

EVM User's Guide: LM3478EVM-FLY

LM3478 評価基板



説明

LM3478 評価基板 (EVM) は、400kHz の固定スイッチング周波数で広い入力電圧範囲に対応した 1 次側安定化フライバックコントローラを紹介しています。この PCB は高い変換効率を達成し、2 層で部品を片側に実装しています。

設計を開始

1. 評価基板を電源と負荷に接続します。
2. アプリケーションの電源をオンにします。

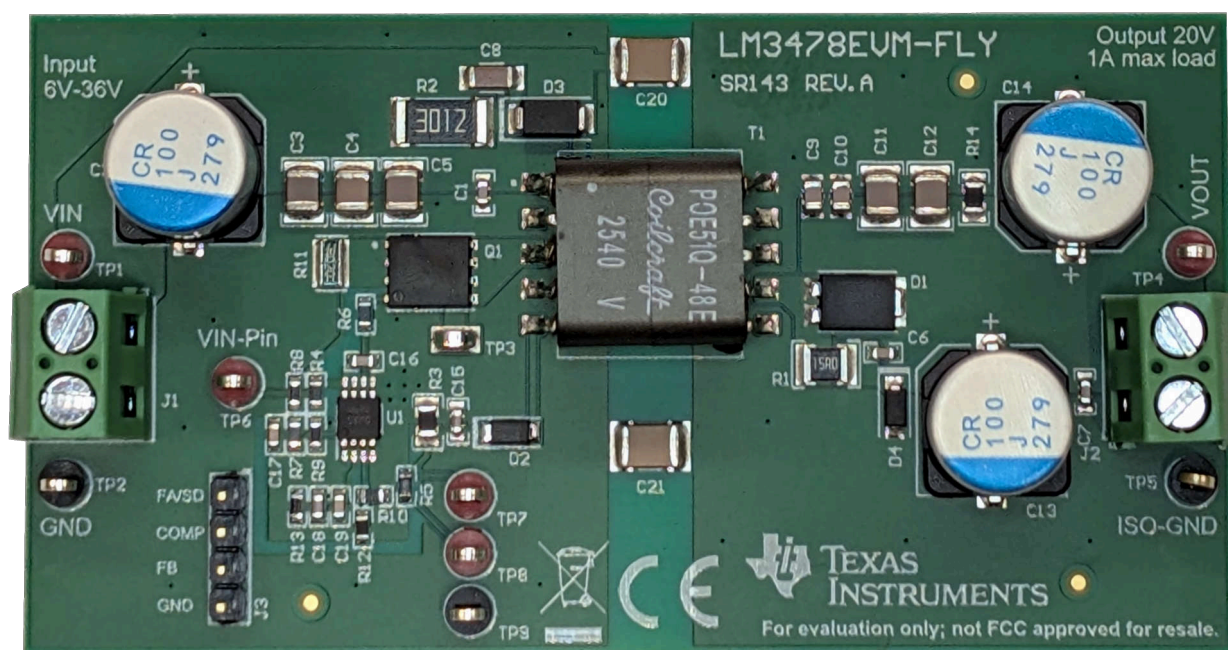
特長

- 1 次側安定化フライバックコントローラ

- 絶縁型 20V 出力電圧レール
- 14W の出力電力
- 5V に安定化済みの補助巻線
- プログラマブルなスイッチング周波数
- プログラム可能なサイクルごとの電流制限
- シャットダウンピン

アプリケーション

- バッテリ マネージメント システム



LM3478EVM-FLY

1 評価基板の概要

1.1 はじめに

LM3478EVM-FLY 評価基板は、1 次側レギュレーションを搭載し、広い入力電圧範囲に対応する絶縁型フライバックコントローラとして LM3478 の機能と性能を紹介します。標準構成は、7V ~ 36V の入力範囲に対応し、400kHz のスイッチング周波数で動作して、20V のレギュレーション済み出力で 700mA を供給する設計を採用しています。この評価基板は、14W の定格電力で 20V の出力電圧を供給します。この評価基板は、構成を容易に実施できることを重視して設計してあるので、同じ基板を使用して多様なアプリケーションを評価することができます。PCB は 2 層であり、部品は片側にのみ実装されています。動作にジャンパ設定は不要です。

1.2 キットの内容

- LM3478EVM-FLY PCB アセンブリ
- EVM の免責事項と手順書 (はじめにお読みください)

1.3 仕様

表 1-1. EVM 仕様

パラメータ	条件	最小値	標準値	最大値	単位
入力電圧	動作	7	12	36	V
出力電圧	負荷接続済み		20		V
出力電力	$V_{IN} > 11V$			700	mA
	$V_{IN} > 7V$			500	mA
スイッチング周波数	$R9 = 49.9k\Omega$		400		kHz
効率	$V_{IN} = 7V, I_{OUT} = 500mA$		86%		
	$V_{IN} = 12V, I_{OUT} = 700mA$		87%		

1.4 製品情報

LM3478 は、スイッチングレギュレータ用の多用途ローサイド N チャンネル MOSFET コントローラです。電流モード制御を使うと、サイクルごとの電流制限が可能になることに加え、優れた帯域幅と過渡応答が得られます。LM3478 には、サーマルシャットダウン、短絡保護、過電圧保護、合計消費電流を 5 μ A まで低減する省電力シャットダウンモードなどの機能が組み込まれています。内部ソフトスタートにより、スタートアップ時の突入電流が制限されます。

2 ハードウェア

2.1 ヘッダー情報

LM3478EVM-FLY は、デバイスの信号を測定し、外部信号を注入してシャットダウン機能を使用したり小信号の安定性分析を実行したりするためのヘッダーとテスト ポイントを備えています。

表 2-1. EVM ヘッダー

コネクタ	ピン	説明
J1	1	電源電圧 (正)
	2	電源電圧 (負)
J2	1	出力電圧 (負)
	2	出力電圧 (正)
J3	1	FA/SD ピン。このピンを 1.4V より高くプルすると、デバイスのシャットダウン機能がアクティブになります。
	2	COMP ピン
	3	FB ピン
	4	GND リファレンス

2.2 テスト ポイント

表 2-2. EVM テスト ポイント

コネクタ	名称	説明
TP1	V_{IN}	V_{IN} のテスト ポイント
TP2	GND (非絶縁型)	GND のテスト ポイント
TP3	SW	スイッチ ノード用のテスト ポイント
TP4	V_{OUT}	V_{OUT} のテスト ポイント
TP5	GND (絶縁型)	GND のテスト ポイント
TP6	V_{IN} -ピン	電力段とコントローラ デバイス用に独立した電源が必要な場合は、R4 を取り外し、このテスト ポイント経由で 2 番目の電源を接続します。
TP7	V_{AUX+}	V_{AUX} 、安定性分析注入のテスト ポイント
TP8	V_{AUX-}	安定性分析注入
TP9	GND (非絶縁型)	GND のテスト ポイント

3 実装結果

3.1 評価設定

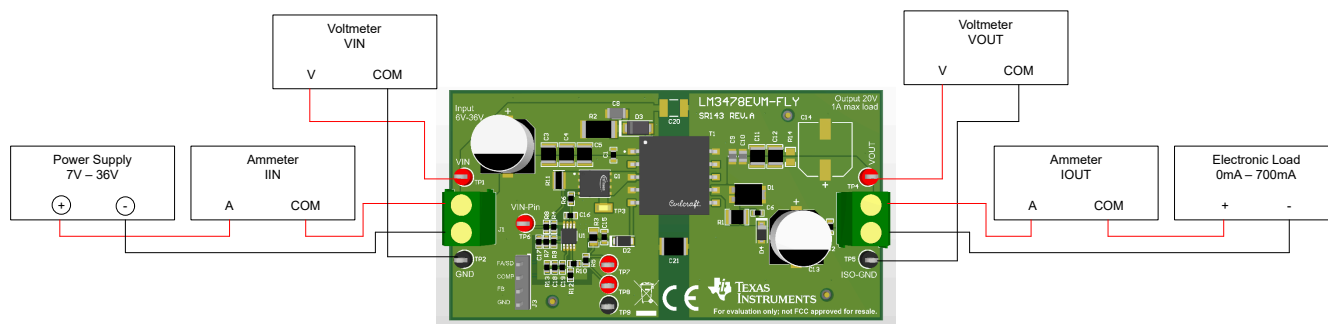


図 3-1. EVM テスト設定

テスト設定

以下の試験装置が必要です。

- 電源
- 電子負荷 (または抵抗性負荷)
- オシロスコープ: 最小 **200MHz** 帯域幅
- マルチメータ (オプション)
 - 電圧計 1 (V_{IN})
 - 電圧計 2 (V_{OUT})
 - 電流計 1 (I_{IN})
 - 電流計 2 (I_{OUT})

テスト方法

1. 以下に従って、電源と負荷を評価基板の対応する接続部に接続します [図 3-1](#)。
2. 電源電圧を **12V**、電子負荷を **0.1A** に設定します。電子負荷電圧は、公称 **20V** 出力でレギュレートされている必要があります。

注

負荷なしで評価基板を動作させると、1 次側レギュレーションによって出力電圧が暴走するリスクがあります。TI は、ゼロ負荷条件下で評価基板を動作させることを推奨しません。過電圧を防止するため、出力にツェナー ダイオード (**D4**) が実装されています。

3. 必要に応じて負荷電流と入力電源電圧を変更します。

3.2 性能データおよび結果

効率

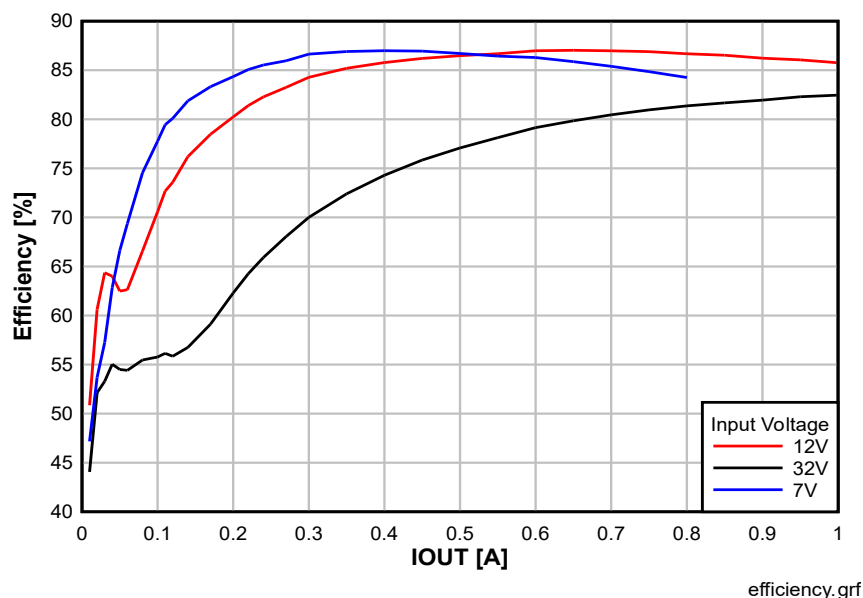


図 3-2. 効率と出力電流との関係

スタートアップ波形

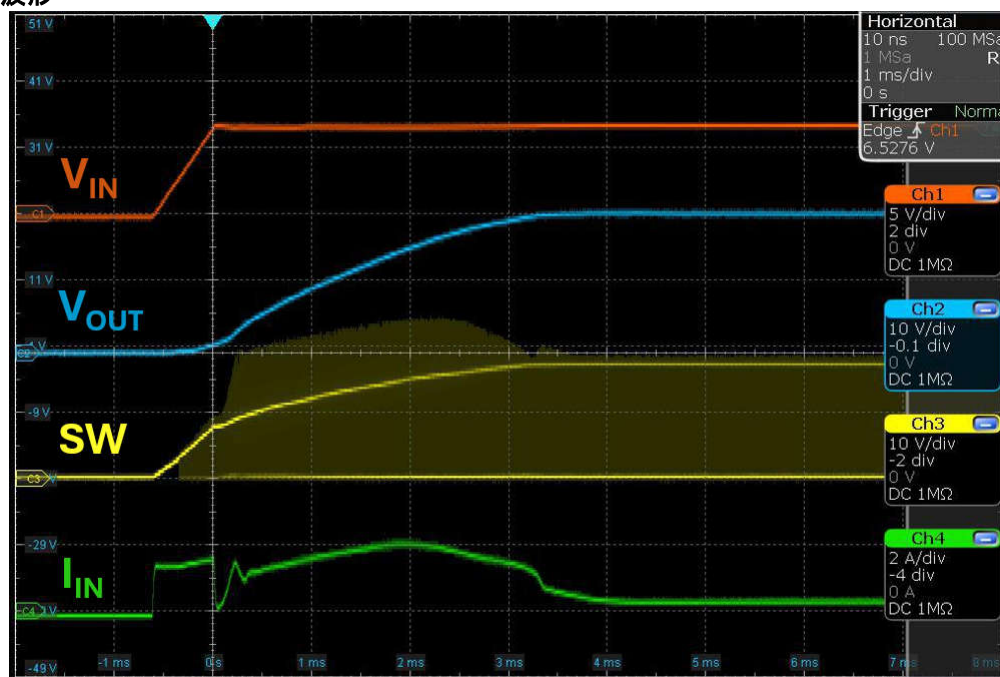


図 3-3. スタートアップ波形、 $V_{IN} = 7V$ 、 $I_{OUT} = 20mA$

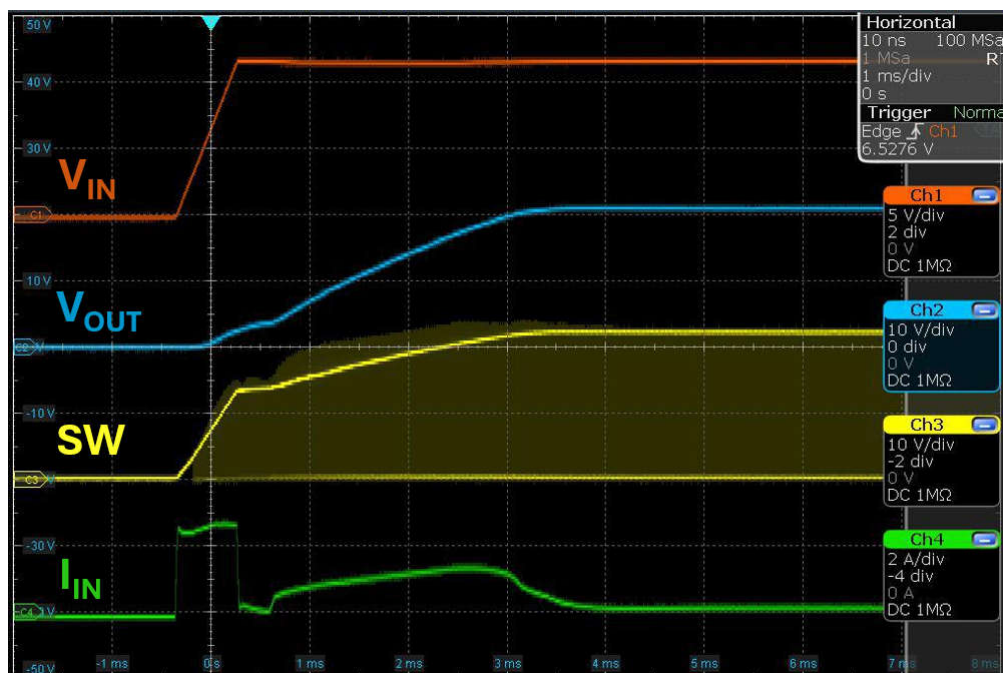


図 3-4. スタートアップ波形、 $V_{IN} = 12V$ 、 $I_{OUT} = 20mA$

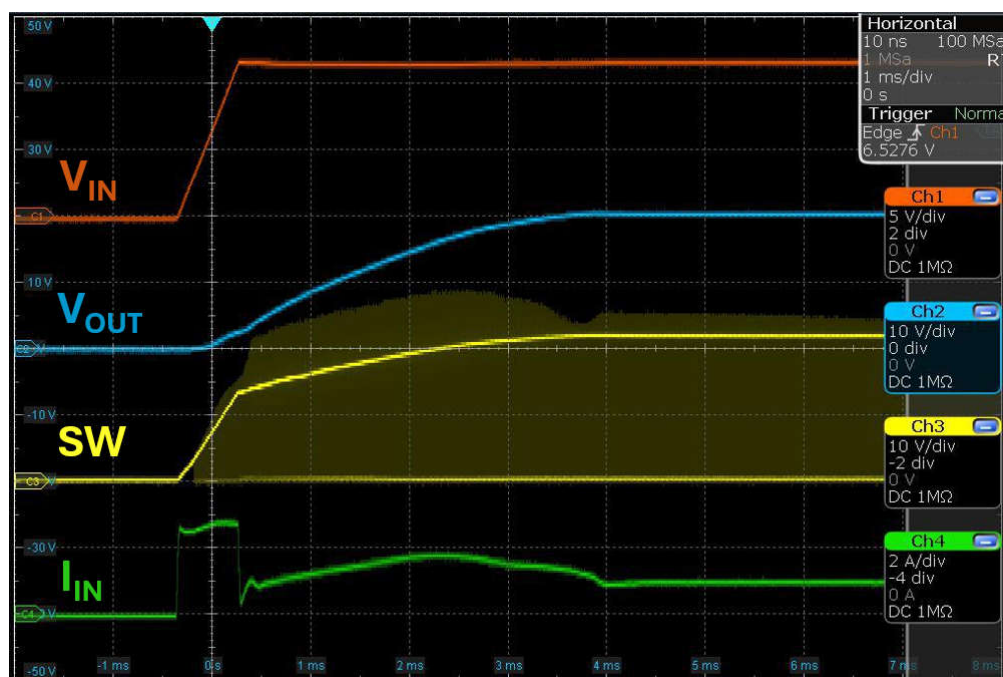


図 3-5. スタートアップ波形、 $V_{IN} = 12V$ 、 $I_{OUT} = 500mA$

定常状態での動作

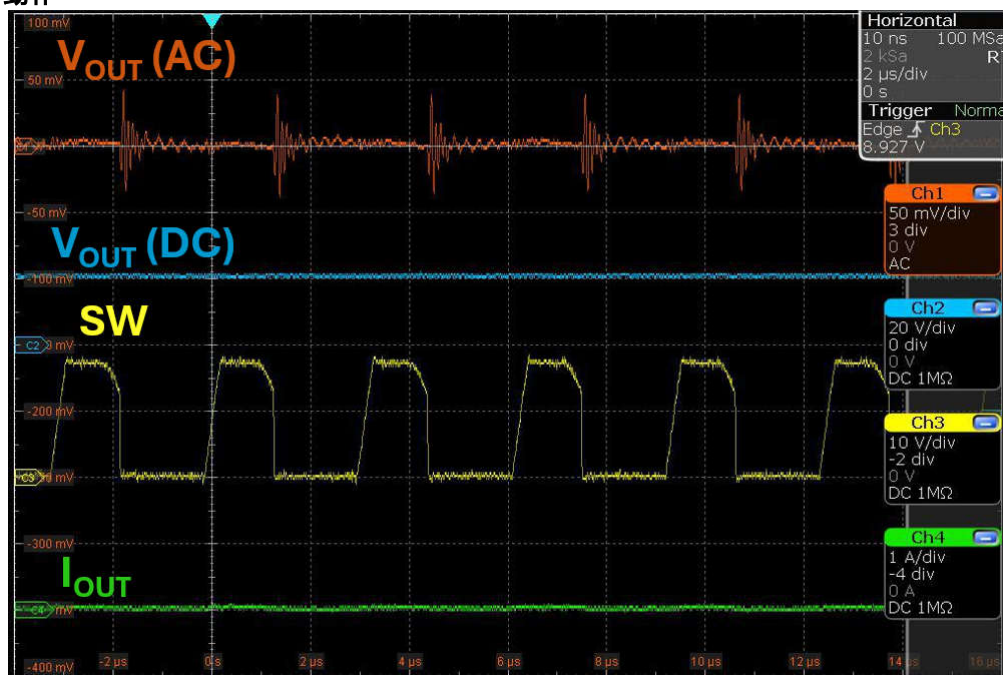


図 3-6. 定常状態、 $V_{IN} = 7V$ 、 $I_{OUT} = 20mA$

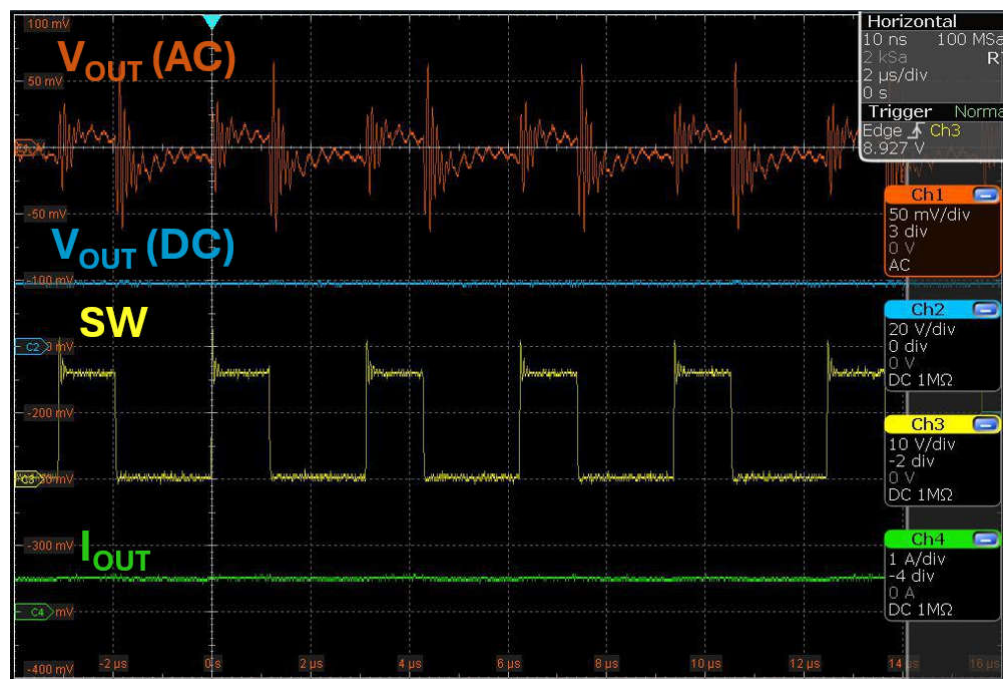


図 3-7. 定常状態、 $V_{IN} = 7V$ 、 $I_{OUT} = 500mA$

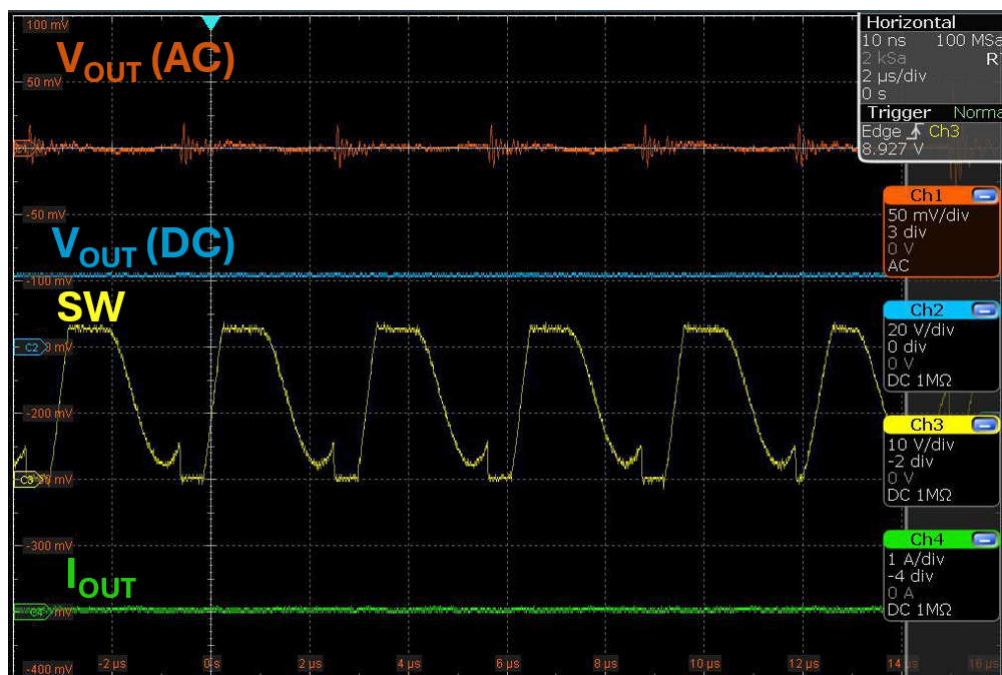


図 3-8. 定常状態、 $V_{IN} = 12V$ 、 $I_{OUT} = 20mA$

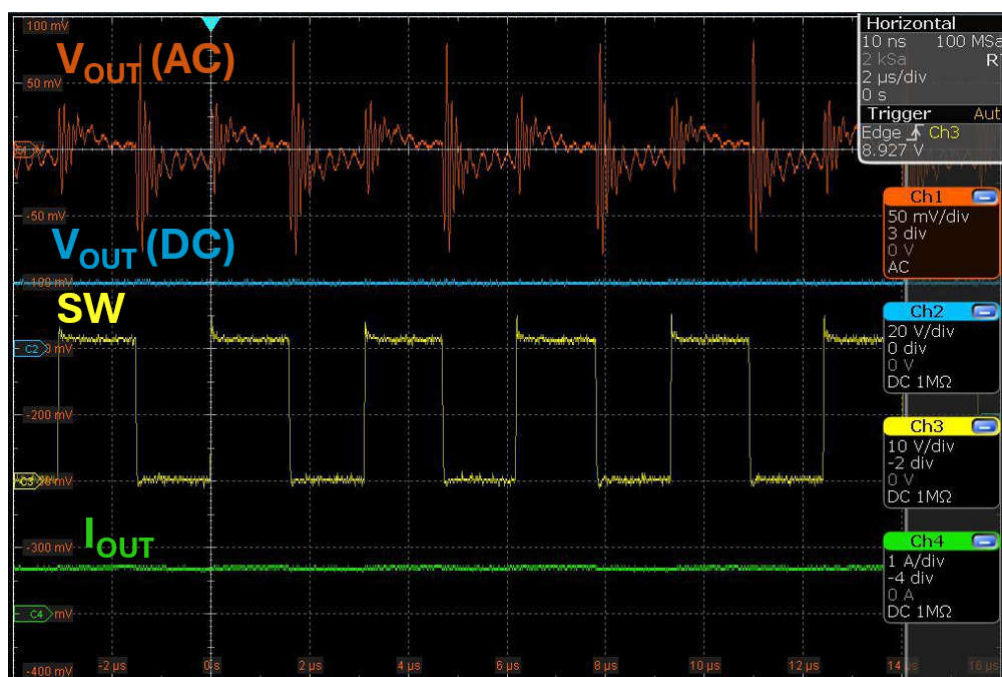


図 3-9. 定常状態、 $V_{IN} = 12V$ 、 $I_{OUT} = 700mA$

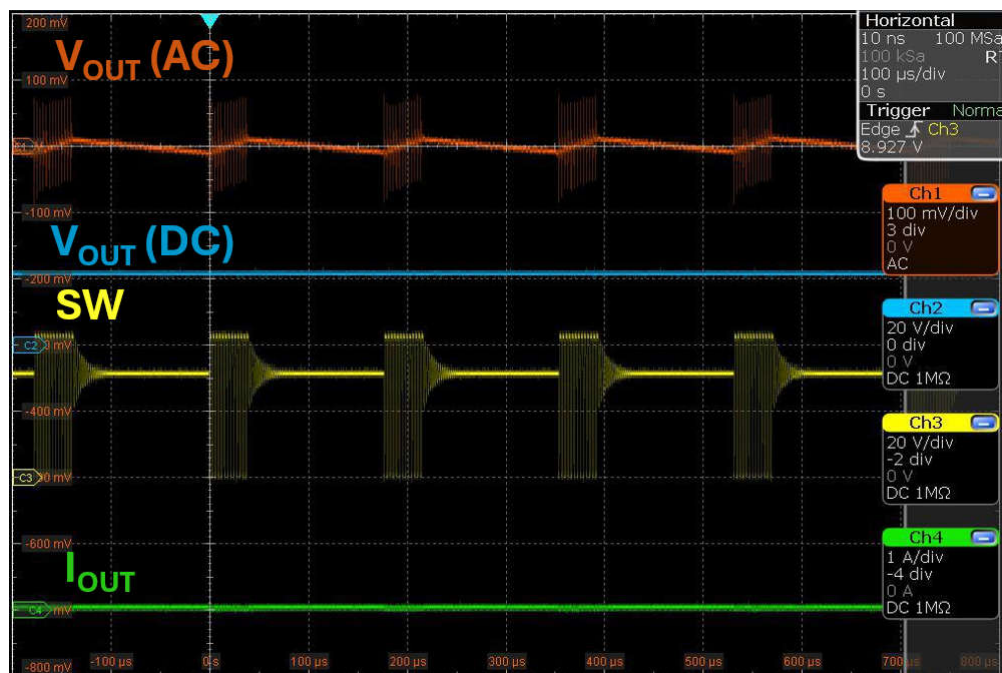


図 3-10. 定常状態、 $V_{IN} = 32V$ 、 $I_{OUT} = 20mA$

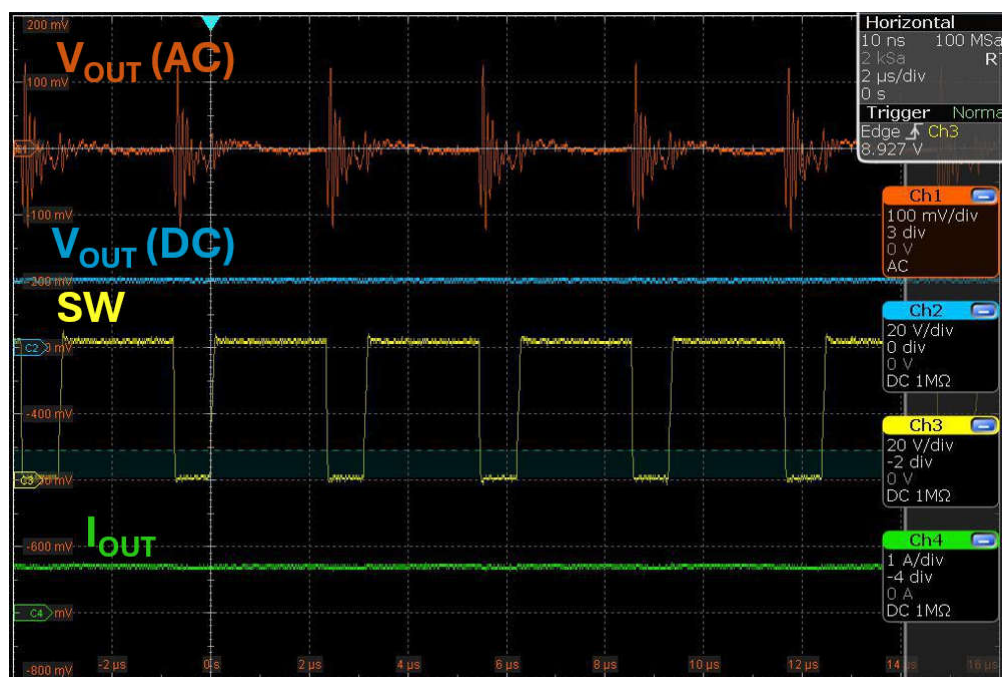
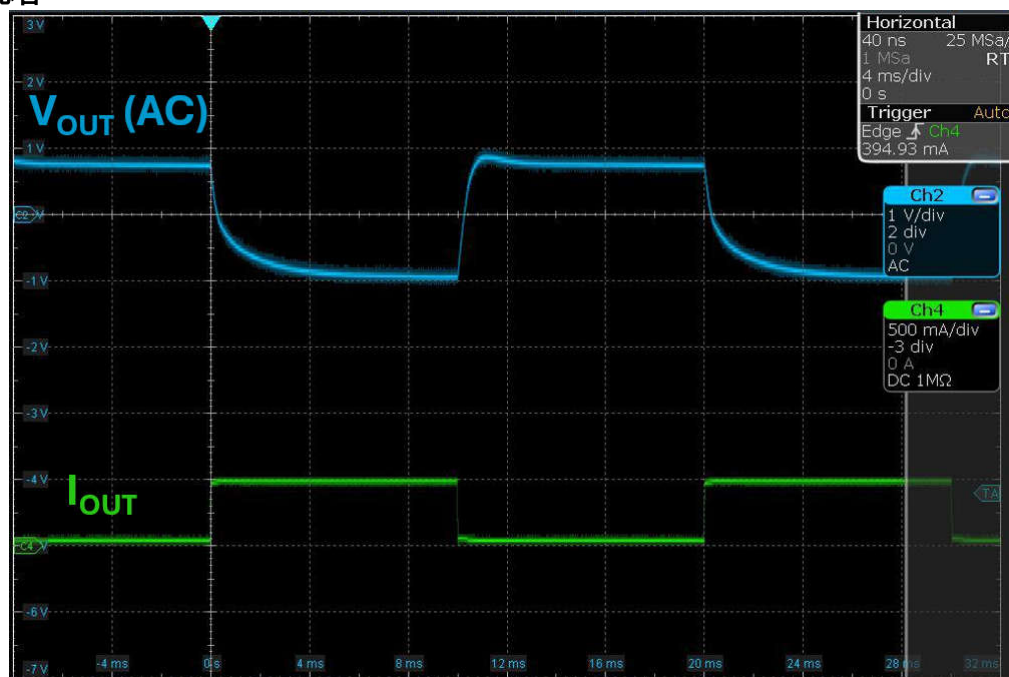
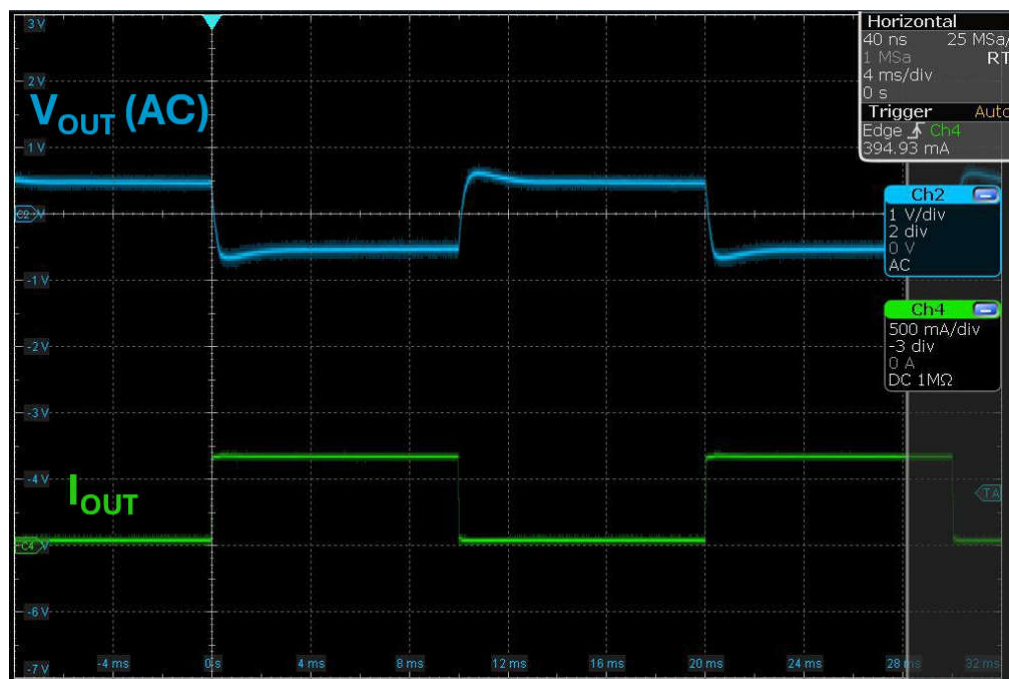


図 3-11. 定常状態、 $V_{IN} = 32V$ 、 $I_{OUT} = 700mA$

ステップ負荷応答

図 3-12. 負荷過渡応答、 $V_{IN} = 7V$ 、 $I_{OUT} = 0mA \sim 500mA$ 、 $1A/\mu s$ 図 3-13. 負荷過渡応答、 $V_{IN} = 12V$ 、 $I_{OUT} = 0mA \sim 700mA$ 、 $1A/\mu s$

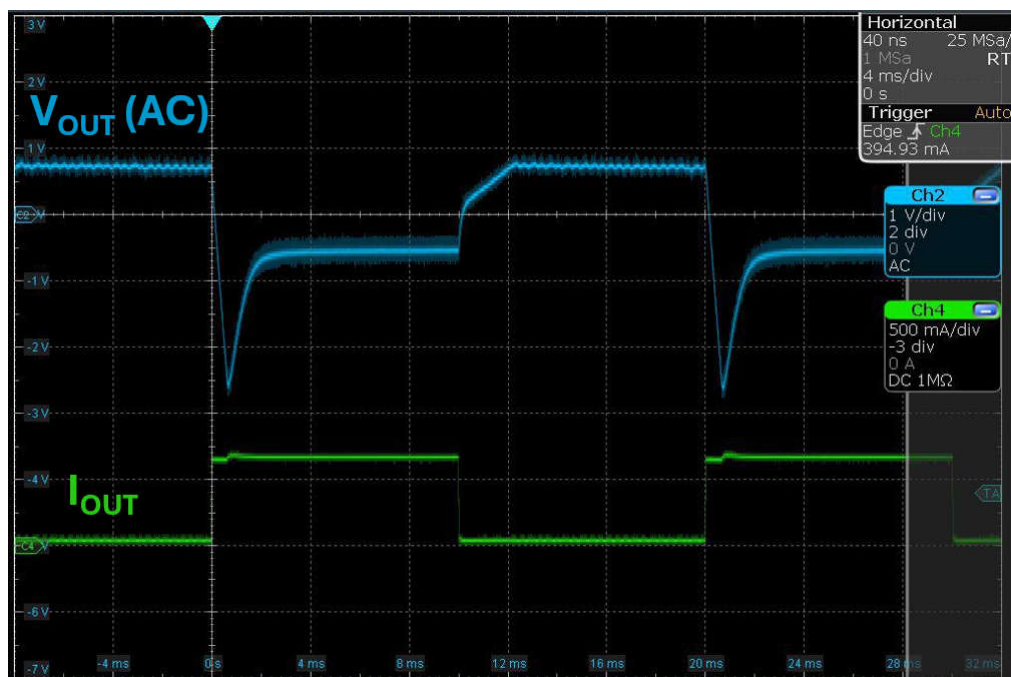


図 3-14. 負荷過渡応答、 $V_{IN} = 32V$ 、 $I_{OUT} = 0mA \sim 700mA$ 、 $1A/\mu s$

AC ループ応答曲線

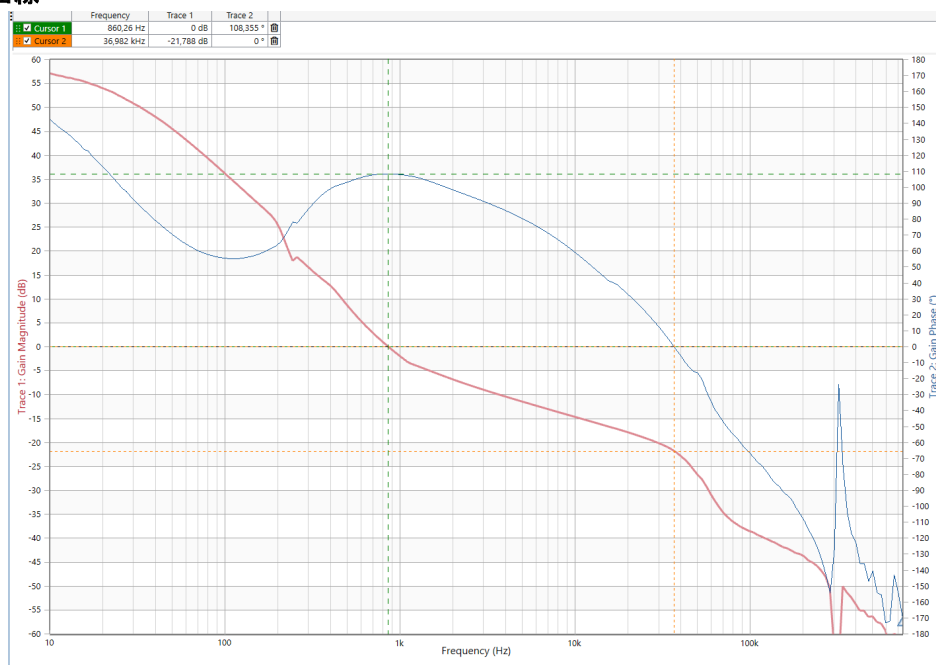
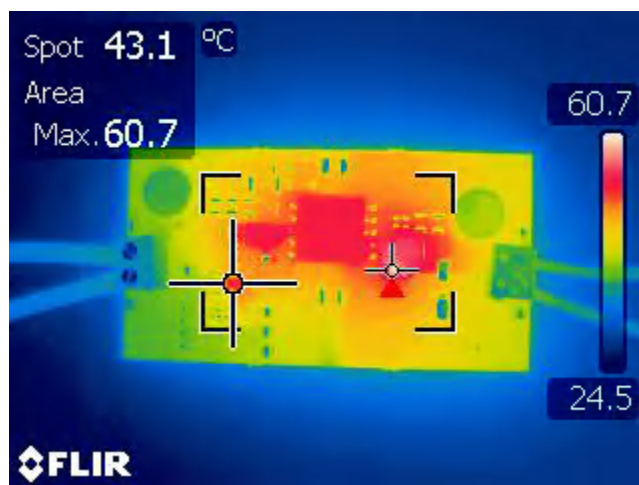
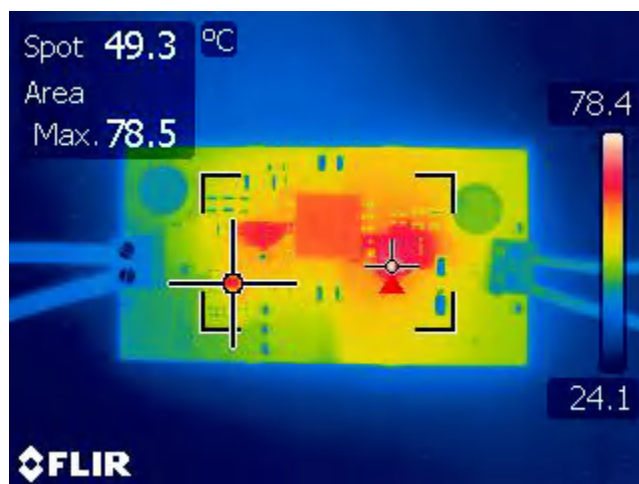


図 3-15. ボード線図、 $V_{IN} = 12V$ 、 $V_{OUT} = 20V$ 、 $I_{OUT} = 500mA$

熱性能

図 3-16. 温度測定、 $V_{IN} = 7V$ 、 $I_{OUT} = 500mA$ 図 3-17. 温度測定、 $V_{IN} = 12V$ 、 $I_{OUT} = 700mA$

4 ハードウェア設計ファイル

4.1 回路図

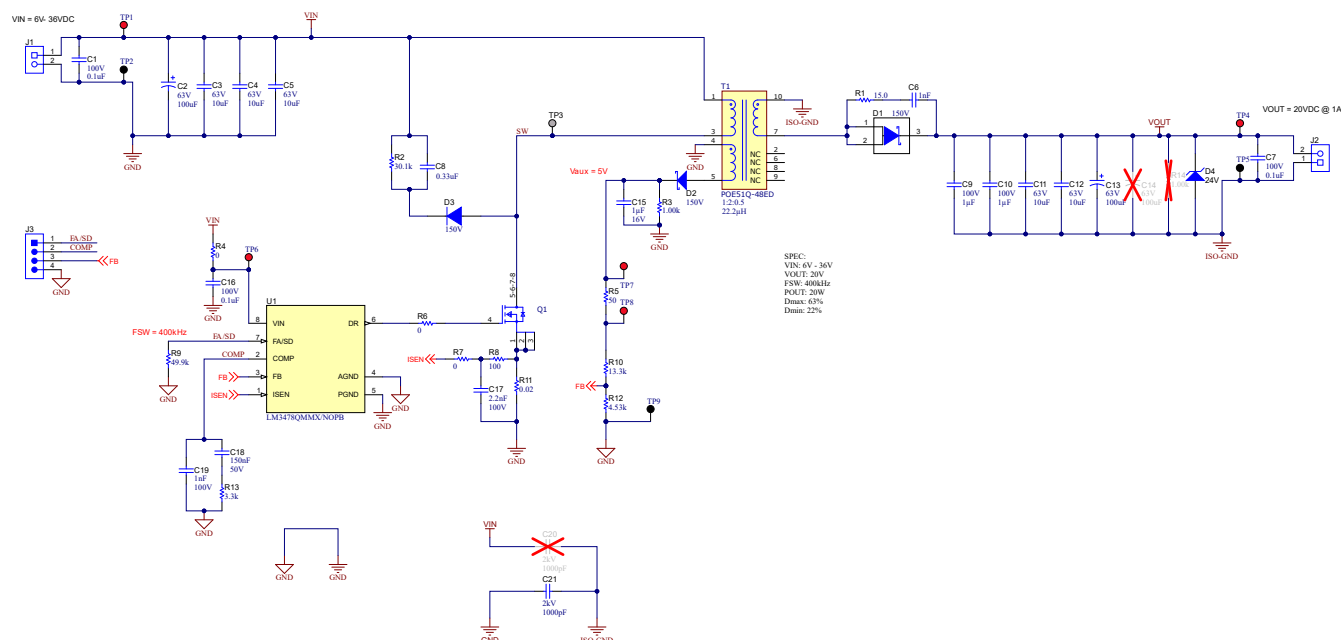


図 4-1. LM3478EVM-FLY 回路図

4.2 PCB のレイアウト

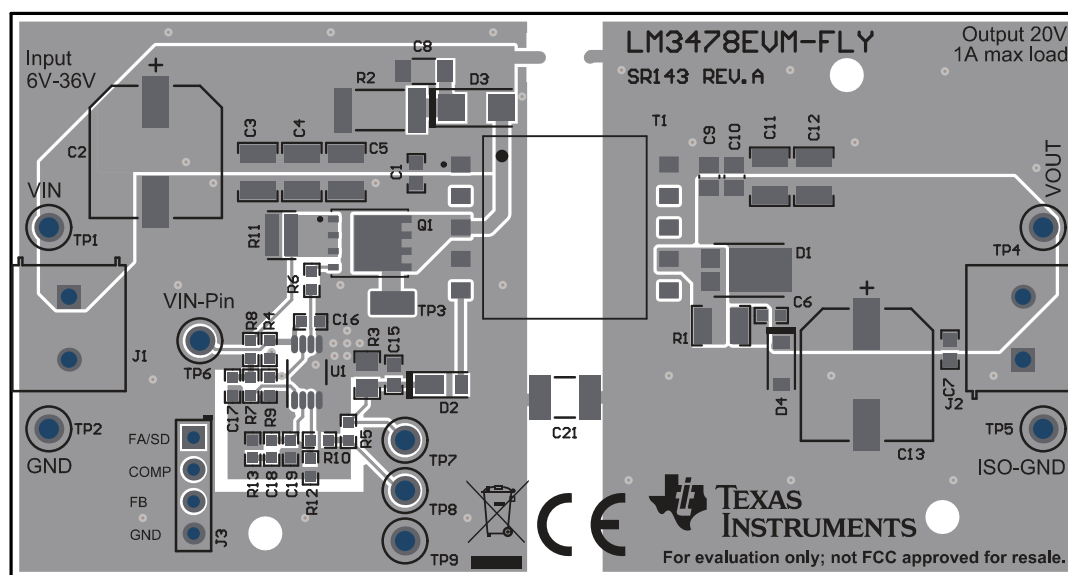


図 4-2. 上面シルク スクリーン

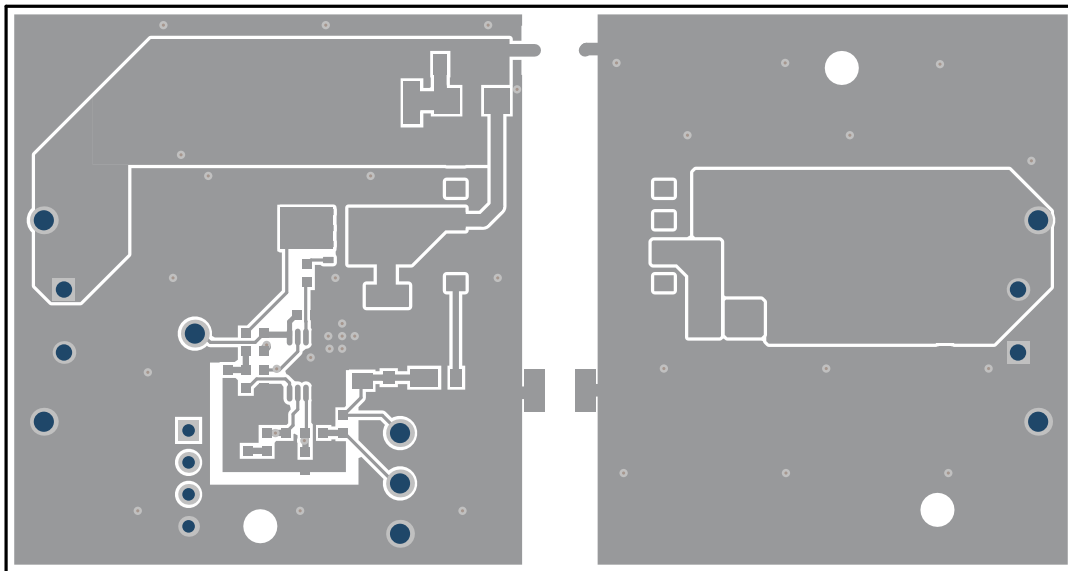


図 4-3. 上層

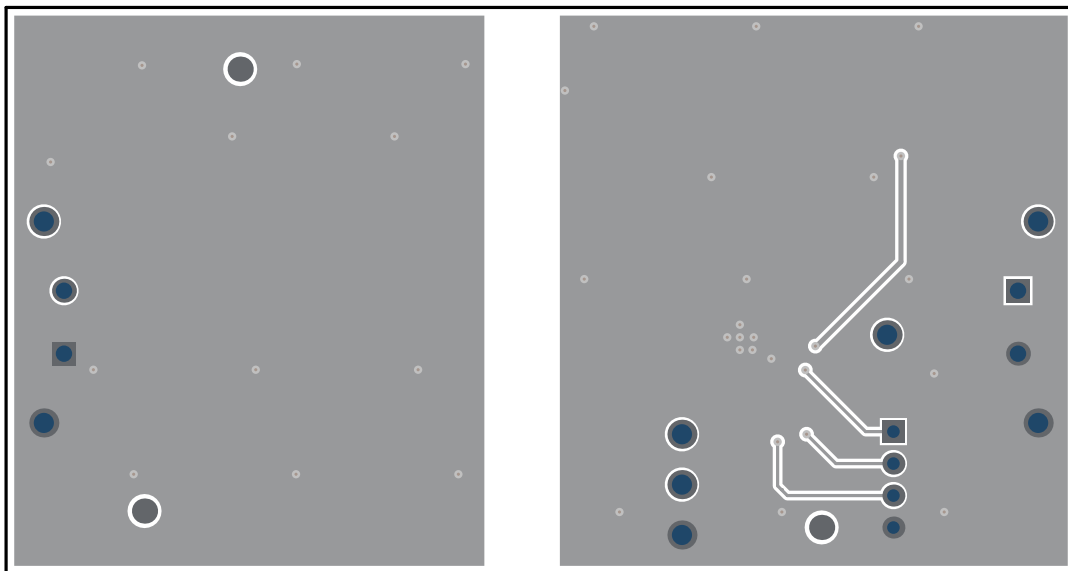


図 4-4. 下層

4.3 部品表 (BOM)

表 4-1. 部品表

参照記号	数量	値	部品番号	メーカー	説明
C1、C7、C16	3	0.1uF	CGA3E3X7S2A104K080AB	TDK	コンデンサ、セラミック、0.1uF、100V、±10%、X7S、AEC-Q200 グレード 1、0603
C2、C13	2	100uF	PCR1J101MCL1GS	Nichicon	CAP、アルミニウム ポリマー、100uF、63V、+/-20%、0.024ohm、SMD、2 リード、直径 10.5mm、ピン間隔 8mm SMD
C3、C4、C5、C11、C12	5	10uF	GRM32ER71H106KA12L	MuRata	コンデンサ、セラミック、10uF、50V、±10%、X7R、1210
C6、C19	2	1000pF	CGA3E2X7R2A102K080A A	TDK	コンデンサ、セラミック、1000pF、100V、±10%、X7R、AEC-Q200 グレード 1、0603
C8	1	0.33uF	C3216X7R2A334K130AA	TDK	コンデンサ、セラミック、0.33uF、100V、±10%、X7R、
C9、C10	2	1uF	KAF21KR72A105KU	AVX	コンデンサ、セラミック、1uF、100V、±10%、X7R、AEC-Q200 グレード 1、0805
C15	1	1uF	C1608X7R1C105K080AC	TDK	コンデンサ、セラミック、1uF、16V、±10%、X7R、0603
C17	1	2200pF	CGA3E2X7R2A222K080A A	TDK	コンデンサ、セラミック、2200pF、100V、±10%、X7R、AEC-Q200 グレード 1、0603
C18	1	0.15uF	CGA3E3X7R1H154K080A B	TDK	コンデンサ、セラミック、0.15uF、50V、±10%、X7R、AEC-Q200 グレード 1、0603
C21	1	1000pF	1812GC102KAT1A	AVX	コンデンサ、セラミック、1000pF、2000V、±10%、X7R、1812
D1	1	150V	PDS4150Q-13	Diodes Inc.	ダイオード、ショットキー、150V、4A、AEC-Q101、PowerDI5
D2	1	150V	DFLS1150-7	Diodes Inc.	ダイオード、ショットキー、150V、1A、PowerDI123
D3	1	150V	ES1C-13F	Diodes Inc.	ダイオード、超高速整流器、150V、1A、SMA
D4	1	24V	DDZ24C-7	Diodes Inc.	ダイオード、ツェナー、24V、500mW、SOD-123
FID4、FID5、FID6	3		該当なし	該当なし	フィデューシヤル マーク。購入または取り付け不要。
H1、H2、H3、H4	4		SJ61A1	3M	Bumpon、円筒形、0.312 × 0.200、黒
J1、J2	2		ED350/2	On-Shore Technology	端子ブロック、5mm、2 極、TH
J3	1		PEC04SAAN	Sullins Connector Solutions	ヘッダ、100mil、4x1、Tin、TH
Q1	1		BSC027N06LS5ATMA1	Infineon	N チャネル 60V 100A (Tc) 83W (Tc) 表面実装 PG-TDSON-8-7
R1	1	15	RC1210FR-0715RL	Yageo	抵抗、15.0、1%、0.5W、1210
R2	1	30.1k	CRCW251230K1FKEG	Vishay-Dale	RES、30.1k、1%、1W、AEC-Q200 グレード 0、2512
R3	1	1.00k	CRCW08051K00FKEA	Vishay-Dale	RES、1.00k、1%、0.125W、AEC-Q200 グレード 0、0805
R4、R6、R7	3	0	CRCW06030000Z0EA	Vishay-Dale	抵抗、0、5%、0.1W、AEC-Q200 グレード 0、0603
R5	1	50	CRCW060350R0FKEA	Vishay-Dale	抵抗、50、1%、0.1W、AEC-Q200 グレード 0、0603
R8	1	100	ERJ-3EKF1000V	Panasonic	抵抗、100、1%、0.1W、AEC-Q200 グレード 0、0603
R9	1	49.9k	ERJ-3EKF4992V	Panasonic	RES、49.9k、1%、0.1W、AEC-Q200 グレード 0、0603

表 4-1. 部品表 (続き)

参照記号	数量	値	部品番号	メーカー	説明
R10	1	13.3k	CRCW060313K3FKEA	Vishay-Dale	RES、13.3k、1%、0.1W、AEC-Q200 グレード 0、0603
R11	1	0.02	PRL1632R020F-T1	Susumu Co Ltd	抵抗、0.02、1%、1W、0612
R12	1	4.53k	CRCW06034K53FKEA	Vishay-Dale	RES、4.53k、1%、0.1W、AEC-Q200 グレード 0、0603
R13	1	3.3k	CRCW06033K30JNEA	Vishay-Dale	RES、3.3k、5%、0.1W、AEC-Q200 グレード 0、0603
T1	1		POE51Q-48ED	Coilcraft	フライバック トランス PoE 51W 22.2uH 48V 4.7A
TP1、TP4、TP6、TP7、TP8	5		5005	Keystone Electronics	テスト ポイント、コンパクト、レッド、TH
TP2、TP5、TP9	3		5006	Keystone Electronics	テスト ポイント、コンパクト、ブラック、TH
TP3	1		5017	Keystone Electronics	PC テスト ポイント、SMT
U1	1		LM3478QMMX/NOPB	テキサス インストルメンツ	スイッチング レギュレータ向け 40V、広い Vin 範囲、ローサイド N チャネル コントローラ、DGK0008A (VSSOP-8)

5 追加情報

5.1 商標

すべての商標は、それぞれの所有者に帰属します。

6 改訂履歴

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

Changes from Revision * (September 2026) to Revision A (September 2026)	Page
• 「説明」の誤字、表記を修正.....	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.
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 - 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.
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 - 2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

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

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

NOTE:

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

3 Regulatory Notices:

3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

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

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

CAUTION

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

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

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, 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/sds/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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東京都新宿区西新宿 6 丁目 2 4 番 1 号
西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/sds/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.

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7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.
10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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