User's Guide

LM5156HEVM-FLY Evaluation Module

ABSTRACT

The LM5156HEVM-FLY evaluation module showcases the features and performance of the LM51561-HTSSOP as wide input non-synchronous flyback controller. The standard configuration is designed to provide a regulate output of 5 V at 4 A from an input of 18 V to 36 V, switching at 250 kHz. This evaluation module is designed for ease of configuration, enabling the user to evaluate many different applications on the same module. The PCB is two layers with components populated only on one side. Functionality includes programmable slope compensation, adjustable soft-start, programmable cycle-by-cycle current limit, hiccup mode short-circuit protection, and programmable line undervoltage lockout

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Trademarks

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1 Introduction

1.1 Features

The LM5156HEVM-FLY supports the following features and performance capabilities:

- Tightly regulated output voltage of 5 V
- High conversion efficiency of > 86% at full load.
- Hiccup mode short-circuit protection
- User adjustable secondary side soft-start time
- 10-V auxiliary winding to power VCC pin
- 250-kHz switching frequency
- 2-layer PCB with components populated on 1 side

1.2 Applications Schematic

The LM5156HEVM-FLY is capable of multiple configurations. Figure 1-1 shows the standard configuration of the LM5156HEVM-FLY for which the parameters in Table 1-1 are valid.

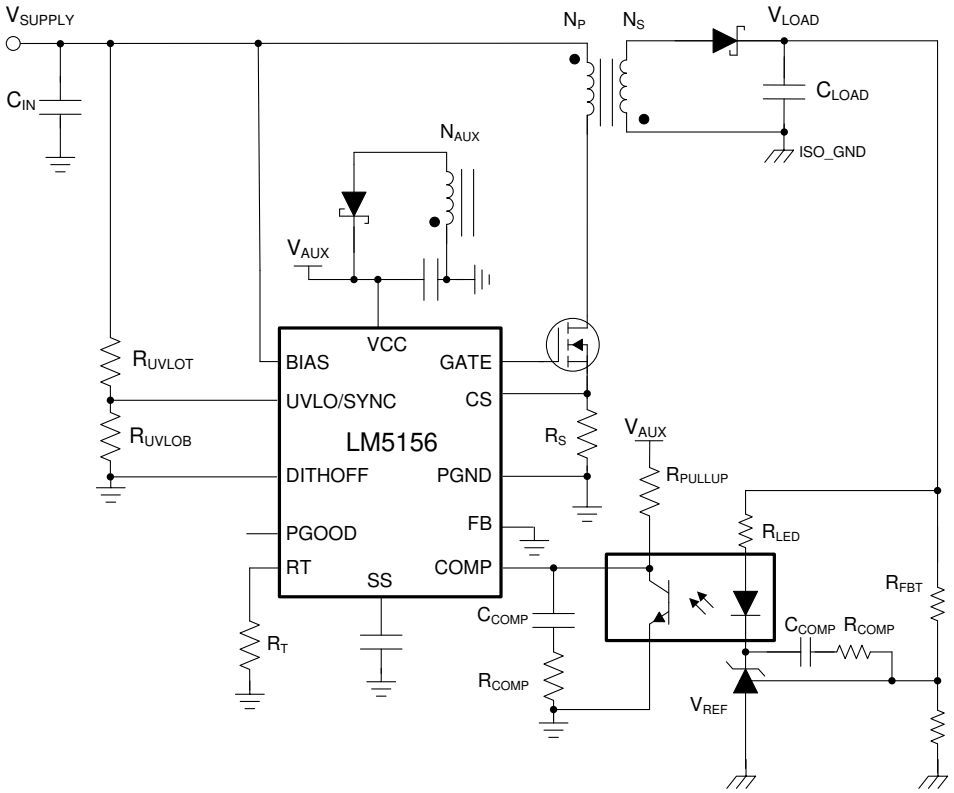

Figure 1-1. Application Circuit

1.3 Electrical Parameters

Table 1-1. Electrical Performance Standard Configuration

Parameter	Test Conditions	MIN	TYP	MAX	UNIT
INPUT CHARACTERISTICS					
Input voltage Range V_{IN}	Operation	18	24	36	V
Input voltage turn on $V_{IN(ON)}$	Adjusted by the UVLO/SYNC resistors		17		V
Input voltage turn off $V_{IN(OFF)}$			16.5		V
OUTPUT CHARACTERISTICS					
Output Voltage V_{OUT}			5		V
Maximum Output Current I_{OUT}			4		A
SYSTEM CHARACTERISTICS					
Switching frequency			250		kHz
Peak efficiency	V_{IN} =18V, I_{OUT} = 1.8A		86.5		%
Junction Temperature, T_J		–40		150	C
Transformer Specifications (Wurth 750319733)					
Primary Inductance			21		µH
Turns Ratio	(3-5):(2-1)		1:1		
	(3-5):(6:10) tie (6+7,9+10)		2:1		
Saturation Current	20% inductance reduction		6.2		A
Leakage Inductance			150	300	nH

2 EVM Setup

Figure 2-1 shows the correct equipment connections and measurement points to recreate the recorded values in the *Test Results* section.

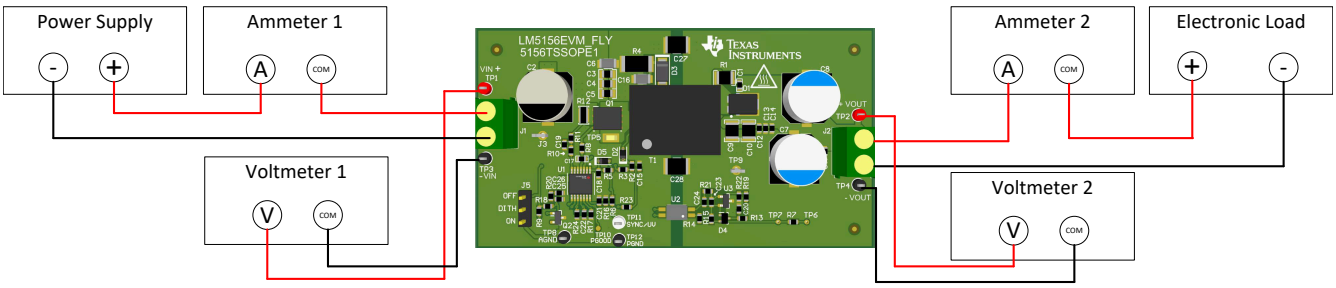

Figure 2-1. Test Setup

2.1 EVM Connectors and Test Points

Table 2-1 indicates the avaliable test points and configuration jumpers.

Table 2-1. Test Point Description

Jumper	Name	Description
TP1	VIN	Positive input voltage sense connection
TP2	VOUT+	Positive output voltage sense connection
TP3	PGND	Negative input voltage sense connection
TP4	ISO_GND	Negative isolated output voltage sense connection
TP5	SW	Probe point for the switch node of the LM5155 flyback circuit
TP6	VOUT+	Loop response positive injection point
TP7	VOUT-	Loop response negative injection point
TP8	AGND	Analog ground connection point
TP9	ISO_GND	Isolated ground connection point
J1	-	Input power connections
J2	-	Output power connections
J3	PGND	Power ground connection point
J4	PGOOD (pin 1)	Probe voltage on the PGOOD pin of the LM5155
	COMP (pin 2)	Probe voltage on the COMP pin of the LM5155
	SS (pin 3)	Probe voltage on the SS pin of the LM5155
	VAUX (pin 4)	Auxiliary winding voltage
	PGND (pin 5)	Power ground connection
J5	DITHOFF	Placing jumper between pin 1 and pin 2 disables frequncy dithering. Placing a jumper between pin 2 and pin 3 enabled frequency dithering

3 Testing Procedures

3.1 Testing Equipment

Power Supply: The input voltage source (VIN) should be a variable supply capable of 0 V to 36 V and source at least 5 A.

Multimeters:

- **Voltmeter 1:** Input voltage, connect from VIN to PGND
- **Voltmeter 2:** Output voltage, connect from VOUT to ISO_GND
- **Ammeter 1:** Input current, must be able to handle 5 A. Shunt resistor can be used as needed.
- **Ammeter 2:** Output current, must be able to handle 5 A. Shunt resistor can be used as needed.

Electronic Load: The load should be constant resistance (CR) or constant current (CC) capable. It should safely handle 4 A at 5 V.

Oscilloscope: 20-MHz bandwidth and AC coupling. Measure the output voltage ripple directly across an output capacitor with a short ground lead. It is not recommended to use a long-leaded ground connection due to the possibility of noise being coupled into the signal. To measure other waveforms, adjust the oscilloscope as needed.

3.2 Precautions

CAUTION

Prolonged operation with low input at full power will cause heating of the diode (D1).

Board surface is hot. Do not touch. Contact may cause burns.

4 Test Results

Section 4.1 through Section 4.8 present the typical performance of the LM5156HEVM-FLY according to the bill of materials and the configuration described in Section 7. Based on measurement techniques and environmental variables measurements, might differ slightly than the data presented

4.1 Efficiency Curve

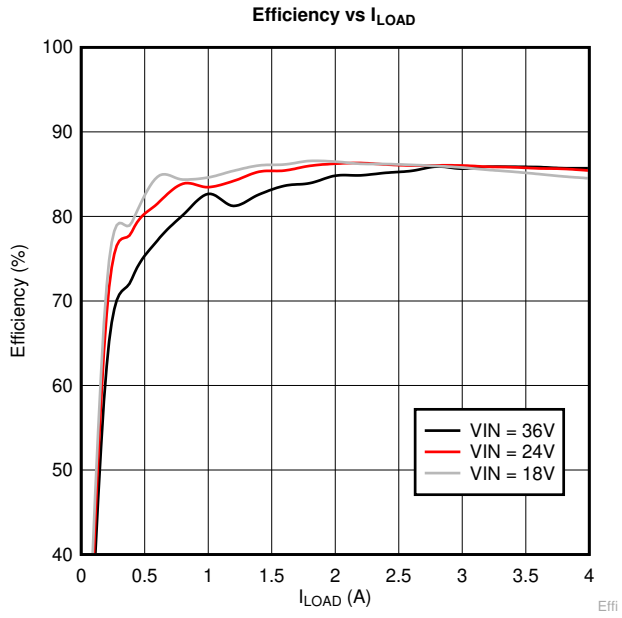

Figure 4-1. Efficiency vs I_{LOAD}

4.2 Load Regulation

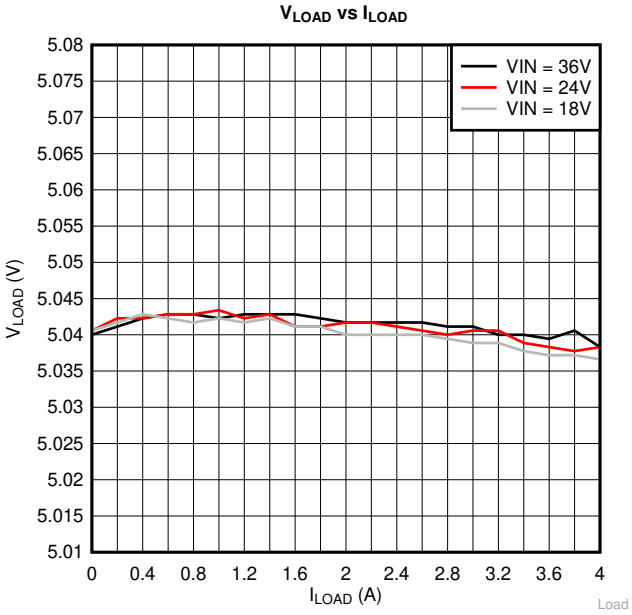

Figure 4-2. Load Regulation

4.3 Thermal Performance

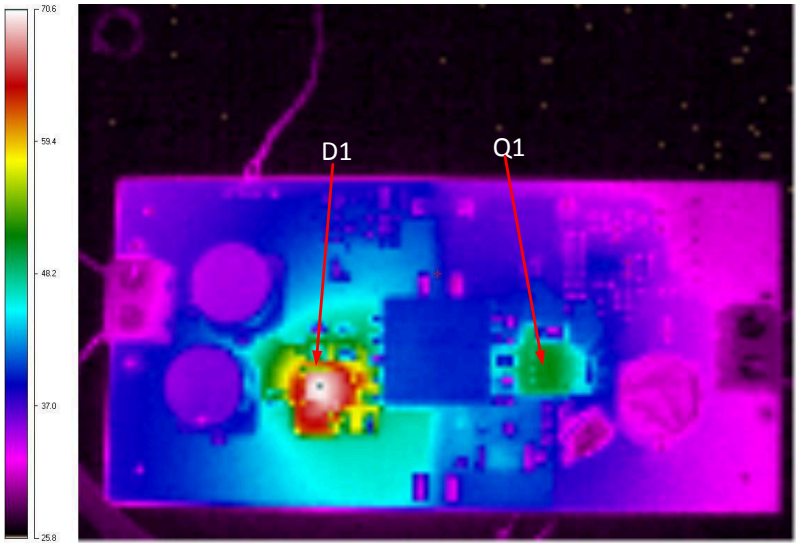

Figure 4-3. Thermal Performance: V_{SUPPLY} = 36V, I_{LOAD} = 4A, No forced air cooling

4.4 Steady State Waveforms

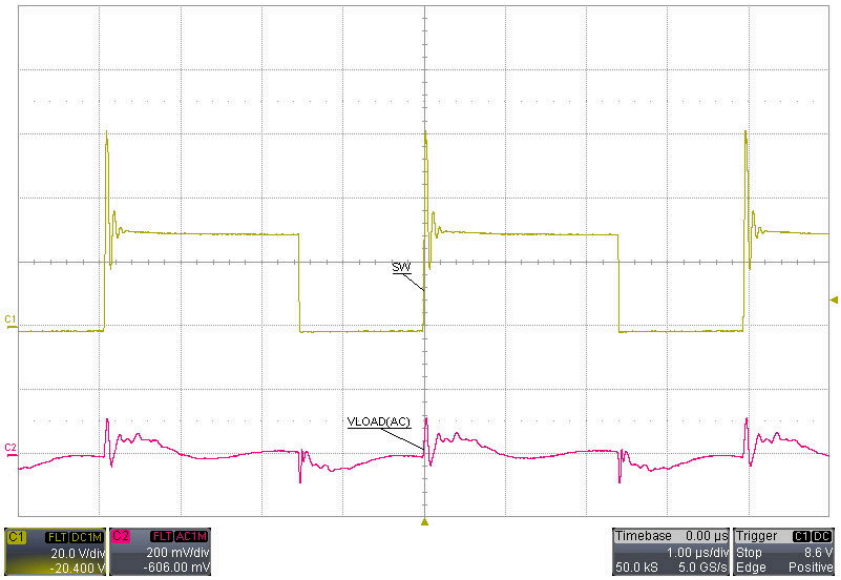

Figure 4-4. Steady State, V_{SUPPLY} = 18V, I_{LOAD} = 4A

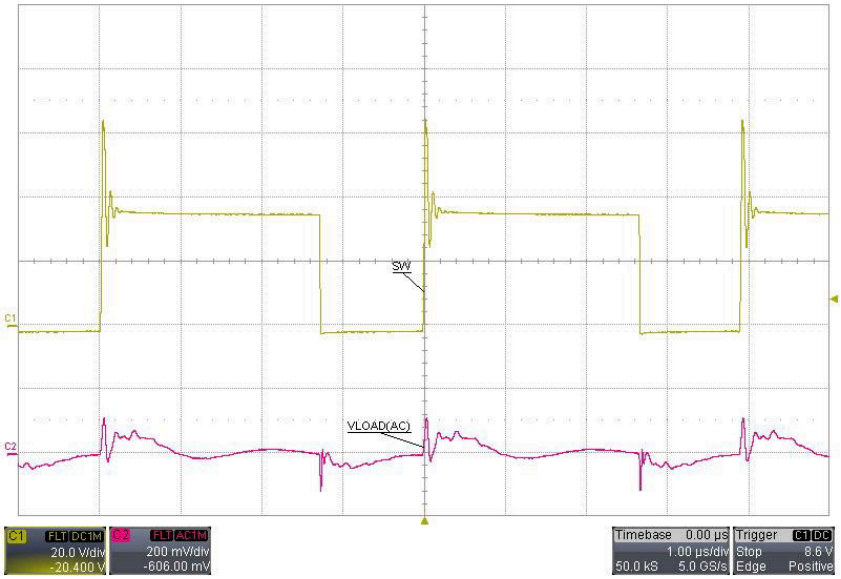

Figure 4-5. Steady State, V_{SUPPLY} = 24V, I_{LOAD} = 4A

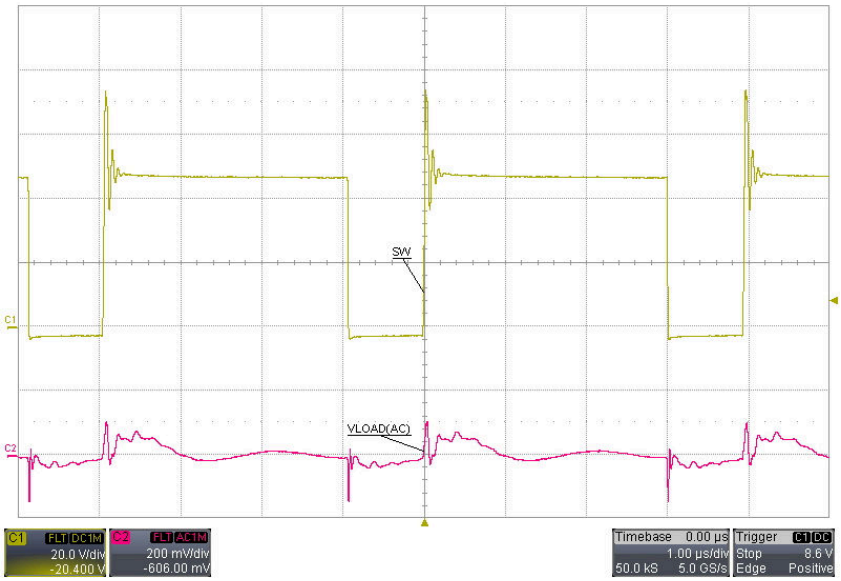

Figure 4-6. Steady State, V_{SUPPLY} = 36V, I_{LOAD} = 4A

4.5 Start-up Waveforms

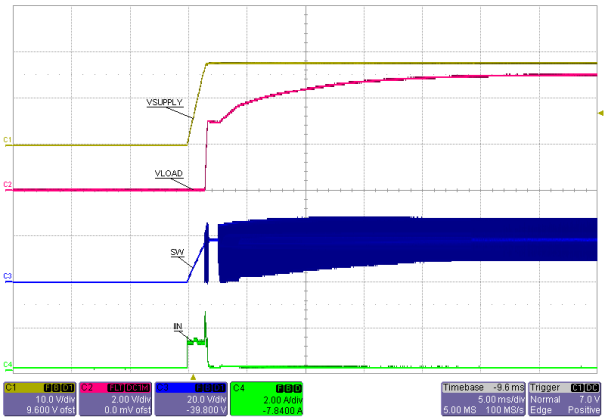

Figure 4-7. Start-Up, V_{SUPPLY} = 18 V, I_{LOAD} = 0 A

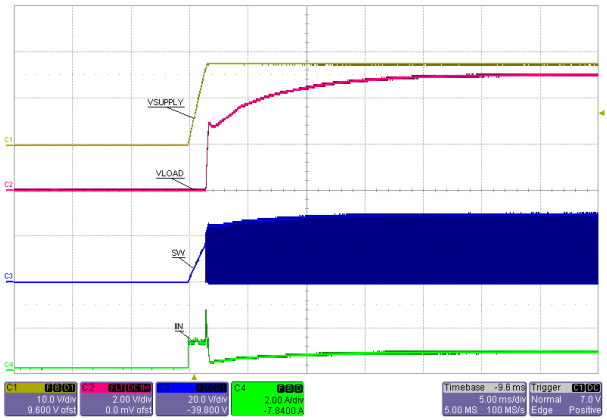

Figure 4-8. Start-Up, V_{SUPPLY} = 18 V, I_{LOAD} = 4 A

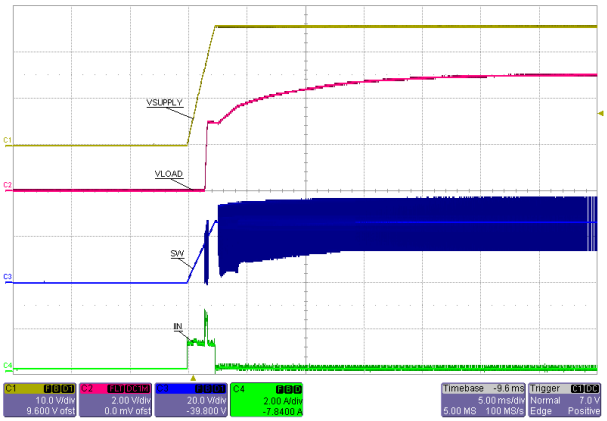

Figure 4-9. Start-Up, V_{SUPPLY} = 24 V, I_{LOAD} = 0 A

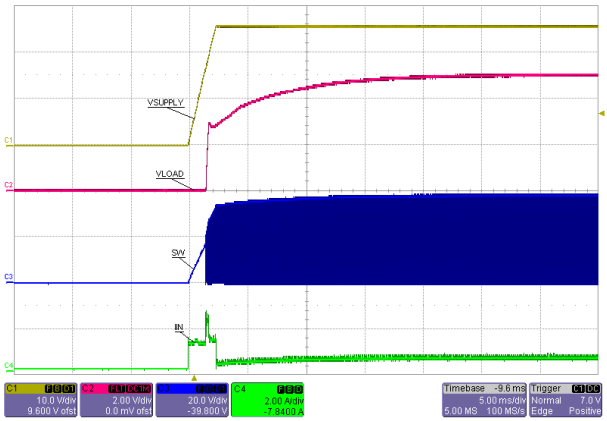

Figure 4-10. Start-Up, V_{SUPPLY} = 24 V, I_{LOAD} = 4 A

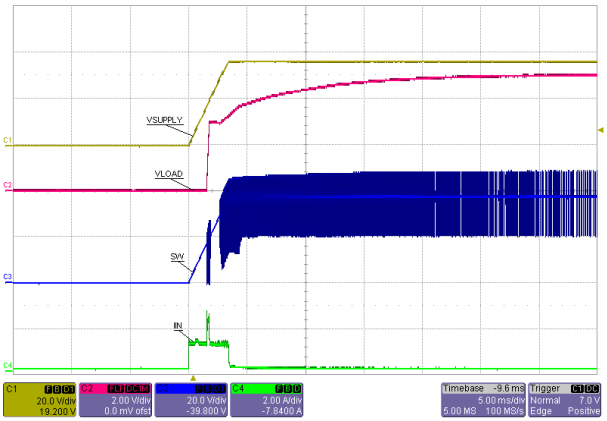

Figure 4-11. Start-Up, V_{SUPPLY} = 36 V, I_{LOAD} = 0 A

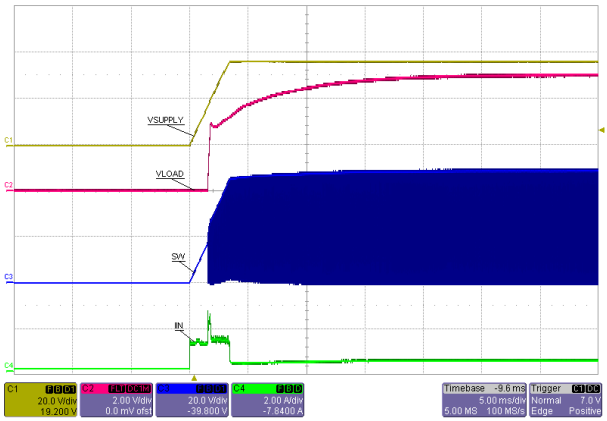

Figure 4-12. Start-Up, V_{SUPPLY} = 36 V, I_{LOAD} = 4 A

4.6 Load Transient Waveforms

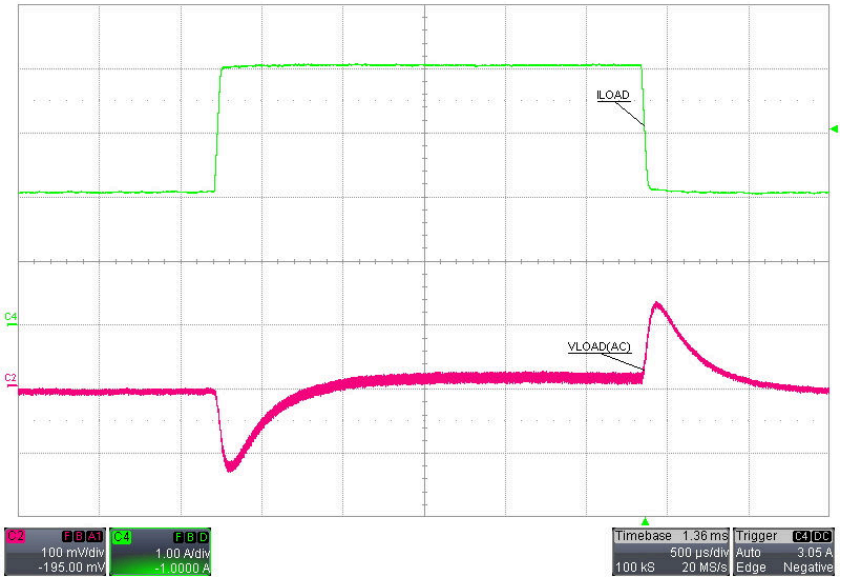

Figure 4-13. Load Transient, V_{SUPPLY} = 18 V, I_{LOAD} = 2 A to 4 A

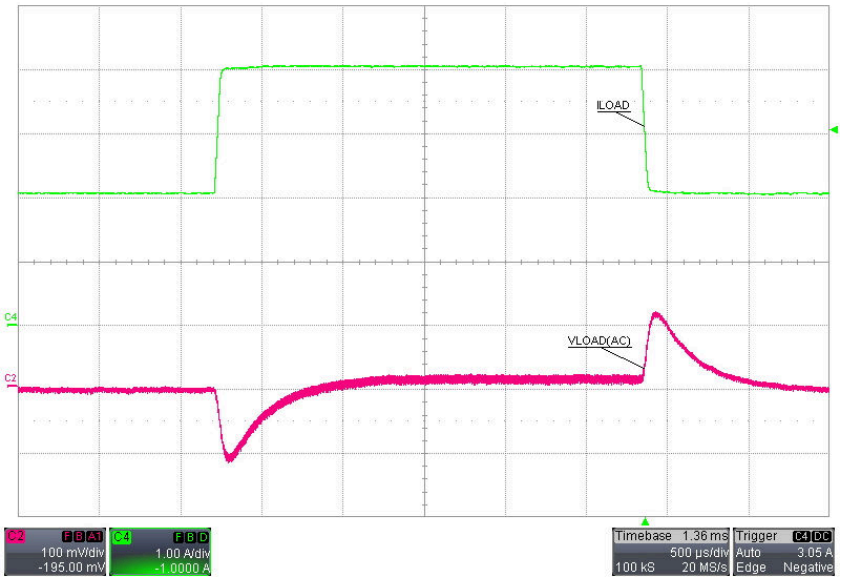

Figure 4-14. Load Transient, V_{SUPPLY} = 24 V, I_{LOAD} = 2 A to 4 A

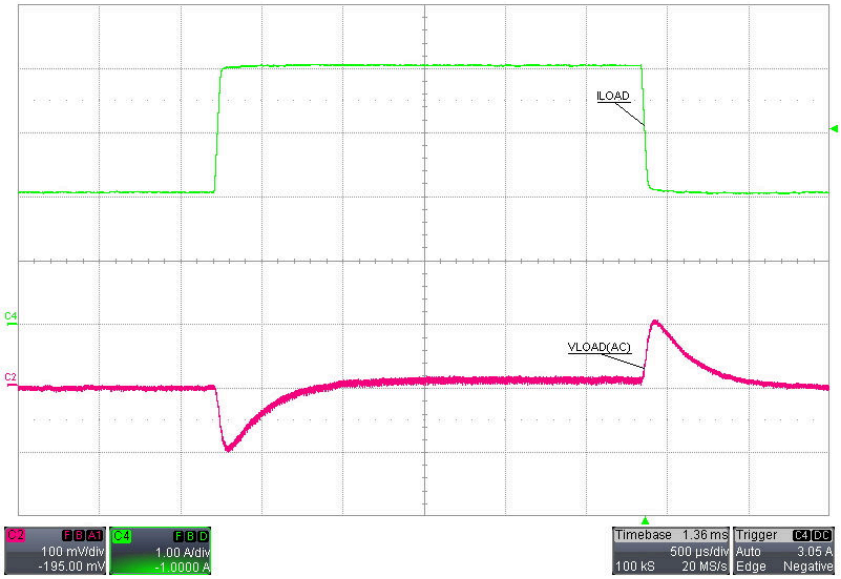

Figure 4-15. Load Transient, V_{SUPPLY} = 36 V, I_{LOAD} = 2 A to 4 A

4.7 Load Short-Circuit

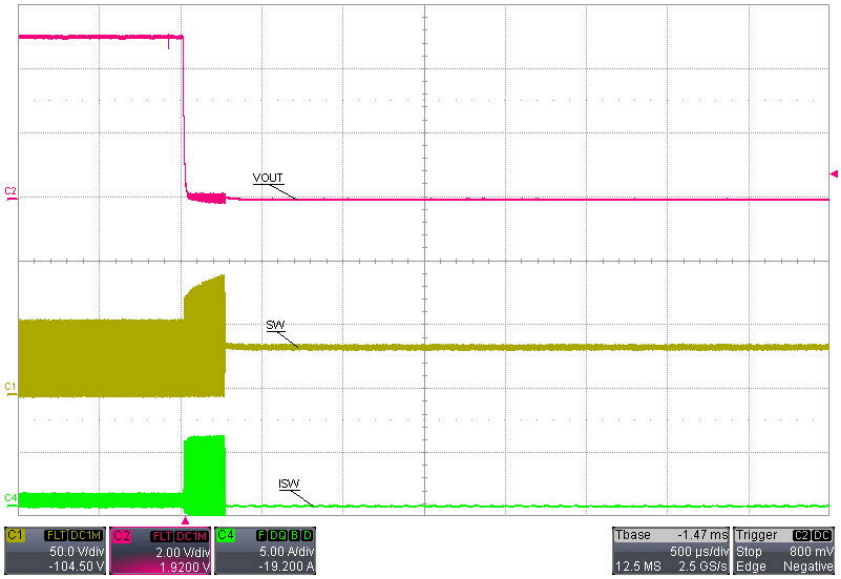

Figure 4-16. Short-Circuit Protection

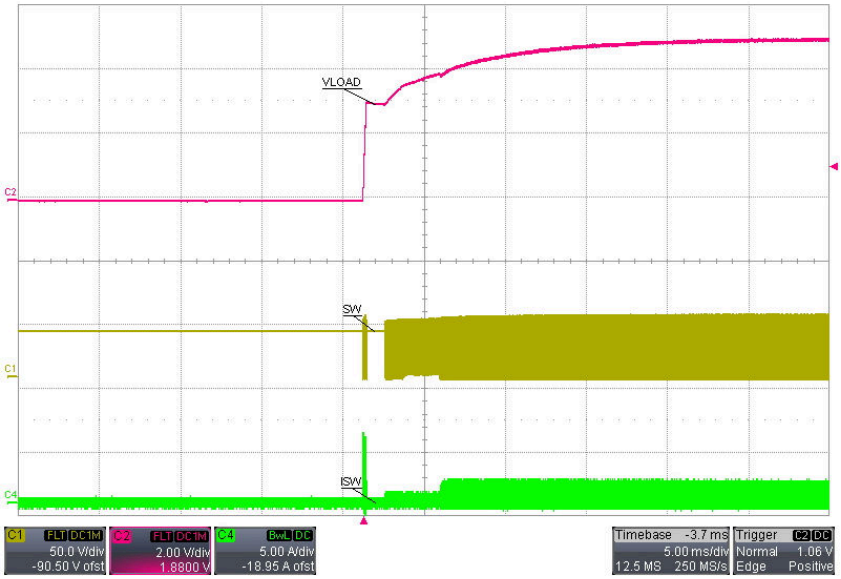

Figure 4-17. Short-Circuit Recovery: V_{SUPPLY} = 36 V

4.8 AC Loop Response

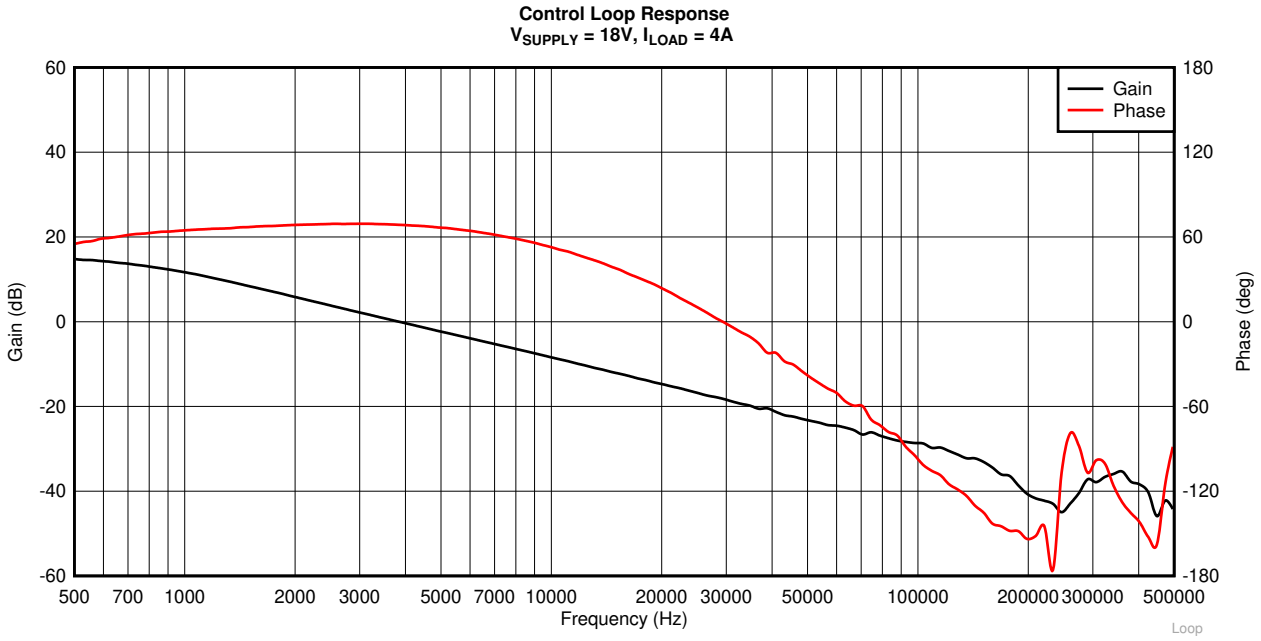

Figure 4-18. Control Loop Response V_{SUPPLY} = 18 V, I_{LOAD} = 4 A

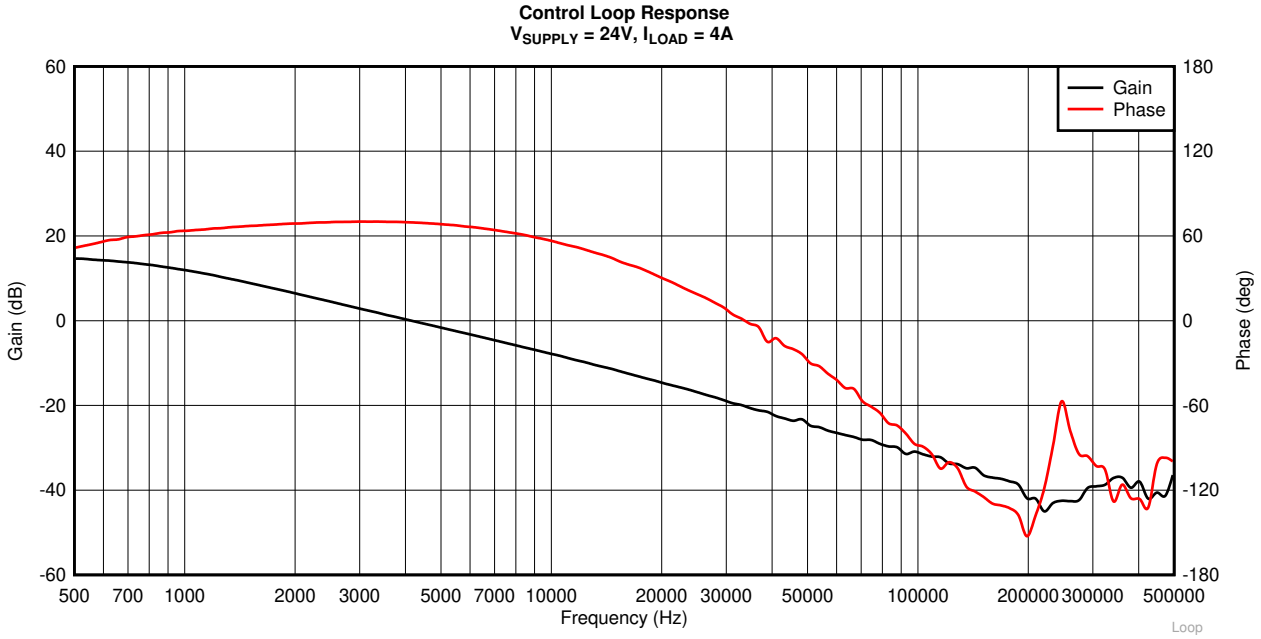

Figure 4-19. Control Loop Response V_{SUPPLY} = 24 V, I_{LOAD} = 4 A

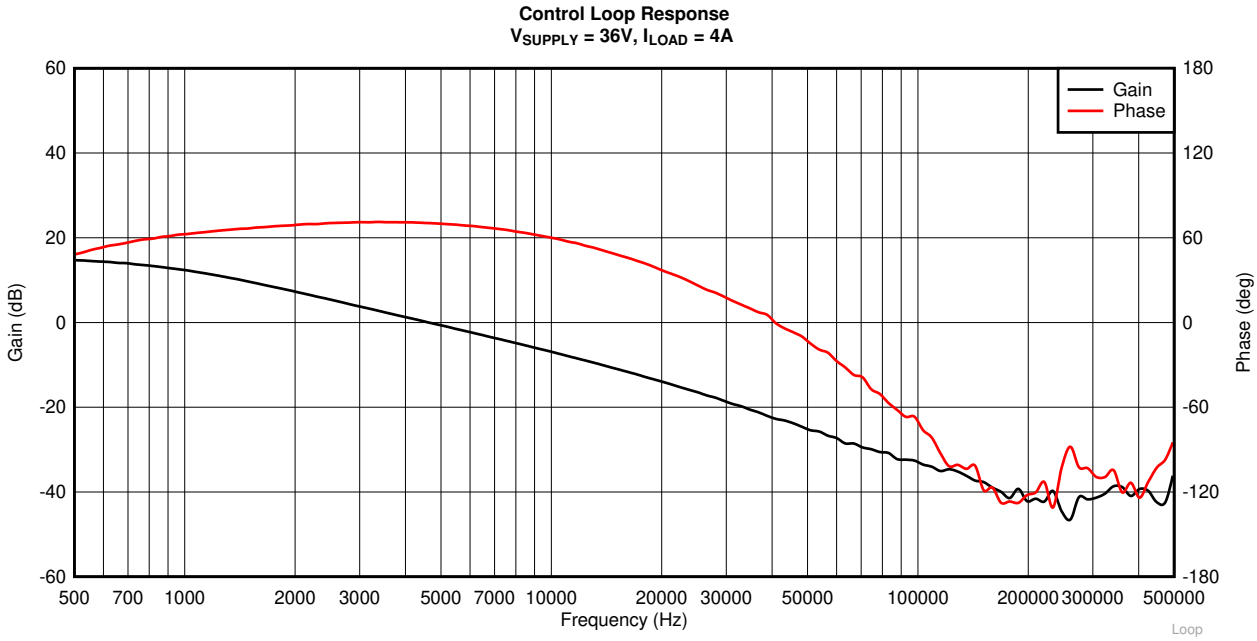

Figure 4-20. Control Loop Response V_{SUPPLY} = 36 V, I_{LOAD} = 4 A

5 PCB Layout

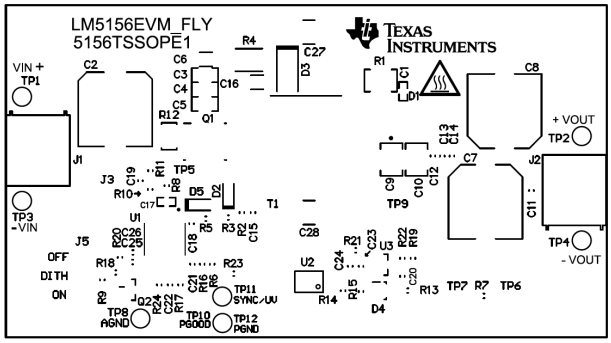

Figure 5-1. Top Silkscreen

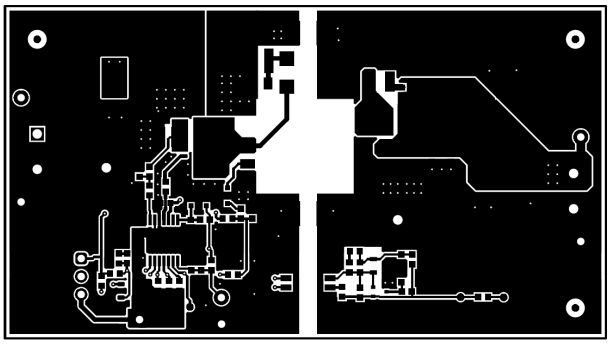

Figure 5-2. Top Layer

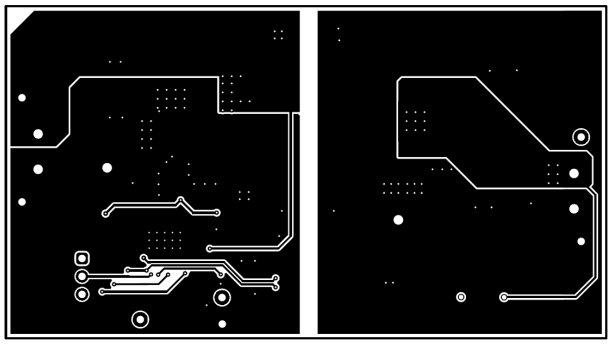

Figure 5-3. Bottom Layer

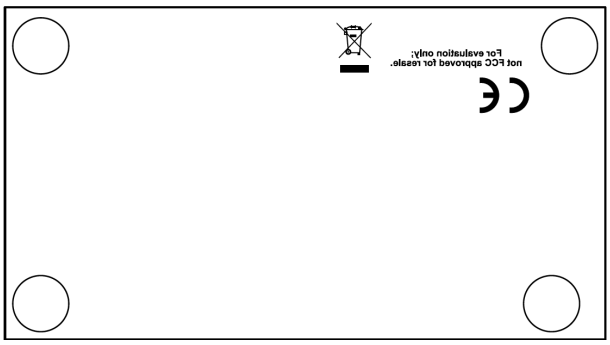

Figure 5-4. Bottom Silkscreen

6 Schematics

Figure 6-1 illustrates the EVM schematic.

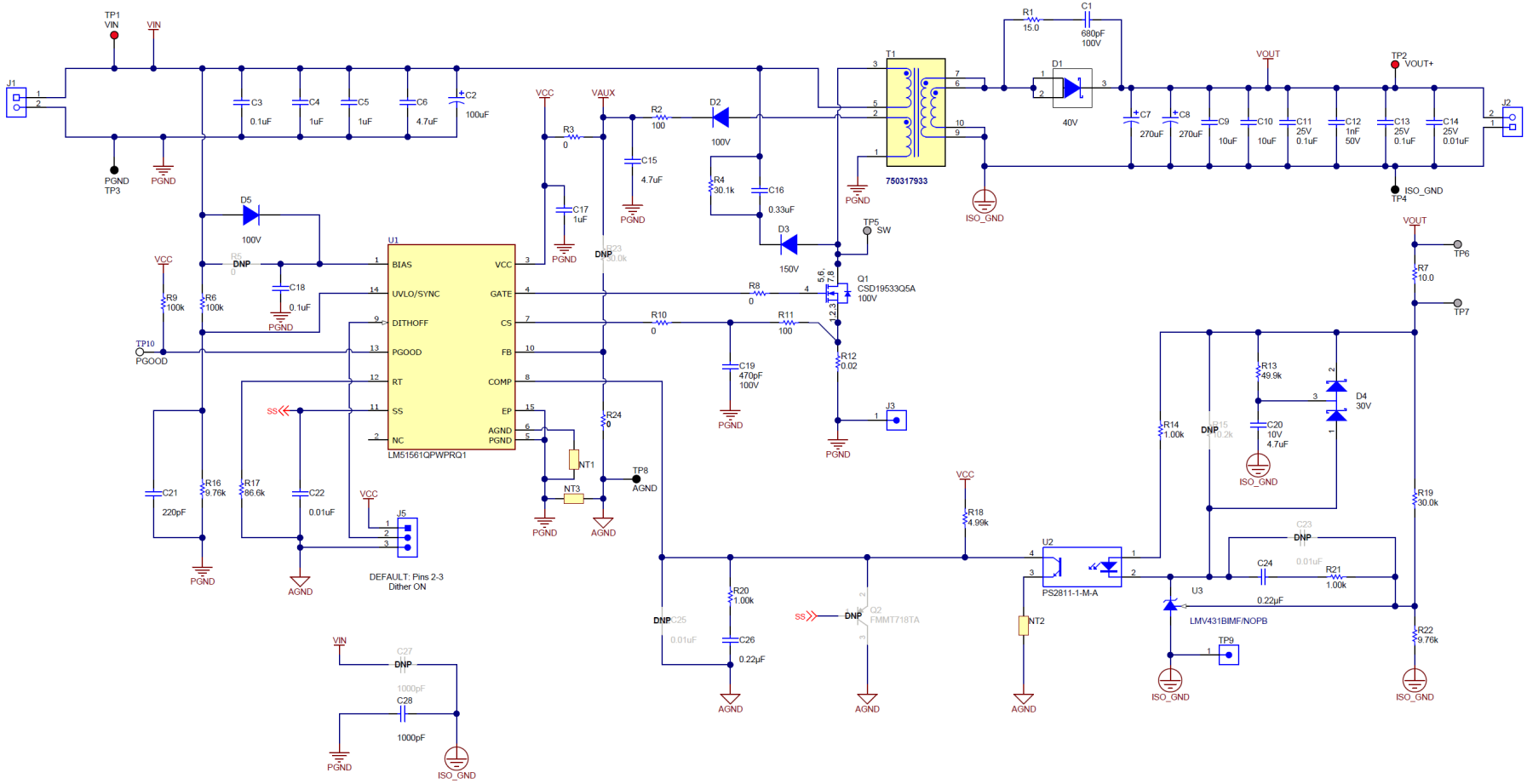

Figure 6-1. LM5156HEVM-FLY Schematic

7 Bill of Materials

Table 7-1 lists the EVM bill of materials.

Table 7-1. LM5156HEVM-FLY Bill of Materials

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
C1	1	680pF	CAP, CERM, 680 pF, 100 V, ±10%, X7R, 0603	0603	GRM188R72A681KA01D	MuRata
C2	1	100uF	CAP, Polymer Hybrid, 100 uF, 50 V, ±20%, 28 ohm, 10x10 SMD	10x10	EEHZC1H101P	Panasonic
C3	1	0.1uF	CAP, CERM, 0.1 uF, 50 V, ±20%, X7R, 0805	0805	08055C104MAT2A	AVX
C4, C5	2	1uF	CAP, CERM, 1 uF, 50 V, ±10%, X7R, 0805	0805	08055C105KAT2A	AVX
C6	1	4.7uF	CAP, CERM, 4.7 uF, 50 V, ±10%, X7R, 1206	1206	C3216X7R1H475K160AC	TDK
C7, C8	2	270uF	CAP, Aluminum Polymer, 270 uF, 25 V, ±20%, 0.027 ohm, D10xL12.7mm SMD	D10xL12.7mm	PCV1E271MCL1GS	Nichicon
C9, C10	2	10uF	CAP, CERM, 10 uF, 25 V,±10%, X7R, 1210	1210	885012209028	Wurth Elektronik
C11, C13	2	0.1uF	CAP, CERM, 0.1 uF, 25 V, ±10%, X7R, 0603	0603	C1608X7R1E104K080AA	TDK
C12	1	1000pF	CAP, CERM, 1000 pF, 50 V, ±10%, X7R, 0603	0603	C0603X102K5RACTU	Kemet
C14, C22	2	0.01uF	CAP, CERM, 0.01 uF, 25 V, ±5%, C0G/NP0, AEC-Q200 Grade 1, 0603	0603	C0603C103J3GECAUTO	Kemet
C15	1	4.7uF	CAP, CERM, 4.7 uF, 35 V, ±10%, X5R, 0603	0603	GRM188R6YA475KE15D	MuRata
C16	1	0.33uF	CAP, CERM, 0.33 uF, 100 V, ±10%, X7R,		C3216X7R2A334K130AA	TDK
C17	1	1uF	CAP, CERM, 1 uF, 16 V, ±20%, X7R, AEC-Q200 Grade 1, 0603	0603	GCM188R71C105MA64D	MuRata
C18	1	0.1uF	CAP, CERM, 0.1 uF, 50 V, ±10%, X7R, 0603	0603	C1608X7R1H104K080AA	TDK
C19	1	470pF	CAP, CERM, 470 pF, 100 V, ±5%, X7R, 0603	0603	06031C471JAT2A	AVX
C20	1	4.7uF	CAP, CERM, 4.7 uF, 10 V, ±20%, X7S, 0603	0603	GRM188C71A475KE11D	MuRata
C21	1	220pF	CAP, CERM, 220 pF, 50 V, ±5%, C0G/NP0, 0603	0603	C0603C221J5GACTU	Kemet
C24, C26	2	0.22uF	CAP, CERM, 0.22 µF, 16 V,±10%, X7R, AEC-Q200 Grade 1, 0603	0603	CL10B224KO8VPNC	Samsung

Table 7-1. LM5156HEVM-FLY Bill of Materials (continued)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
C28	1	1000pF	CAP, CERM, 1000 pF, 2000 V, ±10%, X7R, 1812	1812	1812GC102KA1	AVX
D1	1	40V	Diode, Schottky, 40 V, 10 A, AEC-Q101, TO-277A	TO-277A	SS10P4-M3/87A	Vishay-Semiconductor
D2, D5	2	100V	Diode, Switching, 100 V, 0.2 A, SOD-323	SOD-323	MMDL914-TP	Micro Commercial Components
D3	1	150V	Diode, Superfast Rectifier, 150 V, 1 A, SMA	SMA	ES1C-13-F	Diodes Inc.
D4	1	30V	Diode, Schottky, 30 V, 0.2 A, SOT-323	SOT-323	BAT54SWT1G	Fairchild Semiconductor
H1, H2, H3, H4	4		Bumpon, Cylindrical, 0.312 X 0.200, Black	Black Bumpon	SJ61A1	3M
J1, J2	2		Terminal Block, 5mm, 2-pole, TH	TH, 2-Leads, Body 10x9mm, Pin Spacing 5mm	ED350/2	On-Shore Technology
J3, TP9	2		TEST POINT SLOTTED .118", TH	Test point, TH Slot Test point	1040	Keystone
J5	1		Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec
Q1	1	100V	MOSFET, N-CH, 100 V, 13 A, DQJ0008A (VSONP-8)	DQJ0008A	CSD19533Q5A	Texas Instruments
R1	1	15.0	RES, 15.0, 1%, 0.5 W, 1210	1210	ERJ-14NF15R0U	Panasonic
R2, R11	2	100	RES, 100, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3EKF1000V	Panasonic
R3	1	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R00	Stackpole Electronics Inc
R4	1	30.1k	RES, 30.1 k, 1%, 1 W, AEC-Q200 Grade 0, 2512	2512	CRCW251230K1FKEG	Vishay-Dale
R6, R9	2	100k	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R7	1	10.0	RES, 10.0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310R0FKEA	Vishay-Dale
R8, R10, R24	3	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3GEY0R00V	Panasonic
R12	1	0.02	RES, 0.02, 1%, 1 W, 0612	0612	PRL1632-R020-F-T1	Susumu Co Ltd
R13	1	49.9k	RES, 49.9 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3EKF4992V	Panasonic

Table 7-1. LM5156HEVM-FLY Bill of Materials (continued)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
R14	1	1.00k	RES, 1.00 k, 1%, 0.1 W, 0603	0603	ERJ-3EKF1001V	Panasonic
R16, R22	2	9.76k	RES, 9.76 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06039K76FKEA	Vishay-Dale
R17	1	86.6k	RES, 86.6 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060386K6FKEA	Vishay-Dale
R18	1	4.99k	RES, 4.99 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06034K99FKEA	Vishay-Dale
R19	1	30.0k	RES, 30.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0730KL	Yageo
R20, R21	2	1.00k	RES, 1.00 k, 0.1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERA3AEB102V	Panasonic
SH-J1	1	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
T1	1	21uH	Transformer, 21 uH, SMT	13.97x18.25mm	750317933	Wurth Elektronik
TP1, TP2	2		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP3, TP4, TP8	3		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone
TP10	1		Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone
U1	1		2.2MHz Wide VIN Non-synchronous Boost/SEPIC/ Flyback Controller with Dual Random Spread Spectrum	HTSSOP14	LM51561QPWPRQ1	Texas Instruments
U2	1		Optocoupler, 2.5 kV, 100-200% CTR, SMT	PS2811-1	PS2811-1-M-A	California Eastern Laboratories
U3	1		Low-Voltage (1.24V) Adjustable Precision Shunt Regulators, 3-pin SOT-23, Pb-Free	DBZ0003A	LMV431BIMF/NOPB	Texas Instruments

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。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。
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東京都新宿区西新宿 6 丁目 2 4 番 1 号
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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
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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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