

EVM User's Guide: LM3478EVM-FLY

LM3478 Evaluation Module



Description

The LM3478EVM-FLY evaluation module showcases a primary-side regulated flyback controller for wide input voltage range with fixed switching frequency of 400kHz. The PCB achieves high conversion efficiency and has 2 layers with components populated on 1 side.

Get Started

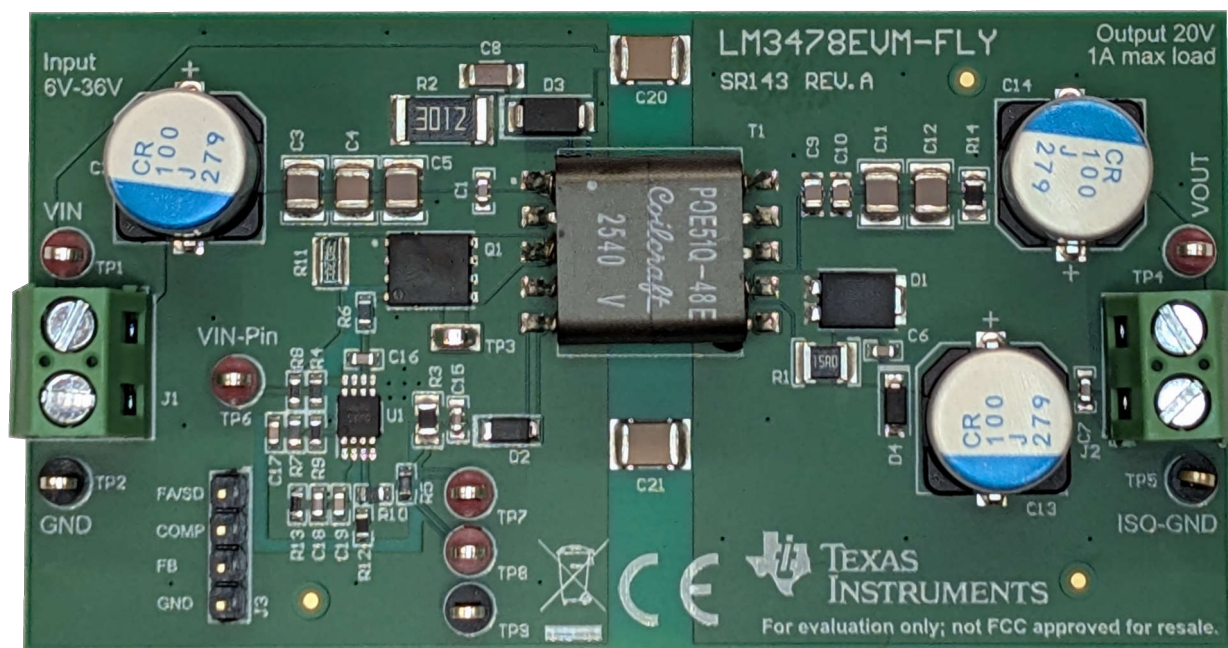
1. Connect the EVM to power supply and load.
2. Power up the application.

Features

- Primary-side regulated flyback controller
- Isolated 20V output voltage rail
- 14W output power
- Auxiliary winding regulated to 5V
- Programmable switching frequency
- Programmable cycle-by-cycle current limiting
- Shutdown pin

Applications

- Battery management system



LM3478EVM-FLY

1 Evaluation Module Overview

1.1 Introduction

The LM3478EVM-FLY evaluation module showcases the features and performance of the LM3478 as an isolated flyback controller with primary-side regulation and wide input voltage range. The standard configuration is designed to provide a regulate output of 20V at 700mA from an input of 7V to 36V, switching at 400kHz. The EVM provides an output voltage of 20V with 14W rated power. 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. No jumper settings are required for operation.

1.2 Kit Contents

- LM3478EVM-FLY PCB assembly
- EVM Disclaimer Read Me

1.3 Specification

Table 1-1. EVM Specification

Parameter	Condition	MIN	TYP	MAX	Unit
Input voltage	Operation	7	12	36	V
Output voltage	Load connected		20		V
Output power	$V_{IN} > 11V$			700	mA
	$V_{IN} > 7V$			500	mA
Switching frequency	$R9 = 49.9k\Omega$		400		kHz
Efficiency	$V_{IN} = 7V, I_{OUT} = 500mA$		86%		
	$V_{IN} = 12V, I_{OUT} = 700mA$		87%		

1.4 Device Information

The LM3478 is a versatile Low-Side N-Channel MOSFET controller for switching regulators. Current mode control provides superior bandwidth and transient response, besides cycle-by-cycle current limiting. The LM3478 has built-in features such as thermal shutdown, short-circuit protection, over voltage protection and power saving shutdown mode to reduce the total supply current to 5 μ A. Internal soft-start limits the inrush current at start-up.

2 Hardware

2.1 Header Information

The LM3478EVM-FLY provides headers and test points for measuring device signals and inject external signals to use the shutdown feature or perform small signal stability analysis.

Table 2-1. EVM Headers

Connector	Pin	Description
J1	1	Supply voltage (positive pole)
	2	Supply voltage (negative pole)
J2	1	Output voltage (negative pole)
	2	Output voltage (positive pole)
J3	1	FA/SD pin. Pull this pin above 1.4V to activate the device shutdown feature.
	2	COMP pin
	3	FB pin
	4	GND reference

2.2 Test Points

Table 2-2. EVM Test Points

Connector	Name	Description
TP1	V_{IN}	Test point for V_{IN}
TP2	GND (non-isolated)	Test point for GND
TP3	SW	Test point for switch node
TP4	V_{OUT}	Test point for V_{OUT}
TP5	GND (isolated)	Test point for GND
TP6	V_{IN} -Pin	If separated supplies for power stage and controller device are required, remove R4 and connect a second supply through this test point.
TP7	V_{AUX}^{+}	Test point for V_{AUX} , stability analysis injection
TP8	V_{AUX}^{-}	Stability analysis injection
TP9	GND (non isolated)	Test point for GND

3 Implementation Results

3.1 Evaluation Setup

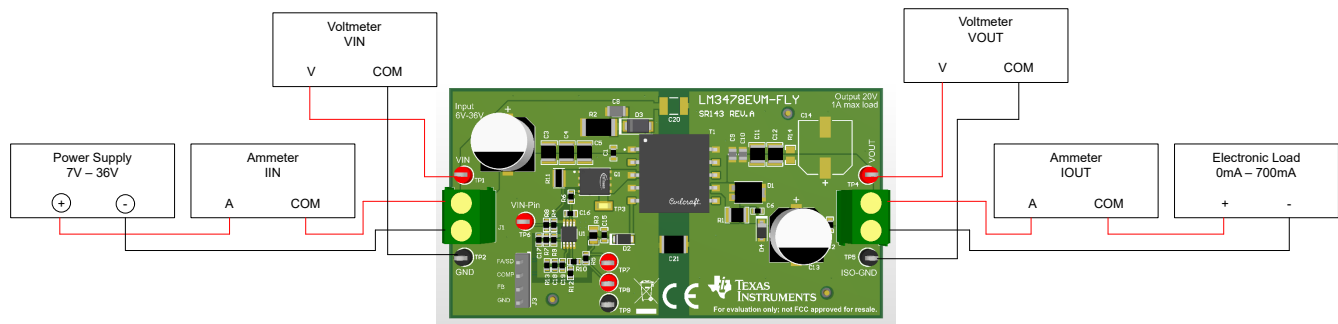


Figure 3-1. EVM Test Setup

Test Setup

The following test equipment is needed:

- Power supply
- Electronic (or resistive) load
- Oscilloscope: minimum 200MHz bandwidth
- Multi meters (optional)
 - Voltmeter 1 (V_{IN})
 - Voltmeter 2 (V_{OUT})
 - Ammeter 1 (I_{IN})
 - Ammeter 2 (I_{OUT})

Test Procedure

1. Connect the power supply and load to the according EVM connections following [Figure 3-1](#).
2. Set the power supply voltage to 12V and the electronic load to 0.1A. The electronic load voltage must be in regulation with a nominal 20V output.

Note

If the EVM is operation without load, there is risk of output voltage run-away due to primary-side regulation. TI does not recommend to operate the EVM under zero-load conditions. A Zener diode (D4) is populated at the output to prevent over voltage.

3. Change load current and input supply voltage as required.

3.2 Performance Data and Results

Efficiency

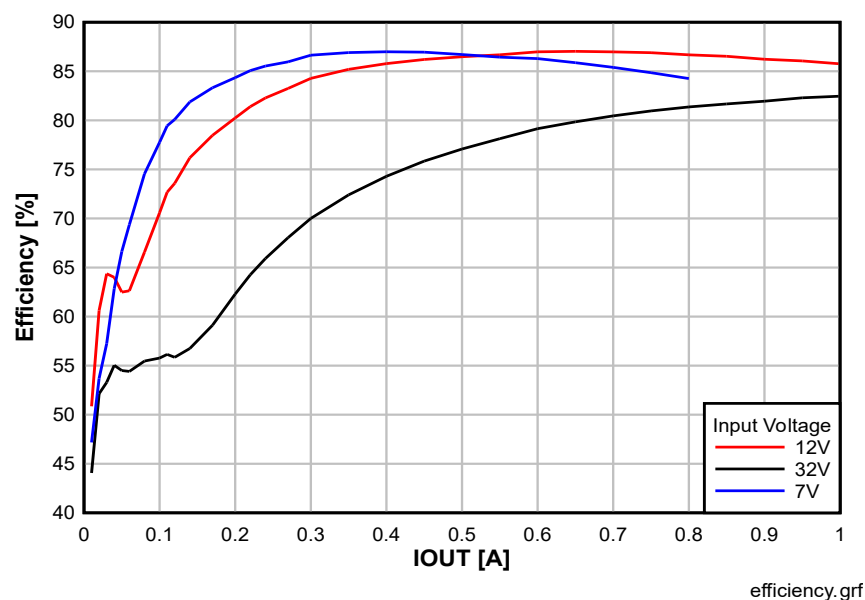


Figure 3-2. Efficiency vs. Output Current

Start-up Waveform

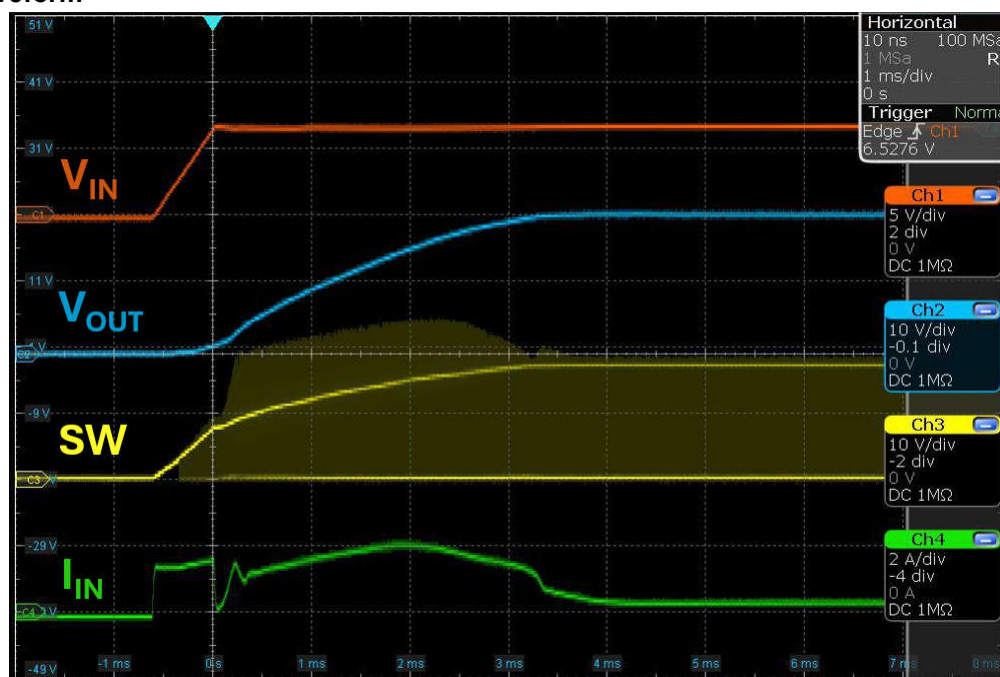


Figure 3-3. Start-up Waveform, $V_{IN} = 7V$, $I_{OUT} = 20mA$

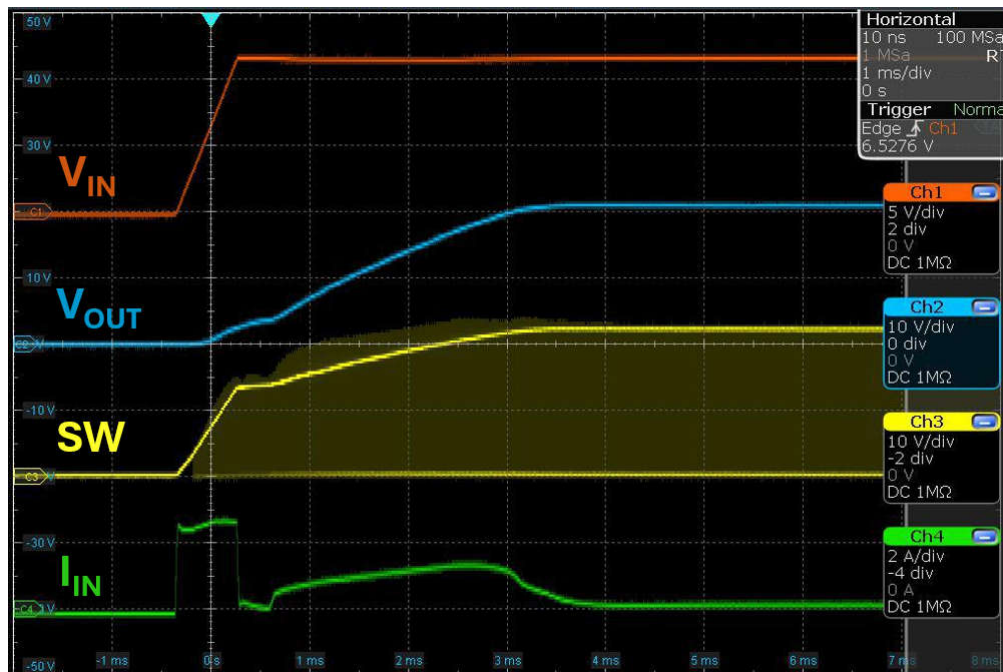


Figure 3-4. Start-up Waveform, $V_{IN} = 12V$, $I_{OUT} = 20mA$

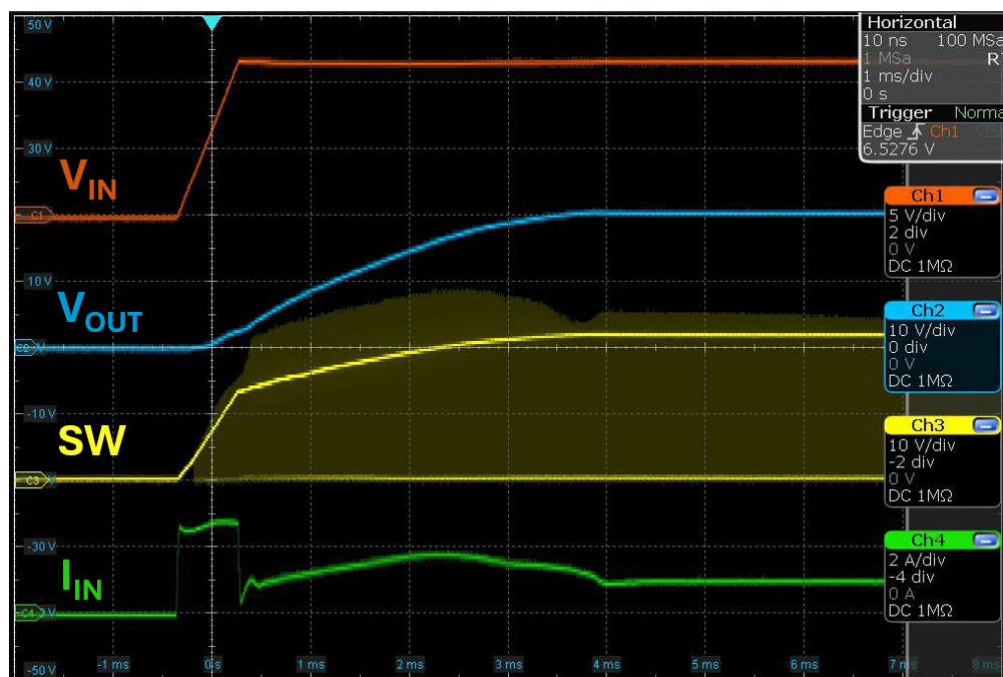


Figure 3-5. Start-up Waveform, $V_{IN} = 12V$, $I_{OUT} = 500mA$

Steady State Operation

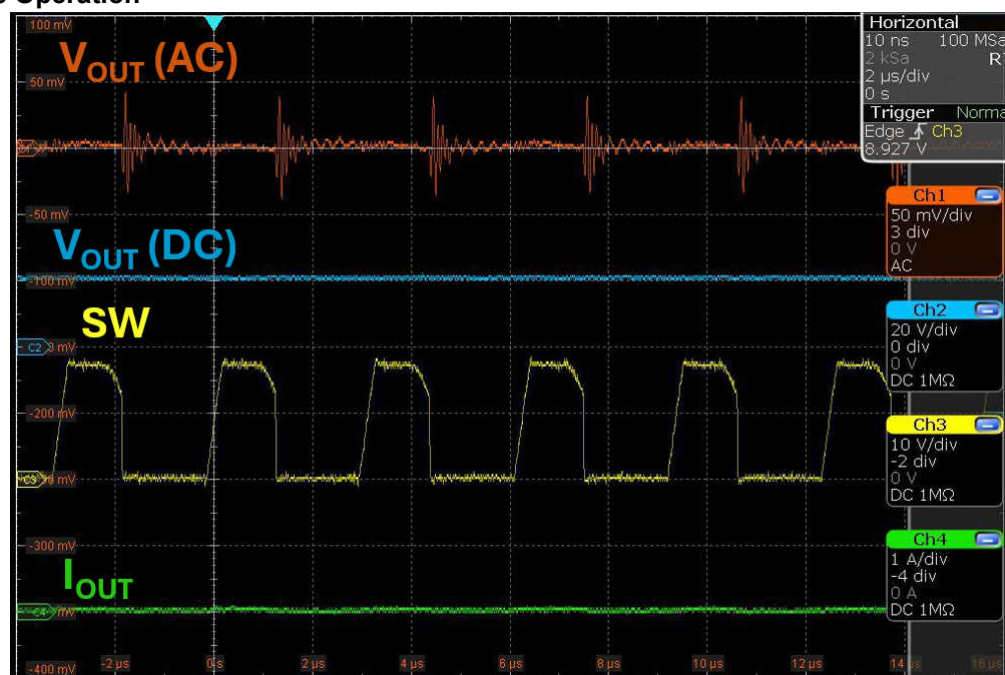


Figure 3-6. Steady State, $V_{IN} = 7V$, $I_{OUT} = 20mA$

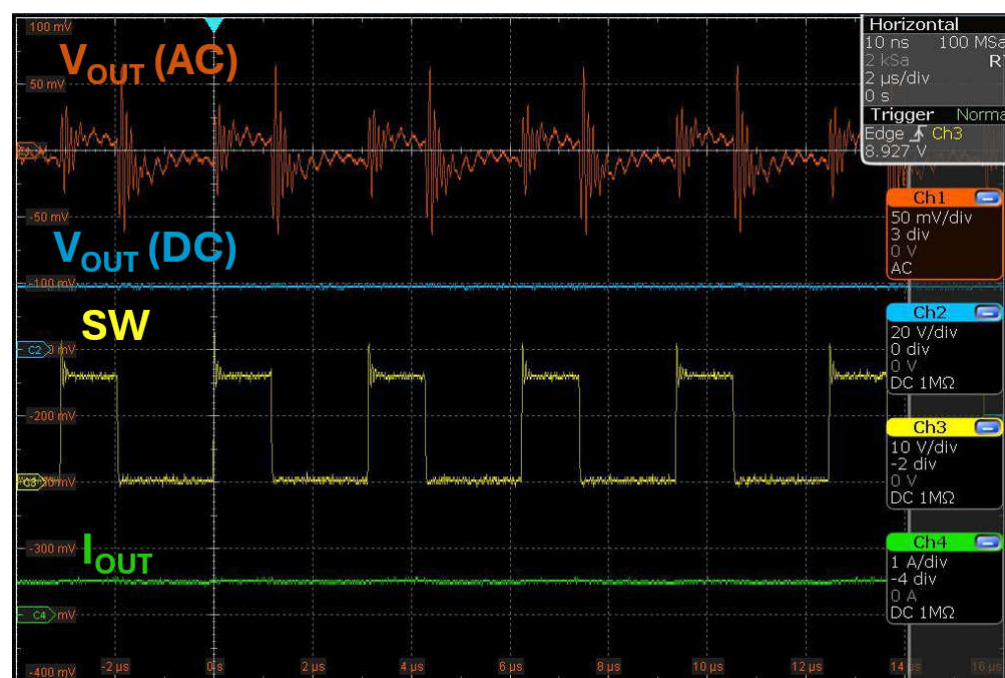


Figure 3-7. Steady State, $V_{IN} = 7V$, $I_{OUT} = 500mA$

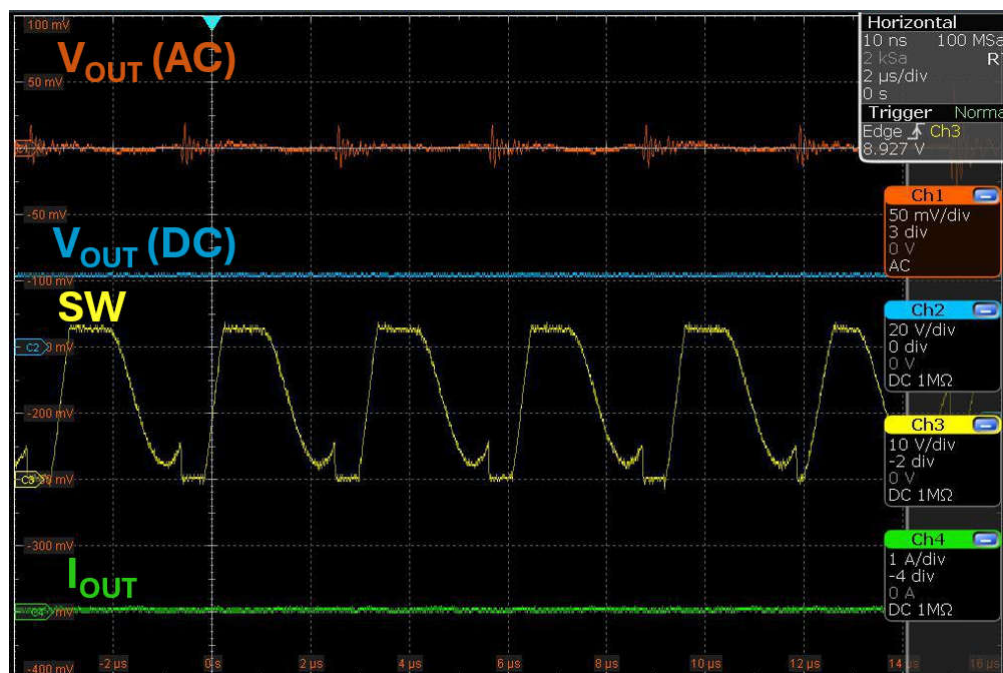


Figure 3-8. Steady State, $V_{IN} = 12V$, $I_{OUT} = 20mA$

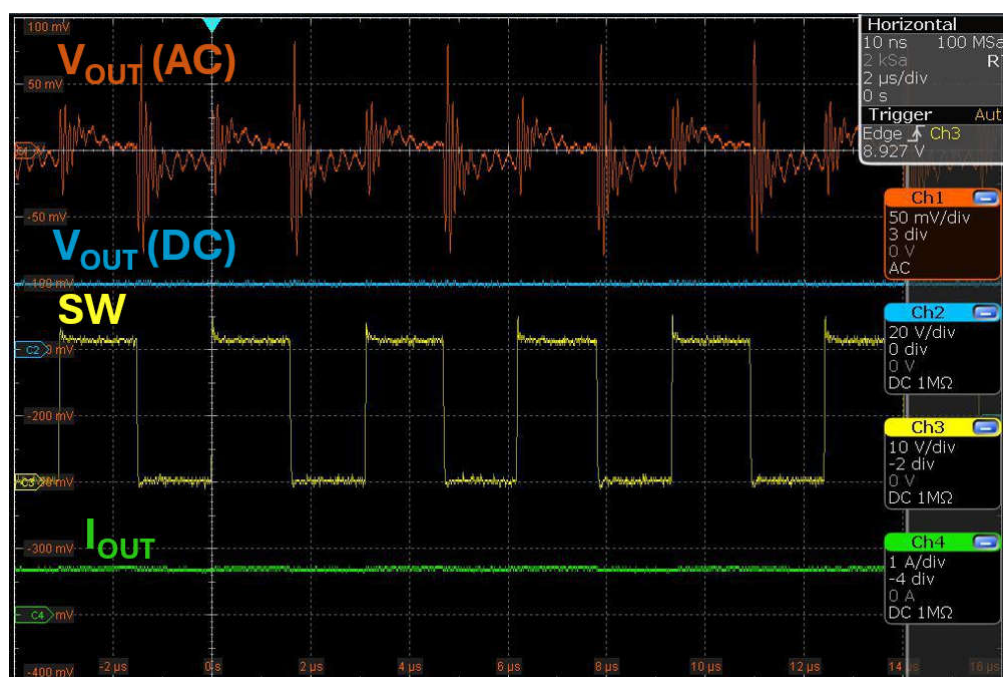


Figure 3-9. Steady State, $V_{IN} = 12V$, $I_{OUT} = 700mA$

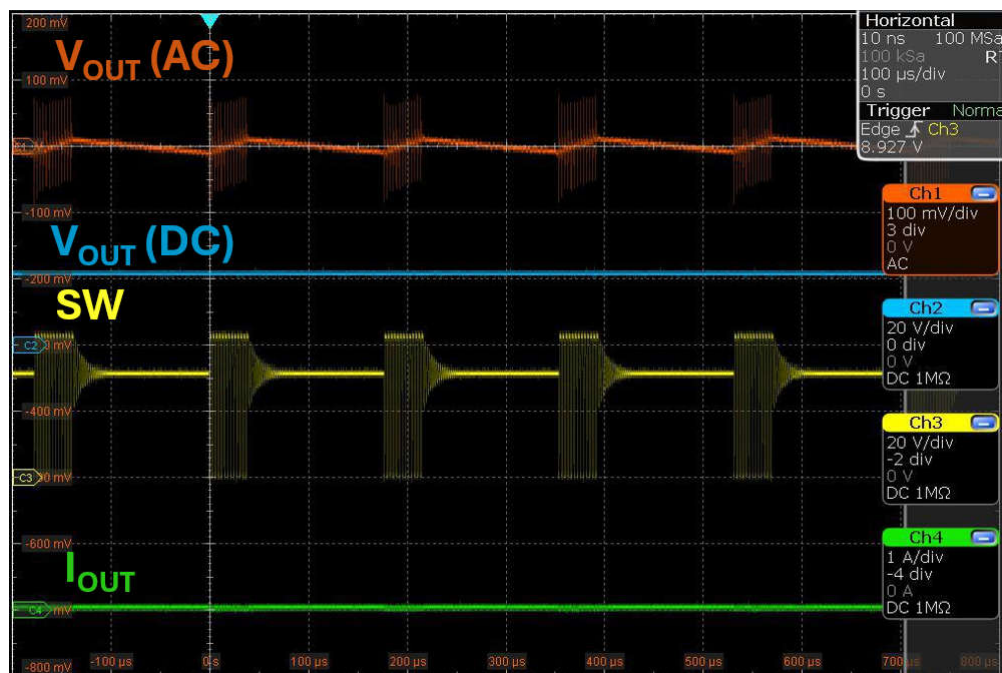


Figure 3-10. Steady State, $V_{IN} = 32V$, $I_{OUT} = 20mA$

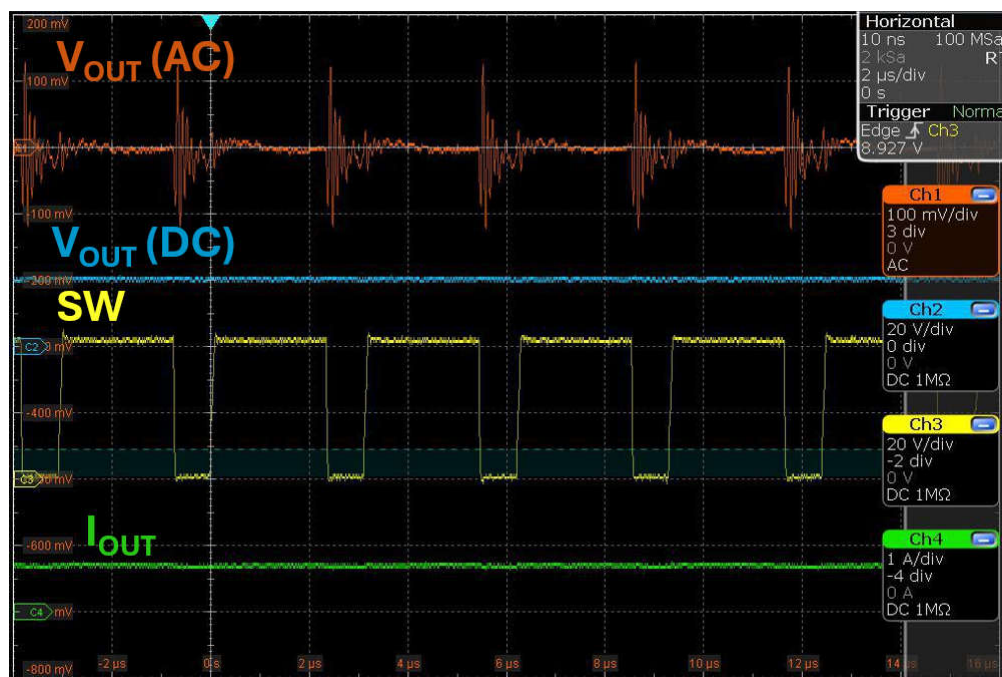


Figure 3-11. Steady State, $V_{IN} = 32V$, $I_{OUT} = 700mA$

Step Load Response

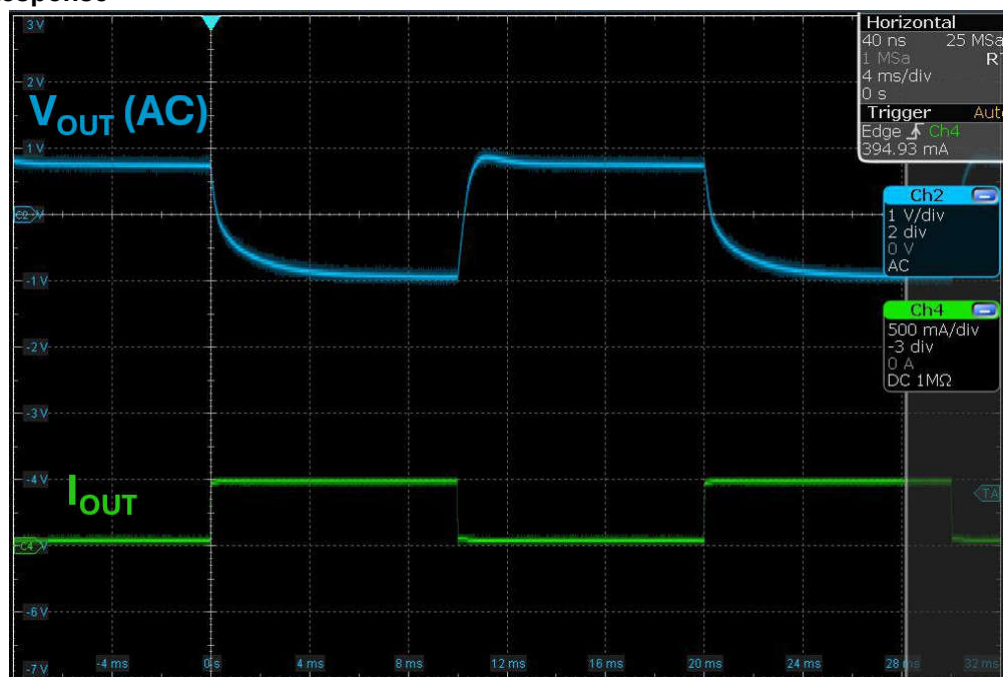


Figure 3-12. Load Transient, $V_{IN} = 7V$, $I_{OUT} = 0mA$ to 500mA at 1A/ μs

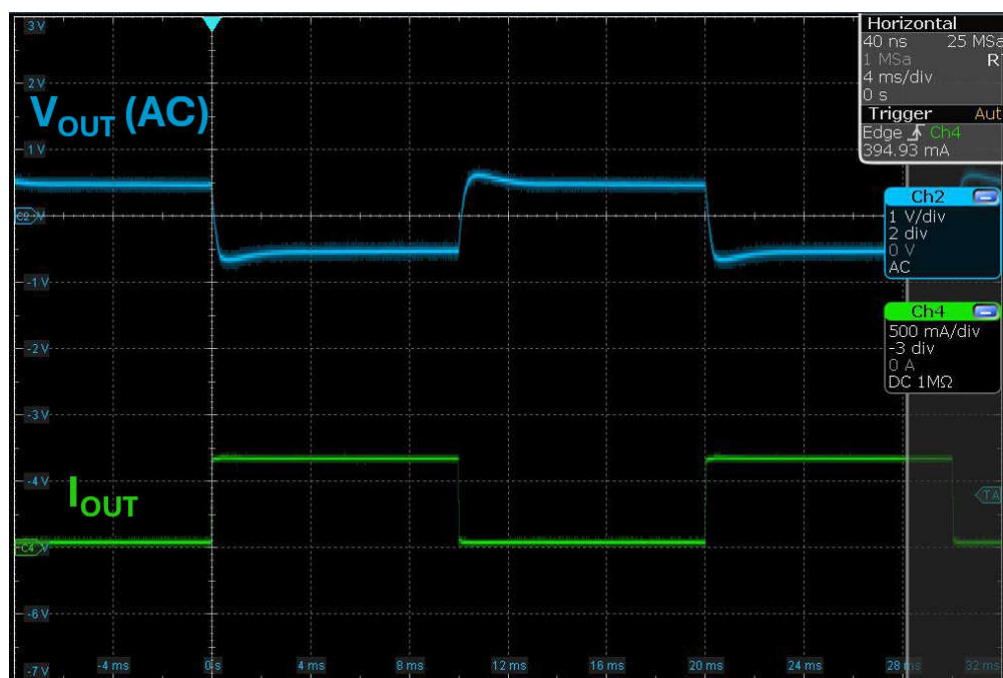


Figure 3-13. Load Transient, $V_{IN} = 12V$, $I_{OUT} = 0mA$ to 700mA at 1A/ μs

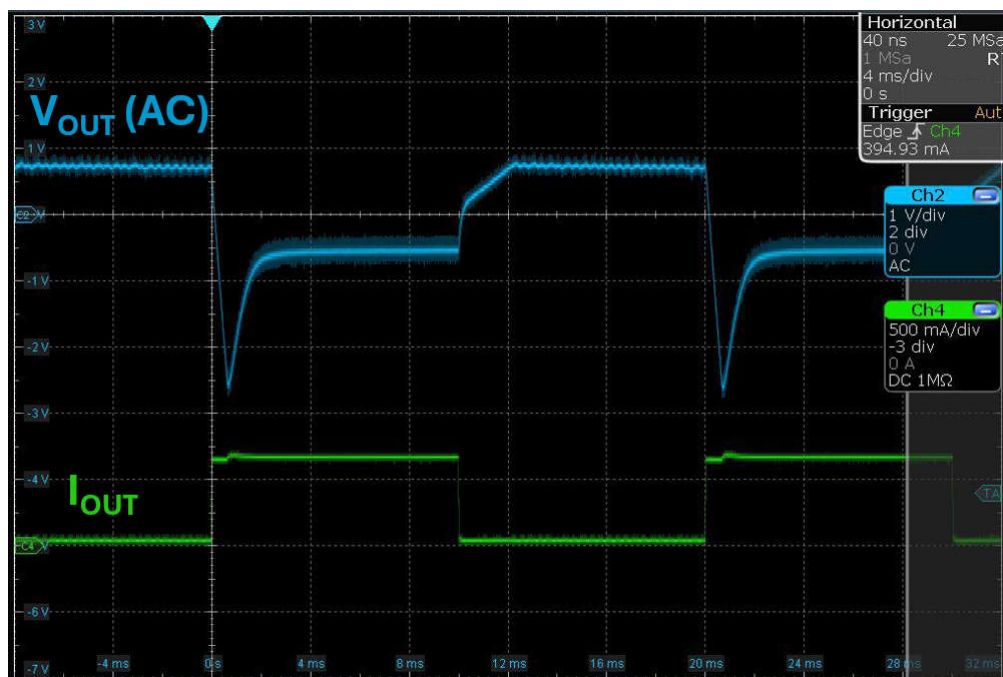


Figure 3-14. Load Transient, $V_{IN} = 32V$, $I_{OUT} = 0mA$ to $700mA$ at $1A/\mu s$

AC Loop Response Curve

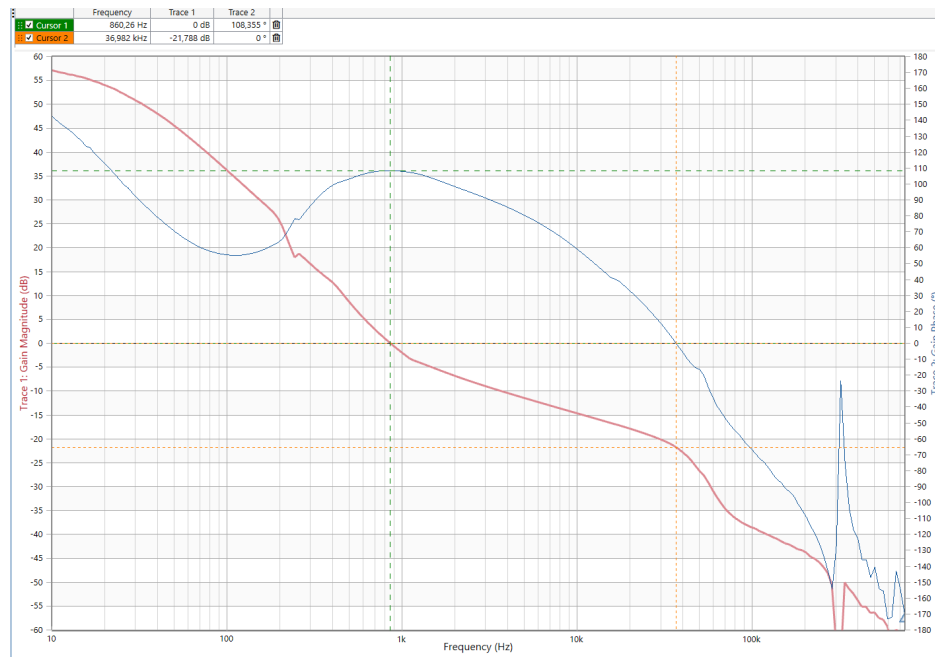
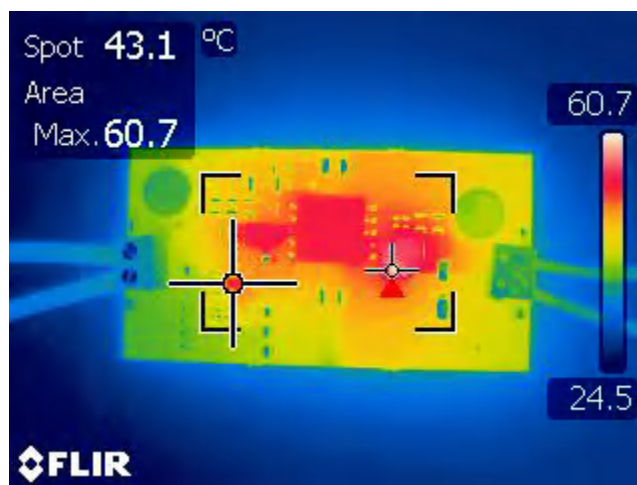
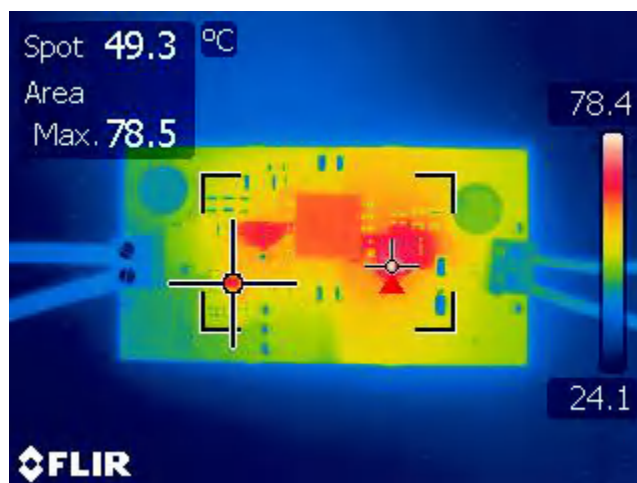


Figure 3-15. Bode Plot, $V_{IN} = 12V$, $V_{OUT} = 20V$, $I_{OUT} = 500mA$

Thermal Performance

Figure 3-16. Temperature Measurement, $V_{IN} = 7V$, $I_{OUT} = 500mA$ Figure 3-17. Temperature Measurement, $V_{IN} = 12V$, $I_{OUT} = 700mA$

4 Hardware Design Files

4.1 Schematics

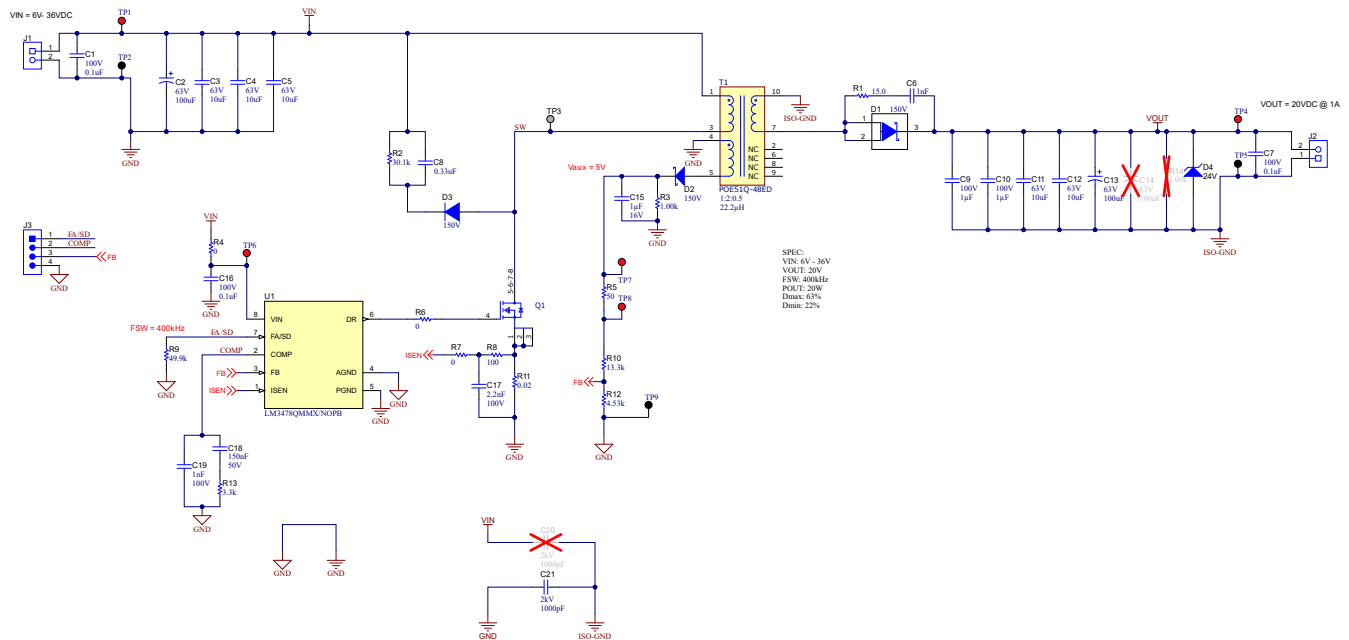


Figure 4-1. LM3478EVM-FLY Schematic

4.2 PCB Layouts

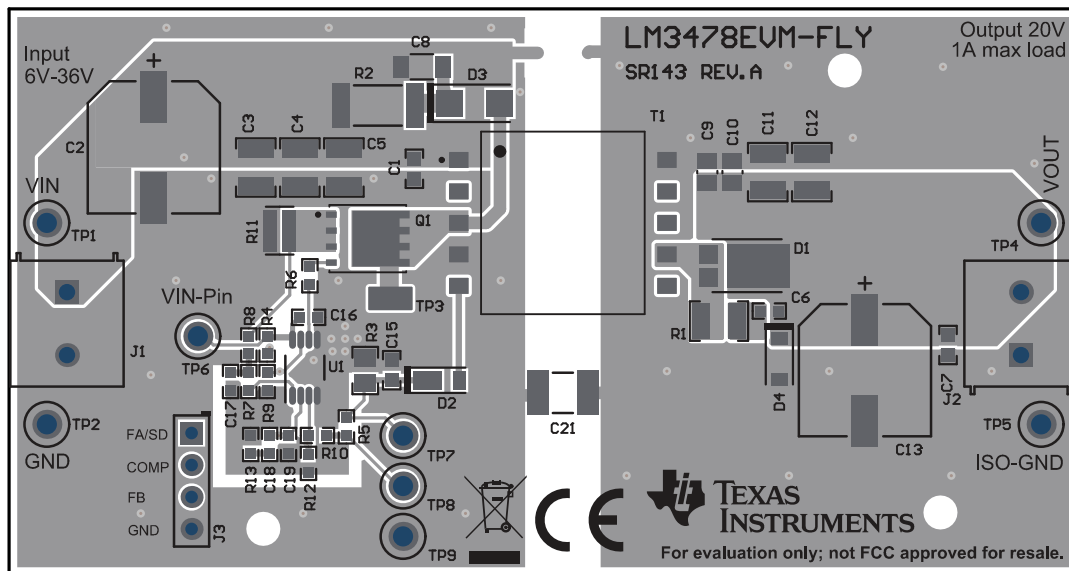
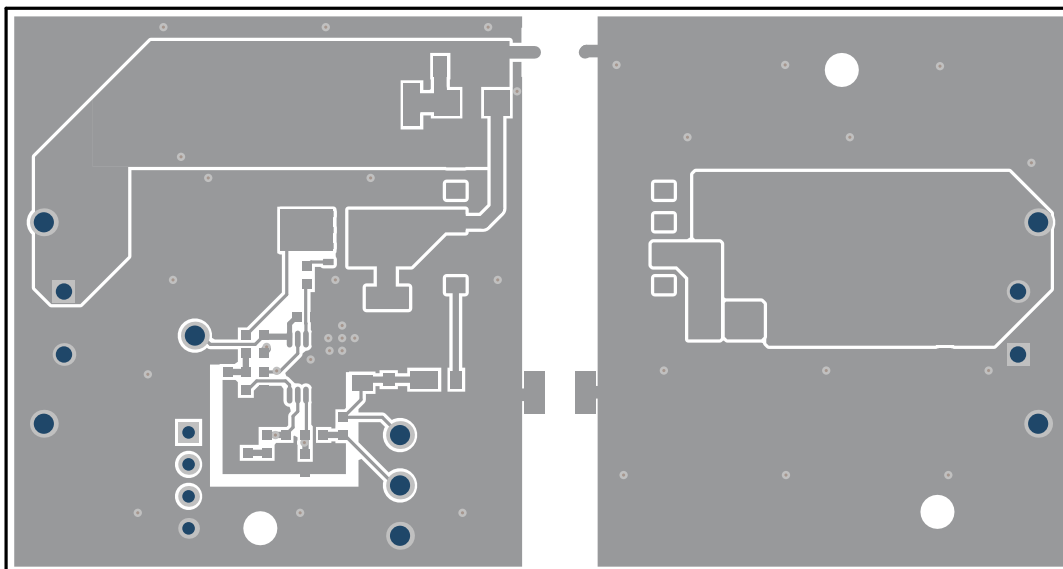
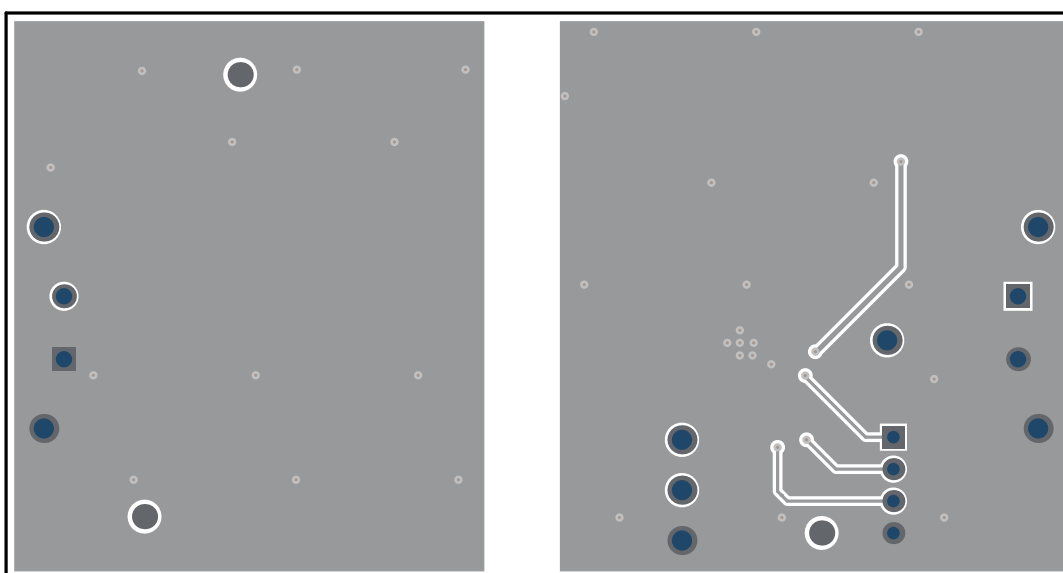


Figure 4-2. Top Layer Silk Screen

**Figure 4-3. Top Layer****Figure 4-4. Bottom Layer**

4.3 Bill of Materials (BOM)

Table 4-1. Bill of Materials

Reference Designator	Quantity	Value	Part Number	Manufacturer	Description
C1, C7, C16	3	0.1uF	CGA3E3X7S2A104K080AB	TDK	CAP, CERM, 0.1uF, 100V, +/- 10%, X7S, AEC-Q200 Grade 1, 0603
C2, C13	2	100uF	PCR1J101MCL1GS	Nichicon	CAP, Aluminum Polymer, 100uF, 63V, +/- 20%, 0.024ohm, SMD, 2-Leads, Dia 10.5mm, Pin Spacing 8mm SMD
C3, C4, C5, C11, C12	5	10uF	GRM32ER71H106KA12L	MuRata	CAP, CERM, 10uF, 50V, +/- 10%, X7R, 1210
C6, C19	2	1000pF	CGA3E2X7R2A102K080A A	TDK	CAP, CERM, 1000pF, 100V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603
C8	1	0.33uF	C3216X7R2A334K130AA	TDK	CAP, CERM, 0.33uF, 100V, +/- 10%, X7R,
C9, C10	2	1uF	KAF21KR72A105KU	AVX	CAP, CERM, 1uF, 100V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805
C15	1	1uF	C1608X7R1C105K080AC	TDK	CAP, CERM, 1uF, 16V, +/- 10%, X7R, 0603
C17	1	2200pF	CGA3E2X7R2A222K080A A	TDK	CAP, CERM, 2200pF, 100V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603
C18	1	0.15uF	CGA3E3X7R1H154K080A B	TDK	CAP, CERM, 0.15uF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603
C21	1	1000pF	1812GC102KAT1A	AVX	CAP, CERM, 1000pF, 2000V, +/- 10%, X7R, 1812
D1	1	150V	PDS4150Q-13	Diodes Inc.	Diode, Schottky, 150V, 4A, AEC-Q101, PowerDI5
D2	1	150V	DFLS1150-7	Diodes Inc.	Diode, Schottky, 150V, 1A, PowerDI123
D3	1	150V	ES1C-13F	Diodes Inc.	Diode, Superfast Rectifier, 150V, 1A, SMA
D4	1	24V	DDZ24C-7	Diodes Inc.	Diode, Zener, 24V, 500mW, SOD-123
FID4, FID5, FID6	3		N/A	N/A	Fiducial mark. There is nothing to buy or mount.
H1, H2, H3, H4	4		SJ61A1	3M	Bumpon, Cylindrical, 0.312X 0.200, Black
J1, J2	2		ED350/2	On-Shore Technology	Terminal Block, 5mm, 2-pole, TH
J3	1		PEC04SAAN	Sullins Connector Solutions	Header, 100mil, 4x1, Tin, TH
Q1	1		BSC027N06LS5ATMA1	Infineon	N-channel 60V 100A (Tc) 83W (Tc) Surface Mount PG-TDSON-8-7
R1	1	15	RC1210FR-0715RL	Yageo	RES, 15.0, 1%, 0.5W, 1210
R2	1	30.1k	CRCW251230K1FKEG	Vishay-Dale	RES, 30.1k, 1%, 1W, AEC-Q200 Grade 0, 2512
R3	1	1.00k	CRCW08051K00FKEA	Vishay-Dale	RES, 1.00k, 1%, 0.125W, AEC-Q200 Grade 0, 0805
R4, R6, R7	3	0	CRCW06030000Z0EA	Vishay-Dale	RES, 0, 5%, 0.1W, AEC-Q200 Grade 0, 0603
R5	1	50	CRCW060350R0FKEA	Vishay-Dale	RES, 50, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R8	1	100	ERJ-3EKF1000V	Panasonic	RES, 100, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R9	1	49.9k	ERJ-3EKF4992V	Panasonic	RES, 49.9k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R10	1	13.3k	CRCW060313K3FKEA	Vishay-Dale	RES, 13.3k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R11	1	0.02	PRL1632R020F-T1	Susumu Co Ltd	RES, 0.02, 1%, 1W, 0612
R12	1	4.53k	CRCW06034K53FKEA	Vishay-Dale	RES, 4.53k, 1%, 0.1W, AEC-Q200 Grade 0, 0603

Table 4-1. Bill of Materials (continued)

Reference Designator	Quantity	Value	Part Number	Manufacturer	Description
R13	1	3.3k	CRCW06033K30JNEA	Vishay-Dale	RES, 3.3k, 5%, 0.1W, AEC-Q200 Grade 0, 0603
T1	1		POE51Q-48ED	Coilcraft	Transformers Flyback PoE 51W 22.2uH 48V 4.7A
TP1, TP4, TP6, TP7, TP8	5		5005	Keystone Electronics	Test Point, Compact, Red, TH
TP2, TP5, TP9	3		5006	Keystone Electronics	Test Point, Compact, Black, TH
TP3	1		5017	Keystone Electronics	PC Test Point, SMT
U1	1		LM3478QMMX/NOPB	Texas Instruments	40V Wide Vin Low-Side N-Channel Controller for Switching Regulators, DGK0008A (VSSOP-8)

5 Additional Information

5.1 Trademarks

All trademarks are the property of their respective owners.

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 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.

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2. 実験局の免許を取得後ご使用いただく。
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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

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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.

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