EVQ4371-V-1000-00A

36V, 11A, Ultra-Low Quiescent Current, Synchronous Step-Down Converter Evaluation Board, AEC-Q100 Qualified

DESCRIPTION

The EVQ4371-V-1000-00A evaluation board is designed to demonstrate the capabilities of the MPQ4371-1000, a synchronous, step-down switching regulator with integrated, low on-resistance high-side and low-side power MOSFETs (HS-FET and LS-FET, respectively). The device provides a 11A output current (I_{OUT}) and employs zero-delay pulse-width modulation (ZDP™) control, an MPS-exclusive technology that delivers extremely fast transient response while reducing the need for costly external capacitors.

The wide 3.3V to 36V input voltage (V_{IN}) range accommodates a variety of step-down applications in automotive input environments. A 1.8μA shutdown mode quiescent current allows for use in battery-powered applications. High power conversion efficiency across a wide load range is achieved by scaling down the switching frequency (f_{SW}) under light-load conditions to reduce the switching and gate driving losses.

An open-drain power good (PG) signal indicates whether the output is within 94% to 106% of its nominal voltage.

Frequency foldback helps prevent inductor current runaway during start-up. Thermal shutdown provides reliable, fault-tolerant operation.

A high duty cycle and low-dropout (LDO) mode are provided to support automotive cold-crank conditions.

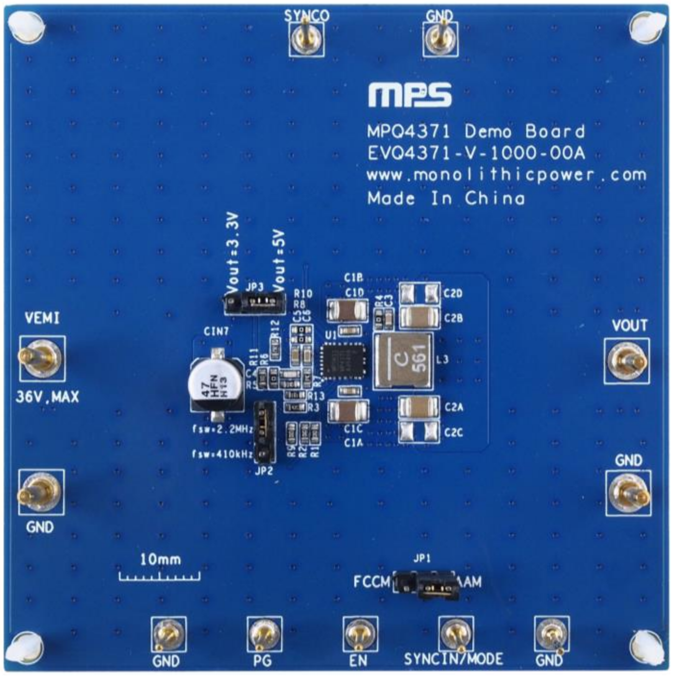
The EVQ4371-V-1000-00A is fully assembled and tested. The MPQ4371-1000 is available in a QFN-23 (4mmx5mm) package with wettable flanks. It is available in AEC-Q100 Grade 1.

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C, unless otherwise noted.

Parameters	Conditions	Value
Input voltage (V_{IN}) range		3.3V to 36V
Output voltage (V_{OUT})	V_{IN} = 3.3V to 36V, I_{OUT} = 0A to 11A	V_{OUT} = 5V
Maximum output current (I_{OUT})	V_{IN} = 3.3V to 36V	11A
Typical efficiency	V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 11A	92.1%
Peak efficiency	V_{IN} = 8V, V_{OUT} = 5V, I_{OUT} = 4A	95.9%
Switching frequency (f_{SW})		2.2MHz

EVQ4371-V-1000-00A EVALUATION BOARD



LxWxH (8.3cmx8.3cmx1.3cm)

Board Number	MPS IC Number
EVQ4371-V-1000-00A	MPQ4371GVE-1000-AEC1

QUICK START GUIDE

The EVQ4371-V-1000-00A evaluation board is easy to set up and can be used to evaluate the MPQ4371-1000's performance. For proper measurement equipment set-up, refer to Figure 2 on page 5 and follow the steps below:

1. Preset the power supply to be between 3.3V and 36V, then turn off the power supply.
2. Set the load current between 0A and 11A. Electronic loads represent a negative impedance to the regulator, and setting the current too high may trigger hiccup mode.
3. If longer cables (>0.5m total) are used between the source and the evaluation board, place a damping capacitor at the input terminals, especially when $V_{IN} \geq 24V$.
4. Connect the power supply terminals to:
   a. Positive (+): VEMI
   b. Negative (-): GND
5. Connect the load terminals to:
   a. Positive (+): VOUT
   b. Negative (-): GND
6. After making the connections, turn on the power supply. The board should automatically start up.
7. To use the enable function, apply a digital input to the EN pin. Drive EN above 1V to turn the regulator on; drive EN below 0.85V to turn the regulator off. If the enable function is not used, EN can be connected directly to VIN.
8. The feedback voltage (V_{FB}) is typically 0.6V for the adjustable output version. The external resistor divider connected to FB sets the output voltage (V_{OUT}) (see Figure 1).

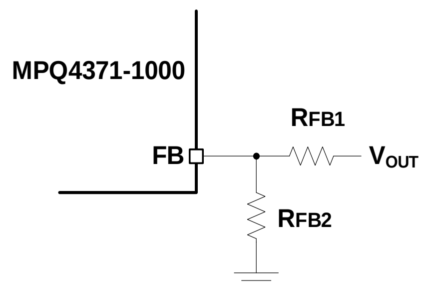


Figure 1: Feedback Divider Network of Adjustable Output Version

Table 1 lists the recommended feedback resistor values for common output voltages.

Table 1: Feedback Resistor Selection for Adjustable Output Version

V_{OUT} (V)	R_{FB1} (kΩ)	R_{FB2} (kΩ)
1	66.5 (1%)	100 (1%)
3.3	100 (1%)	22.1 (1%)
5	100 (1%)	13.7 (1%)

This evaluation board uses JP3 to switch the resistor divider's resistance so that users can choose an output between 3.3V or 5V.

9. The MPQ4371-1000's switching frequency (f_{SW}) can be configured by the FREQ pin's resistor. It can be estimated based on the relationship between f_{SW} and R_{FREQ}. Table 2 shows common values for f_{SW} and R_{FREQ}.

Table 2: f_{SW} vs R_{FREQ}

R_{FREQ} (kΩ)	f_{SW} (kHz)
13	2500
14.3	2330
15	2200
15.8	2100
18.7	1800
22.6	1520
27.4	1270
32.4	1100
41.2	870
51.1	710
71.5	520
88.7	410
100	370
182	210

The evaluation board uses JP2 to switch the FREQ pin's resistor for users to choose between f_{SW} = 2.2MHz or f_{SW} = 410kHz.

10. When the SYNCIN/MODE pin is used as the SYNC input pin (SYNCIN), f_{SW} can be synchronized to the rising edge of a clock signal applied to the SYNCIN/MODE pin. The recommended SYNCIN frequency range is between 90% and 110% of f_{SW}. When the SYNCIN/MODE pin is used for mode selection (MODE), pulling this pin high forces the device to operate in forced continuous conduction mode (FCCM), while pulling it low forces the device to work in advanced asynchronous modulation (AAM) mode (see Table 3).

Table 3: Mode Selection

SYNCIN/MODE Input	Operation
Floating	AAM mode
<0.4V	AAM mode
>1.4V or external clock in	FCCM

Refer to the Application Information section in the MPQ4371's datasheet to calculate the inductance and output capacitance.

Figure 2 shows the measurement equipment set-up.

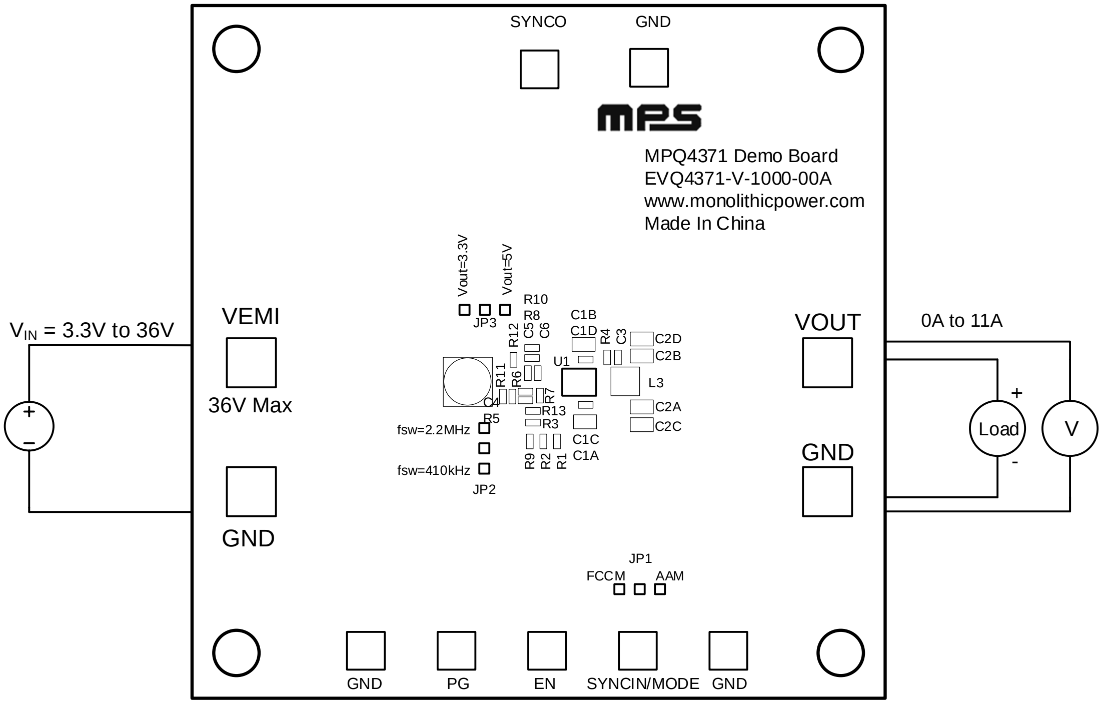


Figure 2: Measurement Equipment Set-Up

EVALUATION BOARD SCHEMATIC

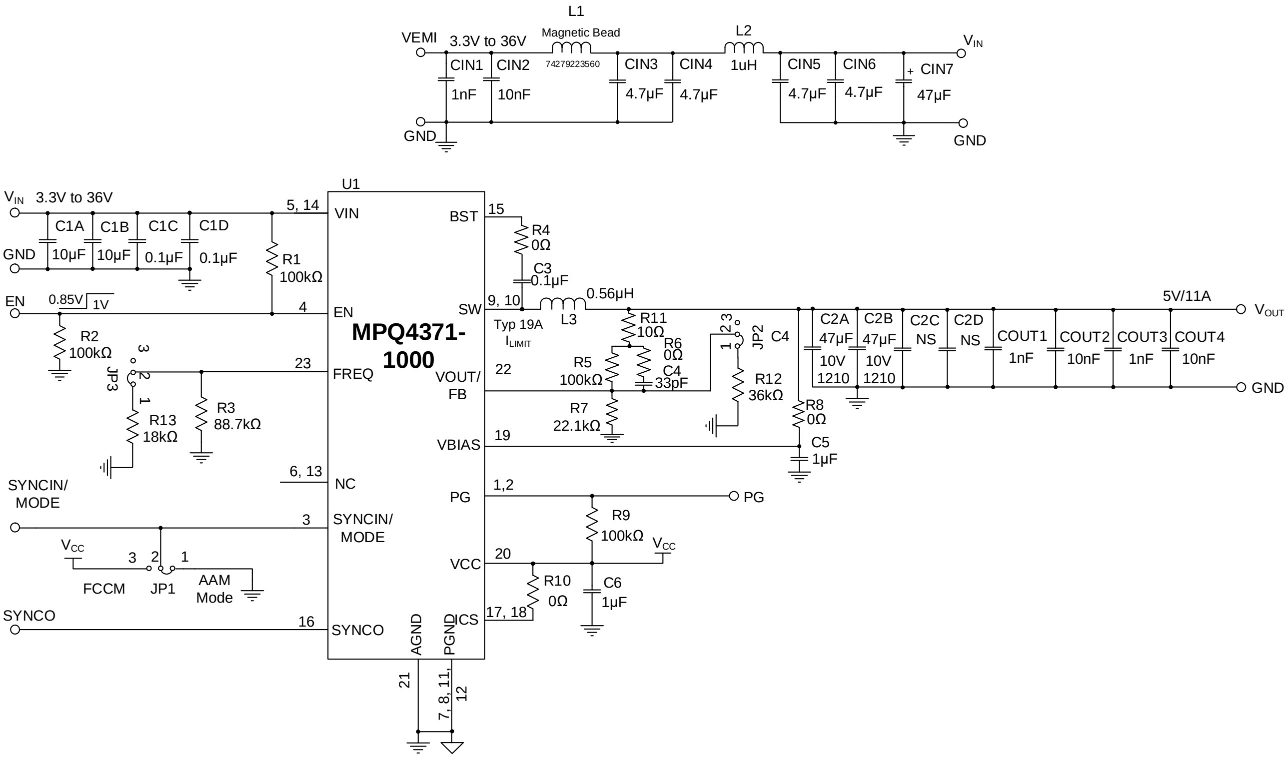
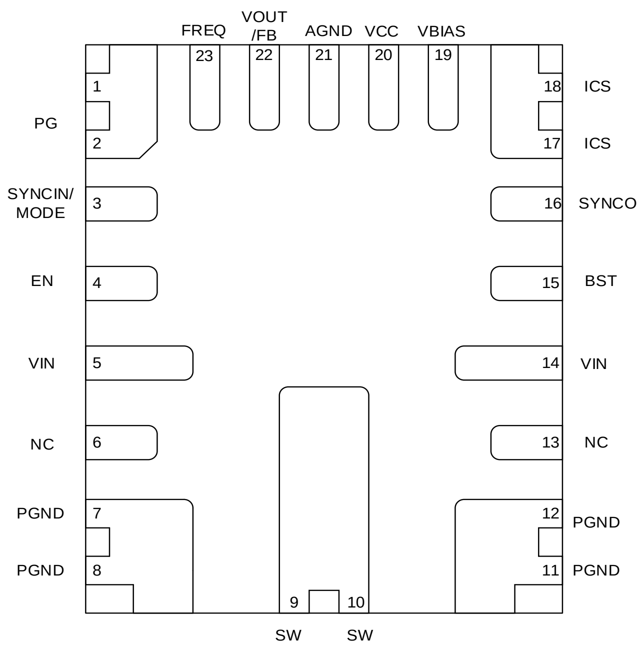


Figure 3: Evaluation Board Schematic

PACKAGE REFERENCE

TOP VIEW



QFN-23 (4mmx5mm)

EVQ4371-V-1000-00A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
3	CIN1, COUT1, COUT3	1nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM216R71H102KA01
3	CIN2, COUT2, COUT4	10nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H103KA01D
4	CIN3, CIN4, CIN5, CIN6	4.7µF	Ceramic capacitor, 50V, X7R	0805	TDK	CGA4J1X7R1H475K
1	CIN7	47µF	Aluminum capacitor, 50V	SMD	Panasonic	EEEFN1H470XP
2	C1A, C1B	10µF	Ceramic capacitor, 50V, X7R	1210	Murata	GRM32ER71H106KA12L
3	C1C, C1D, C3	0.1µF	Ceramic capacitor, 50V, X7R	0603	Murata	GCJ188R71H104KA12D
2	C2A, C2B	47µF	Ceramic capacitor, 10V, X7R	1210	Murata	LMK325B7476MM-TR
1	C4	33pF	Ceramic capacitor, 50V, C0G	0603	TDK	C1608COG1H330J
2	C5, C6	1µF	Ceramic capacitor, 16V, X7R	0603	Murata	GRM188R71C105KA12D
2	C2C, C2D	NS				
1	L1	4.06mm	Magnetic bead	1612	Wurth	74279223560
1	L2	1µH	Inductor, 1µH, 9.4mΩ, 11.1A	SMD	Coilcraft	XAL5030-102MEB/C
1	L3	560nH	Inductor, 560nH, 3mΩ, 29A	SMD	Coilcraft	XAL6030-561MEC
4	R1, R2, R5, R9	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
1	R3	88.7kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0788K7L
1	R13	18kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0718KL
4	R4, R6, R8, R10	0Ω	Film resistor, 5%	0603	Yageo	RC0603JR-070RL
1	R7	22.1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0722K1L
1	R11	10Ω	Film resistor, 1%	0603	Yageo	RC0603FR-0710RL
1	R12	36kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0736KL
3	JP1, JP2, JP3	2.54mm	Test pin, 3-pin	DIP	Any	
4	VEMI GND, VOUT, GND	2mm	Golden pin	DIP	Custom (1)	
7	SYNCIN/MODE, PG, SYNCO, EN, GND	1mm	Golden pin	DIP	Custom (1)	
1	U1	MPQ4371	36V/11A, step-down converter	QFN-23 (4mmx 5mm)	MPS	MPQ4371GVE-1000-AEC1

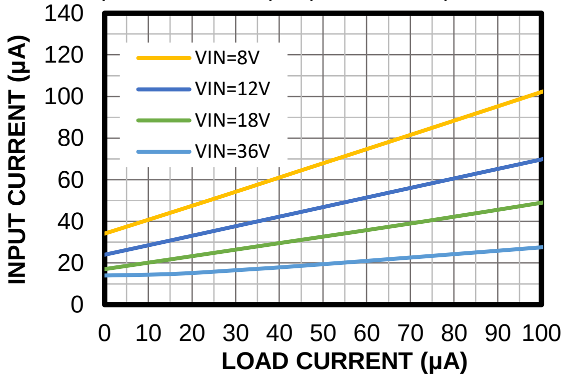
Note:

1) MPS custom-produces these pins. Contact an MPS FAE for more information.

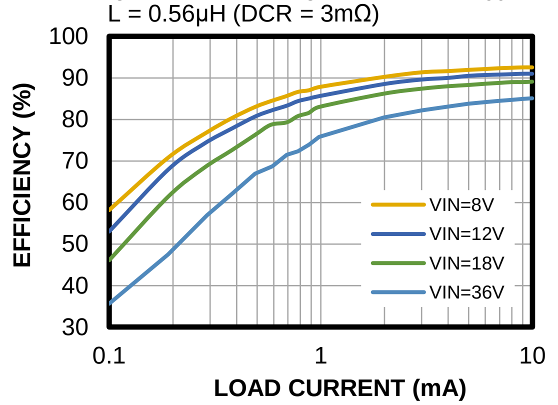
EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, f_{SW} = 2.2MHz, L = 0.56μH (DCR = 3mΩ), T_A = 25°C, unless otherwise noted.

Input Current vs. Load Current
AAM mode, V_{OUT} = 5V,
f_{SW} = 2.2MHz, V_{BIAS} connected to 5V power, L = 0.56μH (DCR = 3mΩ)



Efficiency vs. Load Current
AAM mode, V_{OUT} = 5V,
f_{SW} = 2.2MHz, V_{BIAS} connected to V_{OUT},
L = 0.56μH (DCR = 3mΩ)



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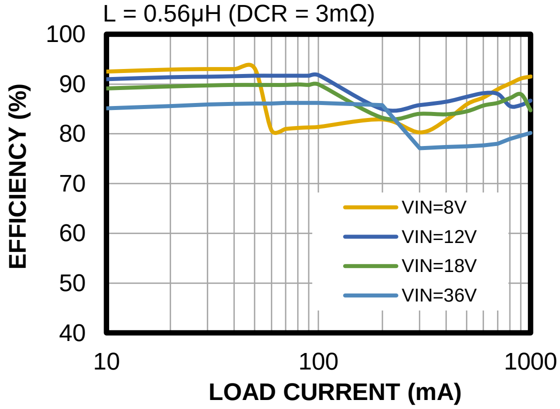

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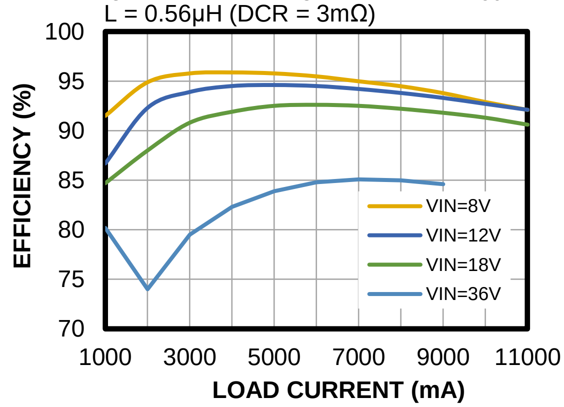

Efficiency vs. Load Current
FCCM, V_{OUT} = 5V, f_{SW} = 2.2MHz,
V_{BIAS} connected to V_{OUT},
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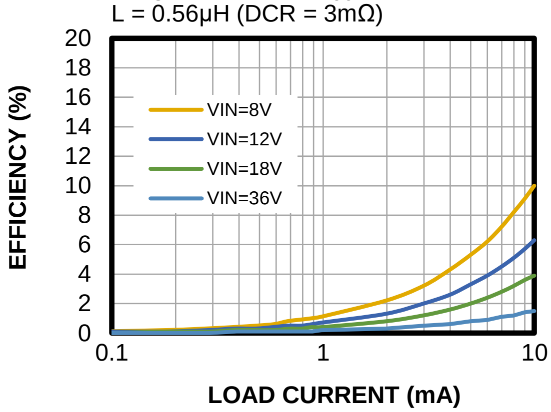

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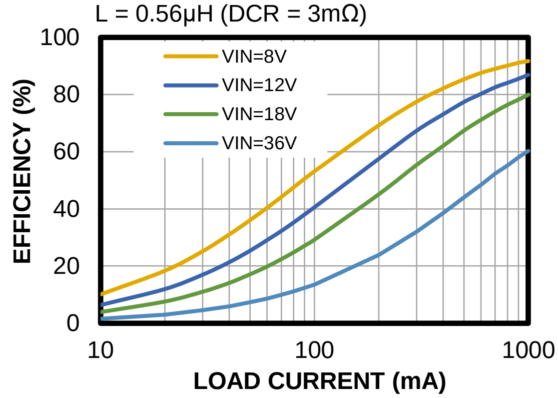

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, f_{SW} = 2.2MHz, L = 0.56µH (DCR = 3mΩ), T_A = 25°C, unless otherwise noted.

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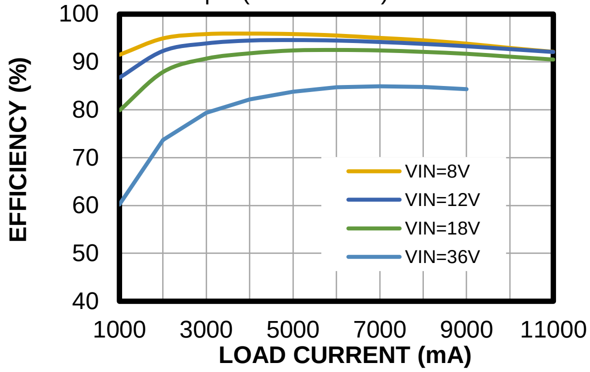
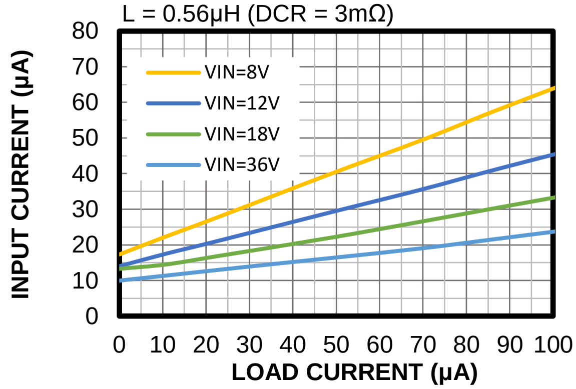


Input Current vs. Load Current
AAM mode, V_{OUT} = 3.3V,
f_{SW} = 2.2MHz, V_{BIAS} connected to GND,
L = 0.56µH (DCR = 3mΩ)



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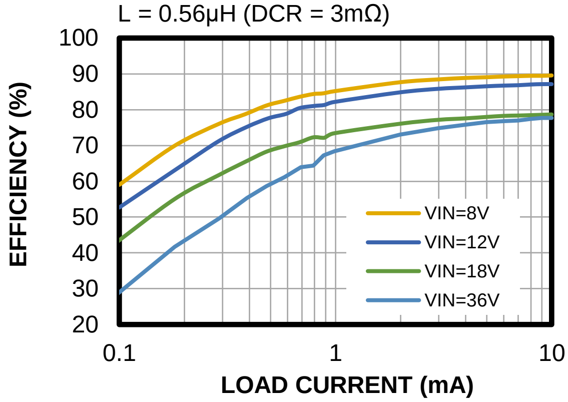

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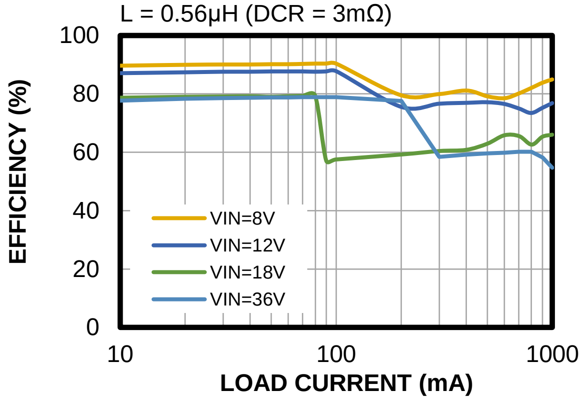
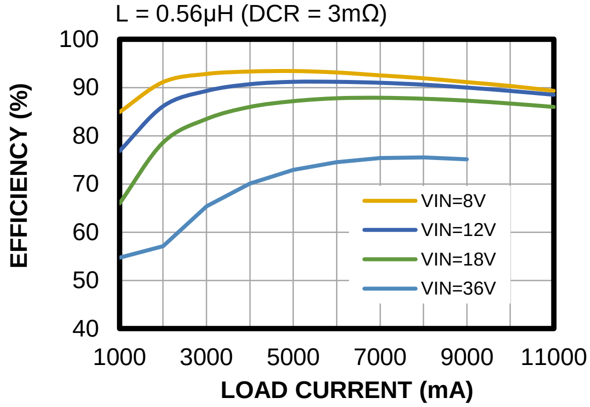
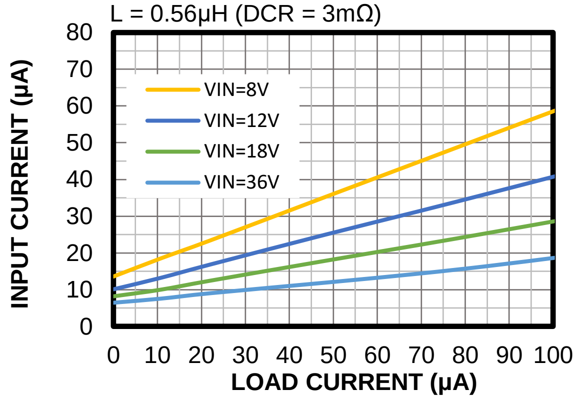


Efficiency vs. Load Current
AAM mode, V_{OUT} = 3.3V,
f_{SW} = 2.2MHz, V_{BIAS} connected to GND,
L = 0.56µH (DCR = 3mΩ)



Input Current vs. Load Current
AAM mode, V_{OUT} = 3.3V,
f_{SW} = 2.2MHz, V_{BIAS} connected to 5V power,
L = 0.56µH (DCR = 3mΩ)



EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, f_{SW} = 2.2MHz, L = 0.56µH (DCR = 3mΩ), T_A = 25°C, unless otherwise noted.

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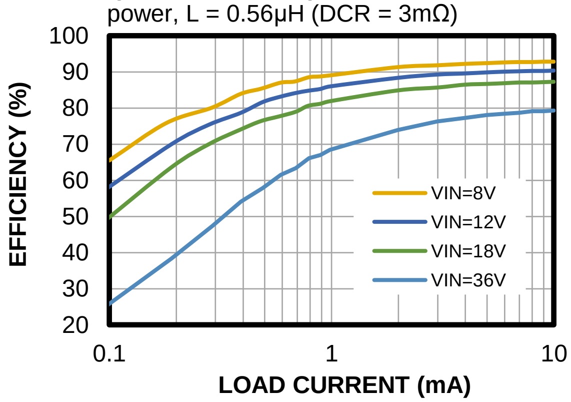

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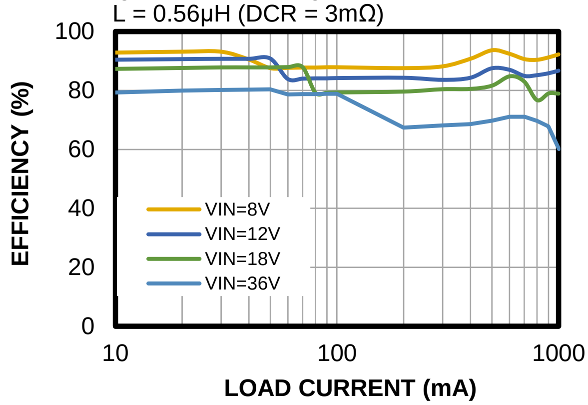

Efficiency vs. Load Current
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V_{BIAS} connected to 5V power,
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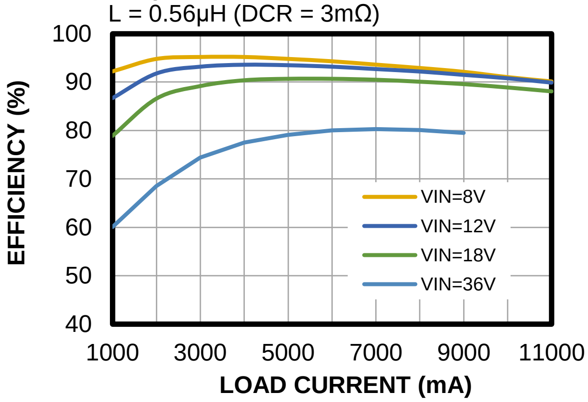
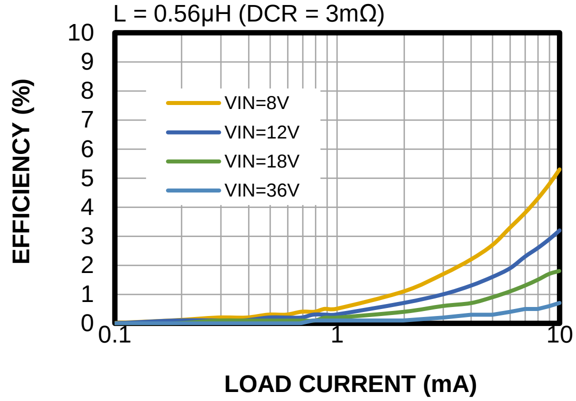


Efficiency vs. Load Current
FCCM, V_{OUT} = 3.3V, f_{SW} = 2.2MHz,
V_{BIAS} connected to GND,
L = 0.56µH (DCR = 3mΩ)



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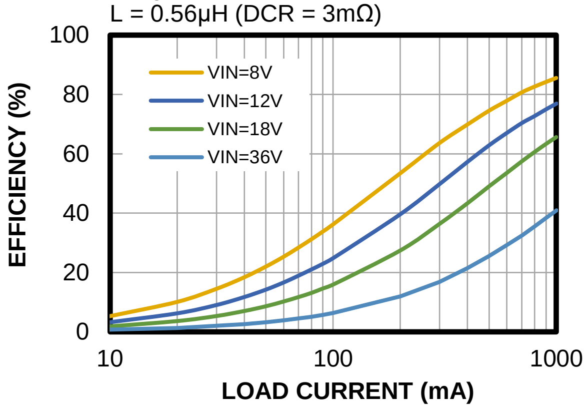

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FCCM, V_{OUT} = 3.3V, f_{SW} = 2.2MHz,
V_{BIAS} connected to GND,
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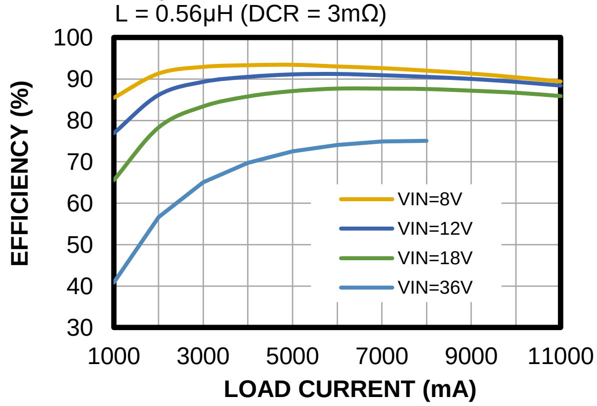
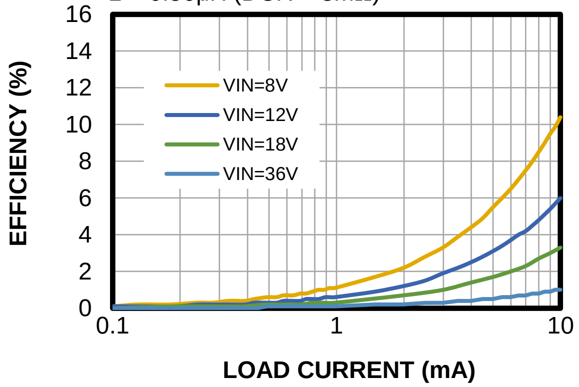


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, f_{SW} = 2.2MHz, L = 0.56µH (DCR = 3mΩ), T_A = 25°C, unless otherwise noted.

Efficiency vs. Load Current
FCCM, V_{OUT} = 3.3V, f_{SW} = 2.2MHz,
V_{BIAS} connected to 5V power,
L = 0.56µH (DCR = 3mΩ)



Efficiency vs. Load Current
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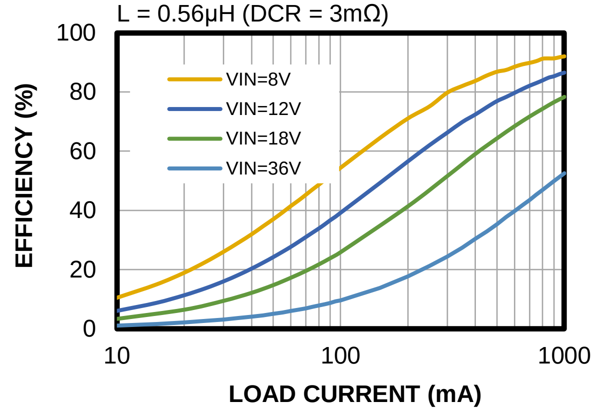
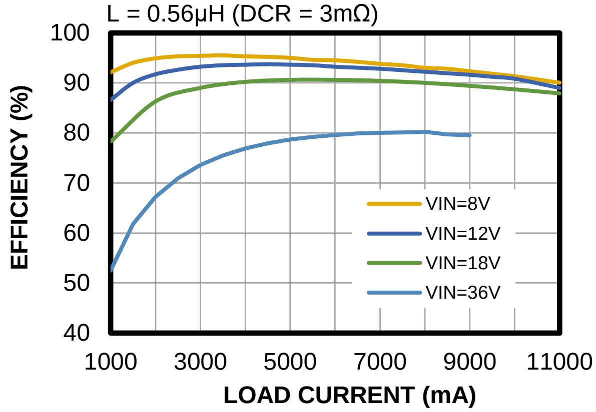
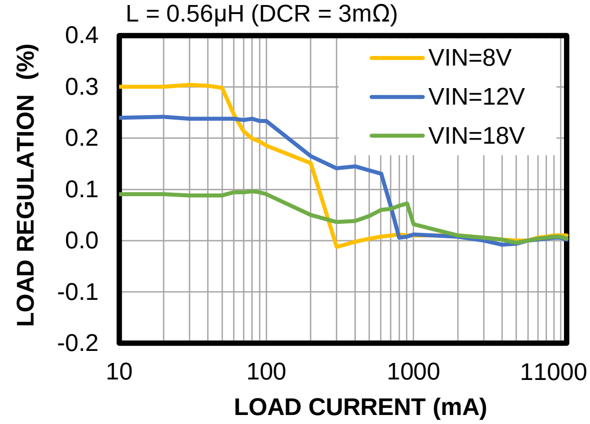
V_{BIAS} connected to 5V power,
L = 0.56µH (DCR = 3mΩ)



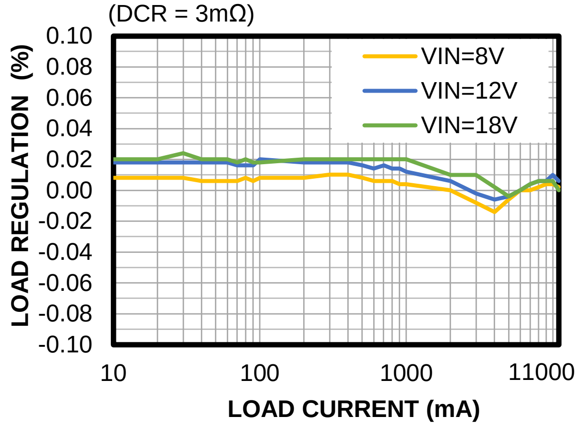
Efficiency vs. Load Current
FCCM, V_{OUT} = 3.3V, f_{SW} = 2.2MHz,
V_{BIAS} connected to 5V power,
L = 0.56µH (DCR = 3mΩ)



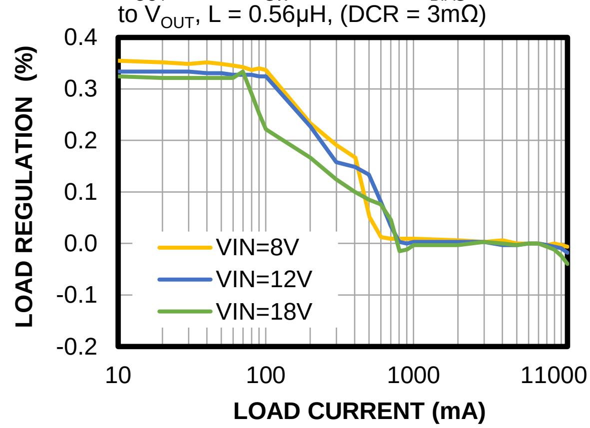
Load Regulation
MPQ4371-1000, AAM mode,
V_{OUT} = 5V, f_{SW} = 2.2MHz,
L = 0.56µH (DCR = 3mΩ)



Load Regulation
MPQ4371-1000, FCCM, V_{OUT} = 5V,
f_{SW} = 2.2MHz, L = 0.56µH
(DCR = 3mΩ)



Load Regulation
MPQ4371-1000, AAM mode,
V_{OUT} = 3.3V, f_{SW} = 2.2MHz, V_{BIAS} connected
to V_{OUT}, L = 0.56µH, (DCR = 3mΩ)



EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, f_{SW} = 2.2MHz, L = 0.56μH (DCR = 3mΩ), T_A = 25°C, unless otherwise noted.

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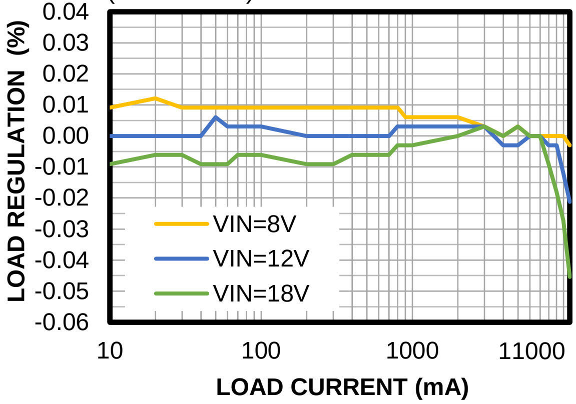
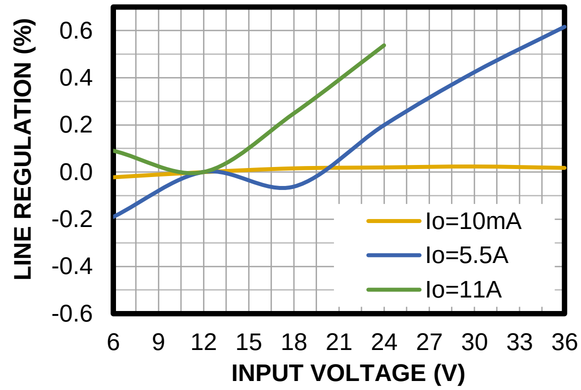
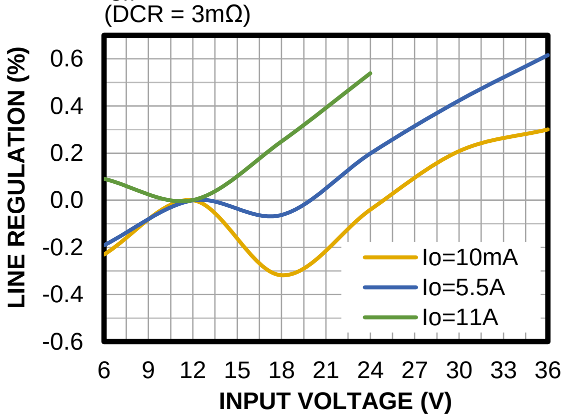
MPQ4371-1000, FCCM, V_{OUT} = 3.3V, f_{SW} = 2.2MHz, L = 0.56μH (DCR = 3mΩ)



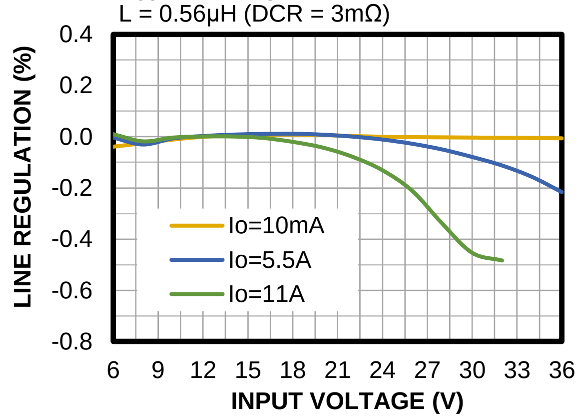
Line Regulation
MPQ4371-1000, AAM mode, V_{OUT} = 5V, f_{SW} = 2.2MHz, L = 0.56μH (DCR = 3mΩ)



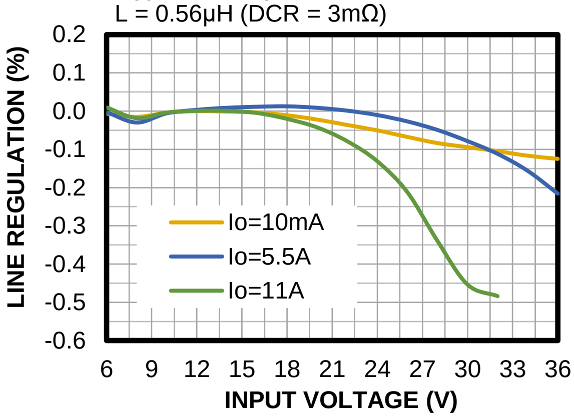
Line Regulation
MPQ4371-1000, FCCM, V_{OUT} = 5V, f_{SW} = 2.2MHz, L = 0.56μH (DCR = 3mΩ)



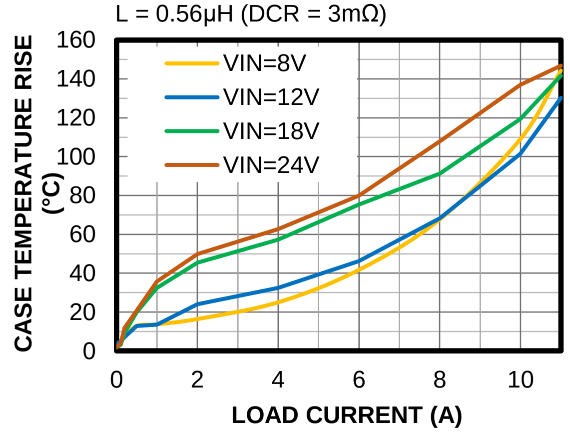
Line Regulation
MPQ4371-1000, AAM mode, V_{OUT} = 3.3V, f_{SW} = 2.2MHz, L = 0.56μH (DCR = 3mΩ)



Line Regulation
MPQ4371-1000, FCCM, V_{OUT} = 3.3V, f_{SW} = 2.2MHz, L = 0.56μH (DCR = 3mΩ)

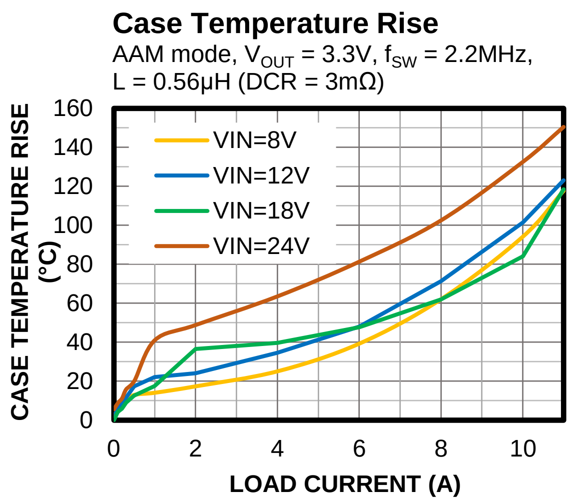


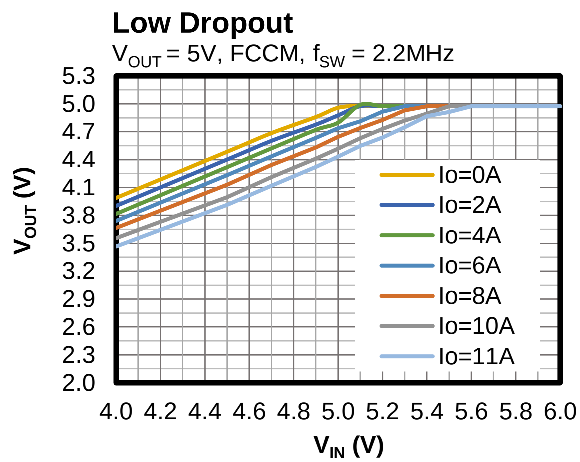
Case Temperature Rise
AAM mode, V_{OUT} = 5V, f_{SW} = 2.2MHz, L = 0.56μH (DCR = 3mΩ)

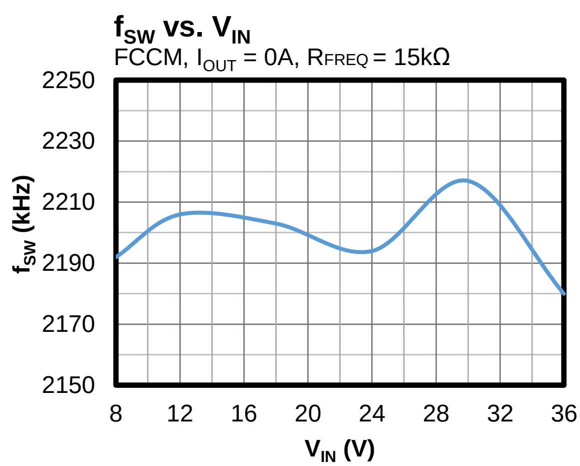


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, f_{SW} = 2.2MHz, L = 0.56μH (DCR = 3mΩ), T_A = 25°C, unless otherwise noted.





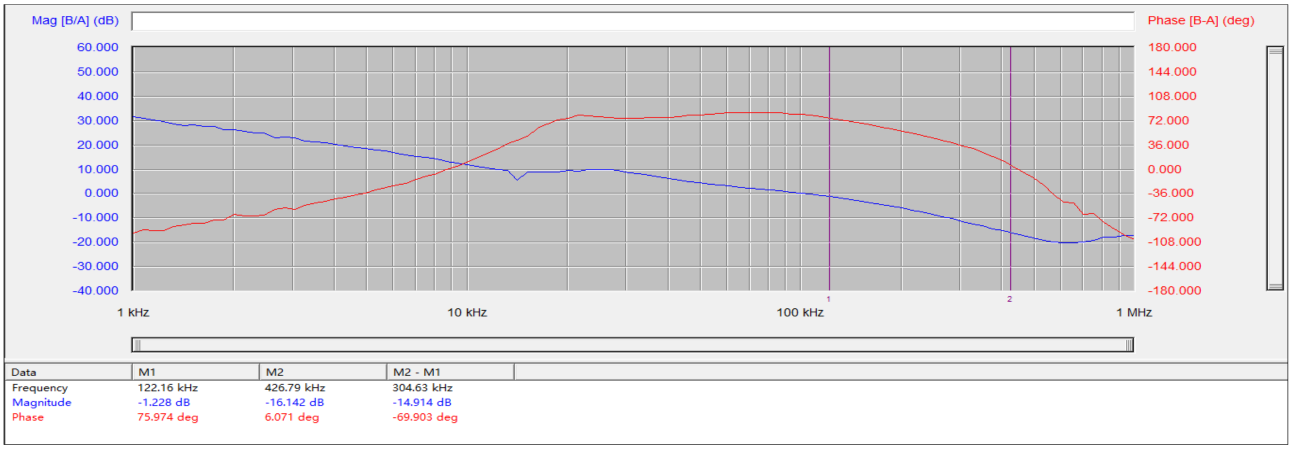


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, f_{SW} = 2.2MHz, L = 0.56µH (DCR = 3mΩ), T_A = 25°C, unless otherwise noted.

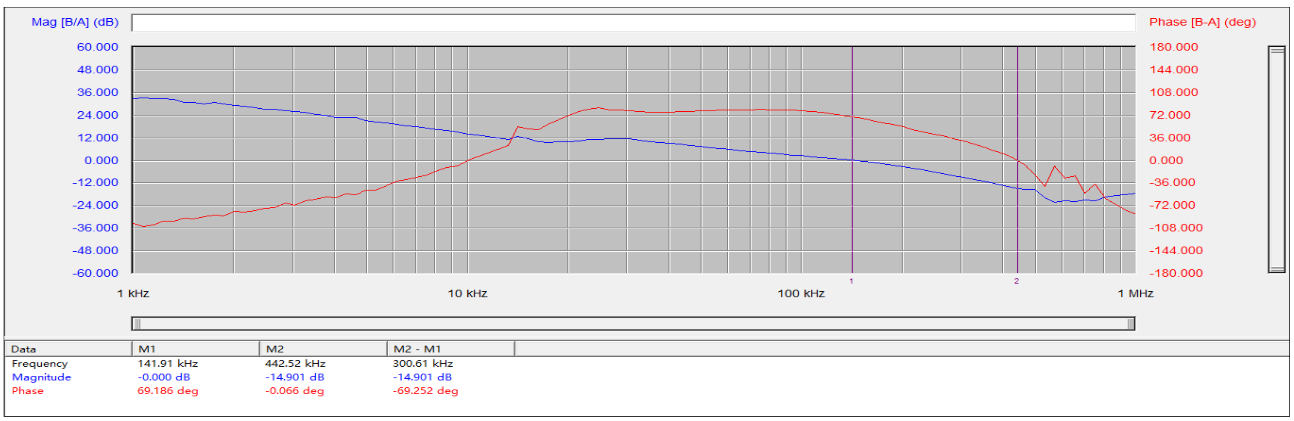
Loop Performance

I_{OUT} = 11A, T_A = 25°C



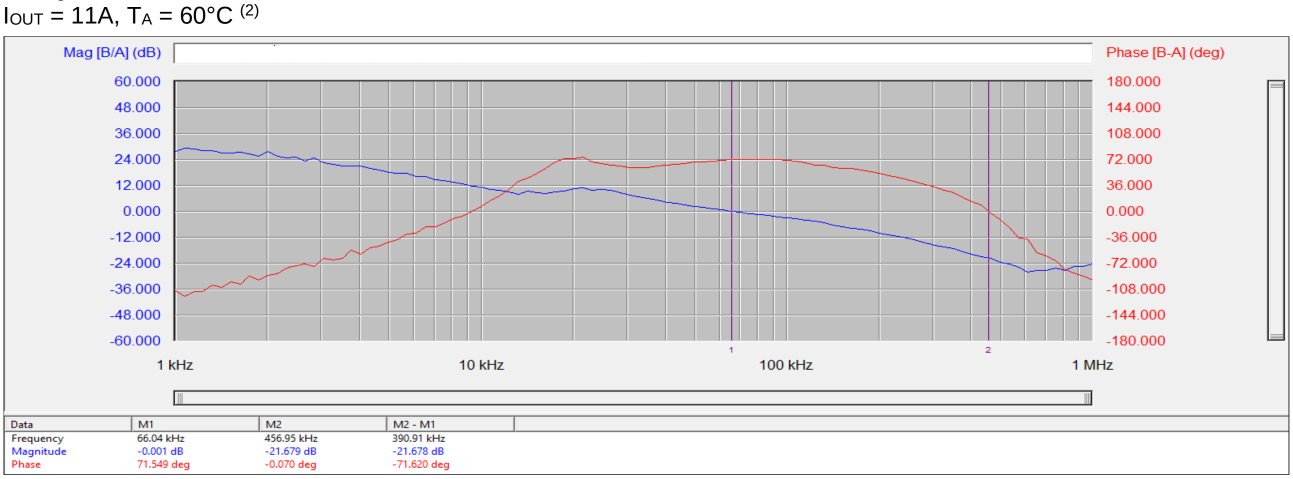
Loop Performance

I_{OUT} = 11A, T_A = -40°C



Loop Performance

I_{OUT} = 11A, T_A = 60°C (2)



Note:

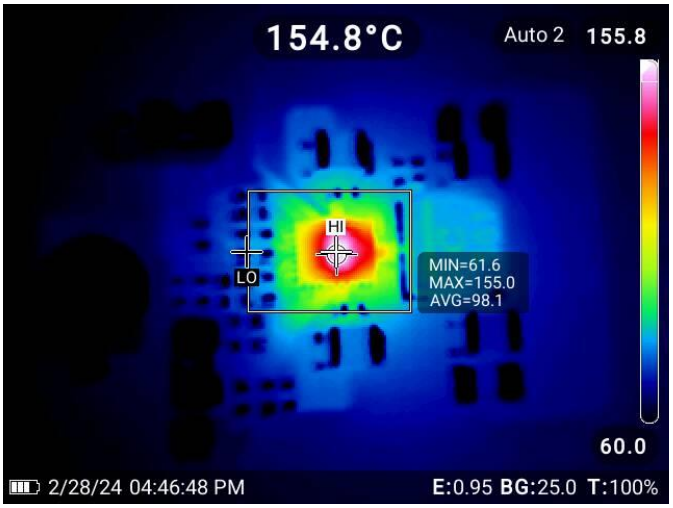
2) Reduce the ambient temperature to avoid triggering over-temperature protection (OTP).

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, f_{SW} = 2.2MHz, L = 0.56µH (DCR = 3mΩ), T_A = 25°C, unless otherwise noted.

Thermal Performance

V_{OUT} = 5V, I_{OUT} = 11A, no forced airflow, T_{CASE} = 155.0°C

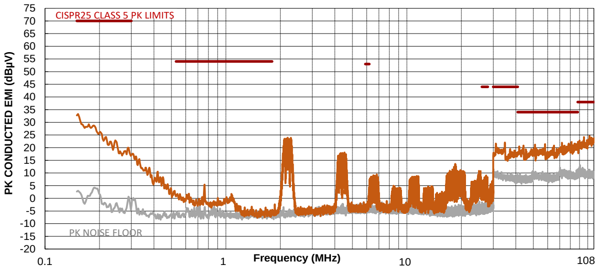


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 11A, f_{SW} = 2.2MHz, L = 0.56µH (DCR = 3mΩ), T_A = 25°C, unless otherwise noted.

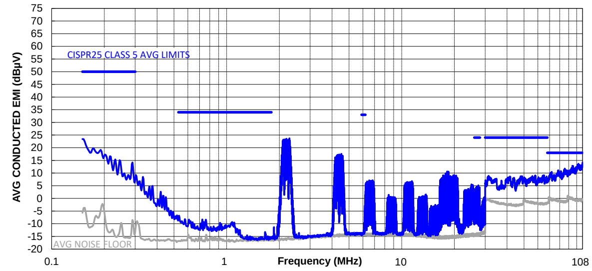
CISPR25 Class 5 Peak Conducted Emissions

150kHz to 108MHz



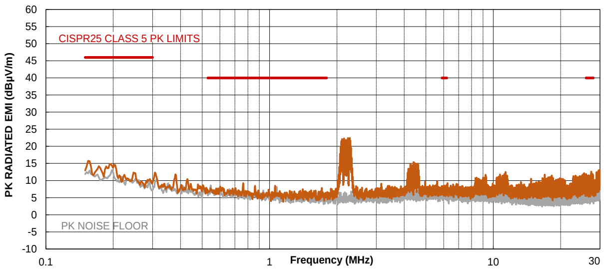
CISPR25 Class 5 Average Conducted Emissions

150kHz to 108MHz



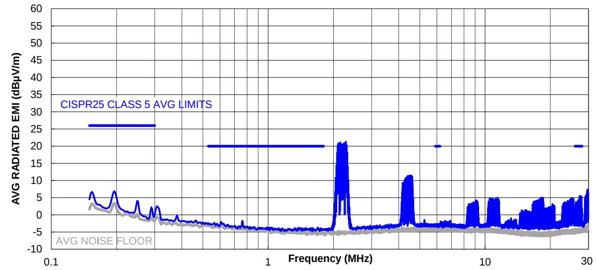
CISPR25 Class 5 Peak Radiated Emissions

150kHz to 30MHz



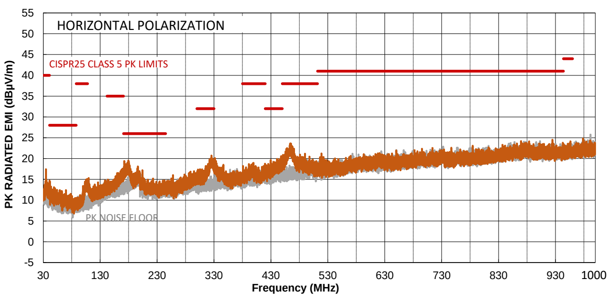
CISPR25 Class 5 Average Radiated Emissions

150kHz to 30MHz



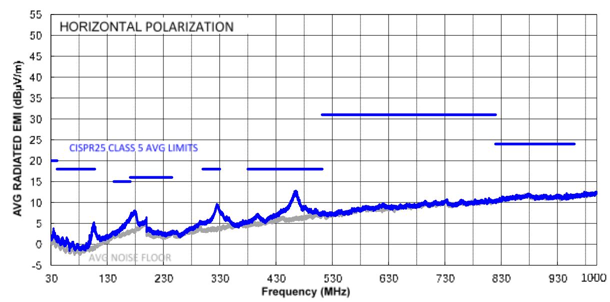
CISPR25 Class 5 Peak Radiated Emissions

Horizontal, 30MHz to 1GHz



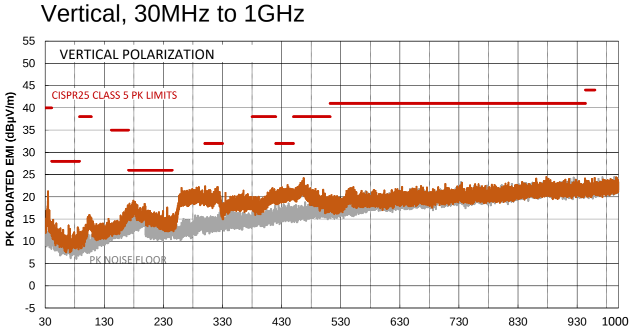
CISPR25 Class 5 Average Radiated Emissions

Horizontal, 30MHz to 1GHz



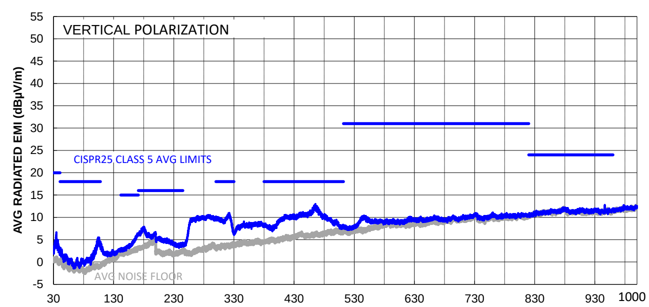
CISPR25 Class 5 Peak Radiated Emissions

Vertical, 30MHz to 1GHz



CISPR25 Class 5 Average Radiated Emissions

Vertical, 30MHz to 1GHz

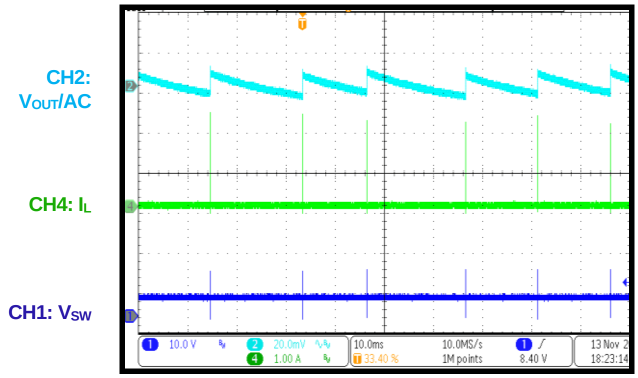


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, L = 0.56µH, f_{SW} = 2.2MHz, AAM mode, T_A = 25°C, unless noted otherwise.

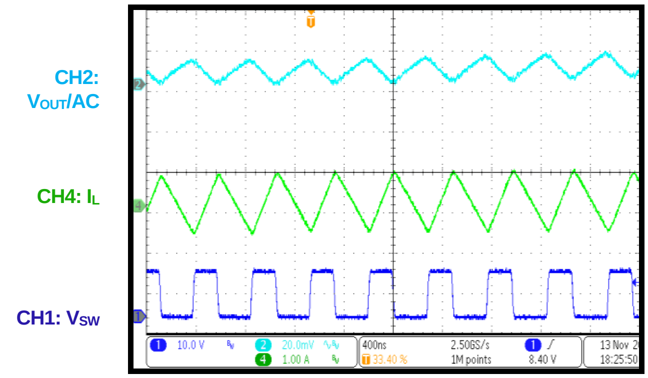
Steady State

I_{OUT} = 0A, AAM mode



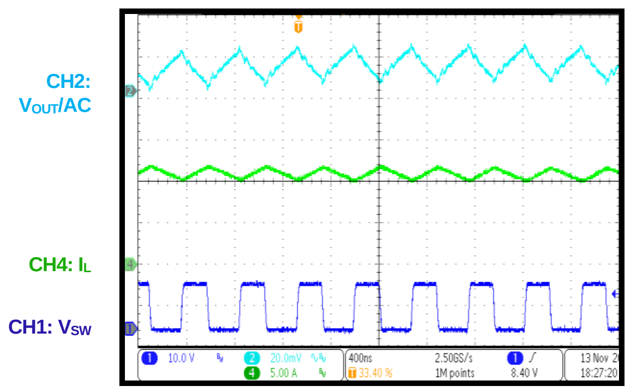
Steady State

I_{OUT} = 0A, FCCM



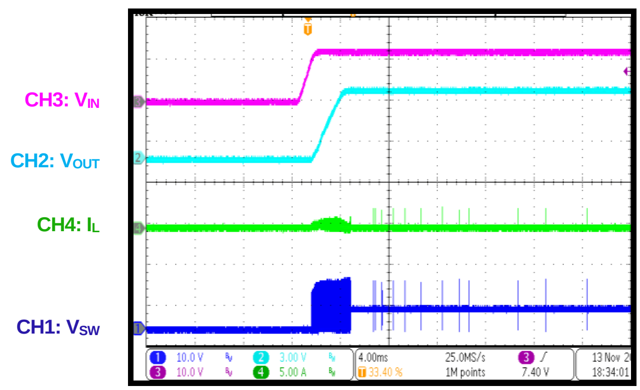
Steady State

I_{OUT} = 11A



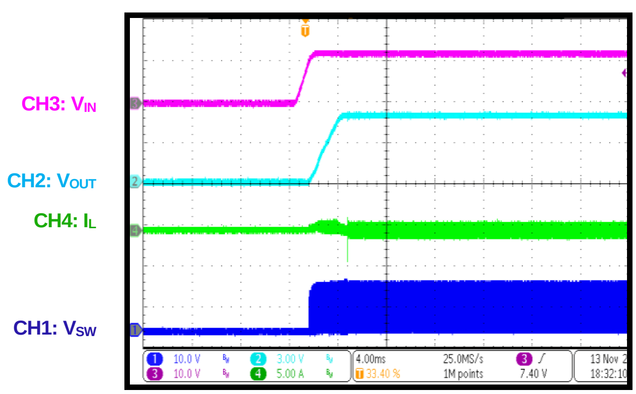
Start-Up through VIN

I_{OUT} = 0A, AAM mode



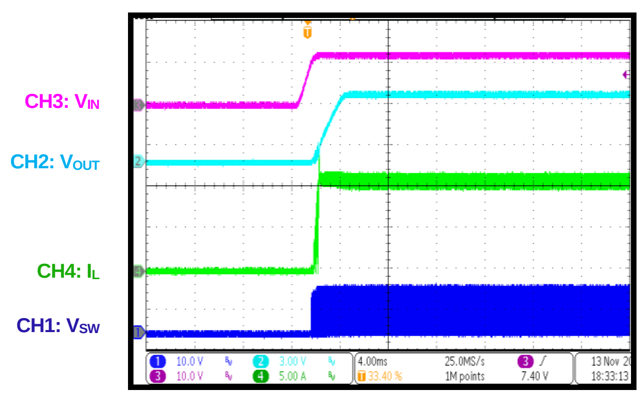
Start-Up through VIN

I_{OUT} = 0A, FCCM



Start-Up through VIN

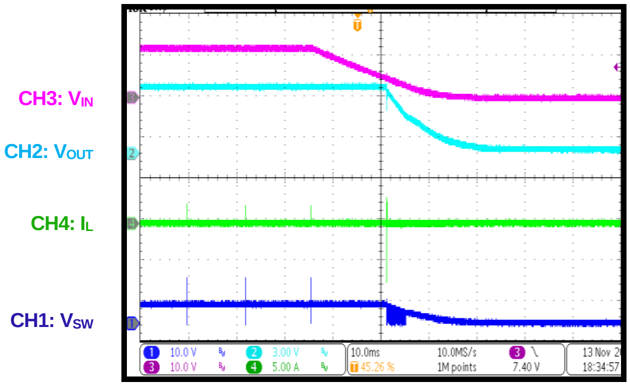
I_{OUT} = 11A



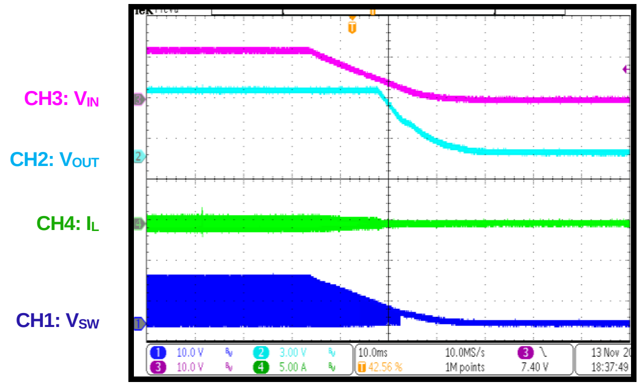
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, L = 0.56µH, f_{SW} = 2.2MHz, AAM mode, T_A = 25°C, unless otherwise noted.

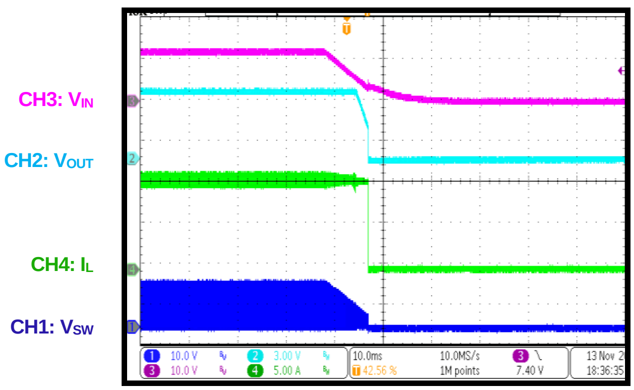
Shutdown through VIN
I_{OUT} = 0A, AAM mode



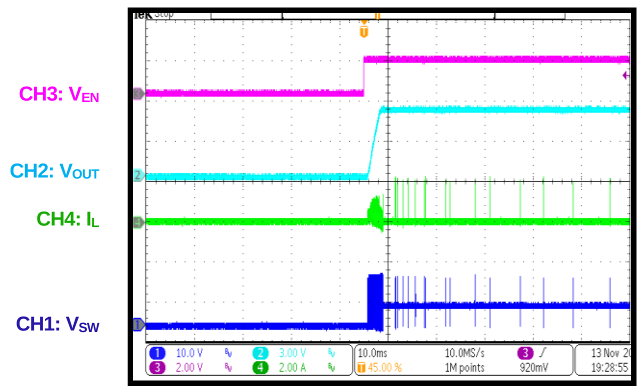
Shutdown through VIN
I_{OUT} = 0A, FCCM



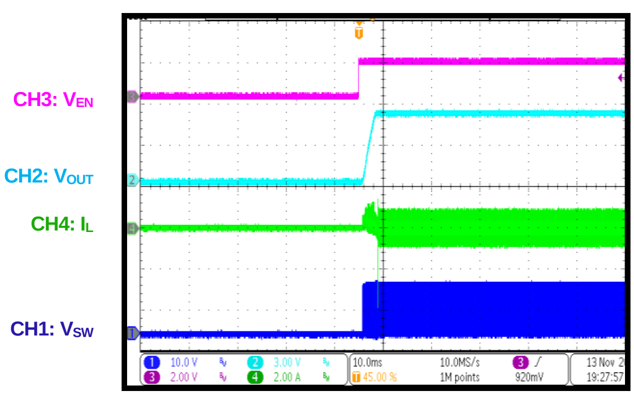
Shutdown through VIN
I_{OUT} = 11A



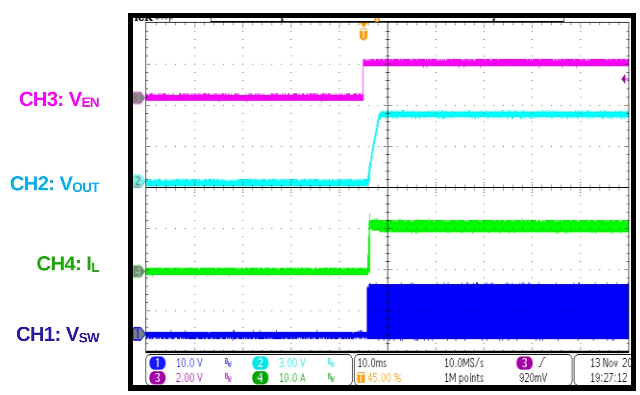
Start-Up through EN
I_{OUT} = 0A, AAM mode



Start-Up through EN
I_{OUT} = 0A, FCCM



Start-Up through EN
I_{OUT} = 11A

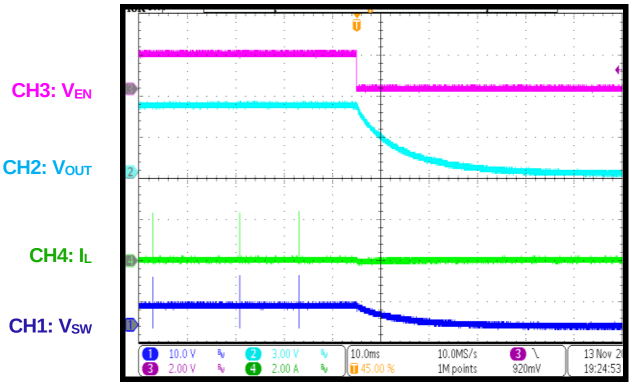


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, L = 0.56µH, f_{SW} = 2.2MHz, AAM mode, T_A = 25°C, unless otherwise noted.

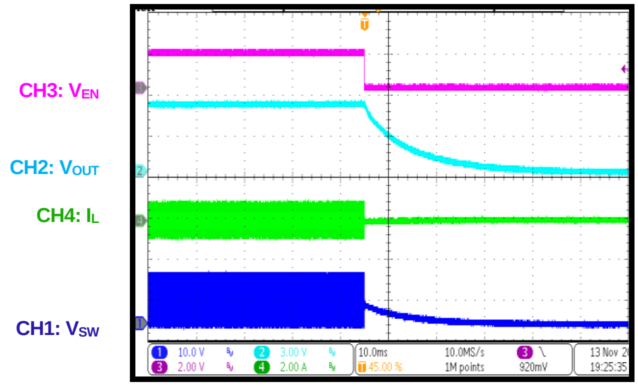
Shutdown through EN

I_{OUT} = 0A, AAM mode



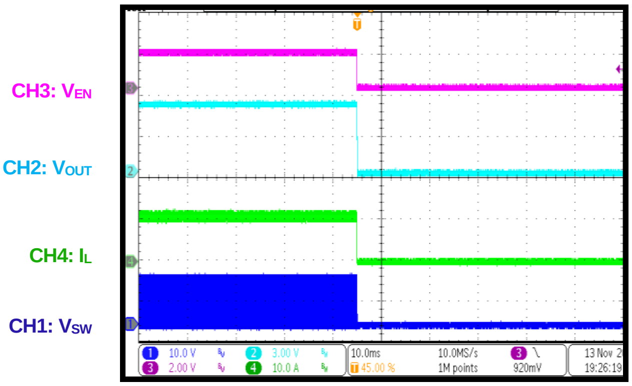
Shutdown through EN

I_{OUT} = 0A, FCCM



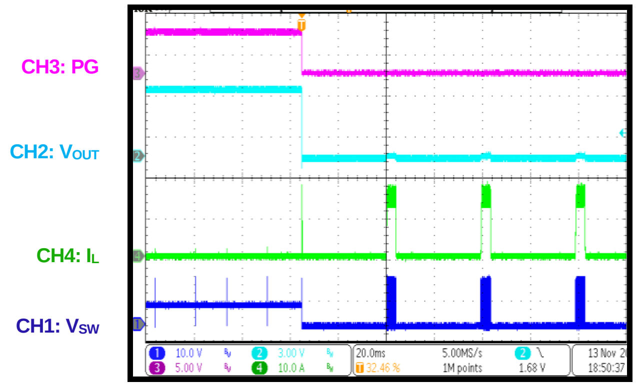
Shutdown through EN

I_{OUT} = 11A



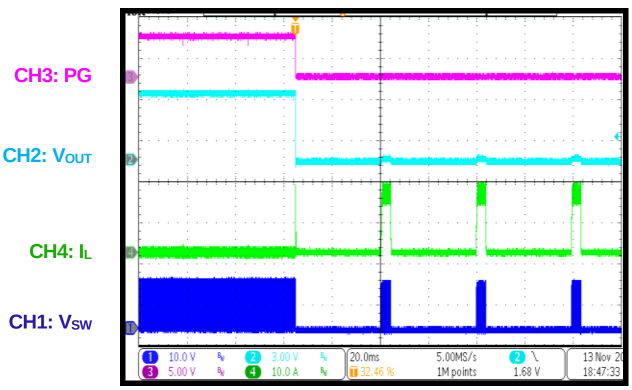
SCP Entry

I_{OUT} = 0A, AAM mode



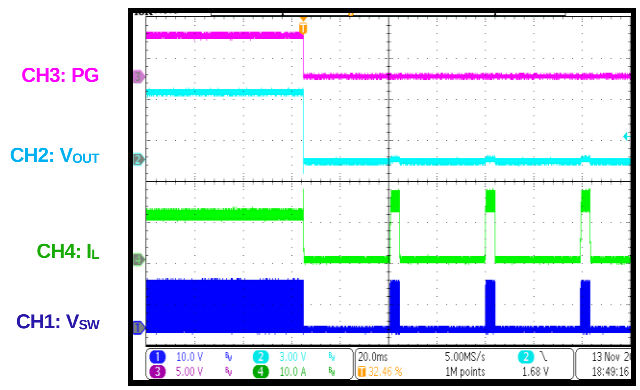
SCP Entry

I_{OUT} = 0A, FCCM



SCP Entry

I_{OUT} = 11A

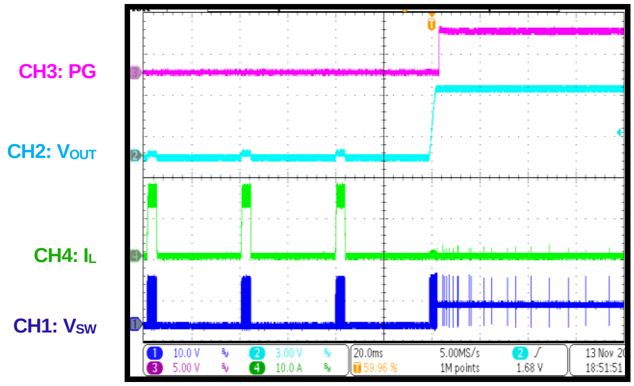


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, L = 0.56µH, f_{SW} = 2.2MHz, AAM mode, T_A = 25°C, unless otherwise noted.

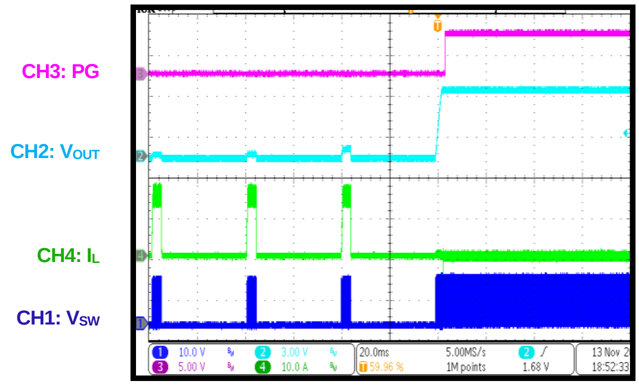
SCP Recovery

I_{OUT} = 0A, AAM mode



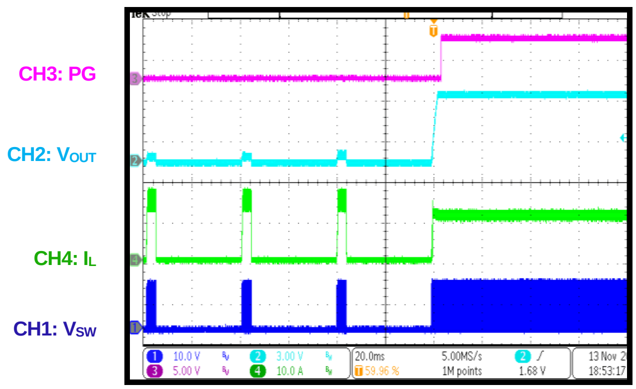
SCP Recovery

I_{OUT} = 0A, FCCM

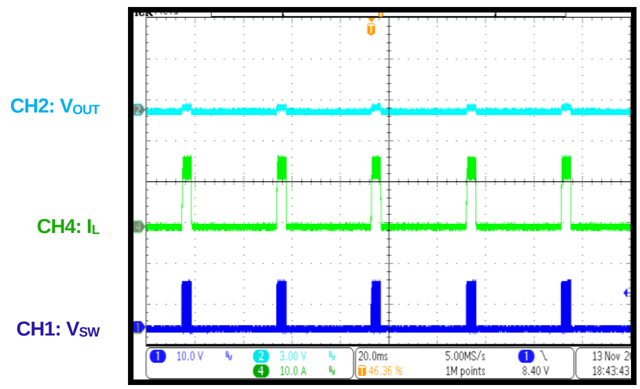


SCP Recovery

I_{OUT} = 11A

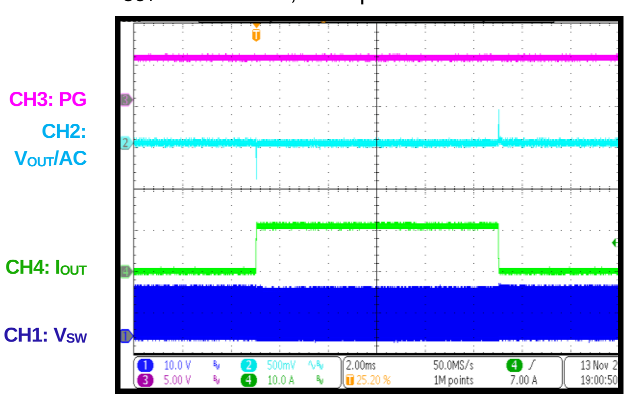


SCP Steady State



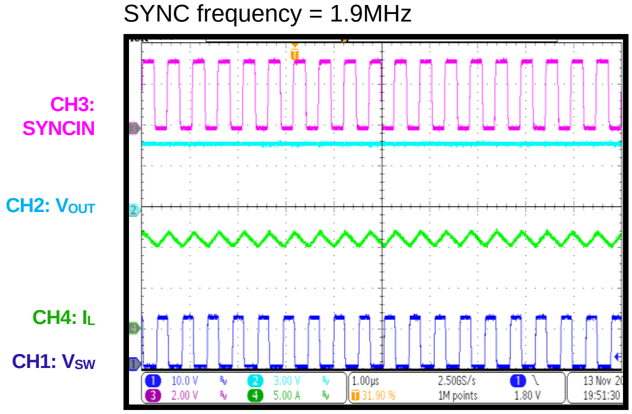
Load Transient Response

I_{OUT} = 0A to 11A, 1.6A/µs



SYNCIN Operation

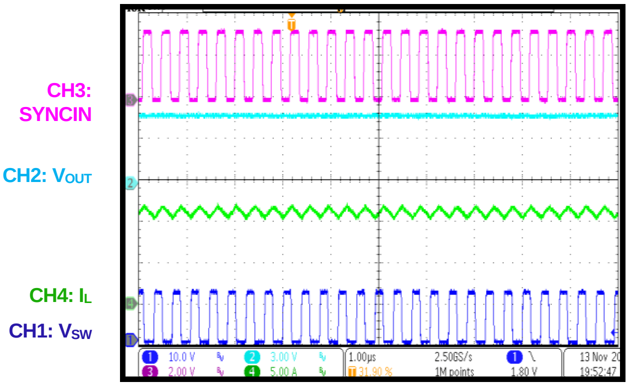
I_{OUT} = 11A, f_{SW} = 2.2MHz,
SYNC frequency = 1.9MHz



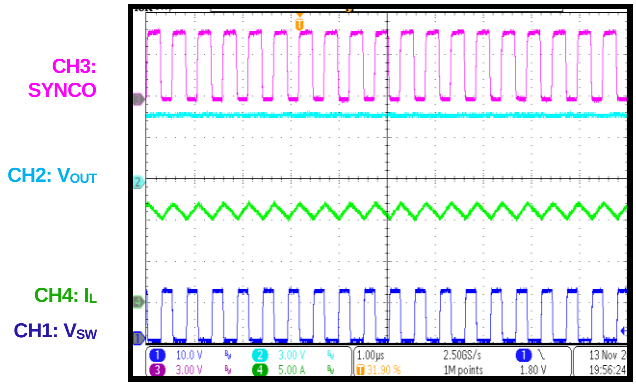
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, L = 0.56µH, f_{SW} = 2.2MHz, AAM mode, T_A = 25°C, unless otherwise noted.

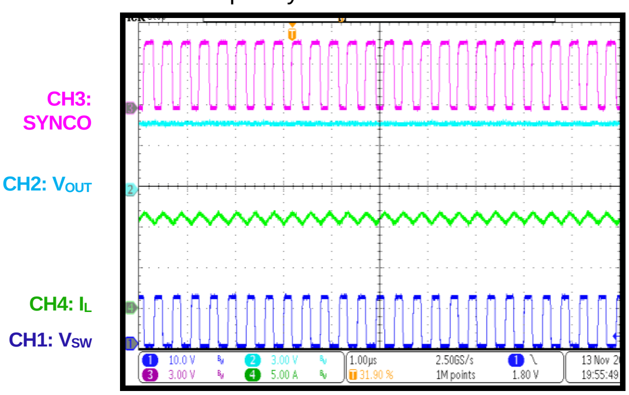
SYNCIN Operation
I_{OUT} = 11A, f_{SW} = 2.2MHz,
SYNC frequency = 2.6MHz



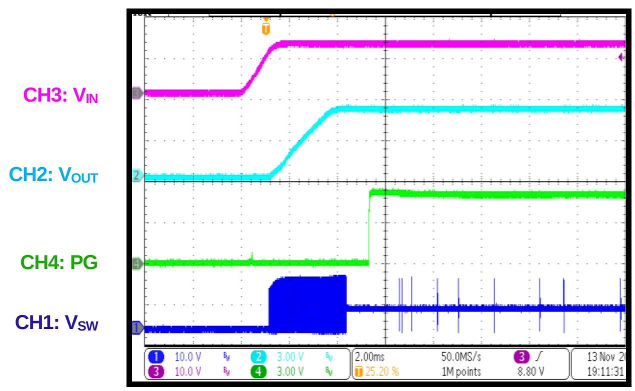
SYNCO Operation
I_{OUT} = 11A, f_{SW} = 2.2MHz,
SYNC frequency = 1.9MHz



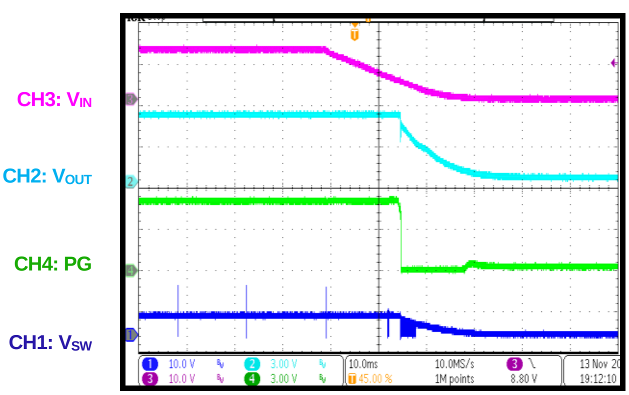
SYNCO Operation
I_{OUT} = 11A, f_{SW} = 2.2MHz,
SYNC frequency = 2.6MHz



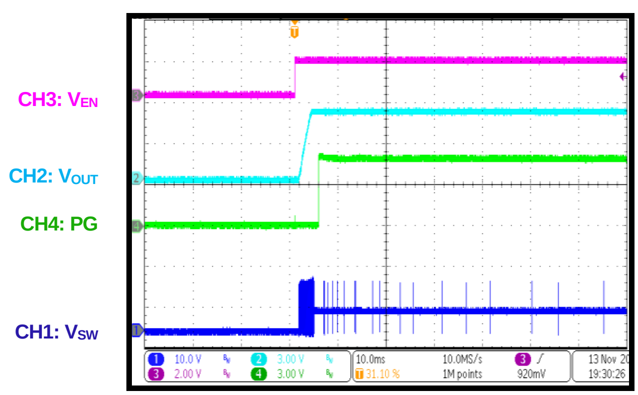
PG in Start-Up through VIN
I_{OUT} = 0A, AAM mode



PG in Shutdown through VIN
I_{OUT} = 0A, AAM mode



PG in Start-Up through EN
I_{OUT} = 0A, AAM mode

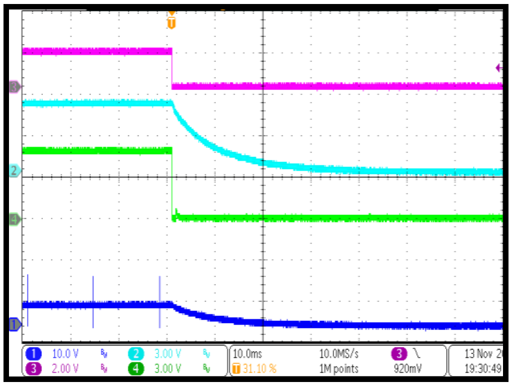


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, L = 0.56µH, f_{SW} = 2.2MHz, AAM mode, T_A = 25°C, unless otherwise noted.

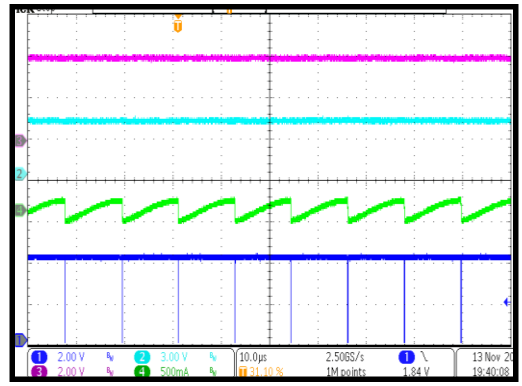
PG in Shutdown through EN

I_{OUT} = 0A, AAM mode



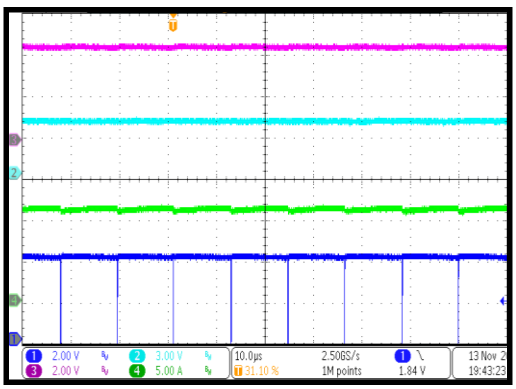
Dropout Operation

V_{IN} = 3.3V, V_{OUT} set to 5V, I_{OUT} = 0A



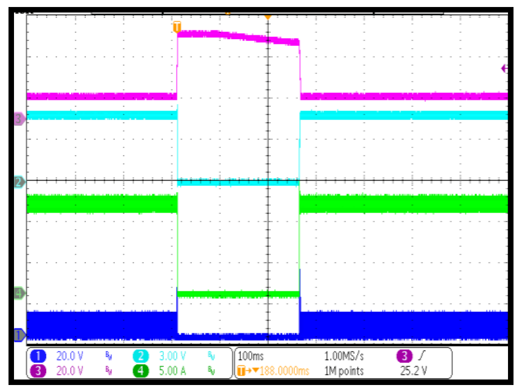
Dropout Operation

V_{IN} = 3.3V, V_{OUT} set to 5V, I_{OUT} = 11A



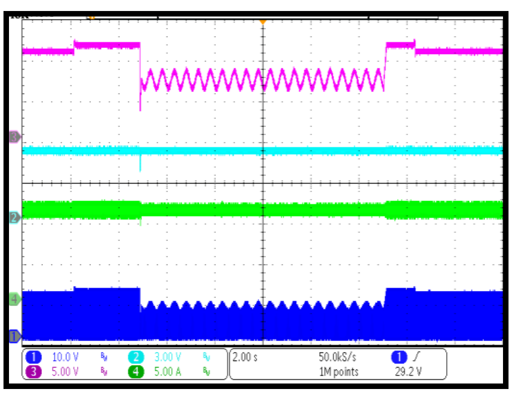
Load Dump

V_{IN} = 12V to 42V, I_{OUT} = 11A



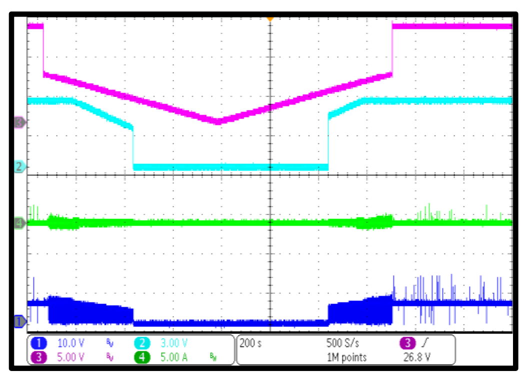
Cold-Crank

I_{OUT} = 11A



V_{IN} Ramping Up and Down

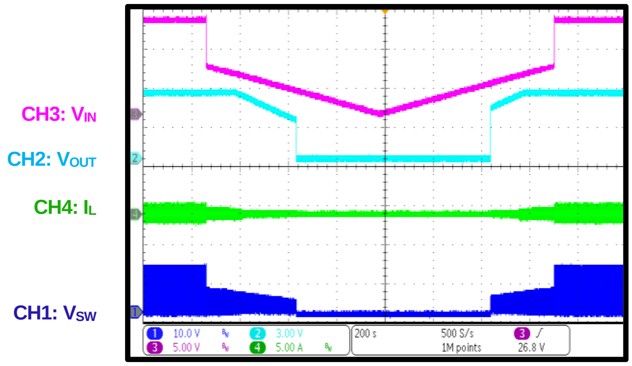
I_{OUT} = 0A, AAM mode



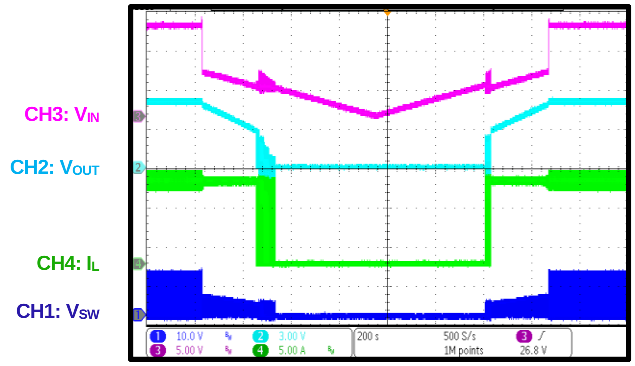
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, L = 0.56μH, f_{SW} = 2.2MHz, AAM mode, T_A = 25°C, unless otherwise noted.

V_{IN} Ramping Up and Down
I_{OUT} = 0A, FCCM



V_{IN} Ramping Up and Down
I_{OUT} = 11A



PCB LAYOUT (3)

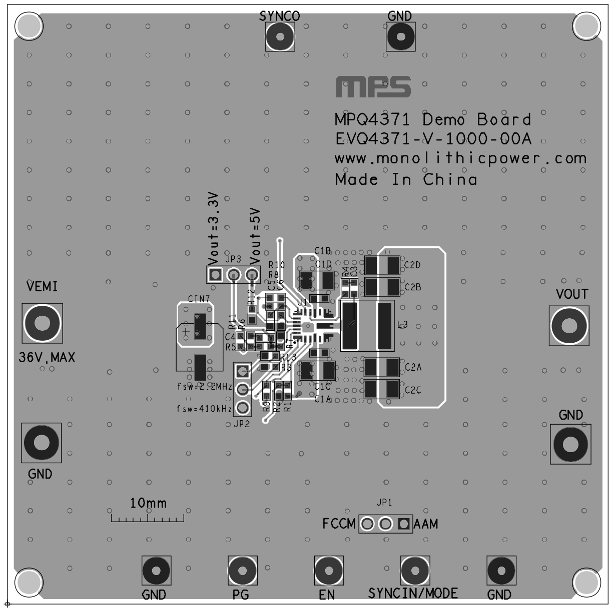


Figure 4: Top Silk and Top Layer

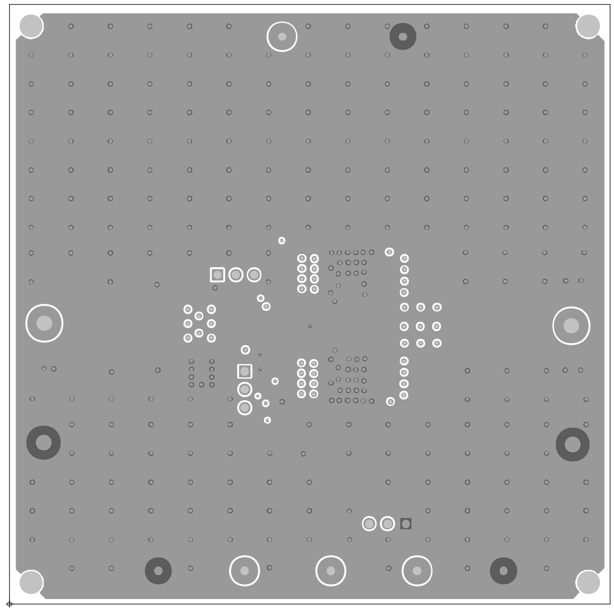


Figure 5: Mid-Layer 1

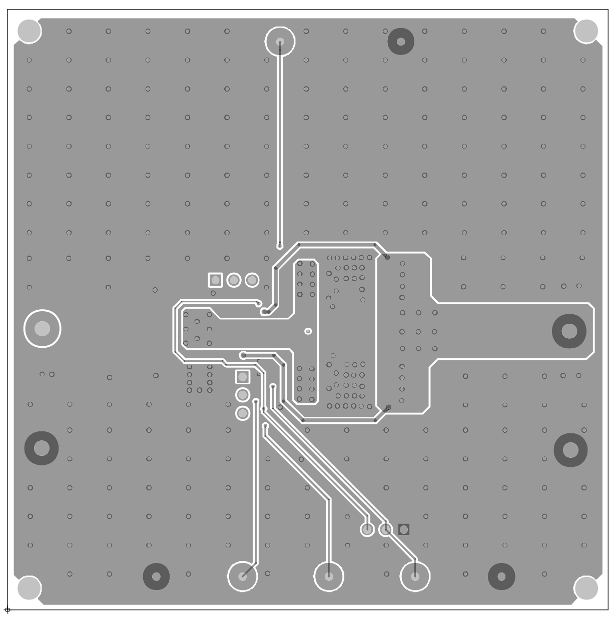


Figure 6: Mid-Layer 2

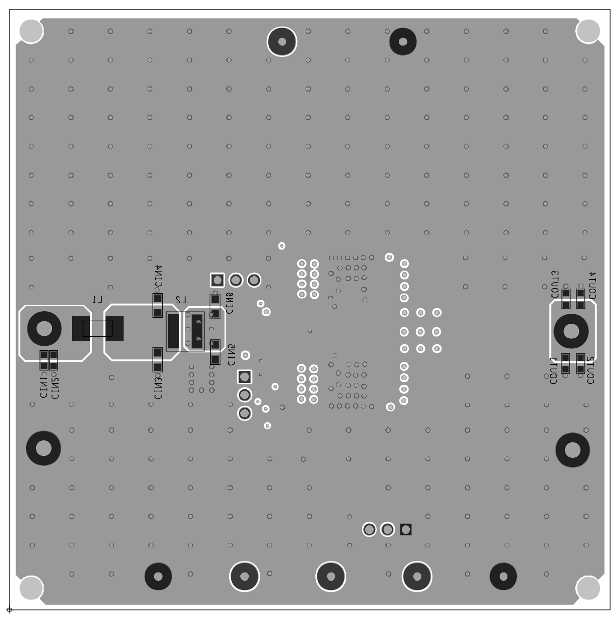


Figure 7: Bottom Layer and Bottom Silk

Note:

3) The copper thickness is 2oz.

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	4/26/2024	Initial Release	-