EVQ3524-D-4000-00A

20V, 4A Peak, Low Quiescent Current, Synchronous, Step-Down Converter Evaluation Board, AEC-Q100 Qualified

DESCRIPTION

The EVQ3524-D-4000-00A evaluation board is designed to demonstrate the capabilities of the MPQ3524GDE-4000-AEC1, a configurable-frequency (350kHz to 2.5MHz), synchronous, step-down switching regulator with integrated, internal high-side and low-side MOSFETs (HS-FETs and LS-FETs, respectively).

The MPQ3524GDE-4000-AEC1 provides up to 4A peak of highly efficient output current (I_{OUT}) with peak current mode control. The wide 3.3V to 20V input voltage (V_{IN}) range accommodates a variety of step-down applications in automotive input environments, such as 12V and 5V buses and multi-cell Li-ion batteries. A 1µA shutdown mode quiescent current (I_Q) 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 loads 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.

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

The EVQ3524-D-4000-00A is fully assembled and tested. The MPQ3524GDE-4000-AEC1 is available in a QFN-12 (2mmx3mm) package with wettable flanks, and is AEC-Q100 qualified.

PERFORMANCE SUMMARY

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

Parameters	Conditions	Value
Input voltage (V_{IN}) range		3.3V to 20V
Output voltage (V_{OUT})	V_{IN} = 6V to 20V, I_{OUT} = 0A to 4A	5V
Maximum output current (I_{OUT})	V_{IN} = 3.3V to 20V	4A
Typical efficiency	V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 4A	92.2%
Peak efficiency	V_{IN} = 8V, V_{OUT} = 5V, I_{OUT} = 1A	96.9%
Switching frequency (f_{SW})		2.2MHz

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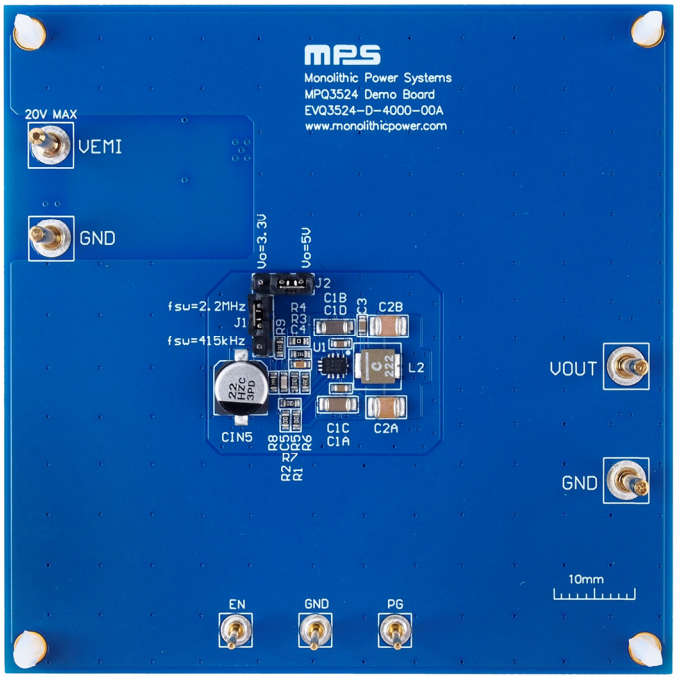
EVQ3524-D-4000-00A EVALUATION BOARD



LxWxH (8.3cmx8.3cmx1cm)

Board Number	MPS IC Number
EVQ3524-D-4000-00A	MPQ3524GDE-4000-AEC1

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QUICK START GUIDE

The EVQ3524-D-4000-00A evaluation board is easy to set up and use to evaluate the performance of the MPQ3524. For proper measurement equipment set-up, refer to Figure 2 on page 4 and follow the steps below:

1. Preset the power supply (V_{IN}) to be between 3.3V and 20V, then turn off the power supply.
2. Set the load current to be between 0A and 4A (peak). 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.
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.
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 EN function is not used, EN can be connected directly to VIN.
8. Connect a resistor between the FREQ and GND pins to set the internal switching frequency (f_{SW}).
9. The external resistor divider sets the output voltage (V_{OUT}) (see Figure 1).

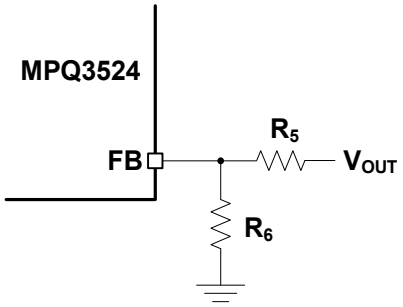

Figure 1: Feedback Divider Network with Adjustable Output

R5 is selected to be at 100kΩ. R6 can then be calculated using Equation (1):

$$R_6 = \frac{R_5}{\frac{V_{OUT}}{0.8V} - 1} \quad (1)$$

Refer to the Application Information section in the MPQ3524 datasheet to calculate the inductance (L) and output capacitance (C_{OUT}) for different V_{OUT} values.

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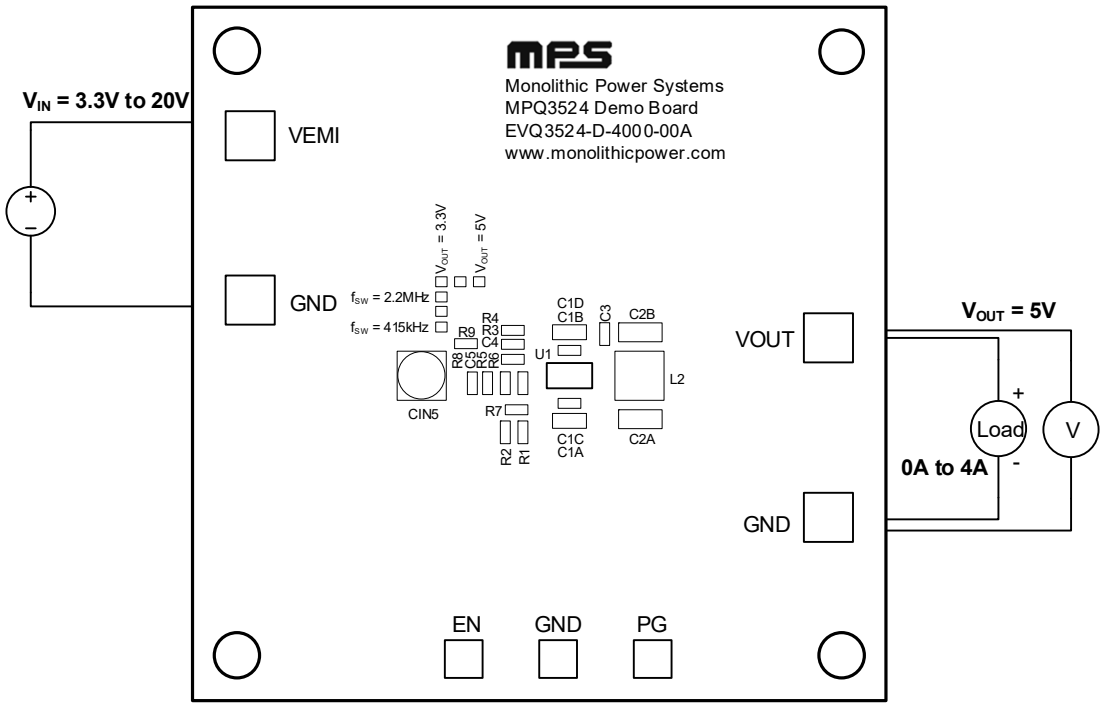

Figure 2: Measurement Equipment Set-Up

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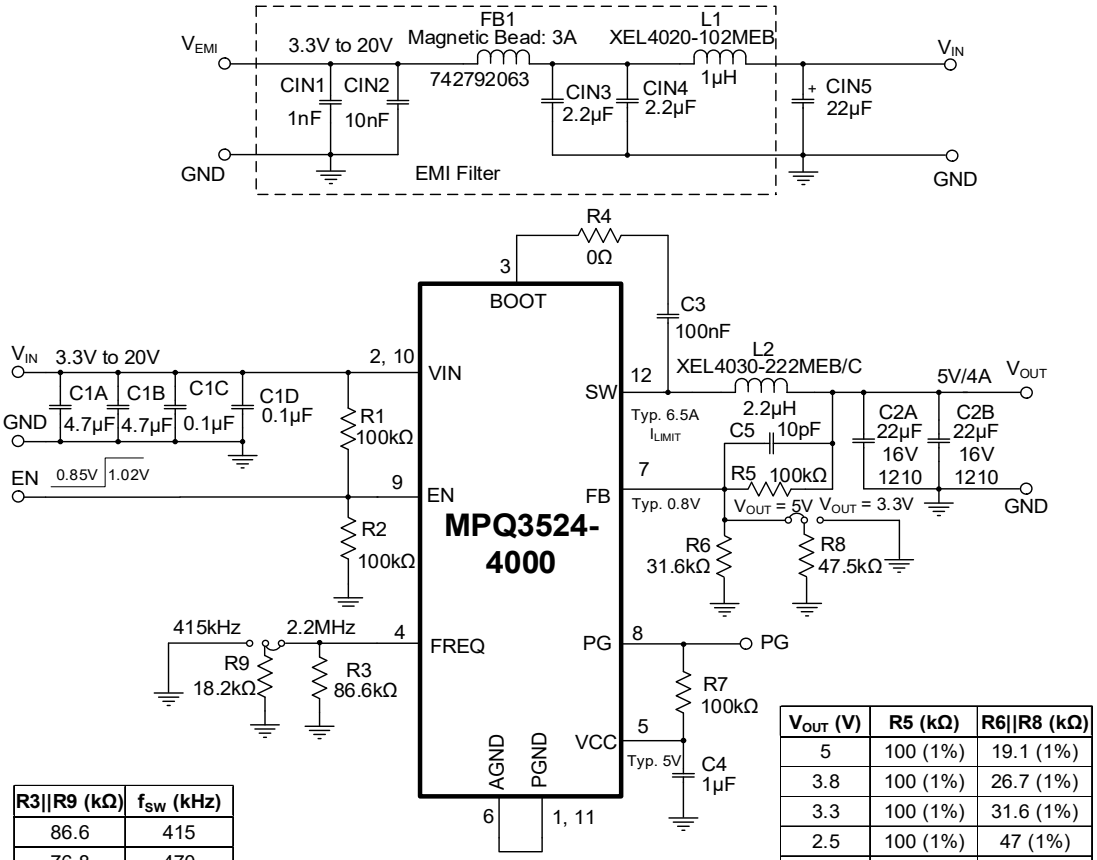
EVALUATION BOARD SCHEMATIC

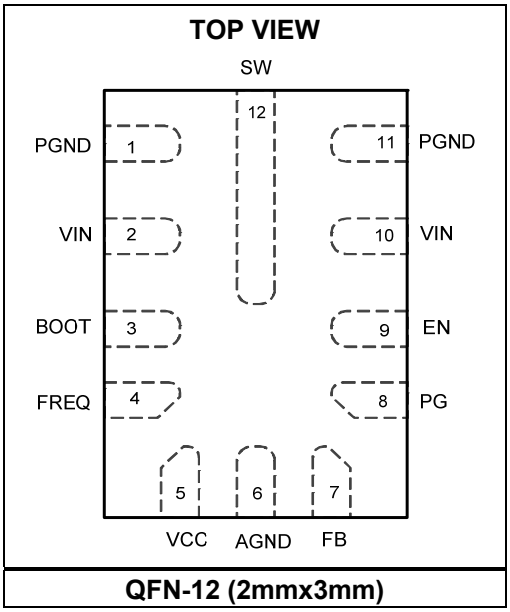


R3||R9 (kΩ)	f_{SW} (kHz)
86.6	415
76.8	470
34.8	1000
15	2200
13.3	2500

V_{OUT} (V)	R5 (kΩ)	R6||R8 (kΩ)
5	100 (1%)	19.1 (1%)
3.8	100 (1%)	26.7 (1%)
3.3	100 (1%)	31.6 (1%)
2.5	100 (1%)	47 (1%)
1.8	100 (1%)	80 (1%)
1	24.9 (1%)	100 (1%)

Figure 3: Evaluation Board Schematic

PACKAGE REFERENCE



QFN-12 (2mmx3mm)

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EVQ3524-D-4000-00A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
1	CIN1	1nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM216R71H102KA01
1	CIN2	10nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H103KA01D
2	CIN3, CIN4	4.7µF	Ceramic capacitor, 50V, X7R	0805	Murata	GRM21BR61H475KE51
1	CIN5	22µF	Aluminum polymer capacitor, 50V	SMD	Panasonic	EEHZC1H220P
2	C1A, C1B	4.7µF	Ceramic capacitor, 50V, X7S	1206	Murata	GRM31CR71H475KA12L
3	C1C, C1D, C3	100nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H104KA93D
2	C2A, C2B	22µF	Ceramic capacitor, 25V, X7R	1210	Murata	GRM32ER71C226KEA8L
1	C5	10pF	Ceramic capacitor, 50V, NP0	0603	Wurth	885012006051
1	C4	1µF	Ceramic capacitor, 25V, X7R	0603	Murata	GCM188R71E105KA64D
1	FB1	3A	Magnetic bead	0805	Wurth	742792063
1	L1	1µH	Inductor, 14.6mΩ, 9.6A	SMD	Coilcraft	XEL4020-102MEB
1	L2	2.2µH	Inductor, 22.1mΩ, 5.8A	SMD	Coilcraft	XEL4030-222MEB
4	R1, R5, R7, R2	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
1	R6	31.6kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0731K6L
1	R3	86.6kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0786K6L
1	R8	47.5kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0747K5L
1	R9	18.2kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0718K2L
1	R4	0Ω	Film resistor, 5%	0603	Yageo	RC0603JR-070RL
2	J1, J2	2.54mm	3-pin, test pin	DIP	Any	
4	VEMI, GND, VOUT, GND	2mm	Golden pin	DIP	Custom (1)	
3	PG, EN, GND	1mm	Golden pin	DIP	Custom (1)	
1	U1	MPQ3524 -AEC1	20V, 4A peak, configurable-frequency, low quiescent current (I_Q), synchronous, step-down converter, AEC-Q100 qualified	QFN-12 (2mmx 3mm)	MPS	MPQ3524GDE-4000-AEC1

Note:

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

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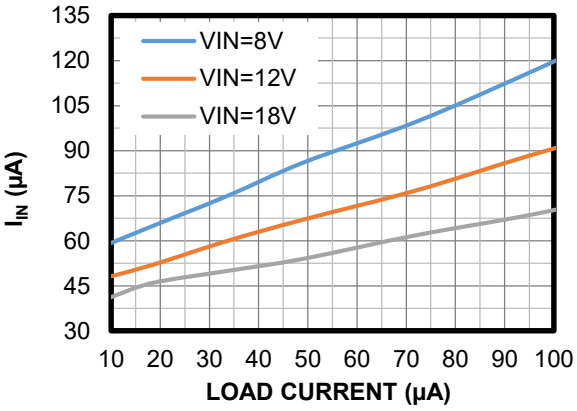
EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, T_A = 25°C, unless otherwise noted.

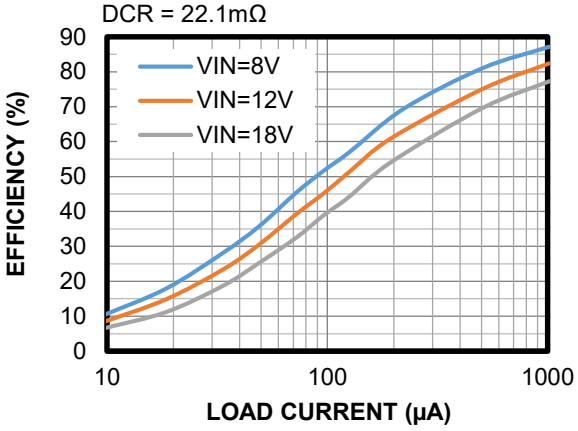
Input Current vs. Load Current

R_{FB1} = 100kΩ, R_{FB2} = 19.1kΩ,
DCR = 22.1mΩ



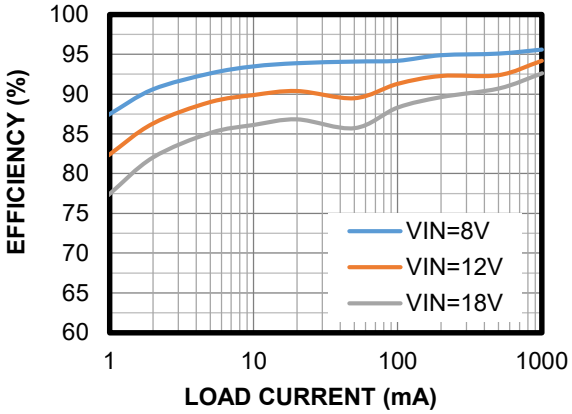
Efficiency vs. Load Current

R_{FB1} = 100kΩ, R_{FB2} = 19.1kΩ,
DCR = 22.1mΩ



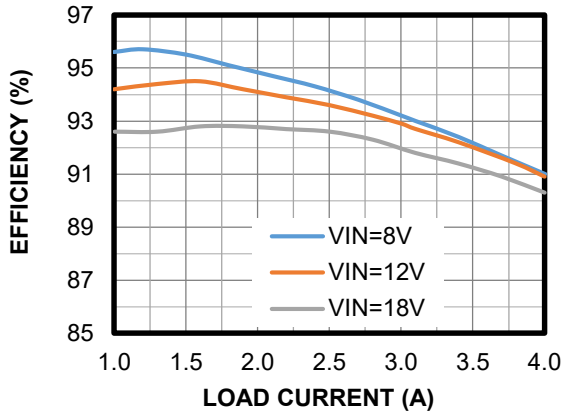
Efficiency vs. Load Current

DCR = 22.1mΩ



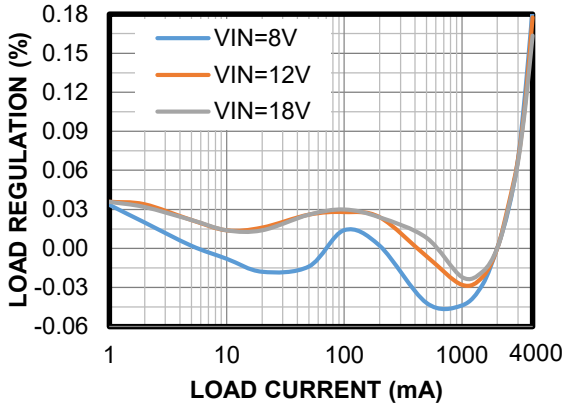
Efficiency vs. Load Current

DCR = 22.1mΩ



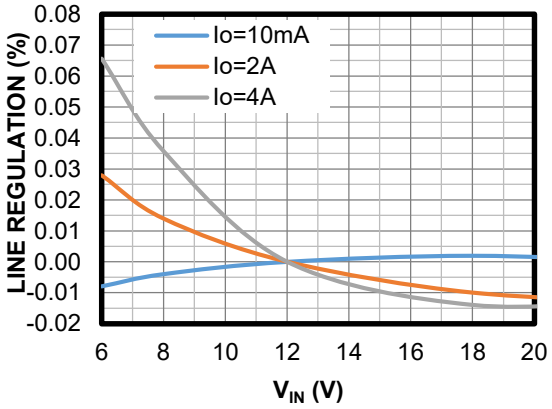
Load Regulation

DCR = 22.1mΩ



Line Regulation

DCR = 22.1mΩ



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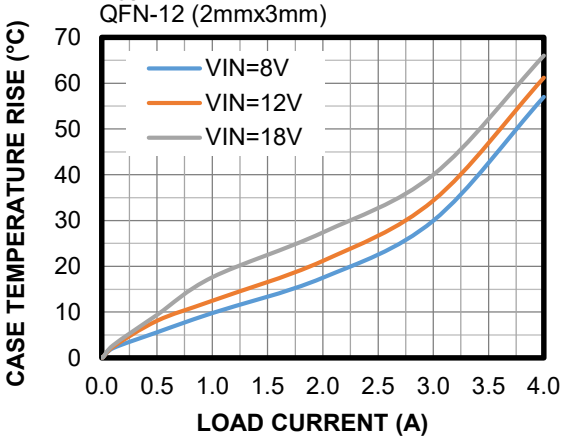
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, T_A = 25°C, unless otherwise noted.

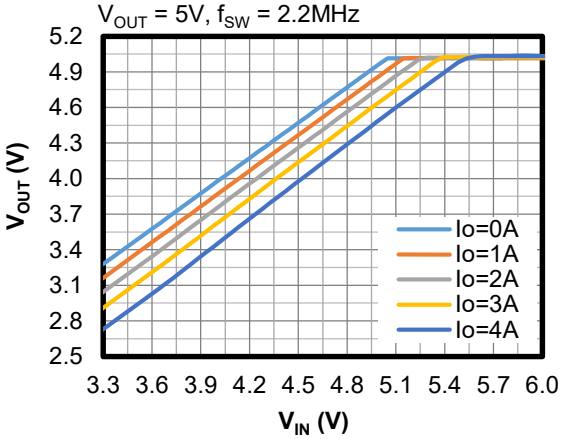
Case Temperature Rise

V_{OUT} = 5V, f_{SW} = 2.2MHz, QFN-12 (2mmx3mm)



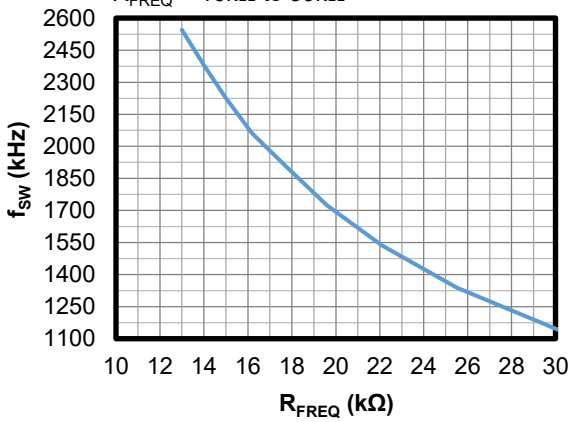
Low-Dropout Mode

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



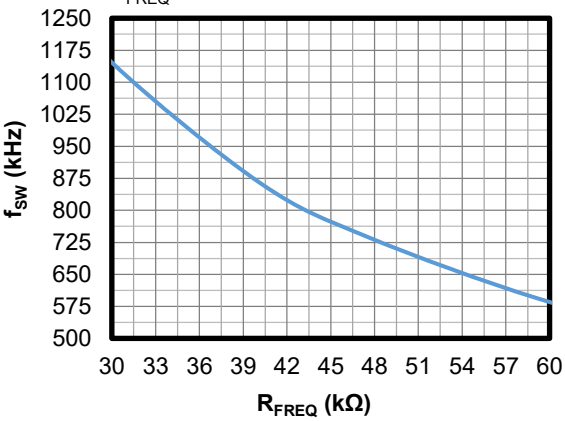
f_{SW} vs. R_{FREQ}

R_{FREQ} = 10kΩ to 30kΩ



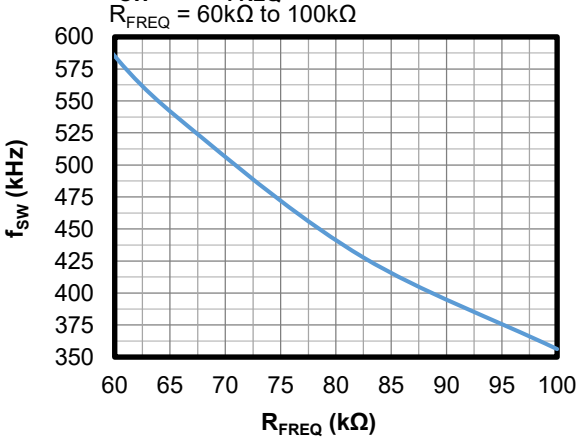
f_{SW} vs. R_{FREQ}

R_{FREQ} = 30kΩ to 60kΩ



f_{SW} vs. R_{FREQ}

R_{FREQ} = 60kΩ to 100kΩ



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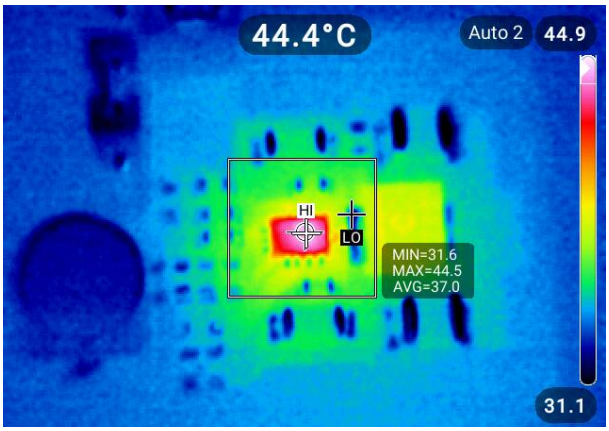
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, T_A = 25°C, unless otherwise noted.

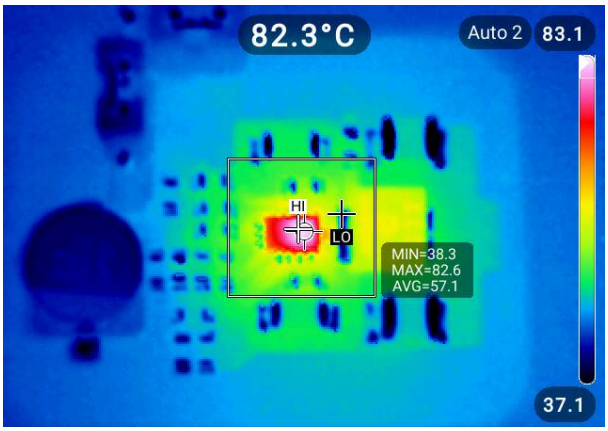
Thermal Performance

I_{OUT} = 2A, no forced airflow, T_{CASE} = 44.5°C



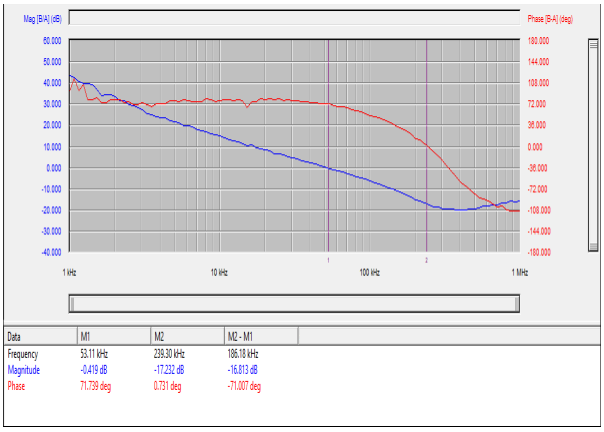
Thermal Performance

I_{OUT} = 4A, no forced airflow, T_{CASE} = 82.6°C



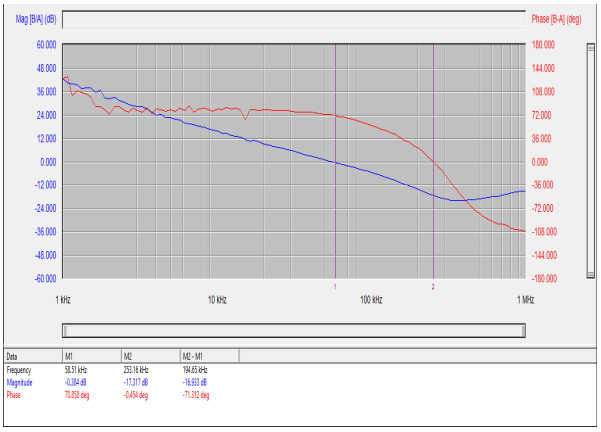
Bode Plot

I_{OUT} = 1A, PM = 71.7°, GM = 17.2dB



Bode Plot

I_{OUT} = 4A, PM = 70.8°, GM = 17.3dB



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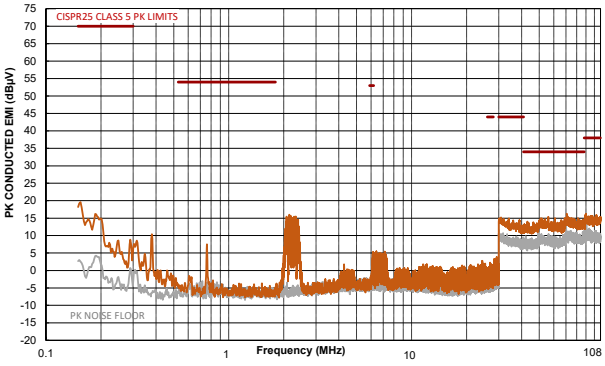
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, T_A = 25°C, unless otherwise noted.

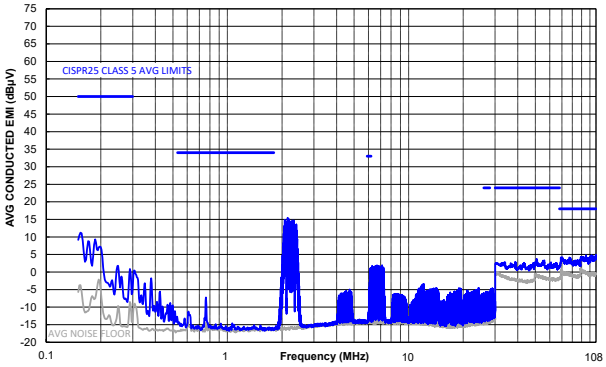
CISPR 25 Class 5 Peak Conducted Emissions

150kHz to 108MHz



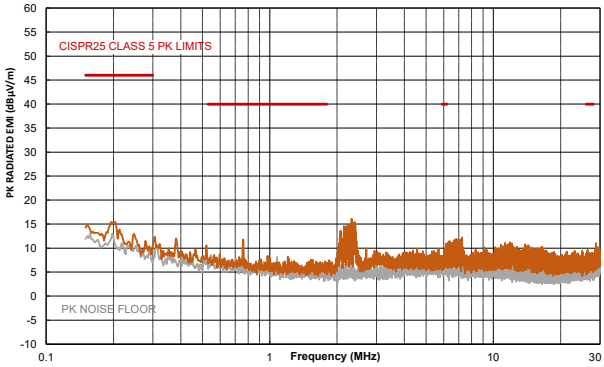
CISPR 25 Class 5 Average Conducted Emissions

150kHz to 108MHz



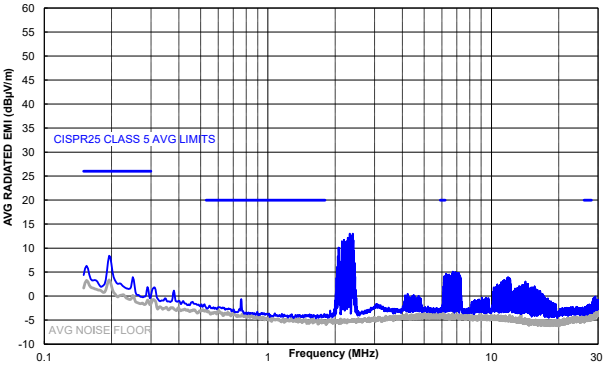
CISPR 25 Class 5 Peak Radiated Emissions

150kHz to 30MHz



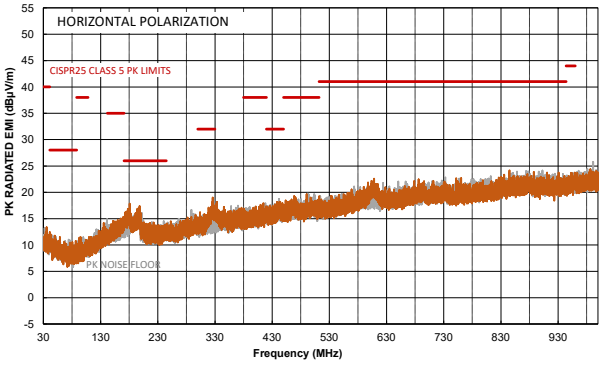
CISPR 25 Class 5 Average Radiated Emissions

150kHz to 30MHz



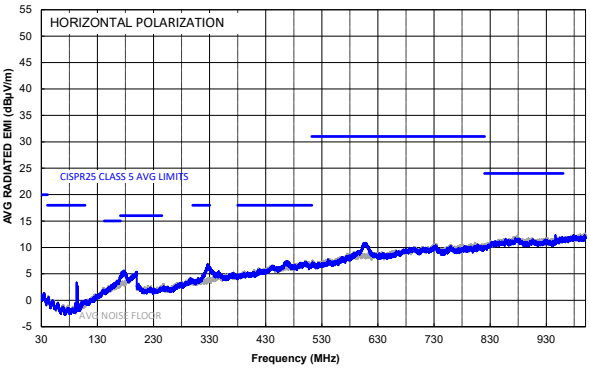
CISPR 25 Class 5 Peak Radiated Emissions

Horizontal, 30MHz to 1GHz



CISPR 25 Class 5 Average Radiated Emissions

Horizontal, 30MHz to 1GHz



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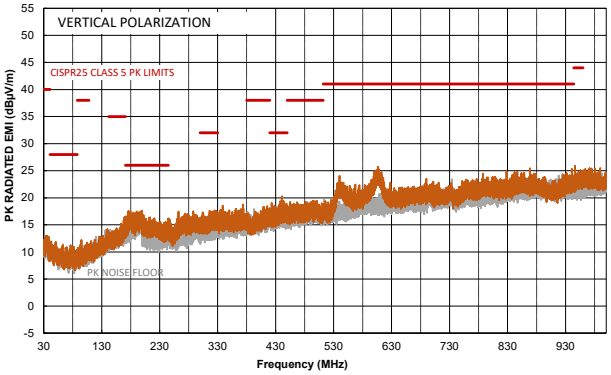
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, T_A = 25°C, unless otherwise noted.

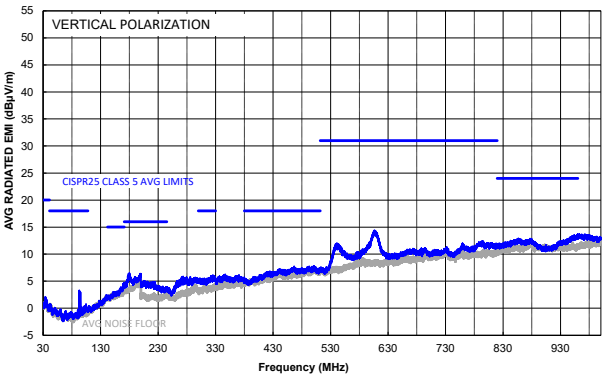
CISPR 25 Class 5 Peak Radiated Emissions

Vertical, 30MHz to 1GHz



CISPR 25 Class 5 Average Radiated Emissions

Vertical, 30MHz to 1GHz



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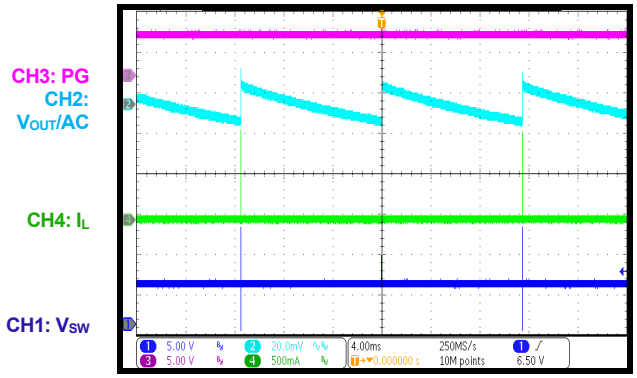
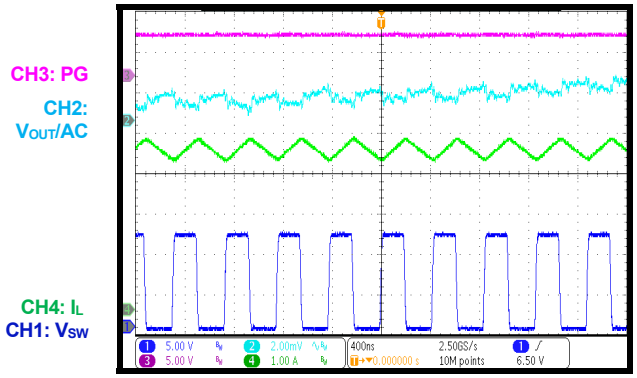
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, T_A = 25°C, unless otherwise noted.

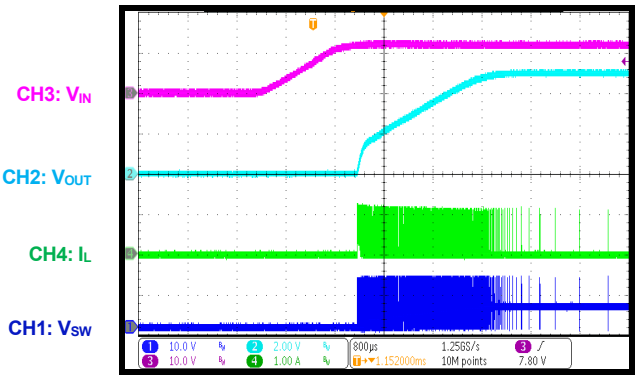
Steady State
I_{OUT} = 0A



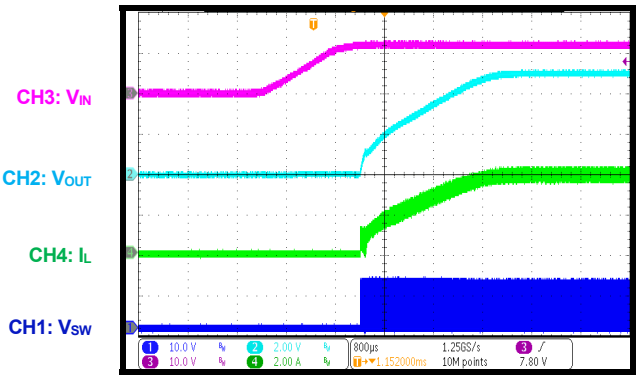
Steady State
I_{OUT} = 4A



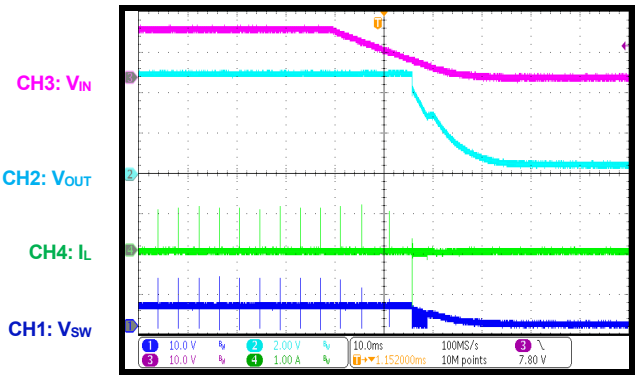
Start-Up through VIN
I_{OUT} = 0A



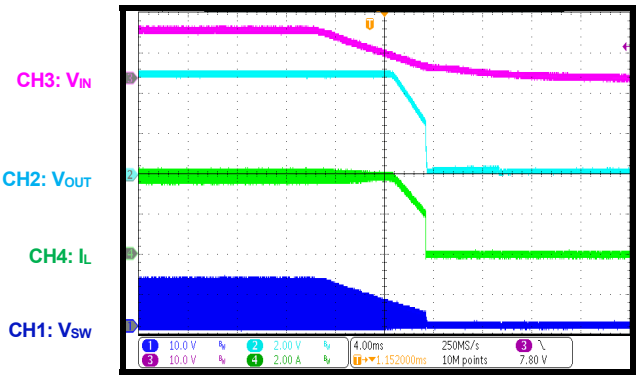
Start-Up through VIN
I_{OUT} = 4A



Shutdown through VIN
I_{OUT} = 0A



Shutdown through VIN
I_{OUT} = 4A



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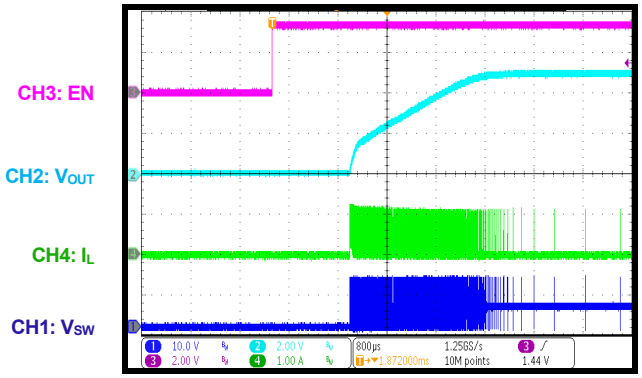
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, T_A = 25°C, unless otherwise noted.

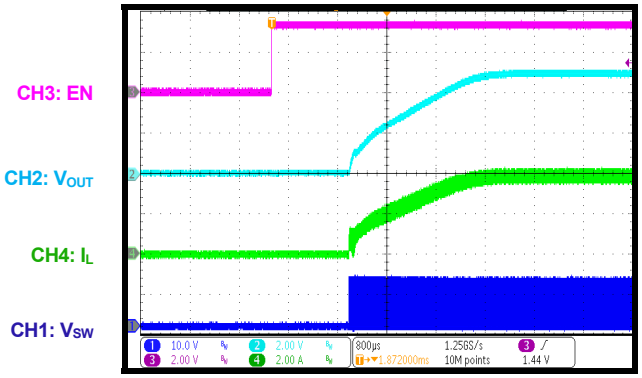
Start-Up through EN

I_{OUT} = 0A



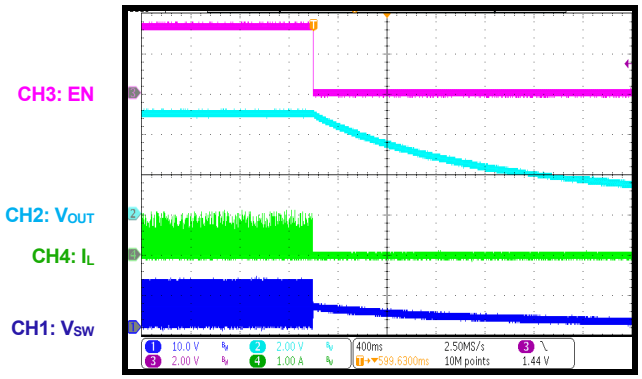
Start-Up through EN

I_{OUT} = 4A



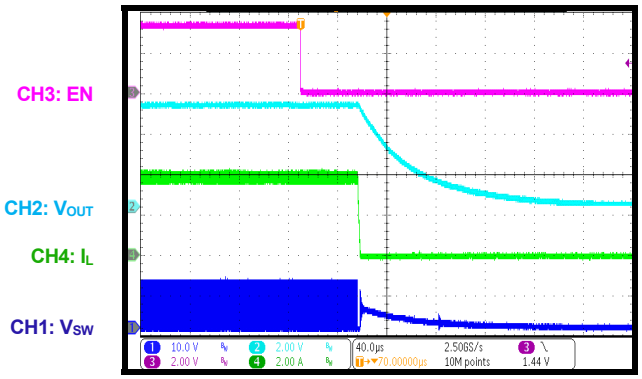
Shutdown through EN

I_{OUT} = 0A



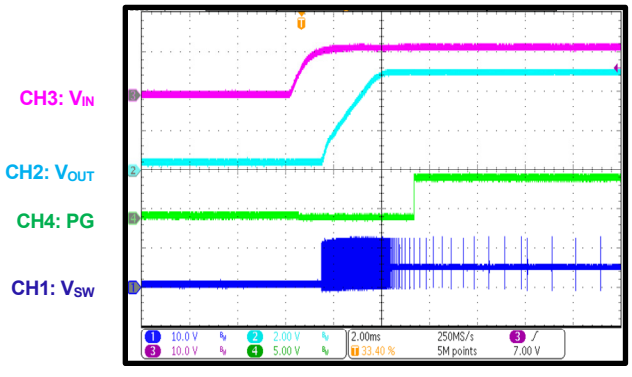
Shutdown through EN

I_{OUT} = 4A



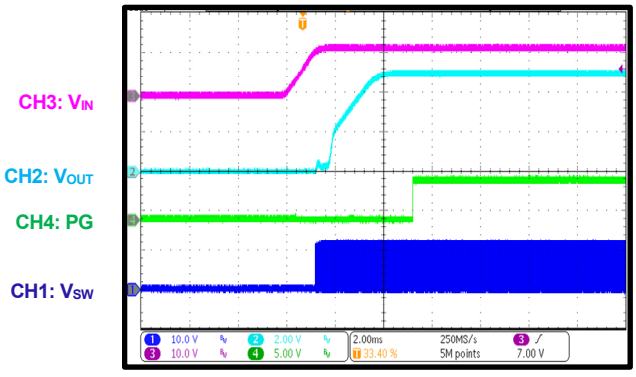
PG Start-Up through VIN

I_{OUT} = 0A



PG Start-Up through VIN

I_{OUT} = 4A



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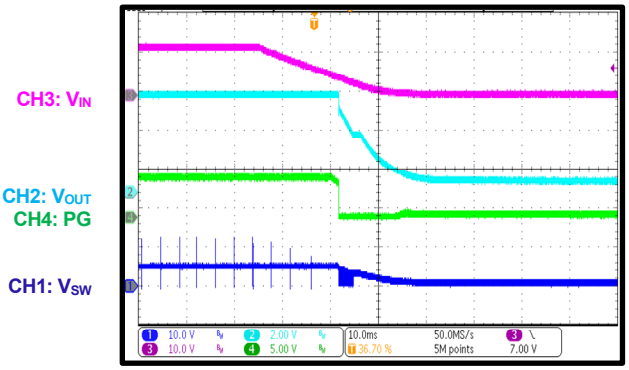
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, T_A = 25°C, unless otherwise noted.

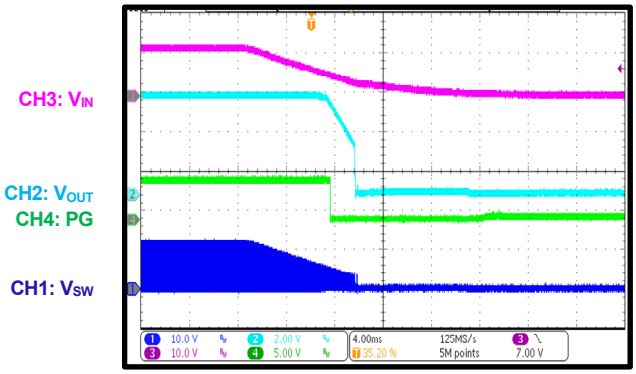
PG Shutdown through VIN

I_{OUT} = 0A



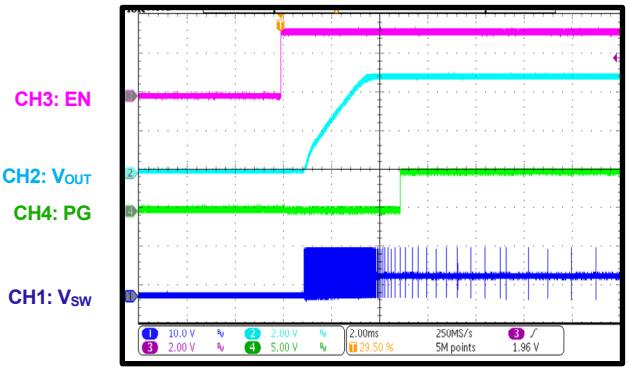
PG Shutdown through VIN

I_{OUT} = 4A



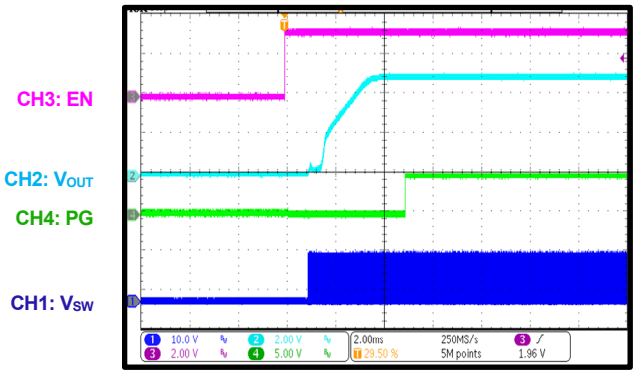
PG Start-Up through EN

I_{OUT} = 0A



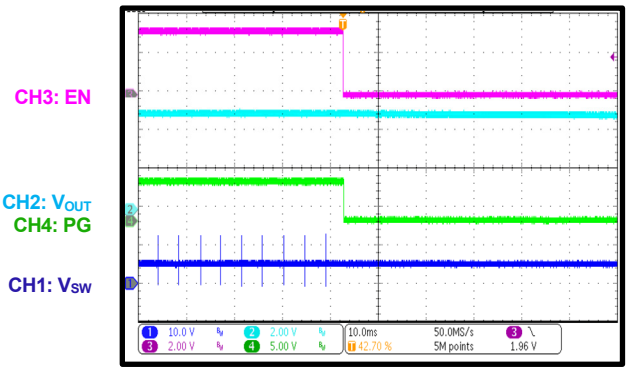
PG Start-Up through EN

I_{OUT} = 4A



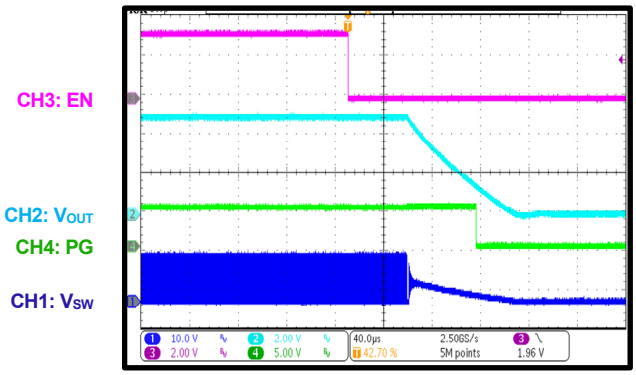
PG Shutdown through EN

I_{OUT} = 0A



PG Shutdown through EN

I_{OUT} = 4A



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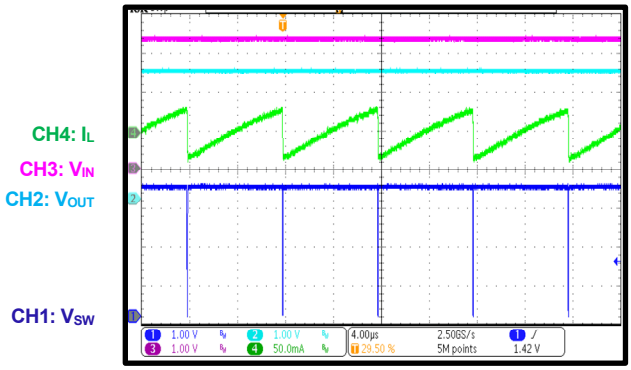
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, T_A = 25°C, unless otherwise noted.

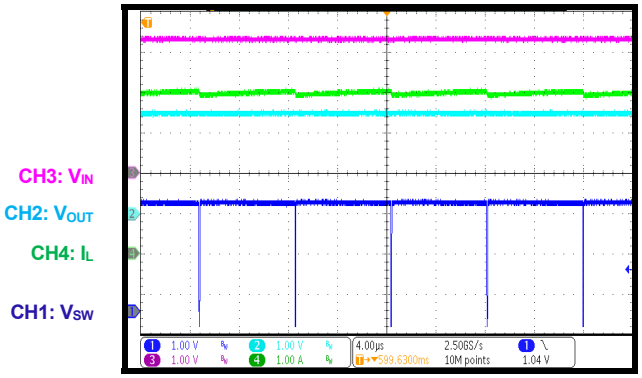
Low-Dropout Mode

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



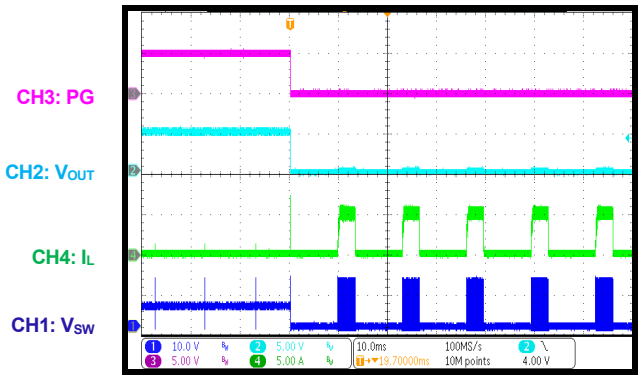
Low-Dropout Mode

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



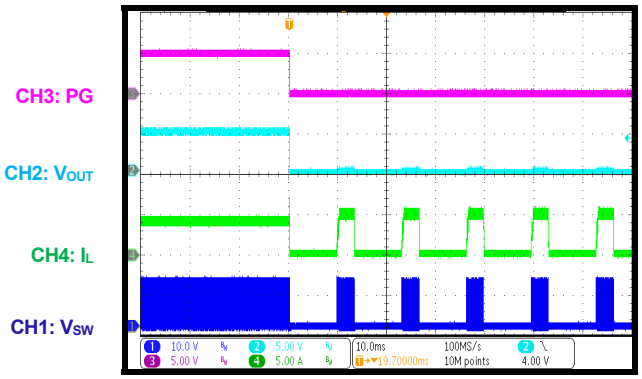
SCP Entry

I_{OUT} = 0A



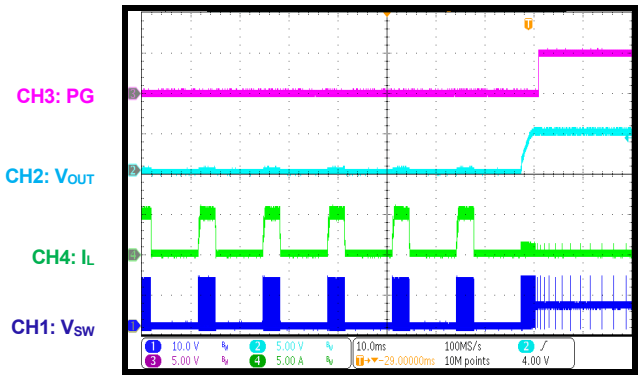
SCP Entry

I_{OUT} = 4A



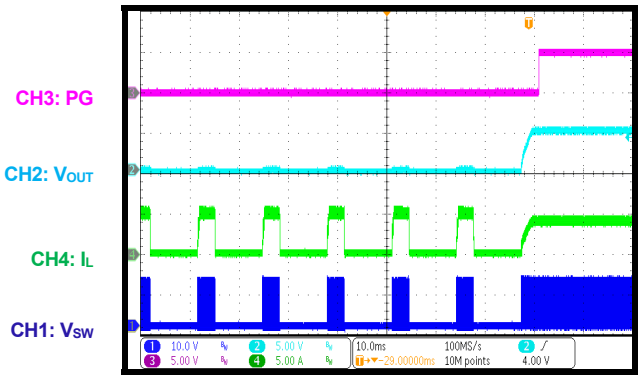
SCP Recovery

I_{OUT} = 0A



SCP Recovery

I_{OUT} = 4A



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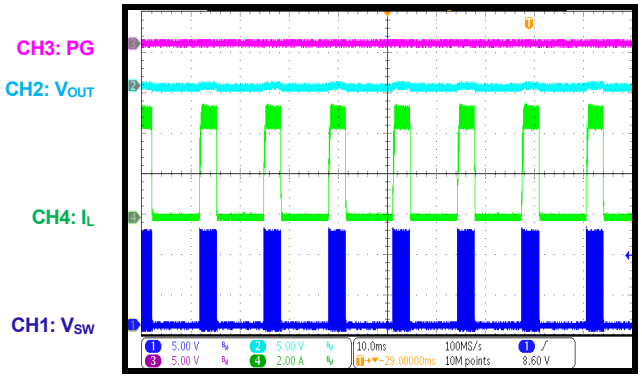
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, T_A = 25°C, unless otherwise noted.

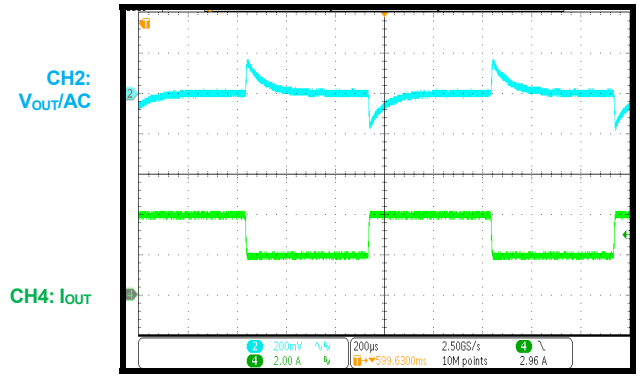
SCP Steady State

I_{OUT} = 0A



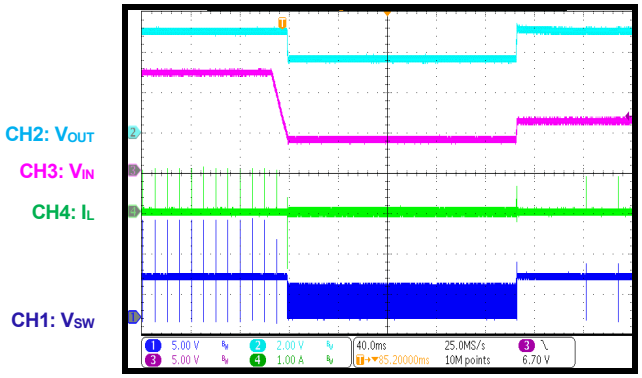
Load Transient

I_{OUT} = 2A to 4A, 1.6A/µs



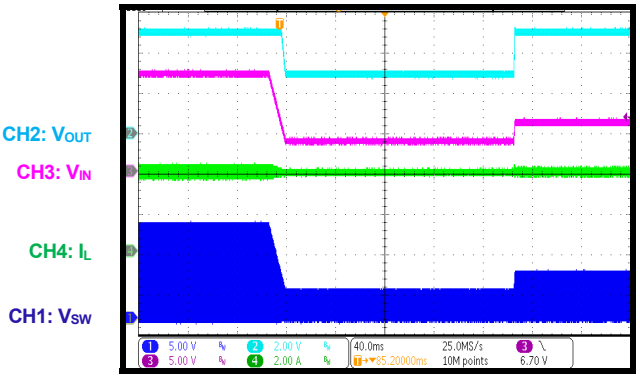
Cold Crank

V_{IN} = 12V to 3.3V to 6V, I_{OUT} = 0A



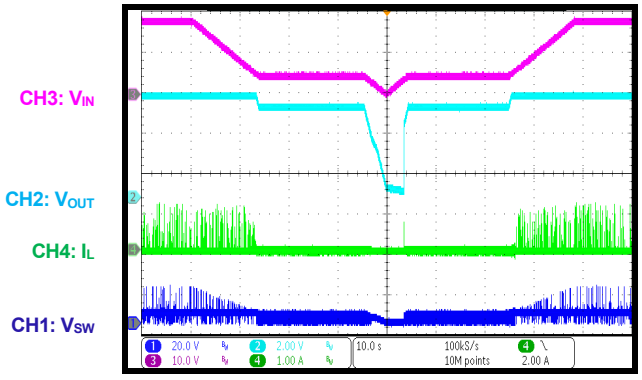
Cold Crank

V_{IN} = 12V to 3.3V to 6V, I_{OUT} = 4A



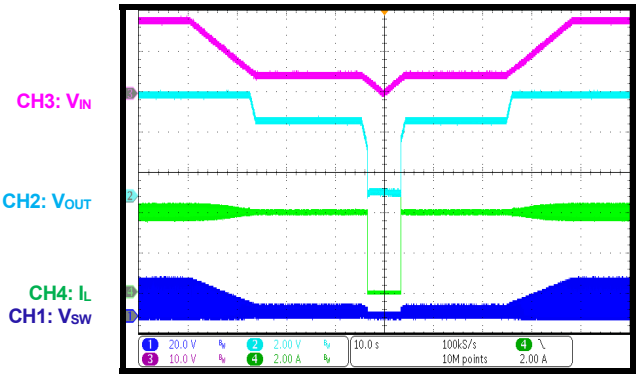
V_{IN} Ramping Down and Up

V_{IN} = 6V to 0V, 0.5V/min, I_{OUT} = 0A



V_{IN} Ramping Down and Up

V_{IN} = 6V to 0V, 0.5V/min, I_{OUT} = 4A



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PCB LAYOUT (2)

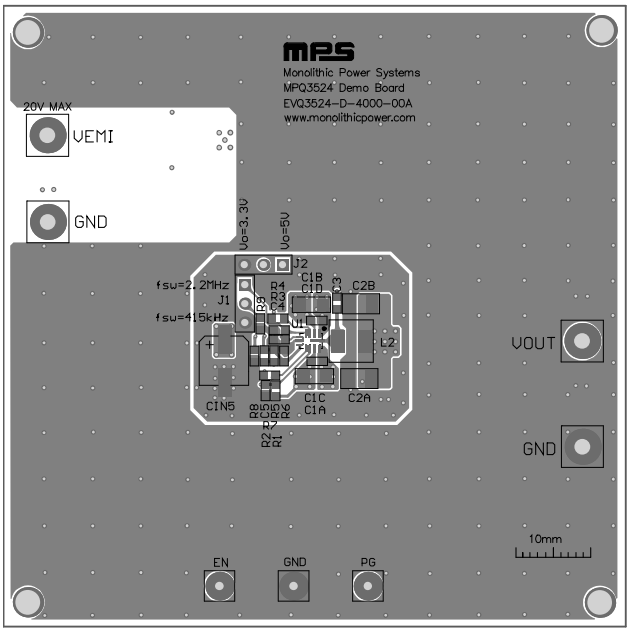

Figure 4: Top Silk and Top Layer

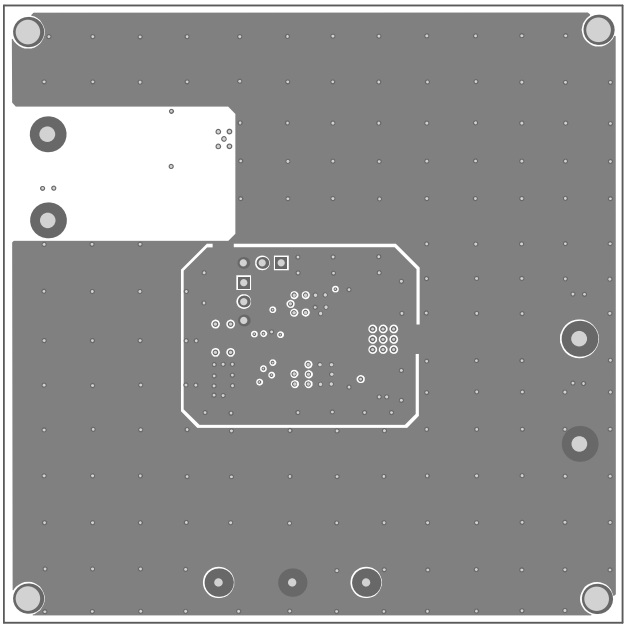

Figure 5: Mid-Layer 1

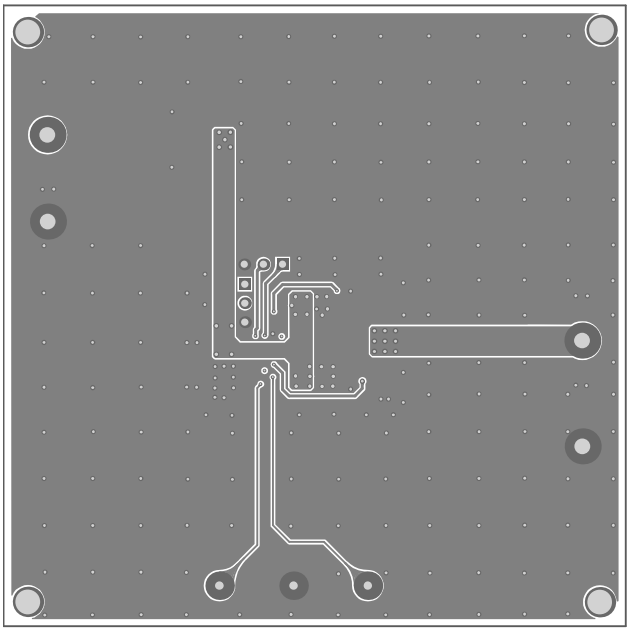

Figure 6: Mid-Layer 2

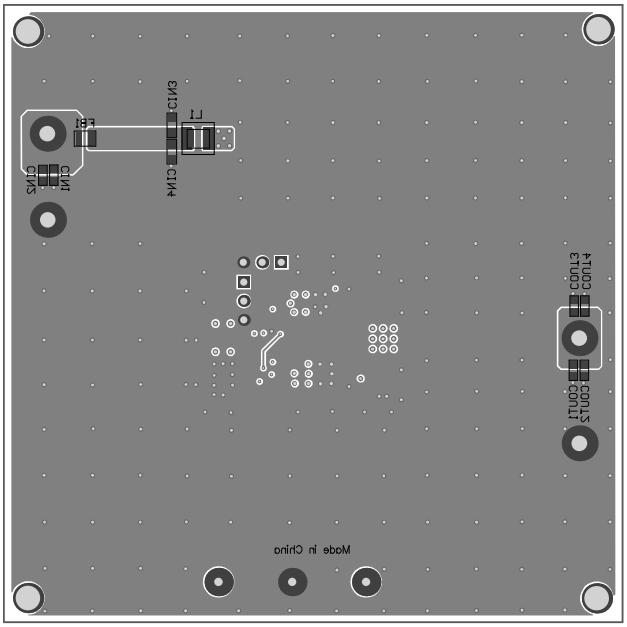

Figure 7: Bottom Layer and Bottom Silk

Note:

2) The copper thickness is 2oz.

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REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	10/22/2024	Initial Release	-

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