EVQ4431-L-00A

36V, 1A, Low Quiescent Current, Synchronous Step-Down Converter Evaluation Board

DESCRIPTION

The EVQ4431-L-00A evaluation board is designed to demonstrate the capabilities of the MP4431 and the MPQ4431.

The MPQ4431 is a frequency-configurable (350kHz to 2.5MHz), synchronous, step-down switching regulator with integrated, internal high-side and low-side power MOSFETs. It provides up to 1A of highly efficient output current with current mode control for fast loop response.

The MPQ4431 employs advanced asynchronous mode (AAM) to achieve high efficiency under light-load conditions by scaling down the switching frequency. This reduces the switching and gate driving losses.

The EVQ4431-L-00A is a fully assembled and tested evaluation board, it generates 3.3V of output voltage at load currents up to 1A from a 3.3V to 36V input voltage range with 450kHz switching frequency.

The MPQ4431 is available in a QFN-16 (3mmx4mm) package.

ELECTRICAL SPECIFICATIONS

Parameter	Symbol	Value	Units
Input voltage	V_{EMI}	3.3 to 36	V
Output voltage	V_{OUT}	3.3	V
Output current	I_{OUT}	1	A

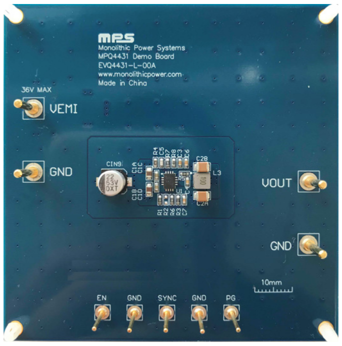
FEATURES

- Wide 3.3V to 36V Operating Input Voltage Range
- 1A of Continuous Output Current
- 1µA Low Shutdown Mode Current
- 10µA Sleep Mode Quiescent Current
- Internal 90mΩ High-Side and 80mΩ Low-Side MOSFETs
- 350kHz to 2.5MHz Configurable Switching Frequency
- Synchronize to External Clock, Selectable In-Phase or 180° Out-of-Phase
- Power Good Indicator
- Configurable Soft-Start Time
- 80ns Minimum On Time
- Selectable FCCM and AAM
- Low-Dropout Mode
- Over-Current Protection with Valley Current Detection and Hiccup Mode
- Thermal Shutdown
- Available in a QFN-16 (3mmx4mm) Package
- Available with Wettable Flanks
- AEC-Q100 Grade 1

APPLICATIONS

- Automotive Systems
- Industrial Power Systems

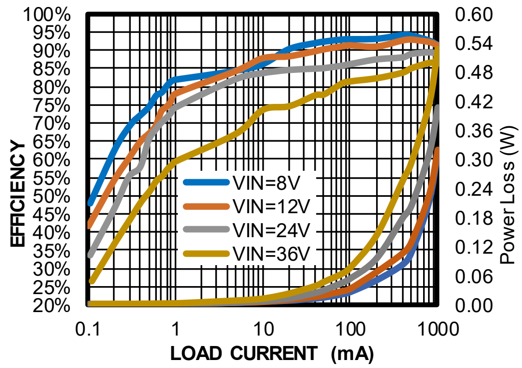
EVQ4431-L-00A EVALUATION BOARD



LxWxH (8.9cmx8.9cmx2cm)

Board Number	MPS IC Number
EVQ4431-L-00A	MP4431GL, MPQ4431GL

Efficiency vs. Load Current
V_{OUT} = 3.3V, AAM



QUICK START GUIDE

1. Preset the power supply (V_{IN}) to be between 3.3V and 36V.

   Note that electronic loads represent a negative impedance to the regulator. If the current is set too high, hiccup mode may be triggered.

2. Turn the power supply off.

   If longer cables (>0.5m total) are used between the source and the evaluation board, a damping capacitor should be installed at the input terminals, especially if $V_{IN} \geq 24V$.

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. Turn the power supply on after making the connections.

6. To use the enable function, apply a digital input to the EN pin. Drive EN above 1.05V to turn the device on; drive EN below 0.93V to turn it off.

7. The IC's oscillating frequency can be configured by an external frequency resistor (R_{FREQ}). R_{FREQ} can be estimated with Equation (1):

$$R_{FREQ}(k\Omega) = \frac{170000}{f_{SW}^{\ 1.11}(kHz)} \quad (1)$$

8. To use the sync function, apply a 350kHz to 2.5MHz clock to the SYNC pin to synchronize the internal oscillator frequency to the external clock. The external clock should be at least 250kHz above the frequency set by R_{FREQ}. The SYNC pin can also select forced continuous conduction mode (FCCM) or advanced asynchronous mode (AAM). Drive SYNC high before the chip starts up to choose FCCM; drive SYNC low (or leave it floating) to select AAM.

9. The output voltage is set by the external resistor divider. The feedback resistor (R_{FB1}) also sets the feedback loop bandwidth with the internal compensation capacitor. For different output voltages, R_{FB1} and R_{FB2} can be calculated with Equation (2):

$$R_{FB2} = \frac{R_{FB1}}{\frac{V_{OUT}}{0.8V} - 1} \quad (2)$$

   Figure 1 shows the resistor divider set-up.

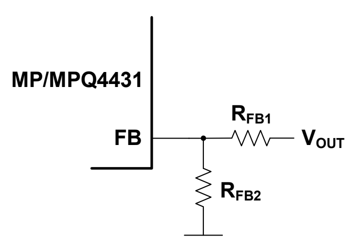


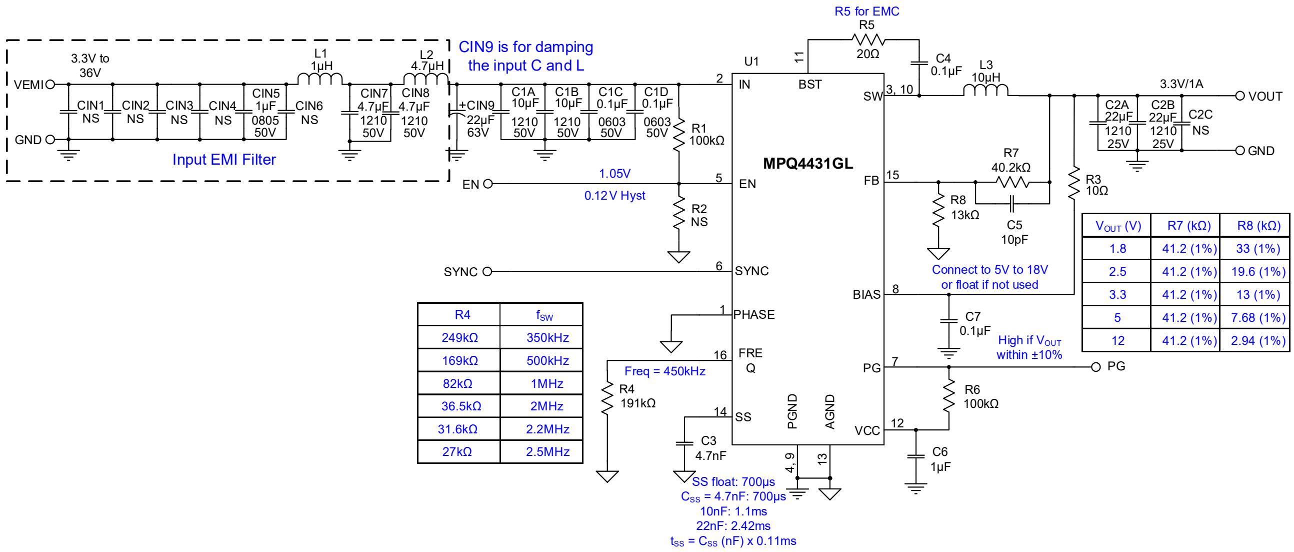
Figure 1: Resistor Divider Set-Up

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

Table 1: Recommended Resistor Dividers

V_{OUT} (V)	R_{FB1} (kΩ)	R_{FB2} (kΩ)
1.8	41.2 (1%)	33 (1%)
2.5	41.2 (1%)	19.6 (1%)
3.3	41.2 (1%)	13 (1%)
5	41.2 (1%)	7.68 (1%)
12	41.2 (1%)	2.94 (1%)

EVALUATION BOARD SCHEMATIC

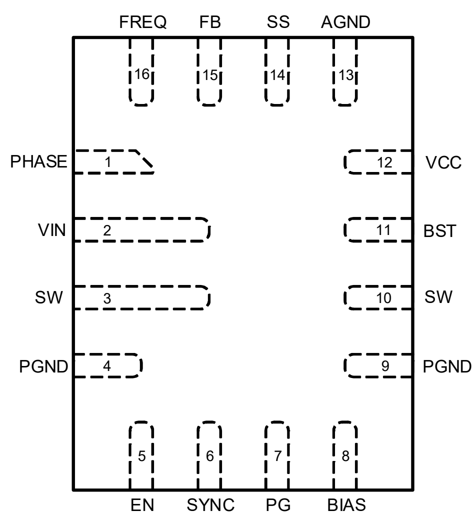


R4	f_{SW}
249kΩ	350kHz
169kΩ	500kHz
82kΩ	1MHz
36.5kΩ	2MHz
31.6kΩ	2.2MHz
27kΩ	2.5MHz

V_{OUT} (V)	R7 (kΩ)	R8 (kΩ)
1.8	41.2 (1%)	33 (1%)
2.5	41.2 (1%)	19.6 (1%)
3.3	41.2 (1%)	13 (1%)
5	41.2 (1%)	7.68 (1%)
12	41.2 (1%)	2.94 (1%)

Figure 2: Evaluation Board Schematic

PACKAGE REFERENCE



QFN-16 (3mmx4mm)

EVQ4431-L-00A BILL OF MATERIALS

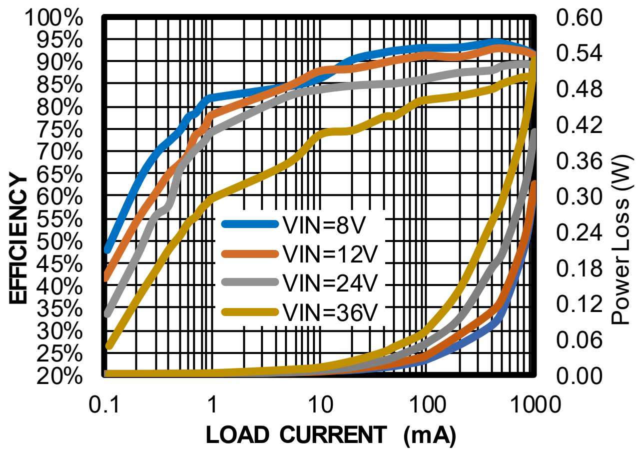
Qty	Ref	Value	Description	Package	Manufacture	Manufacturer P/N
1	CIN5	1µF	Ceramic capacitor, 50V, X7R	0805	Murata	GRM21BR71H105KA12L
4	CIN7, CIN8, C1A, C1B	4.7µF	Ceramic capacitor, 50V, X7S	0805	Murata	GRM21BR71H475KE11L
1	CIN9	22µF	Electrolytic capacitor, 63V	SMD	Jianghai	VTD-63V22
2	C1C, C1D	0.1µF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H104KA93D
2	C2A, C2B	22µF	Ceramic capacitor, 16V, X7R	1210	Murata	GRM32ER71C226KEA8L
1	C3	4.7nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H472KA01D
2	C4, C7	0.1µF	Ceramic capacitor, 16V, X7R	0603	Murata	GRM188R71C104KA01D
1	C5	10pF	Ceramic capacitor, 50V, C0G	0603	Murata	GRM1885C1H100JA01
1	C6	1µF	Ceramic capacitor, 16V, X7R	0603	Murata	GRM188R71C105KA12D
6	CIN1, CIN2, CIN3, CIN4, CIN6, C2C	NS				
1	L1	1µH	Inductor, DCR = 41mΩ, 3.1A	SMD	Cyntec	VCTA20161B-1R0MS6-89
1	L2	4.7µH	Inductor, DCR = 165mΩ, 1.7A	SMD	Cyntec	VCTA25201B-4R7MS6-89
1	L3	10µH	Inductor, DCR = 48.6mΩ, 3.7A	SMD	Cyntec	VCHA042A-100MS6-89
2	R1, R6	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
1	R3	10Ω	Film resistor, 1%	0603	Yageo	RC0603FR-0710RL
1	R4	191kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07191KL
1	R5	20Ω	Film resistor, 1%	0603	Yageo	RC0603FR-0720RL
1	R7	41.2kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0741K2L
1	R8	13kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0713KL
1	R10	1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-071KL
1	R12	11kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0711KL
1	R2	NS				
1	U1	MPQ4431	Step-down converter	QFN-16 (3mmx 4mm)	MPS	MPQ4431GL
4	VEMI, GND, VOUT, GND	Test point	2.0 golden pin	DIP	Any	
5	EN, GND, SYNC, GND, PG	Test point	1.0 golden pin	DIP	Any	

EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, L = 10µH, f_{SW} = 450kHz, T_A = 25°C, unless otherwise noted.

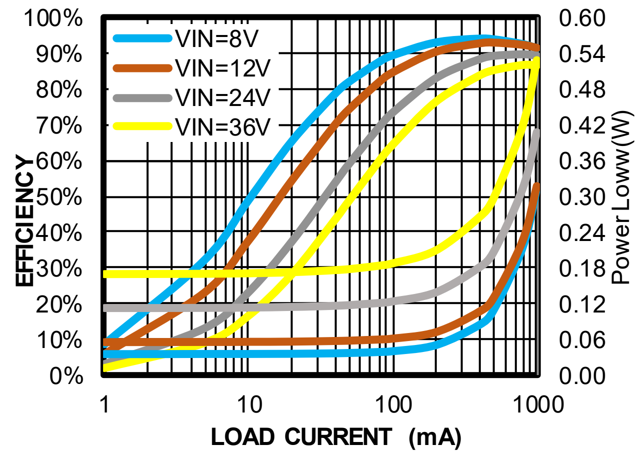
Efficiency vs. Load Current

V_{OUT} = 3.3V, AAM



Efficiency vs. Load Current

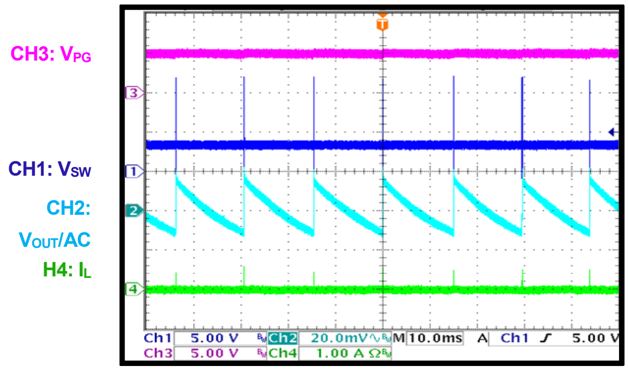
V_{OUT} = 3.3V, CCM



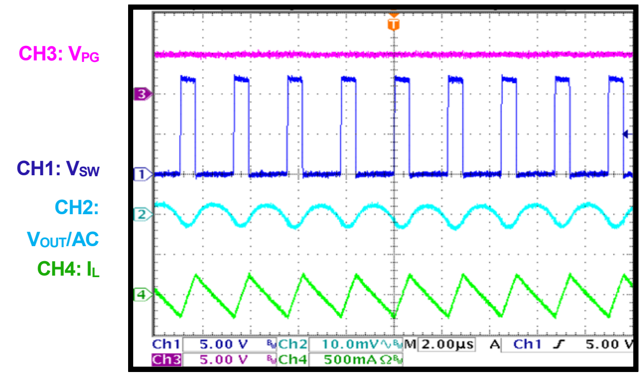
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, L = 10µH, f_{SW} = 450kHz, T_A = 25°C, unless otherwise noted.

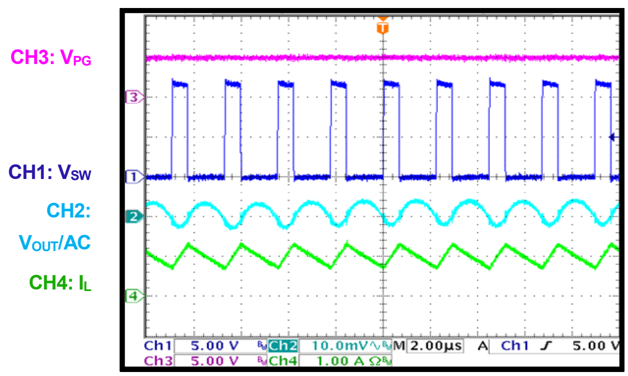
Steady State
V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 0A, AAM



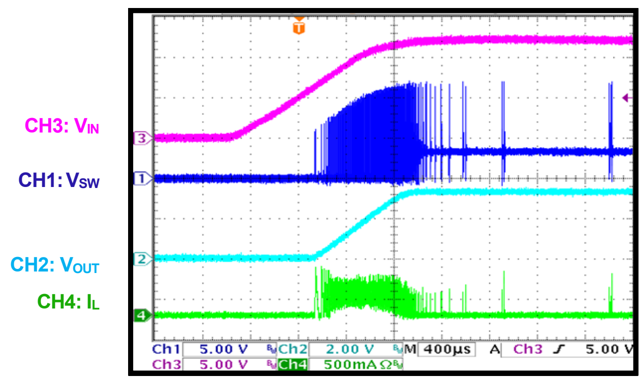
Steady State
V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 0A, CCM



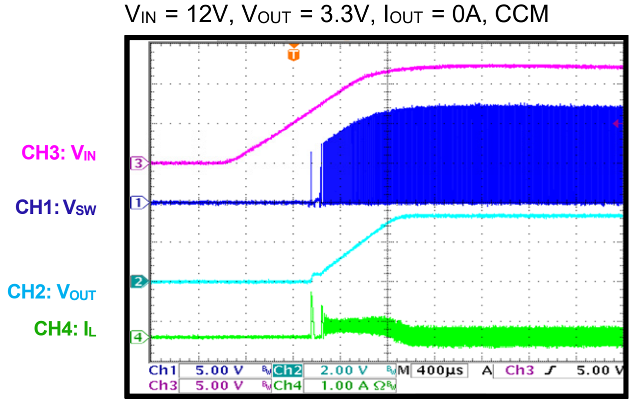
Steady State
V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 1A



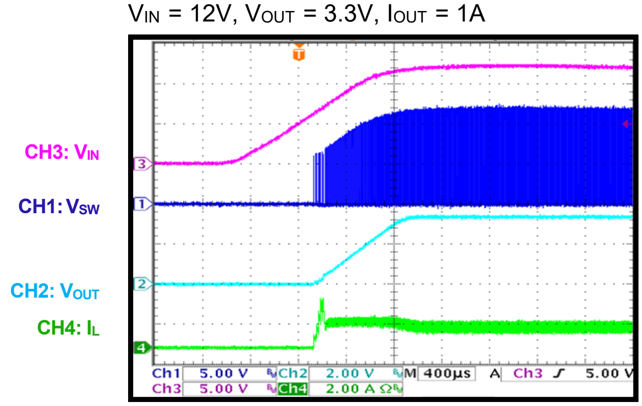
Start-Up
V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 0A, AAM



Start-Up
V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 0A, CCM



Start-Up
V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 1A

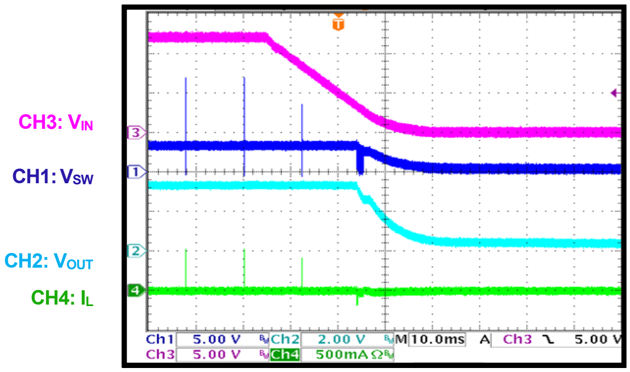


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, L = 10µH, f_{SW} = 450kHz, T_A = 25°C, unless otherwise noted.

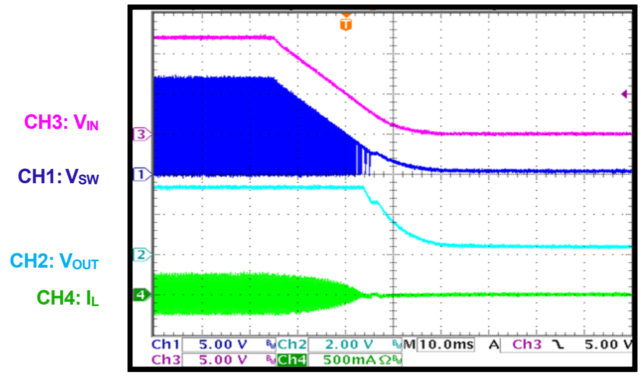
Shutdown

V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 0A, AAM



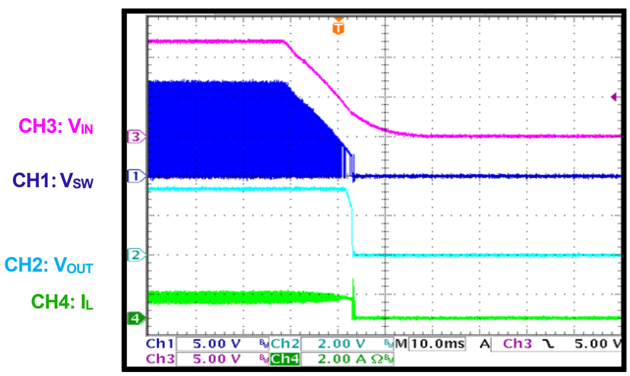
Shutdown

V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 0A, CCM



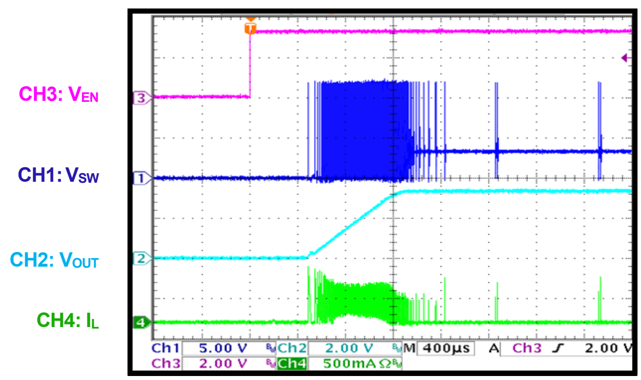
Shutdown

V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 1A



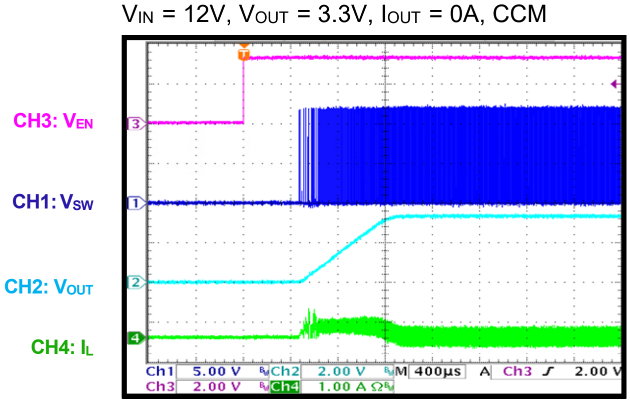
EN On

V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 0A, AAM



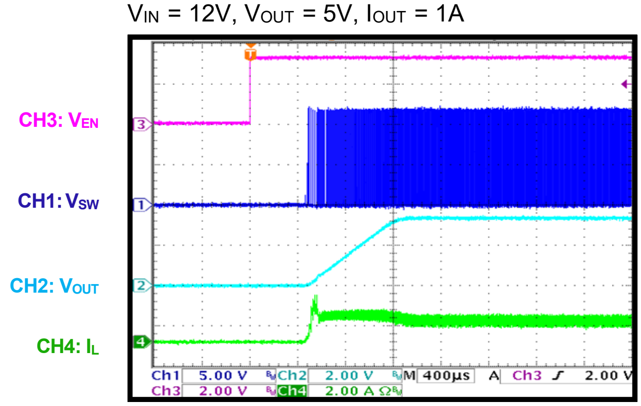
EN On

V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 0A, CCM



EN On

V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 1A

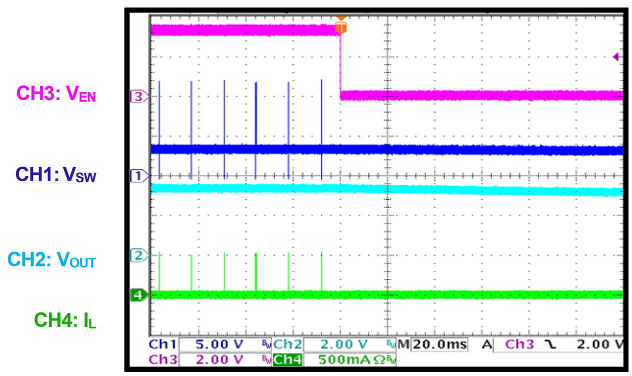


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, L = 10µH, f_{SW} = 450kHz, T_A = 25°C, unless otherwise noted.

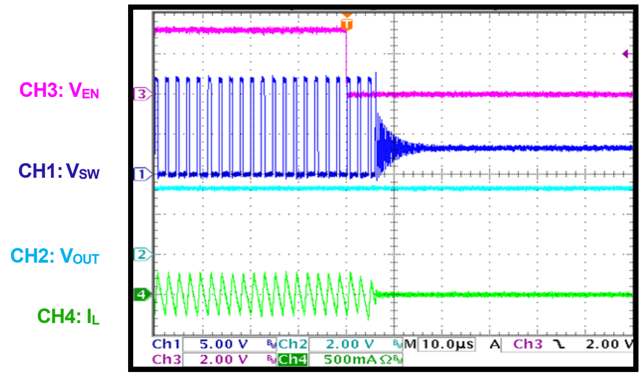
EN Off

V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 0A, AAM



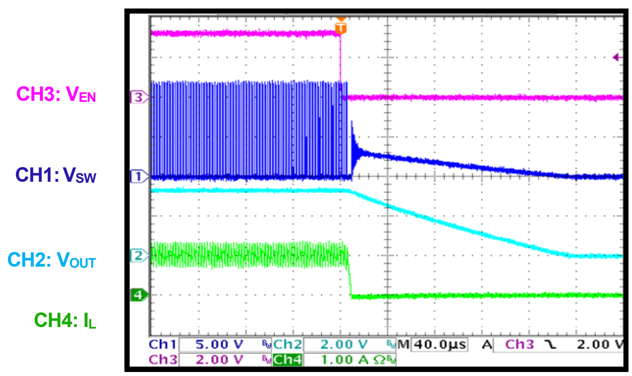
EN Off

V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 0A, CCM



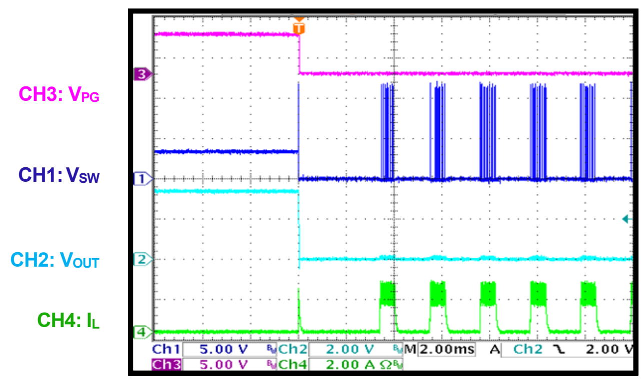
EN Off

V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 1A



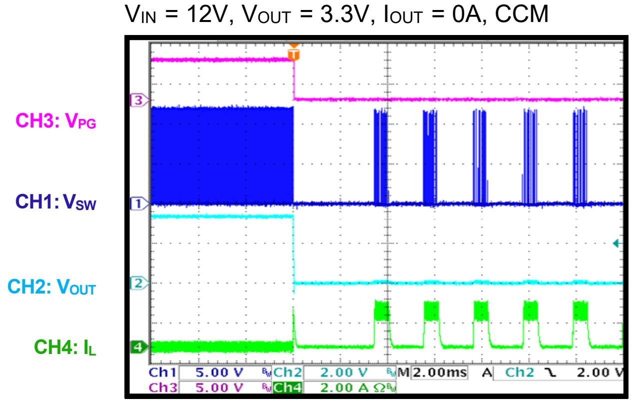
SCP Entry

V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 0A, AAM



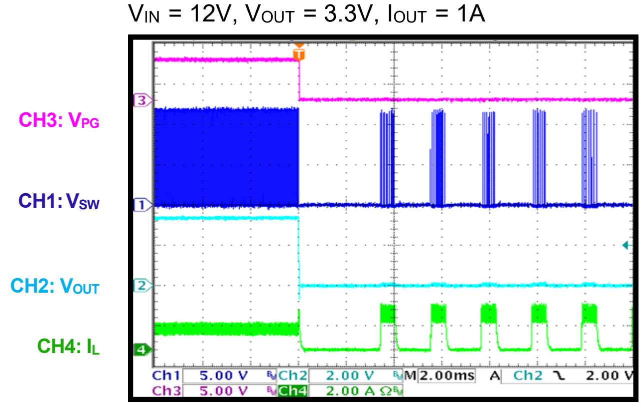
SCP Entry

V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 0A, CCM



SCP Entry

V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 1A

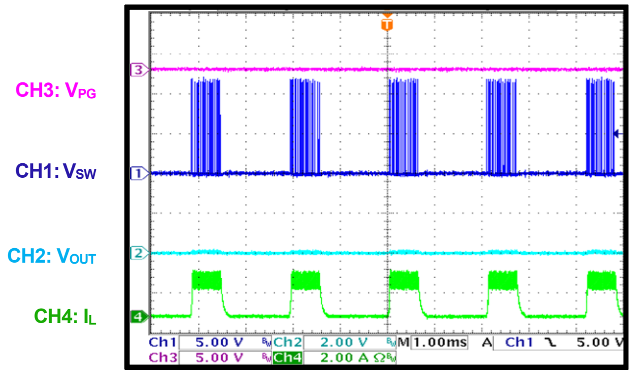


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, L = 10µH, f_{SW} = 450kHz, T_A = 25°C, unless otherwise noted.

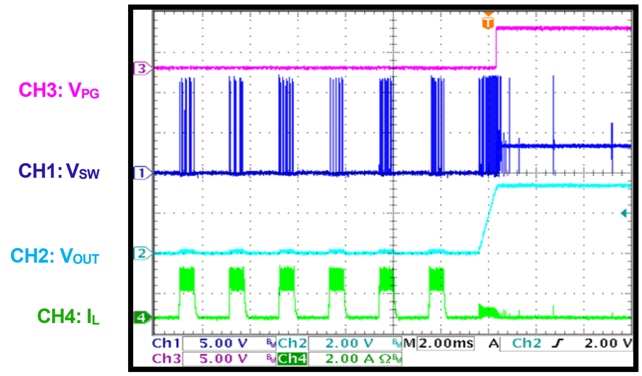
SCP Steady State

V_{IN} = 12V



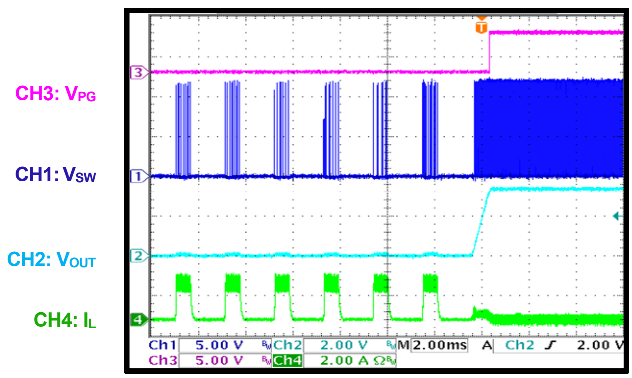
SCP Recovery

V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 0A, AAM



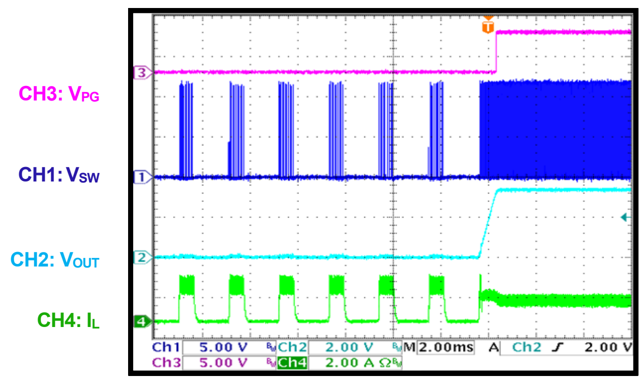
SCP Recovery

V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 0A, CCM



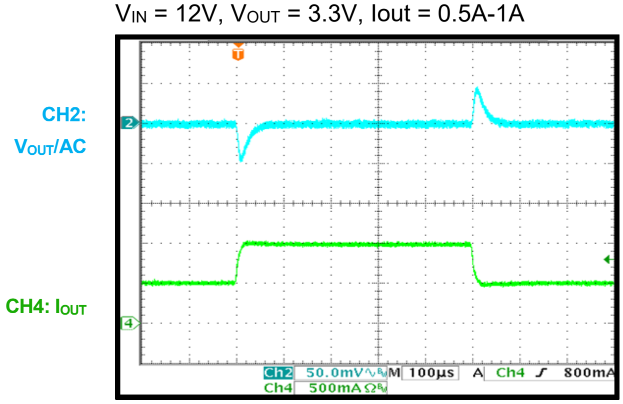
SCP Recovery

V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 1A



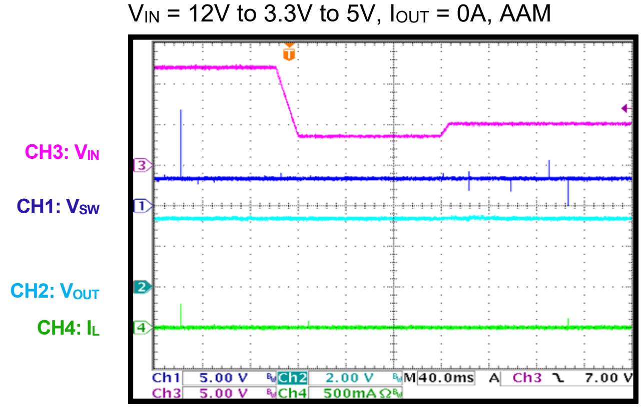
Load Transient

V_{IN} = 12V, V_{OUT} = 3.3V, Iout = 0.5A-1A



Cold-Crank Conditions

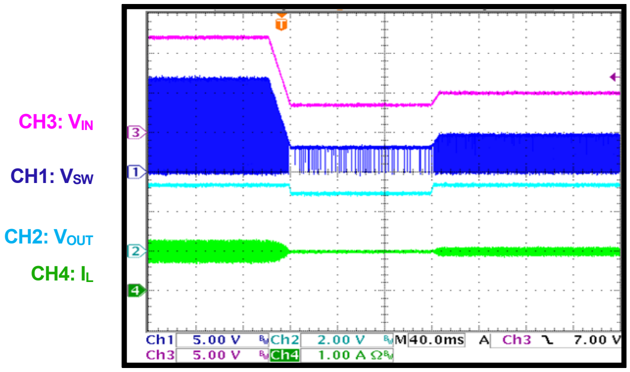
V_{IN} = 12V to 3.3V to 5V, I_{OUT} = 0A, AAM



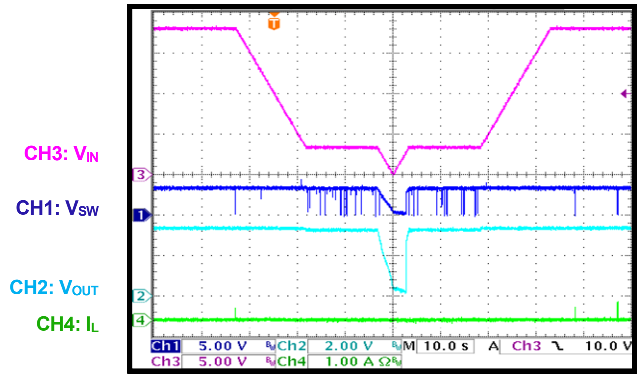
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, L = 10µH, f_{SW} = 450kHz, T_A = 25°C, unless otherwise noted.

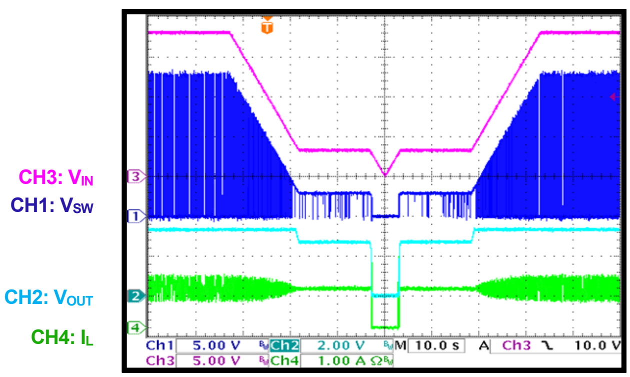
Cold-Crank Conditions
V_{IN} = 12V to 3.3V to 5V, I_{OUT} = 1A



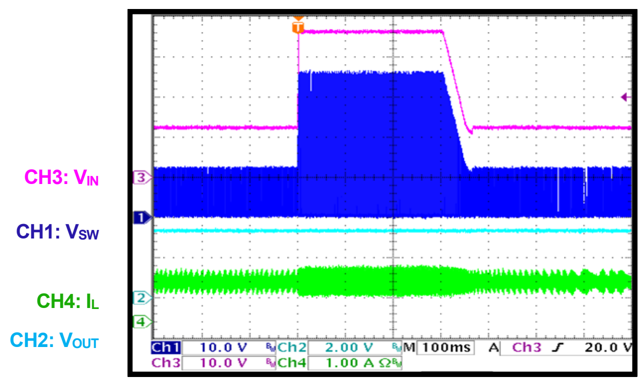
VIN Ramp Down and Up
V_{IN} = 18V to 3.3V to 0V to 3.3V to 18V,
I_{OUT} = 0A, AAM



VIN Ramp Down and Up
V_{IN} = 18V to 3.3V to 0V to 3.3V to 18V,
I_{OUT} = 1A



Load Dump
V_{IN} = 12V to 36V to 12V, I_{OUT} = 1A



PCB LAYOUT

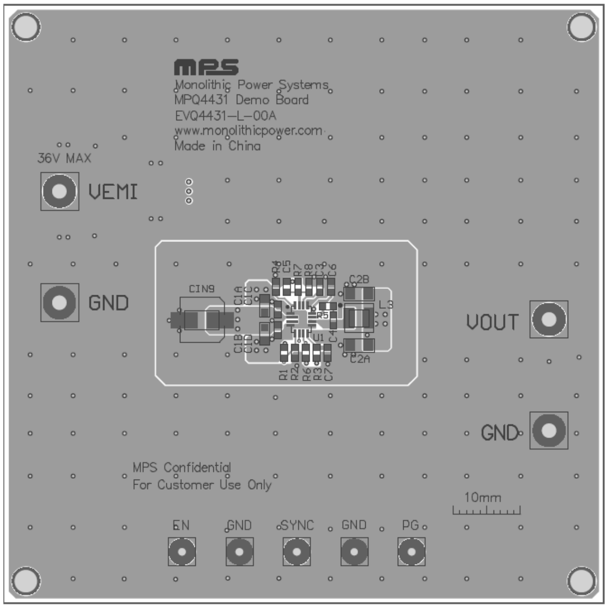


Figure 3: Top Silk Layer and Top Layer

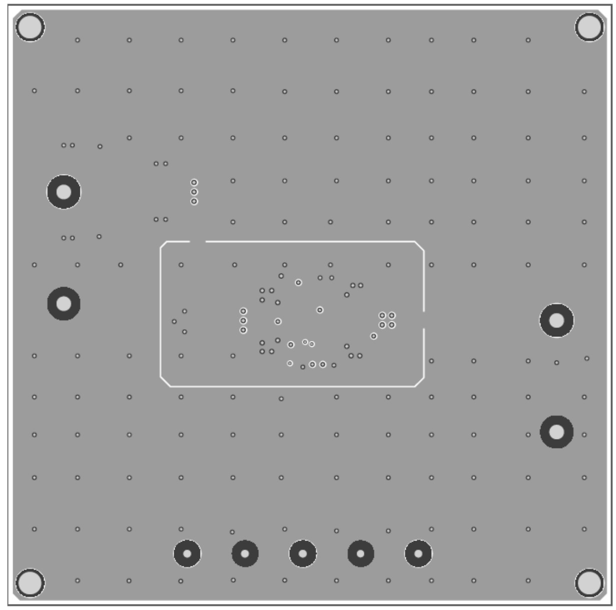


Figure 4: Inner Layer 1

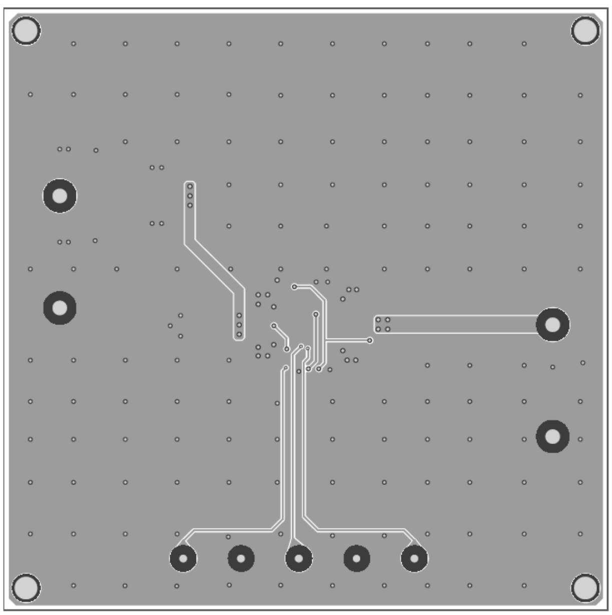


Figure 5: Inner Layer 2

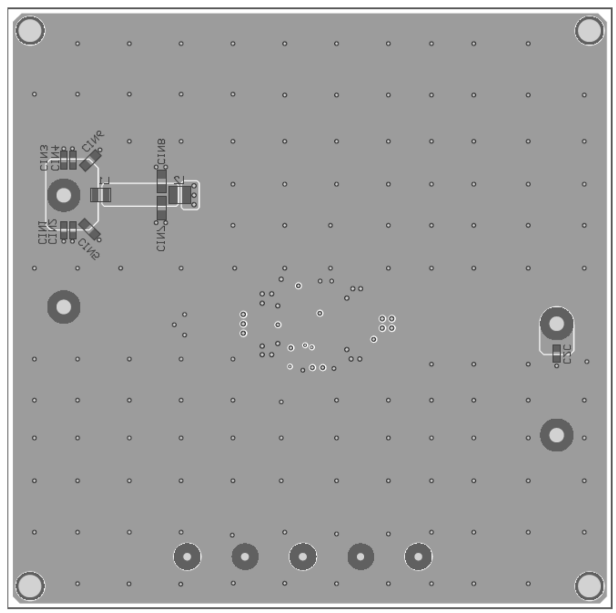


Figure 6: Bottom Silk Layer and Bottom Layer

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	5/27/2021	Initial Release	-