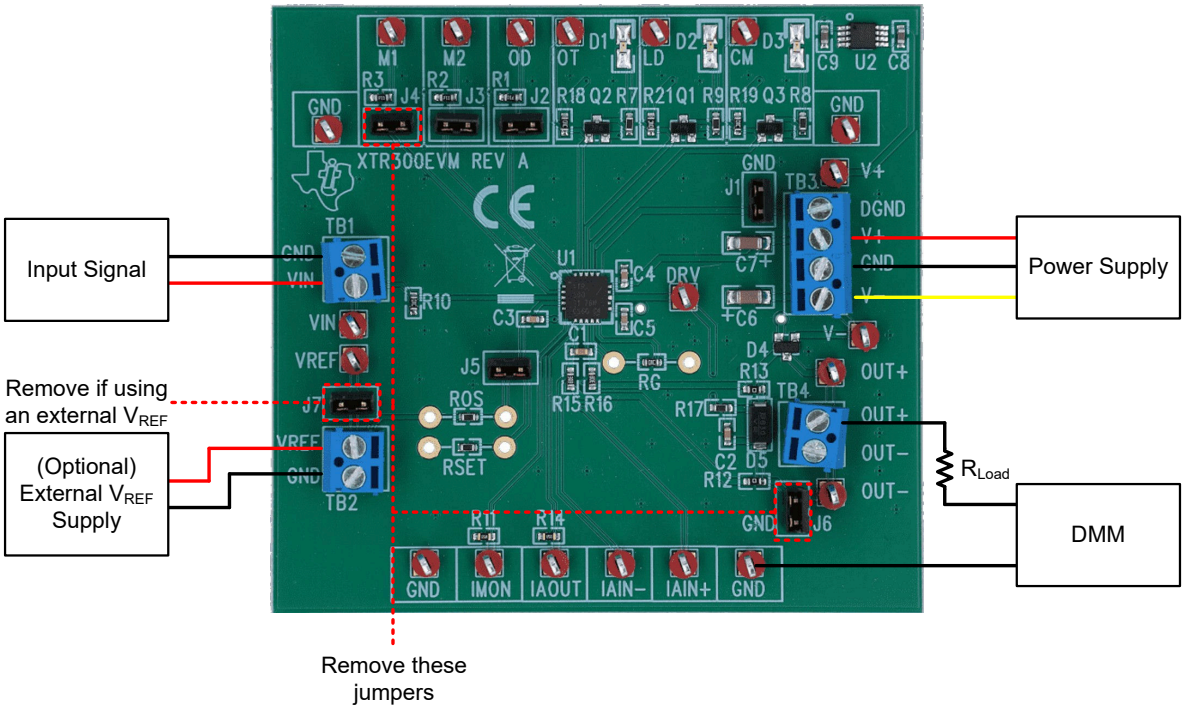


Figure 2-5. XTR300EVM Bidirectional Current Output Configuration Setup

2.4.1.3 Verifying Acceptable Load in Current Mode

Verify that the XTR300 is able to drive the resistive load in a particular application. To calculate this, there are two limits to consider, the output voltage swing and the output current limits.

The output current limits are determined by the minimum short circuit current limit, which can be found in the data sheet as $I_{SC_{Min}} = \pm 24.5mA$. In current mode, the output current is set by the user and directly controlled. The rest of the calculations focus on the output voltage swing limits.

The output voltage swing limits are directly tied to the supply voltages. As shown in Equation 7, the output can only swing up to 3V from the supply rails.

$$(V-) + 3 \leq V_{OUT_{LIMIT\_RANGE}} \leq (V+) - 3 \quad (7)$$

In current mode, the user needs to verify that for whatever the output current range is selected, must not violate the output voltage limits with the system's load. Use Ohm's law to find what minimum and maximum output voltages are needed for the output current range as shown in Equation 8 and Equation 9.

$$V_{OUT_{MIN}} = I_{OUT_{MIN}} \times R_{LOAD} \quad (8)$$

$$V_{OUT_{MAX}} = I_{OUT_{MAX}} \times R_{LOAD} \quad (9)$$

If the output voltage goes beyond the output voltage limit that is set by Equation 7 then the XTR300 cannot drive the load under these conditions.

For example, in a system where the V+=15V, V-=-15V, R_{LOAD} =1kΩ, and require an output current from 0mA to 20mA, to verify that the output does not be saturated, first evaluate what the acceptable output voltage range is by plugging in the supply rails to Equation 7. In this example, the output is able to produce a voltage range of $-12V \leq V_{OUT_{LIMIT\_RANGE}} \leq 12V$.

Plugging in 0mA, 20mA and 1kΩ to Equation 10 and Equation 11 produce:

$$V_{OUT_{MIN}} = 0V \quad (10)$$

and

$$V_{OUT_{MAX}} = 20V \quad (11)$$

The maximum output voltage needed is higher than what the XTR300 is able to output in this example, resulting in a maximum output current to be 12mA.

2.4.2 Voltage Mode Configurations

2.4.2.1 Single-Ended Voltage Output

The first voltage mode configuration creates a single-ended output from a single ended input. The jumper settings for this configuration are listed in Table 2-5. The voltage output is calculated by the transfer function shown in Equation 12:

$$V_{OUT} = \frac{RG \times VIN}{2 \times RSET} \quad (12)$$

The default EVM configurations set RG to 10kΩ and RSET to 2.5kΩ.

Table 2-5. Single-Ended Voltage Output Jumper Settings

Jumper	Function
J1	On
J2	On
J3	Off
J4	Off
J5	Off
J6	On
J7	Off

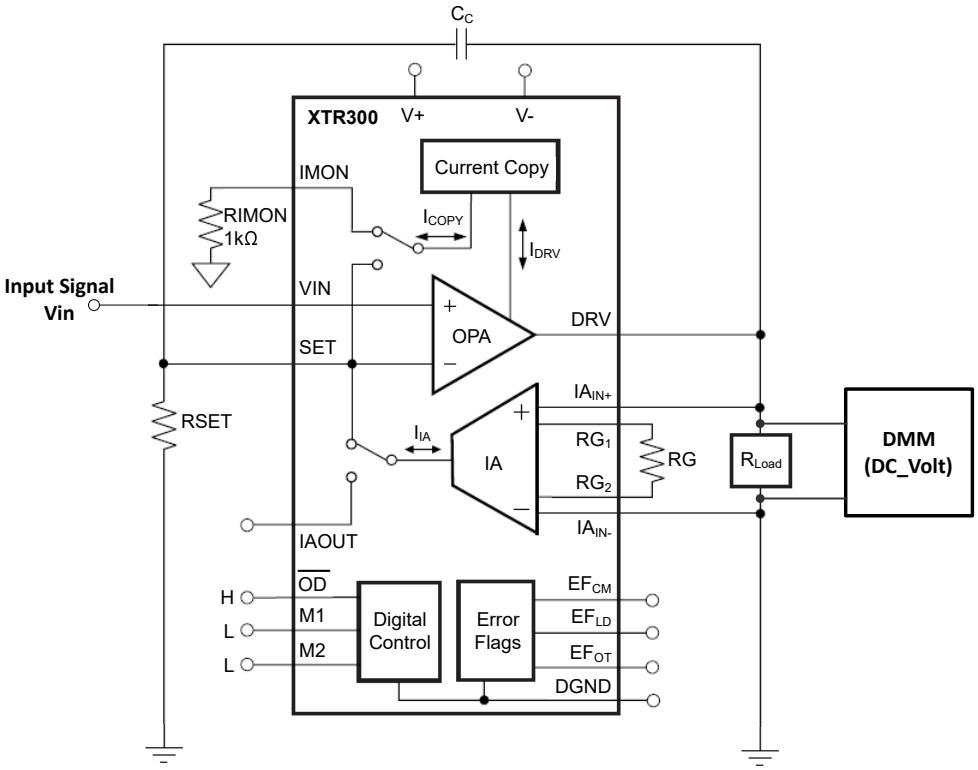


Figure 2-6. XTR300 Single-Ended Voltage Output Configuration Circuit Drawing

Figure 2-7 shows how to setup the XTR300EVM in single-ended voltage output mode. Connect your load to TB4 between OUT+ and OUT–. Apply ±15V to V+ and V–. Apply a 5V signal to VIN. The voltage across TB4 must be 10V with the default board values.

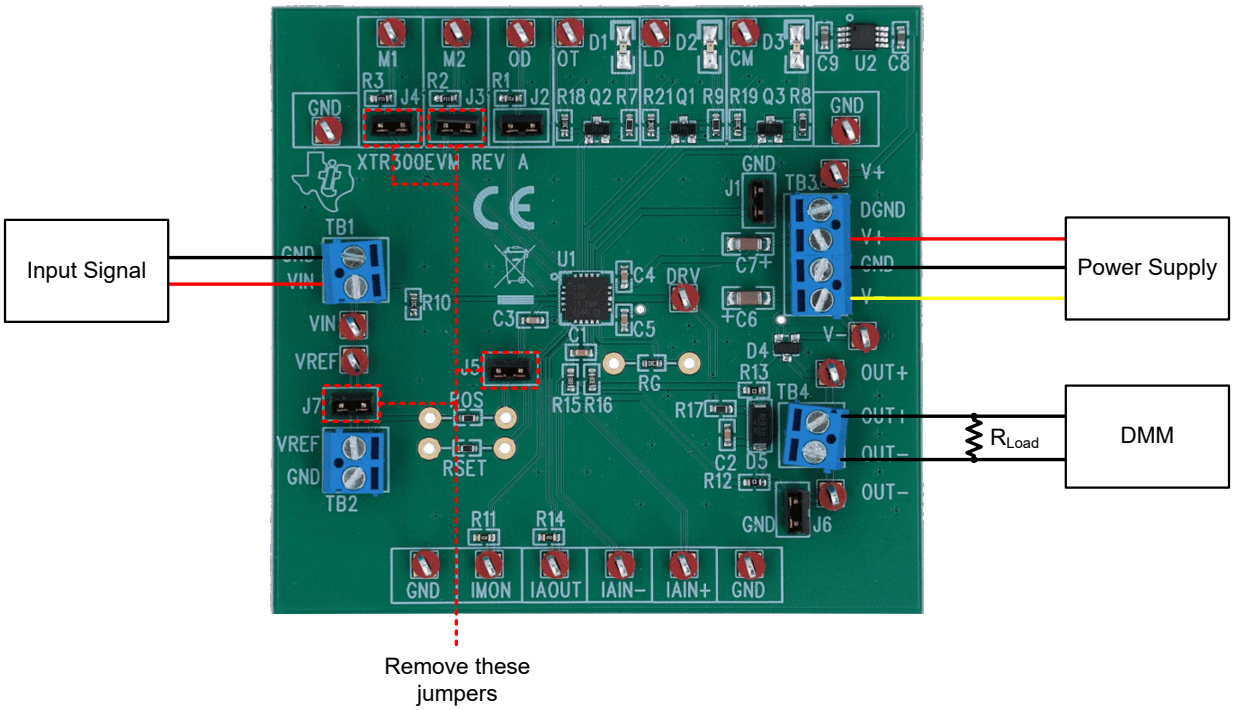


Figure 2-7. XTR300EVM Single-Ended Voltage Output Configuration Setup

2.4.2.2 Bidirectional Voltage Output

The second voltage-mode configuration creates a bidirectional output from a single-ended input. The jumper settings for this configuration are listed in Table 2-6. The voltage output is calculated by the transfer function in Equation 13:

$$V_{OUT} = \frac{RG}{2}\left(\frac{VIN}{RSET} + \frac{VIN - VREF}{ROS}\right) \quad (13)$$

The default EVM configuration sets RG to 10kΩ, RSET to 2.5kΩ, and ROS to 2.5kΩ.

Table 2-6. Bidirectional Voltage Output Jumper Settings

Jumper	Function
J1	On
J2	On
J3	Off
J4	Off
J5	On
J6	On
J7	On(1)

(1) J7 must be off if an external reference is used and on if the internal reference is to be used.

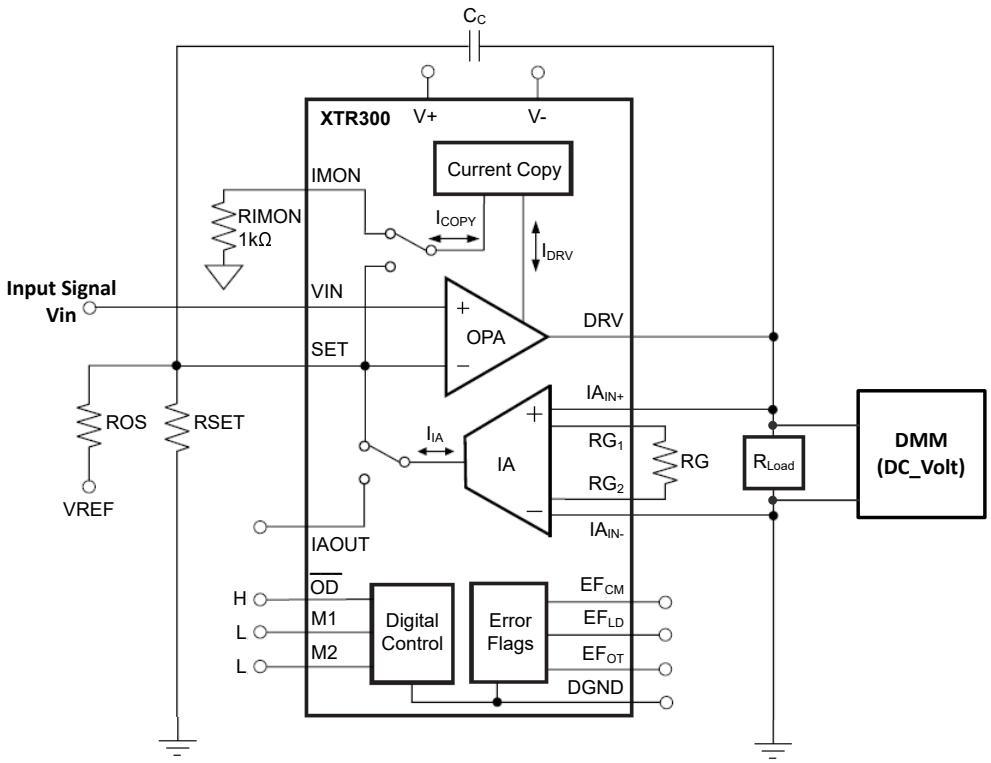


Figure 2-8. XTR300 Bidirectional Voltage Output Configuration Circuit Drawing

Figure 2-9 shows how to setup the XTR300EVM in bidirectional voltage output mode. Connect your load to TB4 between OUT+ and OUT–. Connect ±15V to V+ and V–. Apply a 5V signal to VIN. Connect a 5V reference voltage to VREF. If there is no external reference voltage, a shunt can be placed on J7 to apply an onboard reference voltage of 5V. In this configuration and the board default values, the voltage across TB4 is 10V. If you apply a 0V signal to VIN, the voltage across TB4 is approximately –10V.

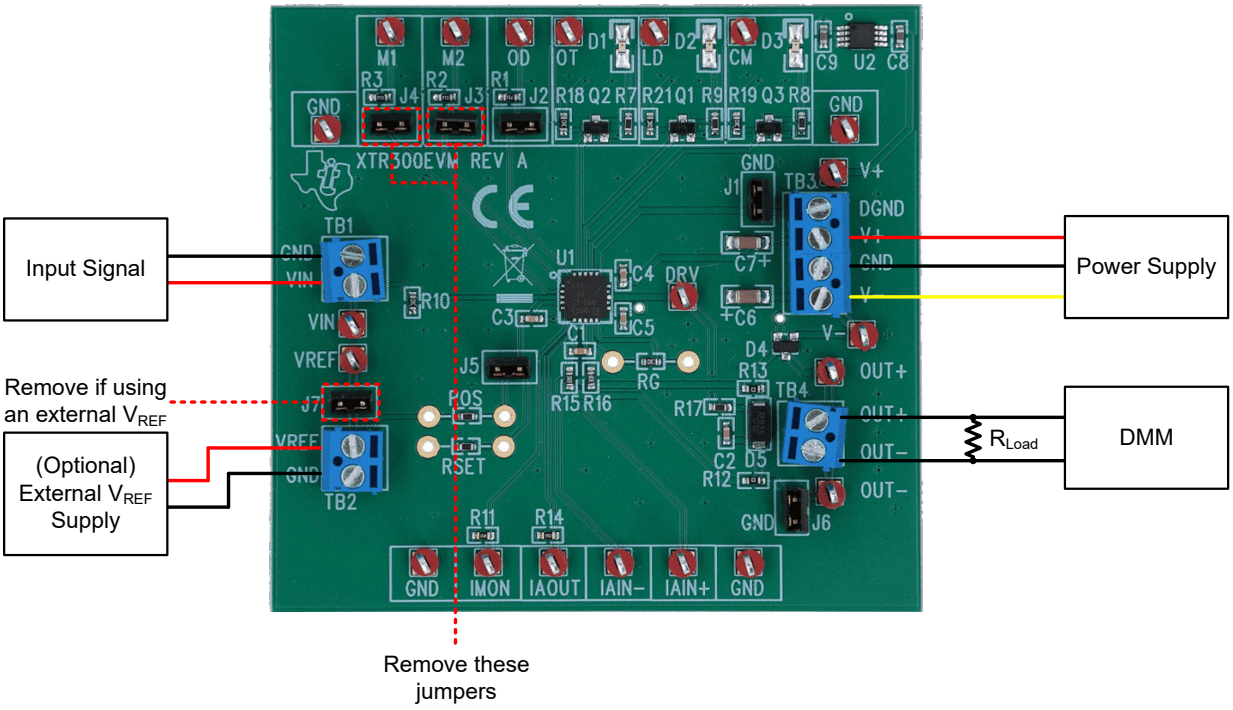


Figure 2-9. XTR300EVM Bidirectional Voltage Output Configuration Screenshot

2.4.2.3 Verifying Acceptable Load in Voltage Mode

Verify that the XTR300 is able to drive the resistive load in a particular application. To calculate this, there are two limits to consider, the output voltage swing and the output current limits.

The output voltage swing limits are directly tied to the supply voltages. As shown in Equation 14, the output can only swing up to 3V from the supply rails.

$$(V-) + 3 \leq V_{OUT_{LIMIT\_RANGE}} \leq (V+) - 3 \tag{14}$$

In voltage mode, the output voltage is set by the user and directly controlled.

The output current swing limits are determined by the minimum short circuit current limit, which can be found in the data sheet as:

$$I_{SC_{Min}} = \pm 15mA \tag{15}$$

In voltage mode, the user needs to verify that for whatever the output voltage range is selected, must not violate the output current limits with the load of the system. Use Ohm's law to find what minimum and maximum output current are needed for the output voltage range as shown in Equation 16 and Equation 17.

$$I_{OUT_{MIN}} = \frac{V_{OUT_{MIN}}}{R_{LOAD}} \tag{16}$$

$$I_{OUT_{MAX}} = \frac{V_{OUT_{MAX}}}{R_{LOAD}} \tag{17}$$

If the output current goes beyond the output current limit of ±15mA then the XTR300 cannot drive the load under these conditions.

For example, in a system where the V+=15V, V-=-15V, R_{LOAD} =200Ω, and require an output voltage from 0V to 10V, to verify that the output does not be saturated, first evaluate what the acceptable output voltage range is by plugging in the supply rails to Equation 7. In this example, the output is able to produce a voltage range of...

$$-12V \leq V_{OUT_{LIMIT\_RANGE}} \leq 12V \tag{18}$$

This confirms that the output voltage is not violated.

Plugging 0V, 10V, and 200Ω to Equation 16 and Equation 17 produce:

$$I_{OUT_{MIN}} = 0mA \tag{19}$$

and

$$I_{OUT_{MAX}} = 50mA \tag{20}$$

The maximum output current needed is higher than what the XTR300 is able to output in this example, resulting in a maximum output voltage to be 3V.

2.5 Power Requirements

Terminal block TB3 contains the positive and negative power-supply connections, V+ and V–, as well as the analog ground (GND) and digital ground (DGND) connections. The valid range for the analog supply voltages is ±10V to ±20V. The supplies are decoupled with a 10µF and 0.1µF ceramic capacitor near the device. The XTR300EVM also contains test points for the positive and negative supply and GND connections located next to TB3.

3 Hardware Design Files

3.1 Schematic

Figure 3-1 shows the schematic of the XTR300EVM board.

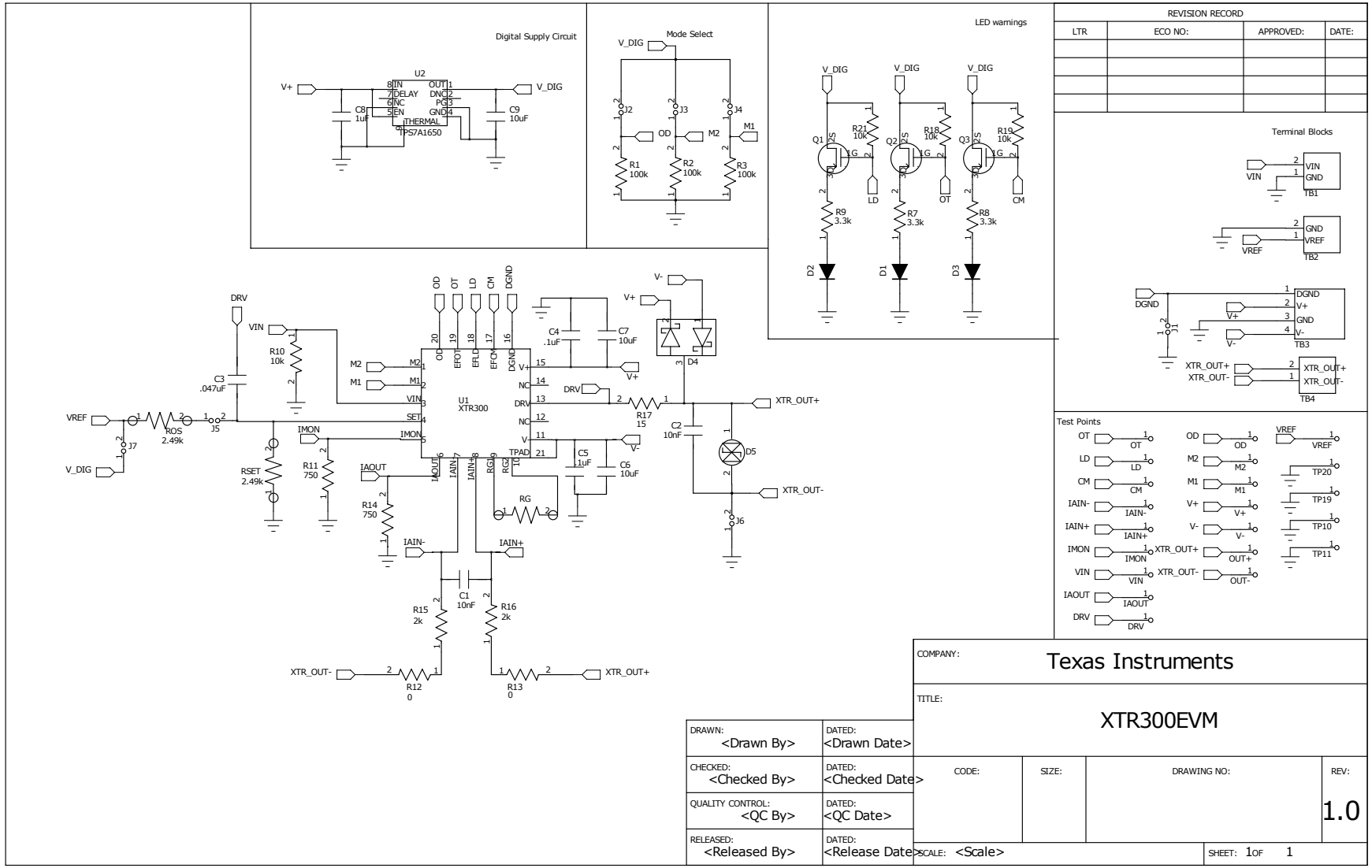


Figure 3-1. XTR300EVM Schematic

3.2 XTR300EVM Top Layer Silkscreen

Figure 3-2 displays the top layer silkscreen and solder for the XTR300EVM.

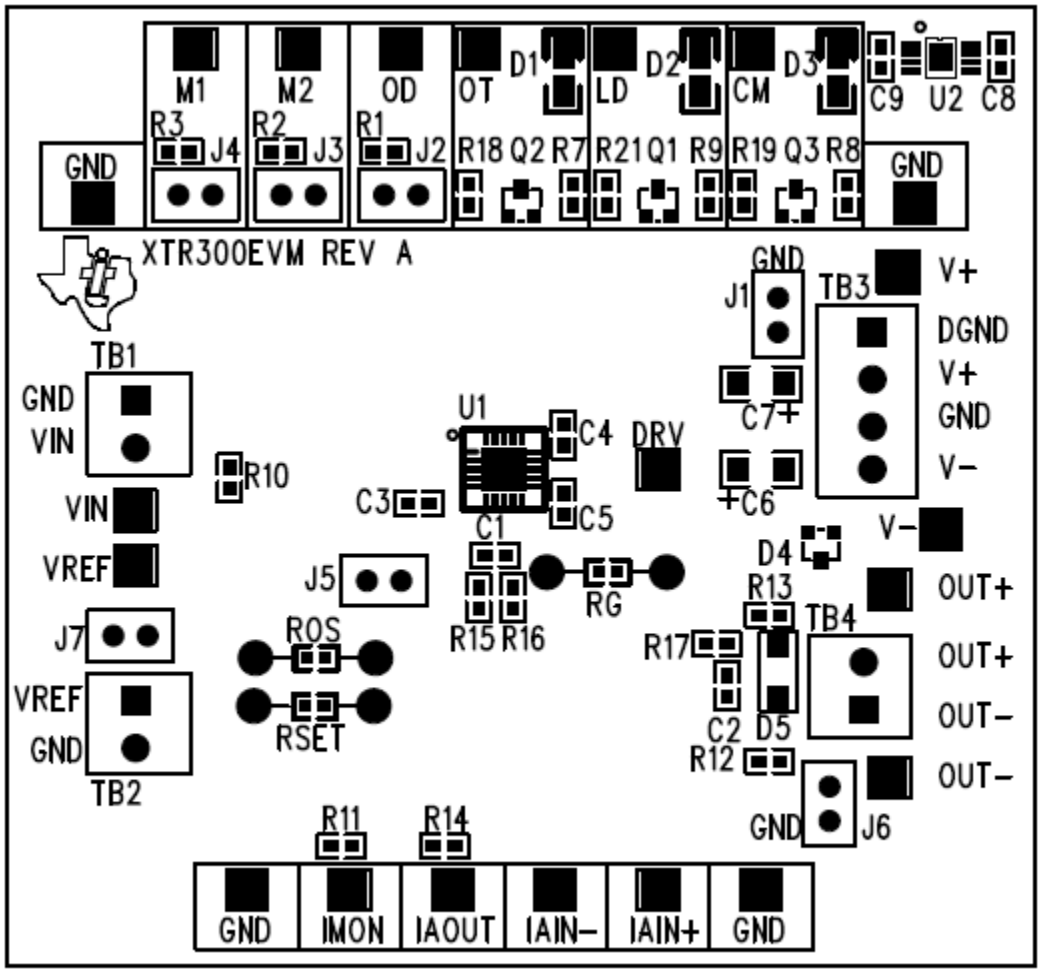


Figure 3-2. XTR300EVM Top Layer Silkscreen

3.3 Bill of Materials

Table 3-1 lists the materials for the XTR300EVM board.

Table 3-1. XTR300EVM Bill of Materials

DESIGNATOR	QTY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
!PCB1	1		Printed Circuit Board		XTR300EVM Rev A	Any
C1,C2	2	10nF	CAP CER 10000PF 50V 10% X7R 0603	0603	GRM188R71H103KA01D	Murata
C3	1	0.047µF	CAP CER 0.047µF 50V 10% X7R 0603	0603	GRM188R71H473KA61D	Murata
C4, C5	2	0.1µF	CAP CER 0.1µF 50V 10% X7R 0603	0603	GRM188R71H104KA93D	Murata
C6, C7	2	10µF	CAP CER 10µF 50V 10% X5R 1206	1206	C3216X5R1H106K160AB	TDK
C8	1	1µF	CAP CER 1µF 50V 10% X5R 0603	0603	C1608X5R1H105K080AB	TDK
C9	1	10µF	CAP CER 10µF 10V 10% X5R 0603	0603	C1608X5R1A106K080AC	TDK
CM, DRV, GND, IAIN-, IAIN+, IAOUT, IMON, LD, M1, M2, OD, OT, OUT-, OUT+, VIN, VREF, V-, V+	21		TEST POINT PC COMPACT .063"D RED	RED COMPACT TESTPOINT	5005	Keystone Electronics
D1, D2, D3	3	Red	LED RED HIGH BRIGHT ESS SMD	SMD	LNJ237W82RA	Panasonic Electronic
D5	1	40V	DIODE TVS 40V 400W BIDIR 5% SMA	SMA	SMAJ400CA	Littelfuse Inc
D4	1	40V	DIODE ARRAY SCHOTTKY 40V SOT23	SOT23	BAS40-04-E3-08	Vishay Semiconductors
J1, J2, J3, J4, J5, J6, J7	1		CONN HEADER 50POS .100" SGL GOLD	CONN HEADER 50POS .100" SGL GOLD	TSW-150-07-G-S	Samtec Inc
Q1, Q2, Q3	3	60V	MOSFET P-CH 60 V 900MA SOT23-3	SOT23-3	ZXMP6A13FTA	Diodes Inc
ROS, RSET	2	2.49k	RES 2.49K OHM 1/10W 1% 0603 SMD	0603	ERJ-3EKF2491V	Panasonic Electronic
R11, R14	2	750	RES 750 OHM 1/10W 1% 0603 SMD	0603	ERJ-3EKF7500V	Panasonic Electronic
R15, R16	2	2k	RES 2.00K OHM 1/10W 1% 0603 SMD	0603	ERJ-3EKF2001V	Panasonic Electronic
R12, R13	2	0	RES 0.0 OHM 1/10W 0603 SMD	0603	ERJ-3GEY0R00V	Panasonic Electronic
R17	1	15	RES 15.0 OHM 1/10W 1% 0603 SMD	0603	ERJ-3EKF15R0V	Panasonic Electronic
R1, R2, R3	3	100k	RES 100K OHM 1/10W 1% 0603 SMD	0603	ERJ-3EKF1003V	Panasonic Electronic
R7, R8, R9	3	3.3k	RES 3.3K OHM 1/10W 1% 0603 SMD	0603	ERJ-3EKF3301V	Panasonic Electronic
R19, R18, R21, RG	4	10k	RES 10.0K OHM 1/10W 1% 0603 SMD	0603	ERJ-3EKF1002V	Panasonic Electronic
TB1, TB2, TB3, TB4	5		TERM BLOCK 2 POS SIDE ENT 3.5MM	TERM BLOCK 2 POS SIDE ENT 3.5MM	1776275-2	TE Connectivity
NA	7		SHUNT LP W/HANDLE 2 POS 30AU	SHUNT LP W/ HANDLE 2 POS 30AU	881545-2	TE Connectivity
U1	1		IC ANLG CURR/VOLT OUT DVR 20VQFN	RGW0020A	XTR300AIRGWT	Texas Instruments
U2	1		IC REG LDO 5V .1A 8MSOP	DGN0008C	TPS7A1650DGNR	Texas Instruments

4 Additional Information

4.1 Trademarks

All trademarks are the property of their respective owners.

5 Related Documentation

For related documentation see the following:

- Texas Instruments, *XTR300 Industrial Analog Current/Voltage Output Driver* data sheet
- Texas Instruments, *XTR305 Industrial Analog Current/Voltage Output Driver* data sheet

6 Revision History

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

Changes from Revision A (February 2013) to Revision B (October 2025)	Page
• Updated all figures throughout the document	0
• *Single Input* renamed to *Input Signal*	4
• Added *Error Flags* section	4
• Added *IMON: Current Monitor Output* section	4
• Added *IAOUT: Voltage Monitor* section	5
• Added Verify Acceptable Load in Current Mode section	8
• Added Verify Acceptable Load in Voltage Mode section	12
• Corrected BOM loaded	15

Changes from Revision * (February 2006) to Revision A (February 2013)	Page
• Changed entire user guide to new version	1

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

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 DEGREDATION 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/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

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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西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。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.

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, INDEMITY 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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