User's Guide

LM5158 Flyback Converter Evaluation Module

ABSTRACT

The LM5158EVM-FLY evaluation module showcases the features and performance of the LM5158 as wide input non-synchronous flyback controller to produce multiple output voltage rails for typical applications of the 3-phase inverter gate driver bias supplies. The standard configuration is designed to provide a regulated output of 10 V at 250 mA from an input of 8 V to 16 V, and three isolated 20-V rails at 75 mA, 75 mA, and 150 mA, respectively. The switching frequency is 250 kHz. This evaluation module was designed for ease of configuration, enabling the user to evaluate different applications on the same module. The PCB has two copper layers.

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Trademarks

All trademarks are the property of their respective owners.

1 Introduction

The LM5158EVM-FLY supports the following features and performance capabilities:

- Tightly regulated main output voltage: V_{O1} = 10 V ±1%
- Three cross-regulated, isolated output voltages:
  - V_{O2} = 20 V
  - V_{O3} = 20 V
  - V_{O4} = 20 V
- Total rated load of 8.5 W:
  - 250 mA at V_{O1}
  - 75 mA at V_{O2}
  - 75 mA at V_{O3}
  - 150 mA at V_{O4}
- Peak efficiency > 90%
- Optional hiccup mode overloading protection
- 250-kHz switching frequency
- 2-layer PCB, 3.5 in × 2.3 in

2 Electrical Parameters

Table 2-1 details the electrical performance standard configuration.

Table 2-1. Electrical Performance Standard Configuration

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input Characteristics					
Input voltage range V_{IN}	Operation	8	12	16	V
Abs max input voltage V_{INMAX}	Operation without damage			18	V
Input voltage turn-on $V_{IN(ON)}$	Adjustable by the UVLO/SYNC resistors		7.6		V
Input voltage turn-on $V_{IN(OFF)}$			7.1		V
Output Characteristics					
Main output voltage V_{O1}			10		V
First isolated output voltage V_{O2}			20		V
Second isolated output voltage V_{O3}			20		V
Third isolated output voltage V_{O4}			20		V
Main output load current I_{O1}				0.250	A
First isolated output load current I_{O2}				0.075	A
Second isolated output load current I_{O3}				0.075	A
Third isolated output load current I_{O4}				0.150	A
System Characteristics					
Switching frequency			250		kHz
Peak efficiency	V_{IN} = 12 V, rated load at all output rails		90		%
Junction temperature		–40		150	°C
Transformer Specifications (Coilcraft ZB1324-AL)					
Primary inductances			8		µH
Turns ratio	(2-4) : (1-3)		1		
	(5-6) : (1-3)		1.2		
	(8-7) : (1-3)		2.4		
	(10-9) : (1-3)		2.4		
	(12-11) : (1-3)		2.4		
Saturation current	20% inductance reduction		5.5		A
Leakage inductance				90	nH

3 Application Schematic

The LM5158EVM-FLY is capable of multiple configurations. Figure 3-1 shows the standard configuration of the LM5158EVM-FLY where the parameters in Table 2-1 are valid.

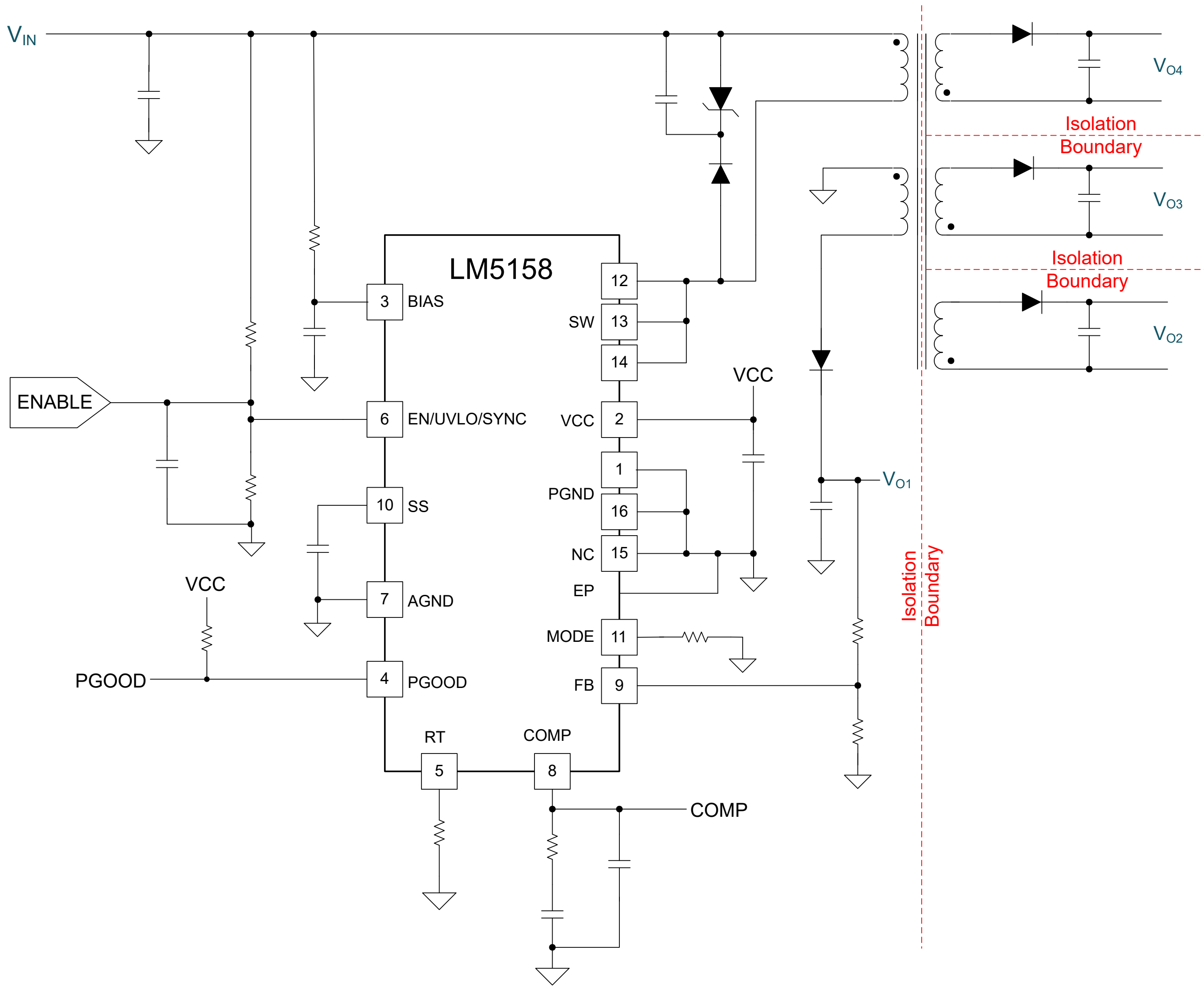


Figure 3-1. Application Circuit

4 EVM Picture

Figure 4-1 is a 3D printout of the EVM from the CAD tool. The actual color of the board can differ. The EVM also includes circuits for extra configurations. Not all components are populated on the EVM.

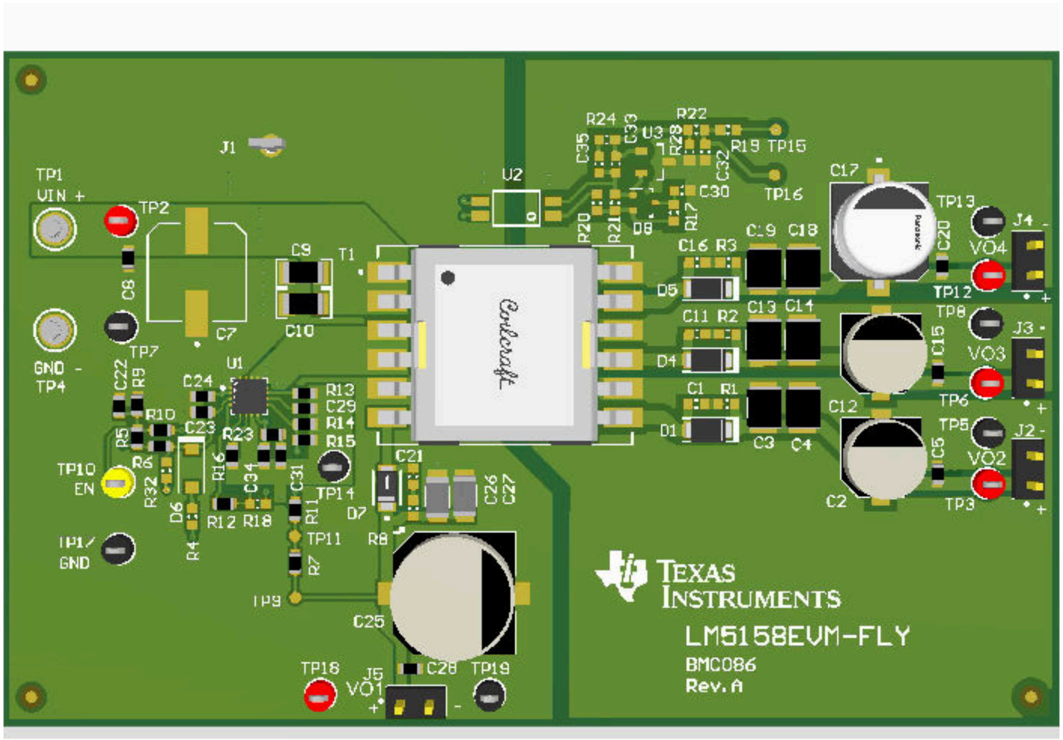


Figure 4-1. EVM Picture

5 Test Setup and Procedure

5.1 EVM Test Setup Schematic

Figure 5-1 shows the correct equipment connections and measurement points.

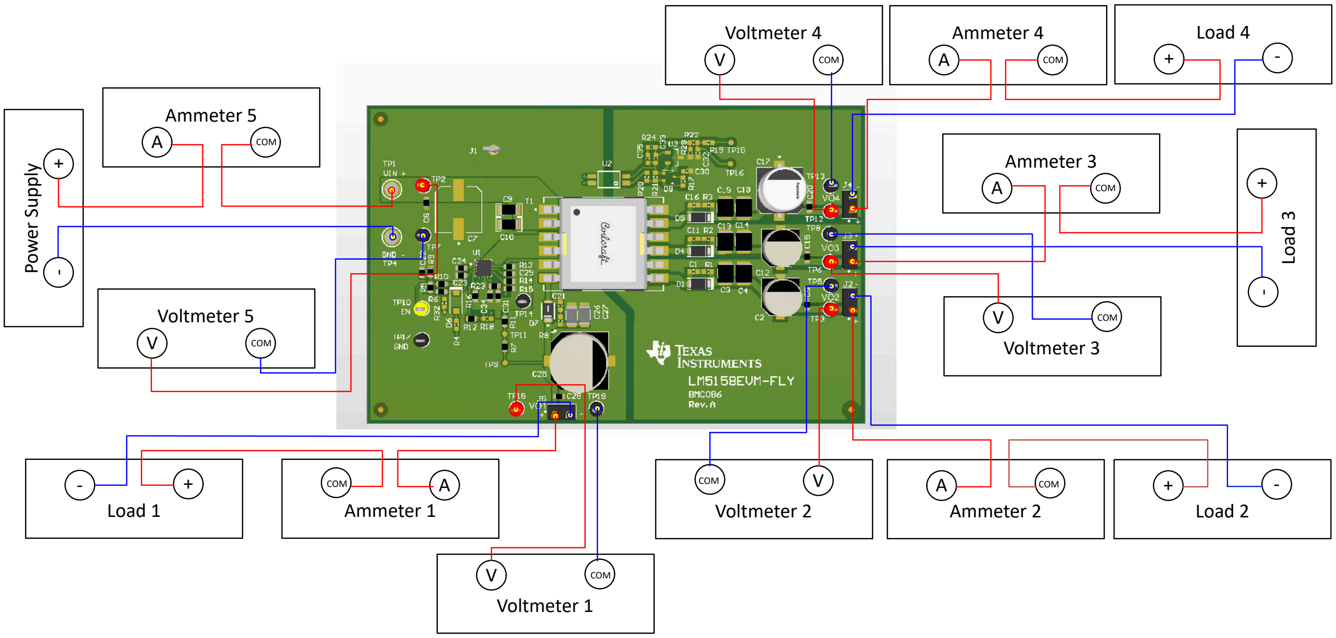


Figure 5-1. Test Setup

5.2 Test Equipment

Power Supply: Use an input voltage source that is a variable supply capable of 0 V to 16 V and sources at least 5 A.

Multimeters:

- Voltmeter 1: Non-isolated 10-V main output voltage V_{O1}, connect from TP18 (+) to TP19 (–).
- Voltmeter 2: Isolated 20-V output voltage V_{O2}, connect from TP3 (+) to TP5 (–).
- Voltmeter 3: Isolated 20-V output voltage V_{O3}, connect from TP6 (+) to TP8 (–).
- Voltmeter 4: Isolated 20-V output voltage V_{O4}, connect from TP12 (+) to TP13 (–).
- Voltmeter 5: Input voltage V_I, connect from TP2 (+) to TP7 (–).
- Ammeter 1: V_{O1} main output current, must be able to handle 1 A
- Ammeter 2: V_{O2} output current, must be able to handle 0.5 A
- Ammeter 3: V_{O3} output current, must be able to handle 0.5 A
- Ammeter 4: V_{O4} output current, must be able to handle 0.5 A
- Ammeter 5: Input current, must be able to handle 3 A

Loads: Electronic loads, pure resistive loads, or a combination of both, can be used at the four outputs.

- An electronic load can be used for each output rail. The electronic load should be constant resistance (CR) or constant current (CC) capable. It should safely handle 0.5 A at 20 V.
- Resistive load can also be used. Limit the minimum resistance for each output, which corresponds to the maximum power, with the following:
  – Load 1: 40 Ω or 250 mA
  – Load 2: 266.7 Ω or 75 mA
  – Load 3: 266.7 Ω or 75 mA
  – Load 4: 133.3 Ω or 150 mA

6 Test Data and Performance Curves

Figure 6-1 through Figure 6-24 present the typical performance of the LM5158EVM-FLY. Based on measurement techniques and environmental variables, measurements can differ slightly to the data presented.

6.1 Efficiency

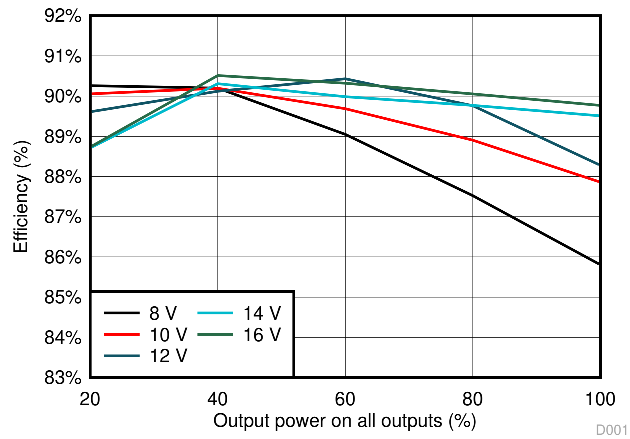


Figure 6-1. Efficiency Under Different Input Voltages and Load Levels

6.2 Output Regulation

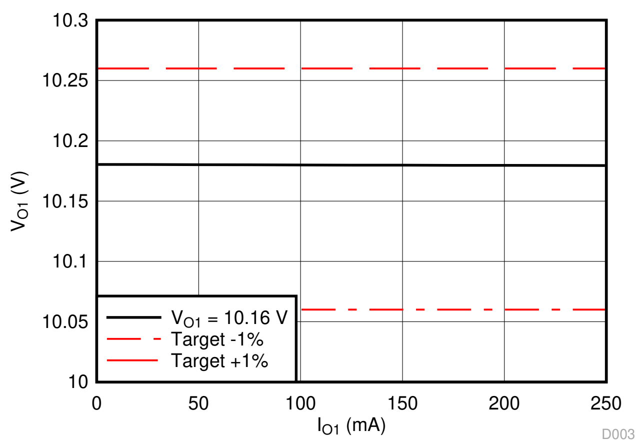


Figure 6-2. Main Output Voltage Regulation Versus Main Output Load (Io2, Io3, Io4 = 10%)

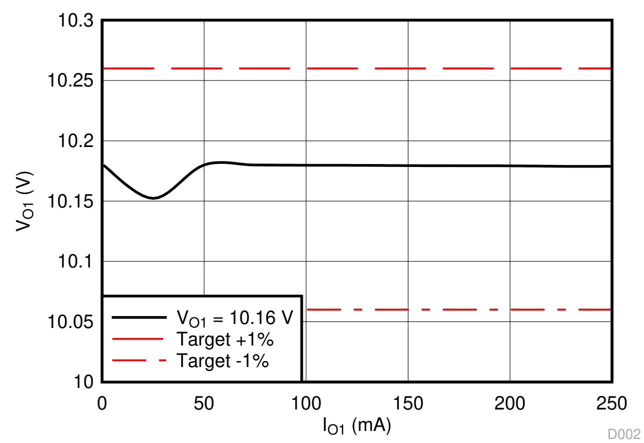


Figure 6-3. Main Output Voltage Regulation Versus Main Output Load (Io2, Io3, Io4 = 100%)

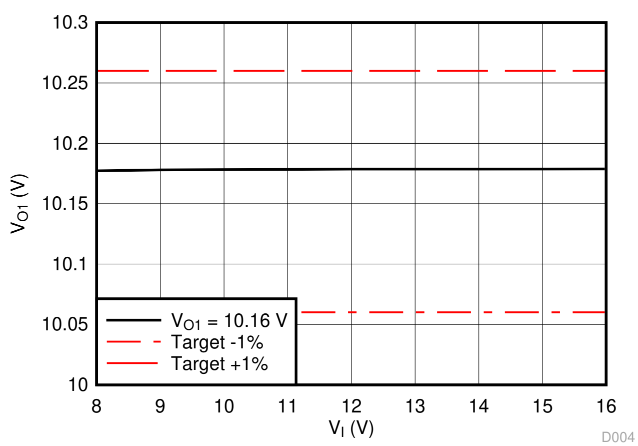


Figure 6-4. Main Output Voltage Regulation Versus Input Voltage (Io2, Io3, Io4 = 100%)

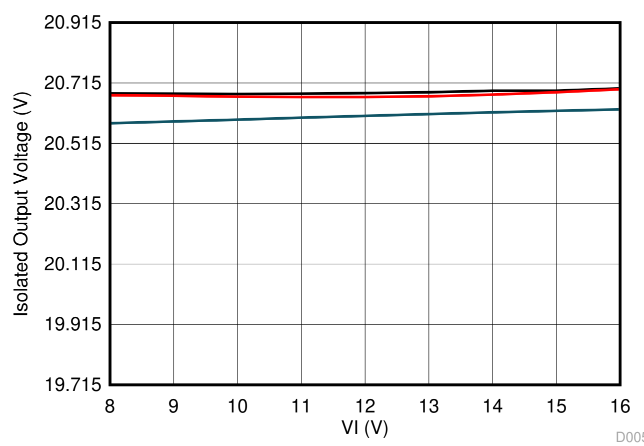


Figure 6-5. Voltage Regulation of Isolated Outputs Versus Input Voltage at 10% load

6.3 Steady-State Waveforms

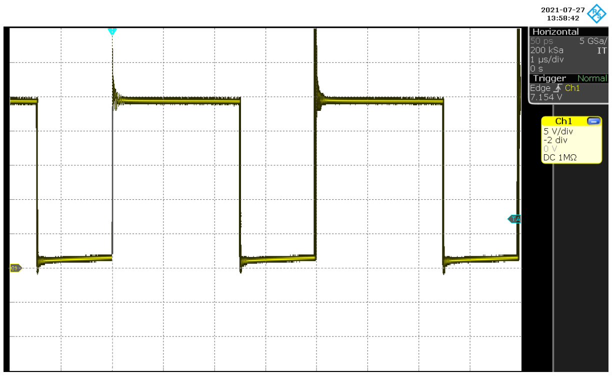


Figure 6-6. SW Waveform at 100% Load, Under 16-V Maximum V_{IN}

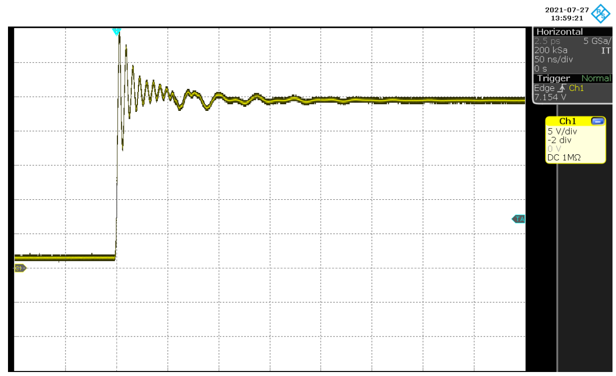


Figure 6-7. Zoomed SW Waveform at 100% Load, Under 16-V Maximum V_{IN}

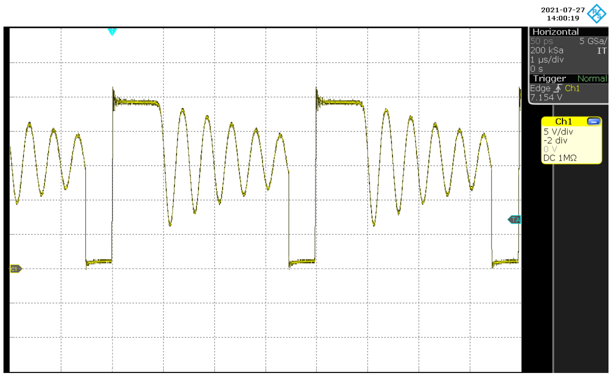


Figure 6-8. SW Waveform at 10% Load, Under 16-V Maximum V_{IN}

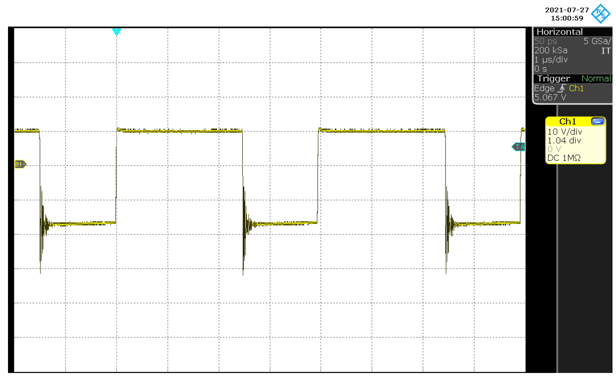


Figure 6-9. PIV of D7 (main Output Rectifier) Under 100% Load and 16-V Maximum V_{IN}

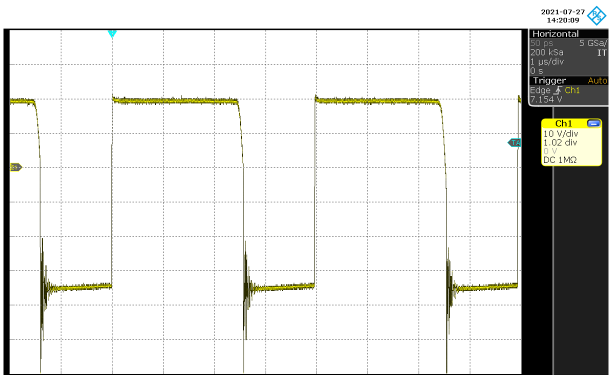


Figure 6-10. PIV of D1 (V_{O2} Rectifier) Under 100% Load and 16-V Maximum V_{IN}

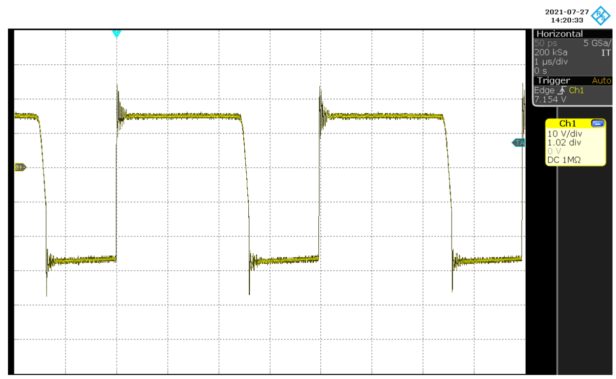


Figure 6-11. PIV of D4 (V_{O3} Rectifier) Under 100% Load and 16-V Maximum V_{IN}

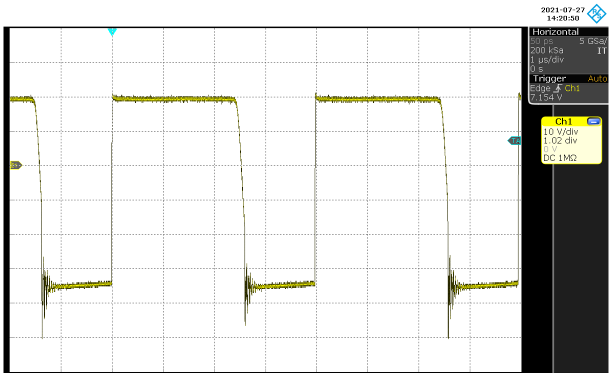


Figure 6-12. PIV of D5 (V_{O4} Rectifier) Under 100% Load and 16-V Maximum V_{IN}

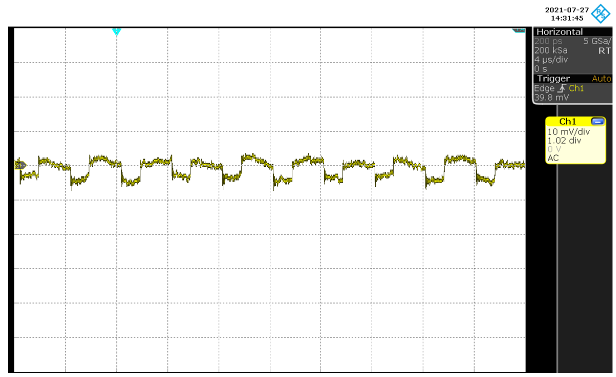


Figure 6-13. Main Output V_{O1} Ripple Voltage Under 250-mA Load

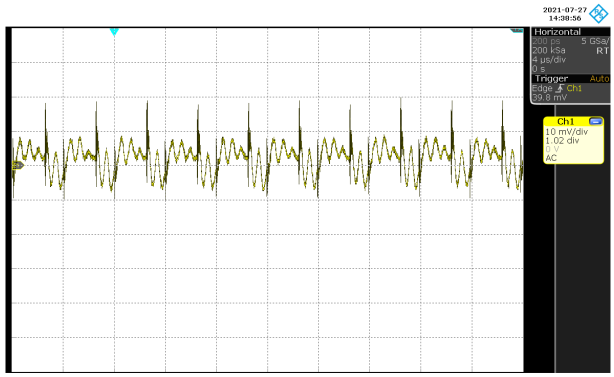


Figure 6-14. Isolated Output V_{O4} Ripple Voltage Under 150-mA Load

6.4 Start-Up Waveforms

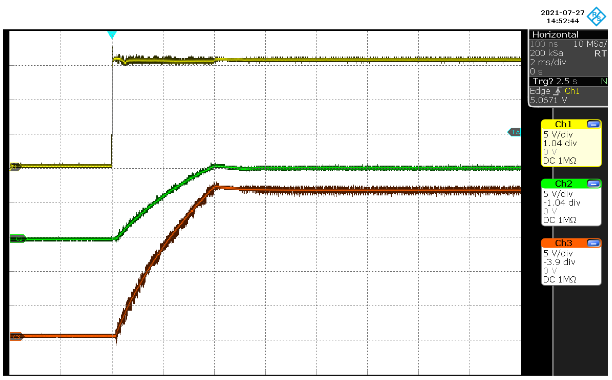


Figure 6-15. Start-Up at 10% Load on Each Output Rail

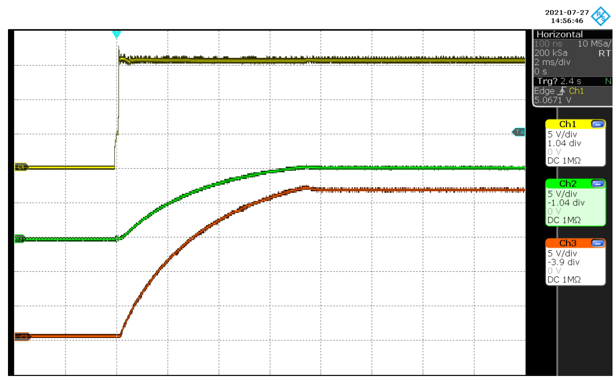


Figure 6-16. Start-Up at 100% Load on Each Output Rail

6.5 Dynamic Responses

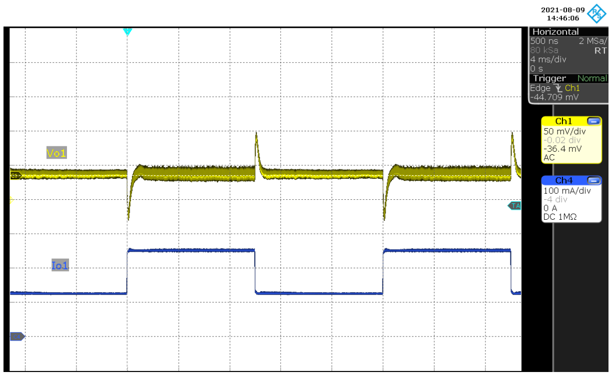


Figure 6-17. V_{O1} Response Under Step Load Between 125 mA and 250 mA, V_{IN} = 12 V, Io2–4 = 10%

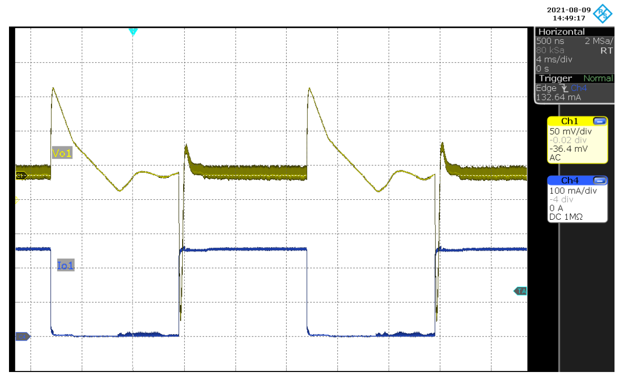


Figure 6-18. V_{O1} Response Under Step Load Between 1 mA to 250 mA, V_{IN} = 12 V, Io2–4 = 10%

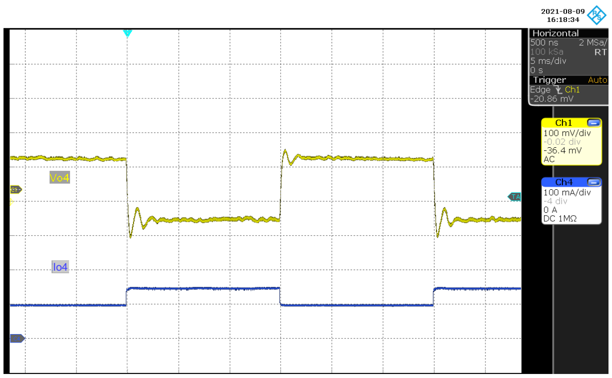


Figure 6-19. V_{O4} Response Under Step Load Between 100 mA and 150 mA, V_{IN} = 12 V, Io1–3 = 10%

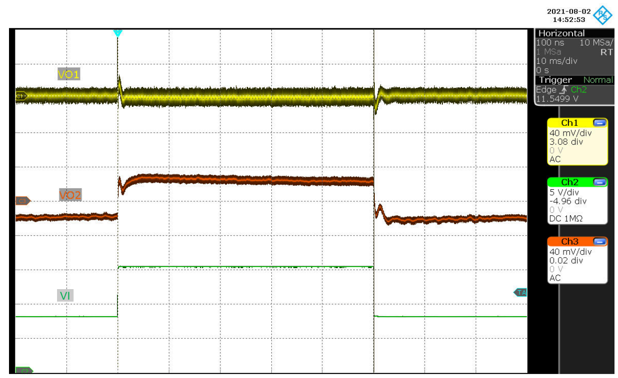


Figure 6-20. V_{O1} Response Under Input Change From 8 V to 16 V, 10% Load

6.6 Short-Circuit Protection

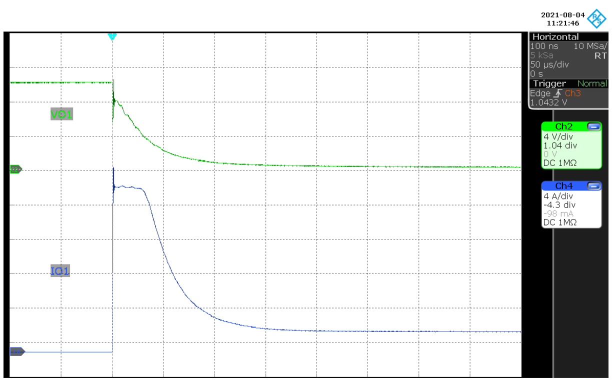


Figure 6-21. Short-Circuit Protection With Hiccup Mode Disabled, V_{IN} = 12 V (R13 = 0 Ω)

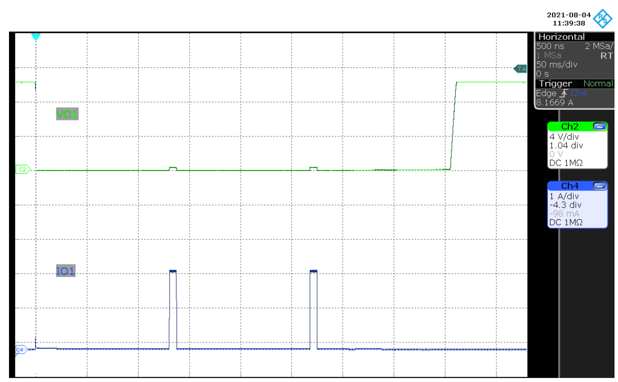


Figure 6-22. Short-Circuit Protection With Hiccup Mode Enabled, V_{IN} = 12 V (R13 = 62 kΩ, C29 = 47 nF)

6.7 Bode Plots

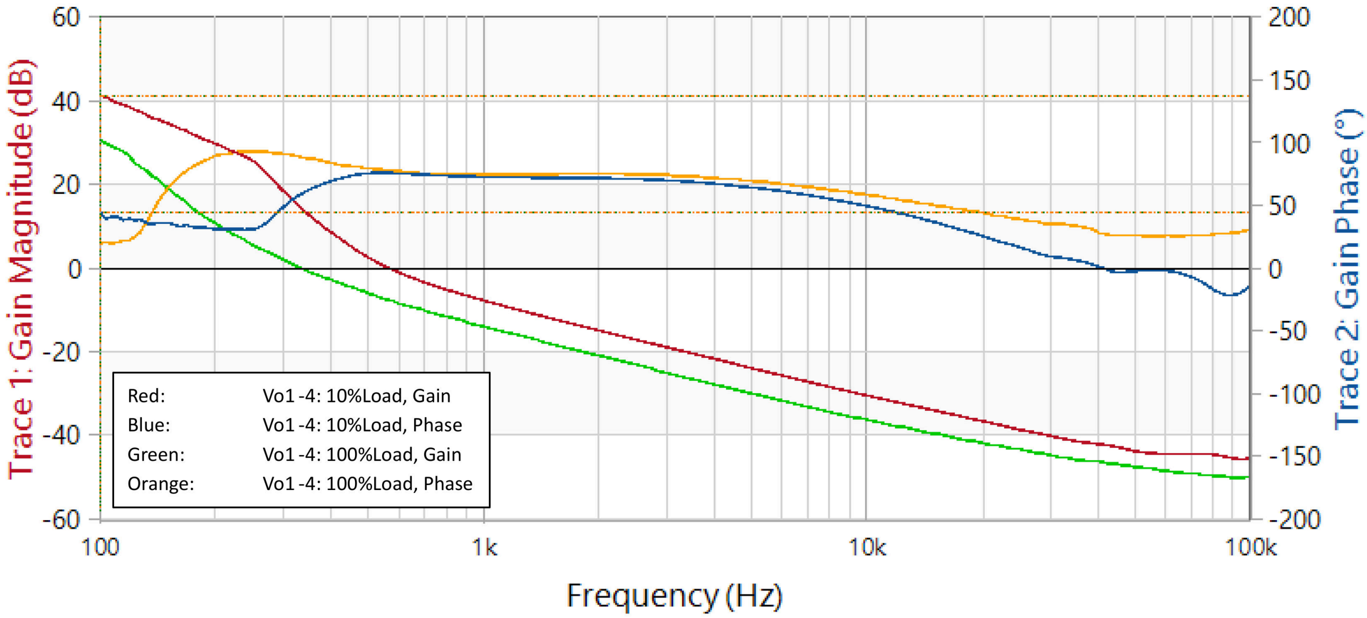


Figure 6-23. Bode Plot (V_{IN} = 12 V)

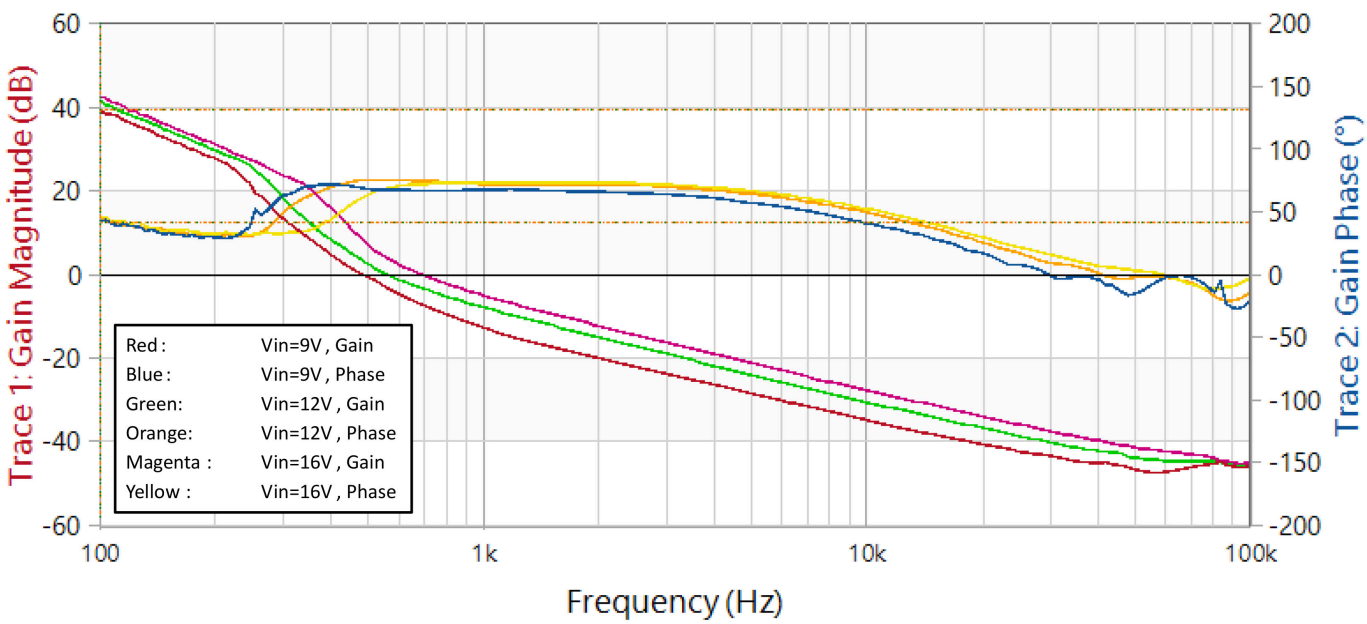


Figure 6-24. Bode Plot (Vo1-4: 100% Load)

6.8 Thermal Image

Figure 6-25 shows the thermal image of the EVM at 12 V_{IN} and 100% load.

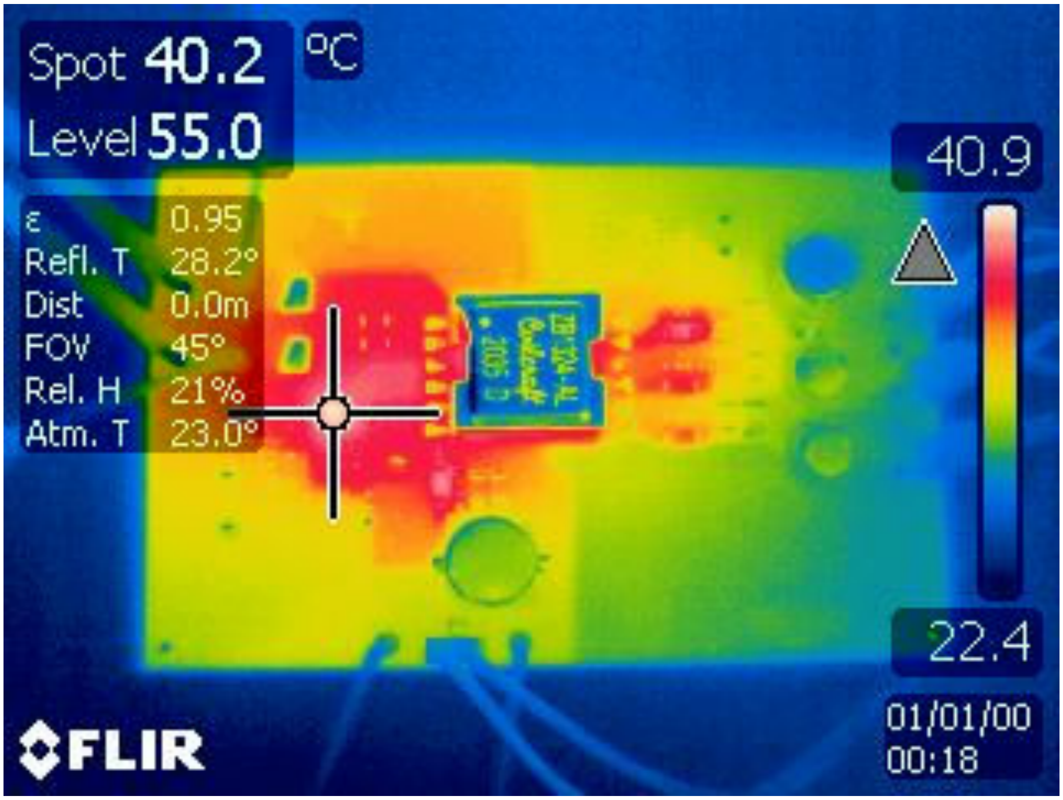
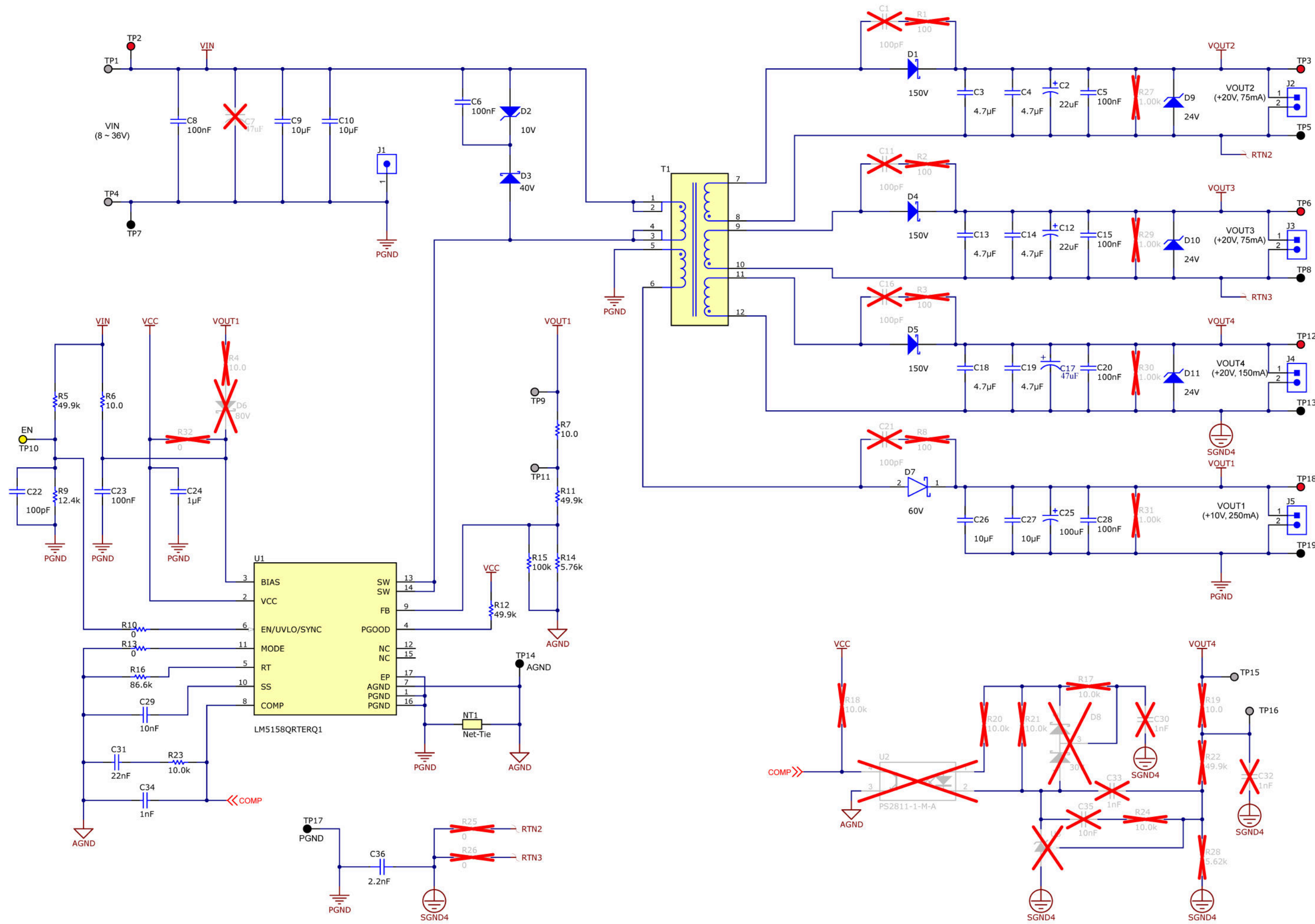


Figure 6-25. EVM Thermal Image at 12 V_{IN} and 100% Load

7 Schematic

Figure 7-1 shows the EVM schematic.



Non-populated components are crossed out.

Figure 7-1. EVM Complete Schematic

8 Bill of Materials

Table 8-1 details the EVM BOM.

Table 8-1. LM5158EVM-FLY Bill of Materials

DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
C2, C12	2	22 µF	CAP, Polymer Hybrid, 22 µF, 50 V, ±20%, 0.08 Ω, AEC-Q200 Grade 1, D6.3xL5.8mm SMD	D6.3xL5.8mm	EEH-ZC1H220P	Panasonic
C3, C4, C13, C14, C18, C19	6	4.7 µF	CAP, CERM, 4.7 µF, 50 V, ±10%, X7R, AEC-Q200 Grade 1, 1210	1210	C1210C475K5RACAUTO	Kemet
C5, C6, C8, C15, C20, C23, C28	7	0.1 µF	CAP, CERM, 0.1 µF, 50 V, ±10%, X7R, AEC-Q200 Grade 1, 0603	603	C0603C104K5RACAUTO	Kemet
C9, C10	2	10 µF	CAP, CERM, 10 µF, 50 V, ±10%, X7R, AEC-Q200 Grade 1, 1206 (alternate: CAP, CERM, 10 µF, 50 V, ±10%, X5R, AEC-Q200, 1206)	1206	CGA5L1X7R1H106K160AE (alternate: GRT31CR61H106KE01L)	TDK (alternate: muRata)
C17	1	47 µF	47-µF 50-V Aluminum - Polymer Capacitors Radial, Can - SMD 30 mΩ 4000 Hrs at 125°C	SMD2	EEH-ZC1H470P	Panasonic
C22	1	100 pF	CAP, CERM, 100 pF, 50 V, ±5%, C0G/NP0, AEC-Q200 Grade 0, 0603	603	CGA3E2NP01H101J080AA	TDK
C24	1	1 µF	CAP, CERM, 1 µF, 25 V, ±10%, X7R, 0603	603	06033C105KAT2A	AVX
C25	1	100 µF	CAP, Aluminum Polymer, 100 µF, 16 V, ±20%, 0.035 Ω, 10 × 10.3 SMD	10 × 10.3	16SVP100M	Panasonic
C26, C27	2	10 µF	CAP, CERM, 10 µF, 16 V, ±10%, X7R, AEC-Q200 Grade 1, 1206	1206	C1206C106K4RACAUTO	Kemet
C29	1	0.01 µF	CAP, CERM, 0.01 µF, 16 V, ±10%, X7R, 0603	603	C0603C103K4RACTU	Kemet
C31	1	0.022 µF	CAP, CERM, 0.022 µF, 25 V, ±10%, X7R, 0603	603	C0603C223K3RACTU	Kemet
C34	1	1000 pF	CAP, CERM, 1000 pF, 50 V, ±5%, X7R, 0603	603	C0603C102J5RACTU	Kemet
C36	1	2.2 nF	2200-pF ±10% 2000-V (2-kV) Ceramic Capacitor X7R (2R1) 1206 (3216 Metric)	1206	1206Y2K00222KET	Knowles Syfer
D1, D4, D5	3	150 V	Diode, Schottky, 150 V, 1 A, PowerDI123	PowerDI123	DFLS1150-7	Diodes Inc.
D2	1	10 V	Diode, Zener, 10 V, 1.5 W, SMA	SMA	1SMA5925BT3G	ON Semiconductor
D3	1	40 V	Diode, Schottky, 40 V, 1 A, AEC-Q101, SMA	SMA	B140Q-13-F	Diodes Inc.
D7	1		DIODE SCHOTTKY 60-V 1-A POWERDI123	PowerDI123	DFLS160-7	Diodes
D9, D10, D11	3	24 V	Diode, Zener, 24 V, 500 mW, SOD-123	SOD-123	DDZ24C-7	Diodes Inc.
R5, R11, R12	3	49.9 k	RES, 49.9 k, 1%, 0.1 W, 0603	603	RC0603FR-0749K9L	Yageo
R6, R7	2	10	RES, 10.0, 1%, 0.1 W, 0603	603	RC0603FR-0710RL	Yageo
R9	1	12.4 k	RES, 12.4 k, 1%, 0.1 W, 0603	603	RC0603FR-0712K4L	Yageo
R10, R13	2	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	ERJ-3GEY0R00V	Panasonic
R14	1	5.76 k	RES, 5.76 k, 1%, 0.1 W, 0603	603	RC0603FR-075K76L	Yageo

Table 8-1. LM5158EVM-FLY Bill of Materials (continued)

DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
R15	1	100 k	RES, 100 k, 0.1%, 0.1 W, AEC-Q200 Grade 0, 0603	603	ERA-3AEB104V	Panasonic
R16	1	86.6 k	RES, 86.6 k, 1%, 0.1 W, 0603	603	RC0603FR-0786K6L	Yageo
R23	1	10.0 k	RES, 10.0 k, 1%, 0.1 W, 0603	603	RC0603FR-0710KL	Yageo
T1	1		FLYBACK TRANSFORMER	SMT_TRANSFORMER_17MM20_21MM97	ZB1324-AL	Coilcraft
U1	1		2.2-MHz Wide VIN 85-V Boost/Sepic/Flyback Converter with Dual Random Spread Spectrum	WQFN16	LM5158QRTERQ1	Texas Instruments
C1, C11, C16, C21	0	100 pF	CAP, CERM, 100 pF, 100 V, ±1%, C0G/NP0, 0603	603	C1608C0G2A101F080AA	TDK
C7	0	47 µF	47-µF 50-V Aluminum - Polymer Capacitors Radial, Can - SMD 30 mΩ 4000 Hrs at 125°C	SMD2	EEH-ZC1H470P	Panasonic
C30, C32, C33	0	1000 pF	CAP, CERM, 1000 pF, 50 V, ±5%, X7R, 0603	603	C0603C102J5RACTU	Kemet
C35	0	0.01 µF	CAP, CERM, 0.01 µF, 16 V, ±10%, X7R, 0603	603	C0603C103K4RACTU	Kemet
D6	0	80 V	Diode, Schottky, 80 V, 0.5 A, SOD-123	SOD-123	MBR0580-TP	Micro Commercial Components
D8	0	30 V	Diode, Schottky, 30 V, 0.2 A, SOT-323	SOT-323	BAT54SWT1G	Fairchild Semiconductor
R1, R2, R3, R8	0	100	RES, 100, 1%, 0.1 W, 0603	603	RC0603FR-07100RL	Yageo
R4, R19	0	10	RES, 10.0, 1%, 0.1 W, 0603	603	RC0603FR-0710RL	Yageo
R17, R18, R20, R21, R24	0	10.0 k	RES, 10.0 k, 1%, 0.1 W, 0603	603	RC0603FR-0710KL	Yageo
R22	0	49.9 k	RES, 49.9 k, 1%, 0.1 W, 0603	603	RC0603FR-0749K9L	Yageo
R25, R26	0	0	RES, 0, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	ERJ-8GEY0R00V	Panasonic
R27, R29, R30, R31	0	1.00 k	RES, 1.00 k, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	ERJ-8ENF1001V	Panasonic
R28	0	5.62 k	RES, 5.62 k, 1%, 0.1 W, 0603	603	RC0603FR-075K62L	Yageo
R32	0	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	ERJ-3GEY0R00V	Panasonic
U2	0		Optocoupler, 2.5 kV, 100-200% CTR, SMT	PS2811-1	PS2811-1-M-A	California Eastern Laboratories
U3	0		Low-Voltage (1.24V) Adjustable Precision Shunt Regulators, 3-pin SOT-23, Pb-Free	DBZ0003A		Texas Instruments

9 EVM Layout

Figure 9-1 through Figure 9-4 illustrate the EVM

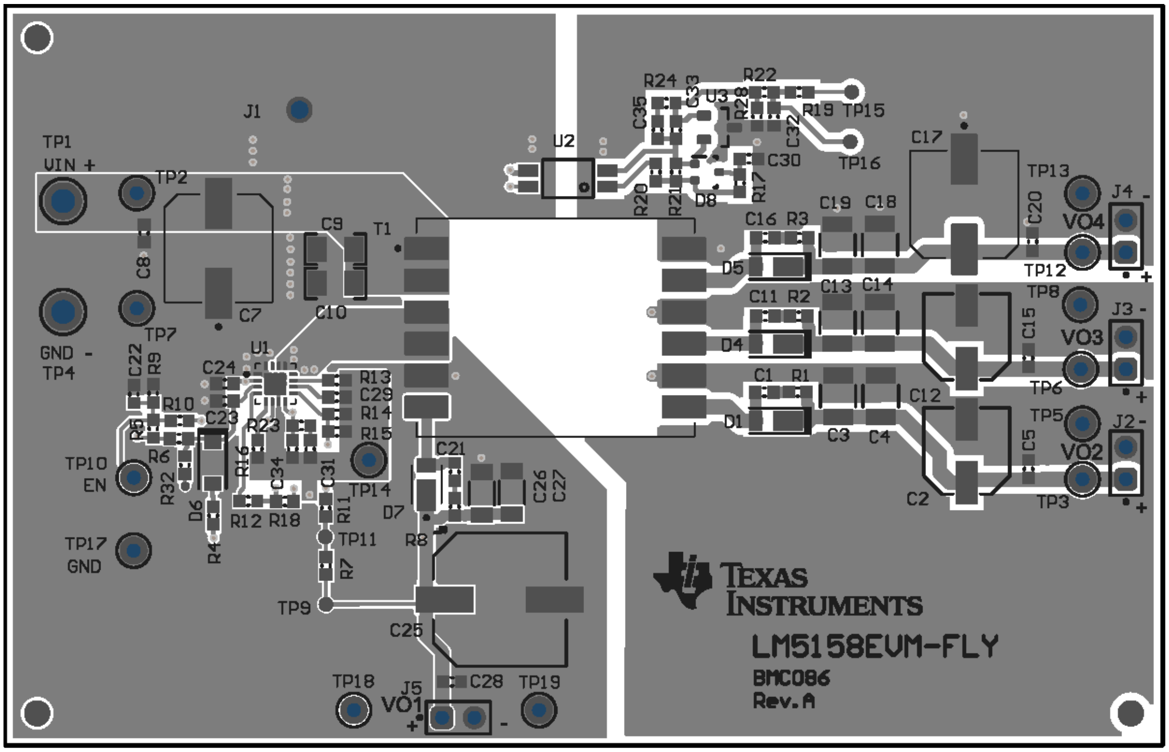


Figure 9-1. Top Layer with Silkscreen

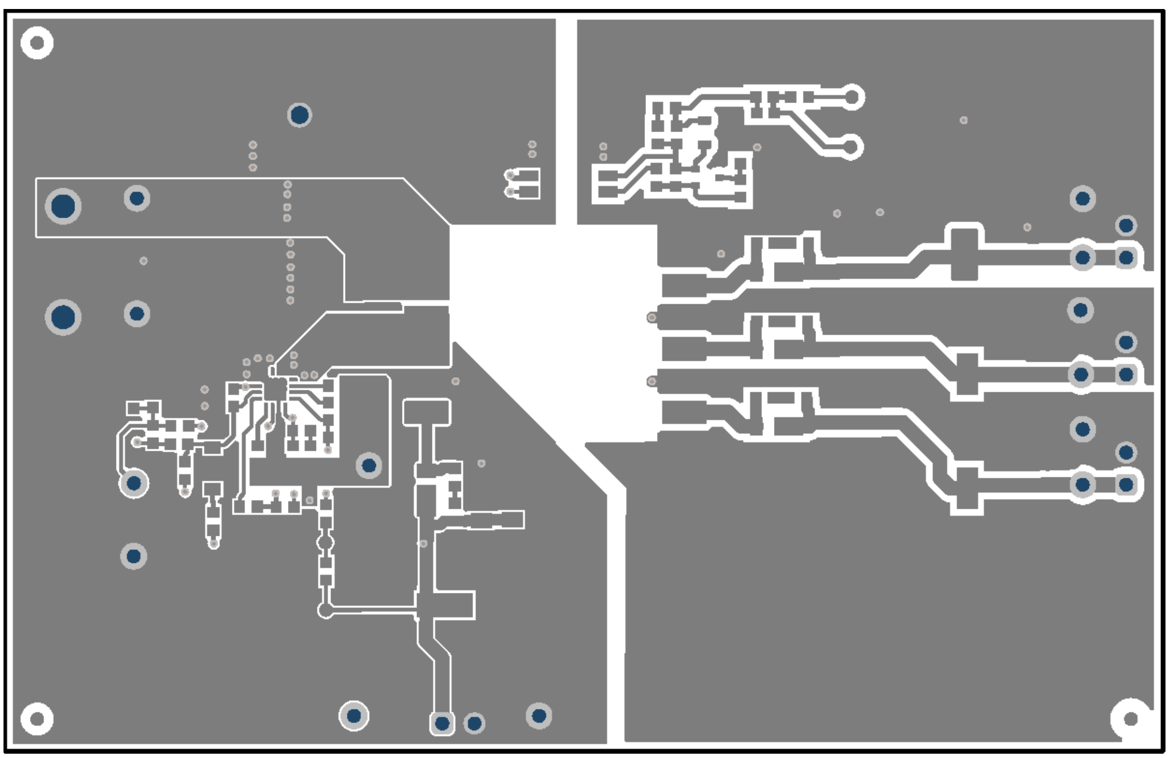


Figure 9-2. Top Layer

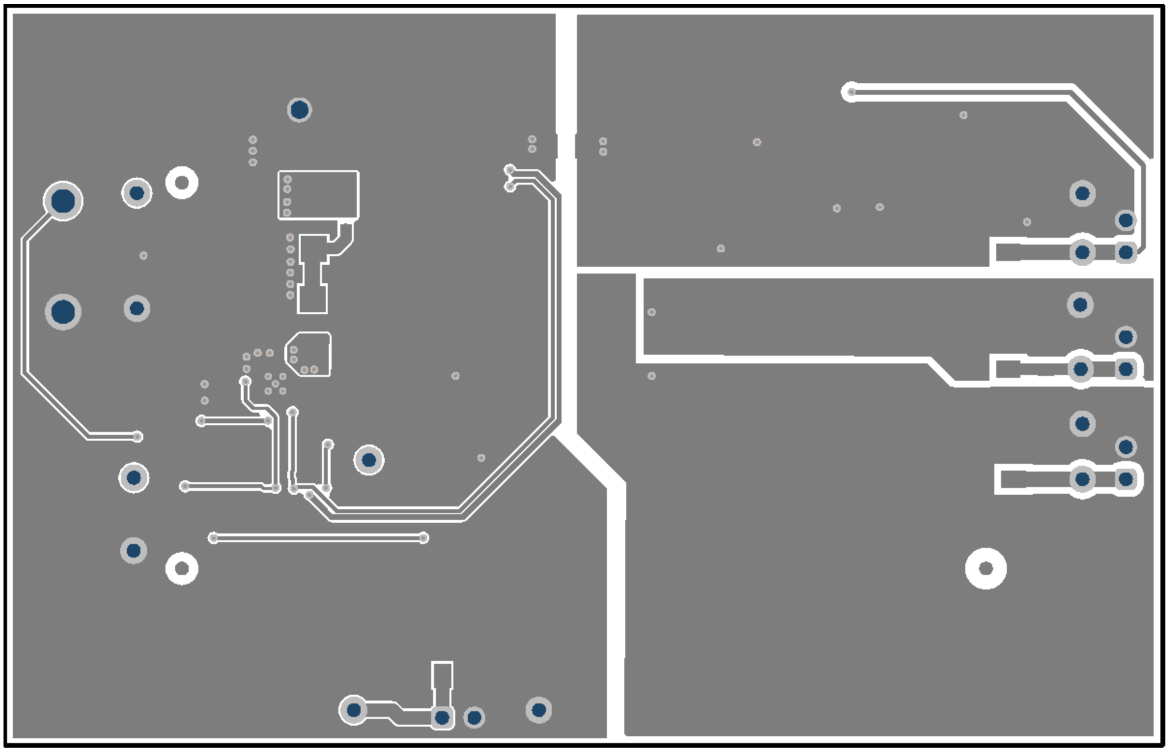


Figure 9-3. Bottom Layer Viewed From Top

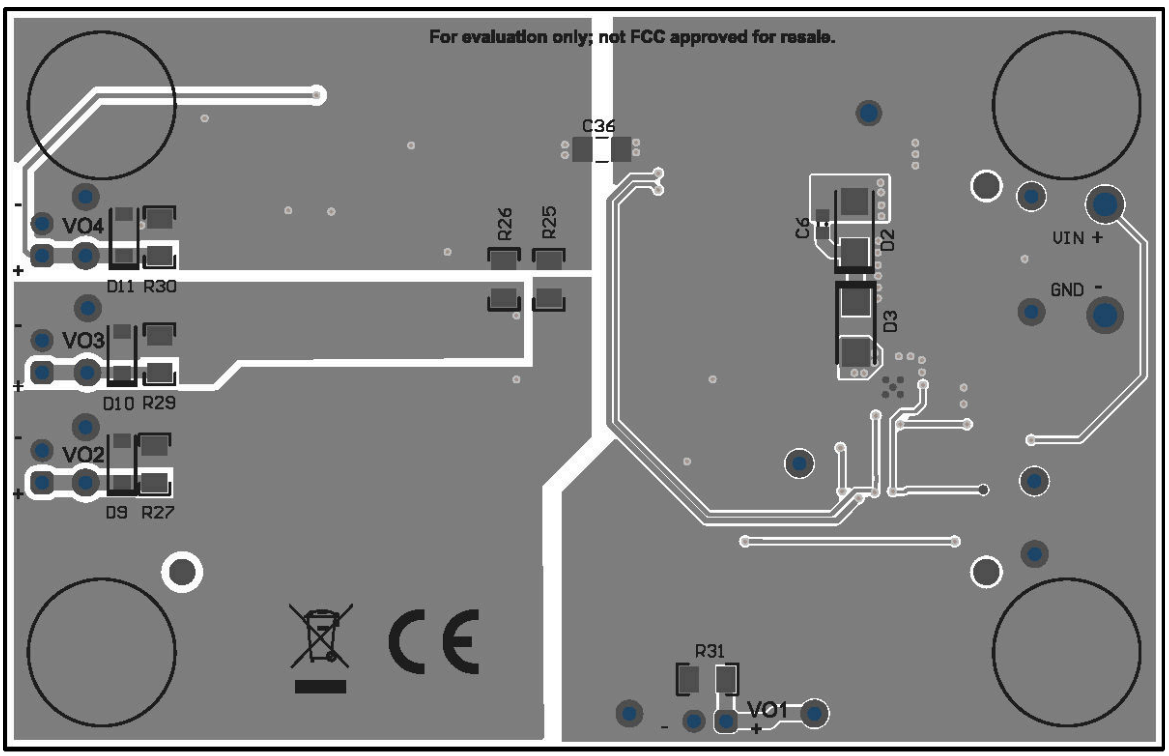


Figure 9-4. Bottom Layer with Silkscreen Viewed From Bottom