User's Guide
SNVU662–June 2020

TPS548B28EVM-023 20-A, Buck Converter Evaluation Module

This user's guide contains information for the TPS548B28EVM-023 evaluation module (EVM) as well as for the TPS548B28 DC/DC converter. Also included are the performance specifications, the schematic, and the list of materials for the TPS548B28EVM.

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Trademarks

D-CAP3 is a trademark of Texas Instruments.
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1 Introduction

The TPS548B28 is a D-CAP3™ synchronous buck converter designed for 20 A output current, and the evaluation module is designed to demonstrate the small printed-circuit-board areas that may be achieved when designing with the device. The high-side and low-side switching MOSFETs are integrated in the device package along with their gate drive circuitry. Rated input voltage and output current ranges for the evaluation module are given in Table 1.

1.1 Background

The EVM is setup to allow the user to evaluate the performance of the TPS548B28 IC, and easily make changes to multiple settings. The low drain-to-source on resistance of the MOSFETs allows the device to achieve high efficiencies and keep the junction temperature low at high output currents. There is no need for external compensation components since this device is designed with D-CAP3™ control topology. On the EVM the switching frequency and the operation mode are externally selectable using a jumper to set the resistor from the MODE pin to AGND. An external resistor divider allows for an adjustable output voltage. Additionally, the device provides adjustable soft start, adjustable OC limit threshold, external reference input, and an open-drain power good indicator. Lastly the TPS548B28 device has a fixed internal VIN under voltage lockout and externally adjustable UVLO using a resistor divider at the EN pin.

Table 1. Input Voltage and Output Current Summary

EVM	INPUT VOLTAGE RANGE	OUTPUT CURRENT RANGE
TPS548B28	V_{IN} = 8 V to 14 V	0 A to 20 A

Figure 1. Safety Warnings

1.2 Performance Specification Summary

A summary of the TPS548B28EVM performance specifications is provided in Table 2. Specifications are given for an input voltage of V_{IN} = 12 V and an output voltage of 1.0 V, unless otherwise specified. The TPS548B28EVM is designed and tested for V_{IN} = 8 V to 14 V. The ambient temperature is 25°C for all measurements, unless otherwise noted. The design can be modified to perform over 4 V to 16 V.

Table 2. TPS548B28EVM Performance Specification Summary

SPECIFICATION	TEST CONDITIONS	MIN	TYP	MAX	Unit
V_{IN} voltage range (without internal Bias)		8	12	14	V
Output voltage setpoint			1.0		V
Output current range	V_{IN} = 8 V to 14 V	0	20	20	A
Internal LDO Voltage			3.0		V
Operating frequency			800		kHz

1.3 Modifications

These evaluation modules are designed to provide access to the features of the TPS548B28. Some modifications can be made to this module.

1.3.1 Output Voltage Setpoint

To change the output voltage of the EVM, it is necessary to change the value of resistor R6 and R7. R9 is fixed at 10 kΩ. Changing the total value of R6 plus R7 can change the output voltage above the 0.6V reference voltage V_{INTREF}. A two resistor configuration of R6+R7 is implemented to give the exact desired output voltage setting. The value of R6 and R7 for a specific output voltage can be calculated using Equation 1.

$$R_{FB\_HS} = \frac{V_O - V_{INTREF}}{V_{INTREF}} \times R_{FB\_LS} \quad (1)$$

V_{INTREF}= 0.6V

$R_{FB\_HS} = R_6 + R_7$

$R_{FB\_LS} = R_9 = 10k\Omega$

1.3.2 Frequency and Operation Mode Setting

To change the frequency and operation mode of the part, the MODE pin is used. J6 and the surrounding circuitry allows for an easy change to the frequency and operation mode setting. All 6 options offered by J6 are shown in Table 3

Table 3. TPS548B28EVM Mode Pin Selection

Switching Frequency (F_{SW})	Operation Mode Under Light Load	Mode Pin Connections	
		Connection	Jumper Setting
600 kHz	Skip Mode	Short to VCC	Short Pins 1 and 2
800 kHz	Skip Mode	243kΩ ±10% to AGND	Short Pins 3 and 4
1000 kHz	Skip Mode	121kΩ ±10% to AGND	Short Pins 5 and 6
1000 kHz	Forced CCM	60.4kΩ ±10% to AGND	Short Pins 7 and 8
800 kHz	Forced CCM	30.1kΩ ±10% to AGND	Short Pins 9 and 10
600 kHz	Forced CCM	Short to AGND	Short Pins 11 and 12

1.3.3 Enable Pin Selection

The converter can be enabled and disabled by J5.

Default setting: EN pin connected to VIN.

Table 4. Enable Pin Selection

Set On Connection	Enable Selection
Pins 2-3 Shorted	EN pin connected to VIN pins through resistor divider
J3 Open	EN pin is left floating
Pins 1-2 Shorted	EN pin connected to PGND

1.3.4 Remote Sensing

The EVM is not set-up for remote sensing by default. To set up remote sensing follow these steps:

1. Replace R8 and R11 with 100Ω resistors
2. Connect your sense points to the Vsns+ and Vsns- test points

1.3.5 Adjustable UVLO

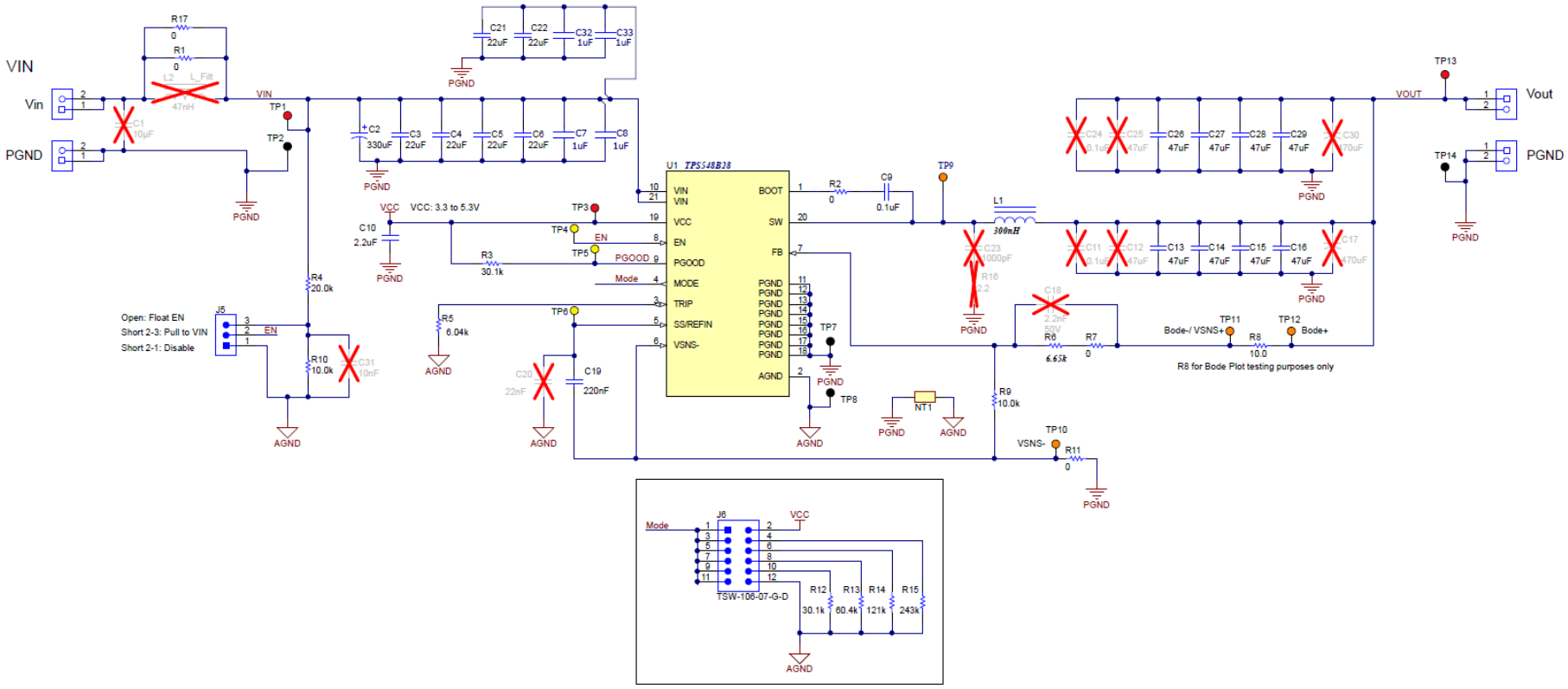
The undervoltage lockout (UVLO) can be adjusted externally using R2 and R9. See the TPS548B28 Data Sheet to get detailed instructions for setting the external UVLO.

2 Schematic, List of Materials, and Layout

This section provides a schematic, a description of the TPS548B28EVM board layout, and layer illustrations.

2.1 Schematic

The following image illustrates the schematic for the TPS548B28EVM.



2.2 List of Materials

Table 5 presents the list of materials for the TPS548B28EVM.

Table 5. TPS548B28EVM List of Materials

DES	QTY	DESCRIPTION	PART NUMBER	MANUFACTURER
C2	1	CAP, AL, 330 uF, 25 V, ±20%, 0.15 ohm, SMD, 330uF	EEE-FC1E331P	Panasonic
C3, C4, C5, C6, C21, C22	6	CAP, CERM, 22 uF, 25 V, ±20%, X6S, 1206_190	GRM31CC81E226ME11L	MuRata
C7, C8, C32, C33	4	CAP CER 1UF 25V X6S 0402	GRM155C81E105KE11D	Murata
C9	1	CAP, CERM, 0.1 uF, 50 V, ±10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E2X7R1H104K080AA	TDK
C10	1	CAP, CERM, 2.2 uF, 10 V, ±10%, X7R, 0603	GRM188R71A225KE15D	MuRata
C13, C14, C15, C16, C26, C27, C28, C29	8	CAP, CERM, 47 uF, 6.3 V, ±10%, X6S, 1206	GRM31CC80J476KE18L	MuRata
C19	1	CAP, CERM, 0.22 uF, 16 V, ±10%, X7R, 0603	C1608X7R1C224K080AC	TDK
L1	1	Inductor, Shielded, Composite, 300 nH, 33.4 A, 0.00106 ohm, SMD	XAL7070-301MEB	Coilcraft
R1, R17	2	RES, 0, 1%, 0.5 W, 1206	5108	Keystone
R2, R7, R11	3	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	RMCF0603ZT0R00	Stackpole Electronics Inc
R3, R12	2	RES, 30.1 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060330K1FKEA	Vishay-Dale
R4	1	RES, 20.0 k, 0.1%, 0.1 W, 0603	RT0603BRD0720KL	Yageo America
R5	1	RES, 6.04 k, 1%, 0.1 W, 0603	CRCW06036K04FKEA	Vishay-Dale
R6	1	RES, 6.65 k, 1%, 0.1 W, 0603	'RC0603FR-076K65L	Yageo
R8	1	RES, 10.0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060310R0FKEA	Vishay-Dale
R9, R10	2	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060310K0FKEA	Vishay-Dale
R13	1	RES, 60.4 k, 1%, 0.1 W, 0603	RC0603FR-0760K4L	Yageo
R14	1	RES, 121 k, 1%, 0.1 W, 0603	RC0603FR-07121KL	Yageo
R15	1	RES, 243 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603243KFKEA	Vishay-Dale
U1	1	4-V to 16-V Input, 20-A Single Synchronous Step-Down Converter, RWW0021A (VQFN-HR-21)	TPS548B28RWWT	Texas Instruments

2.3 Layout

The board layout for the TPS548B28EVM is shown in Figure 2 through Figure 5. The top-side layer of the EVM is laid out in a manner typical of a user application. The top, bottom, and internal layers are 2-oz. copper.

The top layer contains the main power traces for V_{IN}, V_{OUT}, and SW. Also on the top layer are connections for the remaining pins of the TPS548B28 and the majority of the signal traces. The top layer has a dedicated ground plane for quiet analog ground that is connected to the main power ground plane at a single point. The internal layer-1 is a large ground plane. The internal layer-2 contains an additional large ground copper area as well as an additional V_{OUT} copper fill. The bottom layer is another ground plane with two additional traces for the output voltage feedback and various signals routed to test points and headers. There are also additional V_{IN} and V_{OUT} planes on the bottom layer. The top-side ground traces are connected to the bottom and internal ground planes with multiple via groupings placed around the board.

The input decoupling capacitors and bootstrap capacitor are all located as close to the IC as possible. Additionally, the voltage set point resistor divider components are kept close to the IC. The voltage divider network ties to the output voltage at the point of regulation, the copper V_{OUT} trace at the TP4 test point. An additional input bulk capacitor is used to limit the noise entering the converter from the input supply. Critical analog circuits that are noise sensitive are terminated to the quiet analog ground island on the top layer.

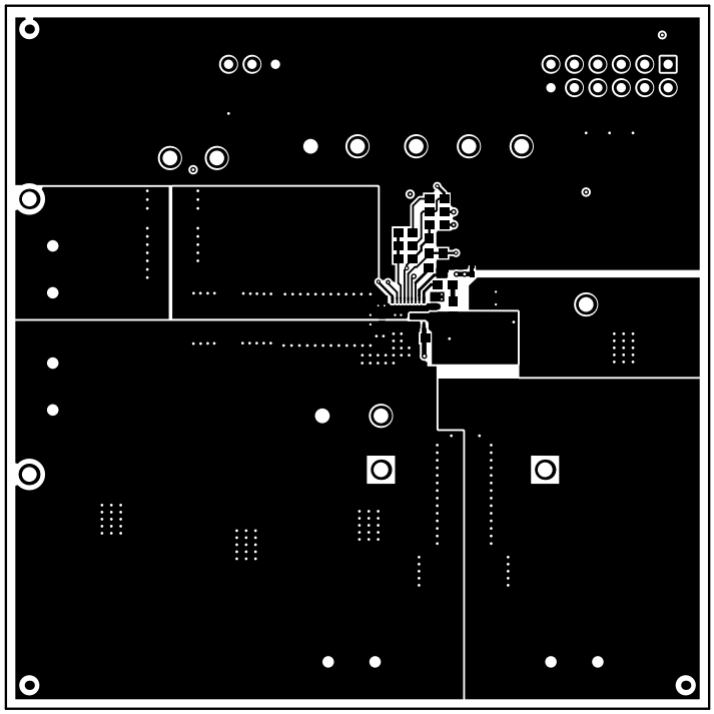


Figure 2. TPS548B28EVM Top-Side Layout

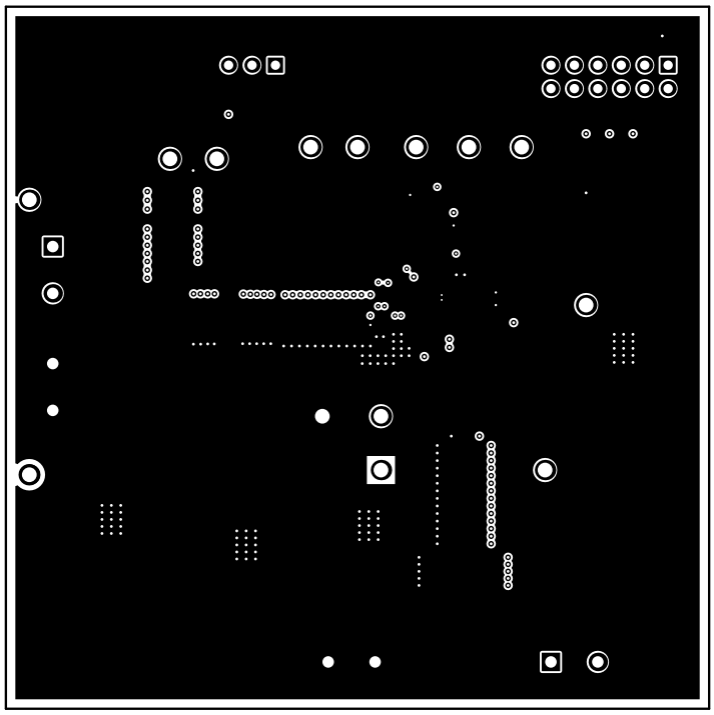


Figure 3. TPS548B28EVM Internal Layer-1 Layout

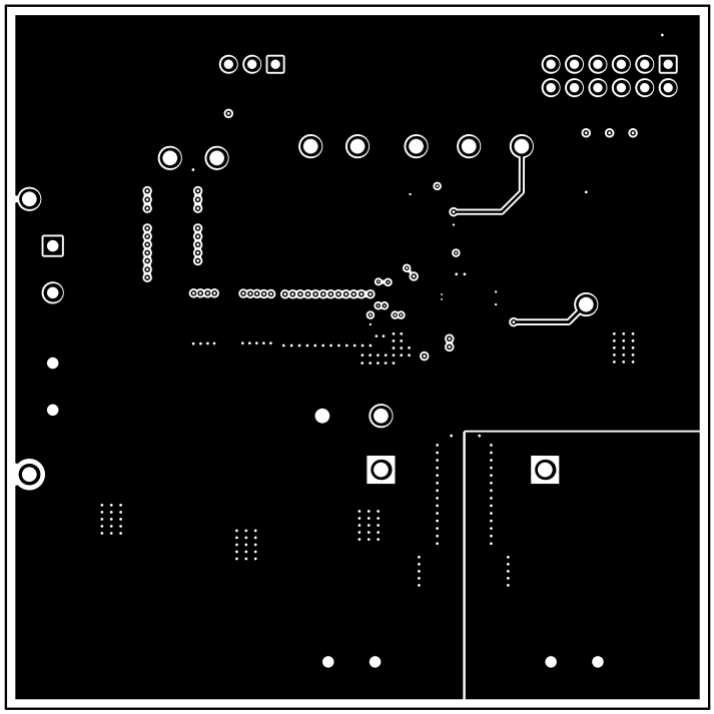


Figure 4. TPS548B28EVM Internal Layer-2 Layout

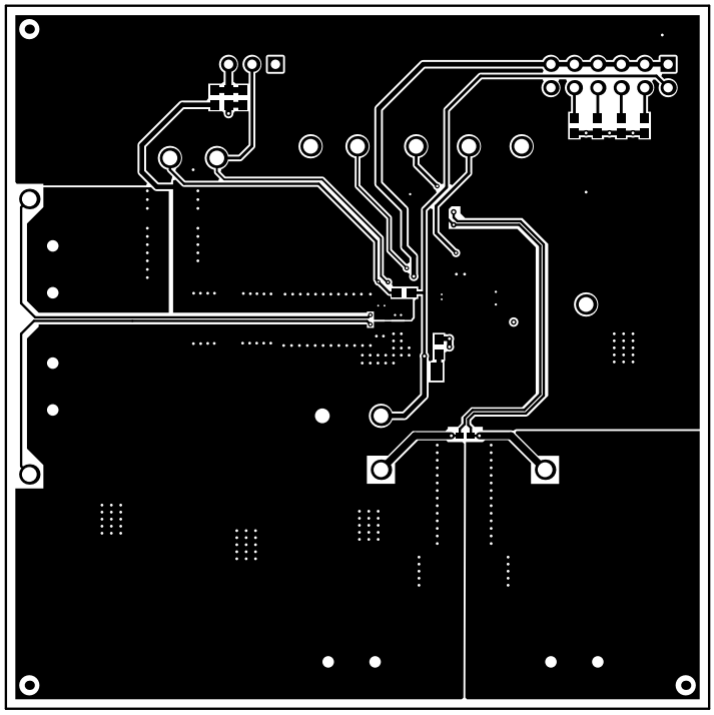


Figure 5. TPS548B28EVM Bottom-Side Layout

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CAUTION

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

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

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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.

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

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

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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

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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.

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