EVQ4316-R-01A

45V, 6A, Low-I_Q, Synchronous Step-Down Converter with Frequency Spread Spectrum Evaluation Board, AEC-Q100 Qualified

DESCRIPTION

The EVQ4316-R-01A evaluation board is designed to demonstrate the capabilities of the MPQ4316, a synchronous, step-down switching regulator with a configurable frequency and integrated, internal high-side MOSFET (HS-FET) and low-side MOSFET (LS-FET). It provides up to 6A of highly efficient output current (I_{OUT}), with current mode control for fast loop response.

The wide 3.3V to 45V input voltage (V_{IN}) range accommodates a variety of step-down applications in automotive input environments. A 1.7μA quiescent current (I_Q) in shutdown mode allows the device to be used 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 driver losses.

Frequency foldback helps prevent inductor current (I_L) runaway during start-up. Thermal shutdown provides reliable, fault-tolerant operation. A high duty cycle and low-dropout mode are provided for automotive cold crank conditions.

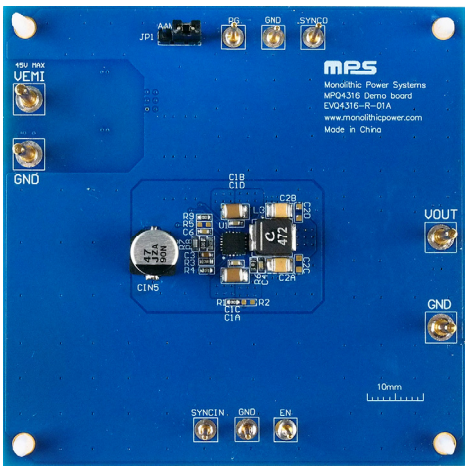
The EVQ4316-R-01A is fully assembled and tested. The MPQ4316 is available in a QFN-20 (4mmx4mm) package with wettable flanks.

PERFORMANCE SUMMARY

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

Parameter	Condition	Value
Input voltage (V_{IN}) range		3.3V to 45V
Output voltage (V_{OUT})	V_{IN} = 3.3V to 45V, I_{OUT} = 0A to 6A	3.3V
Maximum output current (I_{OUT})	V_{IN} = 3.3V to 45V	6A
Typical efficiency	V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 6A	90.4%
Switching frequency (f_{SW})		410kHz

EVQ4316-R-01A EVALUATION BOARD



LxWxH (8.3cmx8.3cmx1.3cm)

Board Number	MPS IC Number
EVQ4316-R-01A	MPQ4316GRE-AEC1

MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

QUICK START GUIDE

1. Preset the power supply (V_{IN}) between 3.3V and 45V, then turn off the power supply. Electronic loads represent a negative impedance to the regulator, and setting a current too high can trigger hiccup mode.
2. If longer cables (>0.5m total) are used between the source and the evaluation board, install a damping capacitor at the input terminals, especially when V_{IN} ≥ 24V.
3. Connect the power supply terminals to:
   a. Positive (+): VEMI
   b. Negative (-): GND
4. Connect the load terminals to:
   a. Positive (+): VOUT
   b. Negative (-): GND
5. After making the connections, turn on the power supply. The board should automatically start up.
6. To use the enable function, apply a digital input to the EN pin. Drive EN above 1V to turn on the regulator; drive EN below 0.85V to turn off the regulator.
7. The MPQ4316's switching frequency (f_{SW}) can be configured by R3, the FREQ pin's resistor (R_{FREQ}). R3 can be estimated based on the relationship between f_{SW} and R_{FREQ} (see Figure 1).

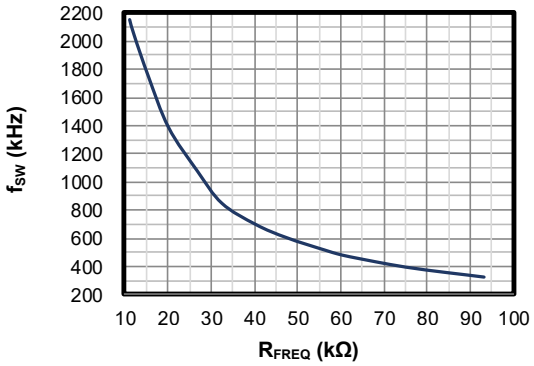


Figure 1: f_{SW} vs. R_{FREQ}

8. To use the sync function, apply a 350kHz to 1000kHz external clock to the SYNCIN pin to synchronize the internal clock's rising edge.
9. The output voltage (V_{OUT}) is set by the external resistor divider. If R7 = 100kΩ, then R8 can be calculated with Equation (1):

$$R8 = \frac{R7}{\frac{V_{OUT}}{0.815V} - 1} \quad (1)$$

Table 1 shows the recommended R7 and R8 values for common output voltages.

Table 1: Resistor Selection for Output Voltages

V_{OUT} (V)	R7 (kΩ)	R8 (kΩ)
3.3	100 (1%)	32.4 (1%)
5	100 (1%)	19.1 (1%)

MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

Figure 2 shows the measurement equipment set-up.

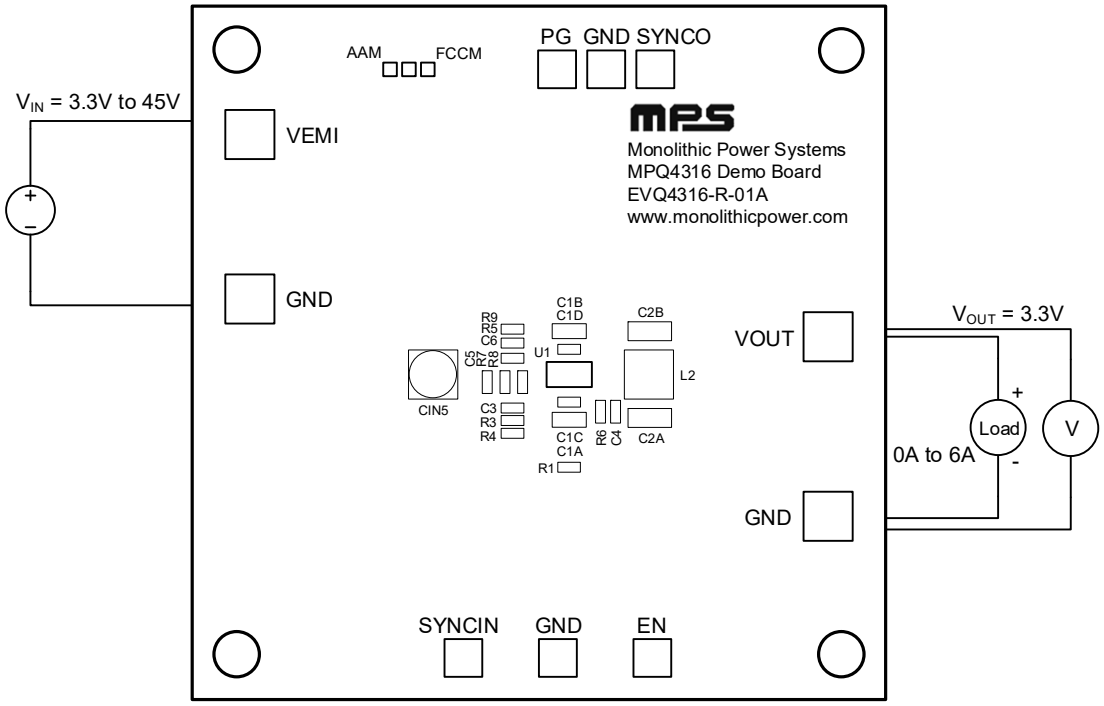


Figure 2: Measurement Equipment Set-Up

MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

EVALUATION BOARD SCHEMATIC

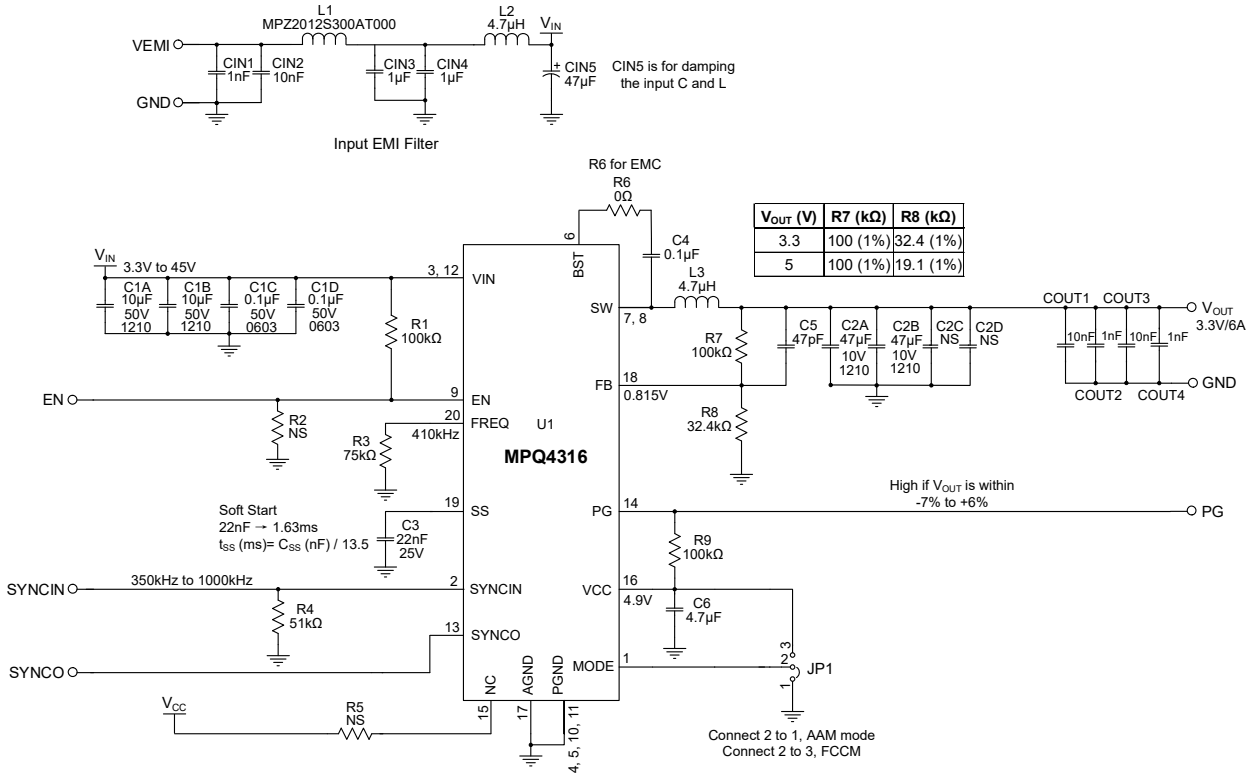
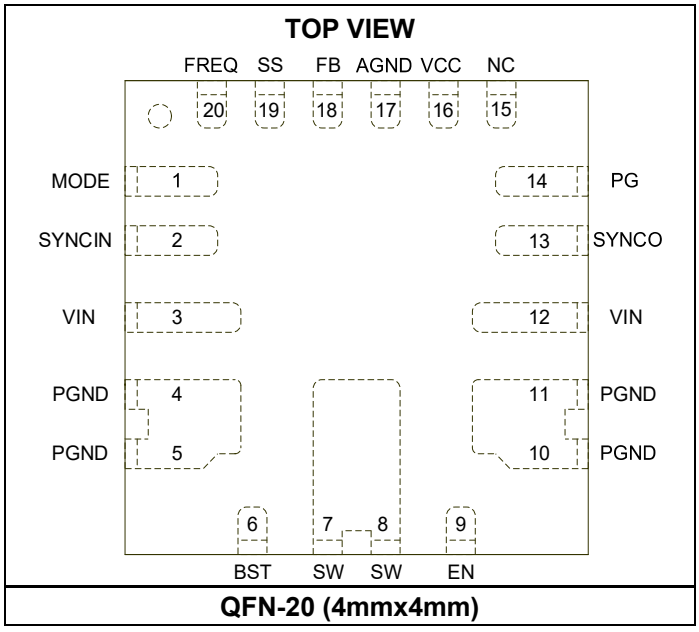


Figure 3: Evaluation Board Schematic

PACKAGE REFERENCE



QFN-20 (4mmx4mm)

MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

EVQ4316-R-01A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
3	CIN1, COUT2, COUT4	1nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM216R71H102KA01
3	CIN2, COUT1, COUT3	10nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H103KA01D
2	CIN3, CIN4	1µF	Ceramic capacitor, 50V, X7R	1206	TDK	C3216X7R1H105K
1	CIN5	47µF	Aluminum capacitor, 63V	SMD	Panasonic	EEHZA1J470P
2	C1A, C1B	10µF	Ceramic capacitor, 50V, X7R	1210	Murata	GRM32ER71H106KA12L
2	C1C, C1D	0.1µF	Ceramic capacitor, 50V, X7R	0603	Murata	GCJ188R71H104KA12D
2	C2A, C2B	47µF	Ceramic capacitor, 10V, X5R	1210	Murata	GRM32ER61A476KE20L
1	C3	22nF	Ceramic capacitor, 25V, X7R	0603	Murata	GRM188R71E223JA01D
1	C4	0.1µF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H104KA93D
1	C5	47pF	Ceramic capacitor, 50V, C0G	0603	TDK	C1608C0G1H470J
1	C6	4.7µF	Ceramic capacitor, 10V, X5R	0603	Murata	GRM188R61A475KE15D
1	L1	10mΩ	Magnetic bead, 6A	0805	TDK	MPZ2012S300AT000
1	L2	4.7µH	Inductor, 31.5mΩ, 6A	SMD	Cyntec	VCMT063T-4R7MN5T
1	L3	4.7µH	Inductor, 15.02mΩ, 12.1A	SMD	Coilcraft	XAL6060-472MEC
3	R1, R7, R9	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
1	R3	75kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0775KL
1	R4	51kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0751KL
1	R6	0Ω	Film resistor, 1%	0603	Yageo	RC0603FR-070RL
1	R8	32.4kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0732K4L
4	C2C, C2D, R2, R5	NS				
1	JP1	2.54mm	Test pin, 3-pin	DIP	Any	
4	VEMI, GND, VOUT, GND	2mm	Golden pin	DIP	Custom (1)	
7	SYNCIN, ICS, PG, SYNCO, EN, GND, GND	1mm	Golden pin	DIP	Custom (1)	
1	U1	MPQ4316	45V, 6A, step-down converter, AEC-Q100	QFN-20 (4mmx 4mm)	MPS	MPQ4316GRE-AEC1

Note:

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

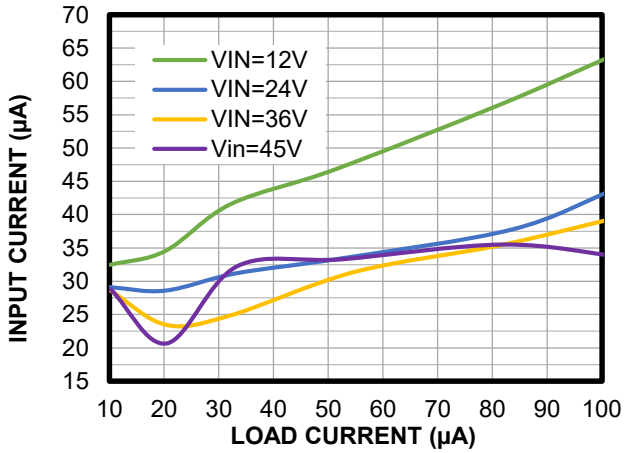
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

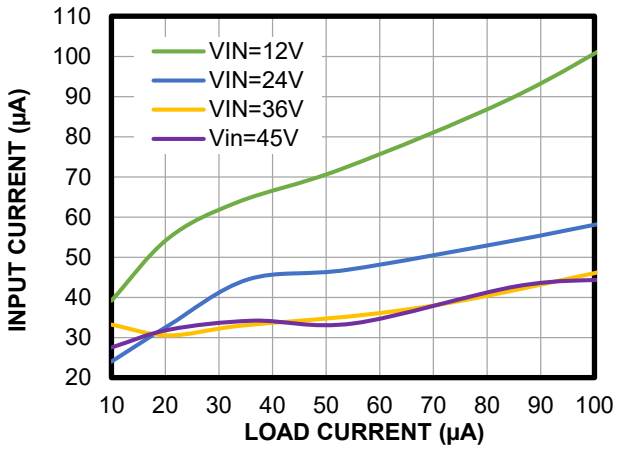
Input Current vs. Load Current

AAM mode, V_{OUT} = 3.3V



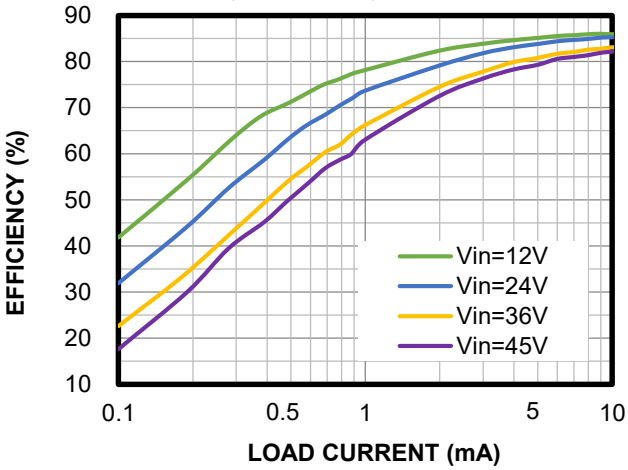
Input current vs. Load Current

AAM mode, V_{OUT} = 5V



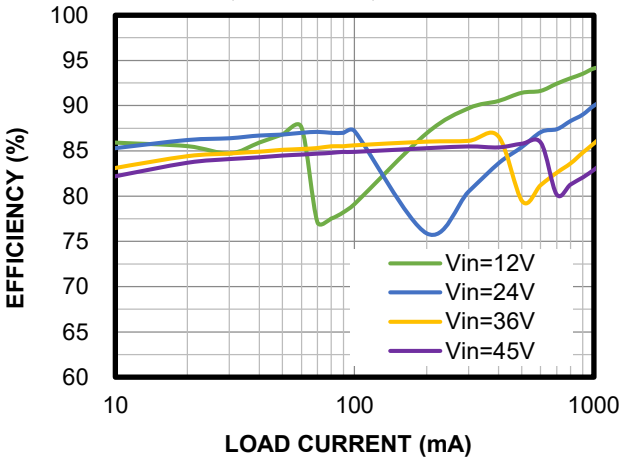
Efficiency vs. Load Current

AAM mode, V_{OUT} = 3.3V, 0.1mA to 10mA



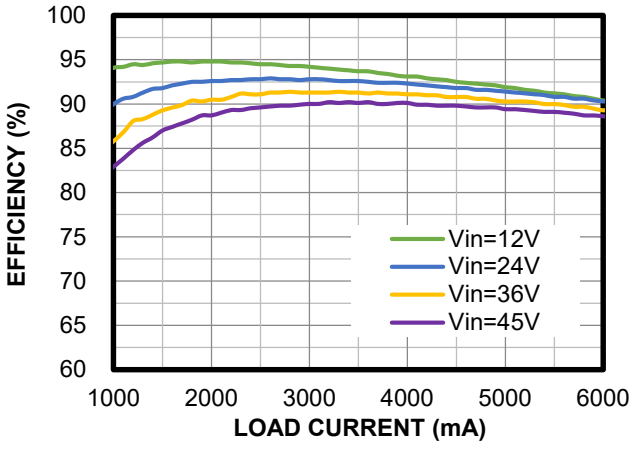
Efficiency vs. Load Current

AAM mode, V_{OUT} = 3.3V, 10mA to 1000mA



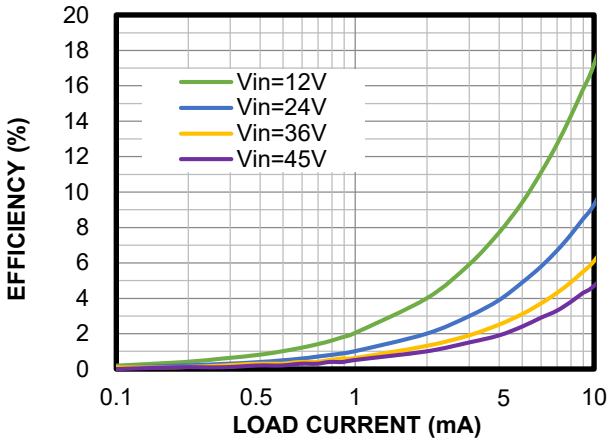
Efficiency vs. Load Current

AAM mode, V_{OUT} = 3.3V, 1A to 6A



Efficiency vs. Load Current

FCCM, V_{OUT} = 3.3V, 0.1mA to 10mA



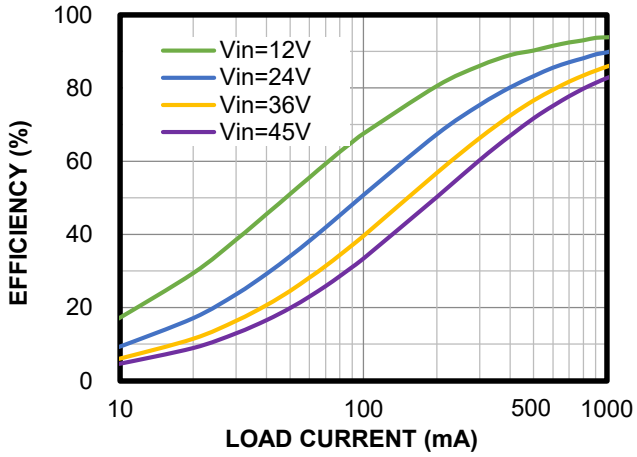
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

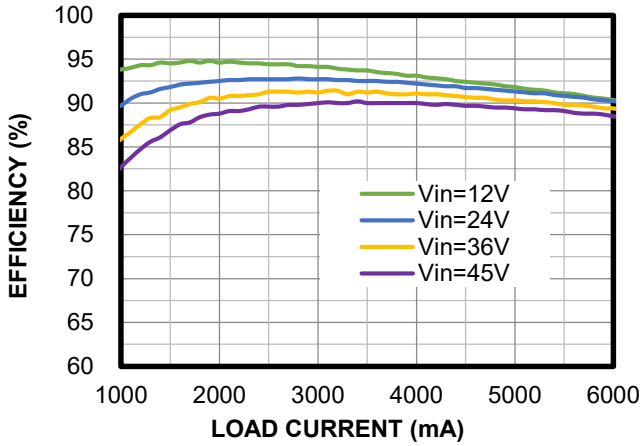
Efficiency vs. Load Current

FCCM, V_{OUT} = 3.3V, 10mA to 1000mA



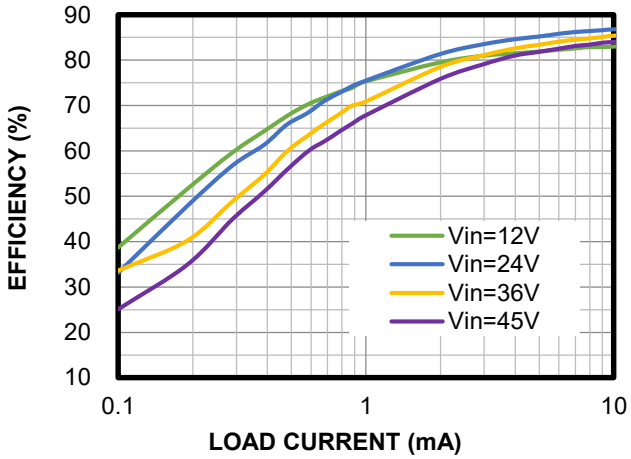
Efficiency vs. Load Current

FCCM, V_{OUT} = 3.3V, 1A to 6A



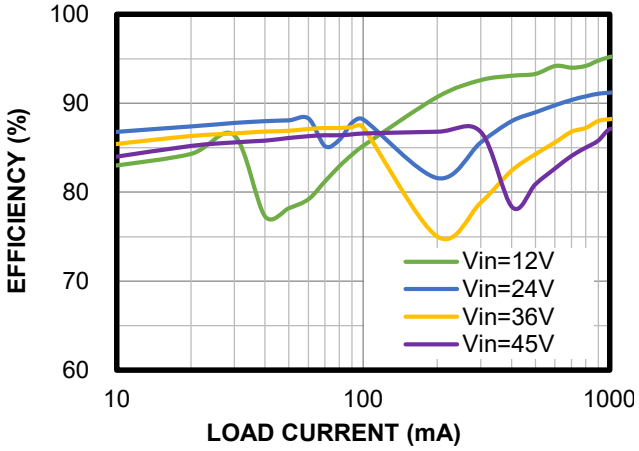
Efficiency vs. Load Current

AAM mode, V_{OUT} = 5V, 0.1mA to 10mA



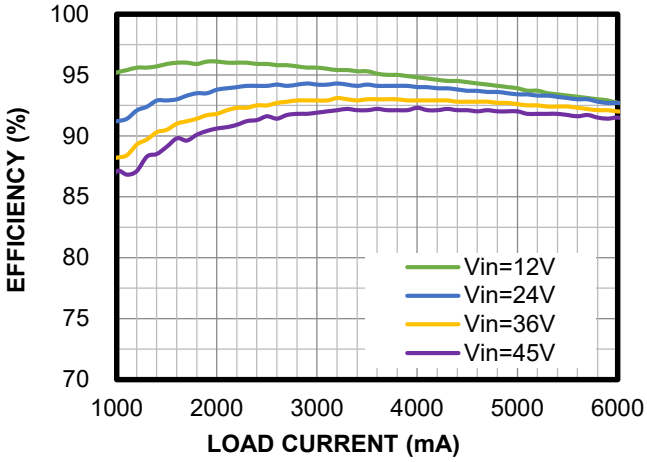
Efficiency vs. Load Current

AAM mode, V_{OUT} = 5V, 10mA to 1000mA



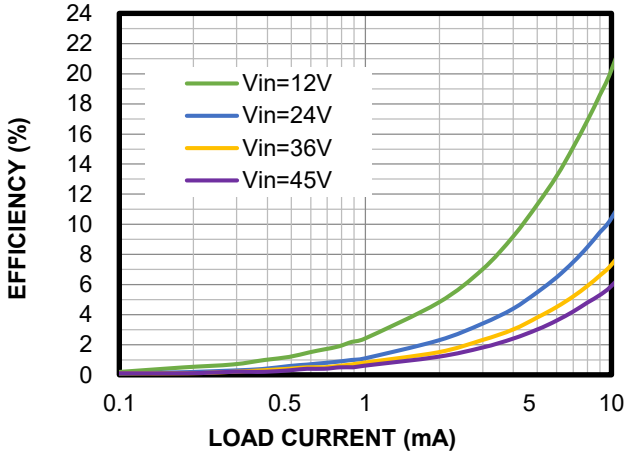
Efficiency vs. Load Current

AAM mode, V_{OUT} = 5V, 1A to 6A



Efficiency vs. Load Current

FCCM, V_{OUT} = 5V, 0.1mA to 10mA



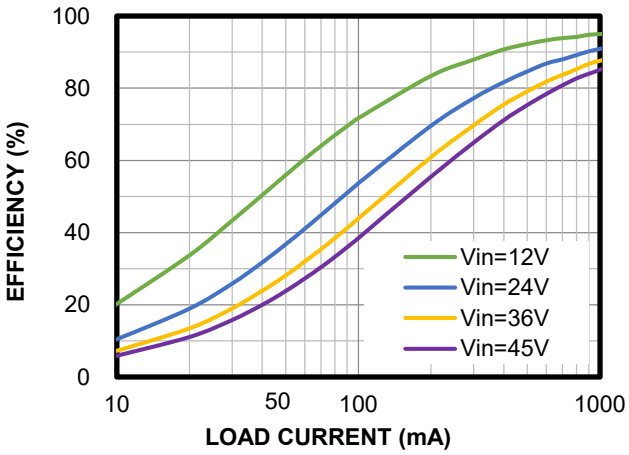
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

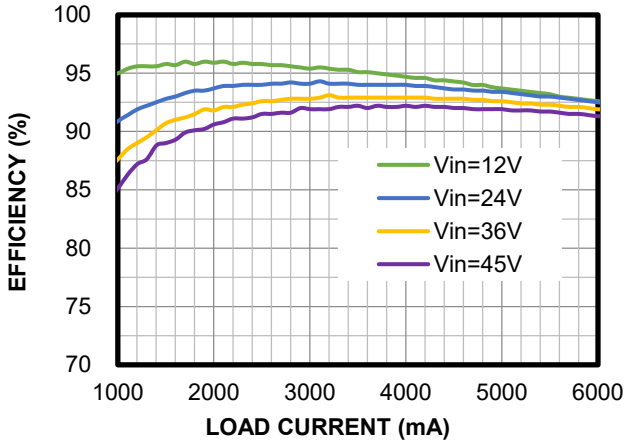
Efficiency vs. Load Current

FCCM, V_{OUT} = 5V, 10mA to 1000mA



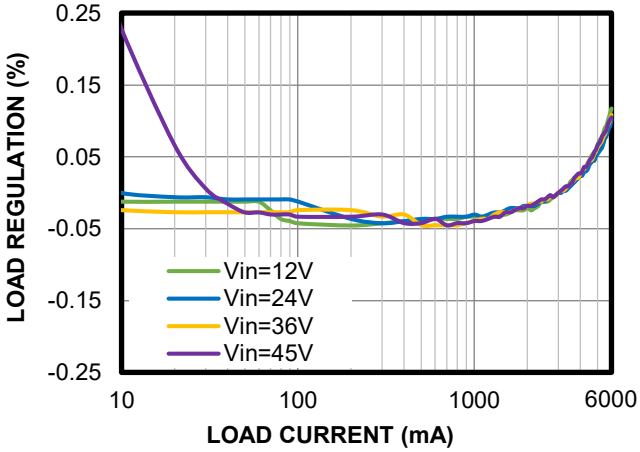
Efficiency vs. Load Current

FCCM, V_{OUT} = 5V, 1A to 6A



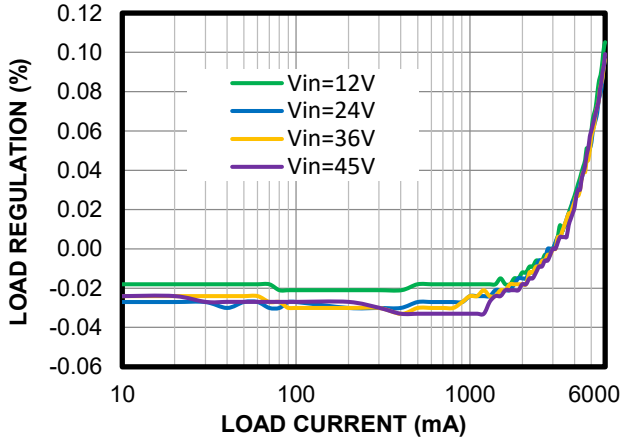
Load Regulation

V_{OUT} = 3.3V, AAM mode



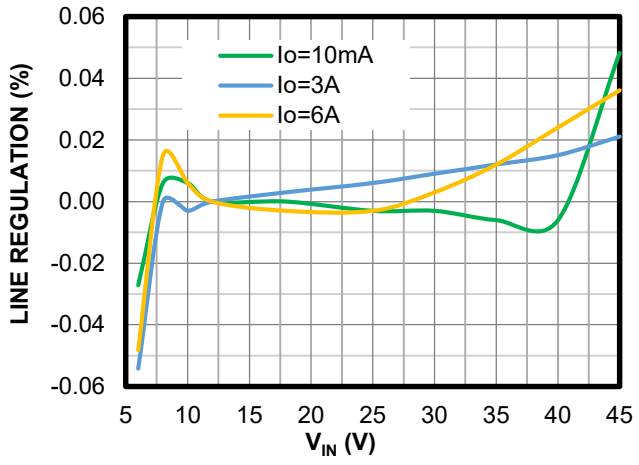
Load Regulation

V_{OUT} = 3.3V, FCCM



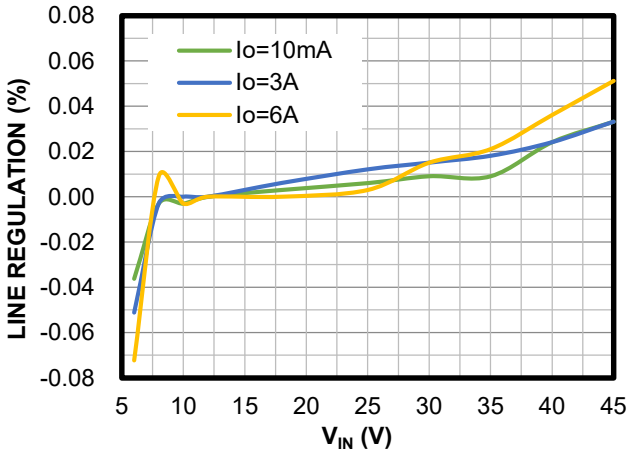
Line Regulation

V_{OUT} = 3.3V, AAM mode



Line Regulation

V_{OUT} = 3.3V, FCCM



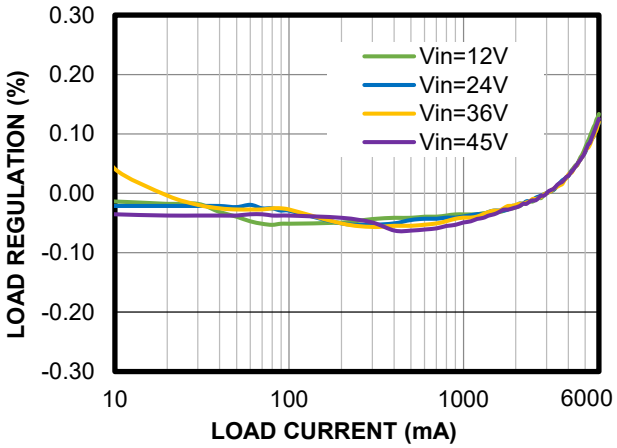
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

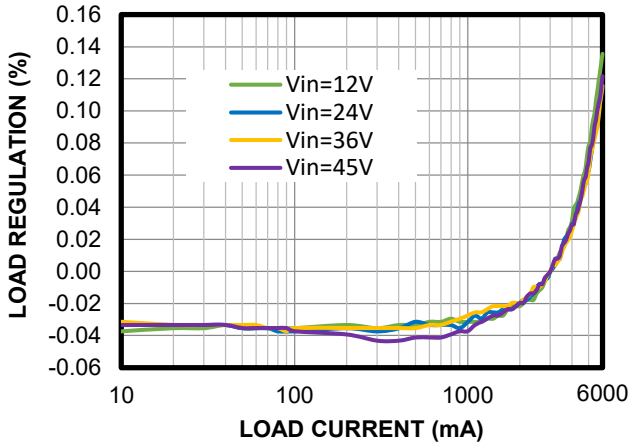
Load Regulation

V_{OUT} = 5V, AAM mode



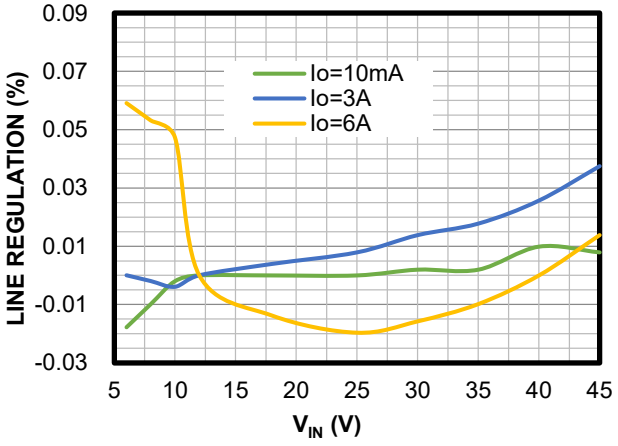
Load Regulation

V_{OUT} = 5V, FCCM



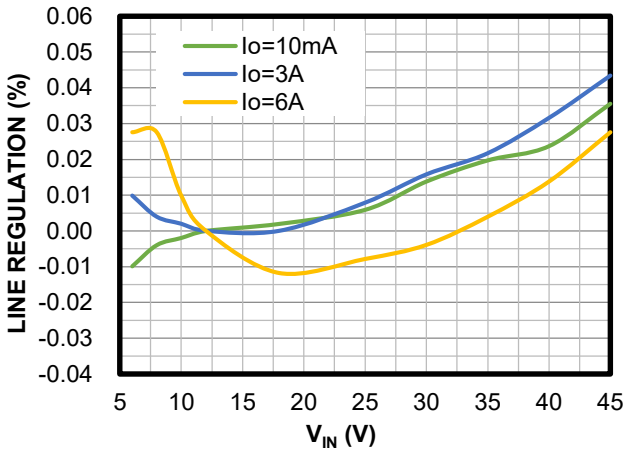
Line Regulation

V_{OUT} = 5V, AAM mode



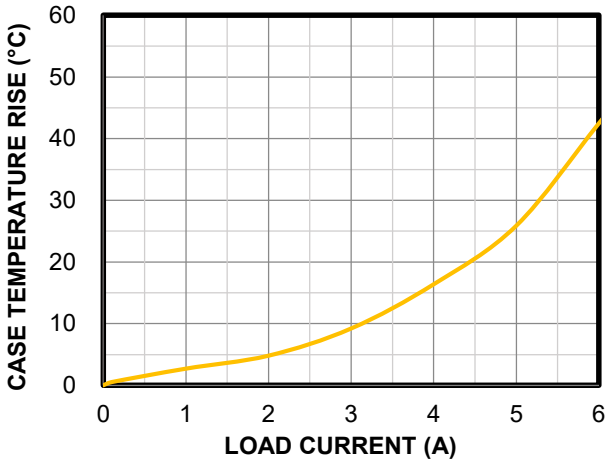
Line Regulation

V_{OUT} = 5V, FCCM



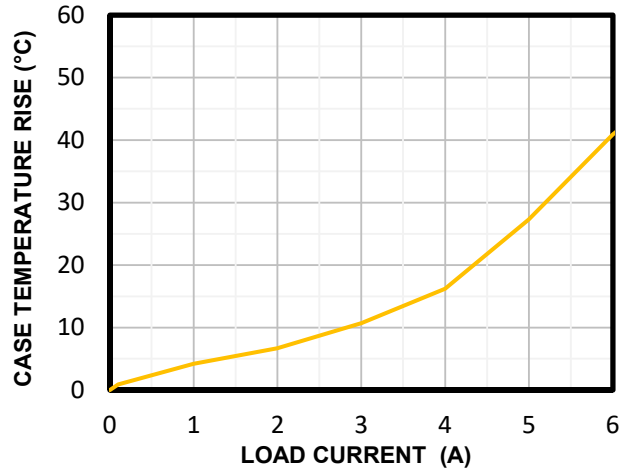
Case Temperature Rise

V_{OUT} = 3.3V



Case Temperature Rise

V_{OUT} = 5V

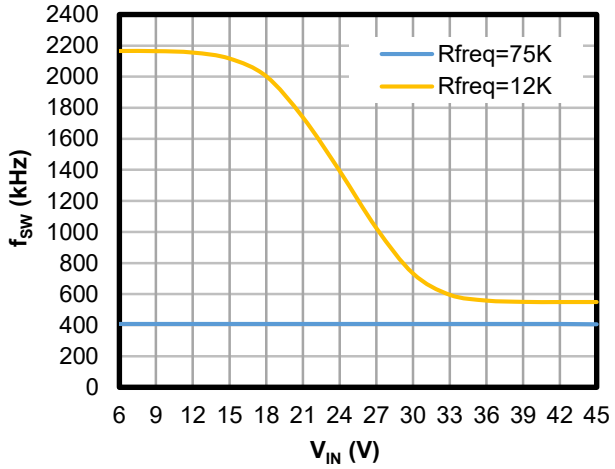


MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

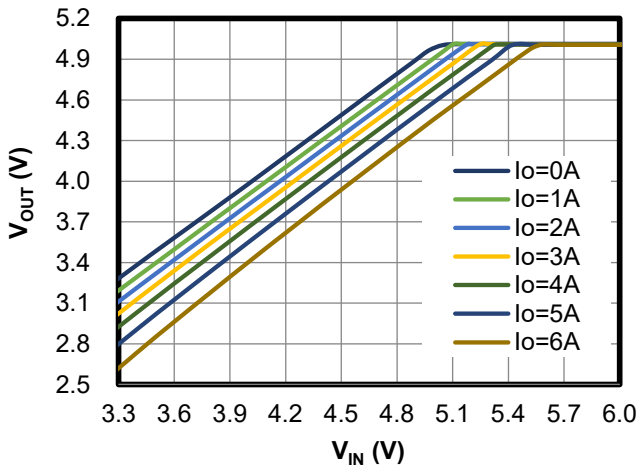
Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

f_{SW} vs. V_{IN}



Low-Dropout Mode

V_{OUT} = 5V



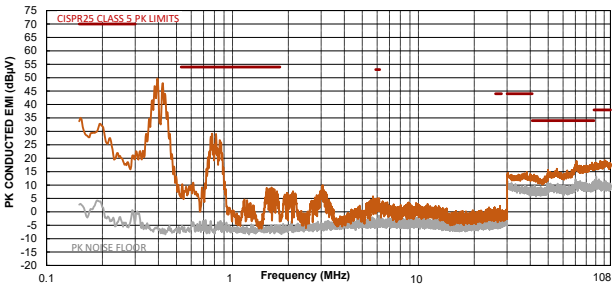
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

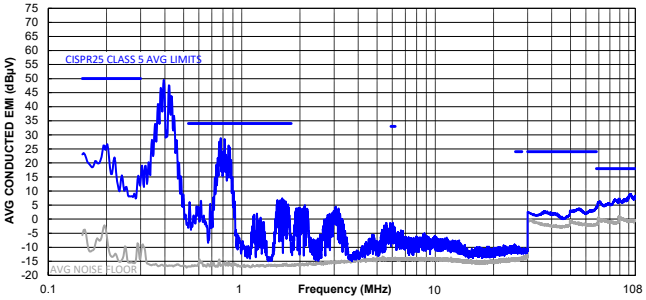
CISPR25 Class 5 Peak Conducted Emissions

150kHz to 108MHz



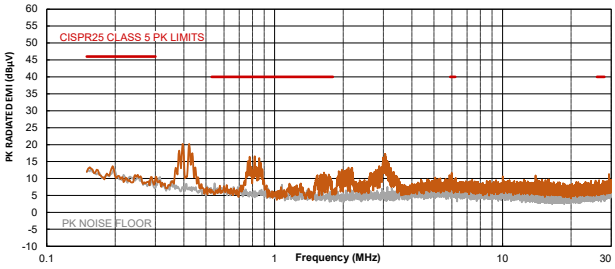
CISPR25 Class 5 Average Conducted Emissions

150kHz to 108MHz



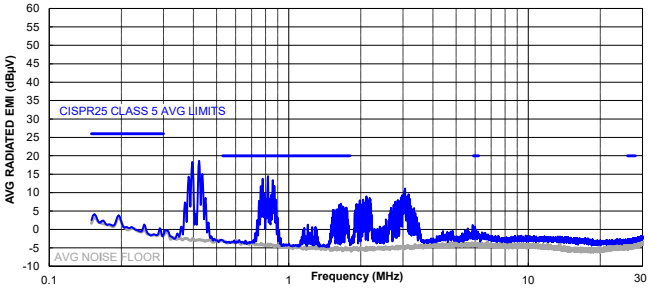
CISPR25 Class 5 Peak Radiated Emissions

150kHz to 30MHz



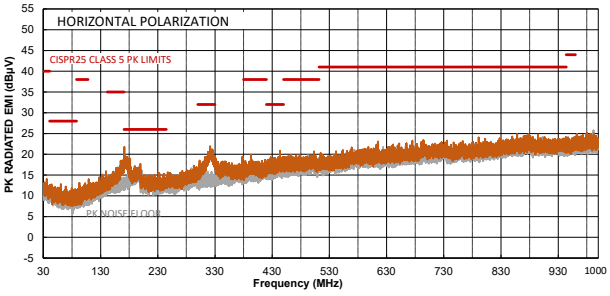
CISPR25 Class 5 Average Radiated Emissions

150kHz to 30MHz



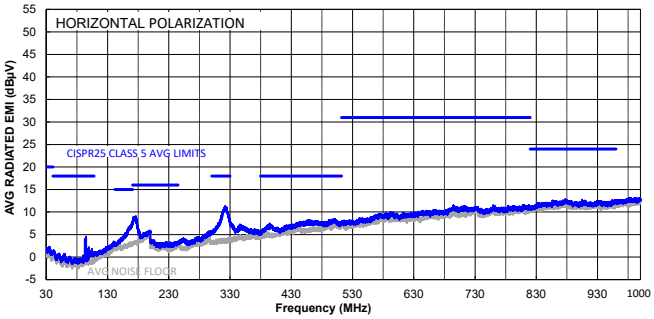
CISPR25 Class 5 Peak Radiated Emissions

Horizontal, 30MHz to 1GHz



CISPR25 Class 5 Average Radiated Emissions

Horizontal, 30MHz to 1GHz



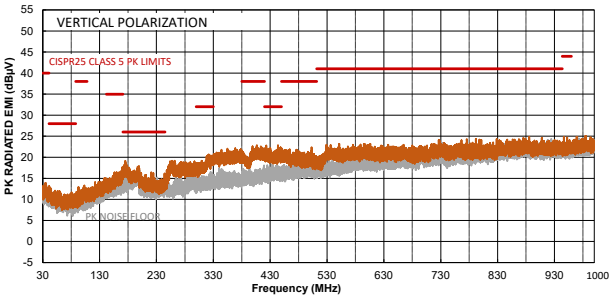
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

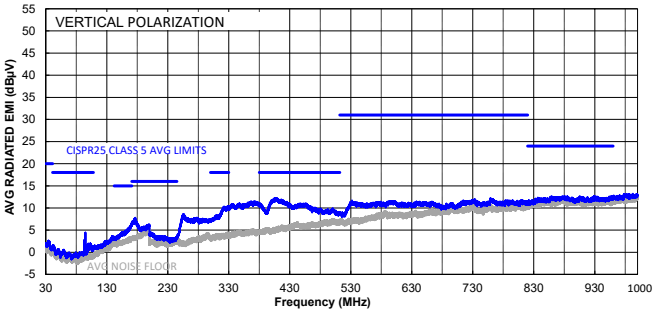
CISPR25 Class 5 Peak Radiated Emissions

Vertical, 30MHz to 1GHz



CISPR25 Class 5 Average Radiated Emissions

Vertical, 30MHz to 1GHz

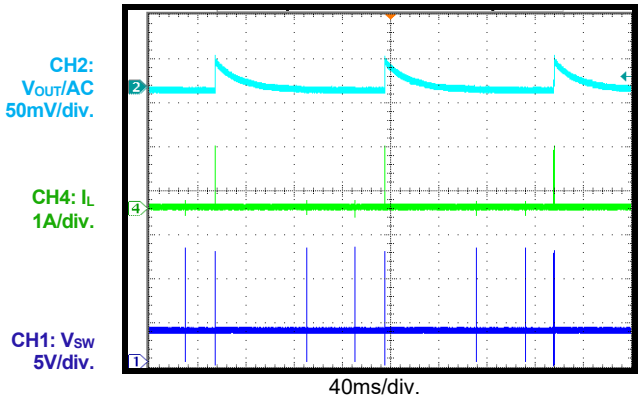


MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

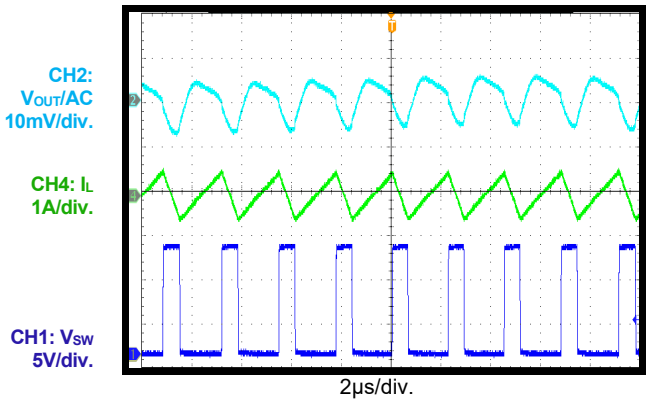
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

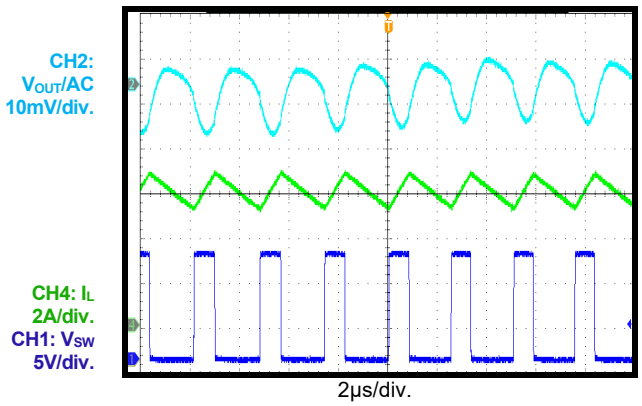
Steady State
I_{OUT} = 0A, AAM mode



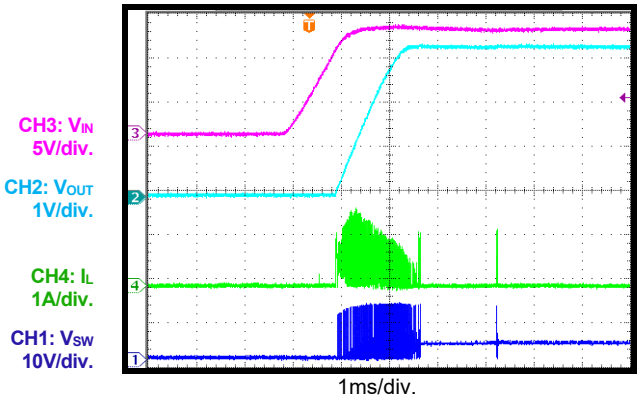
Steady State
I_{OUT} = 0A, FCCM



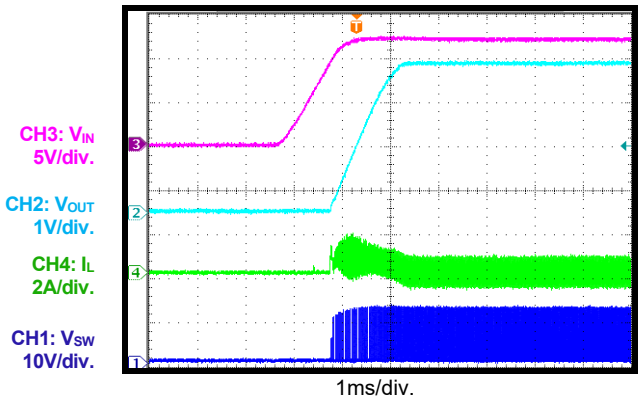
Steady State
I_{OUT} = 6A



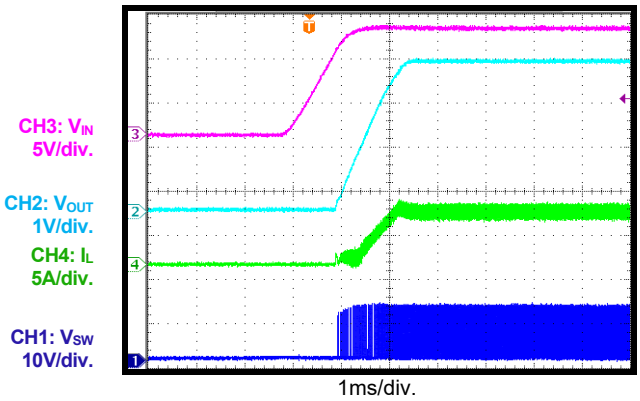
Start-Up through VIN
I_{OUT} = 0A, AAM mode



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



Start-Up through VIN
I_{OUT} = 6A



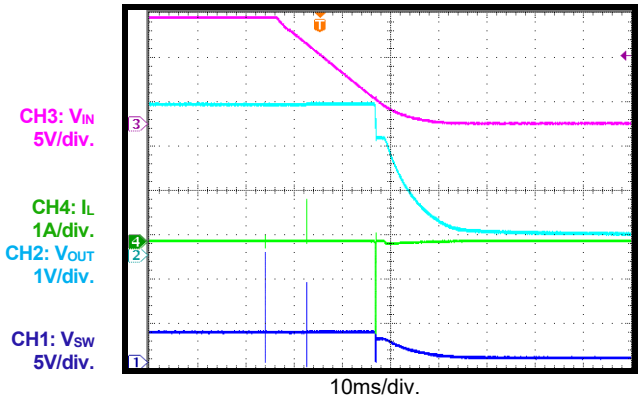
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

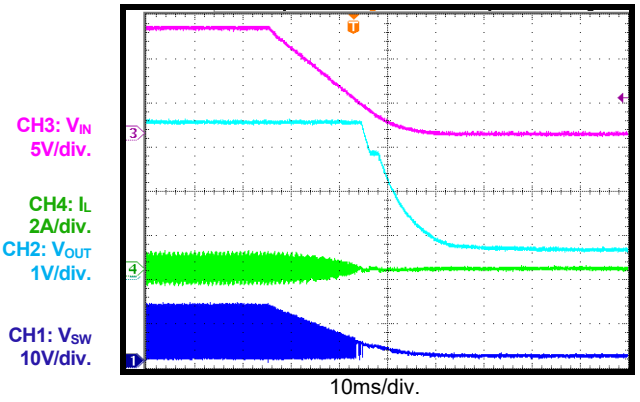
Shutdown through VIN

I_{OUT} = 0A, AAM mode



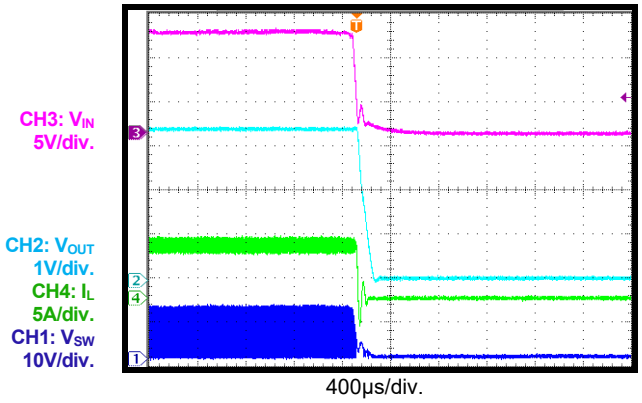
Shutdown through VIN

I_{OUT} = 0A, FCCM



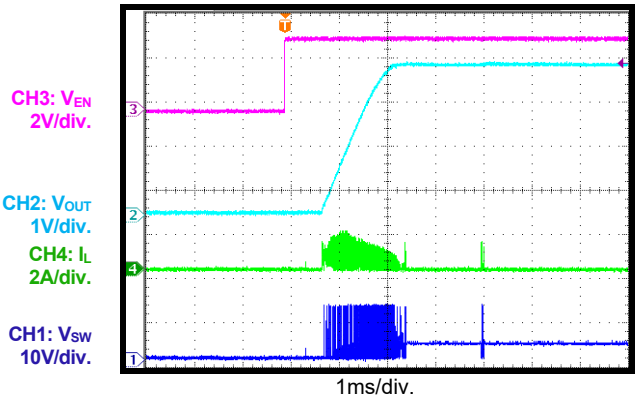
Shutdown through VIN

I_{OUT} = 6A



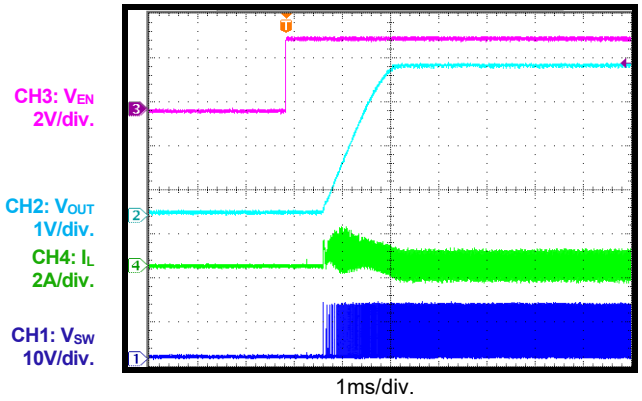
Start-Up through EN

I_{OUT} = 0A, AAM mode



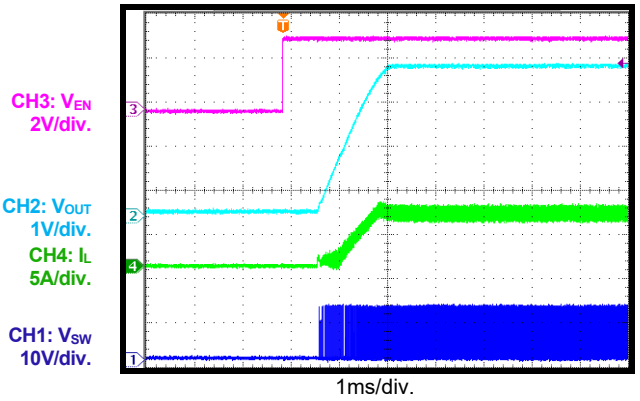
Start-Up through EN

I_{OUT} = 0A, FCCM



Start-Up through EN

I_{OUT} = 6A



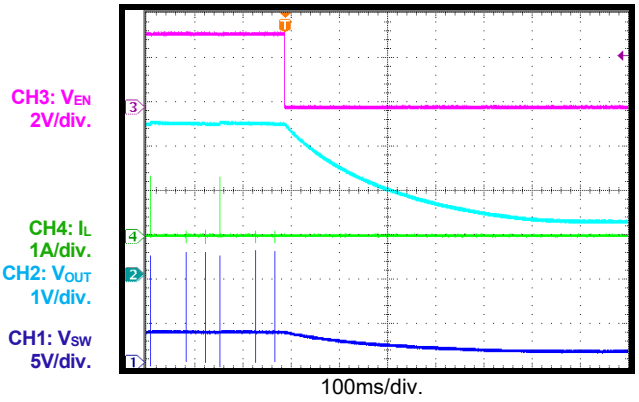
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

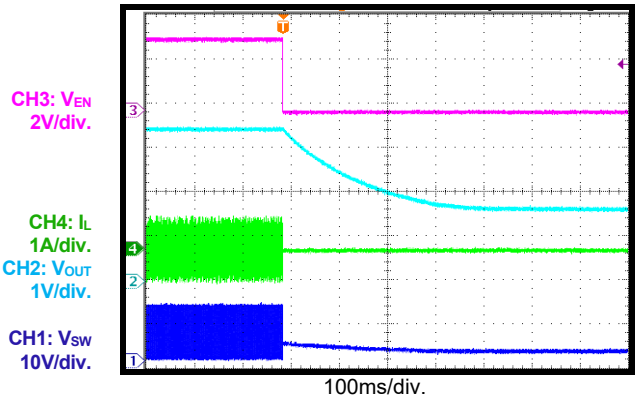
Shutdown through EN

I_{OUT} = 0A, AAM mode



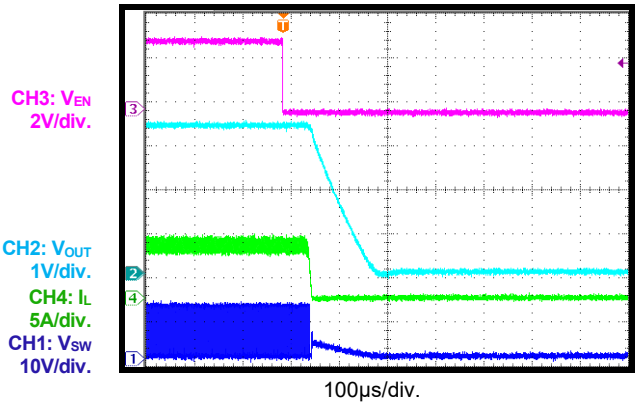
Shutdown through EN

I_{OUT} = 0A, FCCM



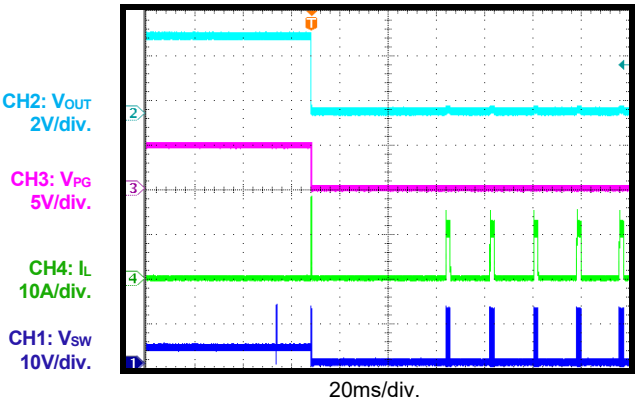
Shutdown through EN

I_{OUT} = 6A



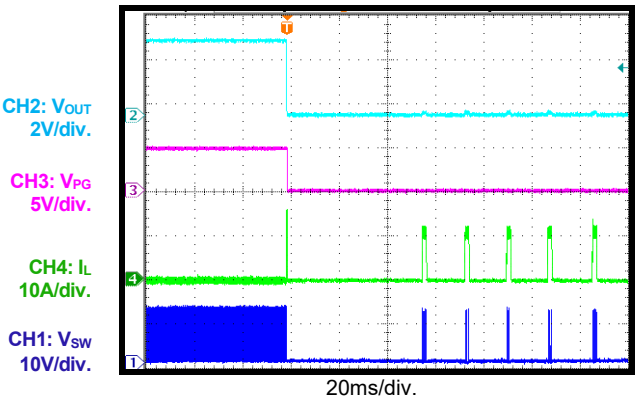
SCP Entry

I_{OUT} = 0A, AAM mode



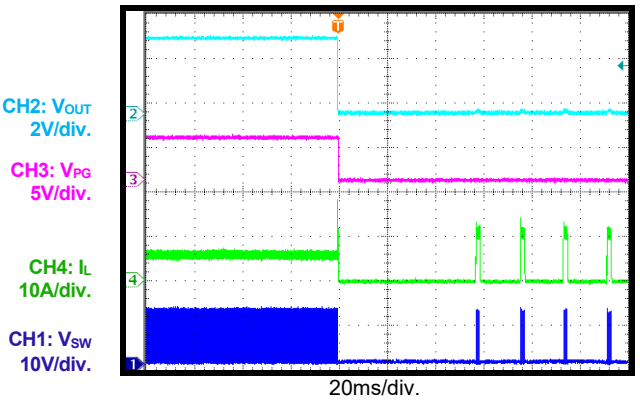
SCP Entry

I_{OUT} = 0A, FCCM



SCP Entry

I_{OUT} = 6A



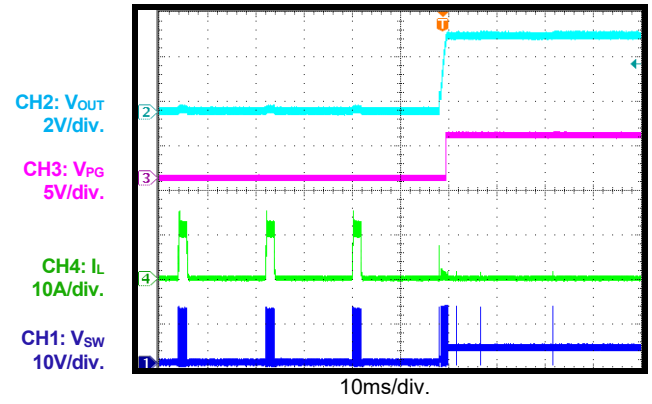
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

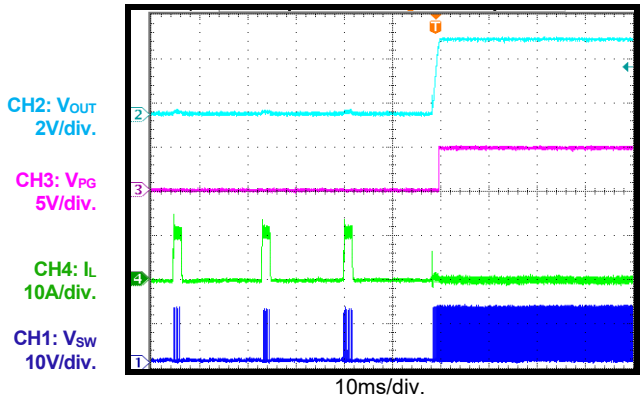
SCP Recovery

I_{OUT} = 0A, AAM mode



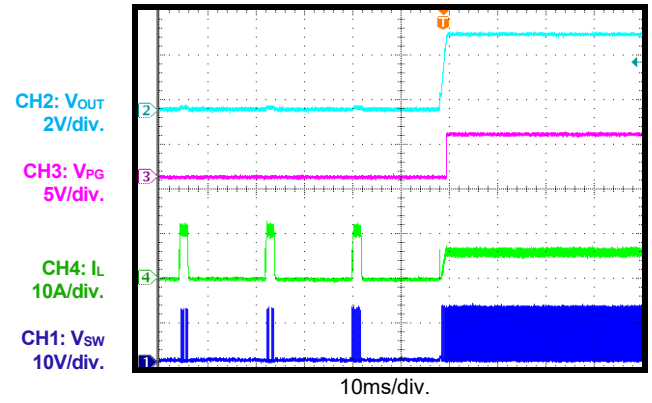
SCP Recovery

I_{OUT} = 0A, FCCM

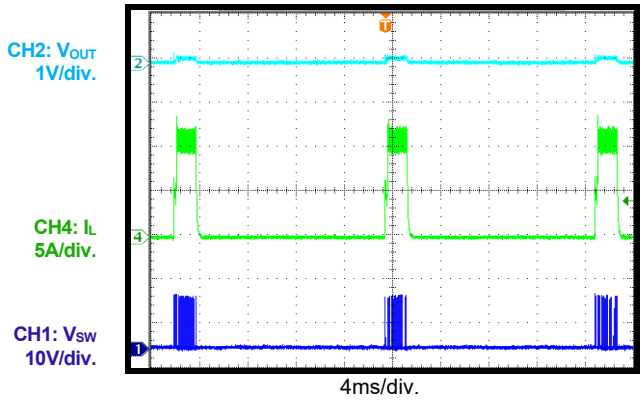


SCP Recovery

I_{OUT} = 6A

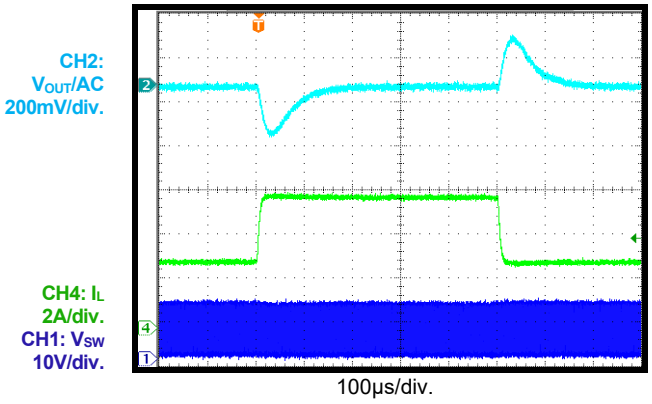


SCP Steady State



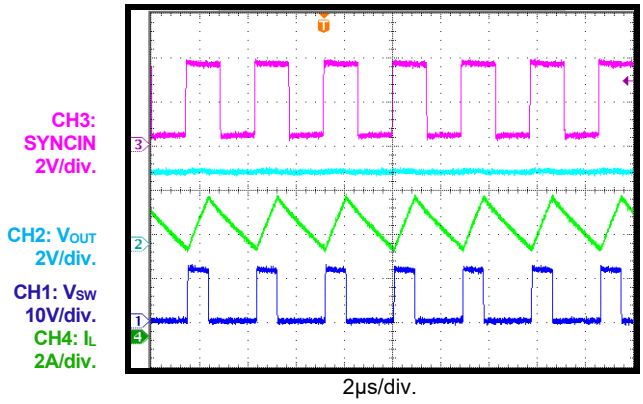
Load Transient Response

I_{OUT} = 3A to 6A



SYNC Operation

I_{OUT} = 6A, SYNC frequency = 350kHz



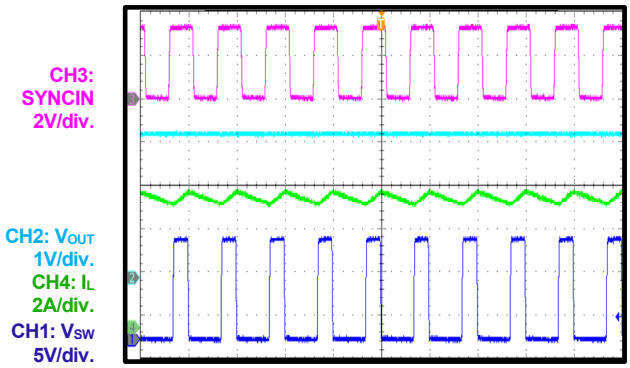
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

SYNC Operation

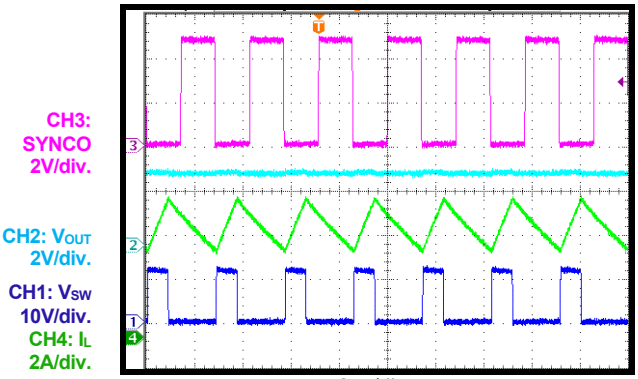
I_{OUT} = 6A, SYNC frequency = 1000kHz



1µs/div.

SYNCO Operation

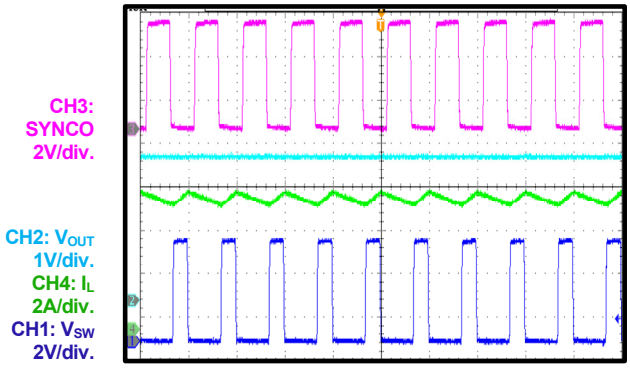
I_{OUT} = 6A, SYNC frequency = 350kHz



2µs/div.

SYNCO Operation

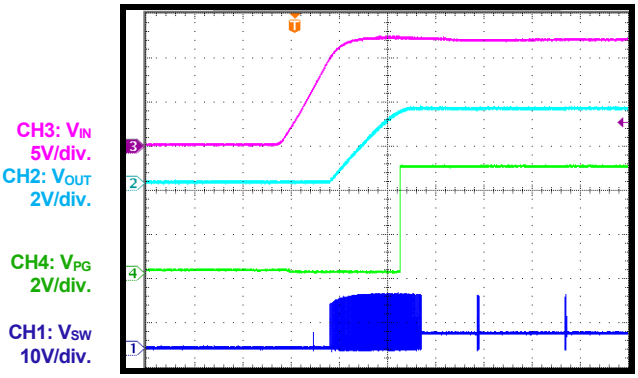
I_{OUT} = 6A, SYNC frequency = 530kHz



1µs/div.

PG in Start-Up through VIN

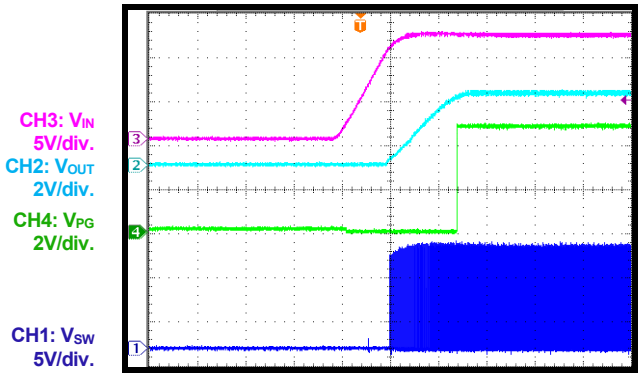
I_{OUT} = 0A



1ms/div.

PG in Start-Up through VIN

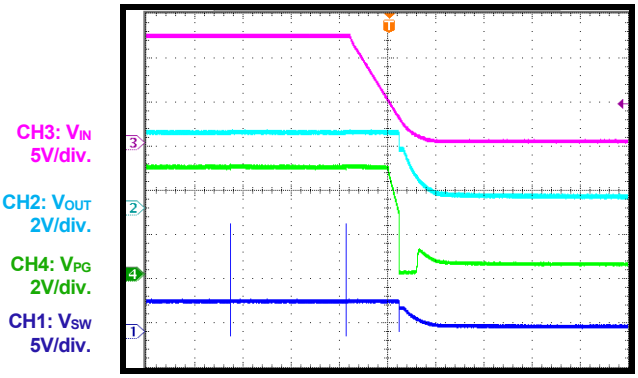
I_{OUT} = 6A



1ms/div.

PG in Shutdown through VIN

I_{OUT} = 0A



20ms/div.

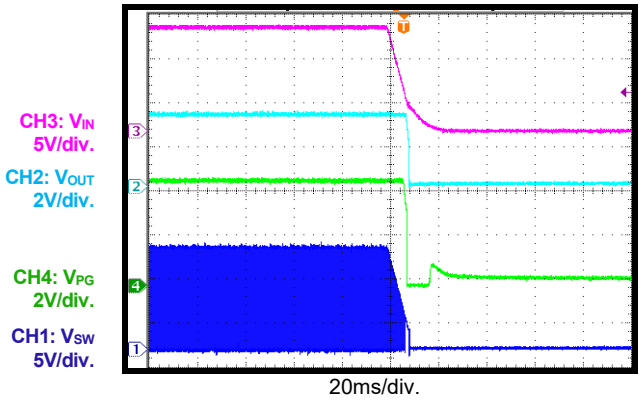
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

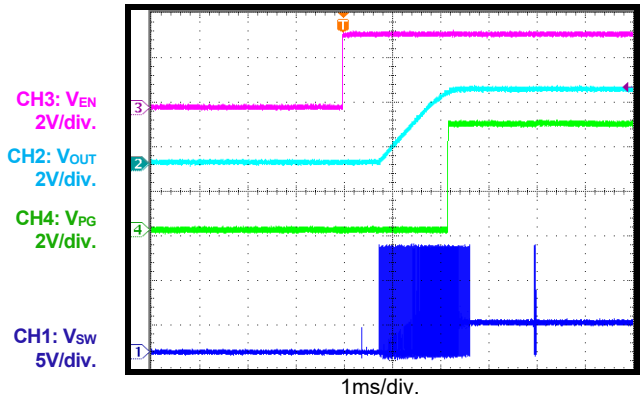
PG in Shutdown through VIN

I_{OUT} = 6A



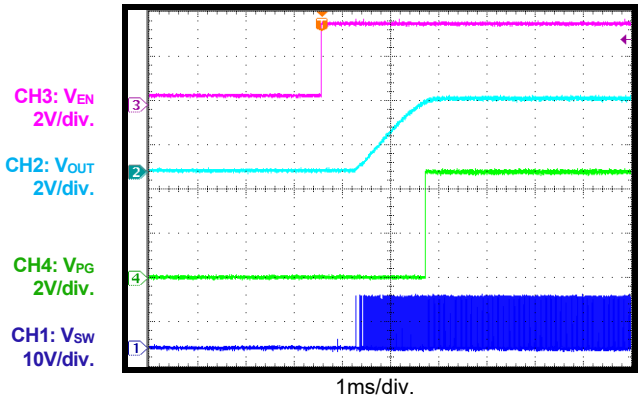
PG in Start-Up through EN

I_{OUT} = 0A



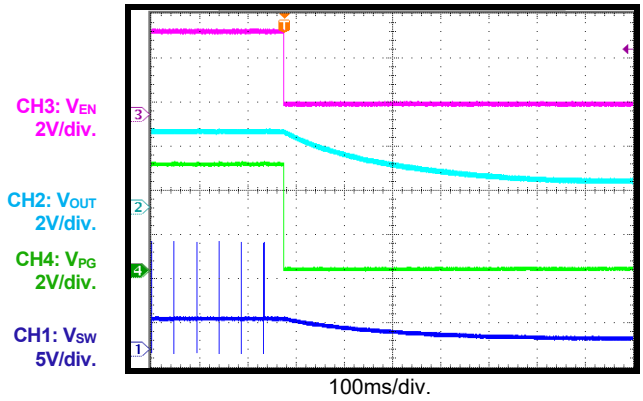
PG in Start-Up through EN

I_{OUT} = 6A



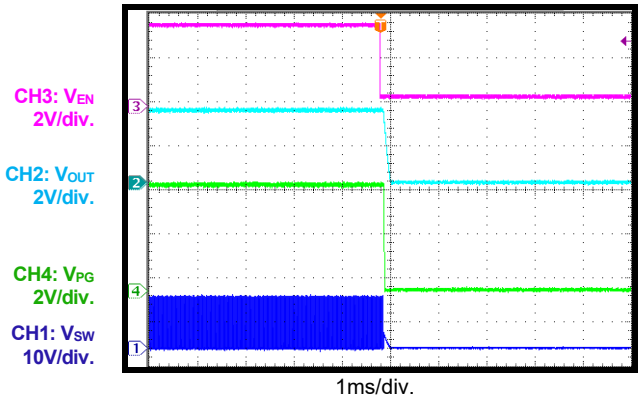
PG in Shutdown through EN

I_{OUT} = 0A



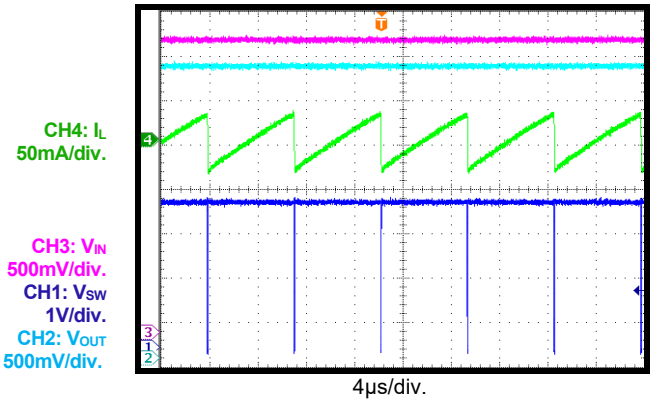
PG in Shutdown through EN

I_{OUT} = 6A



Low-Dropout Mode

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



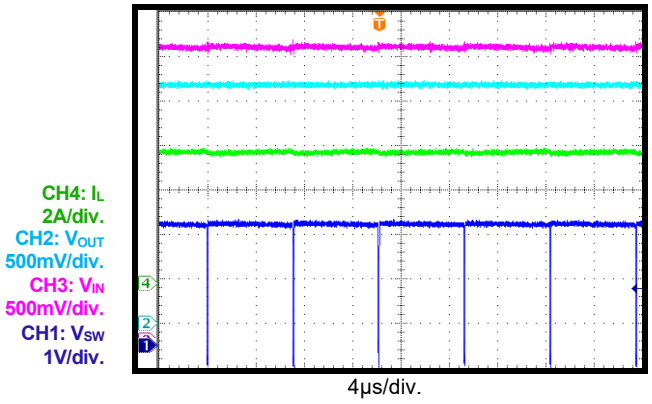
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

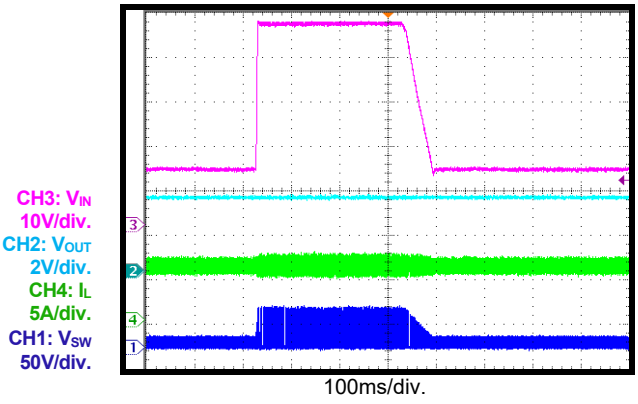
Low-Dropout Mode

V_{IN} = 3.3V, V_{OUT} set to 3.3V, I_{OUT} = 6A



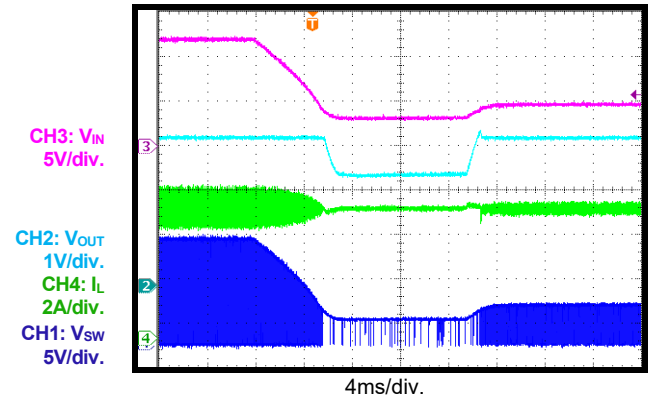
Load Dump

V_{IN} = 12V to 36V, I_{OUT} = 6A



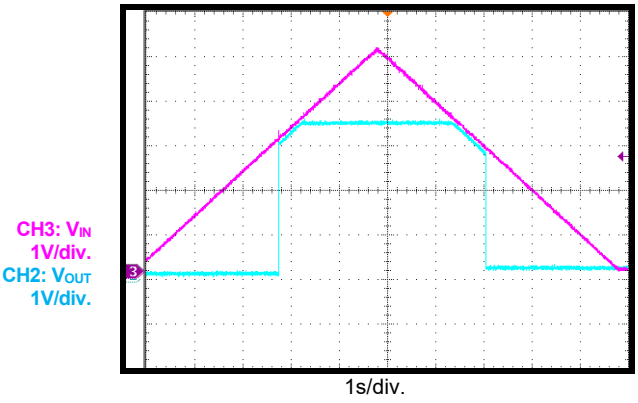
Cold Crank

V_{IN} = 12V to 3.3V to 5V, I_{OUT} = 6A



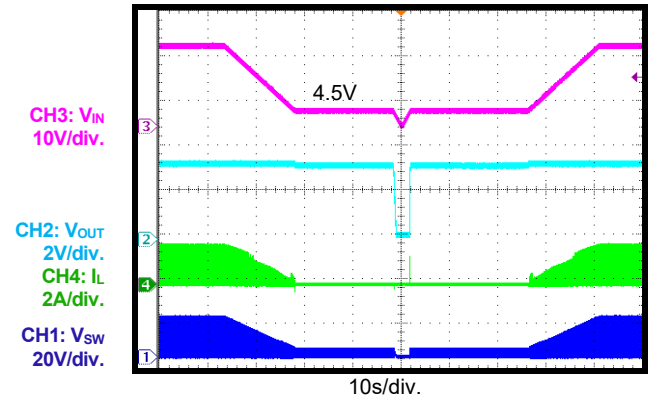
V_{IN} Ramping Up and Down

I_{OUT} = 0.1A



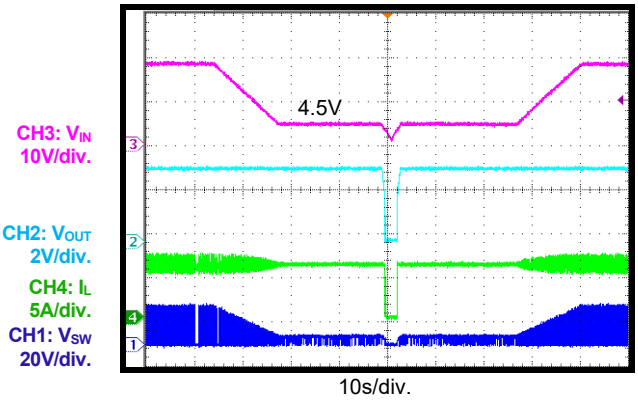
V_{IN} Ramping Down and Up

I_{OUT} = 1mA



V_{IN} Ramping Down and Up

I_{OUT} = 6A



MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

PCB LAYOUT (2)

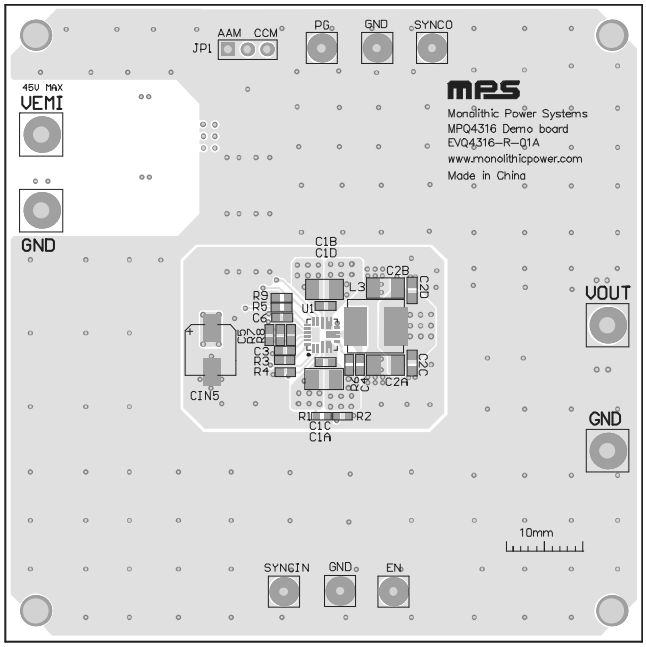


Figure 4: Top Silk and Top Layer

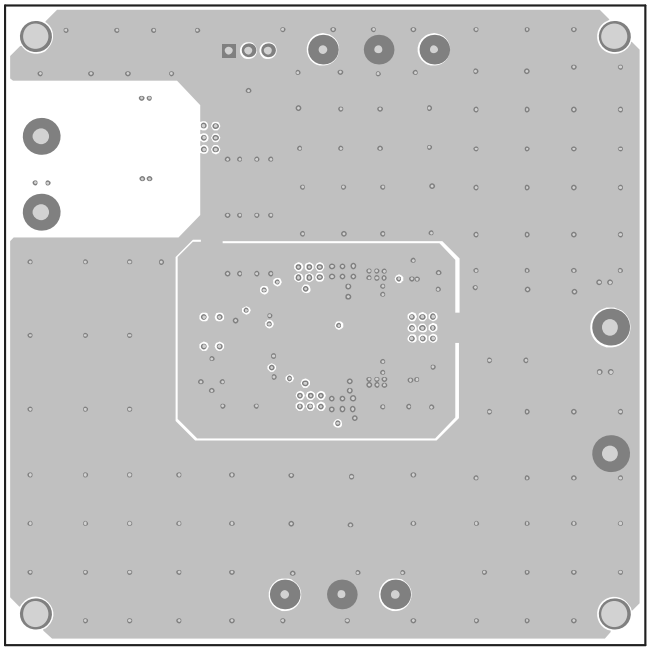


Figure 5: Mid-Layer 1

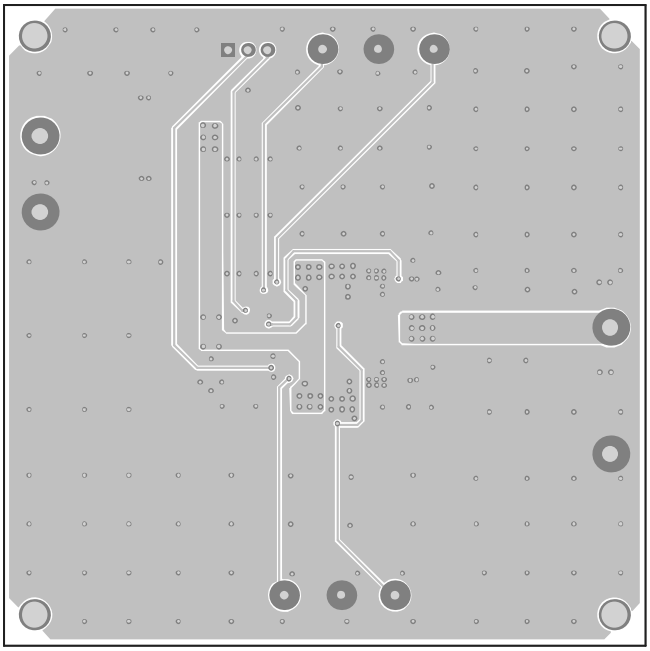


Figure 6: Mid-Layer 2

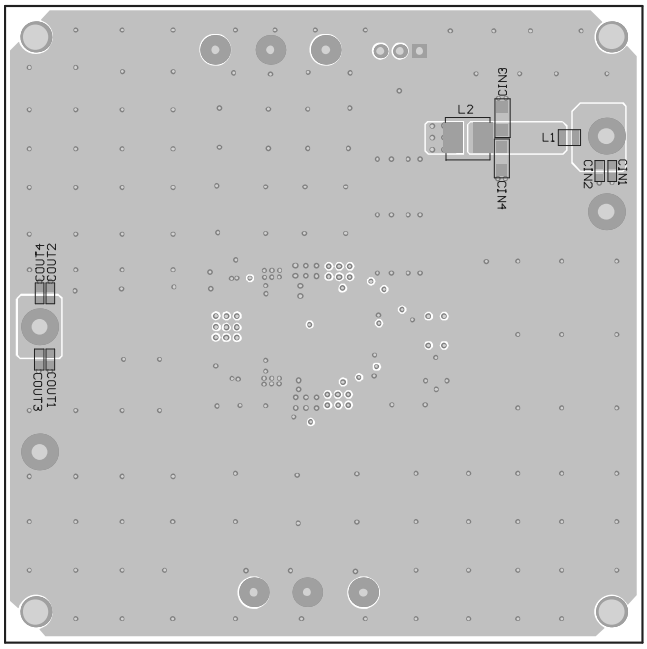


Figure 7: Bottom Layer and Bottom Silk

Note:

2) The copper thickness is 2oz.

MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	5/18/2022	Initial Release	-

Notice: The information in this document is subject to change without notice. Please contact MPS for current specifications. Users should warrant and guarantee that third-party Intellectual Property rights are not infringed upon when integrating MPS products into any application. MPS will not assume any legal responsibility for any said applications.

MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2022 MPS. All Rights Reserved.