EVQ4326B-R-6000-00A

36V, 6A, Low Quiescent Current, Synchronous Buck Converter Evaluation Board, AEC-Q100 Qualified

DESCRIPTION

The EVQ4326B-R-6000-00A evaluation board is designed to demonstrate the capabilities of the MPQ4326B-6000, a synchronous, step-down switching converter with a configurable frequency and integrated, internal high-side and low-side MOSFETs (HS-FET and LS-FET, respectively). The MPQ4326B-6000 provides up to 6A of highly efficient output current (I_{OUT}) with current mode control for fast loop response.

The wide 3.3V to 36V input voltage (V_{IN}) range with 42V load dump support accommodates a variety of step-down applications in automotive input environments. A 1µA shutdown mode quiescent current (I_Q) allows the device to be used in battery-powered applications.

High power conversion efficiency across the wide load range is achieved by scaling down the switching frequency (f_{SW}) under light-load conditions to reduce switching and gate driver losses.

An open-drain power good (PG) signal indicates whether the output is within 94.5% to 105.5% of its nominal voltage. Thermal shutdown provides reliable, fault-tolerant operation. A high duty cycle and low-dropout mode are provided for automotive cold-crank conditions.

The EVQ4326B-R-6000-00A is a fully assembled and tested evaluation board. The MPQ4326B-6000 is available in a QFN-14 (4mmx4mm) package with wettable flanks, and is available in AEC-Q100 Grade 1.

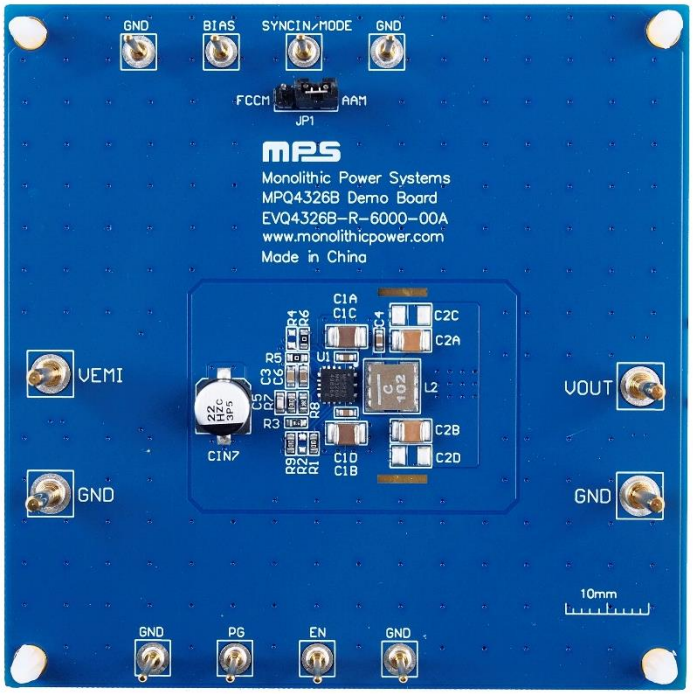
PERFORMANCE SUMMARY

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

Parameters	Conditions	Value
Input voltage (V_{IN}) range		3.3V to 36V
Output voltage (V_{OUT})	V_{IN} = 6V to 36V, I_{OUT} = 0A to 6A	5V
Maximum output current (I_{OUT})	V_{IN} = 3.3V to 36V	6A
Typical efficiency	V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 6A	91.9%
Peak efficiency	V_{IN} = 8V, V_{OUT} = 5V, I_{OUT} = 1.6A	96%
Switching frequency (f_{SW})		2.2MHz

MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

EVQ4326B-R-6000-00A EVALUATION BOARD



LxWxH (8.3cmx8.3cmx1.3cm)

Board Number	MPS IC Number
EVQ4326B-R-6000-00A	MPQ4326BGRE-6000-AEC1

MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

QUICK START GUIDE

The EVQ4326B-R-6000-00A evaluation board is easy to set up and use to evaluate the performance of the MPQ4326B-6000. For proper measurement equipment set-up, refer to Figure 3 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 (I_{LOAD}) to be between 0A and 6A. 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} ≥ 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 start up automatically.
7. To use the enable (EN) function, apply a digital input to the EN pin. Drive EN above 1.02V to turn the regulator on; drive EN below 0.85V to turn it off. If the EN function is not used, connect EN directly to VIN.
8. The MPQ4326B-6000's switching frequency (f_{SW}) can be configured via R3, the FREQ pin's resistor (R_{FREQ}). R3 can be estimated based on the relationship between f_{SW} and R_{FREQ}. Figure 1 shows the relationship between f_{SW} and R_{FREQ} when f_{SW} is between 200kHz and 1000kHz.

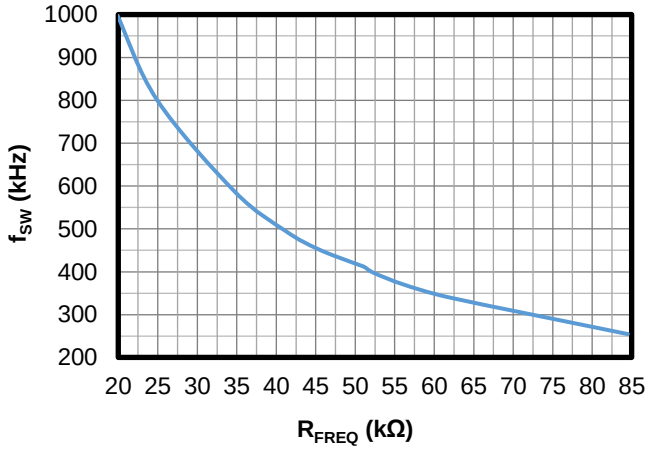


Figure 1: f_{SW} vs. R_{FREQ} (f_{SW} = 200kHz to 1000kHz)

Figure 2 on page 4 shows the relationship between f_{SW} and R_{FREQ} when f_{SW} is between 1000kHz and 2500kHz.

MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

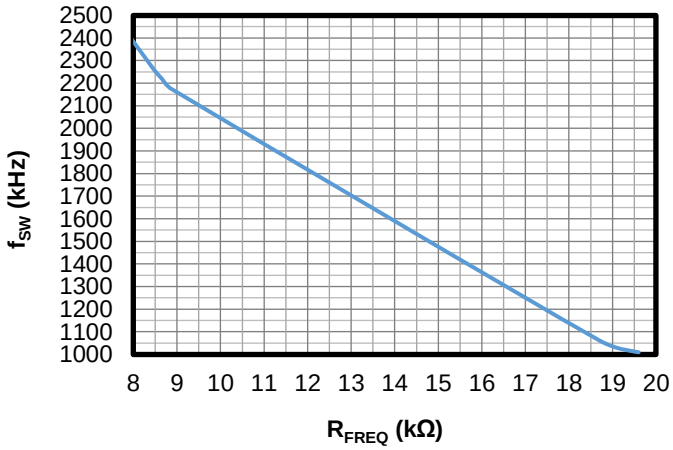


Figure 2: f_{SW} vs. R_{FREQ} (f_{SW} = 1000kHz to 2500kHz)

Table 1 shows some common values for f_{SW} and R_{FREQ}.

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

f_{SW} (kHz)	R_{FREQ} (kΩ)
2500	7.87
2200	8.66
1500	14.3
1060	18.7
1000	19.6
800	24.9
590	34.8
470	43.2
410	49.9
400	52.3
370	56.2
340	62
255	84.5
210	100

9. The output voltage (V_{OUT}) is set via R7 and R8, the external resistor dividers. If R7 = 100kΩ, then R8 can be calculated with Equation (1):

$$R8 = \frac{R7}{\frac{V_{OUT}}{0.8V} - 1} \quad (1)$$

Table 2 shows the recommended external resistance for common output voltages.

Table 2: Resistor Selection for Output Voltages

V_{OUT} (V)	R7 (kΩ)	R8 (kΩ)
3.3	100 (0.1%)	31.6 (0.1%)
5	100 (0.1%)	19.1 (0.1%)

MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

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

Table 3: Mode Selection

SYNC/MODE Input	Operation
<0.4V	AAM mode
>1.4V	FCCM
External clock in	FCCM

Refer to the Application Information section in the MPQ4326B-6000's datasheet to calculate the inductance (L) and output capacitance (C_{OUT}).

Figure 3 shows the measurement equipment set-up.

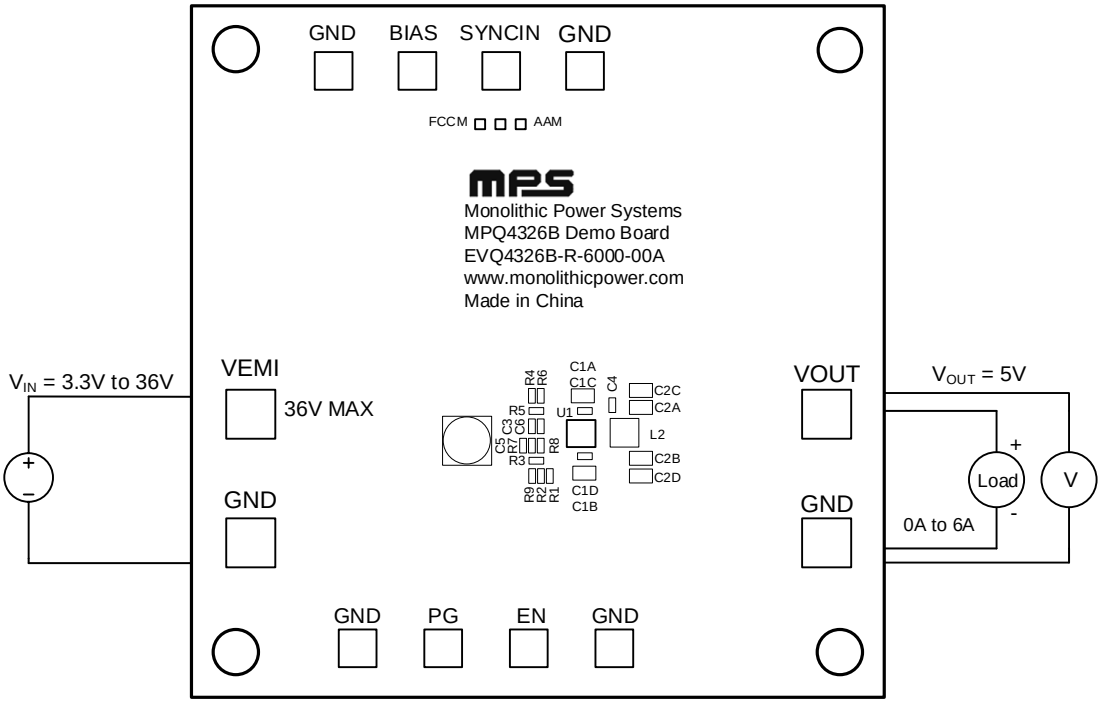


Figure 3: Measurement Equipment Set-Up

MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

EVALUATION BOARD SCHEMATIC

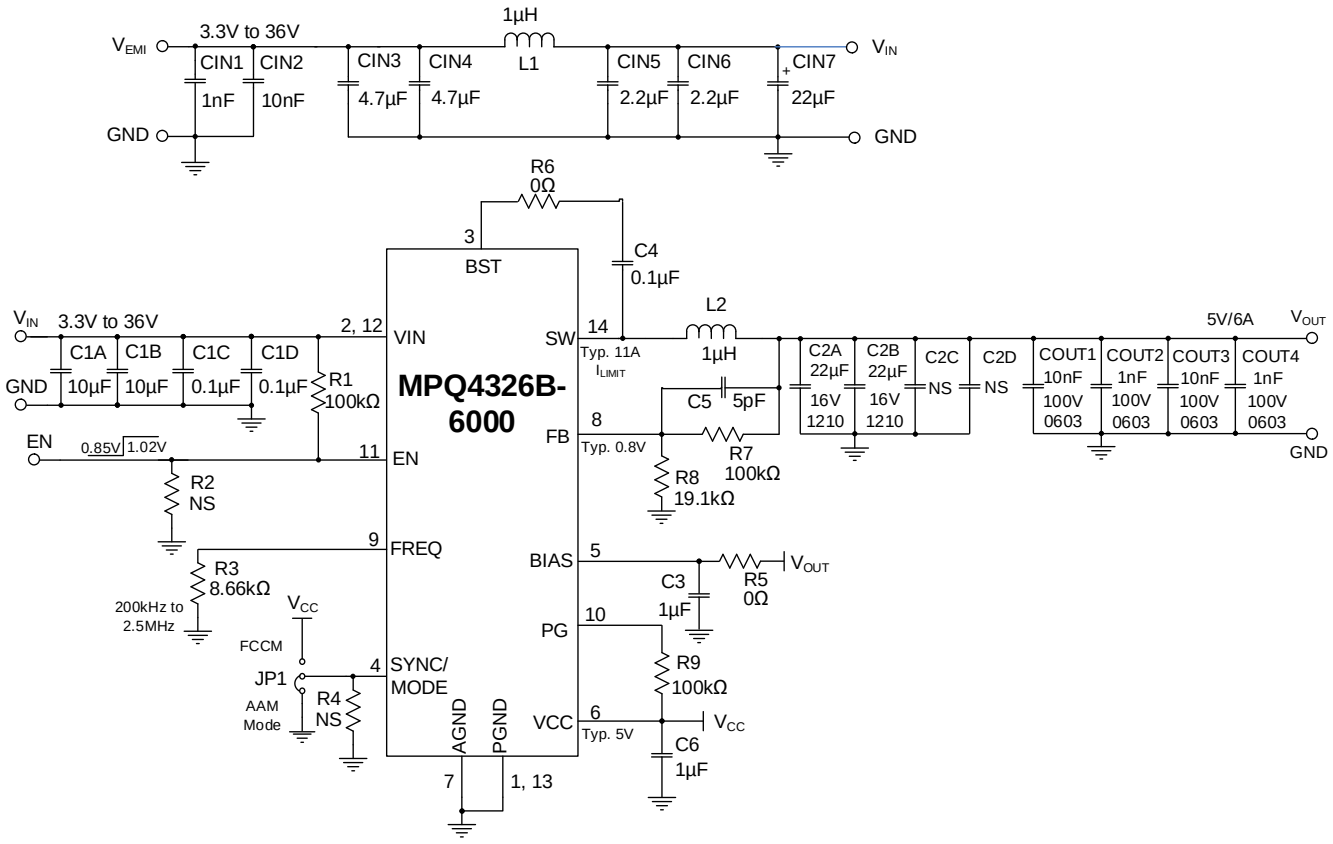
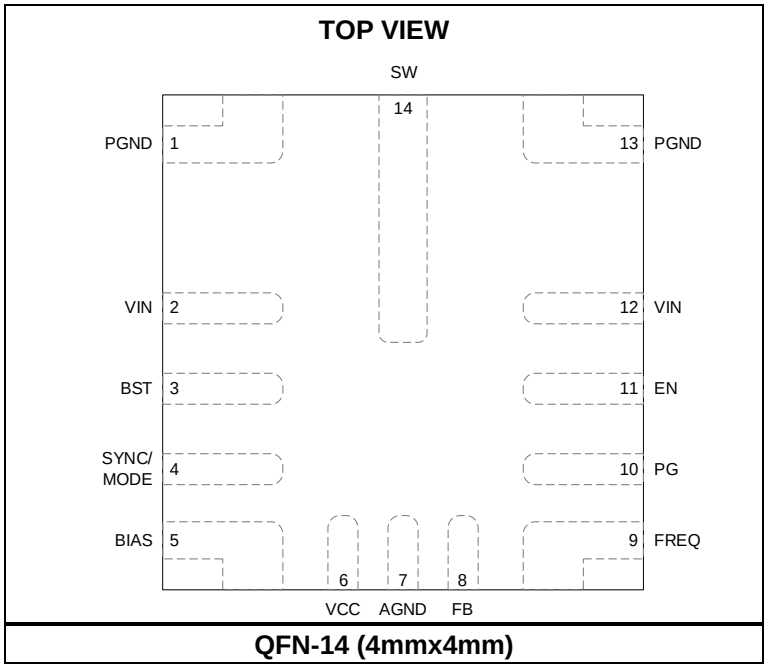


Figure 4: Evaluation Board Schematic

PACKAGE REFERENCE



QFN-14 (4mmx4mm)

MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

EVQ4326B-R-6000-00A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
3	CIN1, COUT2, COUT4	1nF	Ceramic capacitor, 100V, X7R	0603	Murata	GRM188R72A102KA01D
3	CIN2, COUT1, COUT3	10nF	Ceramic capacitor, 100V, X7R	0603	Murata	GRM188R72A103KA01D
2	CIN3, CIN4	4.7µF	Ceramic capacitor, 50V, X7R	1206	Murata	GRM31CR71H475KA12L
2	CIN5, CIN6	2.2µF	Ceramic capacitor, 50V, X7R	1206	Murata	GCM31CR71H225KA55L
1	CIN7	22µF	Aluminum polymer capacitor, 50V	SMD	Panasonic	EEHZC1H220P
2	C1A, C1B	10µF	Ceramic capacitor, 50V, X7R	1210	Murata	GRM32ER71H106KA12L
3	C1C, C1D, C4	0.1µF	Ceramic capacitor, 100V, X7R	0603	Murata	GRM188R72A104KA35D
2	C2A, C2B	22µF	Ceramic capacitor, 16V, X7R	1210	Murata	GRM32ER71C226KEA8L
2	C2C, C2D	NS				
2	C3, C6	1µF	Ceramic capacitor, 25V, X7R	0603	Murata	GCM188R71E105KA64D
1	C5	5pF	Ceramic capacitor, 50V, C0G	0603	TDK	C1608C0G1H050C
1	L1	1µH	Inductor, 9.6A	SMD	Coilcraft	XEL4020-102MEB/C
1	L2	1µH	Inductor, 9.4mΩ, 14A	SMD	Coilcraft	XAL5030-102MEB/C
3	R1, R7, R9	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
2	R2, R4	NS				
1	R3	8.66kΩ	Film resistor, 1%	0603	RoyalOhm	0603SAF8661T5E
2	R5, R6	0Ω	Film resistor, 5%	0603	Yageo	RC0603JR-070RL
1	R8	19.1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0719K1L
1	JP1	2.54mm	Test pin, 3-pin	DIP	Any	
4	VEMI, GND, VOUT, GND	2mm	Golden pin	DIP	Custom (1)	
8	PG, EN, BIAS, SYNCIN/MODE, GND	1mm	Golden pin	DIP	Custom (1)	
1	U1	MPQ4326B-6000-AEC1	36V/6A, synchronous, step-down, switching converter, AEC-Q100	QFN-14 (4mmx 4mm)	MPS	MPQ4326BGRE-6000-AEC1

Note:

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

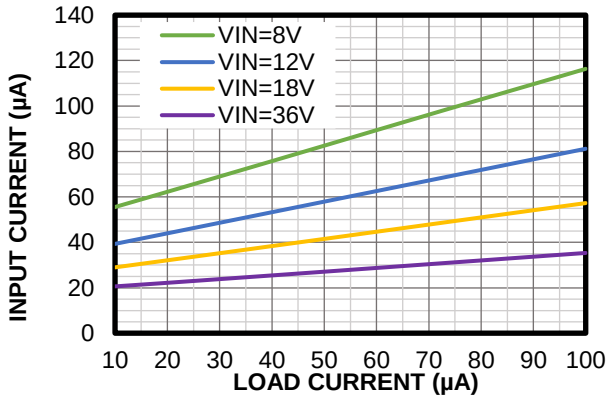
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

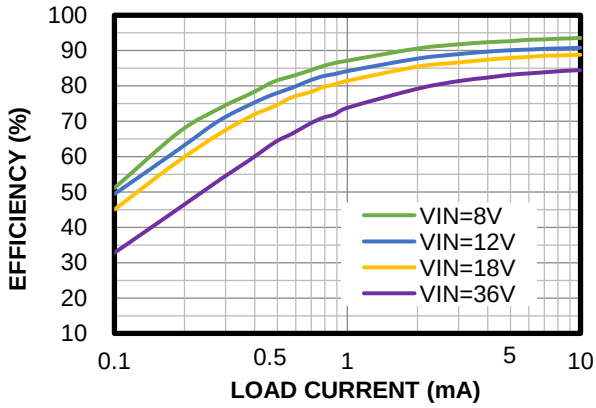
Input Current vs. Load Current

AAM mode, 10µA to 100µA



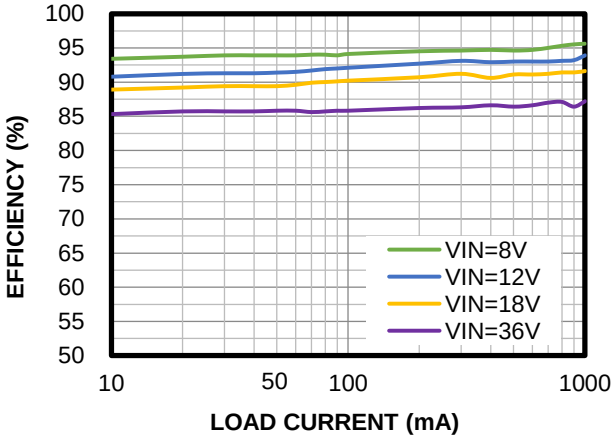
Efficiency vs. Load Current

AAM mode, 0.1mA to 10mA



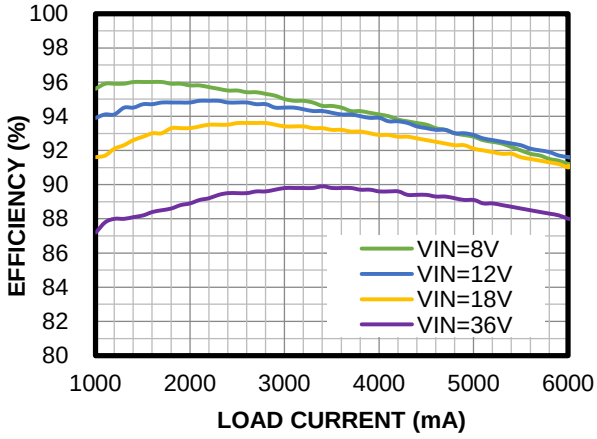
Efficiency vs. Load Current

AAM mode, 10mA to 1000mA



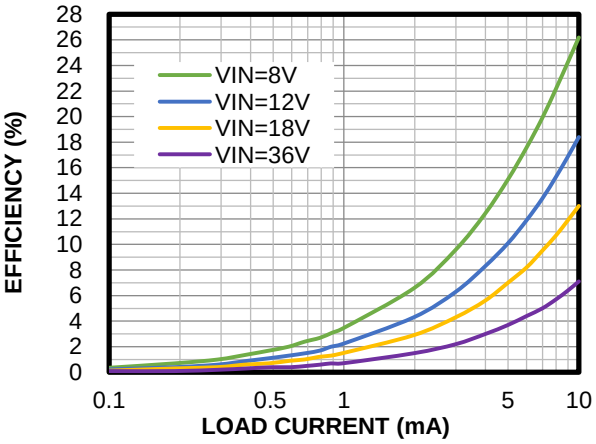
Efficiency vs. Load Current

AAM mode, 1A to 6A



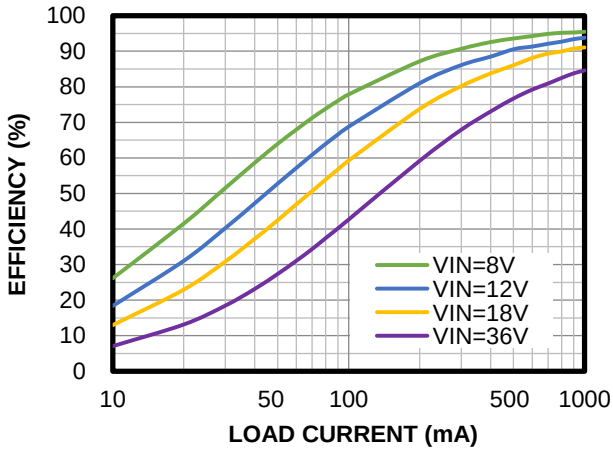
Efficiency vs. Load Current

FCCM, 0.1mA to 10mA



Efficiency vs. Load Current

FCCM, 10mA to 1000mA



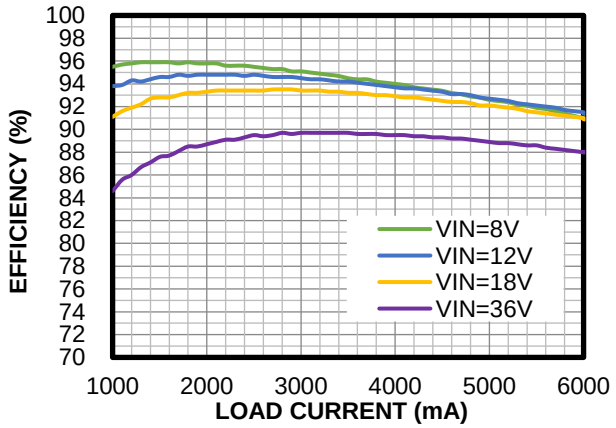
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

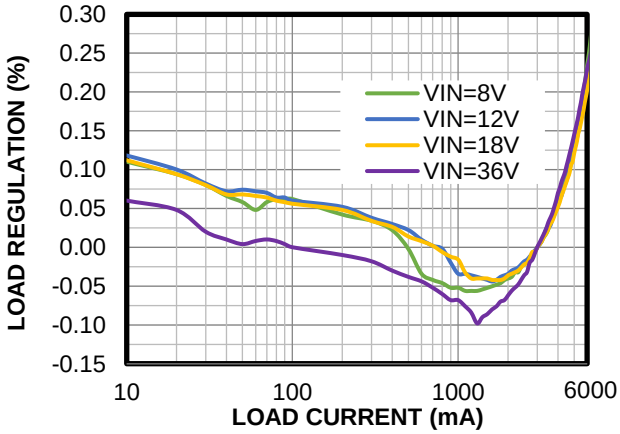
Efficiency vs. Load Current

FCCM, 1A to 6A



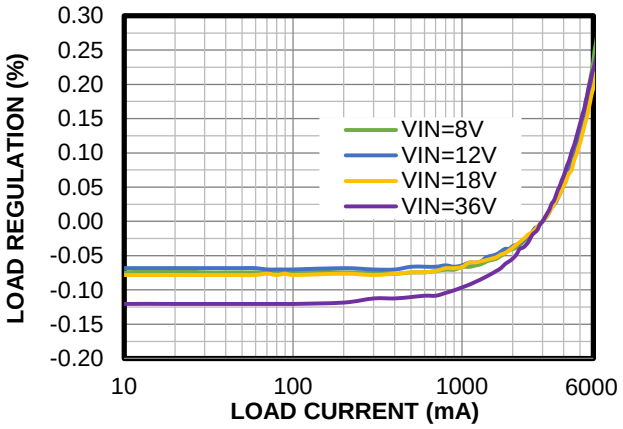
Load Regulation

AAM mode



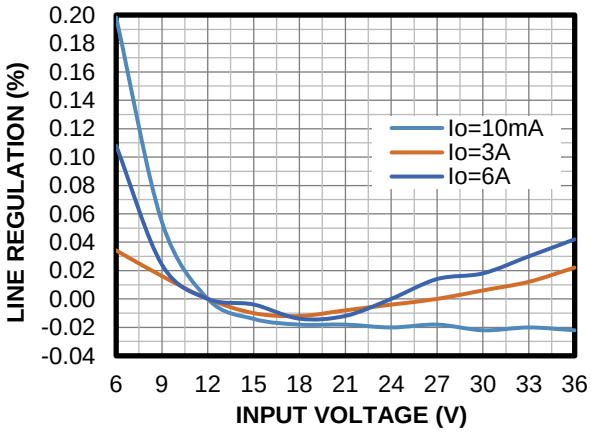
Load Regulation

FCCM



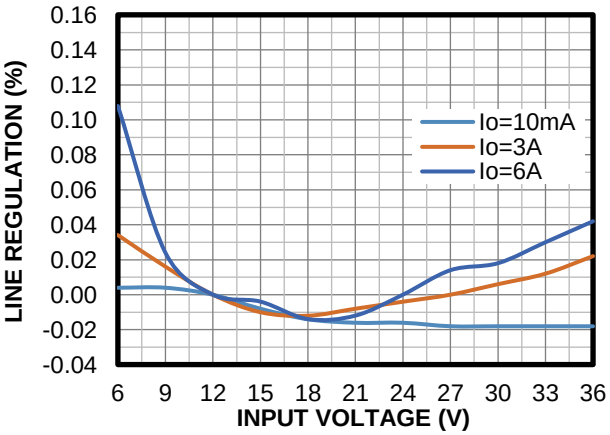
Line Regulation

V_{OUT} = 5V, AAM mode, f_{SW} = 2.2MHz



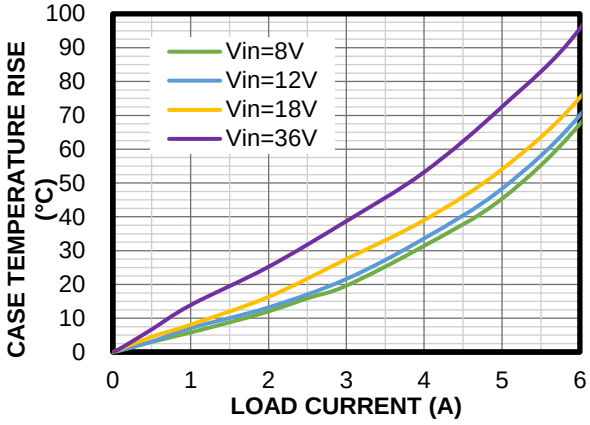
Line Regulation

V_{OUT} = 5V, FCCM, f_{SW} = 2.2MHz



Case Temperature Rise

AAM mode



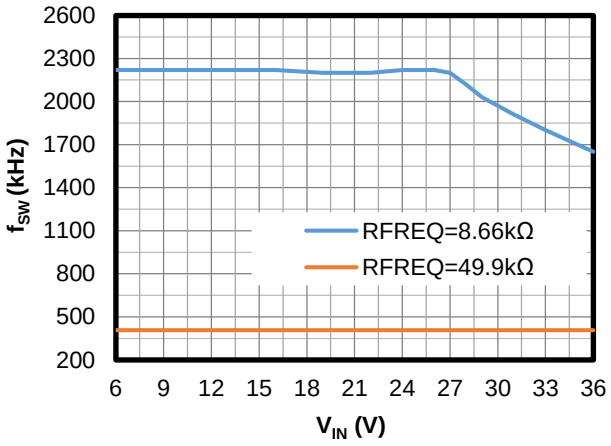
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

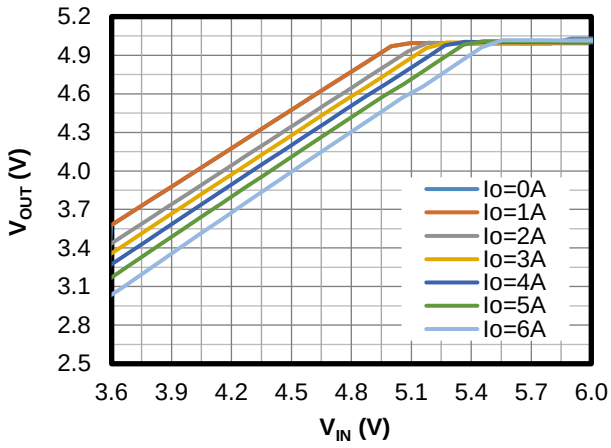
Switching Frequency vs. Input Voltage

FCCM, I_{OUT} = 0A



Low-Dropout Mode

FCCM



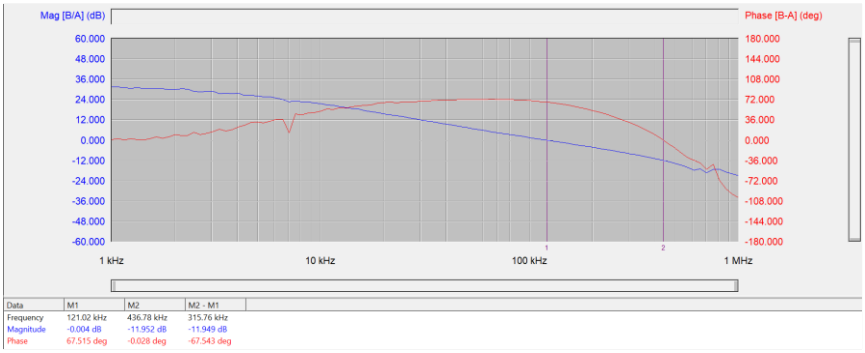
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

Loop Performance

I_{OUT} = 6A, T_A = 25°C



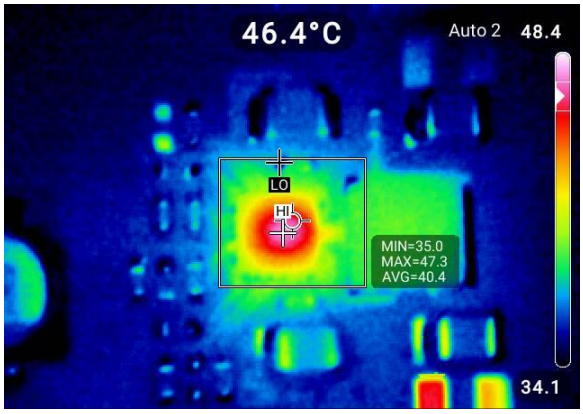
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

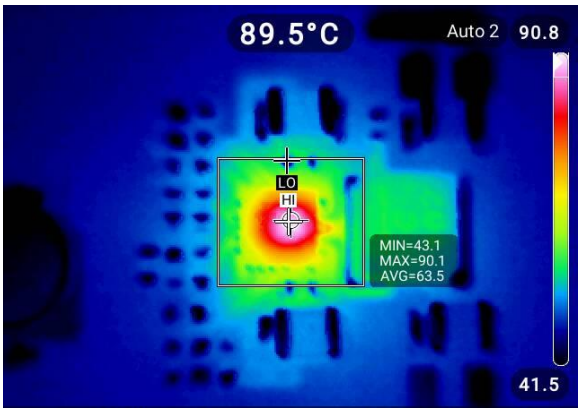
Thermal Performance

I_{OUT} = 3A, no forced airflow, T_{CASE} = 47.3°C



Thermal Performance

I_{OUT} = 6A, no forced airflow, T_{CASE} = 90.1°C



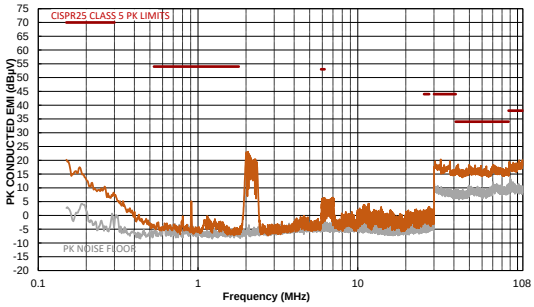
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

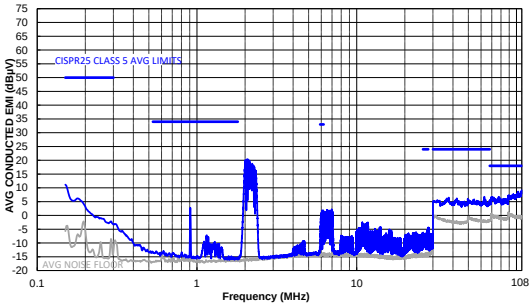
CISPR 25 Class 5 Peak Conducted Emissions

150kHz to 108MHz



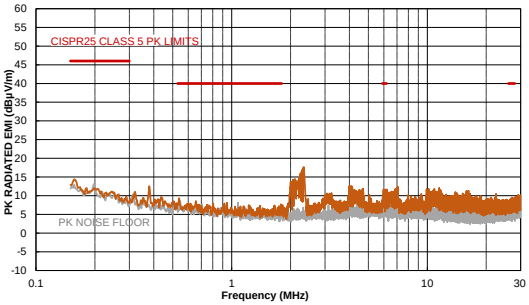
CISPR 25 Class 5 Average Conducted Emissions

150kHz to 108MHz



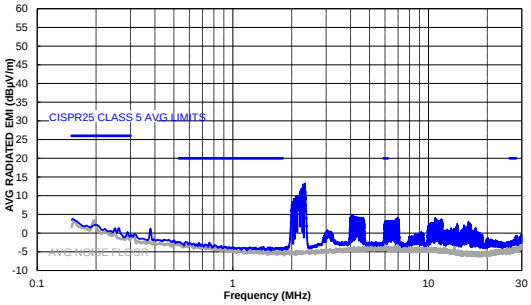
CISPR 25 Class 5 Peak Radiated Emissions

150kHz to 30MHz



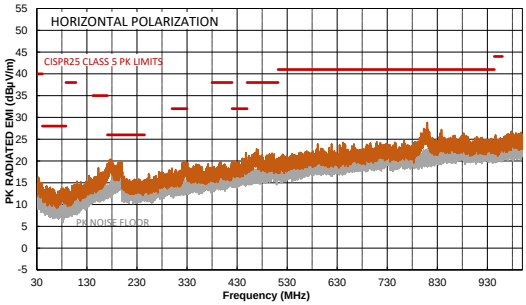
CISPR 25 Class 5 Average Radiated Emissions

150kHz to 30MHz



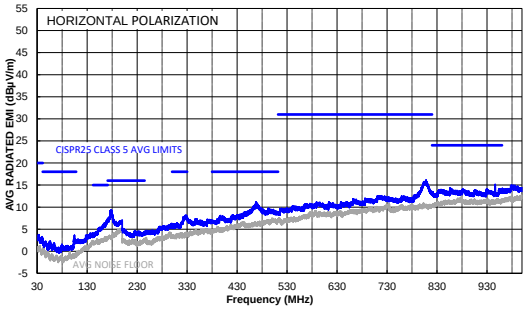
CISPR 25 Class 5 Peak Radiated Emissions

Horizontal, 30MHz to 1GHz



CISPR 25 Class 5 Average Radiated Emissions

Horizontal, 30MHz to 1GHz



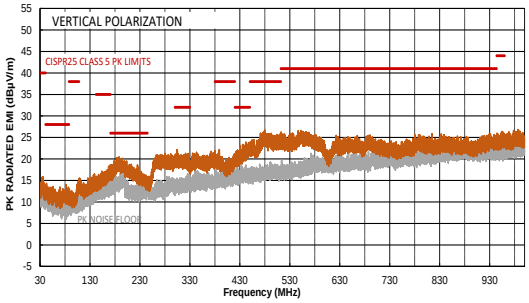
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

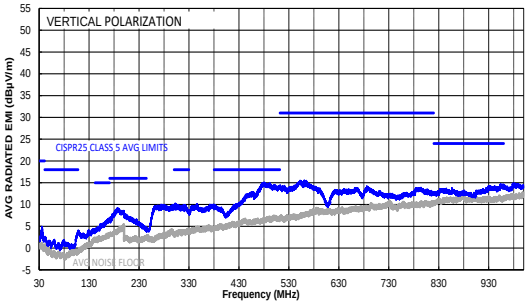
CISPR 25 Class 5 Peak Radiated Emissions

Vertical, 30MHz to 1GHz



CISPR 25 Class 5 Average Radiated Emissions

Vertical, 30MHz to 1GHz

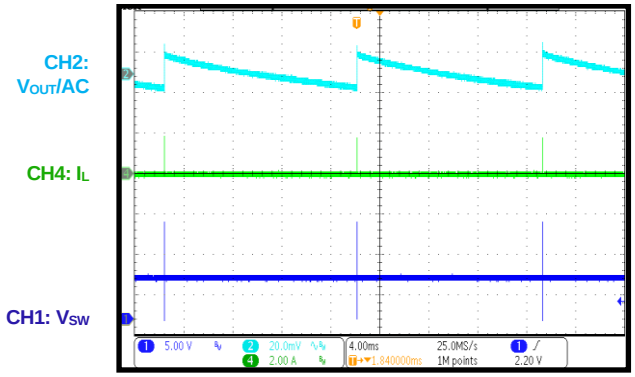


MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

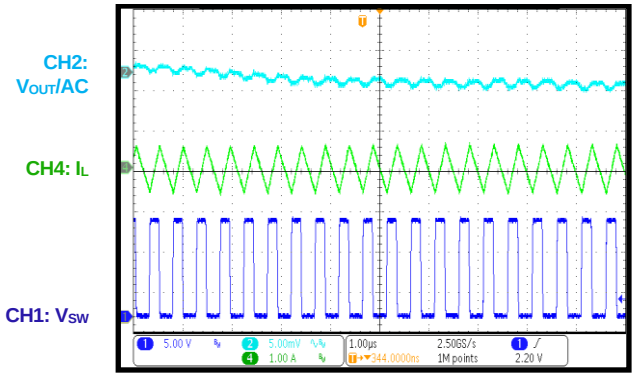
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

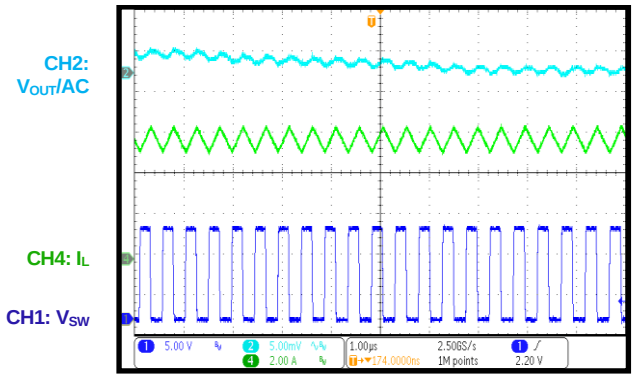
Steady State
I_{OUT} = 0A, AAM mode



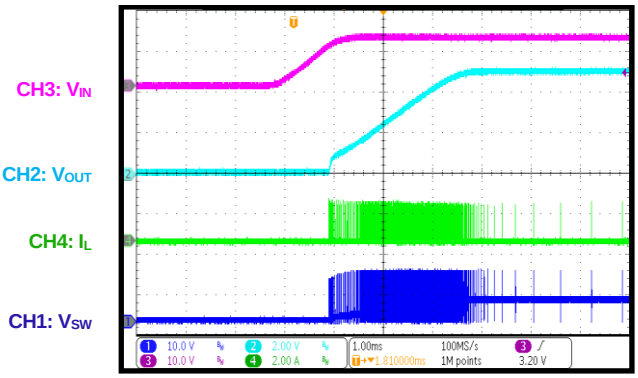
Steady State
I_{OUT} = 0A, FCCM



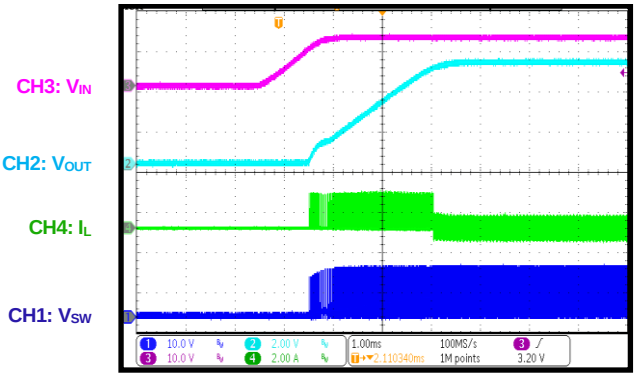
Steady State
I_{OUT} = 6A



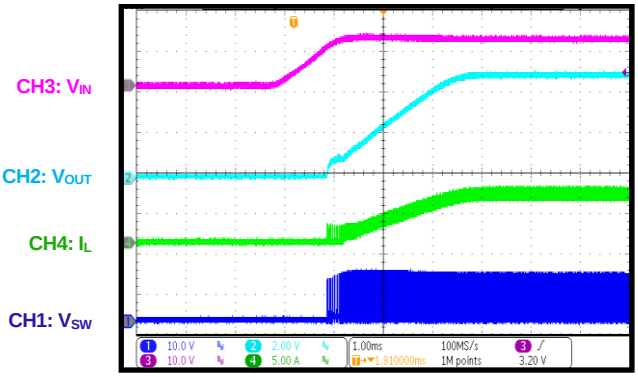
Start-Up through VIN
I_{OUT} = 0A, AAM mode



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



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

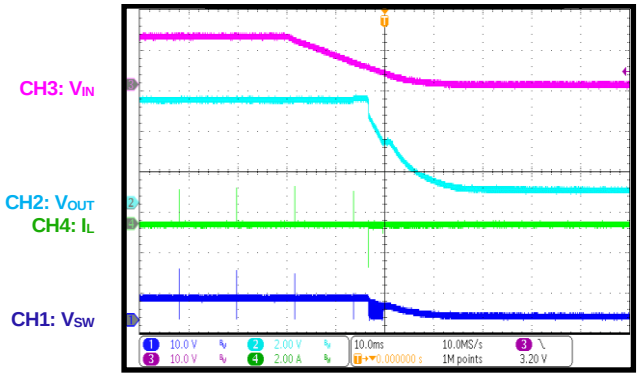


MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

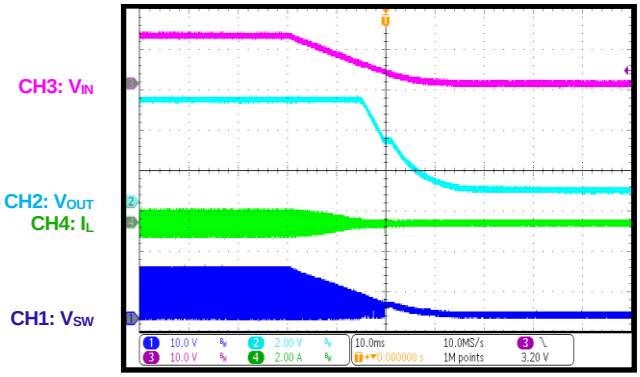
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

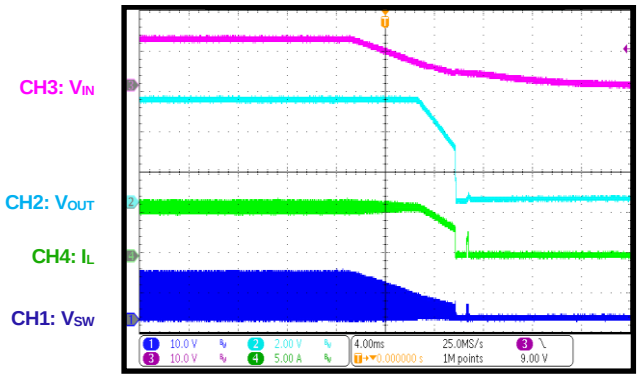
Shutdown through VIN
I_{OUT} = 0A, AAM mode



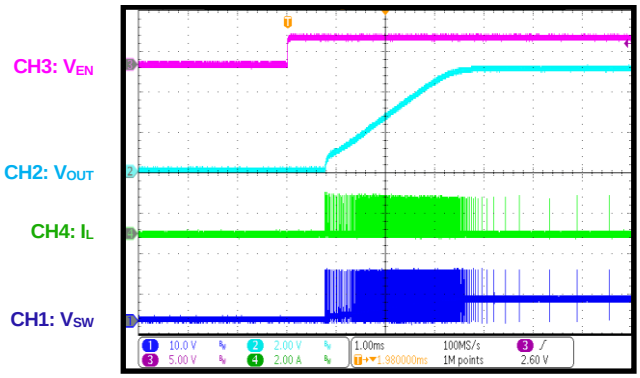
Shutdown through VIN
I_{OUT} = 0A, FCCM



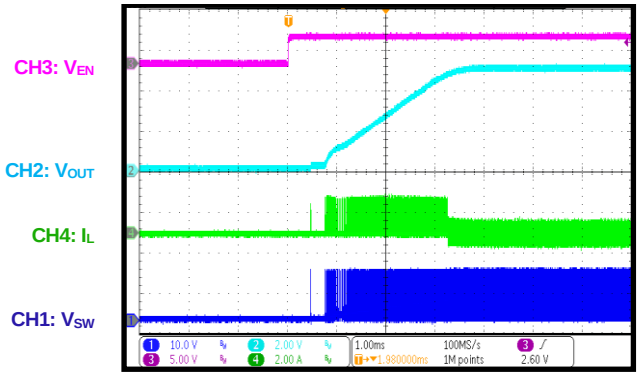
Shutdown through VIN
I_{OUT} = 6A



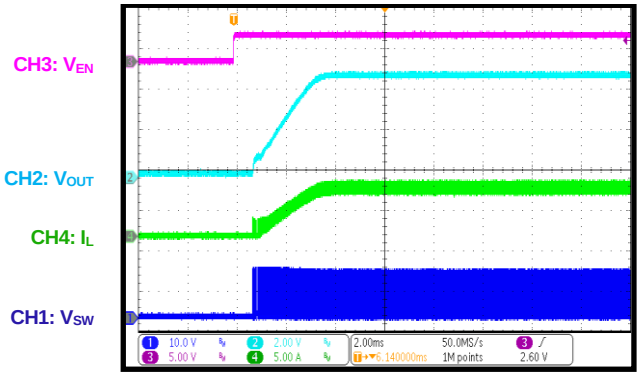
Start-Up through EN
I_{OUT} = 0A, AAM mode



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



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



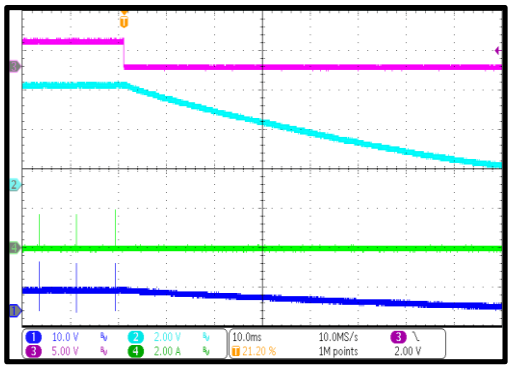
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

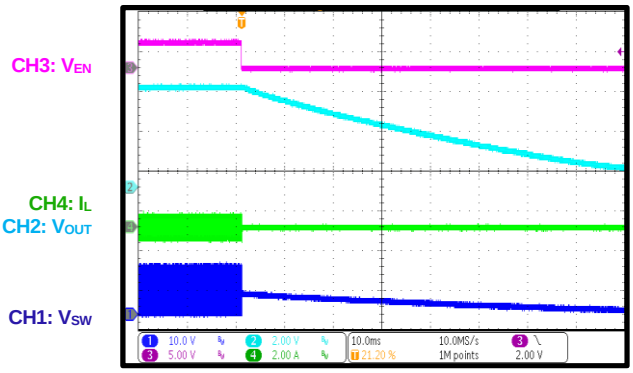
Shutdown through EN

I_{OUT} = 0A, AAM mode



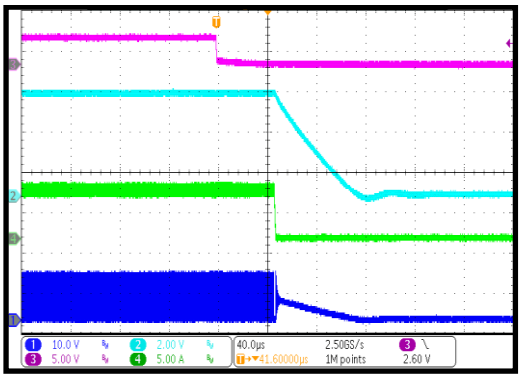
Shutdown through EN

I_{OUT} = 0A, FCCM



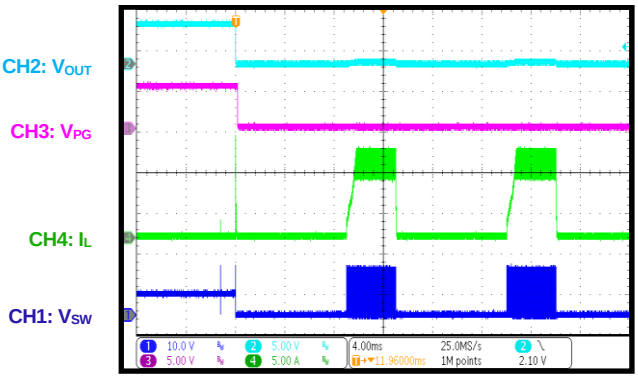
Shutdown through EN

I_{OUT} = 6A



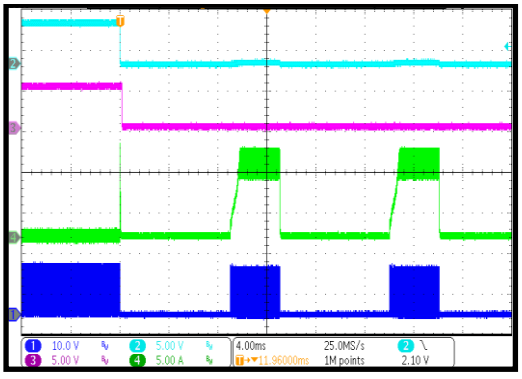
SCP Entry

I_{OUT} = 0A, AAM mode



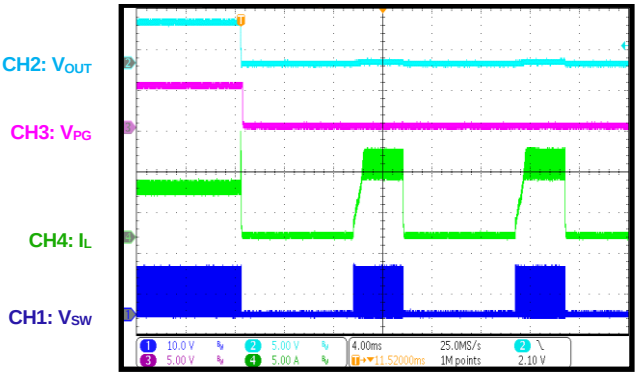
SCP Entry

I_{OUT} = 0A, FCCM



SCP Entry

I_{OUT} = 6A

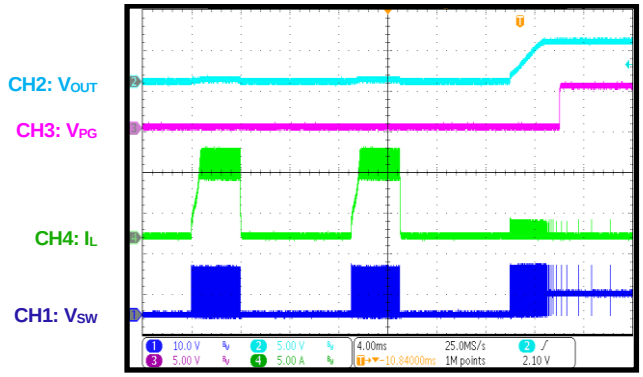


MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

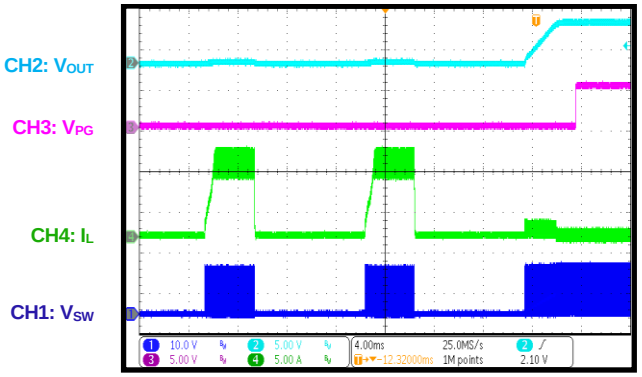
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

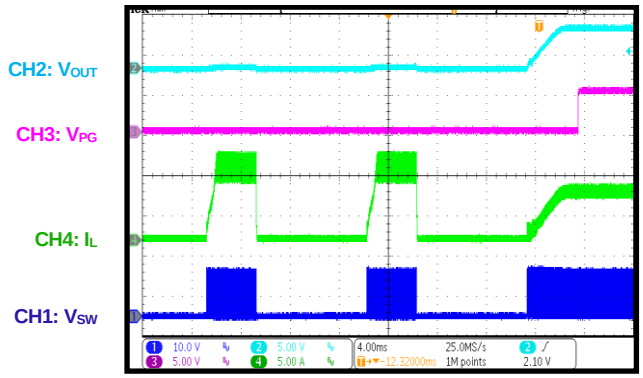
SCP Recovery
I_{OUT} = 0A, AAM mode



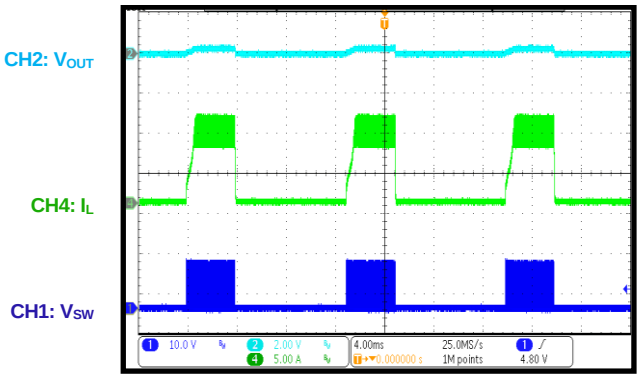
SCP Recovery
I_{OUT} = 0A, FCCM



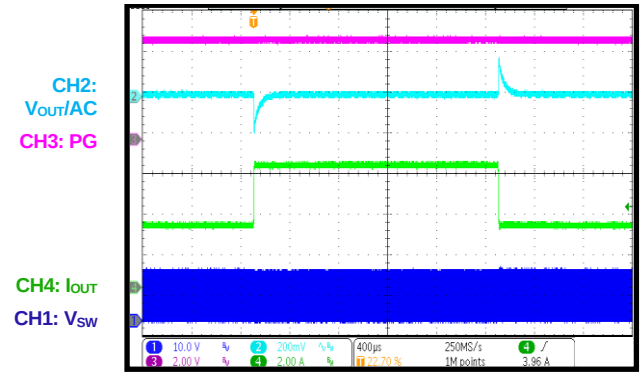
SCP Recovery
I_{OUT} = 6A



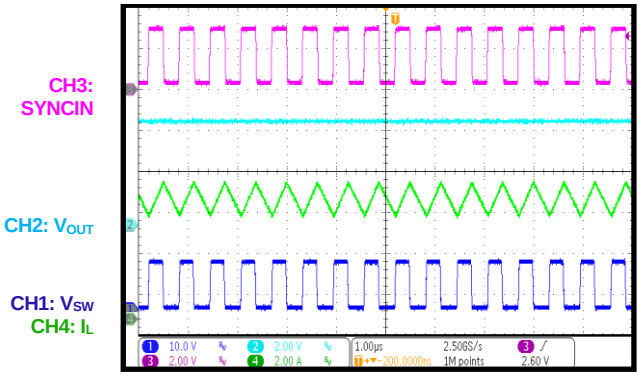
SCP Steady State



Load Transient Response
I_{OUT} = 3A to 6A, 2A/µs



SYNCIN Operation
I_{OUT} = 6A, f_{SYNC} = 1600kHz



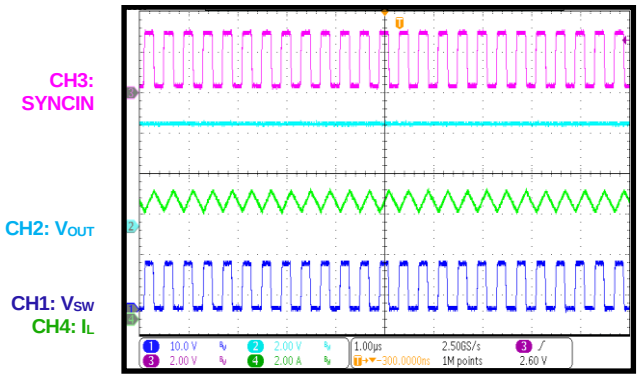
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

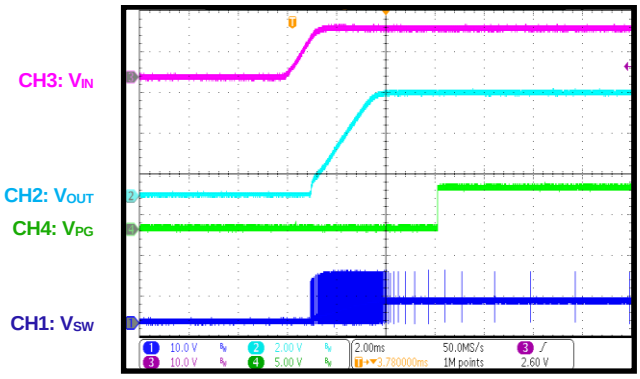
SYNCIN Operation

I_{OUT} = 6A, f_{SYNC} = 2500kHz



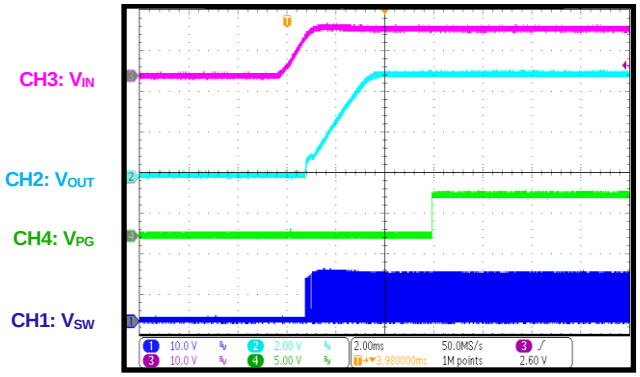
PG in Start-Up through VIN

I_{OUT} = 0A, AAM mode



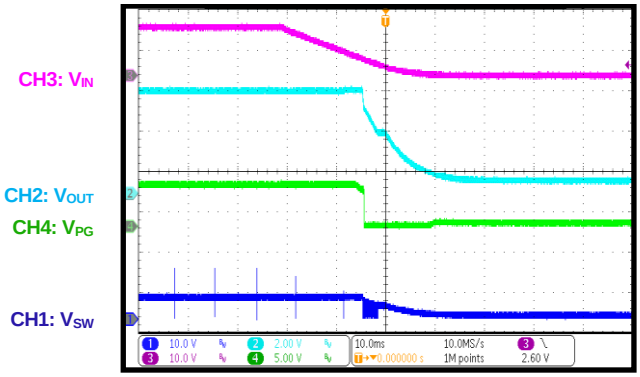
PG in Start-Up through VIN

I_{OUT} = 6A



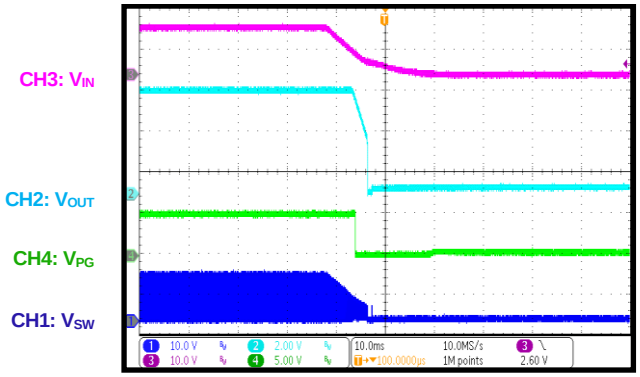
PG in Shutdown through VIN

I_{OUT} = 0A, AAM mode



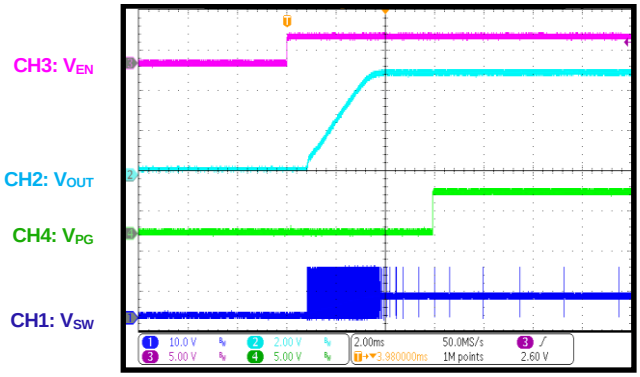
PG in Shutdown through VIN

I_{OUT} = 6A



PG in Start-Up through EN

I_{OUT} = 0A



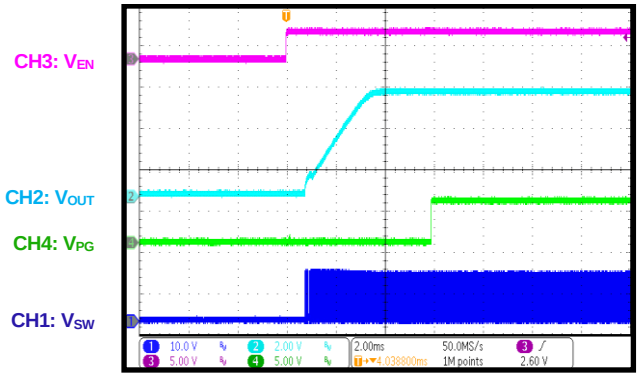
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

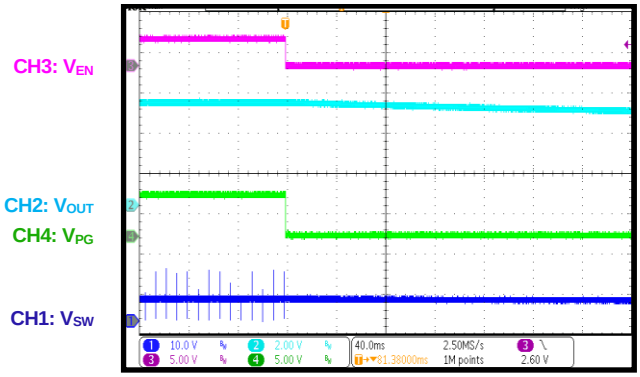
PG in Start-Up through EN

I_{OUT} = 6A



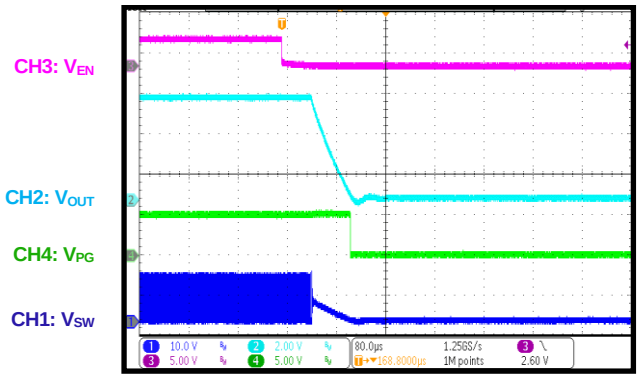
PG in Shutdown through EN

I_{OUT} = 0A



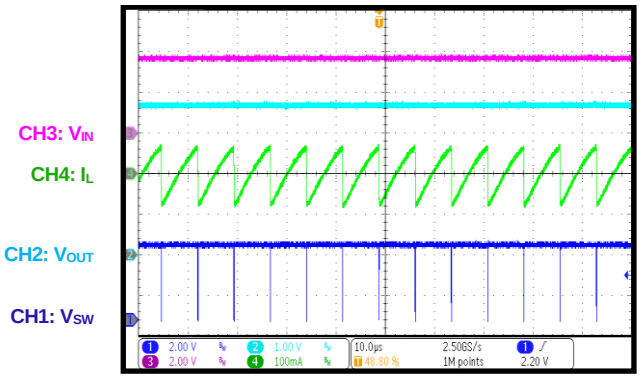
PG in Shutdown through EN

I_{OUT} = 6A



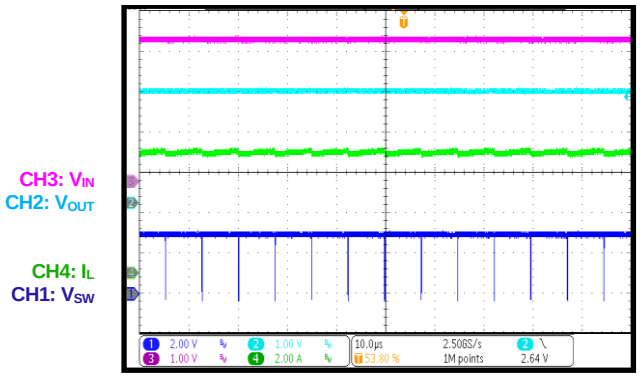
Low-Dropout Mode

V_{IN} = 3.7V, I_{OUT} = 0A



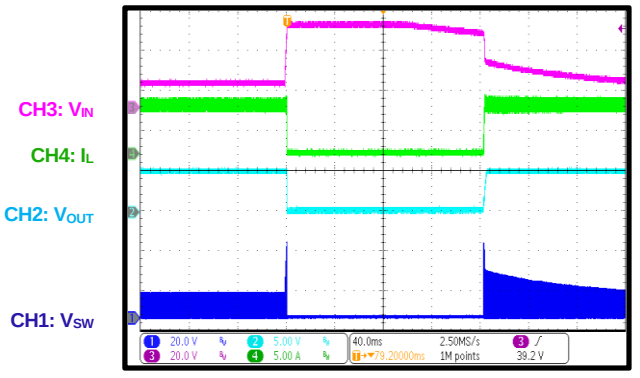
Low-Dropout Mode

V_{IN} = 3.7V, I_{OUT} = 6A



Load Dump

V_{IN} = 12V to 42V, I_{OUT} = 6A



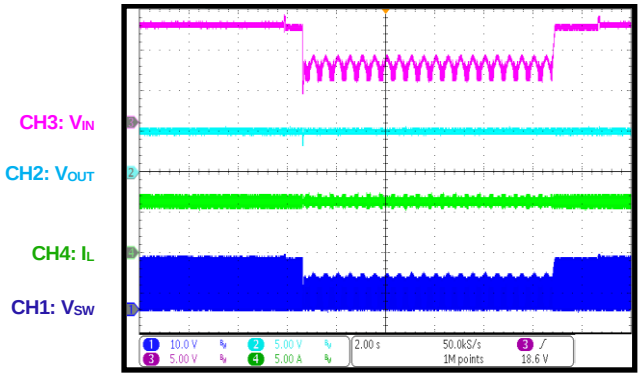
MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

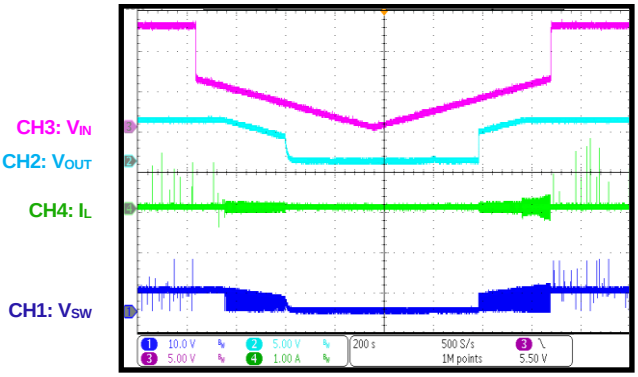
Cold Crank

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



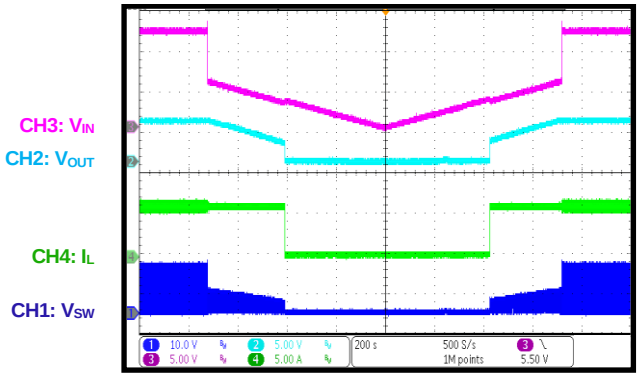
V_{IN} Ramping Down and Up

I_{OUT} = 0A, AAM mode



V_{IN} Ramping Down and Up

I_{OUT} = 6A



MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

PCB LAYOUT (2)

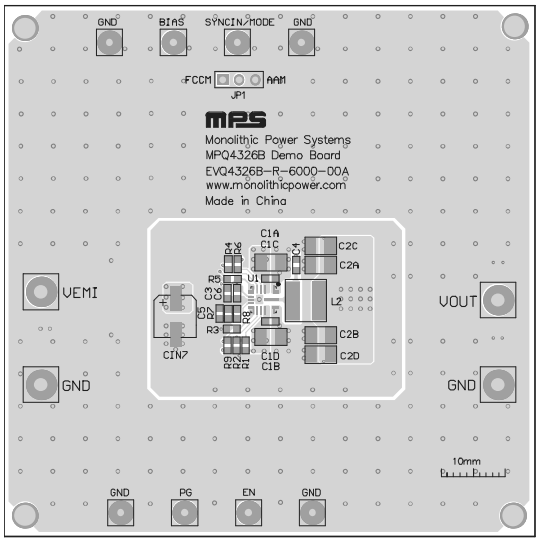


Figure 5: Top Silk and Top Layer

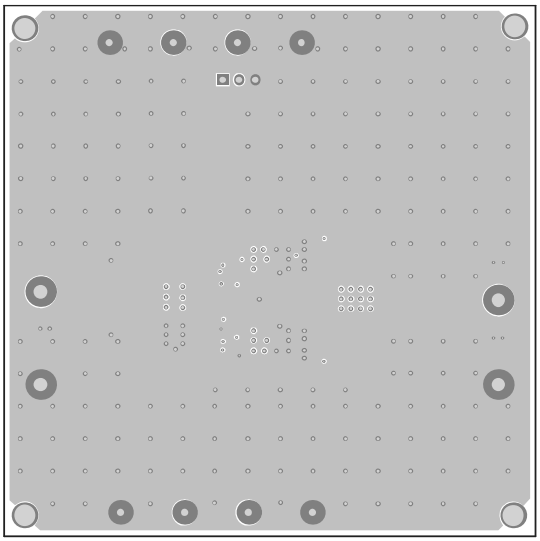


Figure 6: Mid-Layer 1

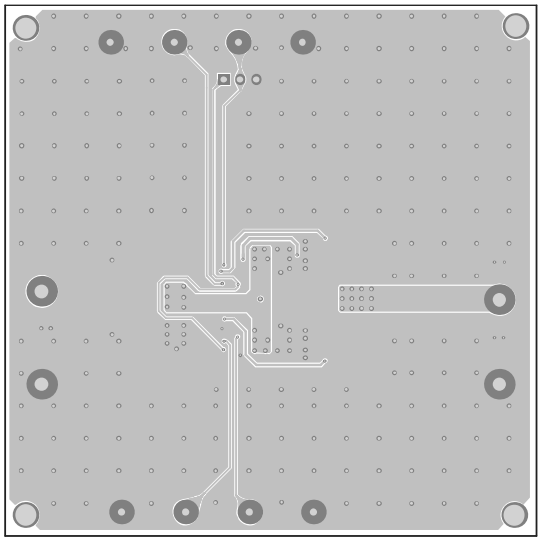


Figure 7: Mid-Layer 2

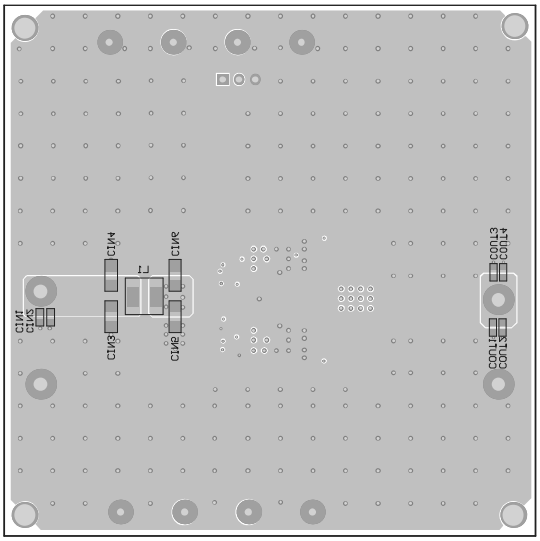


Figure 8: Bottom Layer and Bottom Silk

Note:

2) The copper thickness is 2oz.

MPS Proprietary Information. Patent Protected. Unauthorized Photocopy and Duplication Prohibited.
© 2024 MPS. All Rights Reserved.

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	9/4/2024	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.
© 2024 MPS. All Rights Reserved.