User's Guide

LM5168FEVM EVM User's Guide

ABSTRACT

The LM5168FEVM is a 115-V DC/DC fly-buck regulator that employs synchronous rectification to achieve high conversion efficiency in a small footprint. The EVM operates over a wide input voltage range of 20 V to 115 V (120-V absolute maximum) to provide a regulated 10-V output at up to 0.25 A with a 750-kHz switching frequency. An additional 10-V floating output is provided through the fly-buck topology. The output voltage has better than 1.5% set-point accuracy and is adjustable using an external resistor divider. The module design uses the LM5168F-Q1 synchronous buck converter with wide input voltage range, wide duty-cycle range, integrated high-side and low-side power MOSFETs, advanced overcurrent protection, and precision enable. With AEC-Q100 grade 1 automotive qualification, the LM5168F-Q1 is rated to operate over a junction temperature range of –40°C to +150°C.

Table 1-1. EVM Configuration

EVM	CONVERTER IC	PACKAGE
LM5168FEVM	LM5168F-Q1	8-pin SO package with PowerPAD (4.89 mm × 3.90 mm)

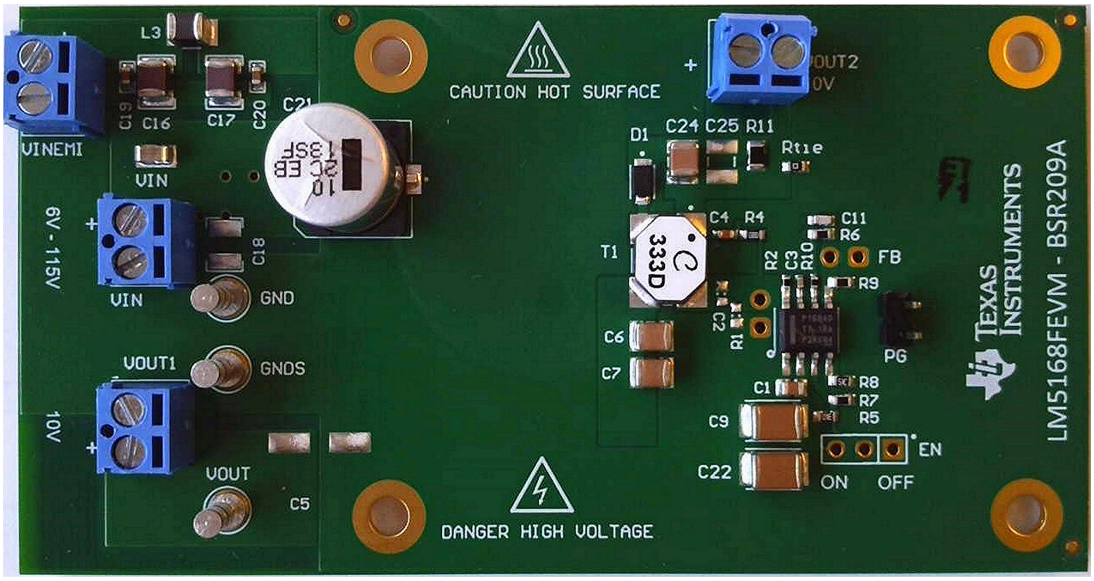


Table of Contents

List of Figures

List of Tables

Trademarks

PowerPAD™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

1 General TI High Voltage Evaluation User Safety Guidelines

Always follow TI's set-up and application instructions, including use of all interface components within their recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure your personal safety and the safety of those working around you. Contact TI's Product Information Center http://support.ti.com for further information.

Save all warnings and instructions for future reference.

Failure to follow warnings and instructions may result in personal injury, property damage, or death due to electrical shock and/or burn hazards.

The term TI HV EVM refers to an electronic device typically provided as an open-framed, unenclosed printed-circuit board assembly. It is intended strictly for use in development laboratory environments, solely for qualified professional users having training, expertise, and knowledge of electrical safety risks in development and application of high-voltage electrical circuits. Any other use and/or application are strictly prohibited by Texas Instruments. If you are not suitably qualified, you should immediately stop from further use of the HV EVM.

- **Work Area Safety:**
  - Maintain a clean and orderly work area.
  - A qualified observer or observers must be present any time circuits are energized.
  - Effective barriers and signage must be present in the area where the TI HV EVM and its interface electronics are energized, indicating operation of accessible high voltages can be present, for the purpose of protecting inadvertent access.
  - All interface circuits, power supplies, evaluation modules, instruments, meters, scopes, and other related apparatus used in a development environment exceeding 50 V_{RMS}/75 VDC must be electrically located within a protected Emergency Power Off (EPO) protected power strip.
  - Use a stable and non-conductive work surface.
  - Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.
- **Electrical Safety:**

  As a precautionary measure, it is always a good engineering practice to assume that the entire EVM can have fully accessible and active high voltages.

  - De-energize the TI HV EVM and all its inputs, outputs, and electrical loads before performing any electrical or other diagnostic measurements. Confirm that TI HV EVM power has been safely de-energized.
  - With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment hook-ups, and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
  - When EVM readiness is complete, energize the EVM as intended.

WARNING

WARNING: While the EVM is energized, never touch the EVM or its electrical circuits as they could be at high voltages capable of causing electrical shock hazard.

- **Personal Safety:**
  - Wear personal protective equipment, for example, latex gloves, safety glasses with side shields, or both, or protect EVM in an adequate lucent plastic box with interlocks from accidental touch.
- **Limitation for Safe Use:**
  - EVMs are not to be used as all or part of a production unit.

Safety and Precautions

The EVM is designed for professionals who have received the appropriate technical training, and is designed to operate from an AC power supply or a high-voltage DC supply. Please read this user's guide and the safety-related documents that come with the EVM package before operating this EVM.

CAUTION

Do not leave the EVM powered when unattended.

WARNING

Hot surface! Contact may cause burns. Do not touch!

WARNING

High Voltage! Electric shock is possible when connecting board to live wire. Board should be handled with care by a professional.
For safety, use of isolated test equipment with overvoltage and overcurrent protection is highly recommended.

2 EVM Characteristics

Unless otherwise specified, the following conditions apply: T_A = 25ºC, I_{OUT1} = primary output current, I_{OUT2} = secondary output current

Table 2-1. LM5168FQEVM Electrical Performance Characteristics

Parameter	Test Conditions		MIN	TYP	MAX	UNITS
INPUT CHARACTERISTICS						
Input voltage range, V_{VIN}	EVM input voltage operating range		20	48	115	V
Input voltage turn-on, $V_{IN(ON)}$	Adjusted by EN/UVLO resistors			6.0		V
Input voltage turn-off, $V_{IN(OFF)}$				5.6		V
Input voltage hysteresis, $V_{IN(HYS)}$				0.4		V
Input current, no load, $I_{IN(NL)}$	I_{OUT} = 0 A	V_{IN} = 48 V		13		mA
Input current, disabled, $I_{IN(OFF)}$	$V_{EN/UVLO}$ = 0 V, no EN divider	V_{IN} = 36 V		10		µA
OUTPUT CHARACTERISTICS						
Output voltage, V_{OUT1}	V_{IN} = 48 V, I_{OUT1} = I_{OUT2} = 0A			10.0		V
Output voltage, V_{OUT2}	V_{IN} = 48 V, I_{OUT1}=0 A, I_{OUT2} = 0A			10.0		
Output current, I_{OUT1}	V_{IN} = 48 V, I_{OUT2} = 0 A			0.25		A
Output current, I_{OUT2}	V_{IN} = 48 V, I_{OUT1} = 0 A			0.25		A
Output voltage regulation, ΔV_{OUT1}	Load regulation, V_{IN} = 48 V	I_{OUT1} = 0 A to 0.25 A, I_{OUT2} = 0 A		1		mV
Output voltage regulation, ΔV_{OUT2}	Load regulation, V_{IN} = 48 V	I_{OUT1} = 0 A to 0.25 A, I_{OUT2} = 0 A		200		
Output voltage regulation, ΔV_{OUT1}	Load regulation, V_{IN} = 48 V	I_{OUT2} = 0 A to 0.25 A, I_{OUT1} = 0 A		7		
Output voltage regulation, ΔV_{OUT2}	Load regulation, V_{IN} = 48 V	I_{OUT2} = 0 A to 0.25 A, I_{OUT1} = 0 A		1000		
Output voltage regulation, ΔV_{OUT1}	Line regulation, I_{OUT1} = I_{OUT2} = 0 A	V_{IN} = 24 V to 115 V		50		
Output voltage regulation, ΔV_{OUT2}	Line regulation, I_{OUT1} = I_{OUT2} = 0 A	V_{IN} = 24 V to 115 V		750		
Maximum output current from primary output	V_{IN} = 48 V, I_{OUT2} = 0 A			0.27		A
Soft-start time, t_{SS}				3.5		ms
SYSTEM CHARACTERISTICS						
Switching frequency	V_{IN} = 36 V, I_{OUT1} = 0 A , I_{OUT2} = 0 A			730		kHz
Half-load efficiency	I_{OUT1} = I_{OUT2} = 0.08 A	V_{IN} = 48 V		70%		
Full load efficiency	I_{OUT1} = I_{OUT2} = 0.125 A	V_{IN} = 48 V		76%		
		V_{IN} = 60 V		72%		

3 LM5168FEVM Evaluation Module

The LM5168FEVM is configured to deliver a regulated 10-V output, 0.25 A at 750-kHz switching frequency, and an additional 10-V floating output. The LM5168 uses a COT control architecture, with input voltage feedforward to provide a constant frequency regulator with tightly regulated output voltage. This type of control requires adequate voltage ripple at the FB input to achieve stable regulation. The LM5168FEVM is set up with type III ripple injection to minimize the output voltage ripple while ensuring a stable regulator. The LM5168FEVM also provides the option to use type I or type II ripple injection. See the *LM516x-Q1 0.65/0.3-A, 120-V Step-Down Converter w/ Fly-Buck Converter Capability Data Sheet* for more information. An overall view of the LM516FEVM and the schematic are shown in Figure 3-1 and Figure 4-1, respectively.

3.1 Quick Start Procedure

1. Connect the input voltage supply to the VIN connector (+ and –).
2. Connect the load or loads to the VOUT and the VOUT2 connectors (+ and –).
3. Set the input supply voltage to an appropriate level between 20 V to 115 V.
4. Turn on the power supply. The EVM powers up and provides V_{OUT} = 10 V, and V_{OUT2} = 10 V.

See Figure 3-1 for the location of the connectors.

CAUTION

Caution Hot surface.
Contact may cause burns.
Do not touch.

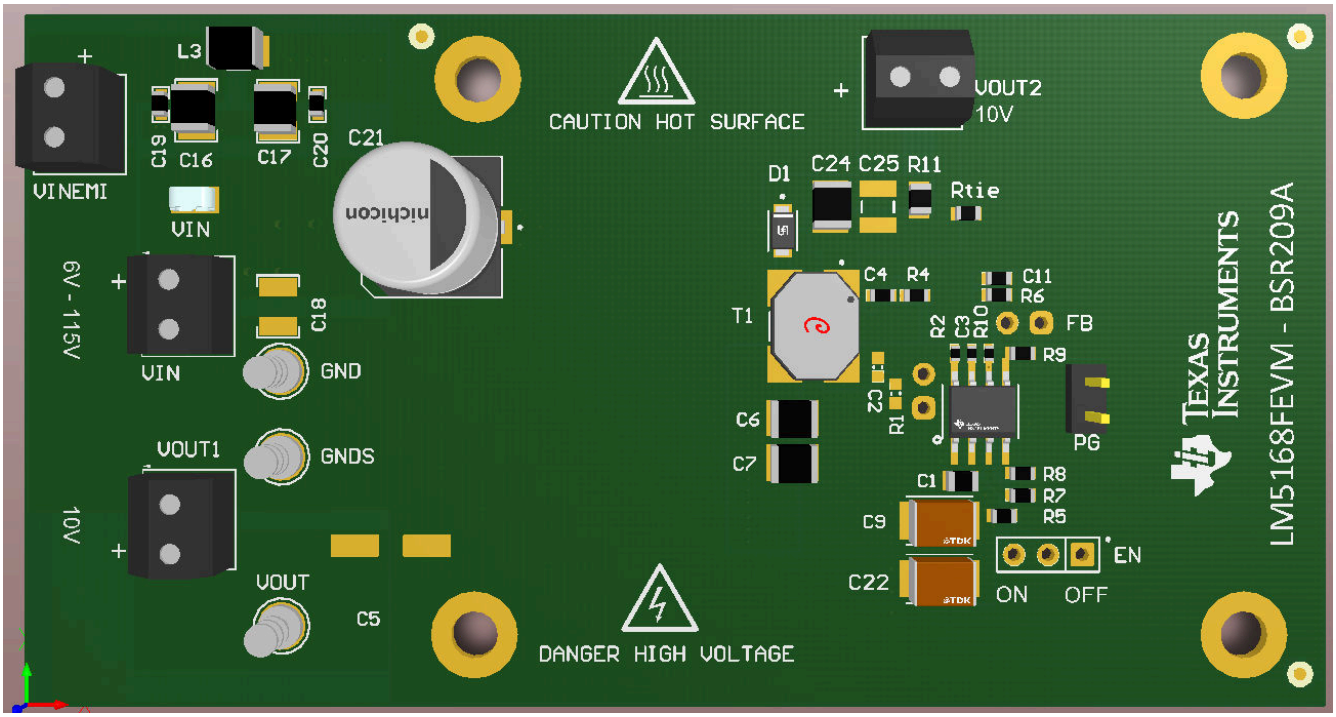


Figure 3-1. LM5168FEVM Top View

3.2 Detailed Descriptions

This section describes the connectors and the test points on the EVM and how to properly connect, set up, and use the LM5168FEVM EVM. See Figure 3-1 for location of connectors and jumpers.

VOUT Output voltage of the converter

VOUT screw terminal connector. Apply load to this connector (+ and –). The VOUT test point is used to monitor output voltage.

VOUT2 Secondary output voltage of the converter

VOUT2 screw terminal connector. One side of this output is connected to the primary ground (GND) through a tie resistor, R_{tie} (R12). This resistor can be removed for a true floating voltage source. Apply load to this connector (+ and –).

GND Ground of the converter

GND and GNDS test points. Used as ground test points for the EVM.

VIN Input voltage to the converter

VIN screw terminal connector. Apply input voltage to this connector (+ and –). The VIN test point is used to monitor input voltage.

VINEMI Input voltage to input filter of the converter

If it is desired to use the built-in EMI filter on the EVM, then connect the input supply to the VINEMI screw terminal connector (+ and –).

Input Filter EMI mitigation

An input EMI filter is provided on the EVM. Note L2 and C18 are not populated and must be installed for the EMI filter to operate. Also, note that the maximum input voltage to the filter is 100 V_{DC}.

EN/UVLO Jumper Set EN/UVLO pin options

Use this jumper to enable/disable the EVM. The resistors connected to this pin set the input UVLO thresholds. Input UVLO thresholds are set to approximately 6 V and 5.6 V. These levels can be changed by changing the values of R5 and R7. For external control of the device, these resistors should be removed and the control signal applied to the center pin of the header. Note that for accurate shutdown current measurement, these resistors must also be removed and the EN input (center pin) grounded.

1. Jumper open (default setup): Device starts up and shuts down with UVLO.
2. Center pin connected to *ON*: Device starts up and shuts down without UVLO.
3. Center pin connected to *OFF*: Device is off.

PGOOD The PGOOD header used as a test point to monitor the power-good indicator. This flag indicates whether the output voltage has reached its regulation level. PGOOD is an open-drain output that is tied to V_{OUT} through a 100-kΩ, resistor R_{10}.

4 Schematic

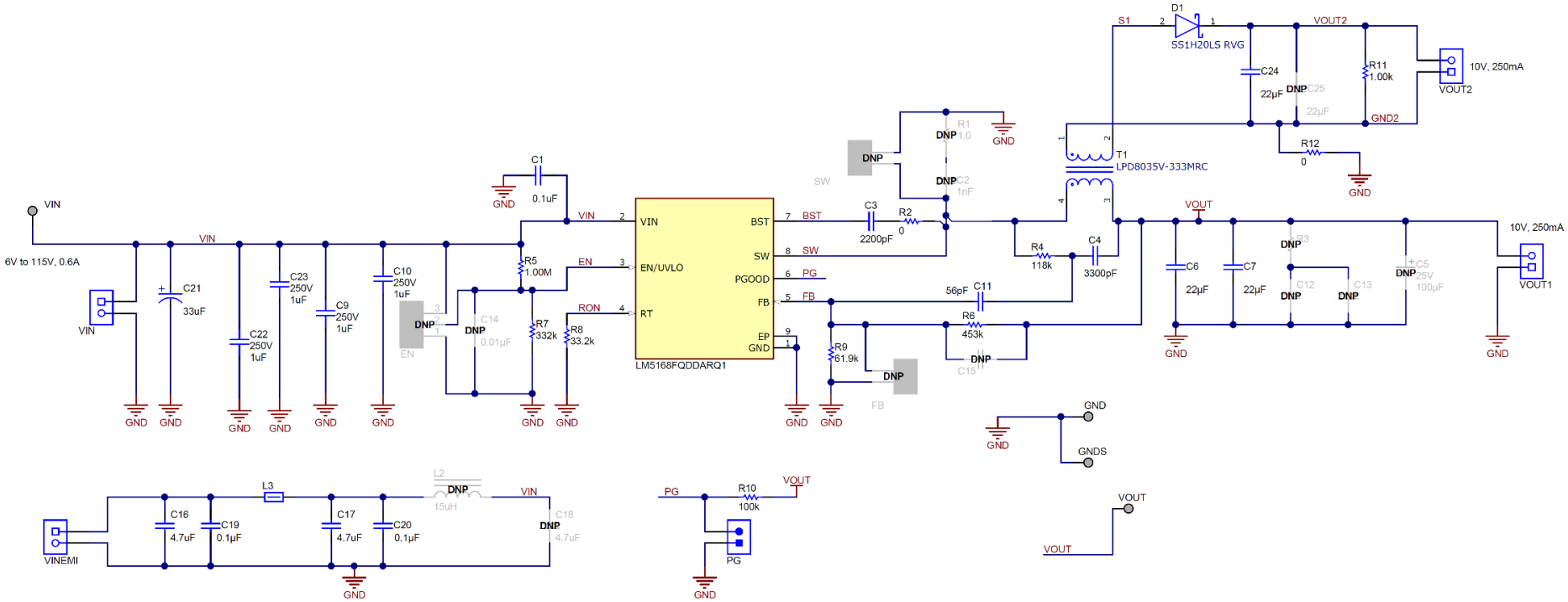


Figure 4-1. LM5168FEVM Schematic

5 PCB Layout

Figure 5-1 through Figure 5-4 show the board layout for the LM5168FEVM.

The 8-pin SO PowerPAD™ package offers an exposed thermal pad, which must be soldered to the copper landing on the PCB for optimal thermal performance. The PCB consists of a 4-layer design. There are 2-oz copper planes on the top and bottom and 1-oz copper mid-layer planes to dissipate heat with an array of thermal vias under the thermal pad to connect to all four layers.

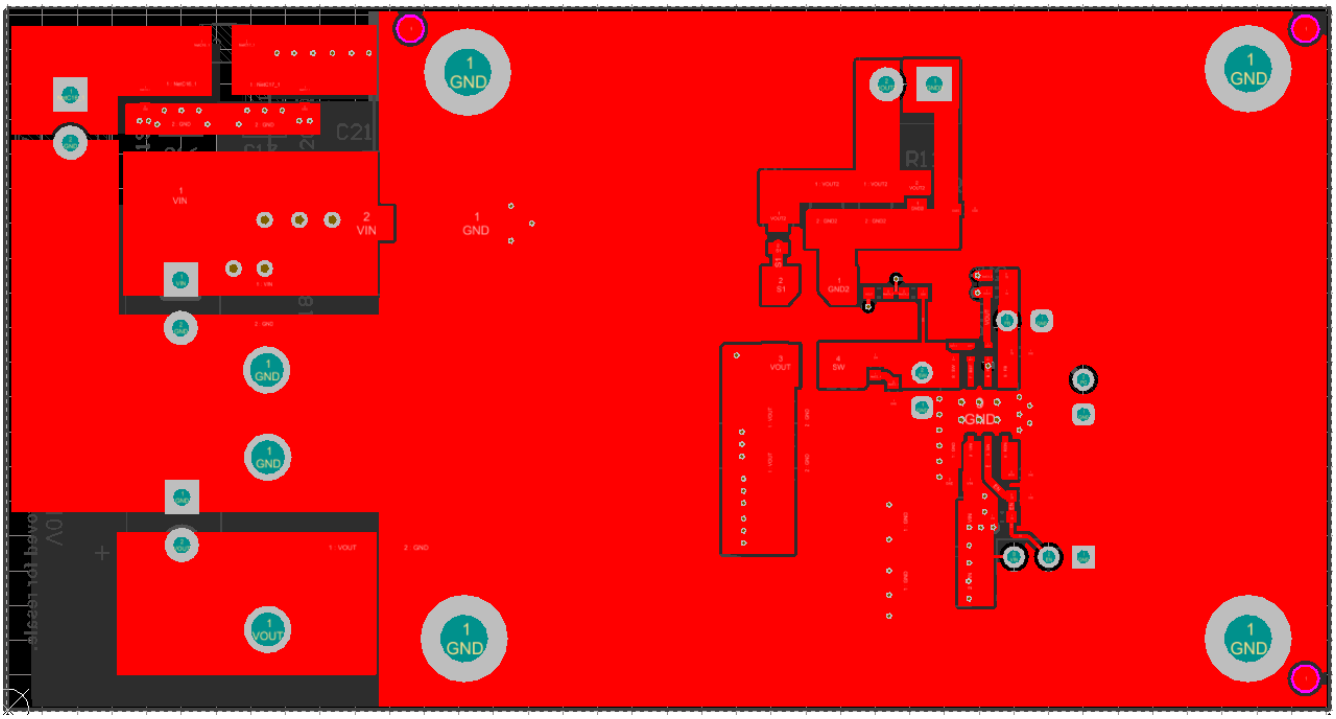


Figure 5-1. Top Layer

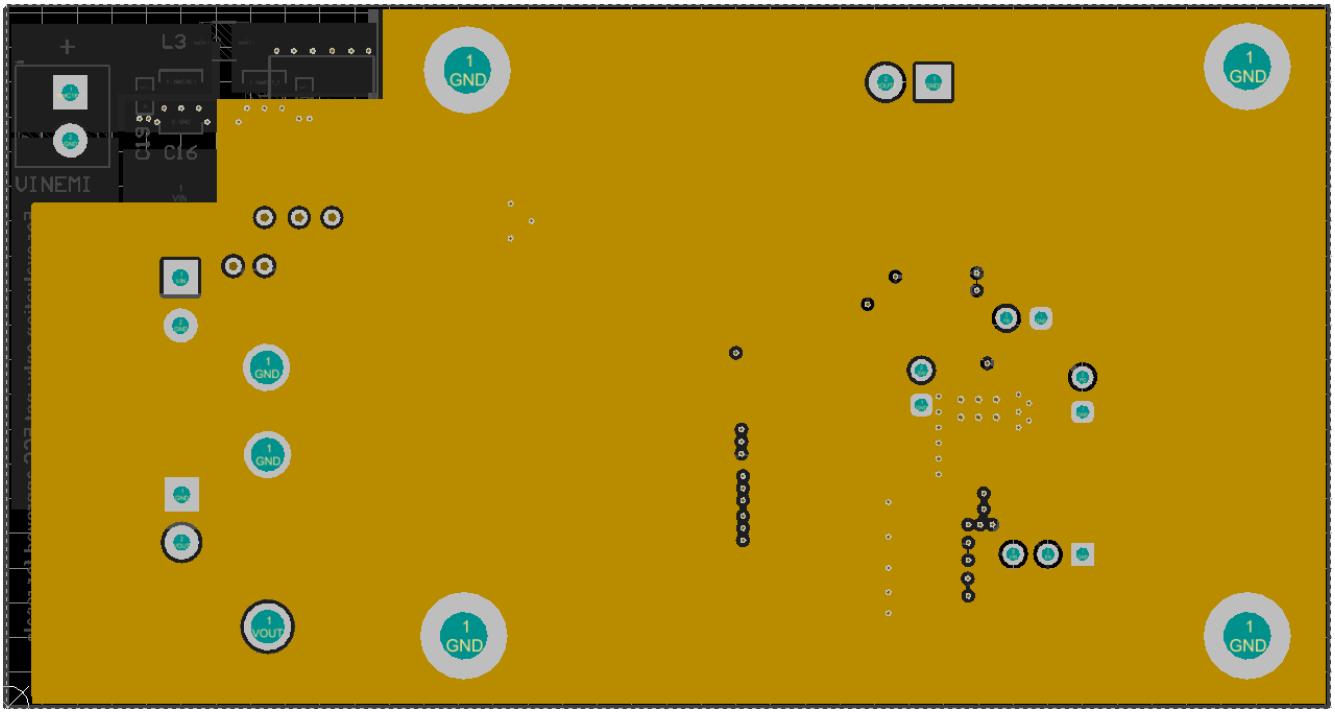


Figure 5-2. Mid-Layer 1 Ground Plane

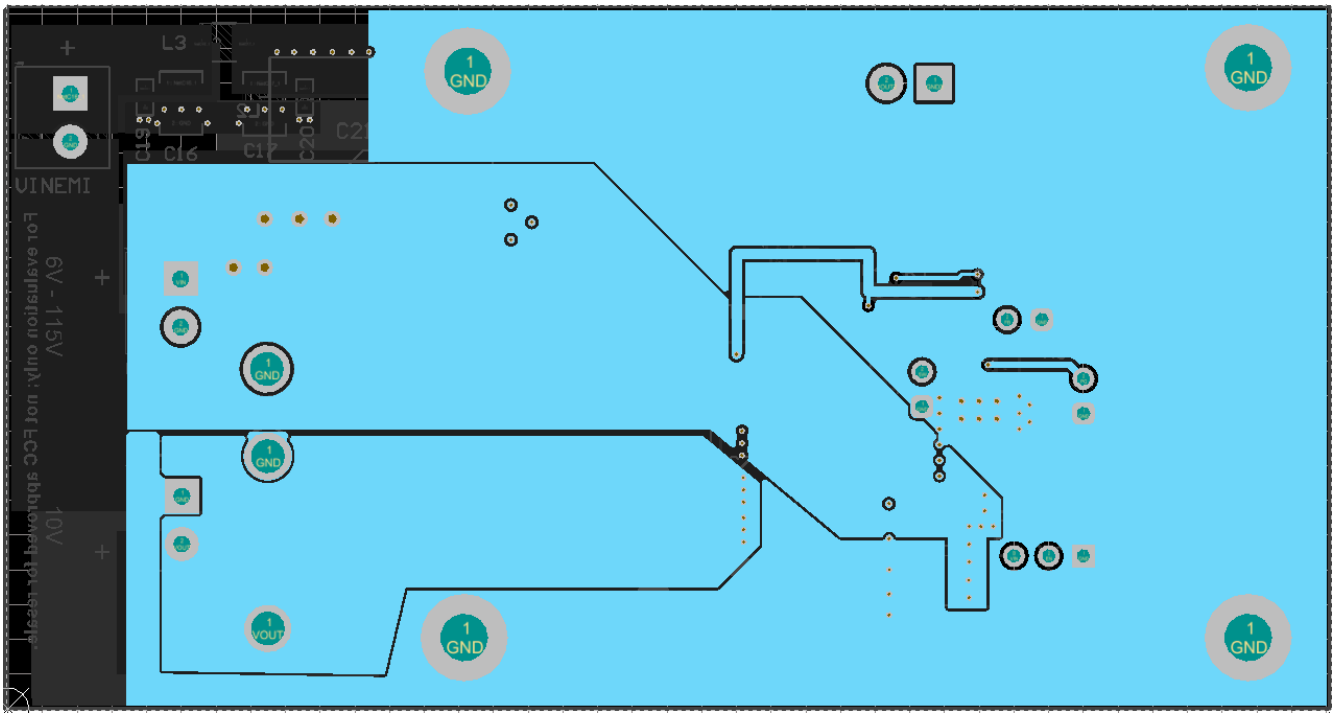


Figure 5-3. Mid-Layer 2 Routing

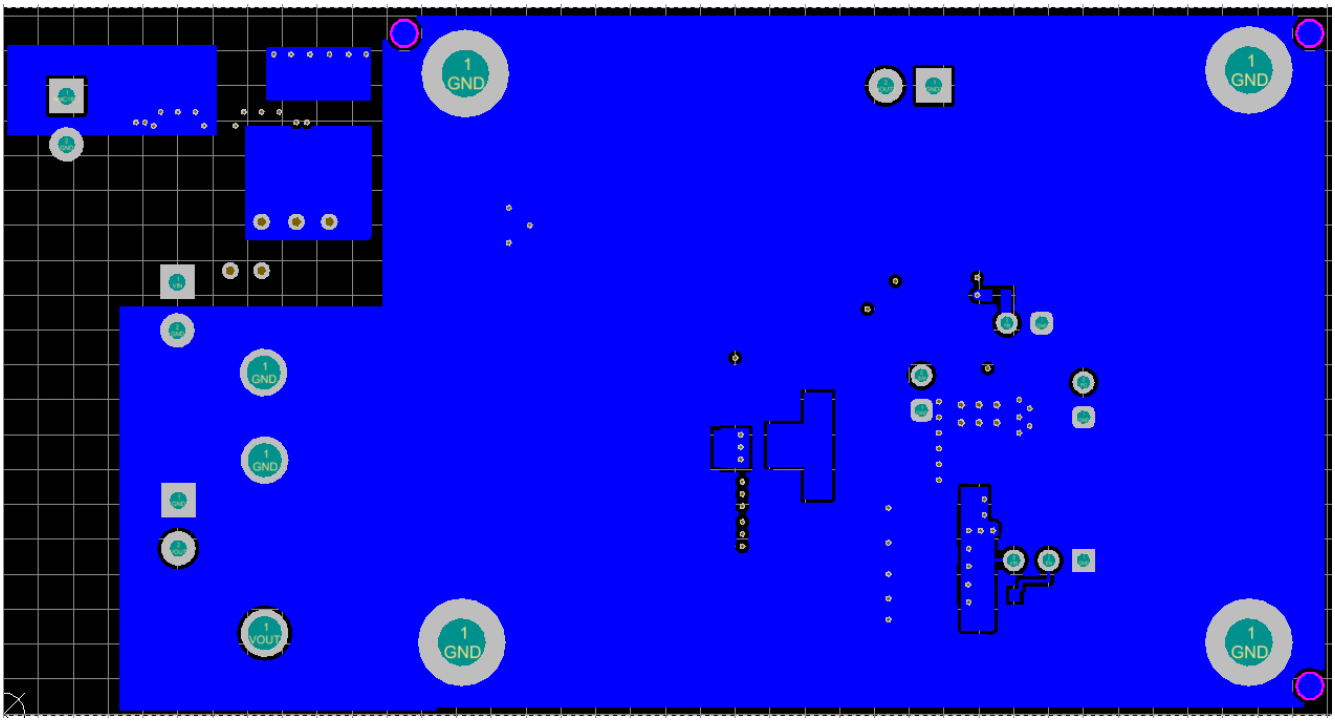


Figure 5-4. Bottom Layer

6 Bill of Materials

Table 6-1. LM5168FEVM Bill of Materials

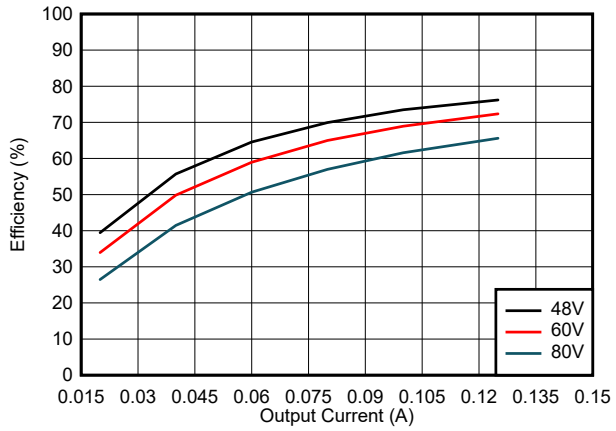
DESIGNATOR	QUANTITY	DESCRIPTION	PART NUMBER	MANUFACTURER
C1	1	CAP, CERM, 0.1 µF, 250 V, ±10%, X7T, 0805	C2012X7T2E104K125AA	TDK
C3	1	CAP, CERM, 2200 pF, 50 V, ±10%, X7R, AEC-Q200 Grade 1, 0402	GCM155R71H222KA37D	MuRata
C4	1	CAP, CERM, 3300 pF, 100 V, ±10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E2X7R2A332K080AA	TDK
C6, C7, C24	3	CAP, CERM, 22 µF, 25 V, ±10%, X5R, AEC-Q200 Grade 3, 1210	GRT32ER61E226KE13L	MuRata
C9, C10, C22, C23	4	Cap Ceramic 1-µF 250-V X7T 10% Pad SMD 1812 +125°C Automotive T/R	CGA8P3X7T2E105K250KE	TDK
C11	1	CAP, CERM, 56 pF, 50 V, ±5%, C0G/NP0, 0603	C0603C560J5GACTU	Kemet
C16, C17	2	CAP, CERM, 4.7 µF, 100 V, ±10%, X7S, AEC-Q200 Grade 1, 1210	CGA6M3X7S2A475K200AB	TDK
C19, C20	2	CAP, CERM, 0.1 µF, 100 V, ±10%, X7R, AEC-Q200 Grade 1, 0603	HMK107B7104KAHT	Taiyo Yuden
C21	1	Aluminum Electrolytic Capacitors Radial 33-µF 20% 160-V, Can - SMD - 2000 Hrs at 125°C	ULT2C330MNL1GS	Nichicon
D1	1	Diode, Schottky, 150 V, 1 A, PowerDI123	DFLS1150-7	Diodes Inc.
J2, J3, J7, J8	4	Terminal Block, 3.5mm Pitch, 2 × 1, TH	ED555/2DS	On-Shore Technology
J6	1	Header, 100 mil, 2 × 1, Gold, TH	TSW-102-07-G-S	Samtec
L3	1	Ferrite Bead, 2000 Ω at 100 MHz, 1.2 A, 1210	FBMH3225HM202NT	Taiyo Yuden
R2	1	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04020000Z0ED	Vishay-Dale
R4	1	RES, 118 k, 1%, 0.1 W, 0603	RC0603FR-07118KL	Yageo
R5	1	RES, 1.00 M, 1%, 0.1 W, 0603	RC0603FR-071ML	Yageo
R6	1	RES, 453 k, 1%, 0.1 W, 0603	RC0603FR-07453KL	Yageo
R7	1	RES, 332 k, 1%, 0.1 W, 0603	RC0603FR-07332KL	Yageo
R8	1	RES, 33.2 k, 1%, 0.1 W, 0603	RC0603FR-0733K2L	Yageo
R9	1	RES, 61.9 k, 1%, 0.1 W, 0603	RC0603FR-0761K9L	Yageo
R10	1	RES, 100 k, 1%, 0.1 W, 0402	ERJ-2RKF1003X	Panasonic
R11	1	RES, 1.00 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	CRCW08051K00FKEA	Vishay-Dale
R12	1	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06030000Z0EA	Vishay-Dale
T1	1	Power inductor, coupled, shielded, 20% tol, RoHS, halogen-free	LPD8035V-333MRC	Coilcraft
TP1	1	Test Lead clips and hooks, SMT	S1751-46	Harwin
TP2, TP3, TP4	3	Terminal, Turret, TH, Triple	1598-2	Keystone
U1	1	IC	LM5168FQDDAR	Texas Instruments
C2	0	CAP, CERM, 1000 pF, 200 V, ±10%, X7R, 0603	GRM188R72D102KW07D	MuRata
C5	0	CAP, AL, 100 µF, 25 V, ±20%, SMD	UWT1E101MCL1GS	Nichicon
C12, C13	0	CAP, CERM, 22 µF, 25 V, ±10%, X7R, AEC-Q200 Grade 1, 1210	TMK325B7226KMHT	Taiyo Yuden
C14	0	CAP, CERM, 0.01 µF, 100 V, ±10%, X8R, AEC-Q200 Grade 0, 0603	CGA3E2X8R2A103K080AD	TDK
C15	0	CAP, CERM, 1000 pF, 50 V, ±5%, X7R, AEC-Q200 Grade 1, 0603	C0603C102J5RACAUTO	Kemet
C18	0	CAP, CERM, 4.7 µF, 100 V, ±10%, X7S, AEC-Q200 Grade 1, 1210	CGA6M3X7S2A475K200AB	TDK
C25	0	CAP, CERM, 22 µF, 25 V, ±10%, X5R, AEC-Q200 Grade 3, 1210	GRT32ER61E226KE13L	MuRata
J1, J5	0	Header, 100 mil, 2 × 1, Gold, TH	TSW-102-07-G-S	Samtec

Table 6-1. LM5168FEVM Bill of Materials (continued)

DESIGNATOR	QUANTITY	DESCRIPTION	PART NUMBER	MANUFACTURER
J4	0	Header, 100 mil, 3 × 1, Gold, TH	HTSW-103-07-G-S	Samtec
L2	0	Inductor, Shielded Drum Core, Ferrite, 15 µH, 1.8 A, 0.05 Ω, AEC-Q200 Grade 1, SMD	MSS7341T-153MLB	Coilcraft
R1	0	RES, 1.0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06031R00JNEA	Vishay-Dale
R3	0	RES, 0.2, 1%, 1 W, 2010	CSRN2010FKR200	Stackpole Electronics Inc

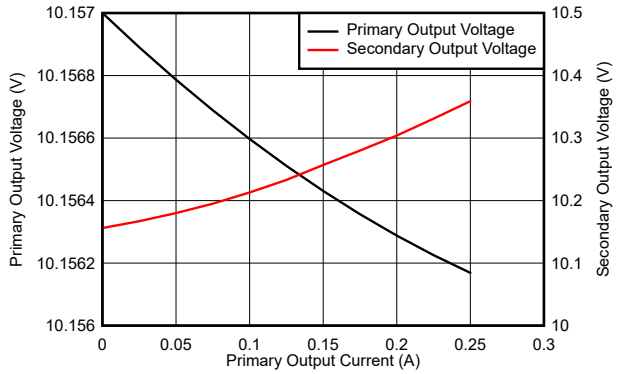
7 Performance Curves

Unless otherwise specified the following condition apply: T_A = 25ºC, I_{OUT1} = primary output current, I_{OUT2} = secondary output current.



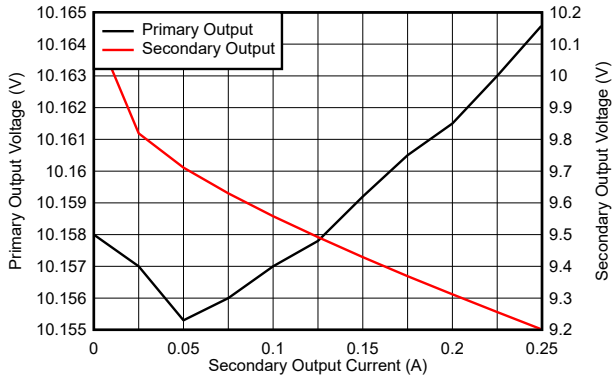
Output Current = I_{OUT1} = I_{OUT2}

Figure 7-1. Efficiency



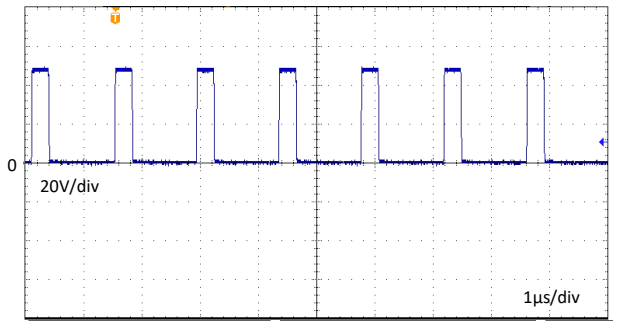
I_{OUT2} = 0 A V_{IN} = 48 V

Figure 7-2. Load Regulation



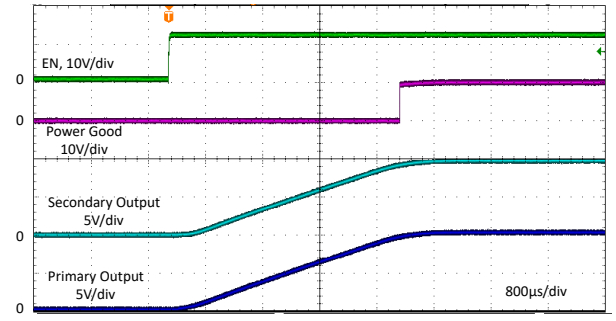
I_{OUT1} = 0 A V_{IN} = 48 V

Figure 7-3. Load Regulation



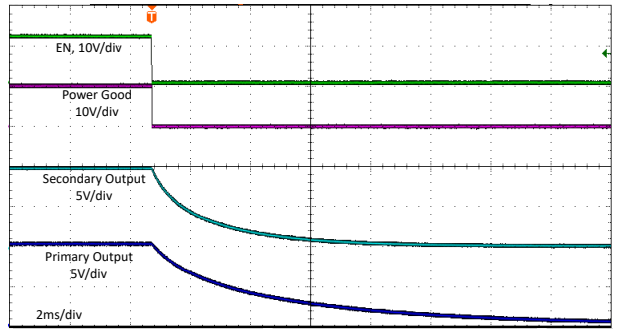
I_{OUT} = 0 A V_{IN} = 48 V

Figure 7-4. Typical Switching Waveform



V_{IN} = 48 V I_{OUT} = I_{OUT2} = 100 mA

Figure 7-5. Typical Start-Up Waveform



V_{IN} = 48 V I_{OUT} = I_{OUT2} = 100 mA

Figure 7-6. Typical Shutdown Waveform

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale, TI’s General Quality Guidelines, or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Last updated 10/2025