EVM3901-QW-00A

60V, 1A, Synchronous Buck Power Module with an Integrated Inductor Evaluation Board, AEC-Q100 Qualified

DESCRIPTION

The EVM3901-QW-00A evaluation board is designed to demonstrate the capabilities of the MPM3901, an easy-to-use, fully integrated, fixed-frequency, synchronous step-down power module with built-in power MOSFETs and an inductor. It can achieve up to 1A of continuous output current (I_{OUT}) with peak current control for excellent transient response.

The wide 4.5V to 60V input voltage (V_{IN}) range accommodates a variety of step-down applications in 12V and 24V automotive battery input environments. The MPM3901's 2µA shutdown-mode quiescent current (I_Q) makes it ideal for battery-powered applications.

The MPM3901 uses advanced asynchronous modulation (AAM) mode to achieve high efficiency under light-load conditions by scaling down the frequency, which reduces switching and gate driver losses.

Standard features include built-in soft start (SS), enable (EN) control, and power good (PG) indication. A high duty cycle and low-dropout mode are provided for automotive cold-crank conditions.

The MPM3901 provides over-current protection (OCP) with valley current detection to avoid current runaway. It also provides short-circuit protection (SCP) with hiccup mode, input under-voltage lockout (UVLO), and auto-recovery thermal protection.

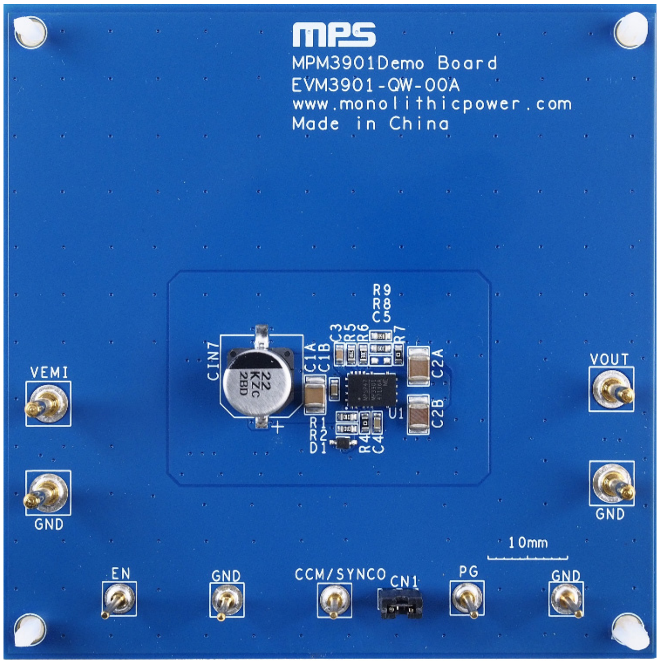
The EVM3901-QW-00A is a fully assembled and tested evaluation board. The MPM3901 is available in a QFN-19 (4mmx6mm) package with wettable flanks, and is available in AEC-Q100 Grade 1.

PERFORMANCE SUMMARY

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

Parameters	Conditions	Value
Input voltage (V_{IN}) range		4.5V to 60V
Output voltage (V_{OUT})	V_{IN} = 6V to 60V, I_{OUT} = 0A to 1A	5V
Maximum output current (I_{OUT})	V_{IN} = 4.5V to 60V	1A
Typical efficiency	V_{IN} = 24V, V_{OUT} = 5V, I_{OUT} = 1A	88.9%
Peak efficiency	V_{IN} = 8V, V_{OUT} = 5V, I_{OUT} = 0.3A	95%
Switching frequency (f_{SW})		400kHz

EVM3901-QW-00A EVALUATION BOARD



LxWxH (8.3cmx8.3cmx1.3cm)

Board Number	MPS IC Number
EVM3901-QW-00A	MPM3901GQWE-AEC1

QUICK START GUIDE

The EVM3901-QW-00A evaluation board is easy to set up and use to evaluate the MPM3901's performance. For proper measurement equipment set-up, refer to Figure 2 on page 4 and follow the steps below:

1. Preset the power supply to be between 4.5V and 60V, then turn off the power supply.
2. Set the load current between 0A and 1A. 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 (EN) function, apply a digital input to the EN pin. Pull EN above 1.45V to turn the regulator on; float or pull EN below 1.12V to turn it off.
8. The MPM3901's switching frequency (f_{SW}) can be configured by R5, which is the FREQ pin's resistor (R_{FREQ}). R_{FREQ} can be estimated with Equation (1):

$$R_{FREQ}(M\Omega) = \frac{30}{f_{SW}\ (kHz)} \tag{1}$$

Figure 1 shows the relationship between f_{SW} and R_{FREQ} based on the bench test.

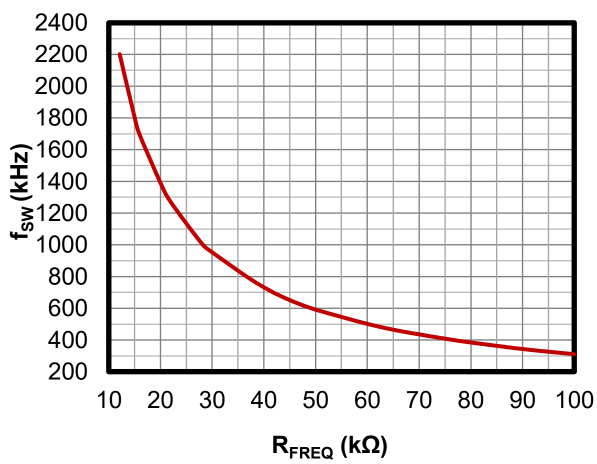


Figure 1: f_{SW} vs. R_{FREQ}

9. The output voltage (V_{OUT}) is set by the external resistor dividers (R8 and R9). If R8 is selected, then R9 can be calculated with Equation (2):

$$R9 = \frac{R8}{\frac{V_{OUT}}{0.8V} - 1} \quad (2)$$

Table 1 shows the recommended R8 and R9 values for common output voltages.

Table 1: Resistor Selection for Output Voltages

V_{OUT} (V)	R8 (kΩ)	R9 (kΩ)
3.3	41.2 (1%)	13 (1%)
5	41.2 (1%)	7.68 (1%)

Refer to the Application Information section in the MPM3901's datasheet to calculate the input and output capacitances.

10. Figure 2 shows the measurement equipment set-up.

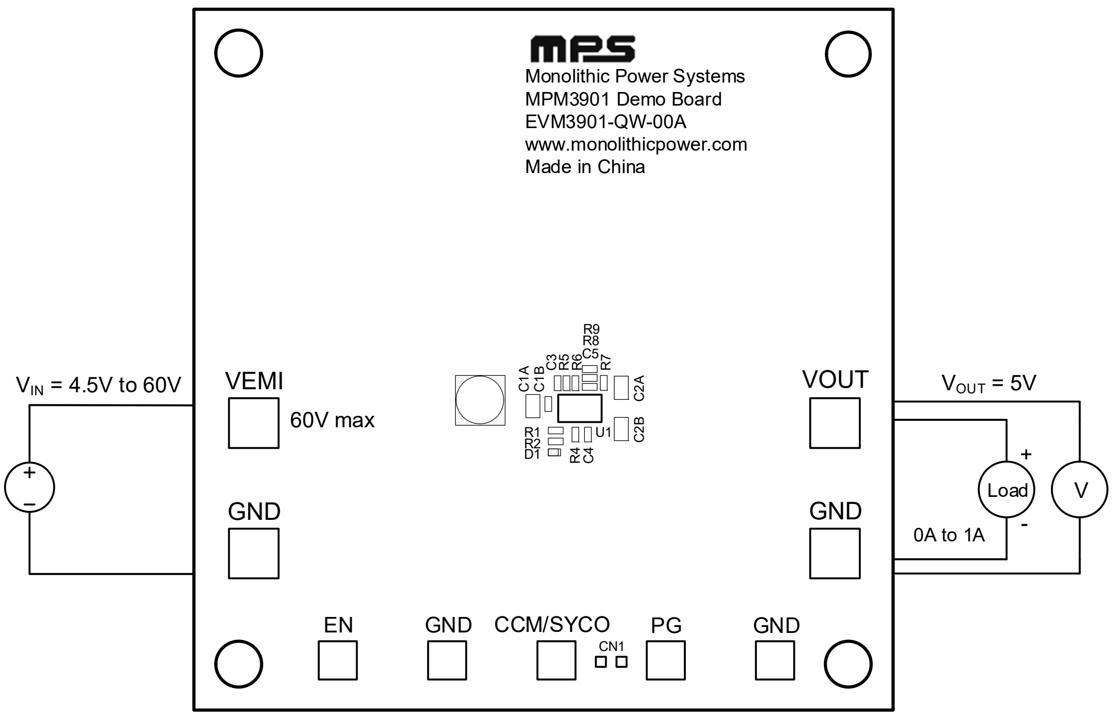


Figure 2: Measurement Equipment Set-Up

EVALUATION BOARD SCHEMATIC

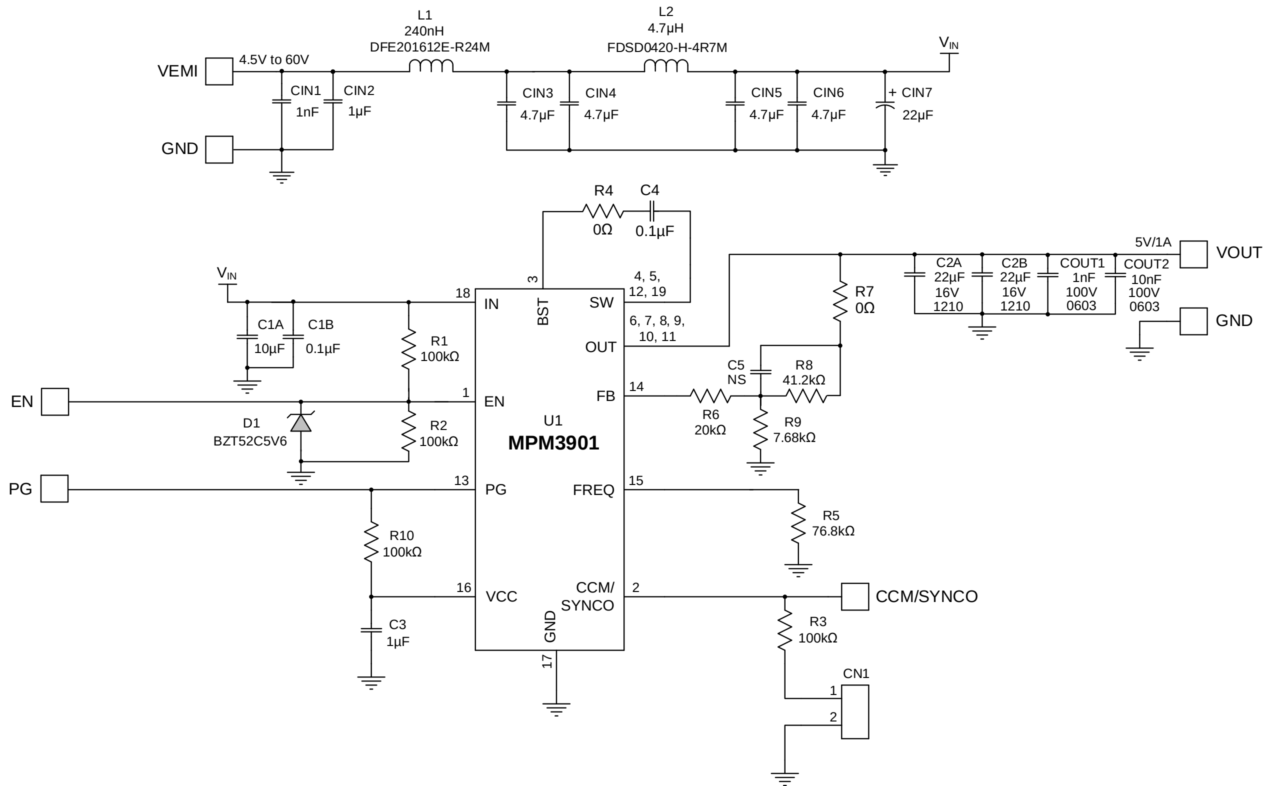
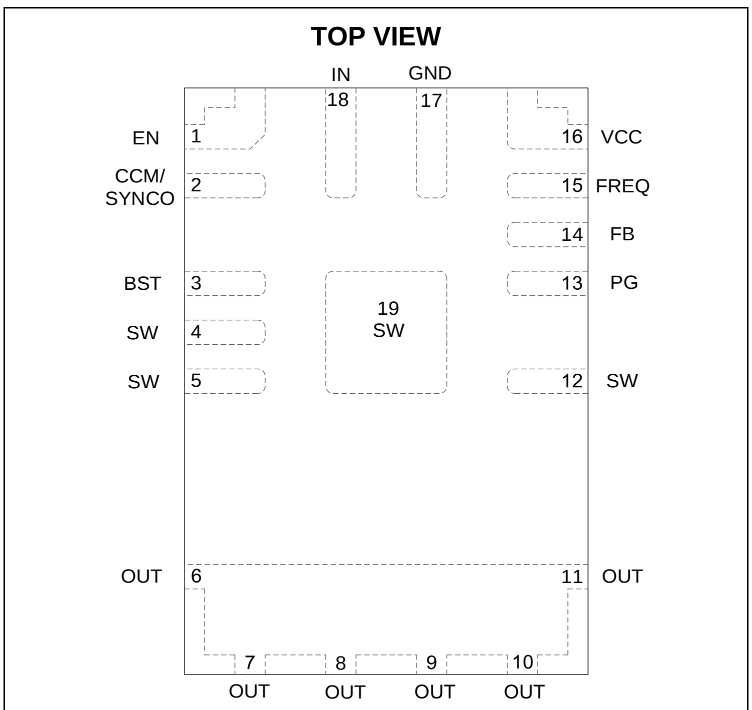


Figure 3: Evaluation Board Schematic

PACKAGE REFERENCE



QFN-19 (4mmx6mm) with Wettable Flanks

EVM3901-QW-00A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
2	CIN1, COUT1	1nF	Ceramic capacitor, 100V, X7R	0603	Murata	GRM188R72A102KA01D
1	COUT2	10nF	Ceramic capacitor, 100V, X7R	0603	Murata	GRM188R72A103KA01D
1	CIN2	1µF	Ceramic capacitor, 100V, X7S	0805	Murata	GRM21BC72A105KE01L
4	CIN3, CIN4, CIN5, CIN6	4.7µF	Ceramic capacitor, 100V, X7S	1206	Murata	GRJ31CC72A475KE01L
1	CIN7	22µF	Electrical capacitor, 80V	SMD	Panasonic	EEHZC1K220P
1	C1A	10µF	Ceramic capacitor, 100V, X7S	1210	Murata	GRM32EC72A106KE05L
2	C1B, C4	0.1µF	Ceramic capacitor, 100V, X7R	0603	Murata	GRM188R72A104KA35D
2	C2A, C2B	22µF	Ceramic capacitor, 16V, X7R	1210	Murata	GRM32ER71C226KEA8
1	C3	1µF	Ceramic capacitor, 16V, X7R	0603	Murata	GCM188R71C105KA64D
1	C5	NS				
1	L1	240nH	Inductor, 19mΩ, 6.6A	SMD	Murata	DFE201612E-R24M=P2
1	L2	4.7µH	Inductor, 83mΩ, 3.6A	SMD	Murata	FDSD0420-H-4R7M=P3
4	R1, R2, R3, R10	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
1	R4, R7	0Ω	Film resistor, 1%	0603	Yageo	RC0603FR-070RL
1	R5	76.8kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0776K8L
1	R6	20kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0720KL
1	R8	41.2kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0741K2L
1	R9	7.68kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-077K68L
1	D1	5.6V	Zener diode	SOD323	Diodes, Inc.	BZT52C5V6S-7-F
1	CN1	2.54mm	Test pin, 2-pin	DIP	Any	
4	VEMI, GND, VOUT, GND	2mm	Golden pin	DIP	Custom (1)	
5	PG, EN, CCM/SYNCO, GND	1mm	Golden pin	DIP	Custom (1)	
1	U1	MPM3901	60V, 1A, synchronous step-down power module, AEC-Q100 qualified	QFN-19 (4mmx 6mm)	MPS	MPM3901GQWE-AEC1

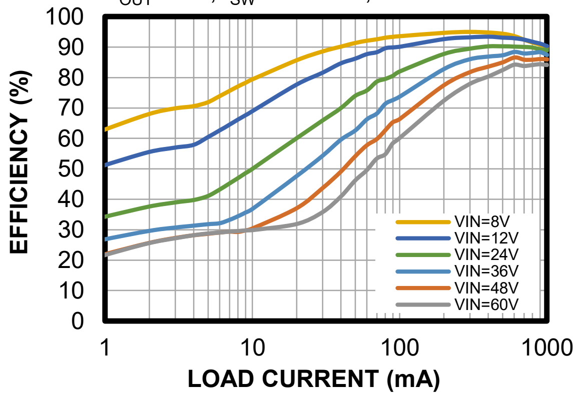
Note:

1) Contact an MPS FAE for more information regarding MPS custom pins.

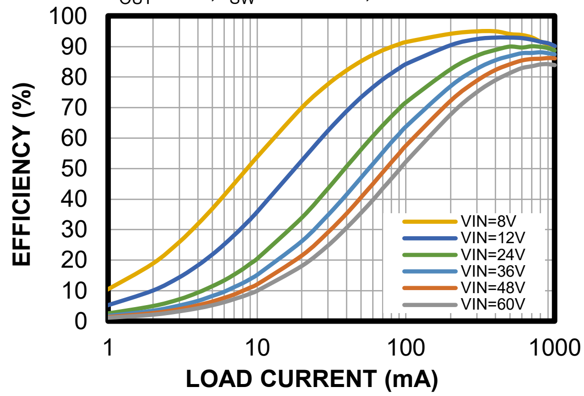
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

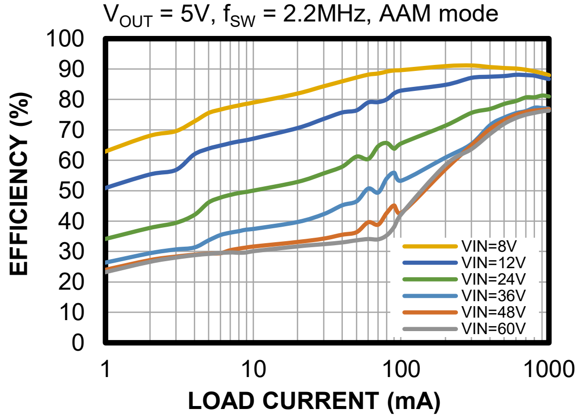
Efficiency vs. Load Current
V_{OUT} = 5V, f_{SW} = 400kHz, AAM mode



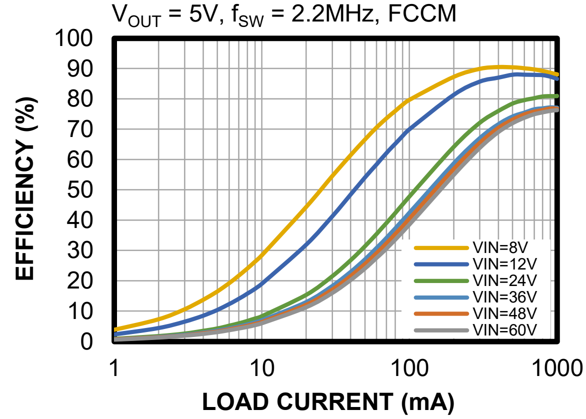
Efficiency vs. Load Current
V_{OUT} = 5V, f_{SW} = 400kHz, FCCM



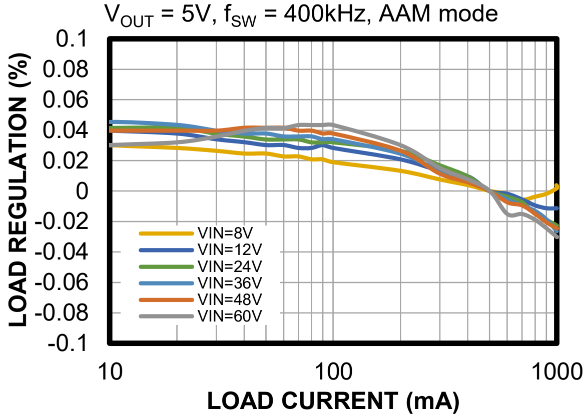
Efficiency vs. Load Current
V_{OUT} = 5V, f_{SW} = 2.2MHz, AAM mode



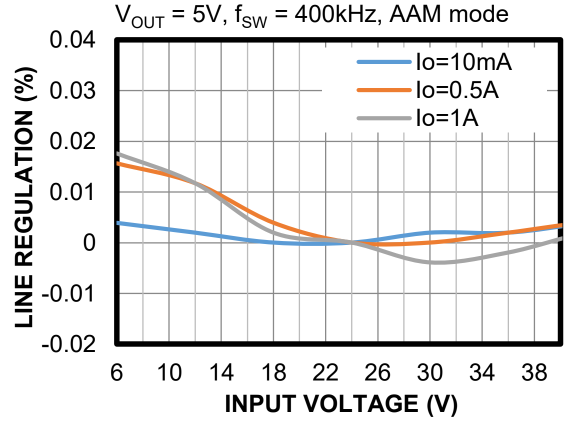
Efficiency vs. Load Current
V_{OUT} = 5V, f_{SW} = 2.2MHz, FCCM



Load Regulation
V_{OUT} = 5V, f_{SW} = 400kHz, AAM mode



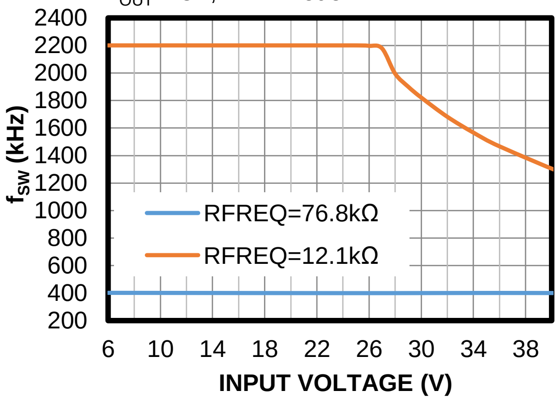
Line Regulation
V_{OUT} = 5V, f_{SW} = 400kHz, AAM mode



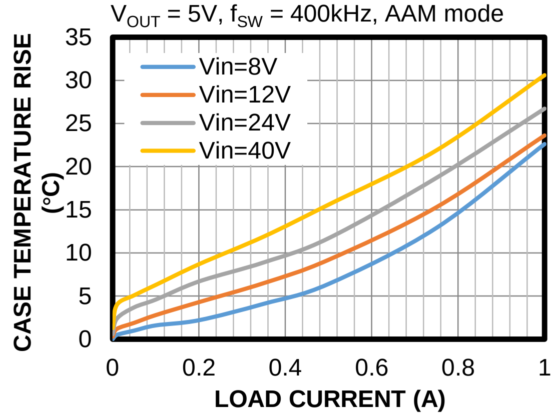
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

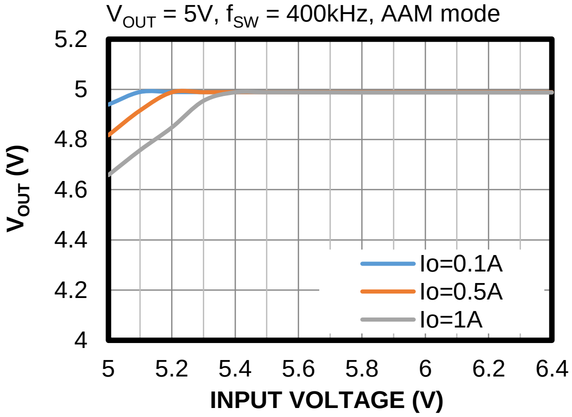
Switching Frequency vs. Input Voltage
V_{OUT} = 5V, AAM mode



Case Temperature Rise vs. Load Current
V_{OUT} = 5V, f_{SW} = 400kHz, AAM mode



Low-Dropout Mode vs. Input Voltage
V_{OUT} = 5V, f_{SW} = 400kHz, AAM mode

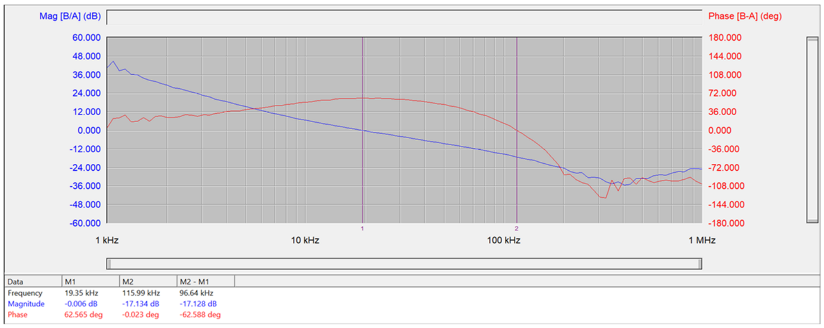


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

Loop Performance

I_{OUT} = 1A, T_A = 25°C

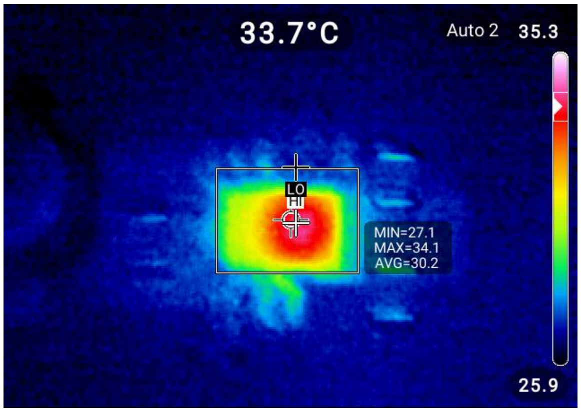


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

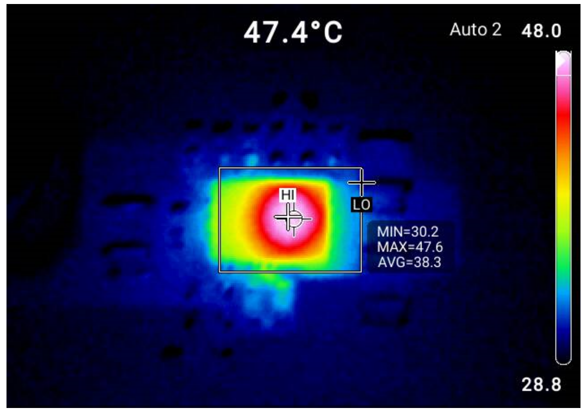
Thermal Performance

I_{OUT} = 0.5A, no forced airflow, T_{CASE} = 34.1°C



Thermal Performance

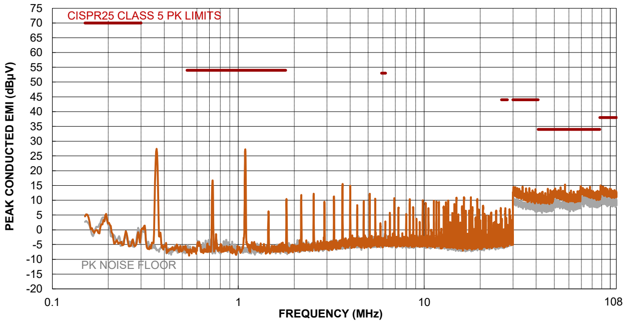
I_{OUT} = 1A, no forced airflow, T_{CASE} = 47.6°C



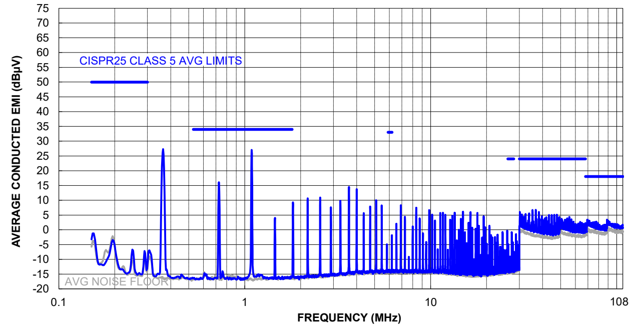
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

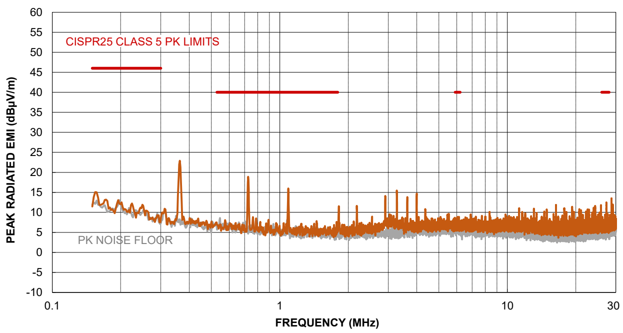
CISPR 25 Class 5 Peak Conducted Emissions
150kHz to 108MHz



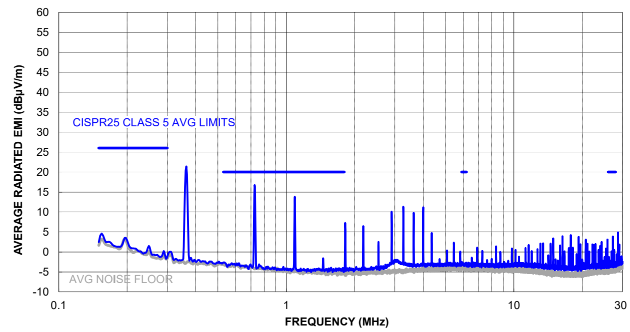
CISPR 25 Class 5 Average Conducted Emissions
150kHz to 108MHz



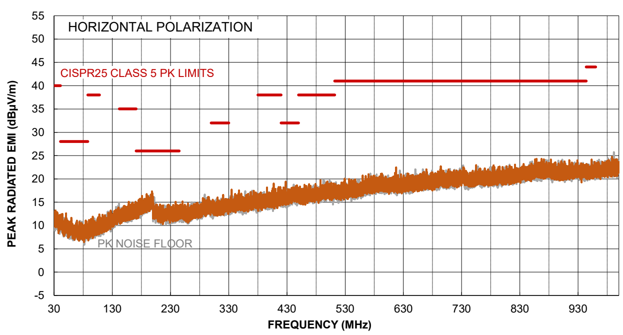
CISPR 25 Class 5 Peak Radiated Emissions
150kHz to 30MHz



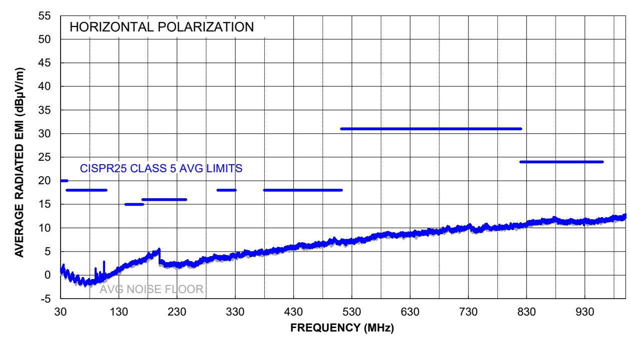
CISPR 25 Class 5 Average Radiated Emissions
150kHz to 30MHz



CISPR 25 Class 5 Peak Radiated Emissions
Horizontal, 30MHz to 1GHz



CISPR 25 Class 5 Average Radiated Emissions
Horizontal, 30MHz to 1GHz

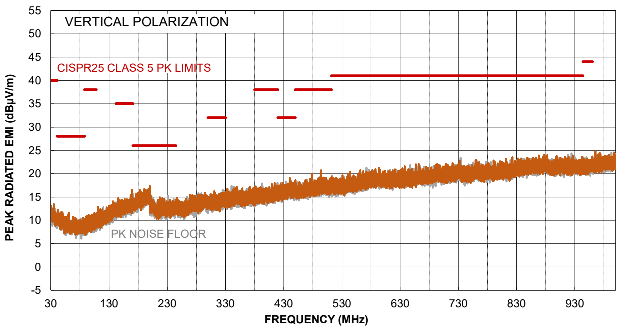


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

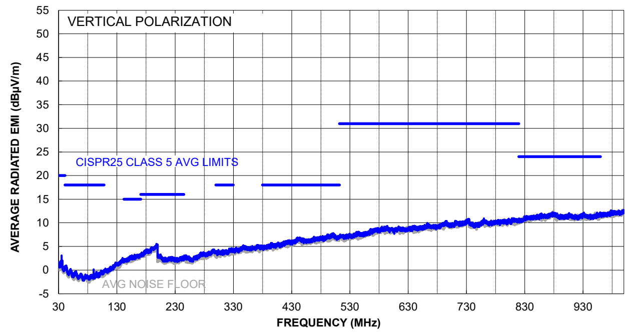
CISPR 25 Class 5 Peak Radiated Emissions

Vertical, 30MHz to 1GHz



CISPR 25 Class 5 Average Radiated Emissions

Vertical, 30MHz to 1GHz

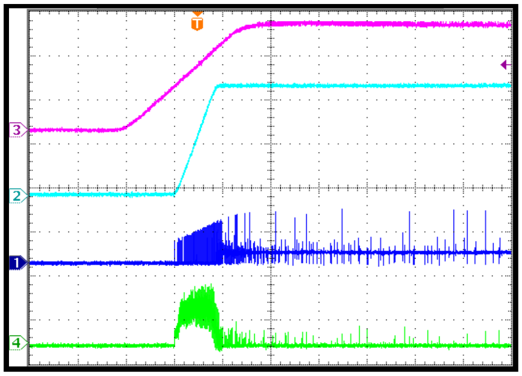


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

Start-Up through VIN

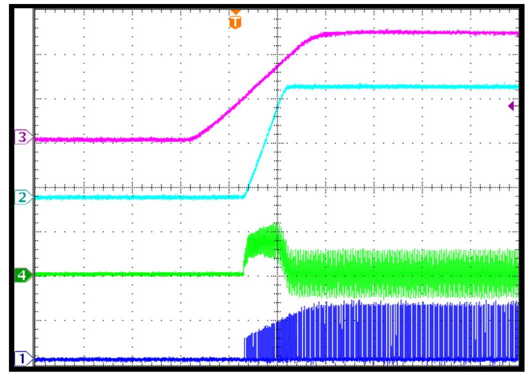
I_{OUT} = 0A, AAM mode



1ms/div.

Start-Up through VIN

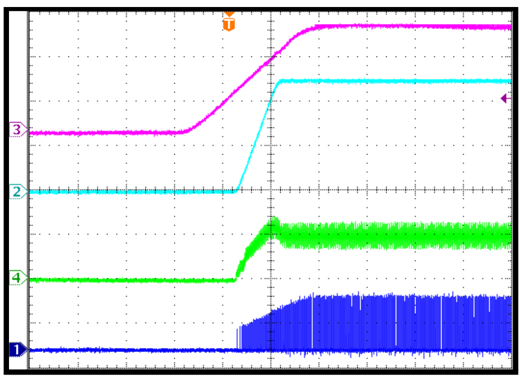
I_{OUT} = 0A, FCCM



1ms/div.

Start-Up through VIN

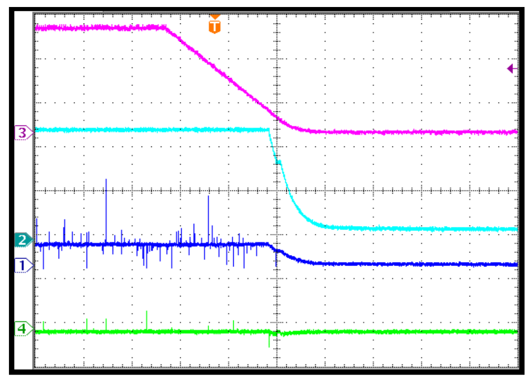
I_{OUT} = 1A



1ms/div.

Shutdown through VIN

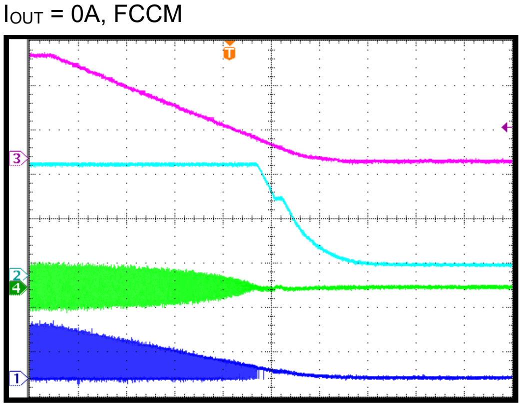
I_{OUT} = 0A, AAM mode



20ms/div.

Shutdown through VIN

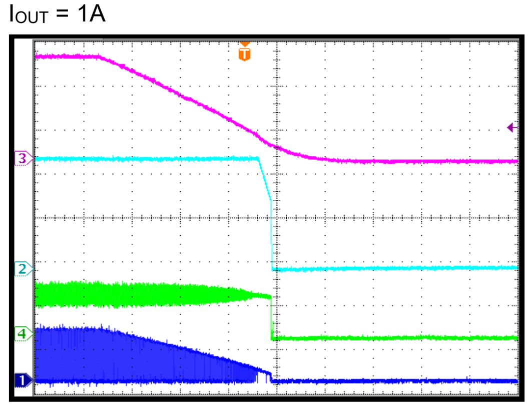
I_{OUT} = 0A, FCCM



10ms/div.

Shutdown through VIN

I_{OUT} = 1A

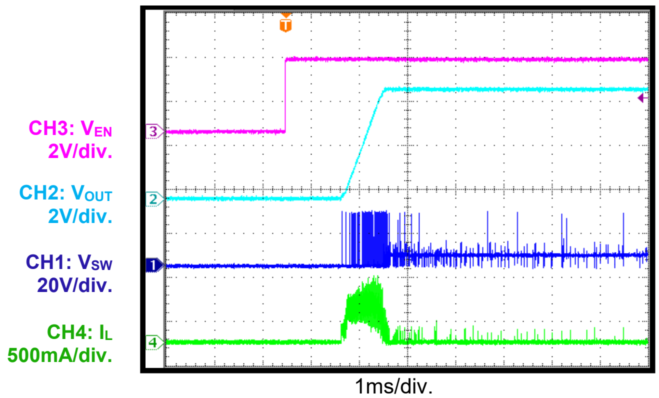


10ms/div.

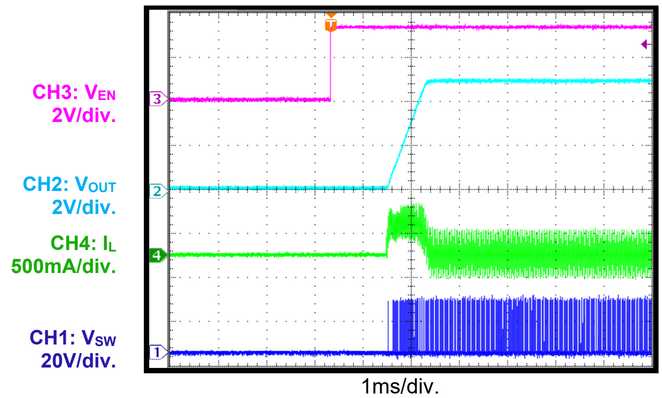
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

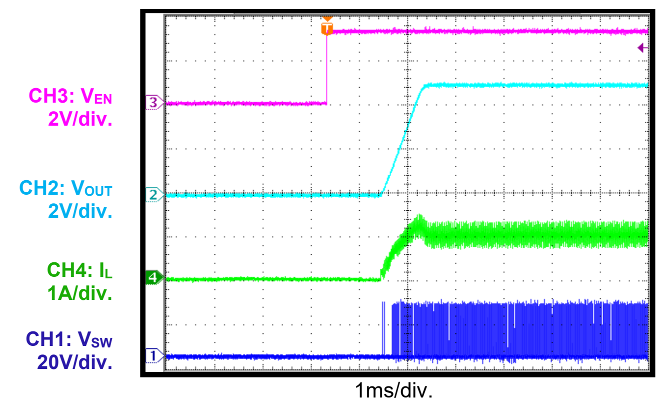
Start-Up through EN
I_{OUT} = 0A, AAM mode



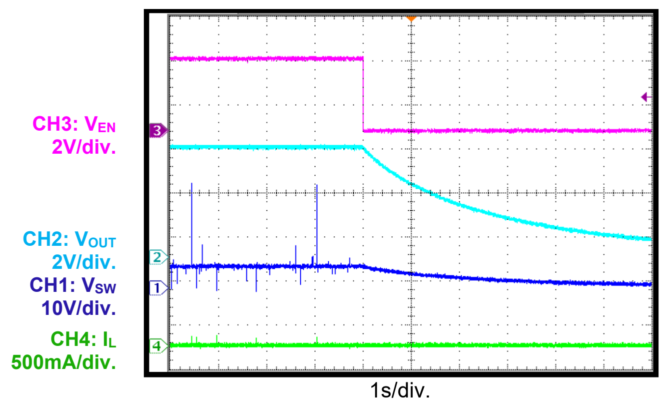
Start-Up through EN
I_{OUT} = 0A, FCCM



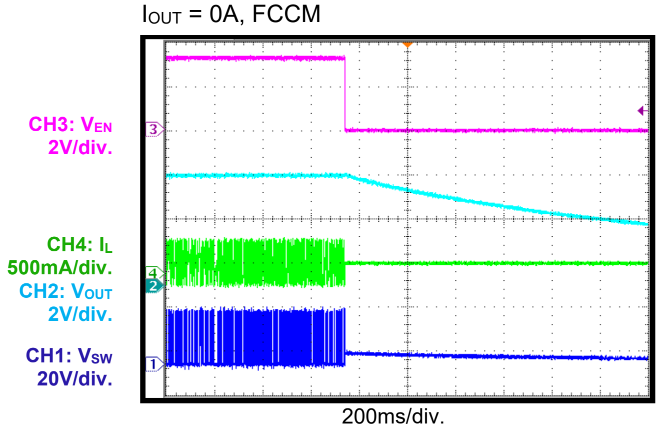
Start-Up through EN
I_{OUT} = 1A



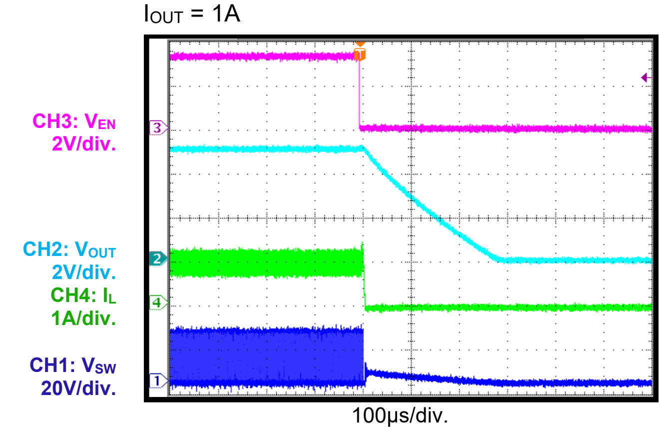
Shutdown through EN
I_{OUT} = 0A, AAM mode



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



Shutdown through EN
I_{OUT} = 1A

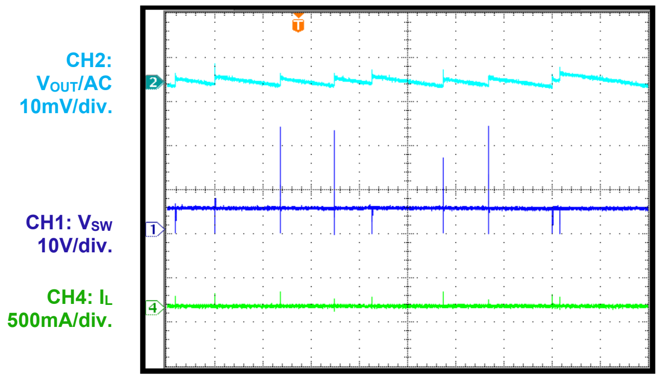


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

Output Ripple

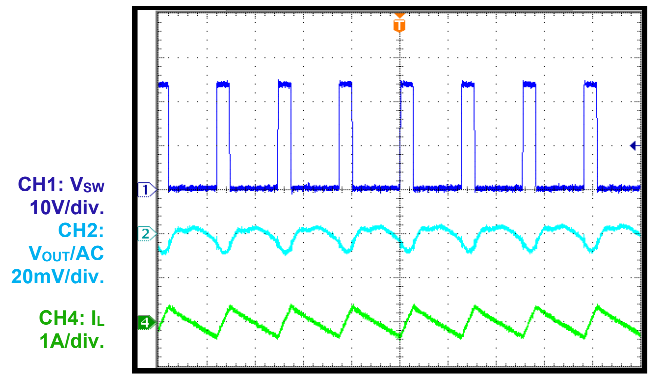
I_{OUT} = 0A, AAM mode



400µs/div.

Output Ripple

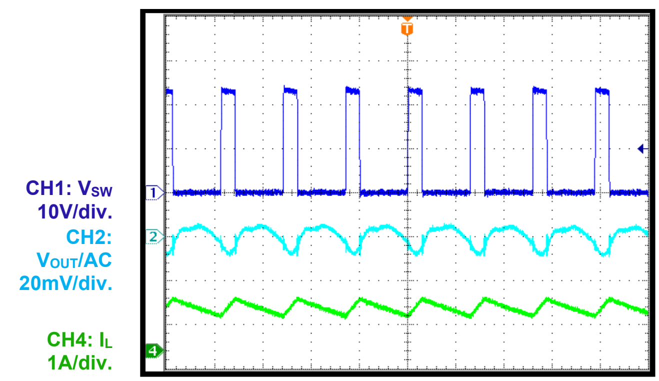
I_{OUT} = 0A, FCCM



2µs/div.

Output Ripple

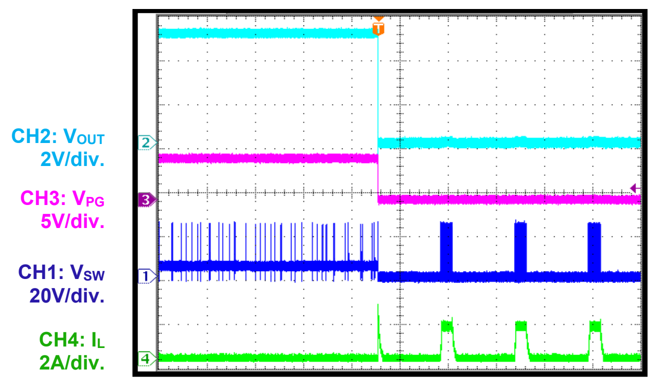
I_{OUT} = 1A



2µs/div.

SCP Entry

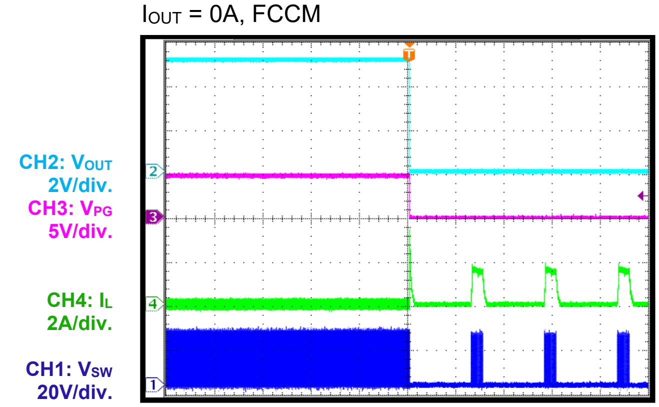
I_{OUT} = 0A, AAM mode



4ms/div.

SCP Entry

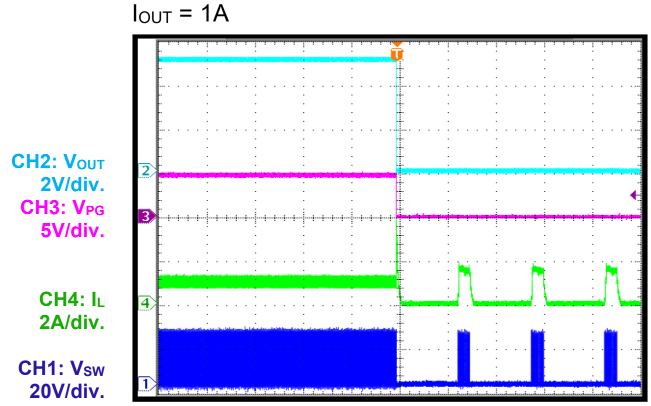
I_{OUT} = 0A, FCCM



4ms/div.

SCP Entry

I_{OUT} = 1A

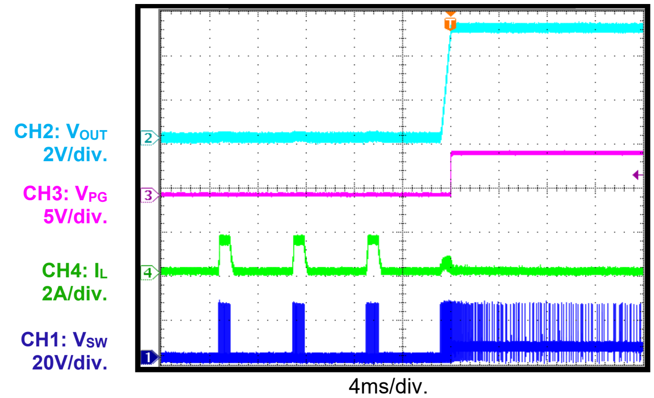


4ms/div.

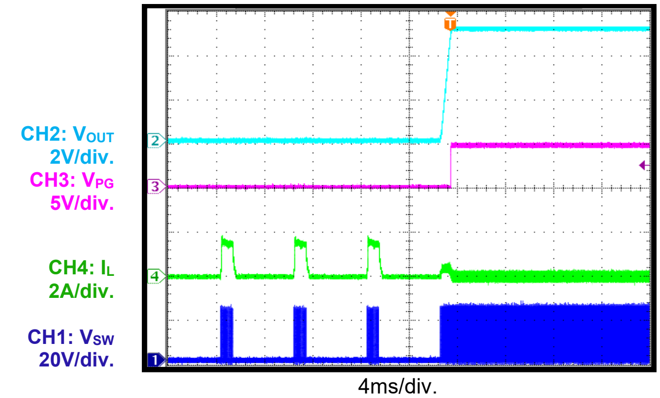
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

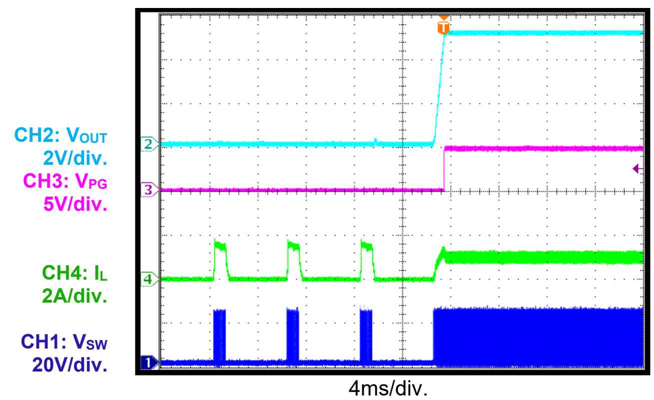
SCP Recovery
I_{OUT} = 0A, AAM mode



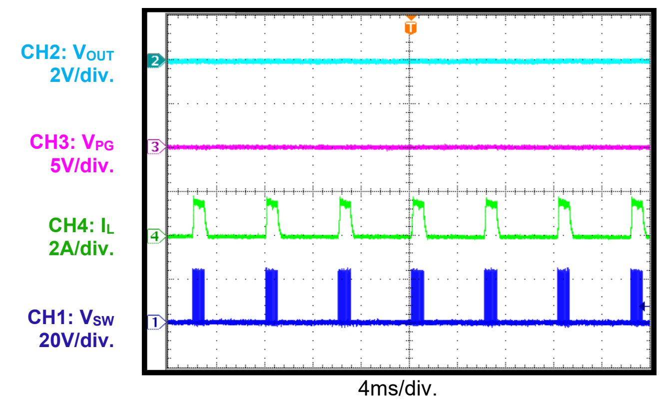
SCP Recovery
I_{OUT} = 0A, FCCM



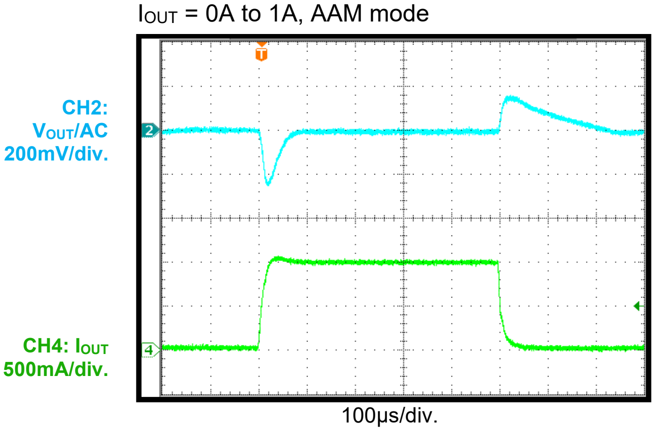
SCP Recovery
I_{OUT} = 1A



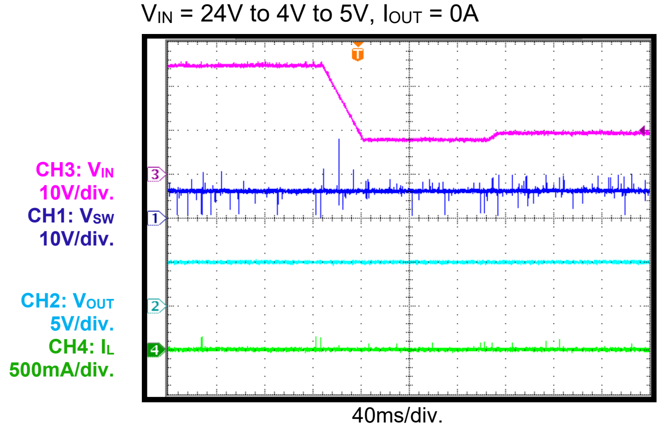
SCP Steady State



Load Transient
I_{OUT} = 0A to 1A, AAM mode



Cold Crank
V_{IN} = 24V to 4V to 5V, I_{OUT} = 0A

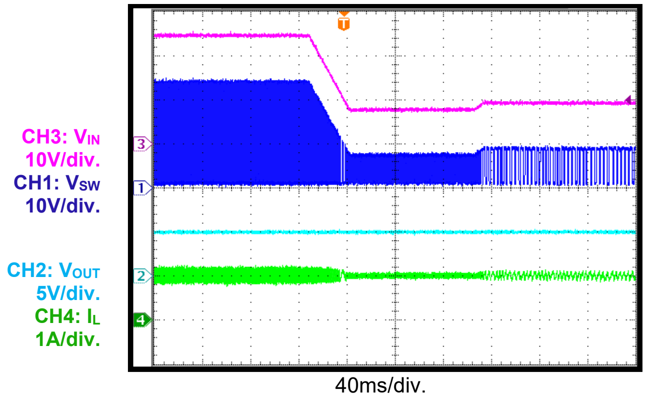


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

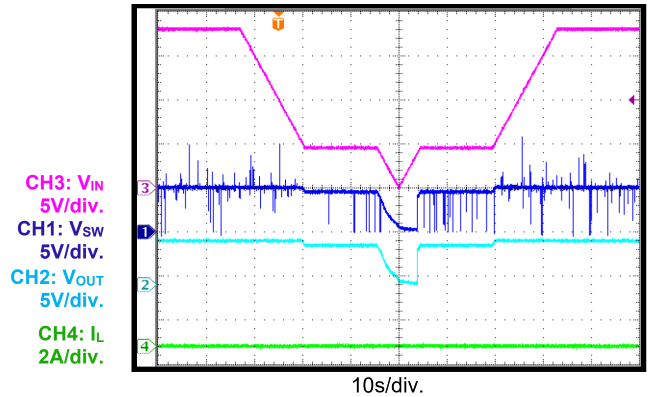
Cold Crank

V_{IN} = 24V to 4V to 5V, I_{OUT} = 1A



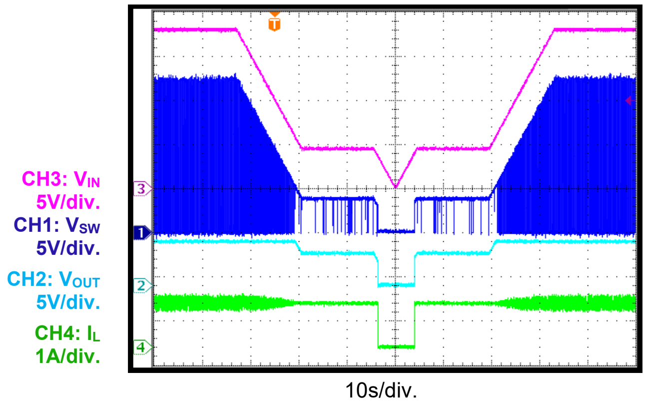
V_{IN} Ramping Down and Up

V_{IN} = 18V to 4.5V to 0V to 4.5V to 18V, I_{OUT} = 0A



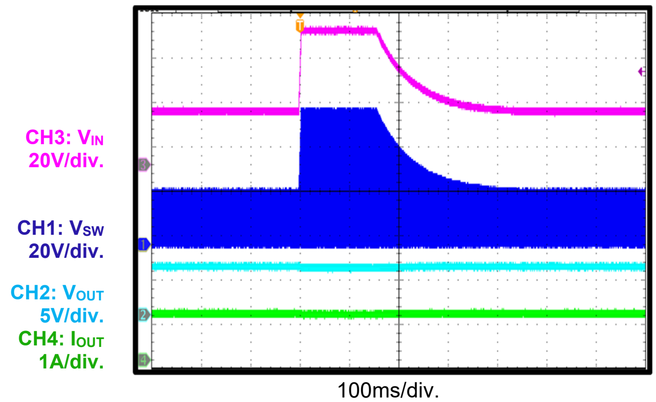
V_{IN} Ramping Down and Up

V_{IN} = 18V to 4.5V to 0V to 4.5V to 18V, I_{OUT} = 1A



Load Dump

V_{IN} = 24V to 60V to 24V, I_{OUT} = 1A



PCB LAYOUT (2)

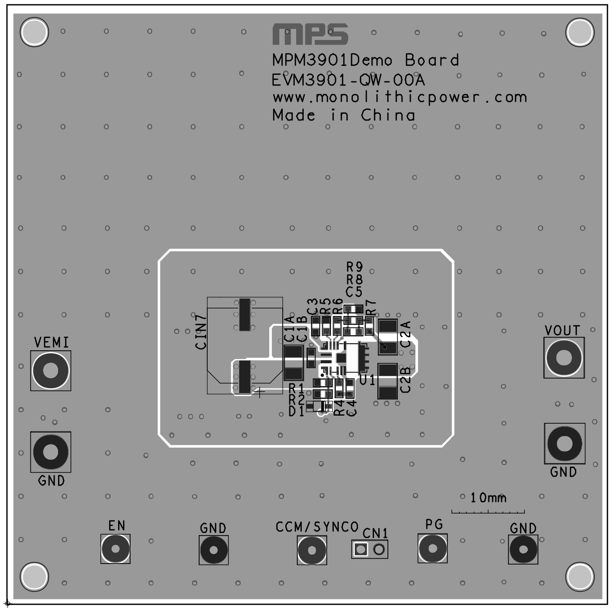


Figure 4: Top Silk and Top Layer

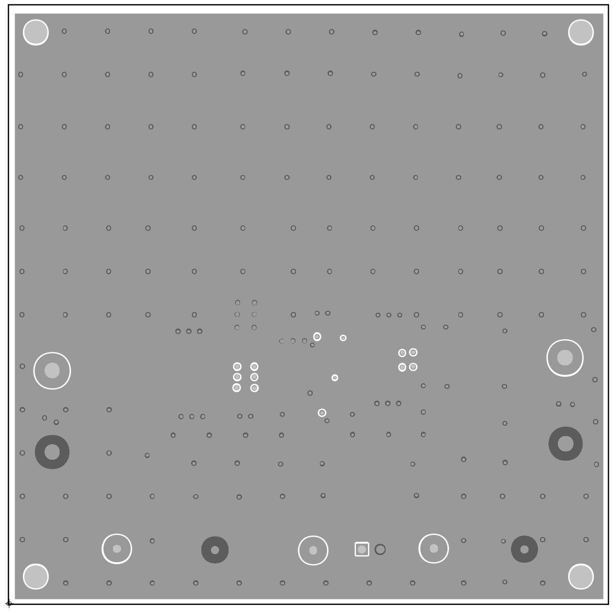


Figure 5: Mid-Layer 1

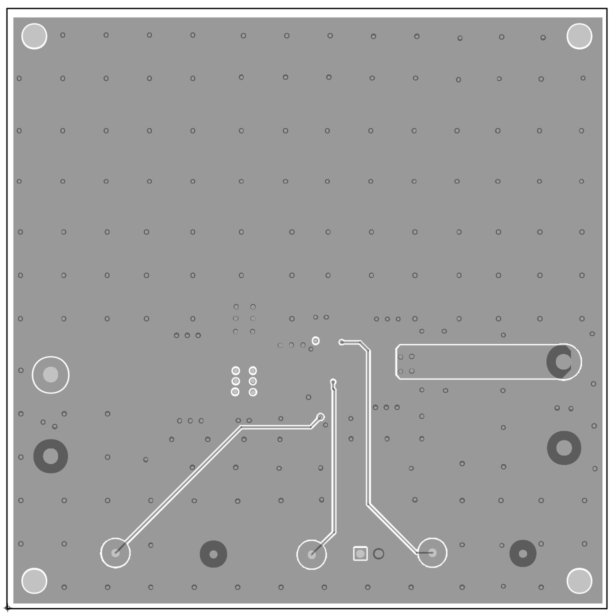


Figure 6: Mid-Layer 2

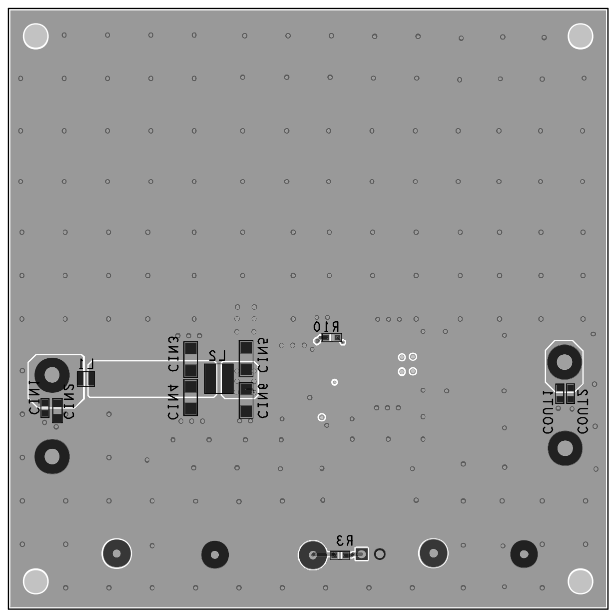


Figure 7: Bottom Layer and Bottom Silk

Note:

2) The copper thickness is 2oz.

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	7/22/2024	Initial Release	-