

# TPS563249 Step-Down Converter Evaluation Module User's Guide



## ABSTRACT

This user's guide contains information for the TPS563249 as well as support documentation for the TPS563249EVM-031 evaluation module. Included are the performance specifications, schematic, and the bill of materials (BOM) of the TPS563249EVM-031.

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## Trademarks

D-CAP3™ is a trademark of Texas Instruments.

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## 1 Introduction

The TPS563249 is a single, adaptive on-time, D-CAP3™ mode, synchronous buck converter requiring a very low external component count. The D-CAP3 control circuit is optimized for low-ESR output capacitors such as POSCAP, SP-CAP, or ceramic types and features fast transient response with no external compensation. The switching frequency is internally set at a nominal 1.4 MHz. The high-side and low-side switching MOSFETs are incorporated inside the TPS563249 package along with the gate-drive circuitry. The low drain-to-source on resistance of the MOSFETs allows the TPS563249 to achieve high efficiencies and helps keep the junction temperature low at high output currents. The TPS563249 dc/dc synchronous converter is designed to provide up to a 3-A output from an input voltage source of 4.5 V to 17 V. Rated input voltage and output current ranges for the evaluation module are given in [Table 1-1](#).

The TPS563249EVM-031 evaluation module (EVM) is a single, synchronous buck converter providing 3.3 V at 3 A from 4.5-V to 17-V input. This user's guide describes the TPS563249EVM-031 performance.

**Table 1-1. Input Voltage and Output Current Summary**

EVM	Input Voltage ( $V_{IN}$ ) Range	Output Current ( $I_{OUT}$ ) Range
TPS563249EVM-031	4.5 V to 17 V	0 A to 3 A

## 2 Performance Specification Summary

A summary of the TPS563249EVM-031 performance specifications is provided in [Table 2-1](#). Specifications are given for an input voltage of 12 V and an output voltage of 3.3 V, unless otherwise noted. The ambient temperature is 25°C for all measurement, unless otherwise noted.

**Table 2-1. TPS563249EVM-031 Performance Specifications Summary**

Specifications		Test Conditions	MIN	TYP	MAX	Unit
$V_{IN}$	Input voltage		4.5	12	17	V
	Output voltage			3.3		V
CH1	Operating frequency	$V_{IN} = 12\text{ V}, I_{OUT} = 3\text{ A}$		1.4		MHz
	Output current range		0		3	A

### 3 Modifications

These evaluation modules are designed to provide access to the features of the TPS563249. Some modifications can be made to this module.

To change the output voltage of the EVMs, it is necessary to change the value of resistor R1. Changing the value of R1 can change the output voltage above 0.60 V. The value of R1 for a specific output voltage can be calculated using [Equation 1](#).

$$V_{\text{OUT}} = 0.6 \times \left(1 + \frac{R1}{R2}\right) \quad (1)$$

[Table 3-1](#) lists the R1 values for some common output voltages. Note that the values given in [Table 3-1](#) are standard values and not the exact value calculated using [Table 3-1](#).

**Table 3-1. Recommended Component Values**

Output Voltage (V)	R1 (kΩ)	R2 (kΩ)	L1 (μH)			C5 + C6 (μF)
			MIN	TYP	MAX	
1	6.65	10.0	0.33	0.56	1	10 to 44
1.05	7.5	10.0	0.33	0.56	1	10 to 44
1.2	10	10.0	0.33	0.68	1.5	10 to 44
1.5	15	10.0	0.47	0.82	1.5	10 to 44
1.8	20	10.0	0.56	1	2.2	10 to 44
2.5	31.6	10.0	0.68	1	2.2	10 to 44
3.3	45.3	10.0	0.82	1.5	3.3	10 to 44
5	73.2	10.0	1	1.5	3.3	10 to 44
6.5	97.6	10.0	1	2.2	3.3	10 to 44

## 4 Test Setup

This section describes how to properly connect, set up, and use the TPS563249EVM-031.

### 4.1 Input/Output Connections

The TPS563249EVM-031 is provided with input/output connectors and test points as shown in [Table 4-1](#). A power supply capable of supplying 3 A must be connected to J1 through a pair of 20-AWG wires. The load must be connected to J2 through a pair of 20-AWG wires. The maximum load current capability is 3 A. Wire lengths must be minimized to reduce losses in the wires. Test point TP1 provides a place to monitor the  $V_{IN}$  input voltages with TP2 providing a convenient ground reference. TP6 is used to monitor the output voltage with TP7 as the ground reference.

**Table 4-1. Connection and Test Points**

Reference Designator	Function
J1	$V_{IN}$ (see <a href="#">Table 1-1</a> for $V_{IN}$ range)
J2	$V_{OUT}$ , 3.3 V at 3-A maximum
JP1	EN control. Shunt EN to GND to disable, shunt EN to $V_{IN}$ to enable.
TP1	$V_{IN}$ positive monitor point
TP2	GND monitor test point
TP3	EN test point
TP4	Switch node test point
TP5	Test point for loop response measurements
TP6	$V_{OUT}$ positive monitor point
TP7	GND monitor test point
TP8	GND monitor test point

### 4.2 Start-Up Procedure

Use the following steps during start-up:

1. Ensure that the jumper at JP1 (Enable control) pins 1 and 2 are covered to shunt EN to GND, disabling the output.
2. Apply appropriate input voltage to  $V_{IN}$  (J1-1) and GND (J1-2).
3. Move the jumper at JP1 (Enable control) from pins 1 and 2 (EN and GND), to pins 2 and 3 (EN and  $V_{IN}$ ) enabling the output.

## 5 Board Layout

This section provides a description of the TPS563249EVM-031, board layout, and layer illustrations.

The board layout for the TPS563249EVM-031 is shown in Figure 5-1, and Figure 5-2. The top layer contains the main power traces for  $V_{IN}$ ,  $V_{OUT}$ , and ground. Also on the top layer are connections for the pins of the TPS563249 and a large area filled with ground. Most of the signal traces are also located on the top side. The input decoupling capacitors, C1, C2, and C3 are located as close to the IC as possible. The input and output connectors, test points, and all of the components are located on the top side. The bottom layer is a ground plane along with the switching node copper fill, signal ground copper fill and the feed back trace from the point of regulation to the top of the resistor divider network.

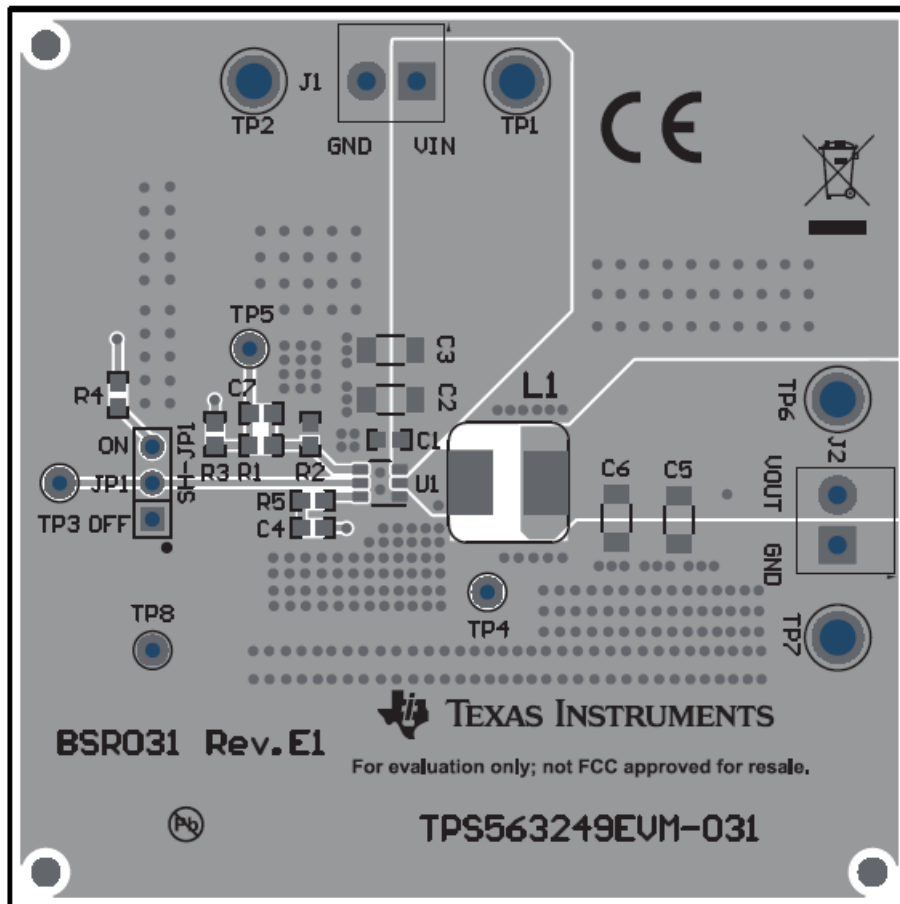
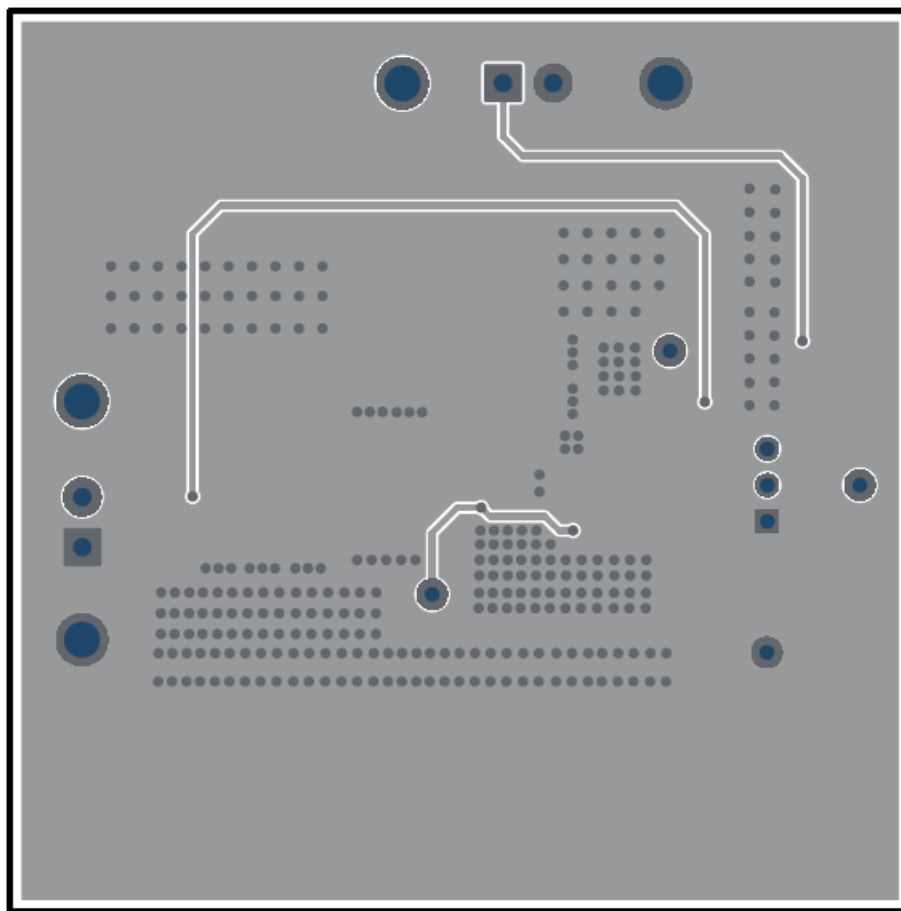


Figure 5-1. Top Layer

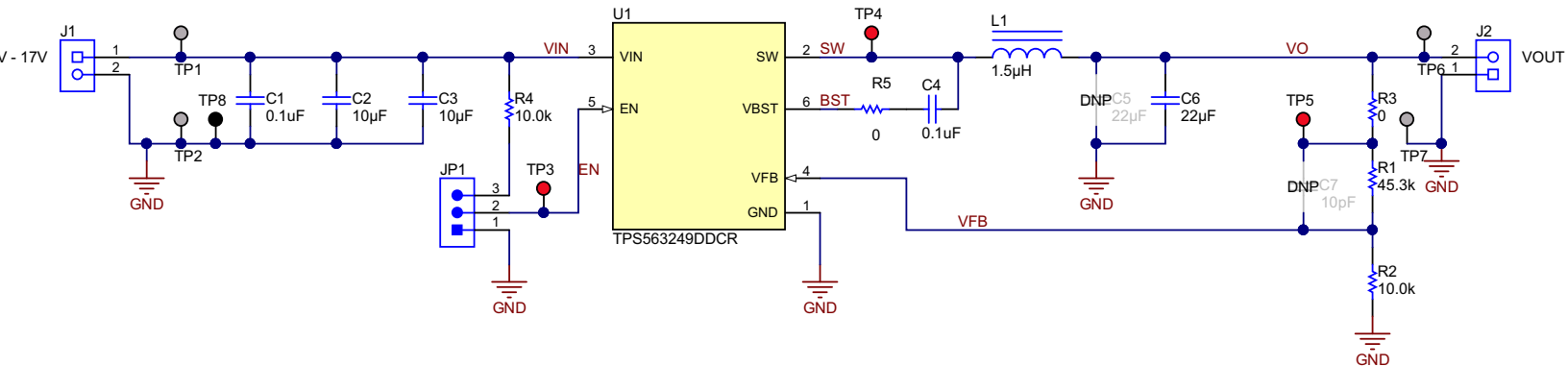


**Figure 5-2. Bottom Layer**

## 6 Schematic, Bill of Materials, and Reference

### 6.1 Schematic

Figure 6-1 is the schematic for the TPS563249EVM-031.



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Figure 6-1. TPS563249EVM-031 Schematic Diagram



## 6.2 Bill of Materials

Table 6-1 displays the TPS563249EVM-031 BOM.

**Table 6-1. Bill of Materials<sup>(1)</sup>**

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
!PCB1	1		Printed Circuit Board		BSR031	Any	-	-
C1, C4	2	0.1uF	CAP, CERM, 0.1uF, 25V, ±10%, X5R, 0603	0603	GRM188R61E104KA01D	Murata		
C2, C3	2	10uF	CAP, CERM, 10 µF, 25 V,± 10%, X5R, 1206	1206	GRM31CR61E106KA12L	Murata		
C6	1	22uF	CAP, CERM, 22 µF, 10 V,± 10%, X7R, 1206	1206	GRM31CR71A226KE15L	Murata		
J1, J2	2		Terminal Block, 3.5mm Pitch, 2x1, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology		
JP1	1		Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100mil, Tin	PEC03SAAN	Sullins Connector Solutions		
L1	1	1.5uH	Inductor, Shielded Drum Core, Superflux, 1.5 µH, 11 A, 0.0078 ohm, SMD	WE-HC4	744311150	Würth Elektronik		
R1	1	45.3k	RES, 45.3 k ohm, 1%, 0.1W, 0603	0603	CRCW060345K3FKEA	Vishay-Dale		
R2, R4	2	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale		
R3, R5	2	0	RES, 0 ohm, 5%, 0.1W, 0603	0603	ERJ-3GEY0R00V	Panasonic		
SH-JP1	1	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec
TP1, TP2, TP6, TP7	4		Terminal, Turret, TH, Double	Keystone1502-2	1502-2	Keystone		
TP3, TP4, TP5	3		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone		
TP8	1		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone		
U1	1		17 V, 3 A, 1.4 MHz Synchronous Step-Down Voltage Regulator, DDC0006A (SOT-23-T-6)		TPS563249DDCR	Texas Instruments	TPS563249DDCT	Texas Instruments
C5	0	22uF	CAP, CERM, 22 µF, 10 V,± 10%, X7R, 1206	1206	GRM31CR71A226KE15L	Murata		
C7	0	10pF	CAP, CERM, 10 pF, 100 V, ± 5%, C0G/NP0, 0603	0603	GRM1885C2A100JA01D	Murata		
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A		

(1) Unless otherwise noted in the *Alternate Part Number* or *Alternate Manufacturer* columns, all parts may be substituted with equivalents.

## 7 Revision History

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

<b>Changes from Revision * (January 2018) to Revision A (July 2021)</b>	<b>Page</b>
• Updated the numbering format for tables, figures, and cross-references throughout the document. ....	<a href="#">2</a>
• Updated user's guide title.....	<a href="#">2</a>

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**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

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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.

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[http://www.tij.co.jp/lstds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page)

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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.

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- 
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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, 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.

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