EVQ4312-R-01A

45V, 2A, Low-I_Q, Synchronous Step-Down Converter with Frequency Spread Spectrum Evaluation Board, AEC-Q100 Qualified

DESCRIPTION

The EVQ4312-R-01A evaluation board is designed to demonstrate the capabilities of the MPQ4312, a synchronous, step-down switching regulator with a configurable frequency and an integrated, internal high-side MOSFET (HS-FET) and low-side MOSFET (LS-FET). It provides up to 2A 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 (I_L) runaway during start-up. Thermal shutdown provides reliable, fault-tolerant operation. High-duty cycle and low-dropout mode are provided for automotive cold crank conditions.

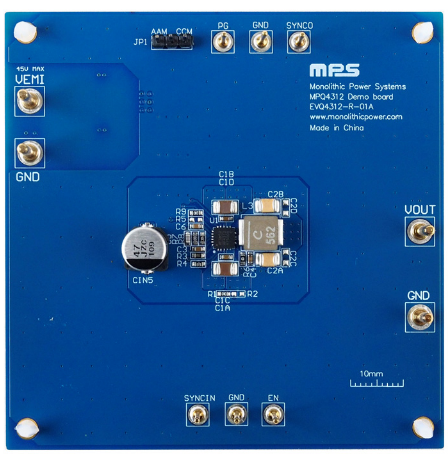
The EVQ4312-R-01A is fully assembled and tested. The MPQ4312 is available in a QFN-20 (4mmx4mm) package with wettable flanks, and is AEC-Q100 Grade 1 qualified.

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 2A	3.3V
Maximum output current (I_{OUT})	V_{IN} = 3.3V to 45V	2A
Typical efficiency	V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 2A	94.7%
Switching frequency (f_{SW})		410kHz

EVQ4312-R-01A EVALUATION BOARD



LxWxH (8.3cmx8.3cmx1.3cm)

Board Number	MPS IC Number
EVQ4312-R-01A	MPQ4312GRE-AEC1

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 $V_{IN} \geq 24V$.
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. 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 MPQ4312'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).

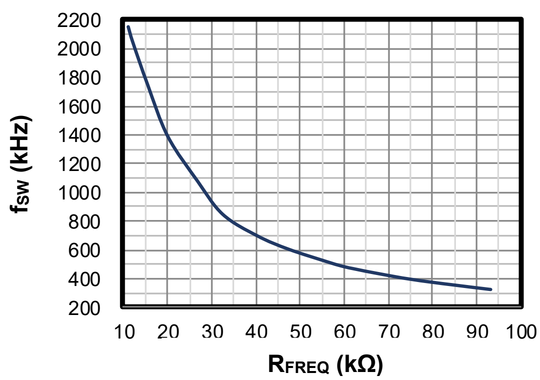


Figure 1: f_{SW} vs. R_{FREQ}

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 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 shows the measurement equipment set-up.

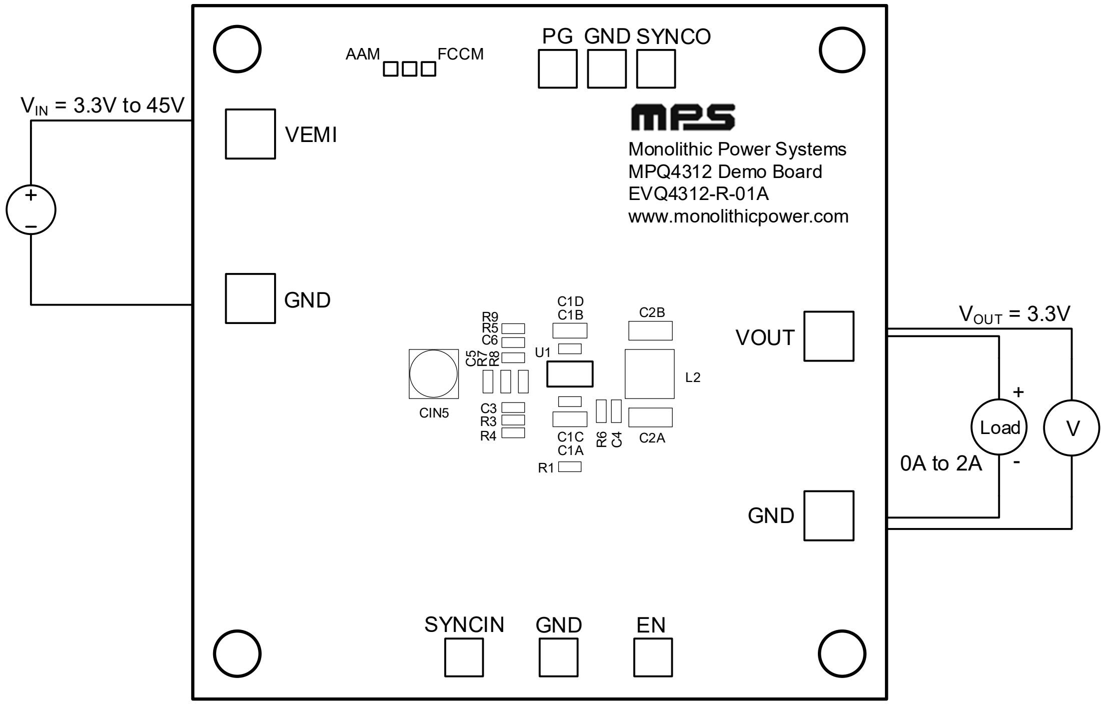
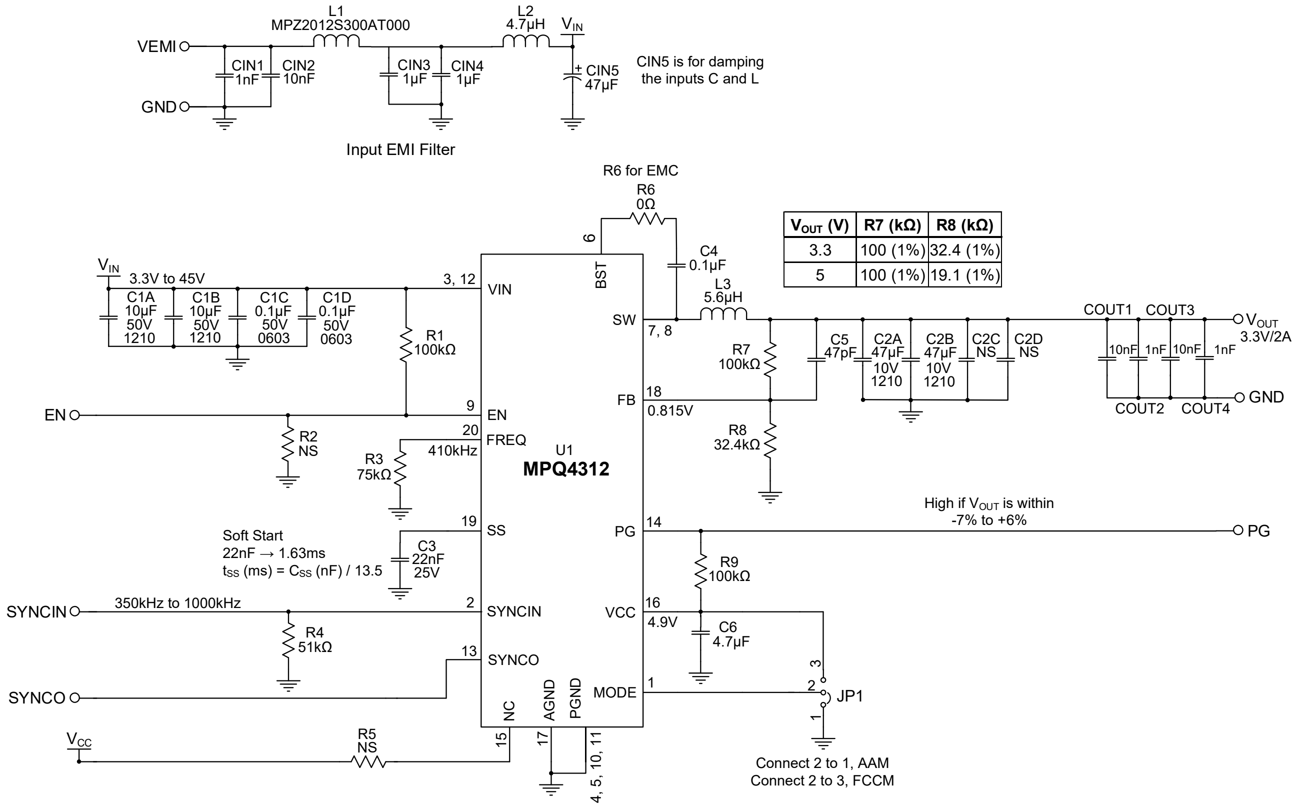


Figure 2: Measurement Equipment Set-Up

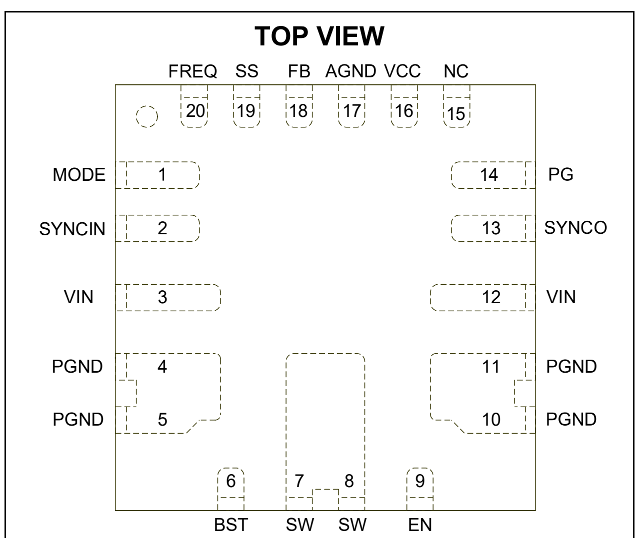
EVALUATION BOARD SCHEMATIC



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

Figure 3: Evaluation Board Schematic

PACKAGE REFERENCE



QFN-20 (4mmx4mm)

EVQ4312-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	0.1uF	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	30mΩ	Magnetic bead, 6A	0805	TDK	MPZ2012S300AT000
1	L2	4.7uH	Inductor, 31.5mΩ, 6A	SMD	Cyntec	VCMT063T-4R7MN5T
1	L3	5.6µH	Inductor, 14.5mΩ, 9.9A	SMD	Coilcraft	XAL6060-562MEC
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	MPQ4312	45V, 2A, step-down converter, AEC-Q100	QFN-20 (4mmx 4mm)	MPS	MPQ4312GRE-AEC1

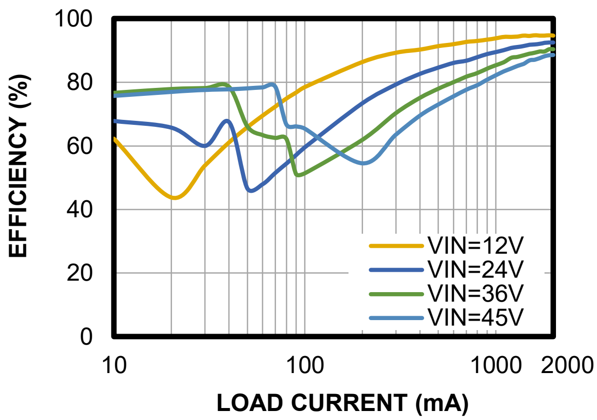
Note:

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

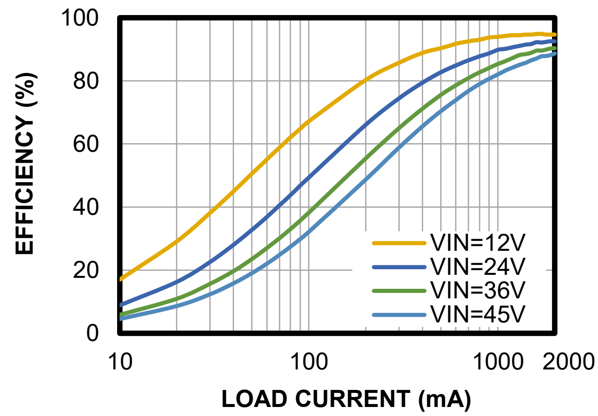
EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 5.6µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

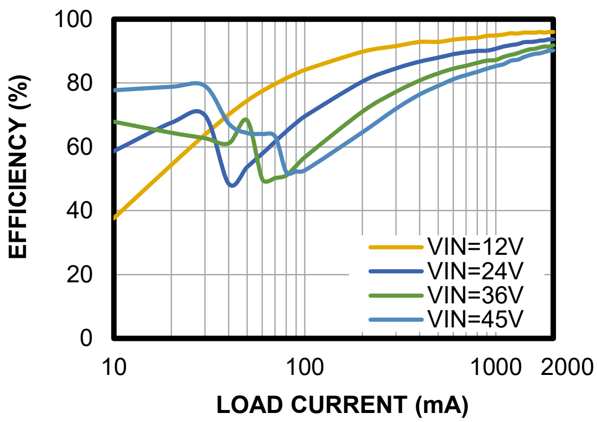
Efficiency vs. Load Current
AAM mode



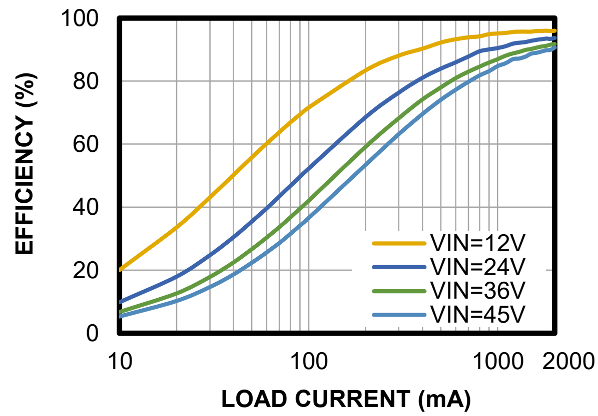
Efficiency vs. Load Current
FCCM



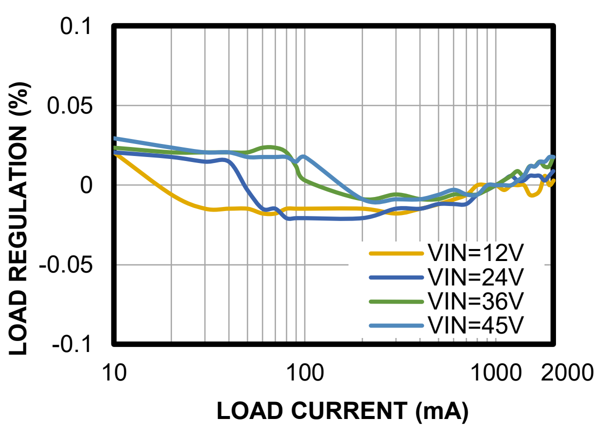
Efficiency vs. Load Current
AAM mode, V_{OUT} = 5V



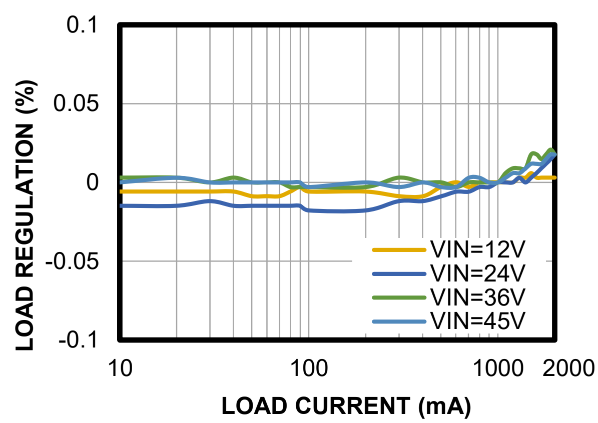
Efficiency vs. Load Current
FCCM, V_{OUT} = 5V



Load Regulation
AAM mode



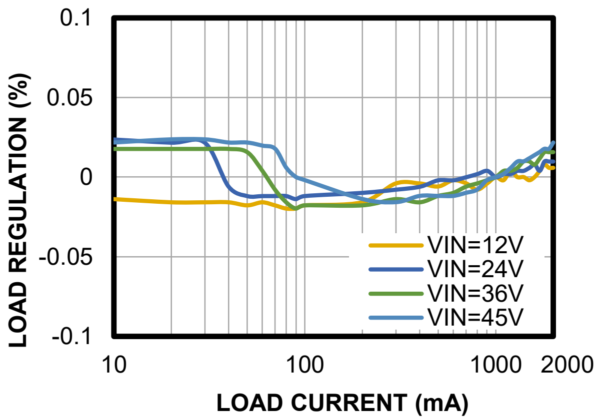
Load Regulation
FCCM



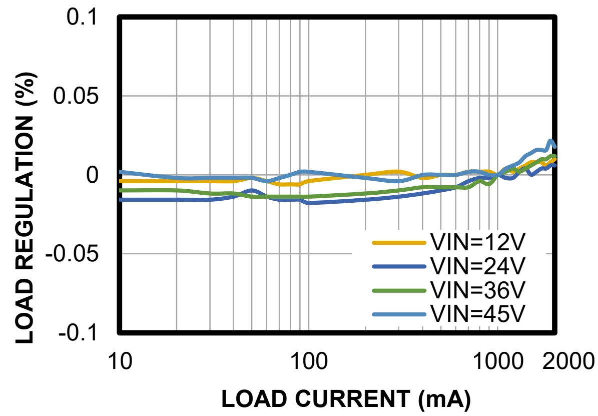
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 5.6µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

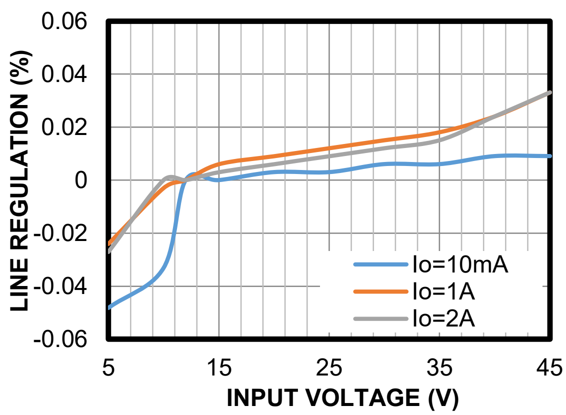
Load Regulation
AAM mode, V_{OUT} = 5V



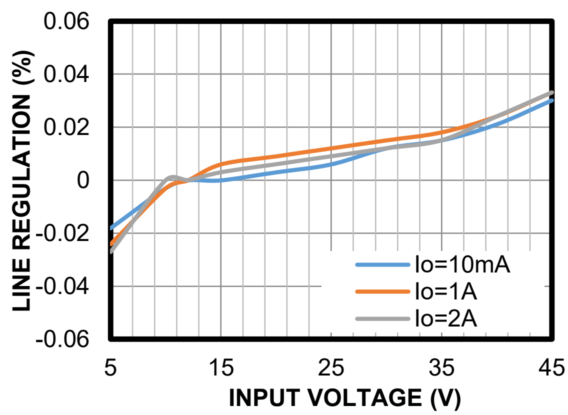
Load Regulation
FCCM, V_{OUT} = 5V



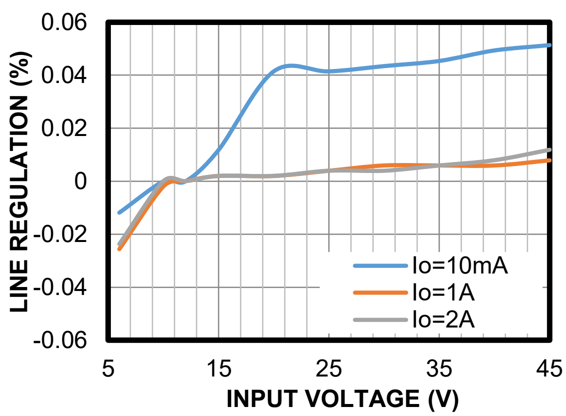
Line Regulation
AAM mode



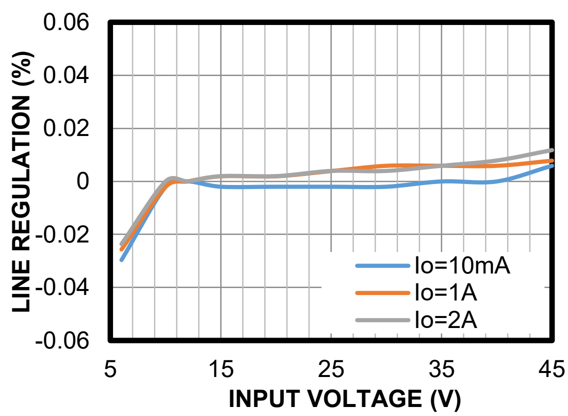
Line Regulation
FCCM



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



Line Regulation
FCCM, V_{OUT} = 5V

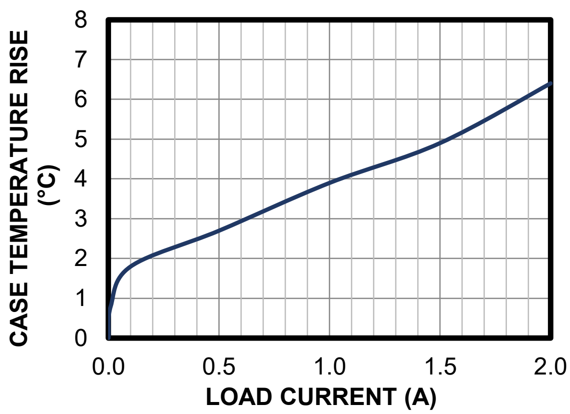


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 5.6µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

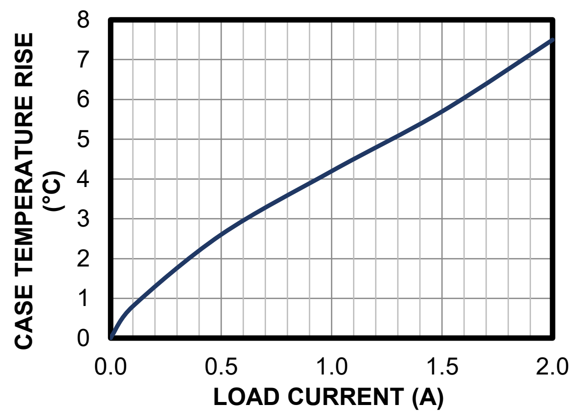
Case Temperature Rise

V_{OUT} = 3.3V

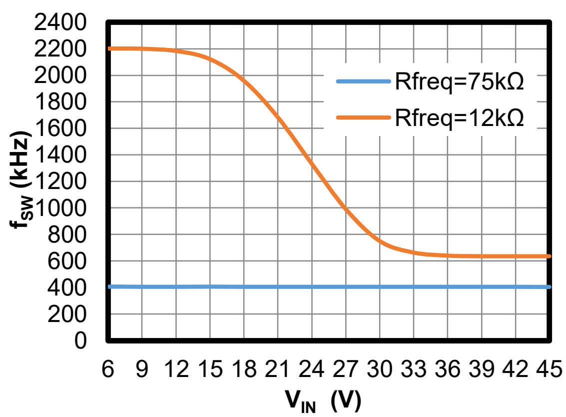


Case Temperature Rise

V_{OUT} = 5V

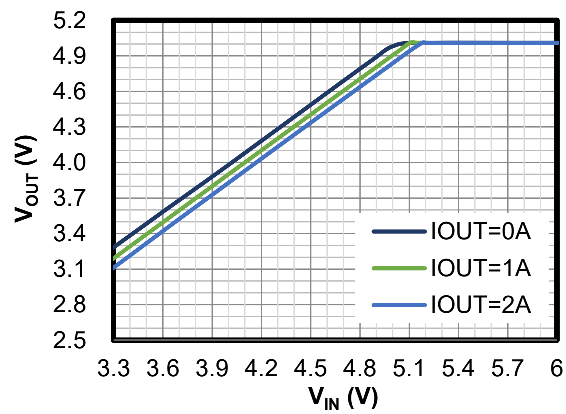


f_{SW} vs. V_{IN}



Low-Dropout Mode

V_{OUT} = 5V



EVB TEST RESULTS *(continued)*

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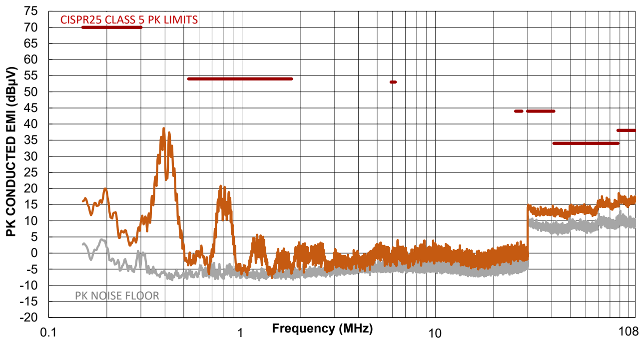
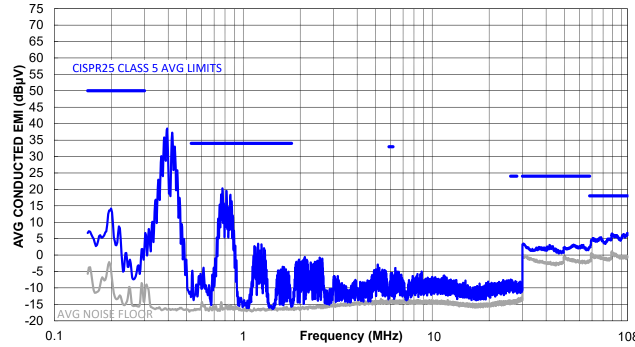
CISPR25 Class 5 Peak Conducted Emissions

150kHz to 108MHz



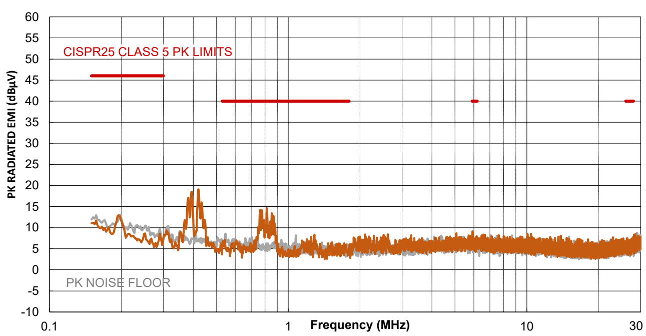
CISPR25 Class 5 Average Conducted Emissions

150kHz to 108MHz



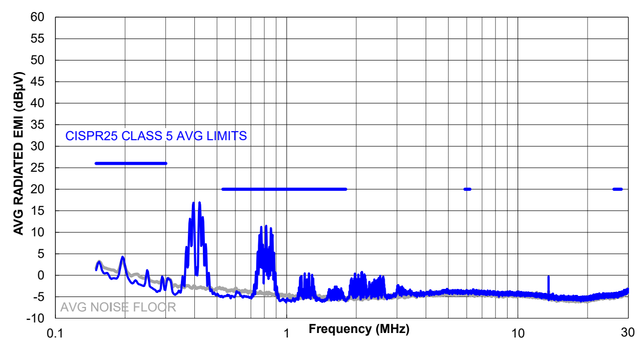
CISPR25 Class 5 Peak Radiated Emissions

150kHz to 30MHz



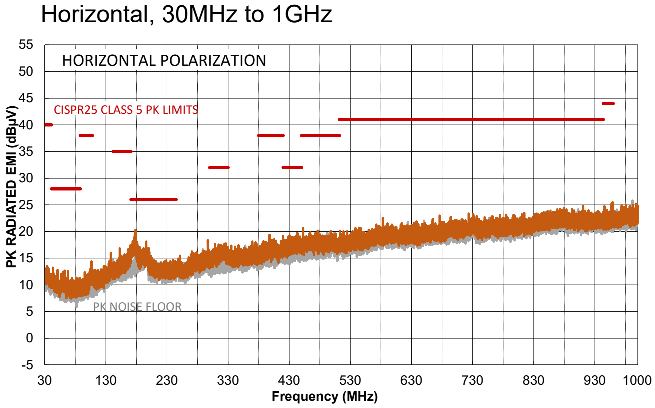
CISPR25 Class 5 Average Radiated Emissions

150kHz to 30MHz



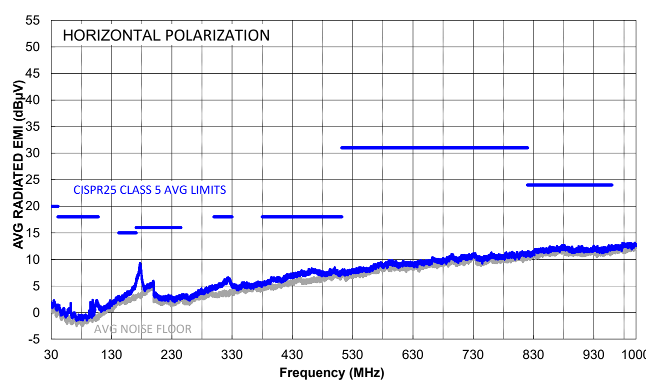
CISPR25 Class 5 Peak Radiated Emissions

Horizontal, 30MHz to 1GHz



CISPR25 Class 5 Average Radiated Emissions

Horizontal, 30MHz to 1GHz

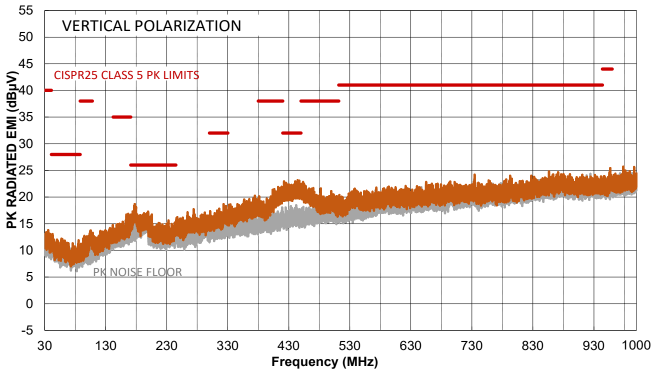


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 5.6µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

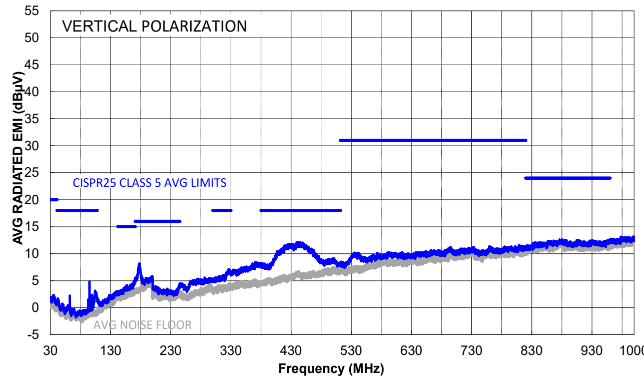
CISPR25 Class 5 Peak Radiated Emissions

Vertical, 30MHz to 1GHz



CISPR25 Class 5 Average Radiated Emissions

Vertical, 30MHz to 1GHz



EVB TEST RESULTS *(continued)*

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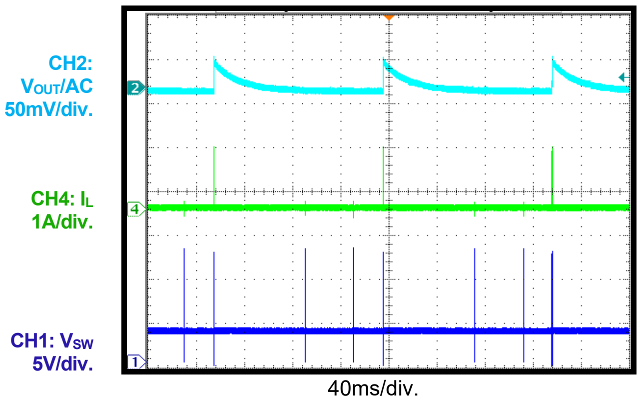
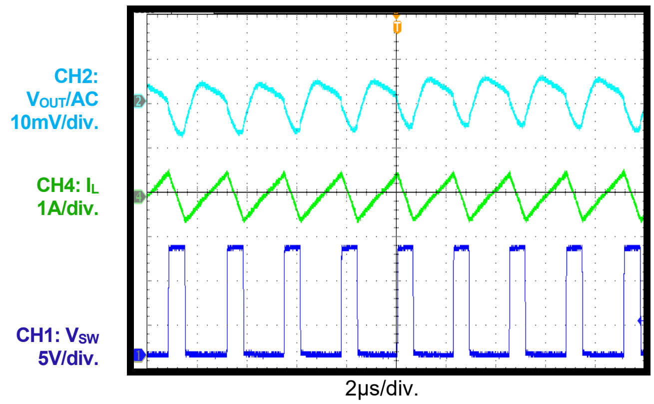
Steady State

I_{OUT} = 0A, AAM mode



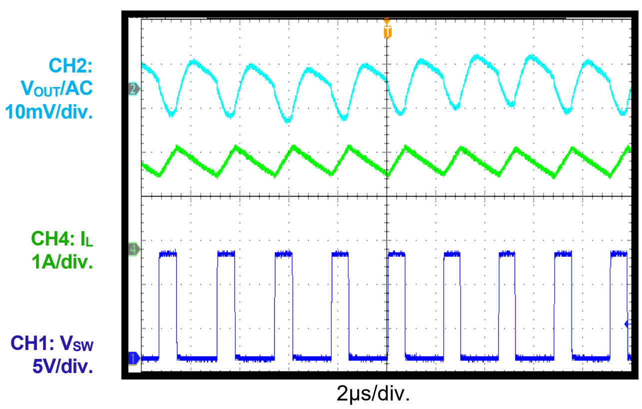
Steady State

I_{OUT} = 0A, FCCM



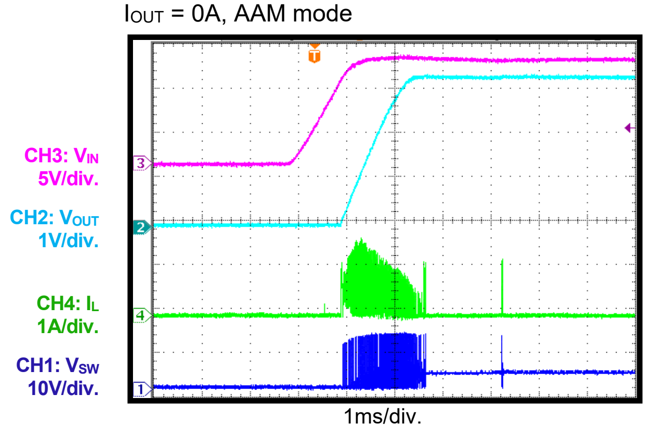
Steady State

I_{OUT} = 2A



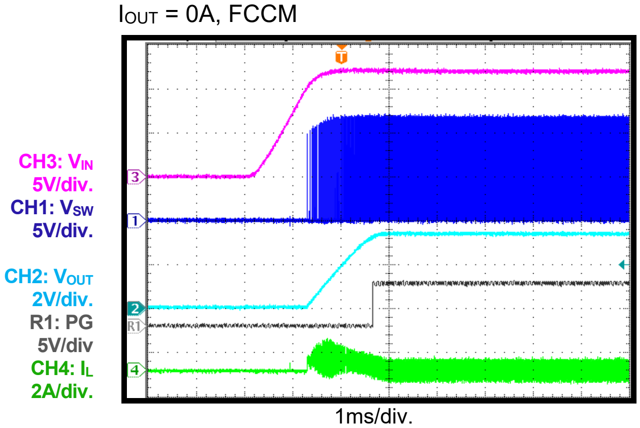
Start-Up through VIN

I_{OUT} = 0A, AAM mode



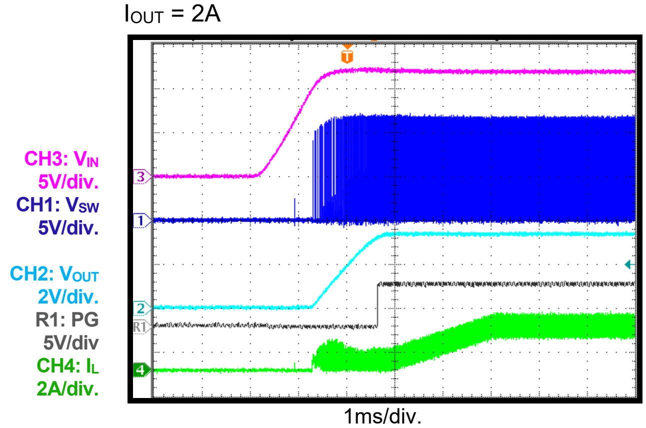
Start-Up through VIN

I_{OUT} = 0A, FCCM



Start-Up through VIN

I_{OUT} = 2A



EVB TEST RESULTS *(continued)*

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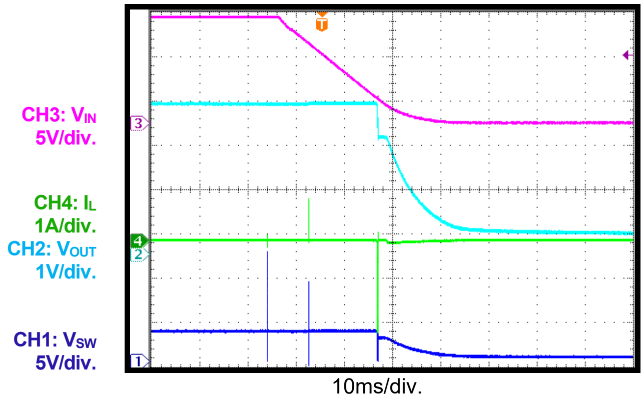
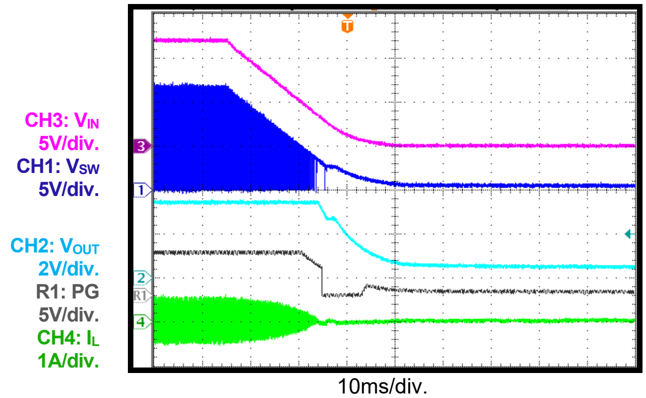
Shutdown through VIN

I_{OUT} = 0A, AAM mode



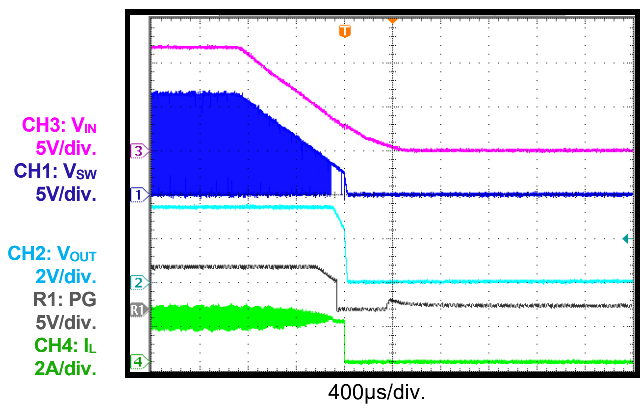
Shutdown through VIN

I_{OUT} = 0A, FCCM



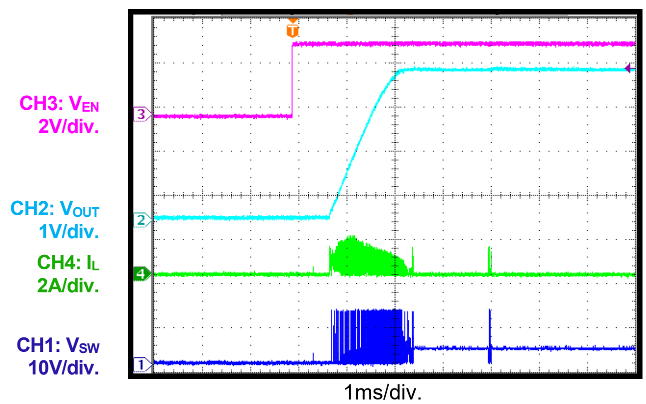
Shutdown through VIN

I_{OUT} = 2A



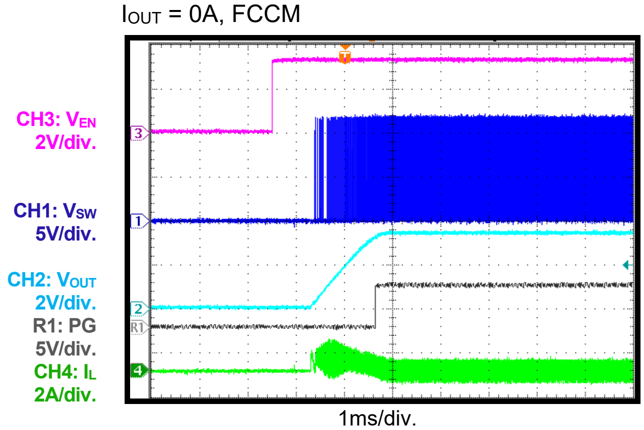
Start-Up through EN

I_{OUT} = 0A, AAM mode



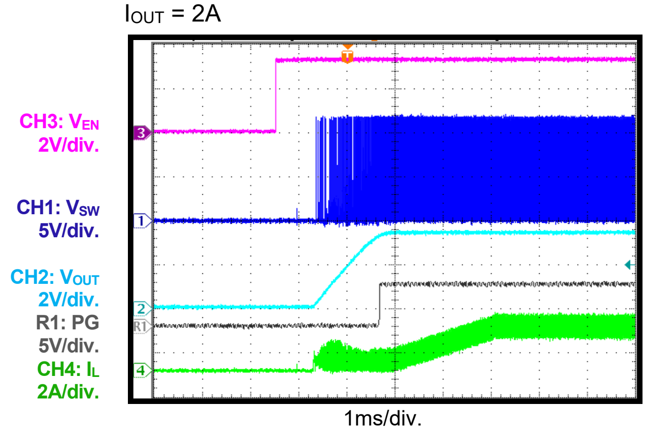
Start-Up through EN

I_{OUT} = 0A, FCCM



Start-Up through EN

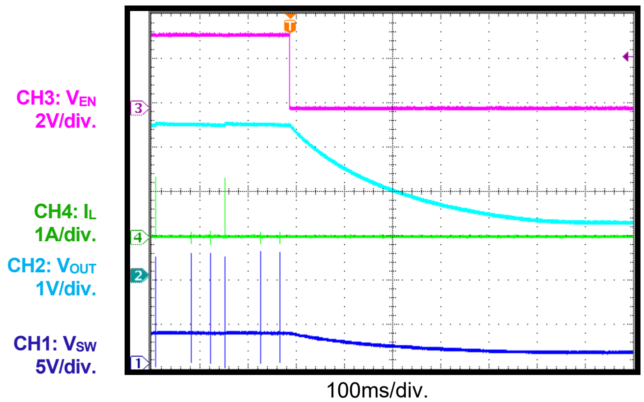
I_{OUT} = 2A



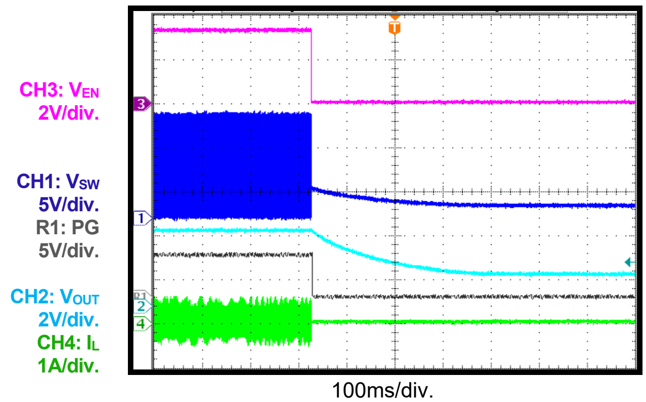
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 5.6µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

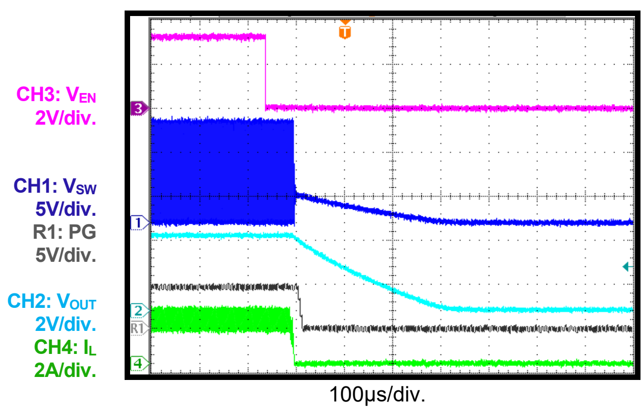
Shutdown through EN
I_{OUT} = 0A, AAM mode



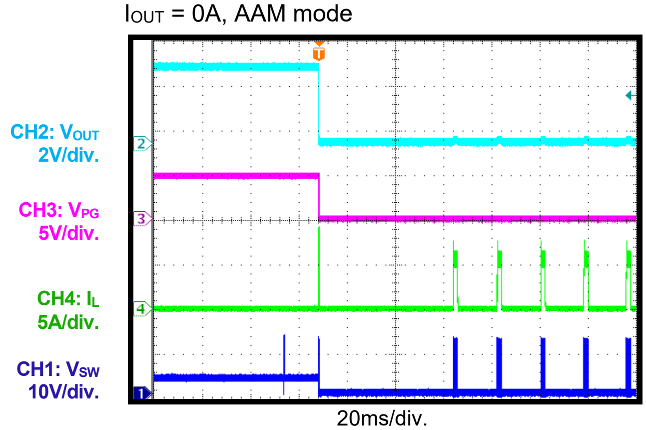
Shutdown through EN
I_{OUT} = 0A, FCCM



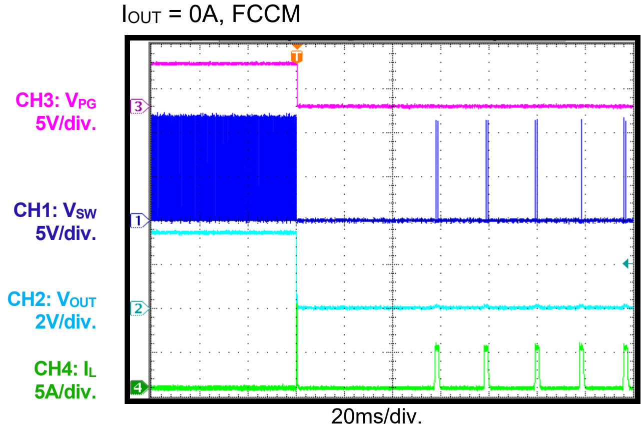
Shutdown through EN
I_{OUT} = 2A



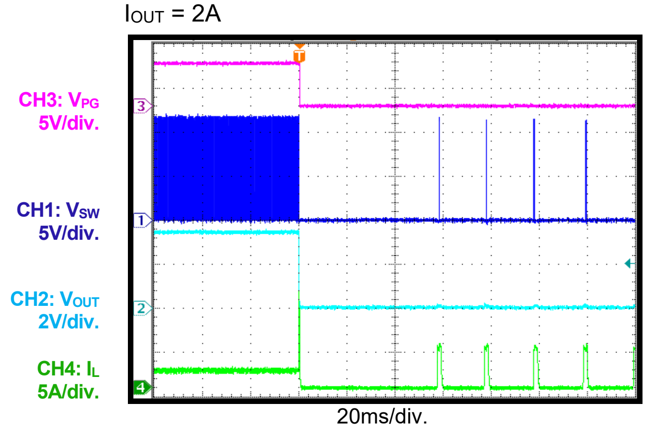
SCP Entry
I_{OUT} = 0A, AAM mode



SCP Entry
I_{OUT} = 0A, FCCM



SCP Entry
I_{OUT} = 2A

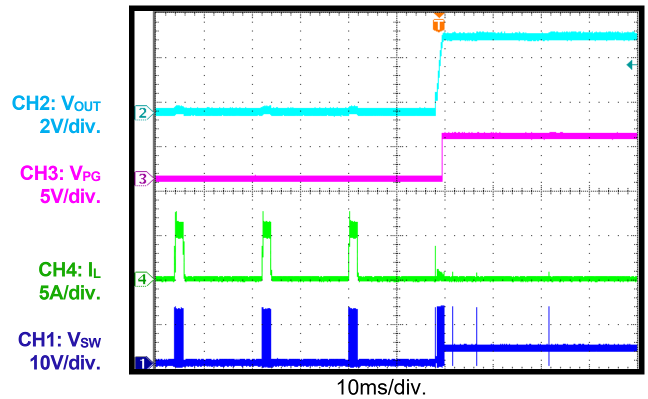


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 5.6µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

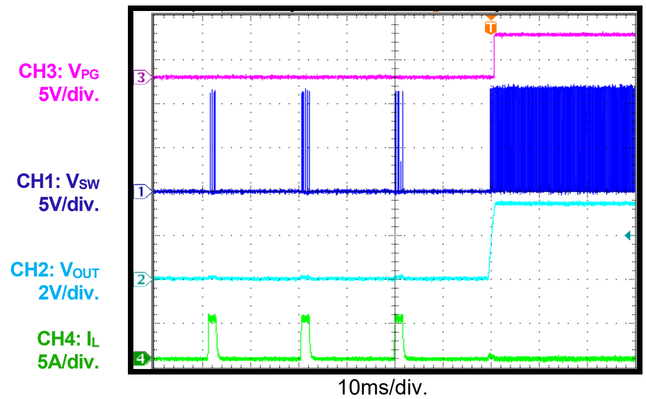
SCP Recovery

I_{OUT} = 0A, AAM mode



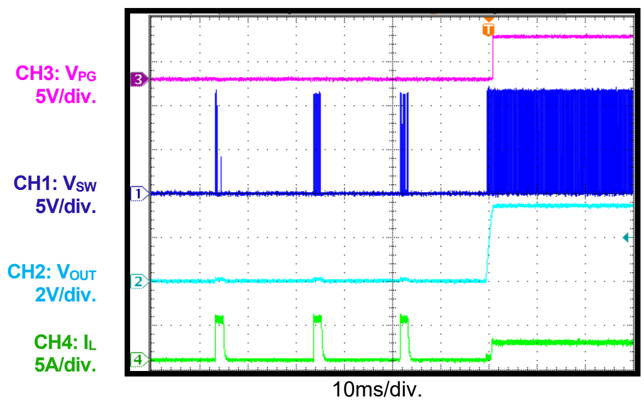
SCP Recovery

I_{OUT} = 0A, FCCM

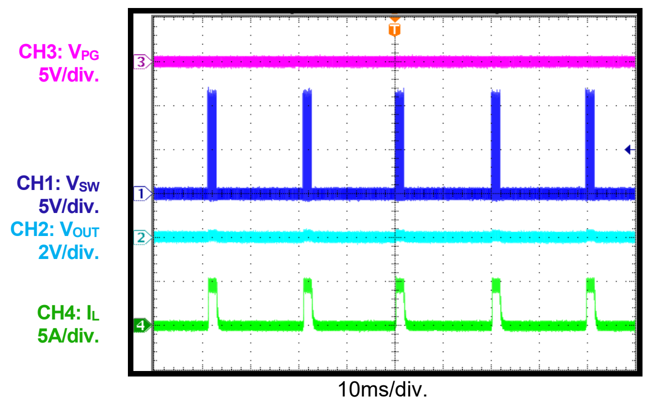


SCP Recovery

I_{OUT} = 2A

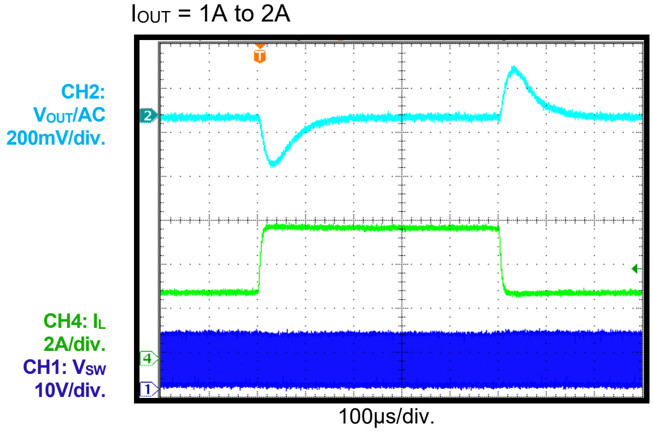


SCP Steady State



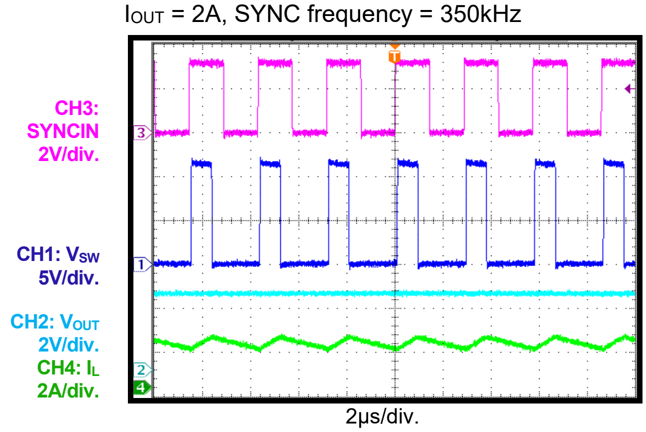
Load Transient

I_{OUT} = 1A to 2A



SYNC Operation

I_{OUT} = 2A, SYNC frequency = 350kHz

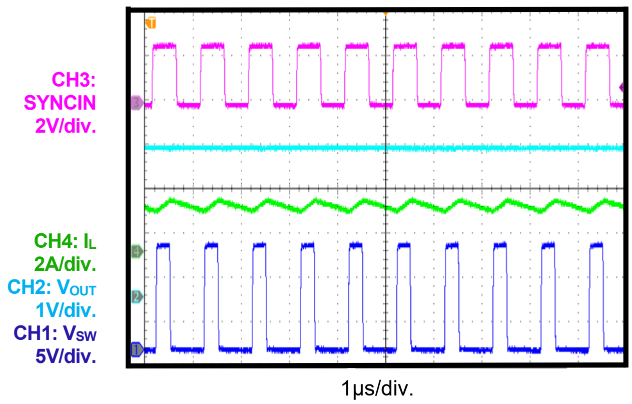


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 5.6µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

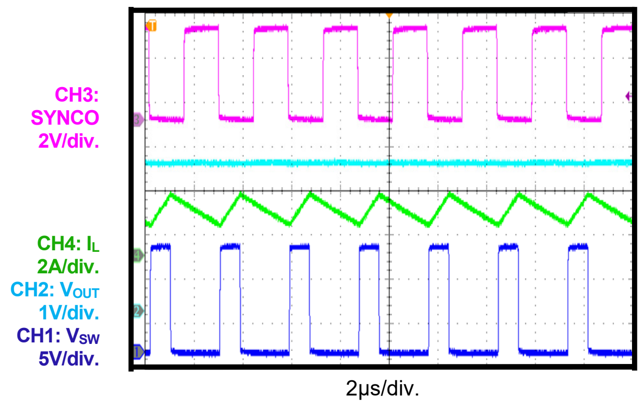
SYNC Operation

I_{OUT} = 2A, SYNC frequency = 1000kHz



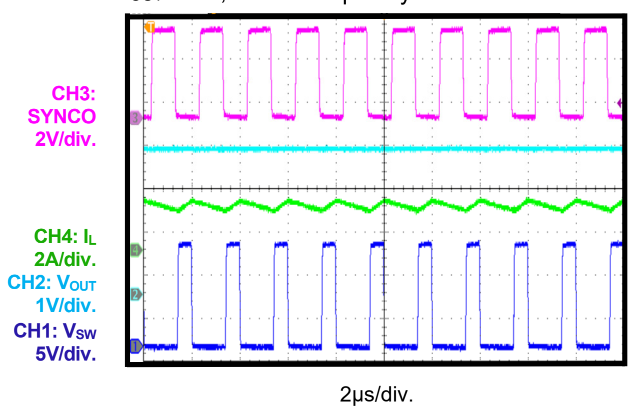
SYNCO Operation

I_{OUT} = 2A, SYNC frequency = 350kHz



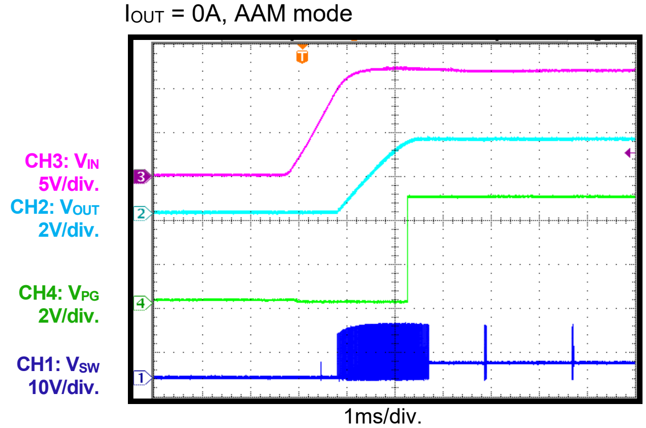
SYNCO Operation

I_{OUT} = 2A, SYNC frequency = 530kHz



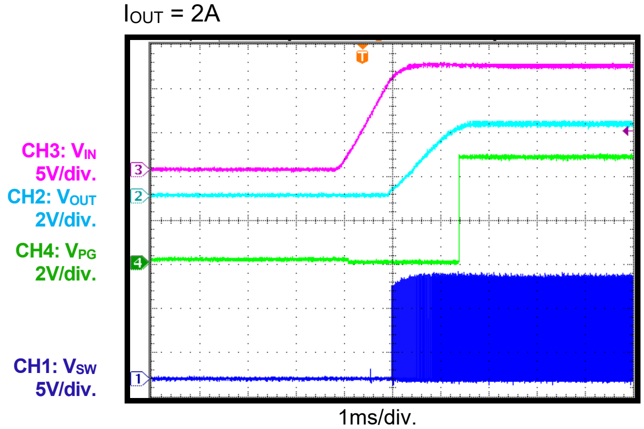
PG in Start-Up through VIN

I_{OUT} = 0A, AAM mode



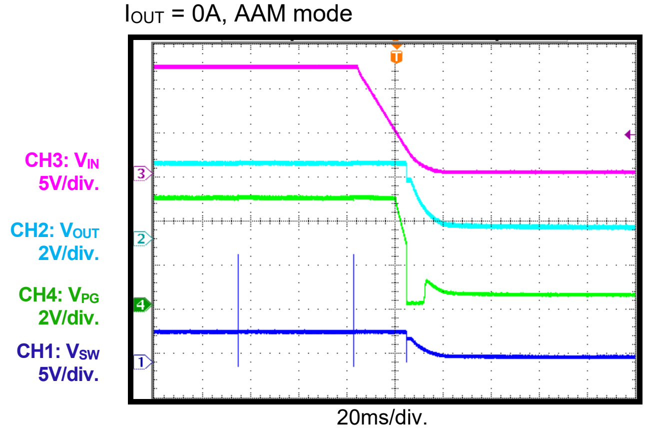
PG in Start-Up through VIN

I_{OUT} = 2A



PG in Shutdown through VIN

I_{OUT} = 0A, AAM mode

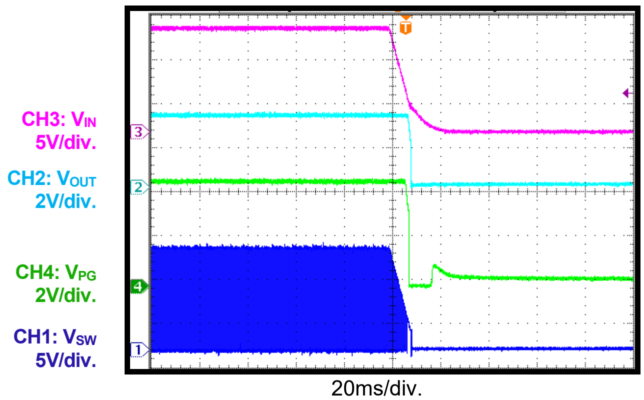


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 5.6µH, f_{SW} = 410kHz, T_A = 25°C, unless otherwise noted.

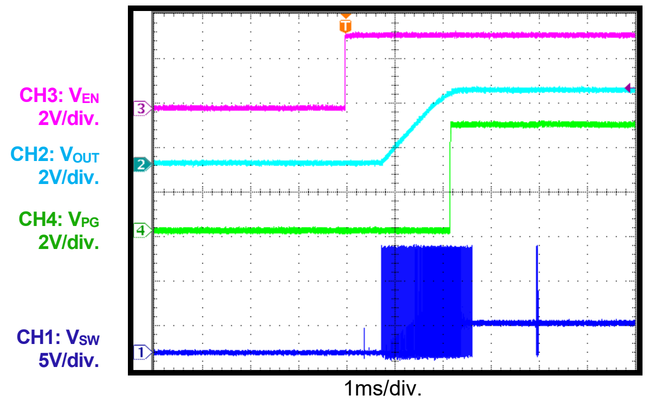
PG in Shutdown through VIN

I_{OUT} = 2A



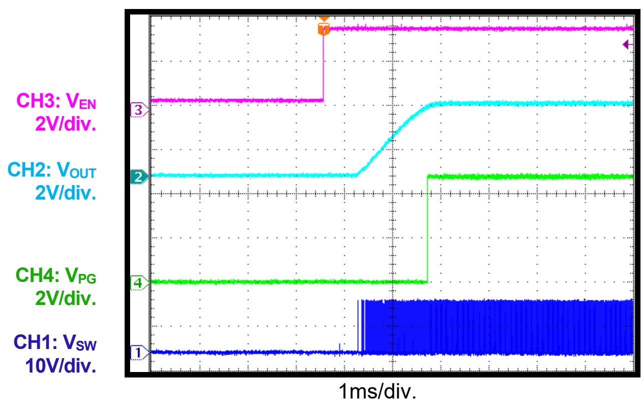
PG in Start-Up through EN

I_{OUT} = 0A, AAM mode



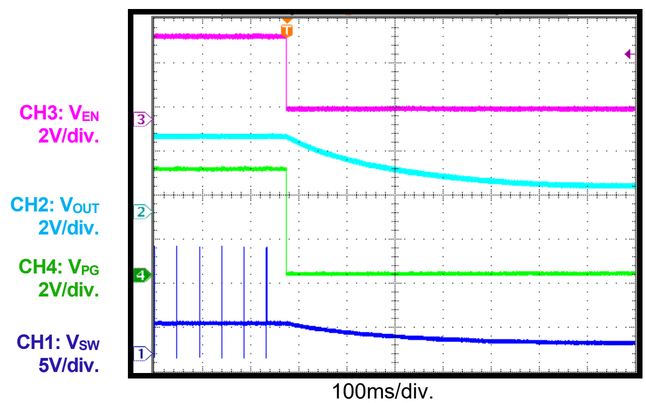
PG in Start-Up through EN

I_{OUT} = 2A



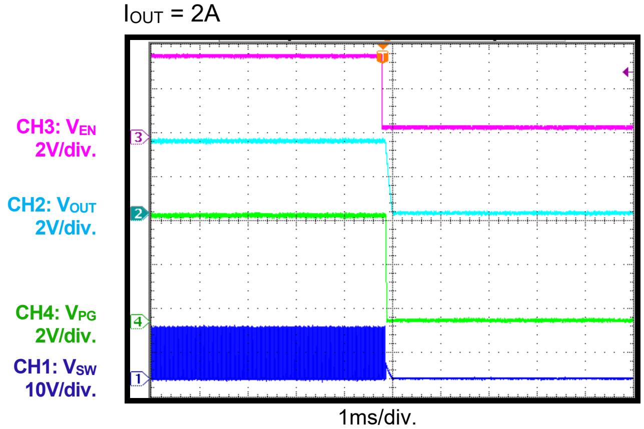
PG in Shutdown through EN

I_{OUT} = 0A, AAM mode



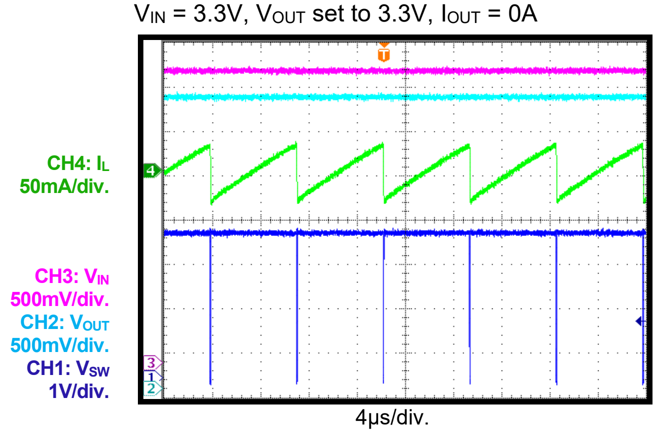
PG in Shutdown through EN

I_{OUT} = 2A



Low-Dropout Mode

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



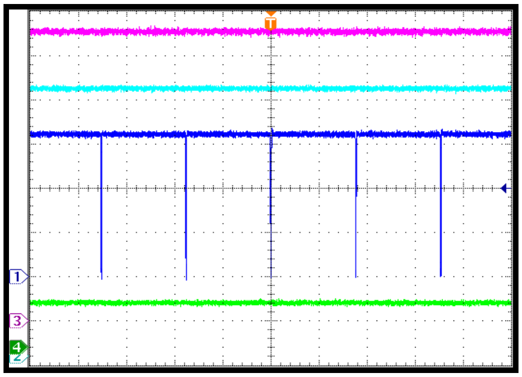
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, V_{OUT} = 3.3V, C_{OUT} = 2 x 47µF, L = 5.6µH, 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} = 2A

CH1: V_{SW} 1V/div.
CH3: V_{IN} 500mV/div.
CH4: I_L 2A/div.
CH2: V_{OUT} 500mV/div.

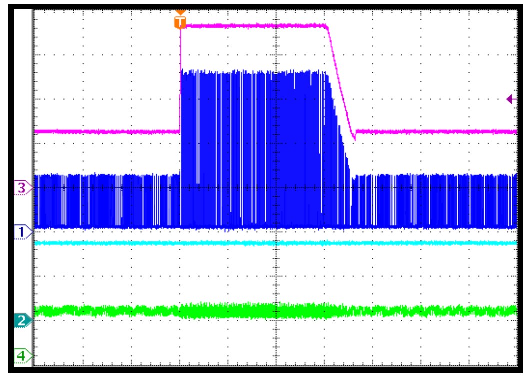


4µs/div.

Load Dump

V_{IN} = 12V to 36V, I_{OUT} = 2A

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

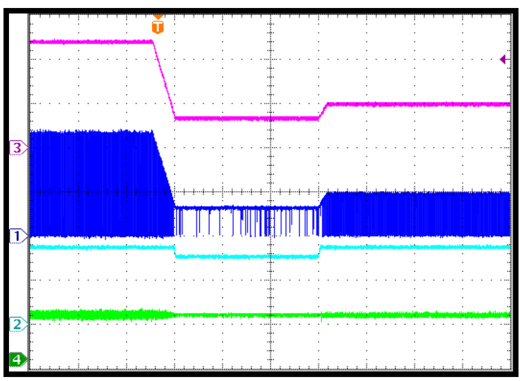


100ms/div.

Cold Crank

V_{IN} = 12V to 3.3V to 5V, I_{OUT} = 2A

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

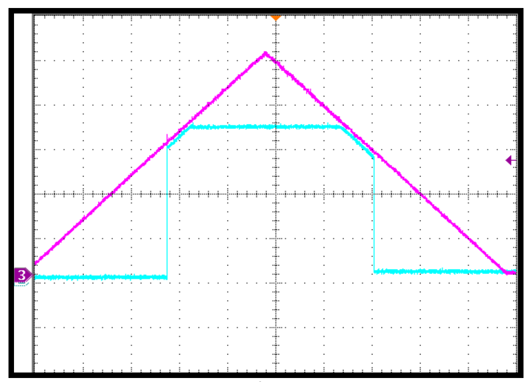


40ms/div.

V_{IN} Ramping Up and Down

I_{OUT} = 0.1A

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

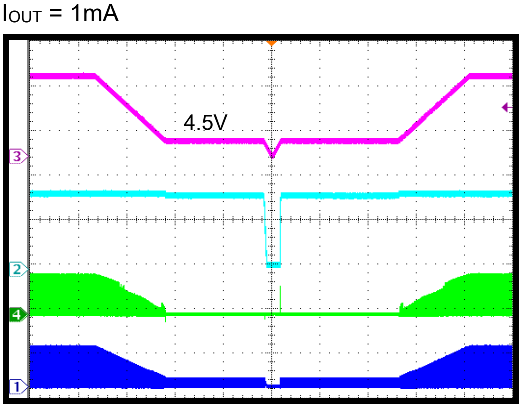


1s/div.

V_{IN} Ramping Down and Up

I_{OUT} = 1mA

CH3: V_{IN} 10V/div.
CH2: V_{OUT} 2V/div.
CH4: I_L 2A/div.
CH1: V_{SW} 20V/div.

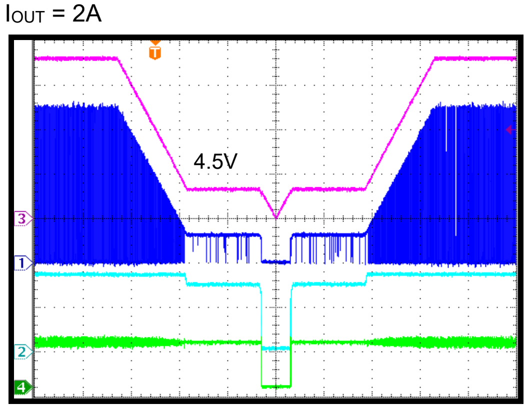


10s/div.

V_{IN} Ramping Down and Up

I_{OUT} = 2A

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



10s/div.

PCB LAYOUT (2)

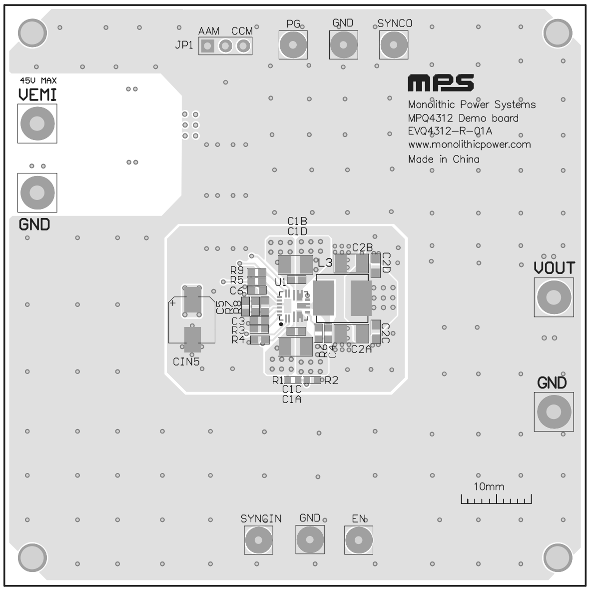


Figure 4: Top Silk and Top Layer

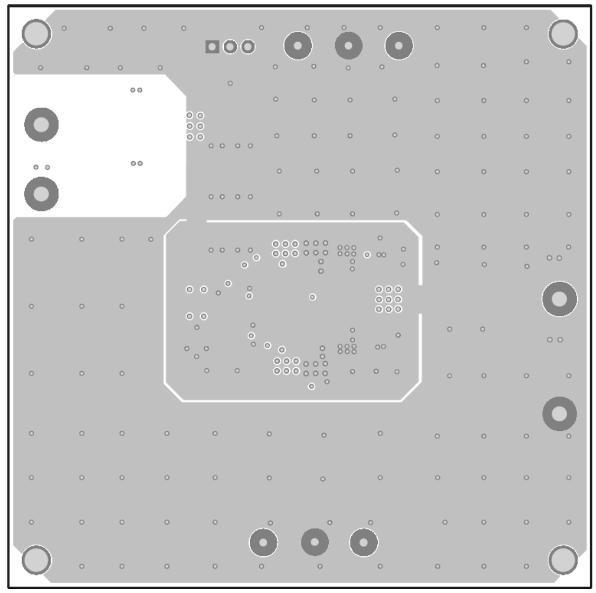


Figure 5: Mid-Layer 1

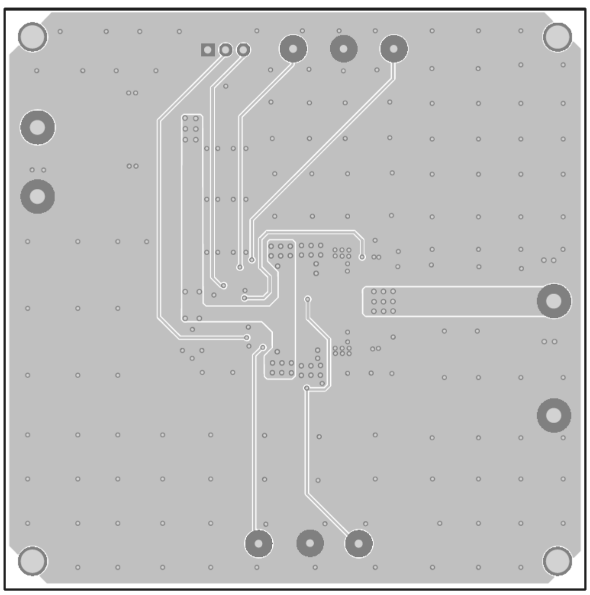


Figure 6: Mid-Layer 2

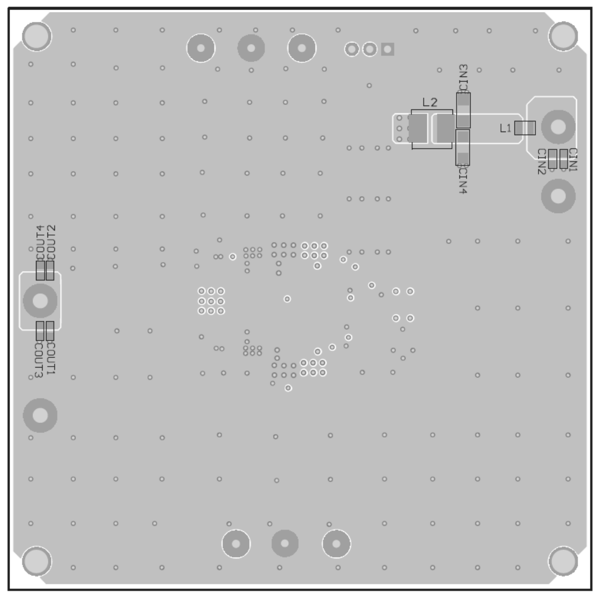


Figure 7: Bottom Layer and Bottom Silk

Note:

2) The copper thickness is 2oz.

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	5/26/2022	Initial Release	-