EVQ4314-R-01A

45V, 4A, Low-I_Q, Synchronous Step-Down Converter with Frequency Spread Spectrum Evaluation Board, AEC-Q100 Qualified

DESCRIPTION

The EVQ4314-R-01A evaluation board is designed to demonstrate the capabilities of the MPQ4314, 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 4A 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 switching and gate driver losses.

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

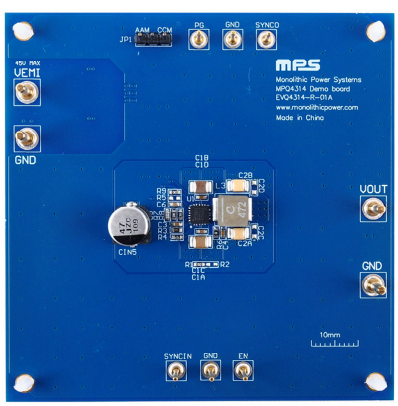
The EVQ4314-R-01A is fully assembled and tested. The MPQ4314-AEC1 is available in a QFN-20 (4mmx4mm) wettable flank package, and is AEC-Q100 Grade 1 qualified.

PERFORMANCE SUMMARY

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

Parameter	Conditions	Value
Input voltage (V_{IN}) range		3.3V to 45V
Output voltage (V_{OUT})	V_{IN} = 3.3V to 45V, I_{OUT} = 0A to 4A	V_{OUT} = 3.3V
Maximum output current (I_{OUT})	V_{IN} = 3.3V to 45V	4A
Typical efficiency	V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 4A	93.1%
Switching frequency (f_{SW})		410kHz

EVQ4314-R-01A EVALUATION BOARD



LxWxH (8.3cmx8.3cmx1.3cm)

Board Number	MPS IC Number
EVQ4314-R-01A	MPQ4314GRE-AEC1

QUICK START GUIDE

1. Preset the power supply (V_{IN}) between 3.3V and 45V. Electronic loads represent a negative impedance to the regulator, and setting a current too high triggers hiccup mode.
2. Turn off V_{IN}. If longer cables are used between the source and the evaluation board (>0.5m total), then install a damping capacitor at the input terminals, especially if V_{IN} ≥ 24V.
3. Connect the power supply terminals to (see Figure 2 on page 3):
    a. Positive (+): VEMI
    b. Negative (-): GND
4. Connect the load terminals to (see Figure 2 on page 3):
    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 the regulator on; drive EN below 0.85V to turn the regulator off.
7. The MPQ4314's oscillating (switching) frequency can be configured by an external frequency resistor (R3). R3 can be estimated based on the switching frequency (f_{SW}) vs. frequency resistance (R_{FREQ}) curve (see Figure 1).

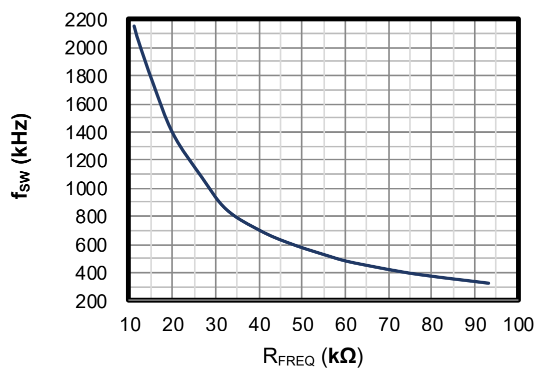


Figure 1: R3 Frequency Resistance

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 using 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%)

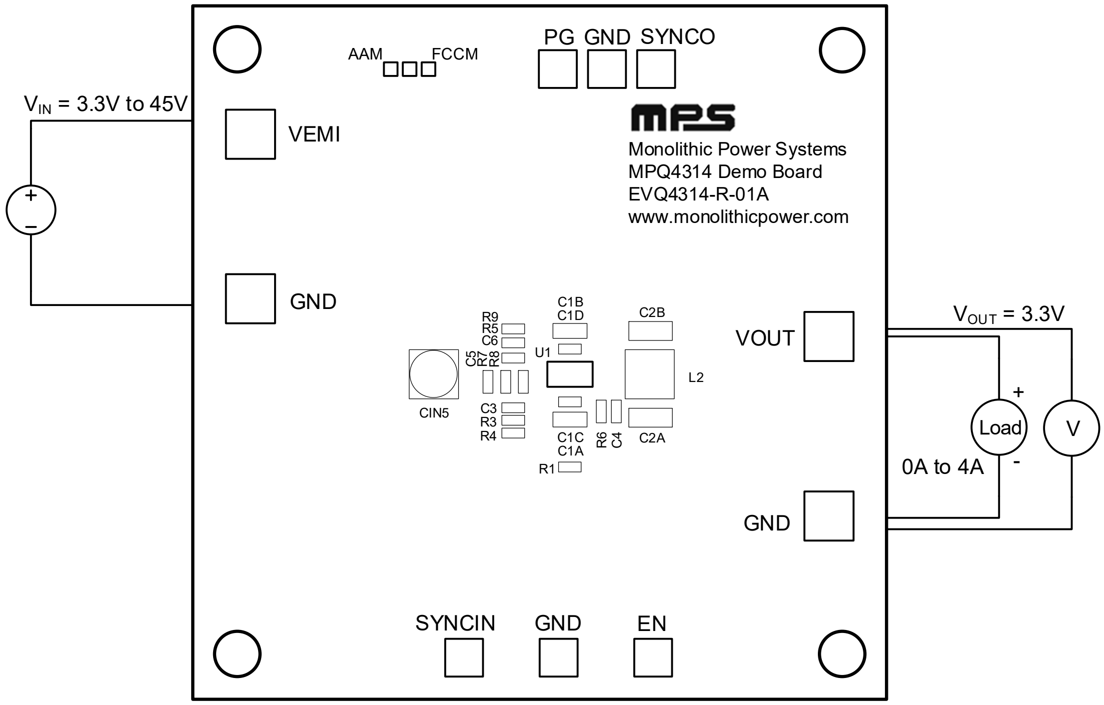


Figure 2: Measurement Equipment Set-Up

EVALUATION BOARD SCHEMATIC

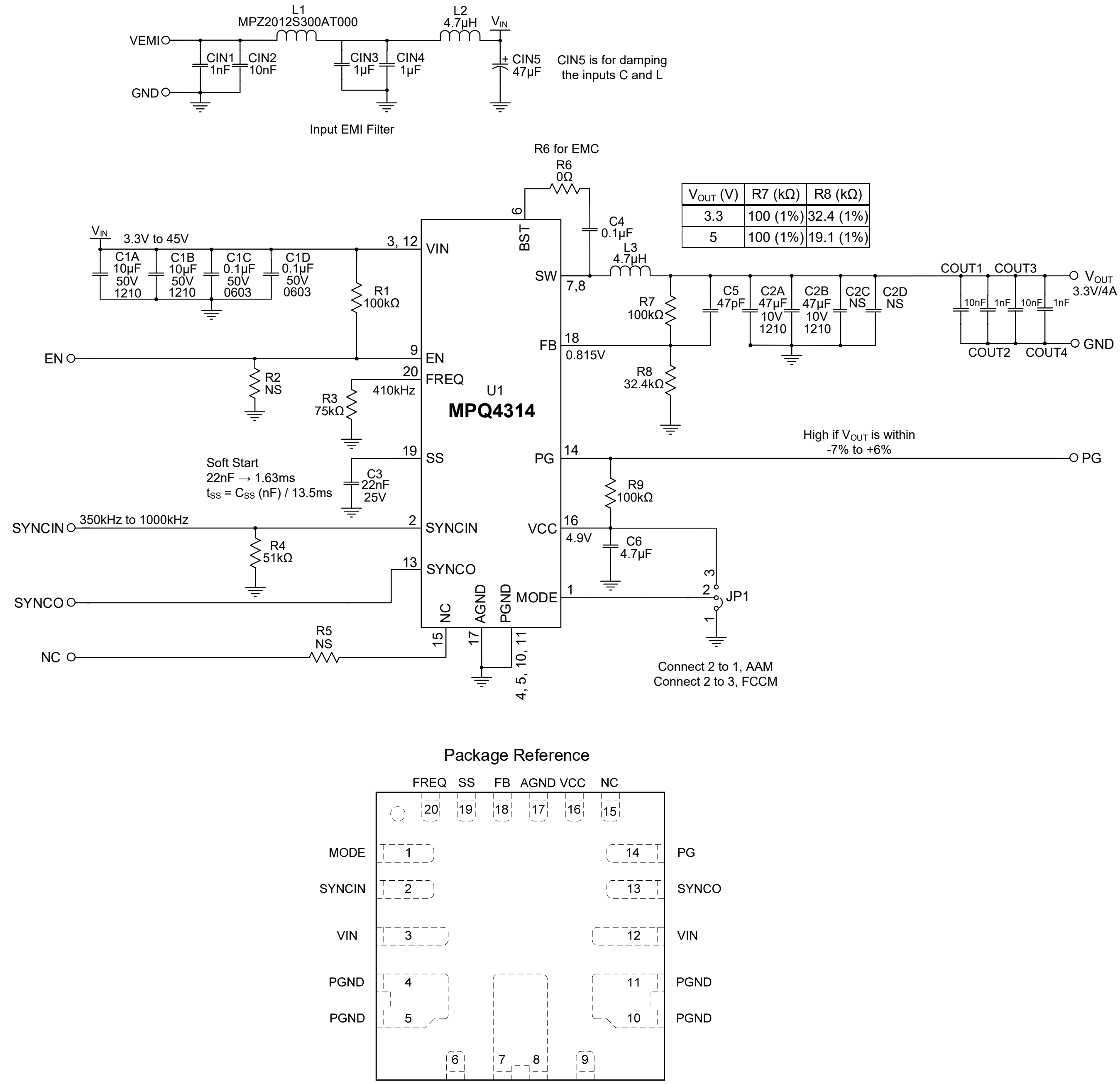


Figure 3: Evaluation Board Schematic and Package Reference

EVQ4314-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 test pin	DIP	Custom (1)	
7	SYNCIN, ICS, PG, SYNCO, EN, GND, GND	1mm	Golden test pin	DIP	Custom (1)	
1	U1	MPQ4314	45V/4A, step-down converter, AEC-Q100	QFN-20 (4mmx 4mm)	MPS	MPQ4314GRE-AEC1

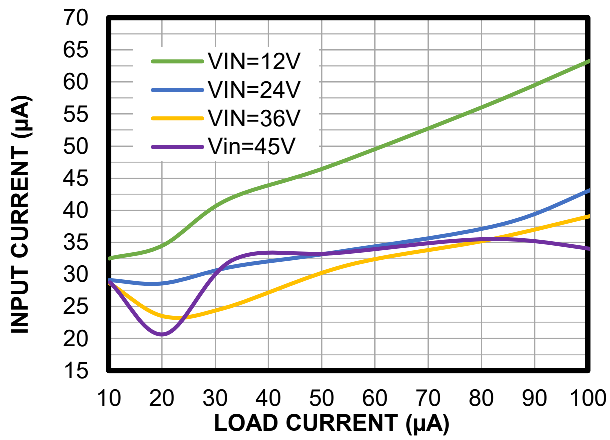
Note:

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

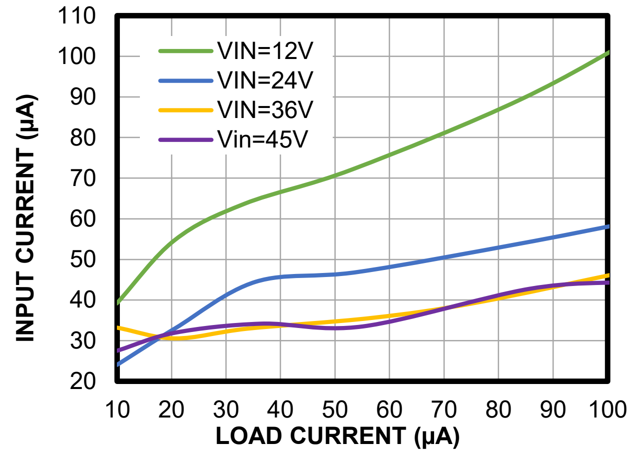
EVB TEST RESULTS

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.

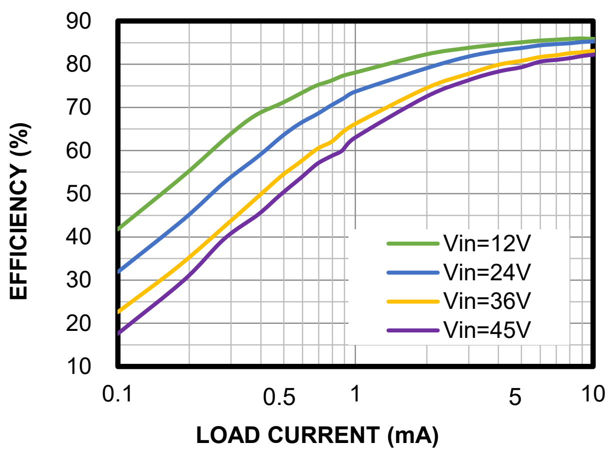
Input Current vs. Load Current
AAM mode, V_{OUT} = 3.3V



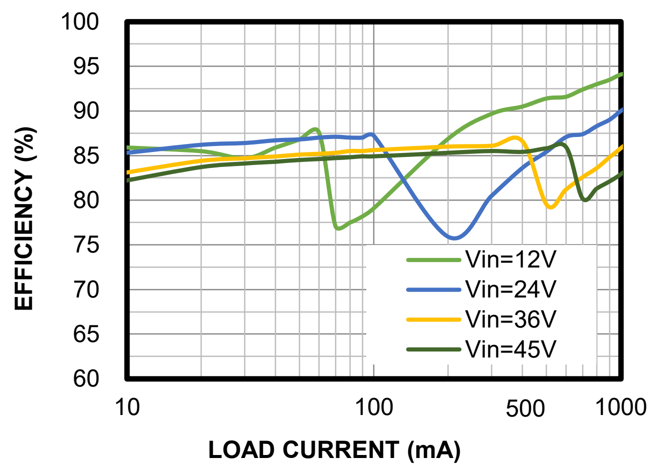
Input Current vs. Load Current
AAM mode, V_{OUT} = 5V



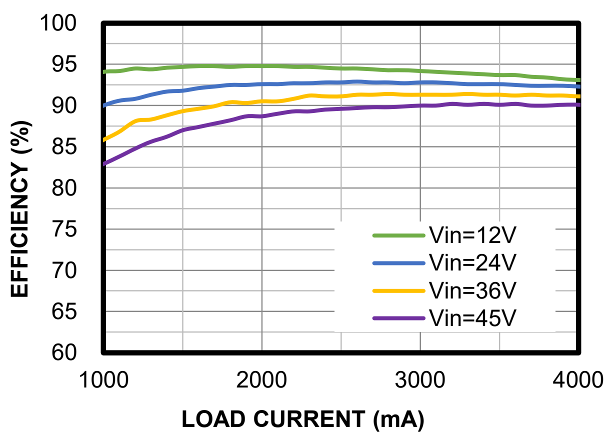
Efficiency vs. Load Current
AAM mode, V_{OUT} = 3.3V, 0.1mA to 10mA



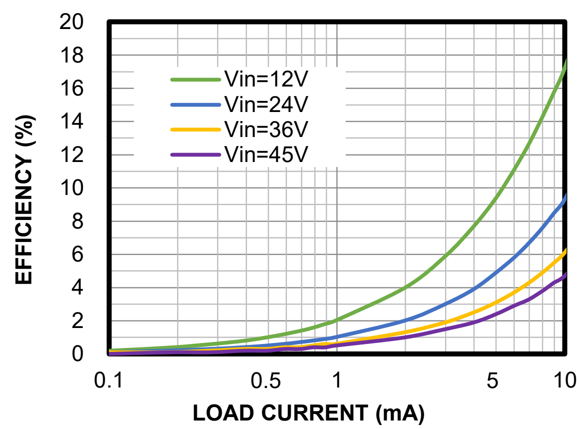
Efficiency vs. Load Current
AAM mode, V_{OUT} = 3.3V, 10mA to 1000mA



Efficiency vs. Load Current
AAM mode, V_{OUT} = 3.3V. 1A to 4A

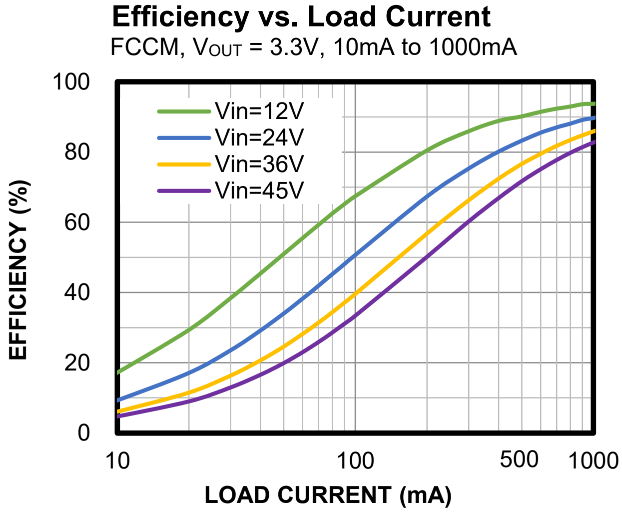


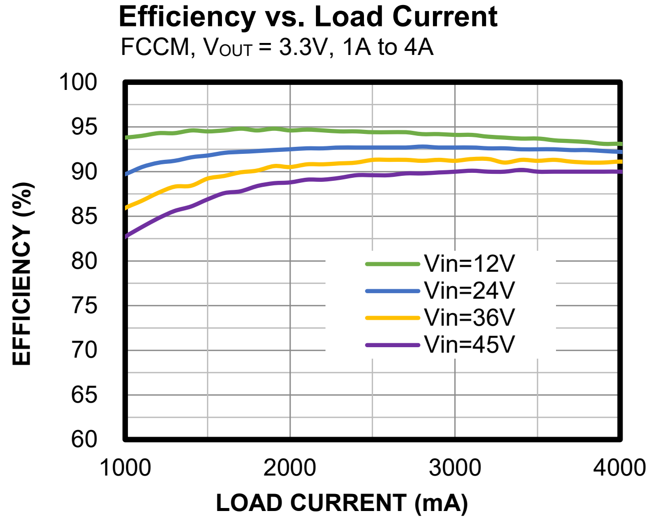
Efficiency vs. Load Current
FCCM, V_{OUT} = 3.3V, 0.1mA to 10mA

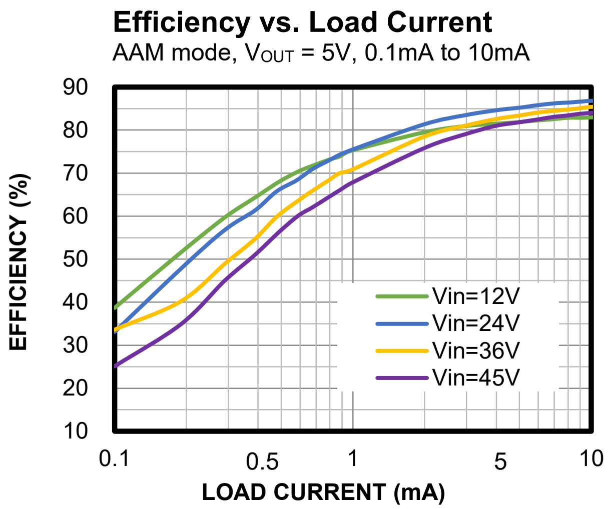


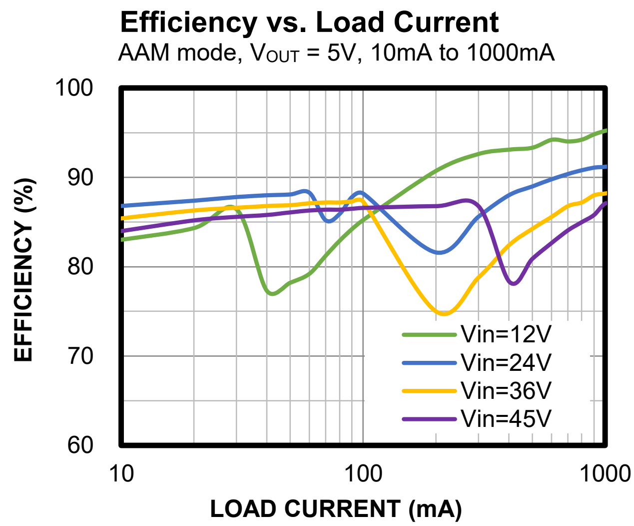
EVB TEST RESULTS *(continued)*

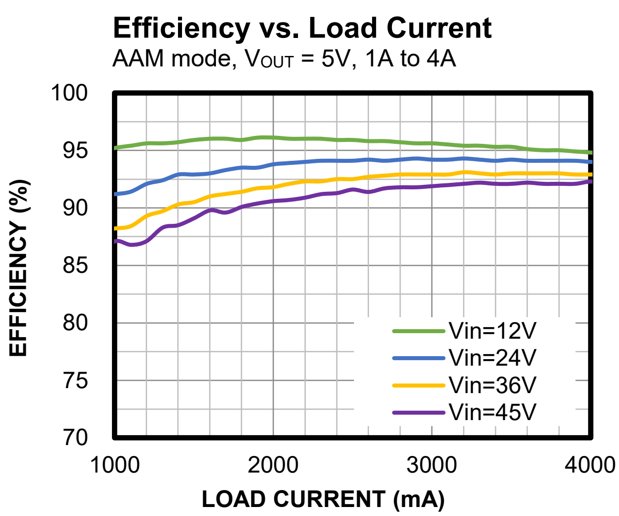
Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

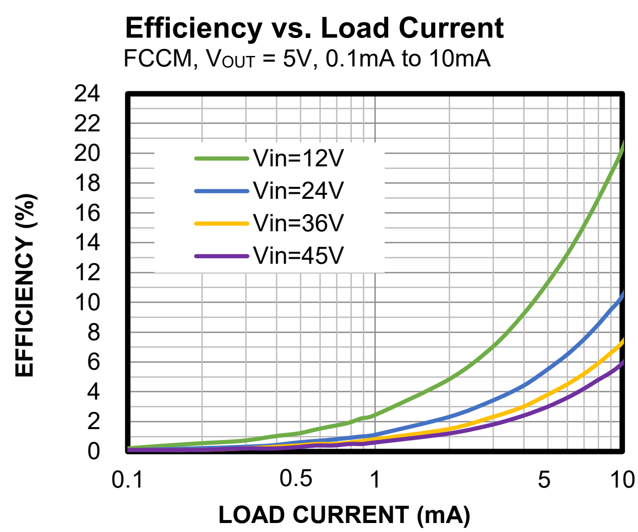








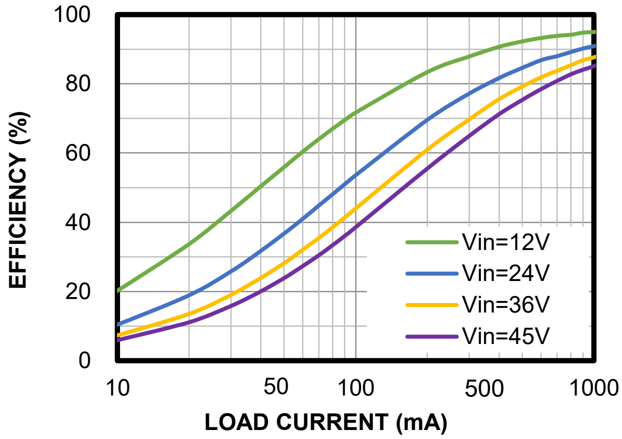




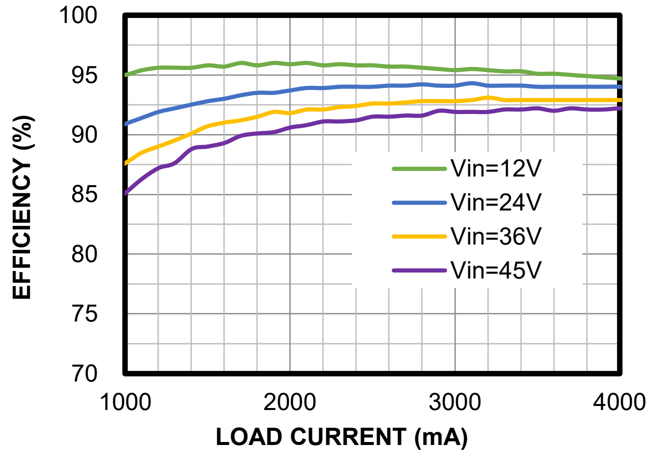
EVB TEST RESULTS *(continued)*

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.

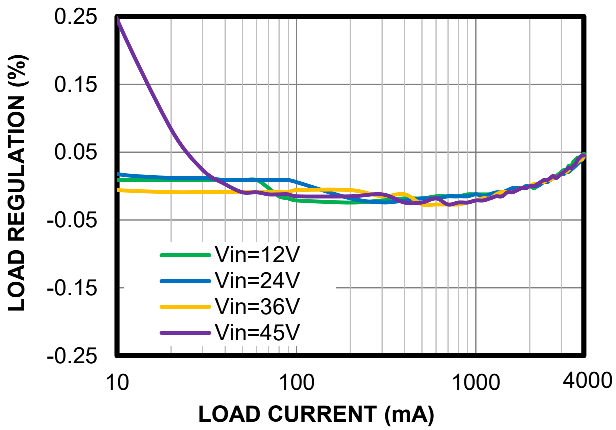
Efficiency vs. Load Current
FCCM, V_{OUT} = 5V, 10mA to 1000mA



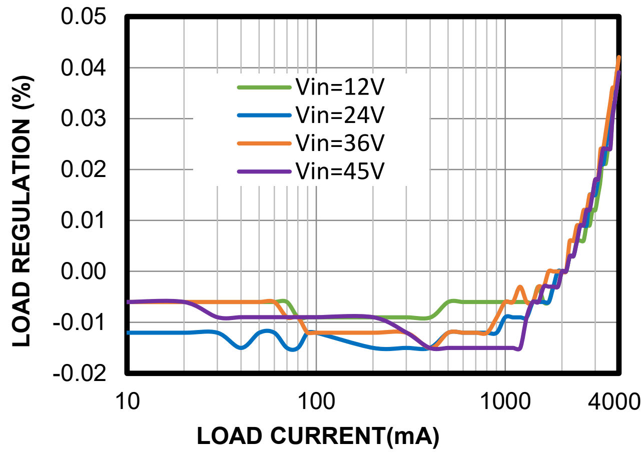
Efficiency vs. Load Current
FCCM, V_{OUT} = 5V, 1A to 4A



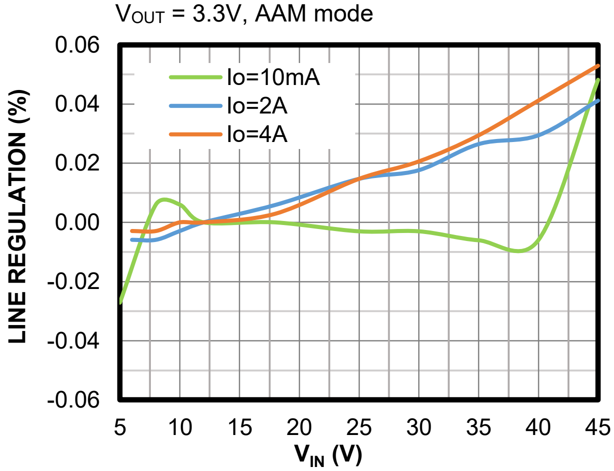
Load Regulation
V_{OUT} = 3.3V, AAM mode



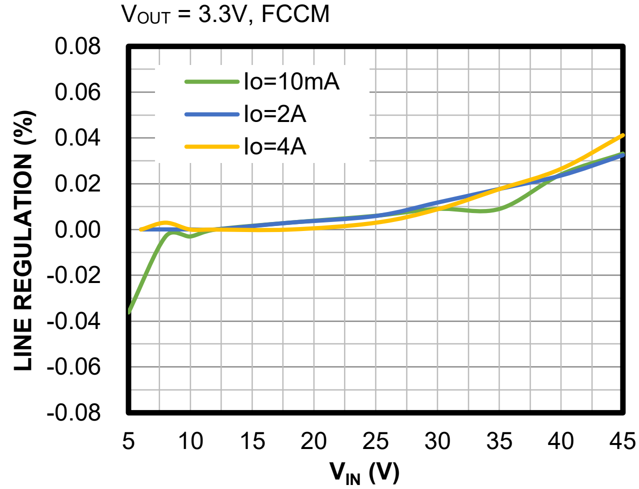
Load Regulation
V_{OUT} = 3.3V, FCCM



Line Regulation
V_{OUT} = 3.3V, AAM mode



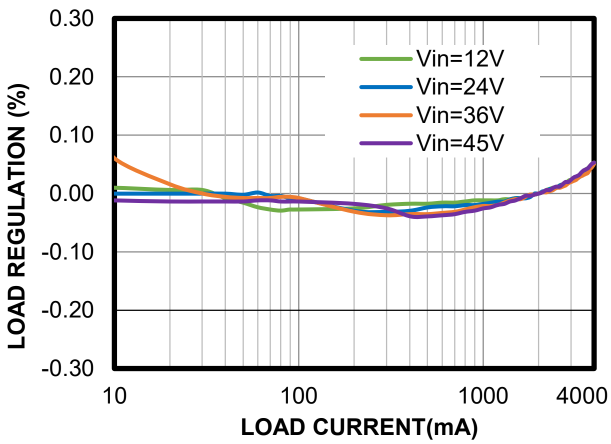
Line Regulation
V_{OUT} = 3.3V, FCCM



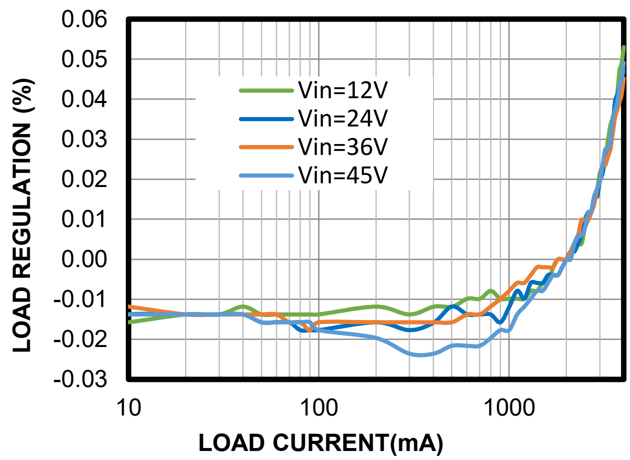
EVB TEST RESULTS *(continued)*

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.

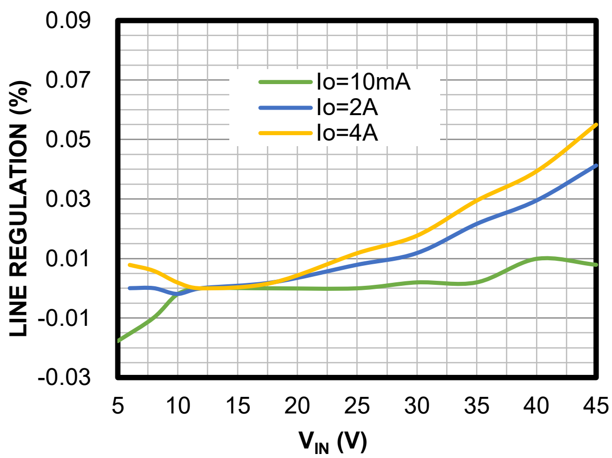
Load Regulation
V_{OUT} = 5V, AAM mode



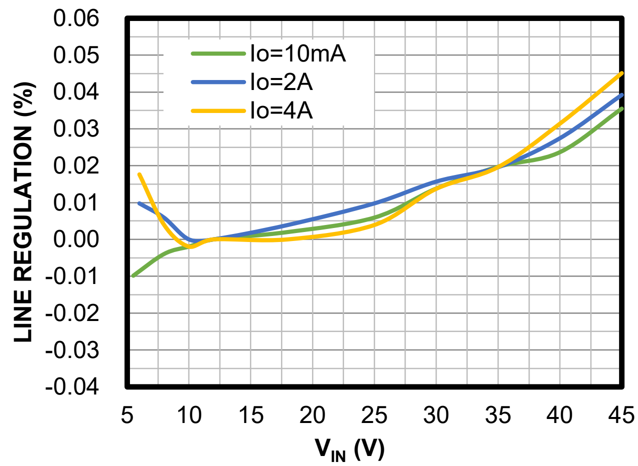
Load Regulation
V_{OUT} = 5V, FCCM



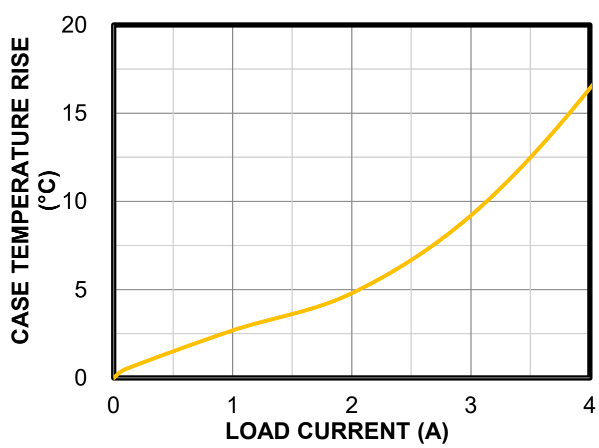
Line Regulation
V_{OUT} = 5V, AAM mode



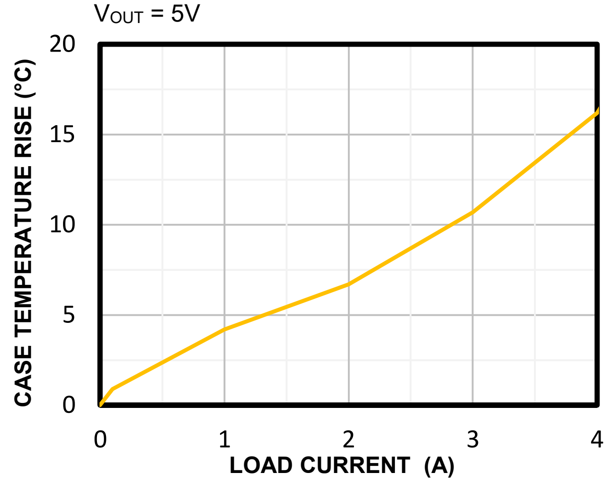
Line Regulation
V_{OUT} = 5V, FCCM



Case Temperature Rise
V_{OUT} = 3.3V



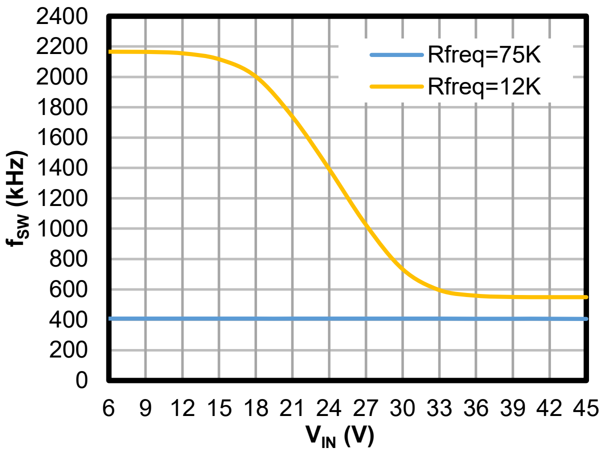
Case Temperature Rise
V_{OUT} = 5V



EVB TEST RESULTS *(continued)*

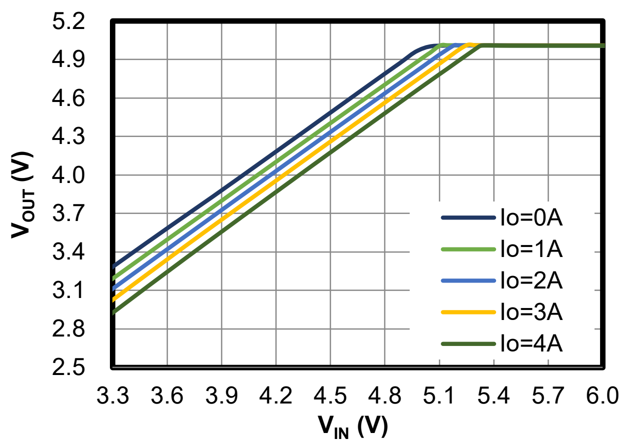
Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 4.7µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

f_{SW} vs. V_{IN}



Low-Dropout Mode

V_{OUT} = 5V

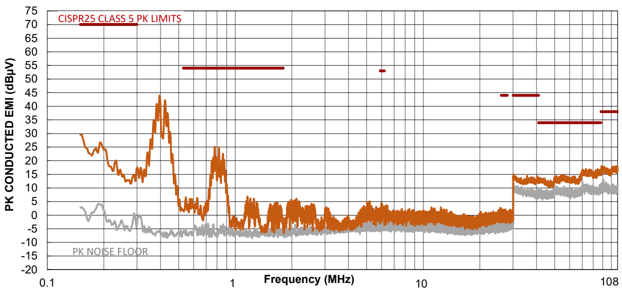


EVB TEST RESULTS *(continued)*

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.

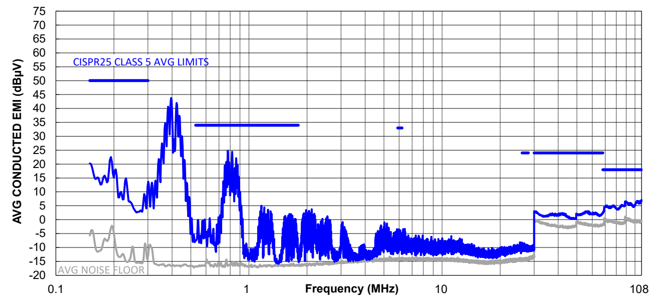
CISPR25 Class 5 Peak Conducted Emissions

150kHz to 108MHz



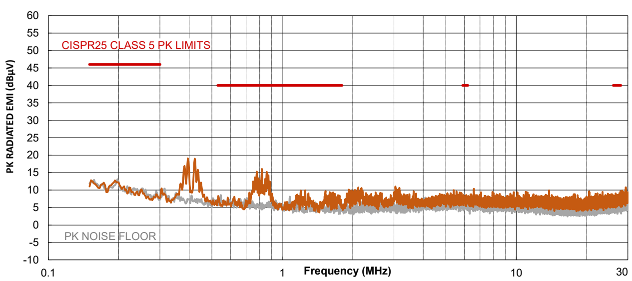
CISPR25 Class 5 Average Conducted Emissions

150kHz to 108MHz



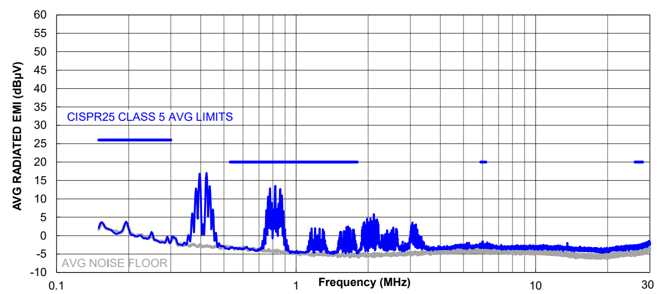
CISPR25 Class 5 Peak Radiated Emissions

150kHz to 30MHz



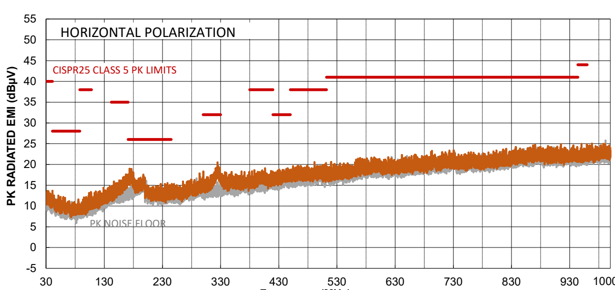
CISPR25 Class 5 Average Radiated Emissions

150kHz to 30MHz



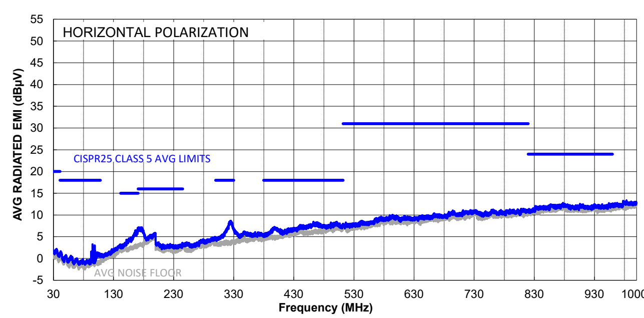
CISPR25 Class 5 Peak Radiated Emissions

Horizontal, 30MHz to 1GHz



CISPR25 Class 5 Average Radiated Emissions

Horizontal, 30MHz to 1GHz

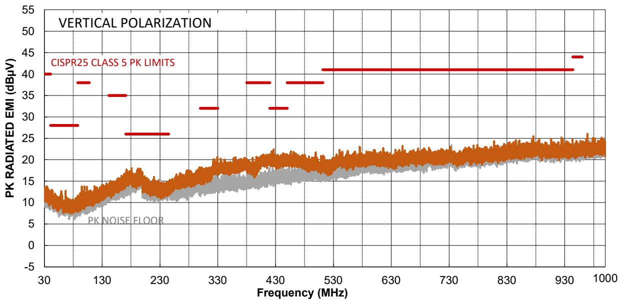


EVB TEST RESULTS *(continued)*

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.

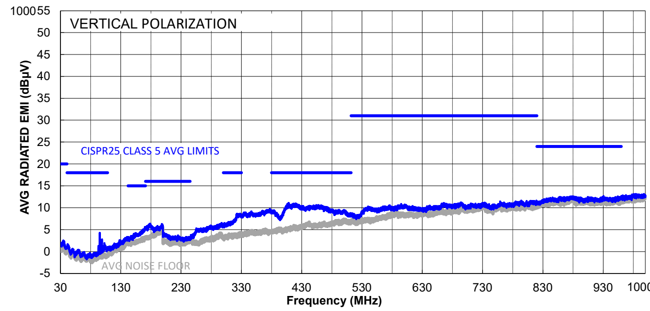
CISPR25 Class 5 Peak Radiated Emissions

Vertical, 30MHz to 1GHz



CISPR25 Class 5 Average Radiated Emissions

Vertical, 30MHz to 1GHz

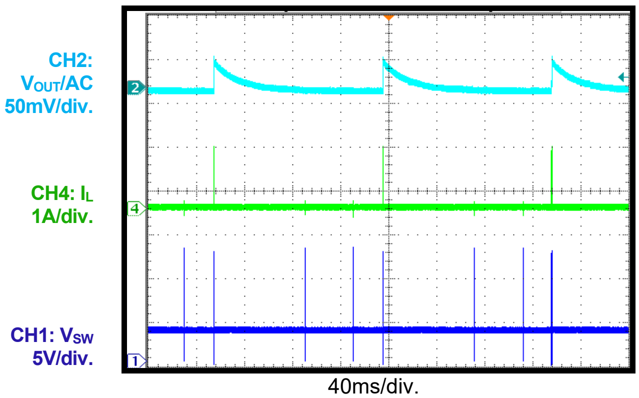


EVB TEST RESULTS *(continued)*

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.

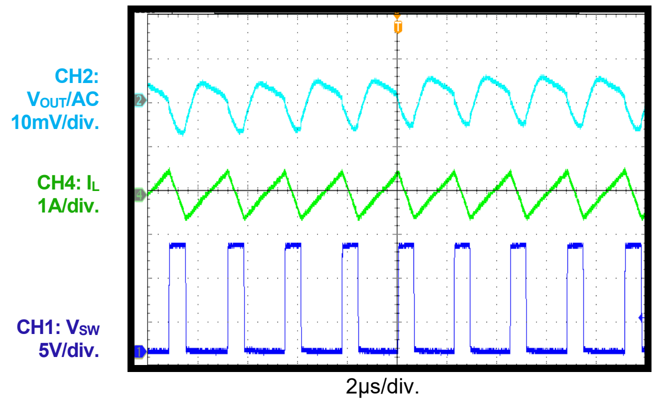
Steady State

I_{OUT} = 0A, AAM mode



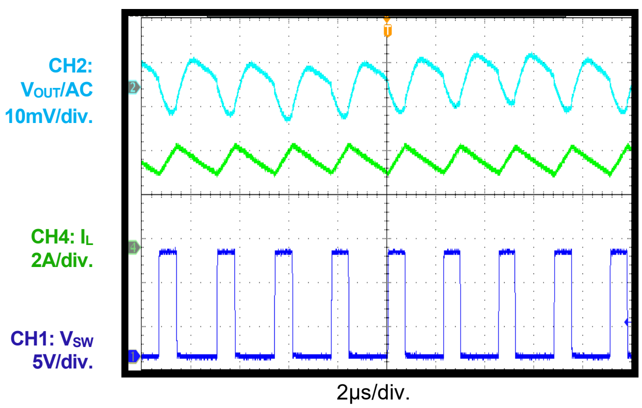
Steady State

I_{OUT} = 0A, FCCM



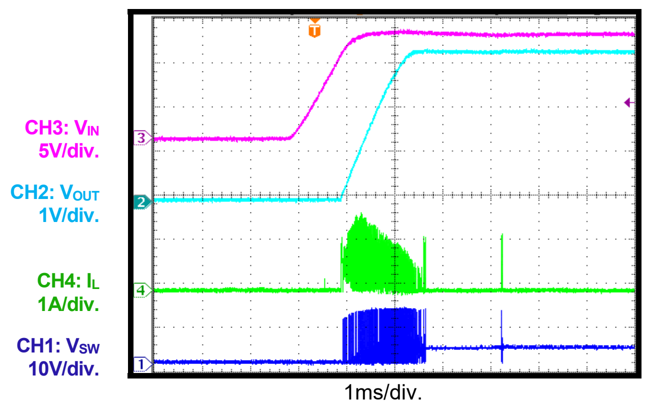
Steady State

I_{OUT} = 4A



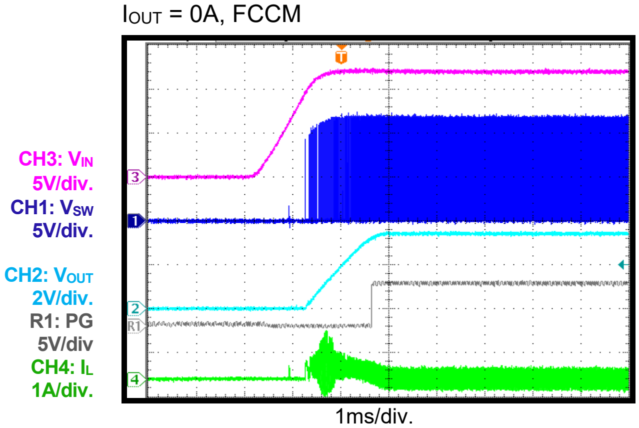
Start-Up through VIN

I_{OUT} = 0A, AAM mode



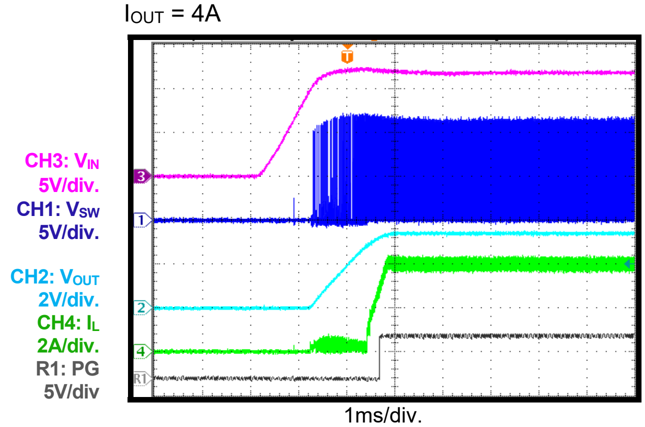
Start-Up through VIN

I_{OUT} = 0A, FCCM



Start-Up through VIN

I_{OUT} = 4A

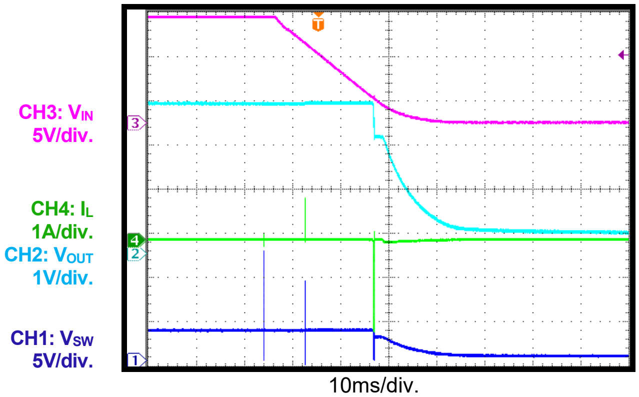


EVB TEST RESULTS *(continued)*

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.

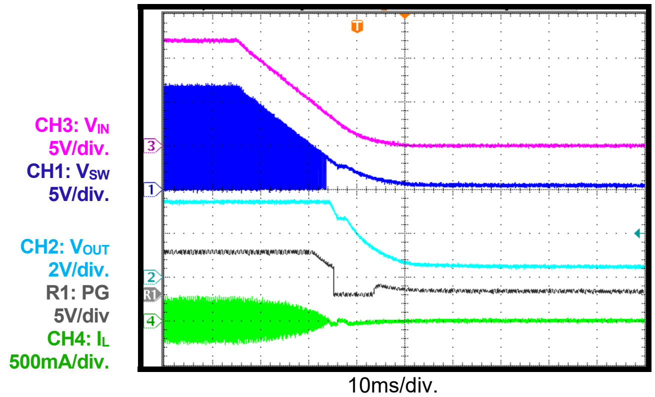
Shutdown through VIN

I_{OUT} = 0A, AAM mode



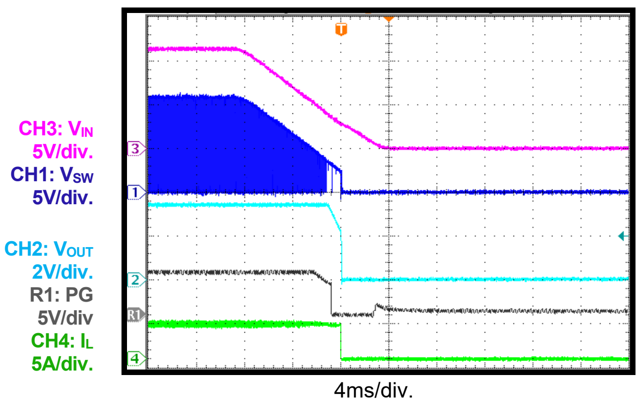
Shutdown through VIN

I_{OUT} = 0A, FCCM



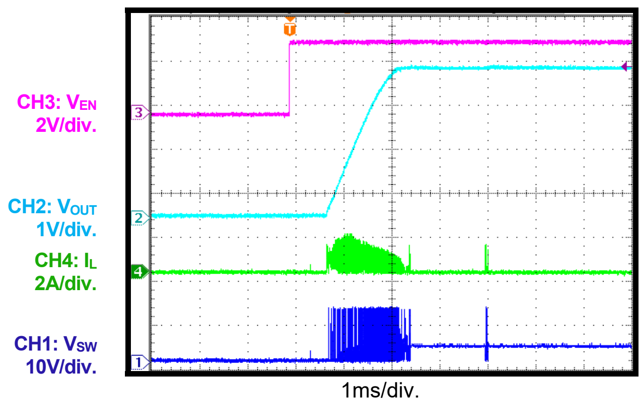
Shutdown through VIN

I_{OUT} = 4A



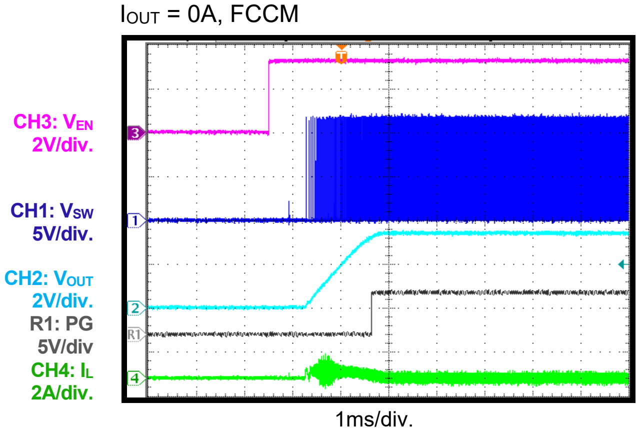
Start-Up through EN

I_{OUT} = 0A, AAM mode



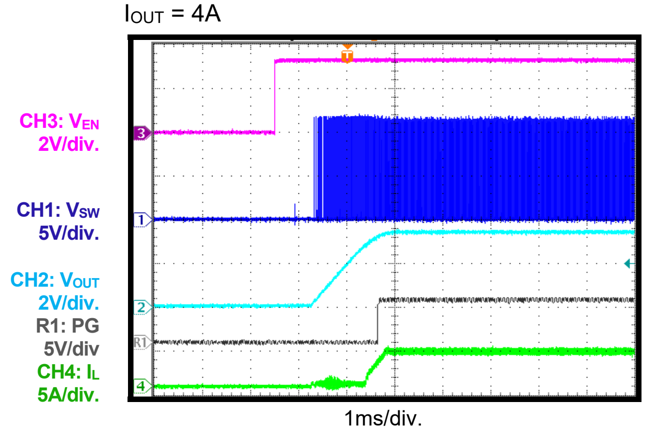
Start-Up through EN

I_{OUT} = 0A, FCCM



Start-Up through EN

I_{OUT} = 4A

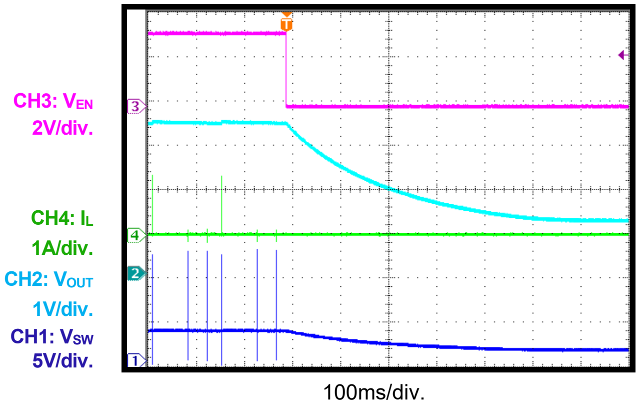


EVB TEST RESULTS *(continued)*

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.

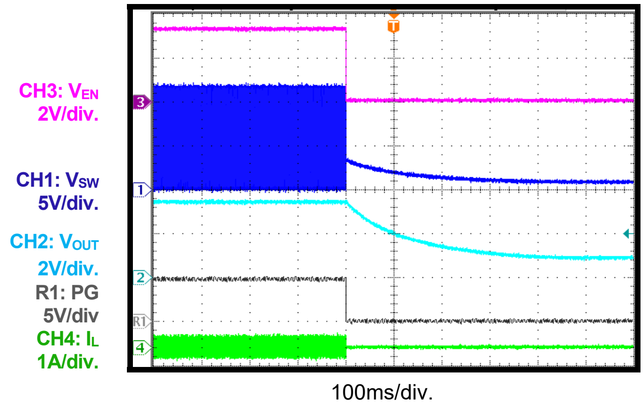
Shutdown through EN

I_{OUT} = 0A, AAM mode



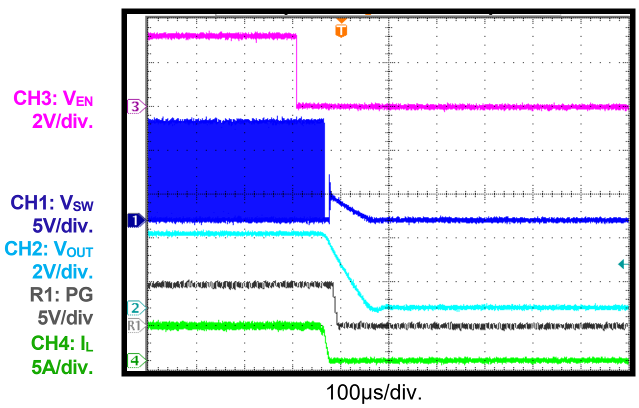
Shutdown through EN

I_{OUT} = 0A, FCCM



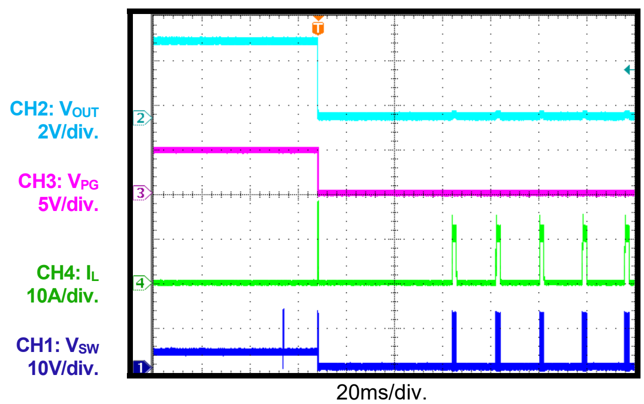
Shutdown through EN

I_{OUT} = 4A



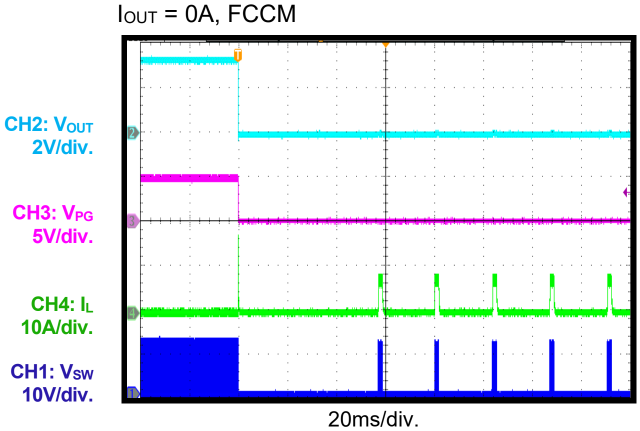
SCP Entry

I_{OUT} = 0A, AAM mode



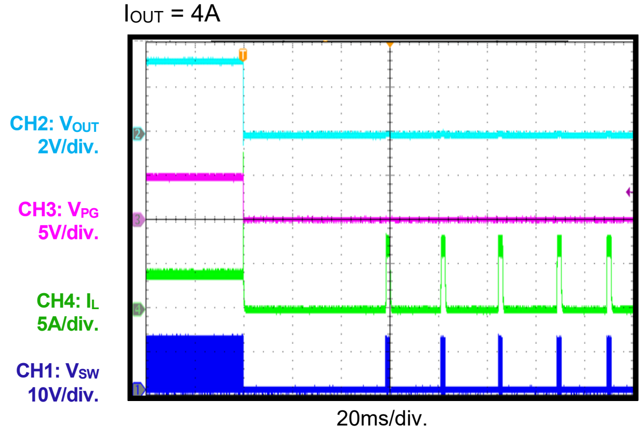
SCP Entry

I_{OUT} = 0A, FCCM



SCP Entry

I_{OUT} = 4A



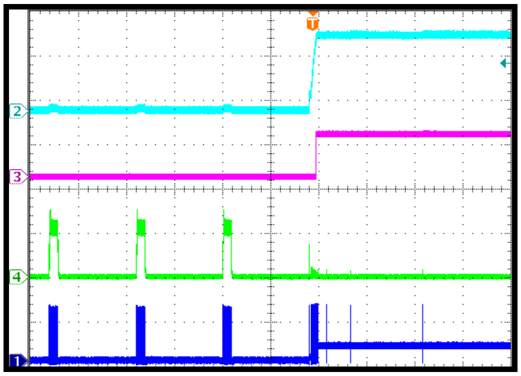
EVB TEST RESULTS *(continued)*

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

CH2: V_{OUT} 2V/div.
CH3: V_{PG} 5V/div.
CH4: I_L 5A/div.
CH1: V_{SW} 10V/div.

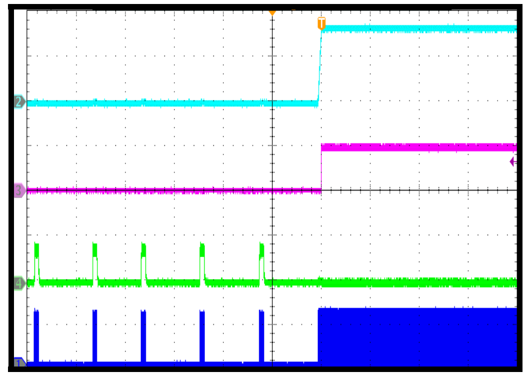


10ms/div.

SCP Recovery

I_{OUT} = 0A, FCCM

CH2: V_{OUT} 2V/div.
CH3: V_{PG} 5V/div.
CH4: I_L 10A/div.
CH1: V_{SW} 10V/div.

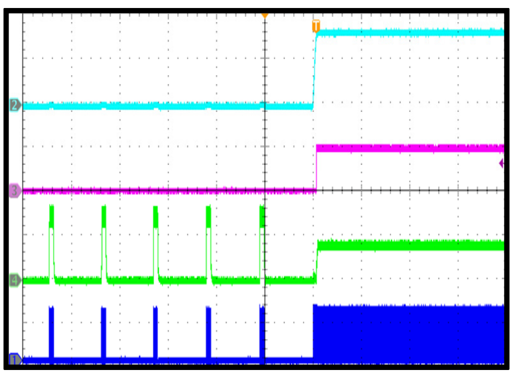


20ms/div.

SCP Recovery

I_{OUT} = 4A

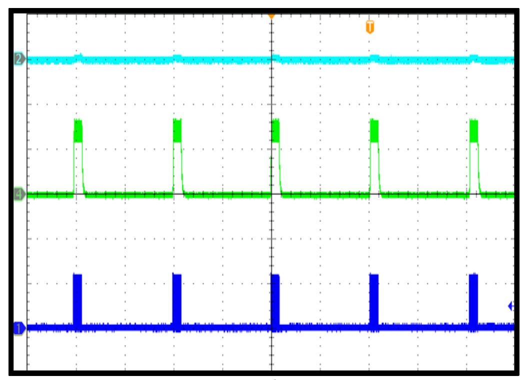
CH2: V_{OUT} 2V/div.
CH3: V_{PG} 5V/div.
CH4: I_L 5A/div.
CH1: V_{SW} 10V/div.



20ms/div.

SCP Steady State

CH2: V_{OUT} 1V/div.
CH4: I_L 5A/div.
CH1: V_{SW} 10V/div.

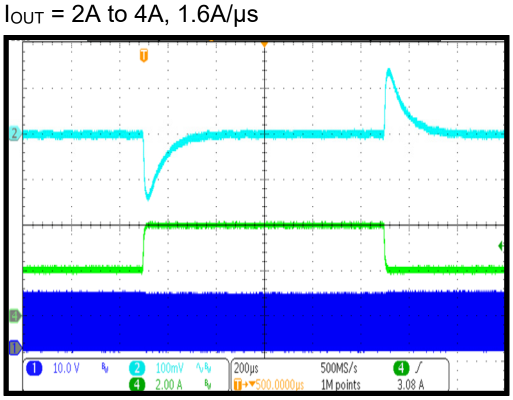


10ms/div.

Load Transient

I_{OUT} = 2A to 4A, 1.6A/µs

CH2: V_{OUT}/AC 100mV/div.
CH4: I_{OUT} 2A/div.
CH1: V_{SW} 10V/div.

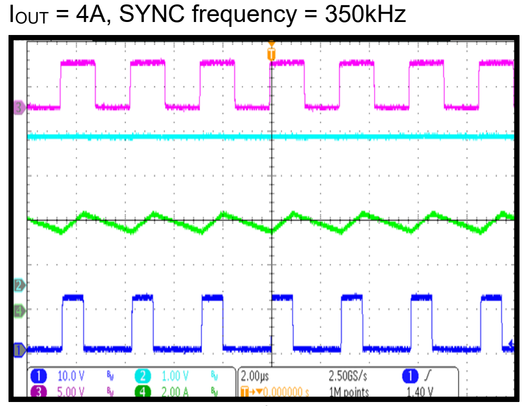


200µs/div.

SYNC Operation

I_{OUT} = 4A, SYNC frequency = 350kHz

CH3: SYNCIN 5V/div.
CH2: V_{OUT} 1V/div.
CH4: I_L 2A/div.
CH1: V_{SW} 10V/div.



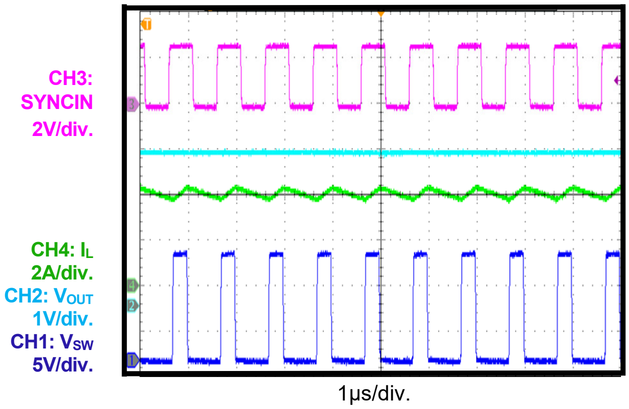
2µs/div.

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.

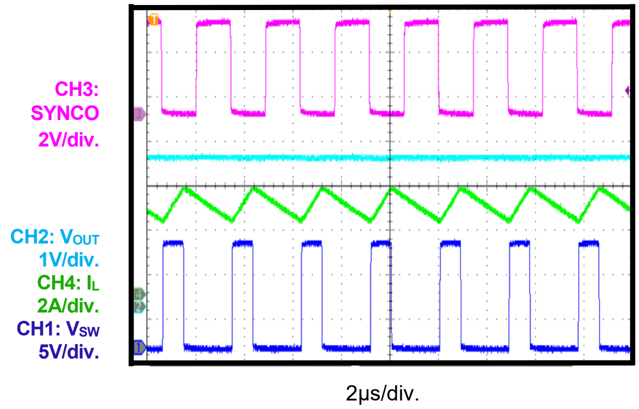
SYNC Operation

I_{OUT} = 4A, SYNC frequency = 1000kHz



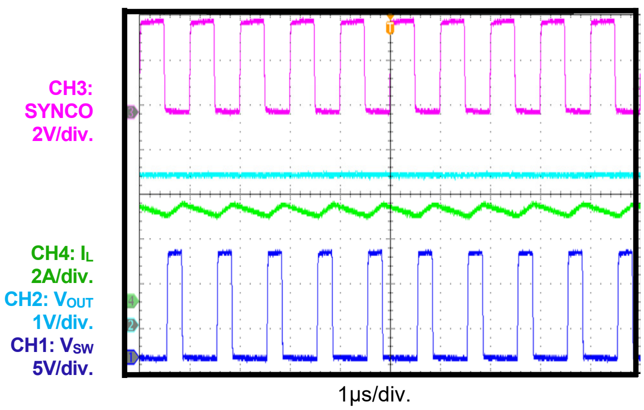
SYNCO Operation

I_{OUT} = 4A, SYNC frequency = 350kHz



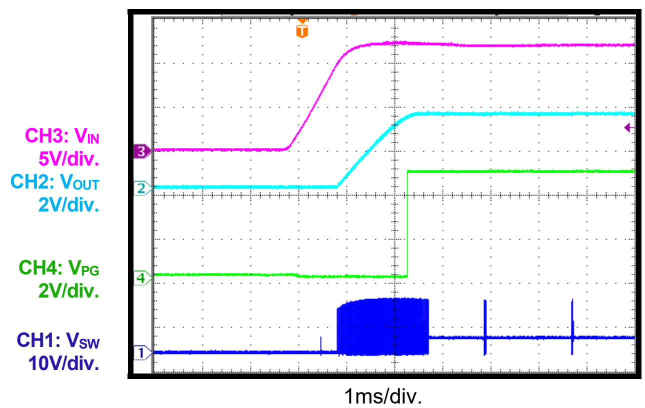
SYNCO Operation

I_{OUT} = 4A, SYNC frequency = 1000kHz



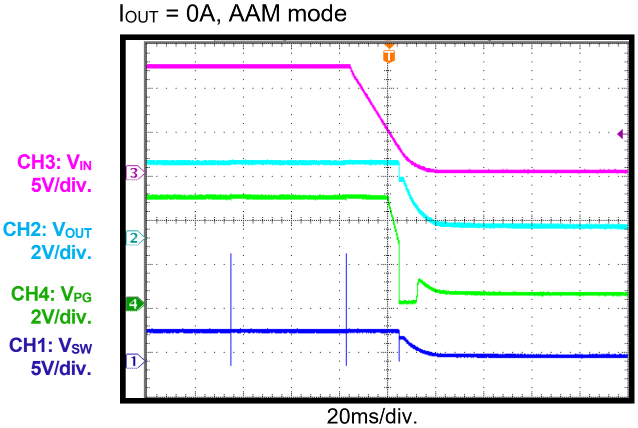
PG in Start-Up through VIN

I_{OUT} = 0A, AAM mode



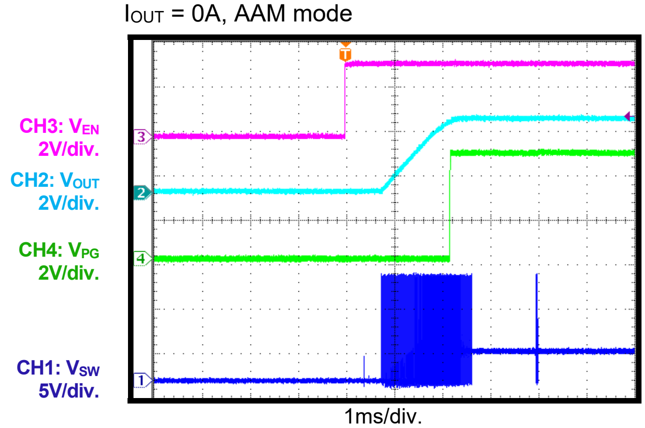
PG in Shutdown through VIN

I_{OUT} = 0A, AAM mode



PG in Start-Up through EN

I_{OUT} = 0A, AAM mode



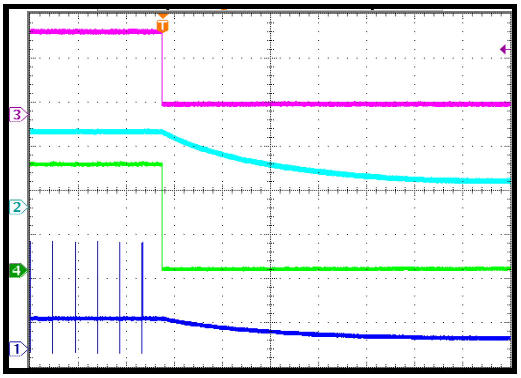
EVB TEST RESULTS *(continued)*

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

PG in Shutdown through EN

I_{OUT} = 0A, AAM mode

CH3: V_{EN} 2V/div.
CH2: V_{OUT} 2V/div.
CH4: V_{PG} 2V/div.
CH1: V_{SW} 5V/div.

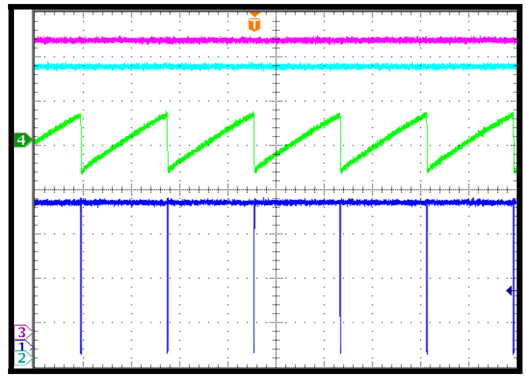


100ms/div.

Low-Dropout Mode

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

CH4: I_L 50mA/div.
CH3: V_{IN} 500mV/div.
CH1: V_{SW} 1V/div.
CH2: V_{OUT} 500mV/div.

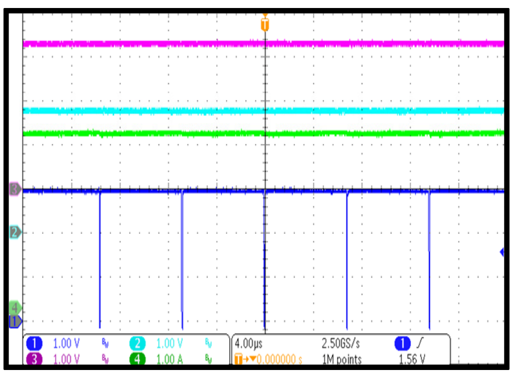


4µs/div.

Low-Dropout Mode

V_{IN} = 3.3V, V_{OUT} set to 3.3V, I_{OUT} = 4A

CH3: V_{IN} 1V/div.
CH2: V_{OUT} 1V/div.
CH4: I_L 1A/div.
CH1: V_{SW} 1V/div.

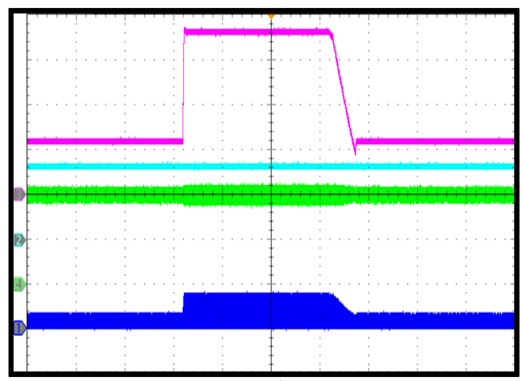


4µs/div.

Load Dump

V_{IN} = 12V to 36V, I_{OUT} = 4A

CH3: V_{IN} 10V/div.
CH2: V_{OUT} 2V/div.
CH4: I_L 2A/div.
CH1: V_{SW} 50V/div.

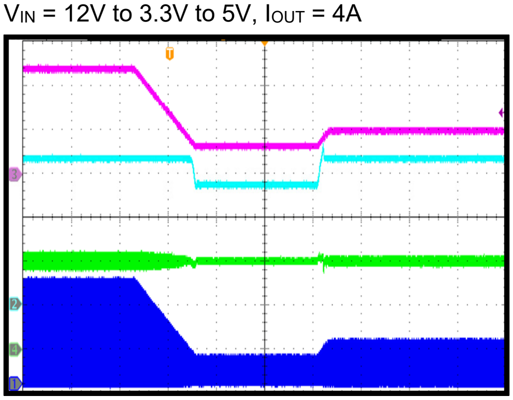


100ms/div.

Cold Crank

V_{IN} = 12V to 3.3V to 5V, I_{OUT} = 4A

CH3: V_{IN} 5V/div.
CH2: V_{OUT} 1V/div.
CH4: I_L 2A/div.
CH1: V_{SW} 5V/div.

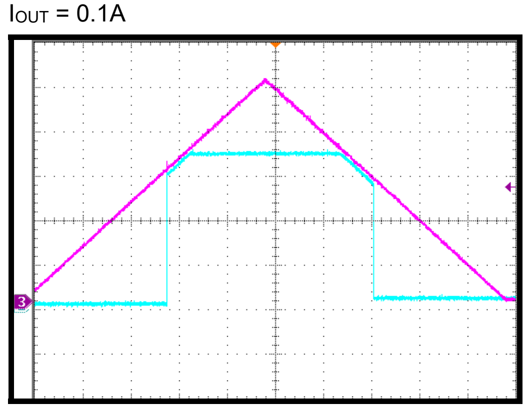


4ms/div.

V_{IN} Ramping Up and Down

I_{OUT} = 0.1A

CH3: V_{IN} 1V/div.
CH2: V_{OUT} 1V/div.



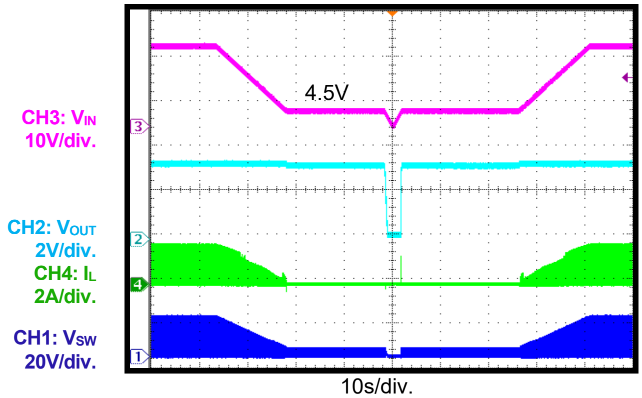
1s/div.

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.

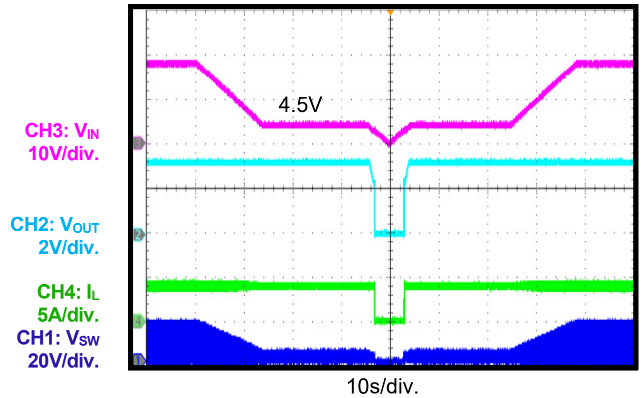
V_{IN} Ramping Down and Up

I_{OUT} = 1mA



V_{IN} Ramping Down and Up

I_{OUT} = 4A



PCB LAYOUT (2)

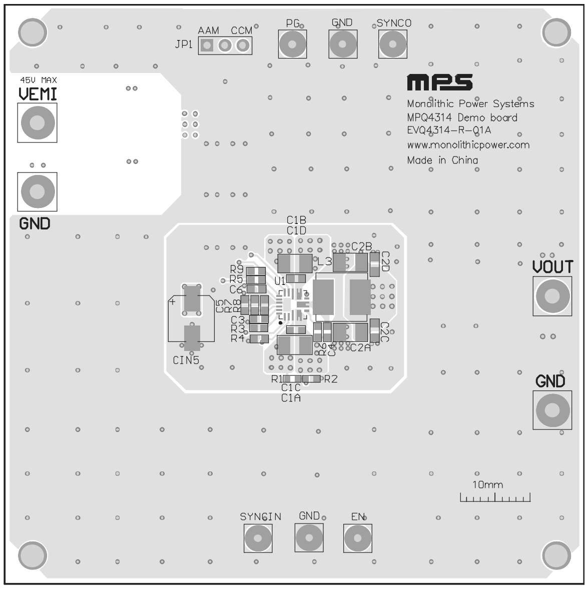


Figure 4: Top Silk and Top Layer

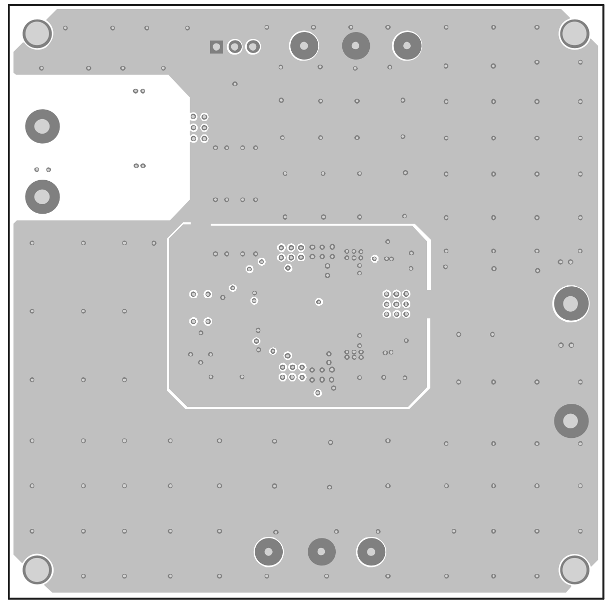


Figure 5: Mid-Layer 1

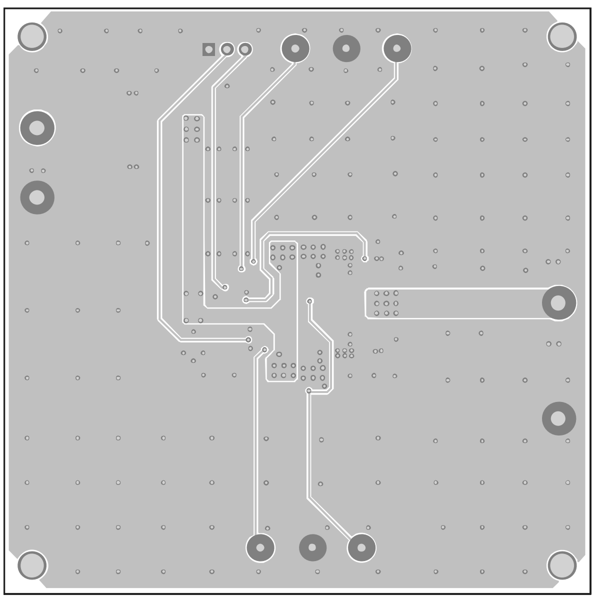


Figure 6: Mid-Layer 2

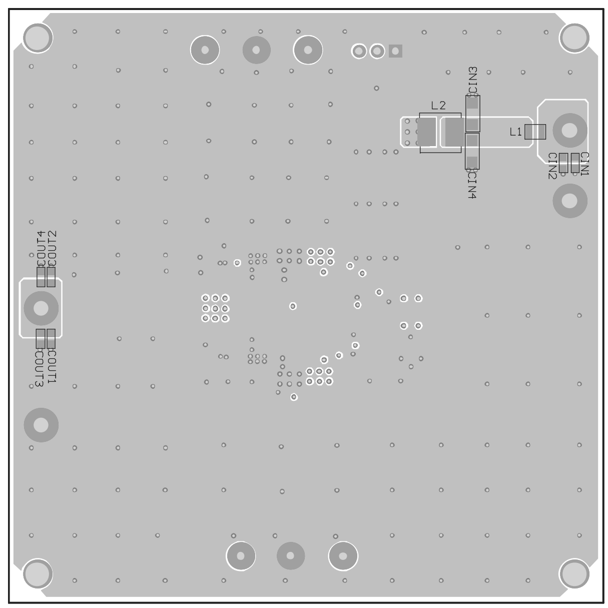


Figure 7: Bottom Layer and Bottom Silk

Note:

2) The copper thickness is 2oz.

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	3/21/2022	Initial Release	-