EVQ4334-RH-4000-00A

36V, 4A, Low Quiescent Current, Synchronous Step-Down Converter Evaluation Board in QFN-14 (2.5mmx3.5mm), AEC-Q100 Qualified

DESCRIPTION

The EVQ4334-RH-4000-00A is an evaluation board designed to demonstrate the capabilities of the MPQ4334GRHE-4000-AEC1, a configurable-frequency (200kHz to 2.5MHz), synchronous, step-down switching converter with an integrated, internal high-side MOSFET (HS-FET) and low-side MOSFET (LS-FET).

The MPQ4334GRHE-4000-AEC1 provides up to 4A of highly efficient output current (I_{OUT}) with peak current mode control. The wide 3V to 36V input voltage (V_{IN}) range and 40V load dump tolerance accommodates a variety of step-down applications in automotive input environments. A 0.5μA 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-load conditions to reduce switching and gate driver losses.

An open-drain power good (PG) signal indicates whether the output voltage (V_{OUT}) is within 94.5% to 105.5% of its nominal voltage.

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 (LDO) mode are provided for automotive cold-crank conditions.

The EVQ4334-RH-4000-00A is a fully assembled and tested evaluation board. The MPQ4334GRHE-4000-AEC1 is available in a QFN-14 (2.5mmx3.5mm) 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		3V to 36V
Output voltage (V_{OUT})	V_{IN} = 6V to 36V, I_{OUT} = 0A to 4A	5V
Maximum output current (I_{OUT})	V_{IN} = 3V to 36V	4A
Typical efficiency	V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 4A	91.5%
Peak efficiency	V_{IN} = 8V, V_{OUT} = 5V, I_{OUT} = 1A	96%
Switching frequency (f_{SW})		2.2MHz

EVQ4334-RH-4000-00A EVALUATION BOARD

LxWxH (8.3cmx8.3cmx1cm)

Board Number	MPS IC Number
EVQ4334-RH-4000-00A	MPQ4334GRHE-4000-AEC1

QUICK START GUIDE

The EVQ4334-RH-4000-00A evaluation board is easy to set up and use to evaluate the performance of the MPQ4334. 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 6V and 36V, then turn off the power supply.
2. Set the load current between 0A and 4A. Electronic loads represent a negative impedance to the regulator, and setting the current too high can trigger hiccup mode.
3. If longer cables (>0.5m total) are used between the source and the evaluation board, place a damping capacitor at the input terminals (especially when $V_{IN} \geq 24V$).
4. Connect the power supply terminals to:
    a. Positive (+): VEMI
    b. Negative (-): GND
5. Connect the load terminals to:
    a. Positive (+): VOUT
    b. Negative (-): GND
6. After making the connections, turn on the power supply. The board should start up automatically.
7. To use the enable (EN) function, apply a digital input to the EN pin. Pull EN above 1.02V to turn the regulator on; pull EN below 0.85V to turn it off. If the enable 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. Set the output voltage (V_{OUT}) using the external resistor divider (see Figure 1).

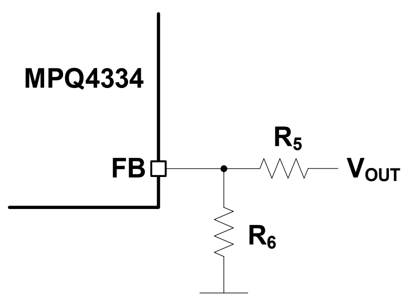


Figure 1: Feedback Divider Network with Adjustable Output

R5 should be 100kΩ. Then R6 can be calculated with Equation (1):

$$R_6 = \frac{R_5}{\frac{V_{OUT}}{0.8V} - 1} \tag{1}$$

Refer to the Application Information section in the MPQ4334 datasheet to calculate the inductance (L) and output capacitance (C_{OUT}) for different output voltages.

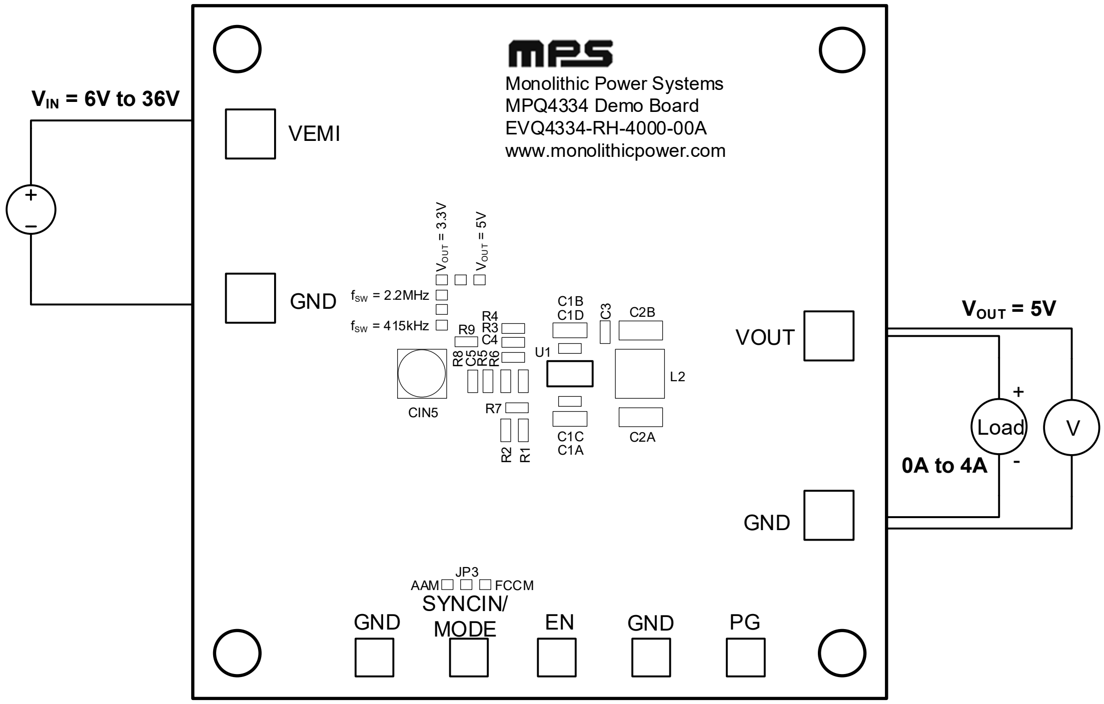
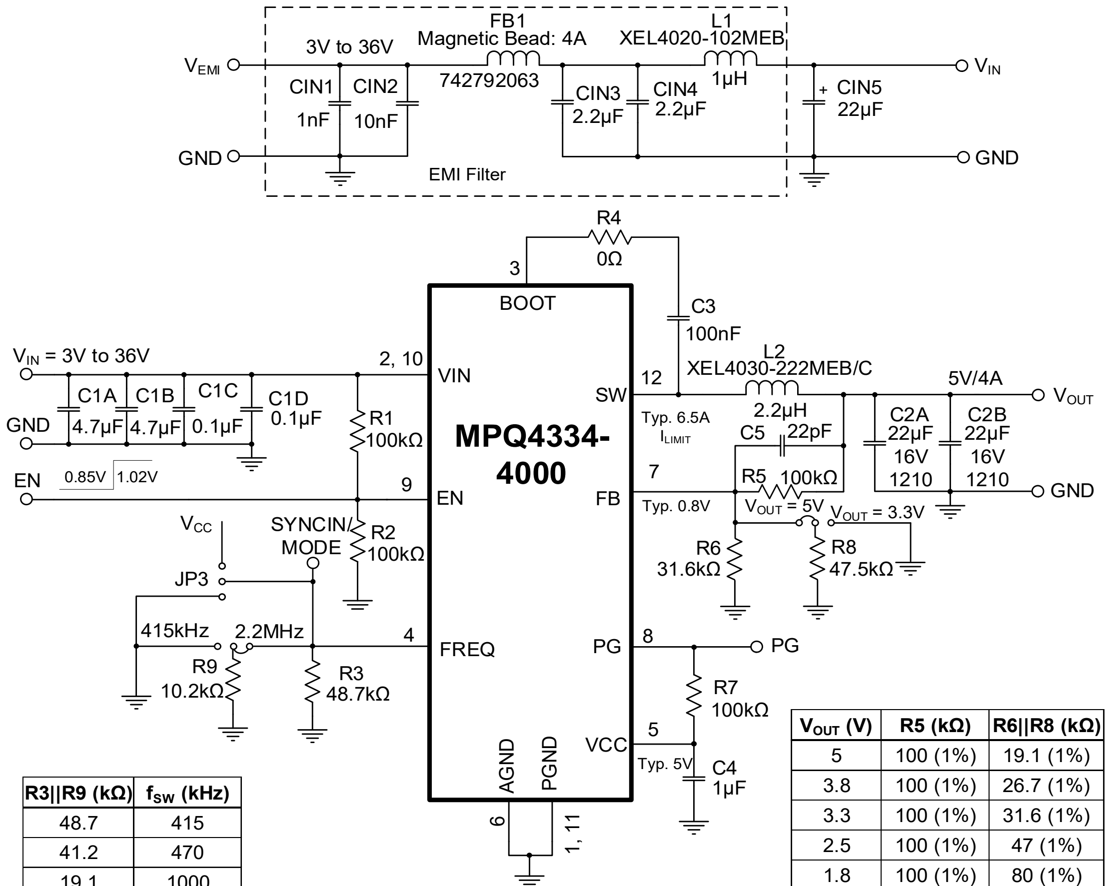


Figure 2: Measurement Equipment Set-Up

EVALUATION BOARD SCHEMATIC

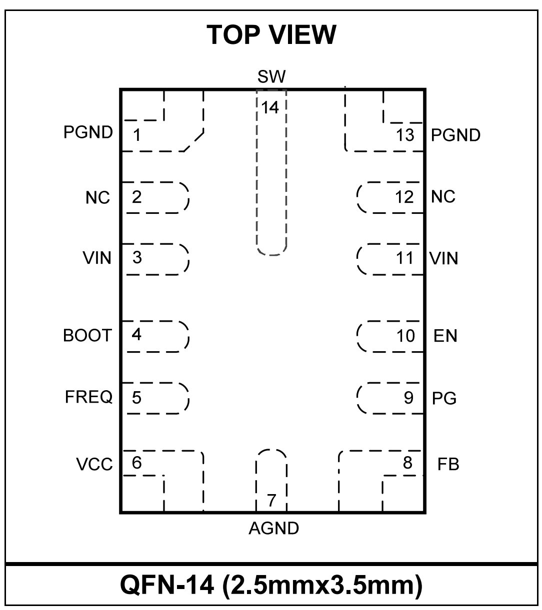


R3||R9 (kΩ)	f_{SW} (kHz)
48.7	415
41.2	470
19.1	1000
8.45	2200
7.87	2500

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



EVQ4334-RH-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	2.2μF	Ceramic capacitor, 50V, X7R	0805	Murata	GRM21BD72A225KE01L
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, 16V, X7R	1210	Murata	GRM32ER71C226KE18L
1	C5	22pF	Ceramic capacitor, 100V, C0G	0603	Murata	GCM1885C2A220JA16D
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	R3	48.7kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0748K7L
1	R4	0Ω	Film resistor, 5%	0603	Yageo	RC0603JR-070RL
1	R6	31.6kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0731K6L
1	R8	47.5kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0747K5L
1	R9	10.2kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0710K2L
3	J1, J2, JP3	2.54mm	Test pin, 3-pin	DIP	Any	
4	VEMI, GND, VOUT, GND	2mm	Golden pin	DIP	Custom (1)	
5	SYNCIN, GND, PG, EN, GND	1mm	Golden pin	DIP	Custom (1)	
1	U1	MPQ4334-4000-AEC1	4A, low-I_Q, synchronous step-down converter, AEC-Q100 qualified	QFN-14 (2.5mmx3.5mm)	MPS	MPQ4334GRHE-4000-AEC1

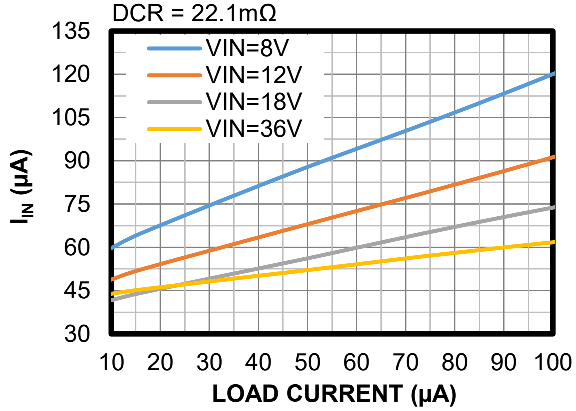
Note:

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

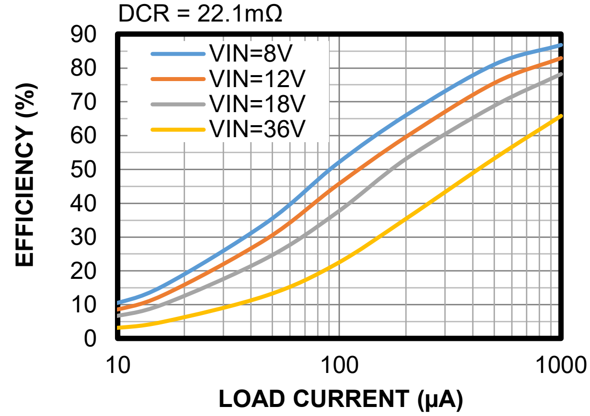
EVB TEST RESULTS

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

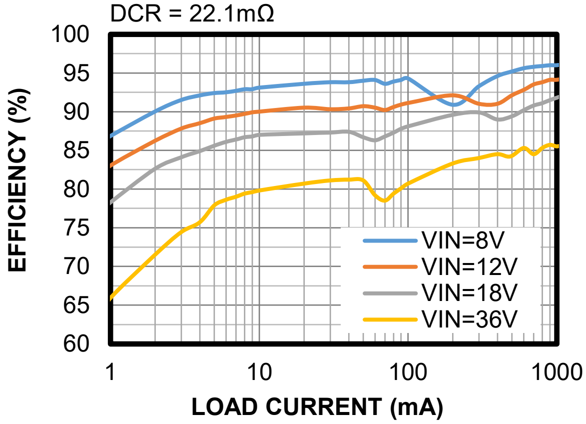
Input Current vs. Load Current for 4000 Version
R_{FB1} = 100kΩ, R_{FB2} = 19.1kΩ,
DCR = 22.1mΩ



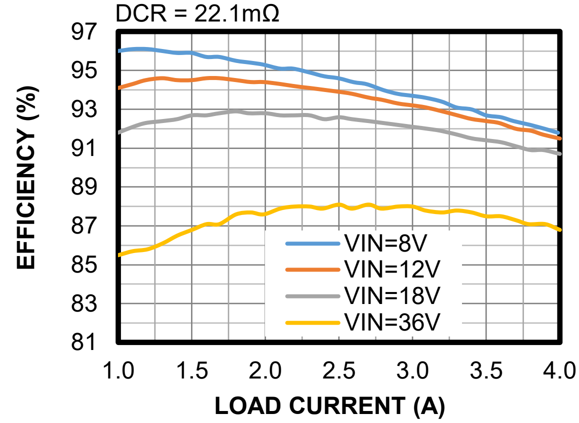
Efficiency vs. Load Current for 4000 Version
R_{FB1} = 100kΩ, R_{FB2} = 19.1kΩ,
DCR = 22.1mΩ



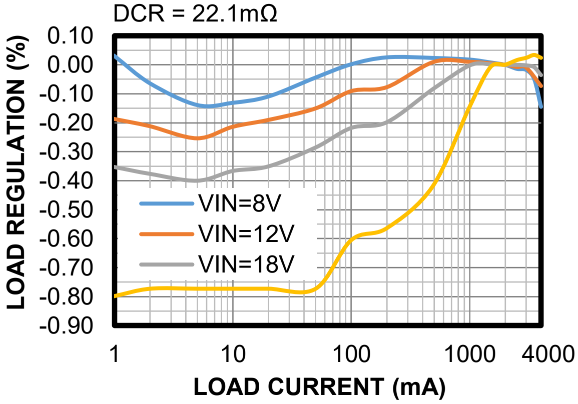
Efficiency vs. Load Current for 4000 Version
DCR = 22.1mΩ



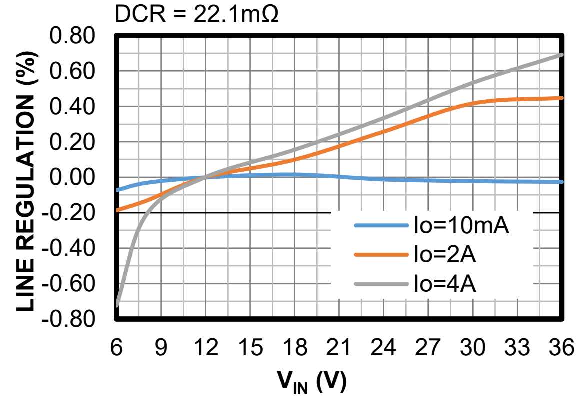
Efficiency vs. Load Current for 4000 Version
DCR = 22.1mΩ



Load Regulation for 4000 Version
DCR = 22.1mΩ



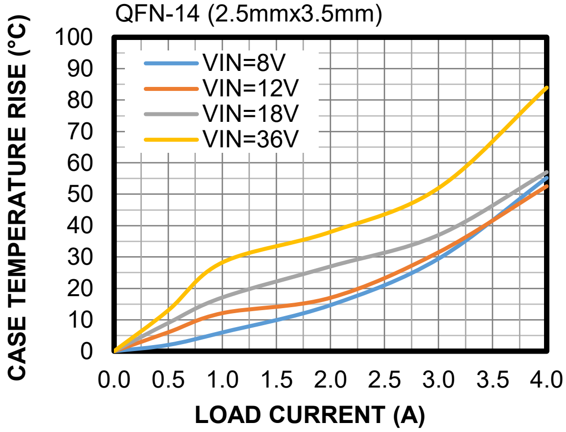
Line Regulation for 4000 Version
DCR = 22.1mΩ



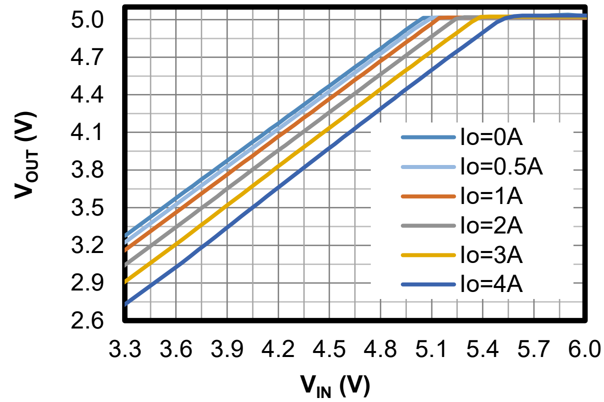
EVB TEST RESULTS *(continued)*

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

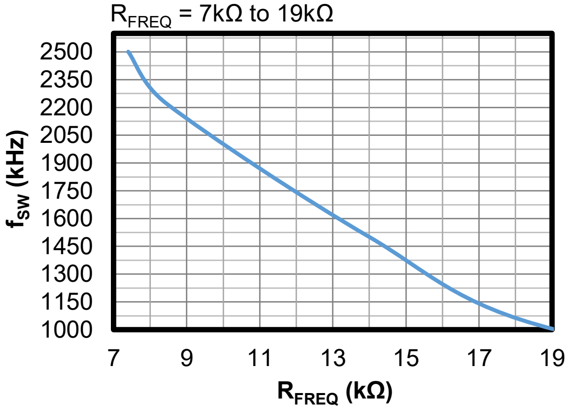
Case Temperature Rise
V_{OUT} = 5V, f_{SW} = 2.2MHz, QFN-14 (2.5mmx3.5mm)



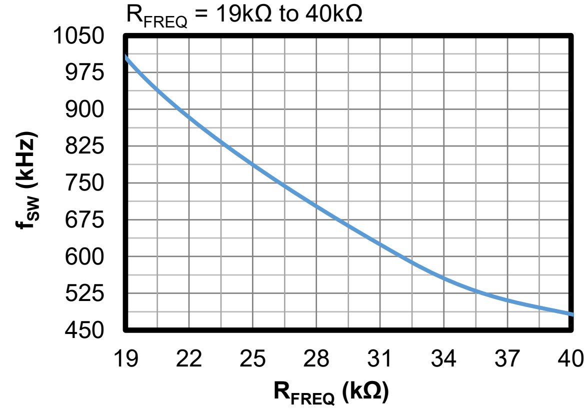
Low-Dropout Mode
V_{OUT} = 5V, f_{SW} = 2.2MHz



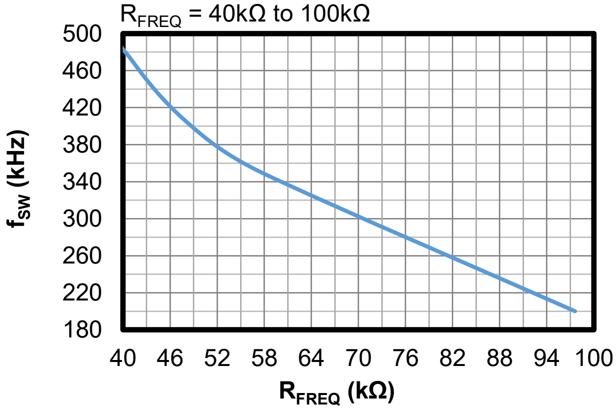
Switching Frequency vs. Frequency Resistor
R_{FREQ} = 7kΩ to 19kΩ



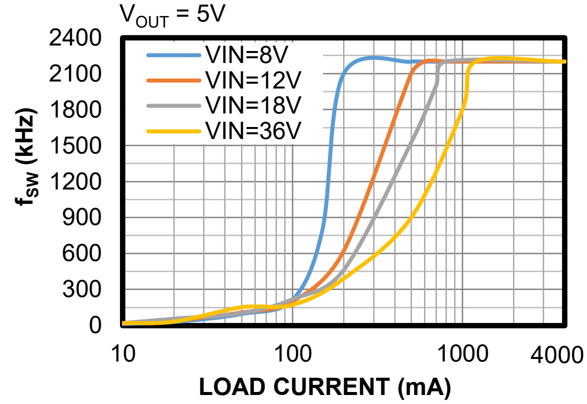
Switching Frequency vs. Frequency Resistor
R_{FREQ} = 19kΩ to 40kΩ



Switching Frequency vs. Frequency Resistor
R_{FREQ} = 40kΩ to 100kΩ



Switching Frequency vs. Load Current for 4000 Version
V_{OUT} = 5V

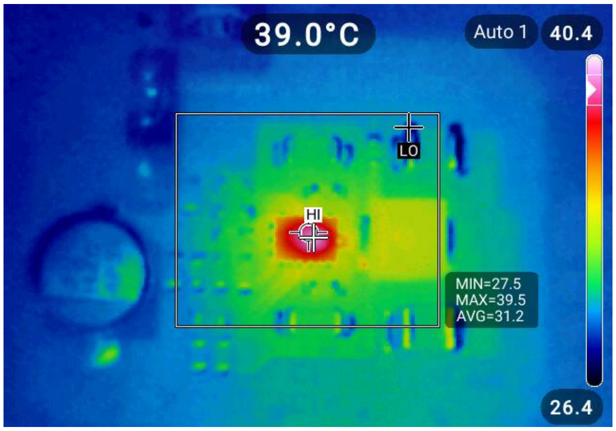


EVB TEST RESULTS *(continued)*

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

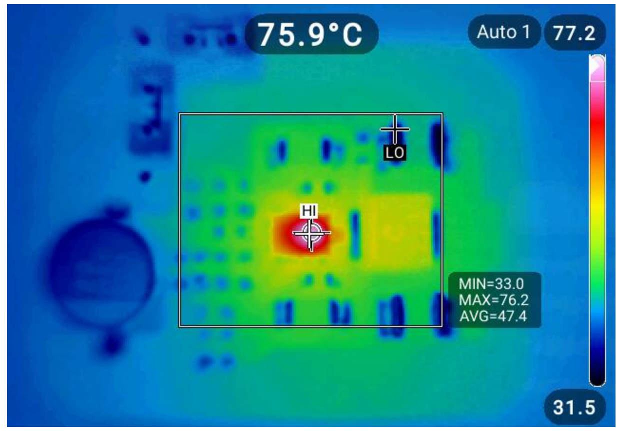
Thermal Performance

I_{OUT} = 2A, no forced airflow, T_{CASE} = 39.5°C



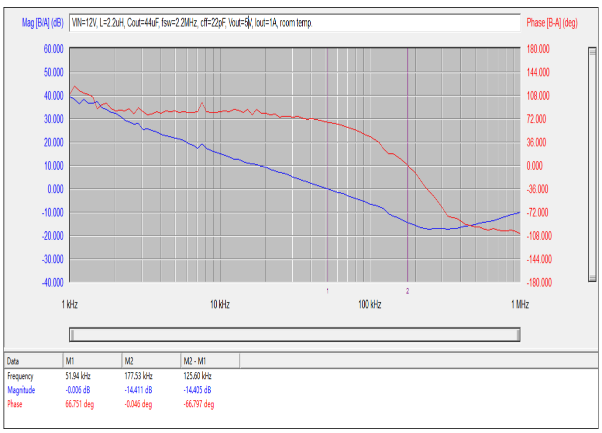
Thermal Performance

I_{OUT} = 4A, no forced airflow, T_{CASE} = 76.2°C



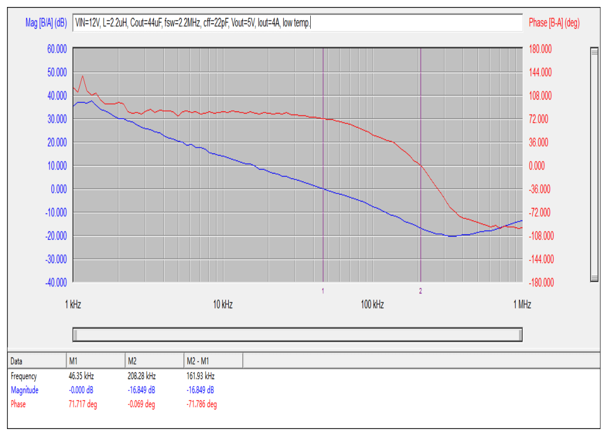
Bode Plot

I_{OUT} = 1A, PM = 66.8°, GM = 14.4dB



Bode Plot

I_{OUT} = 4A, PM = 71.7°, GM = 16.8dB

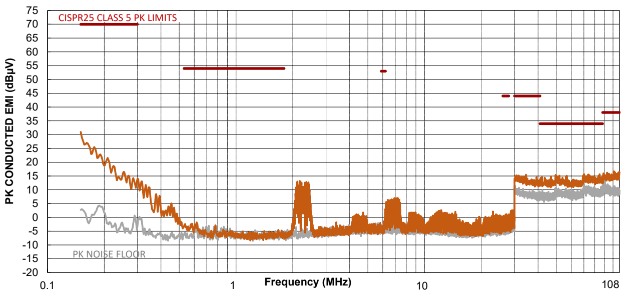


EVB TEST RESULTS *(continued)*

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

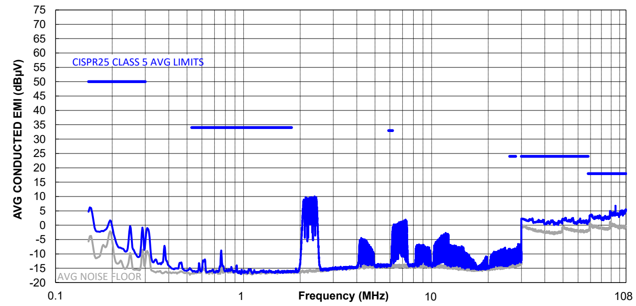
CISPR 25 Class 5 Peak Conducted Emissions

150kHz to 108MHz



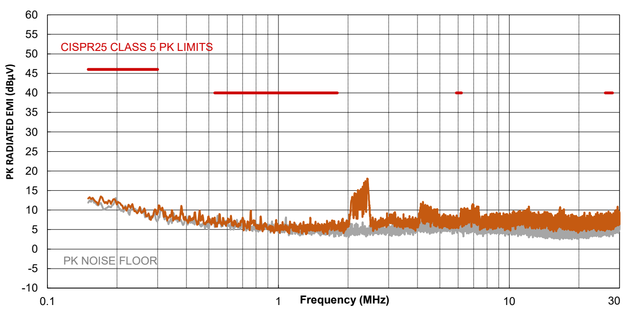
CISPR 25 Class 5 Average Conducted Emissions

150kHz to 108MHz



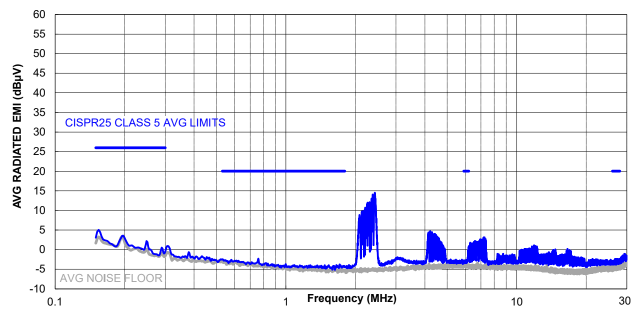
CISPR 25 Class 5 Peak Radiated Emissions

150kHz to 30MHz



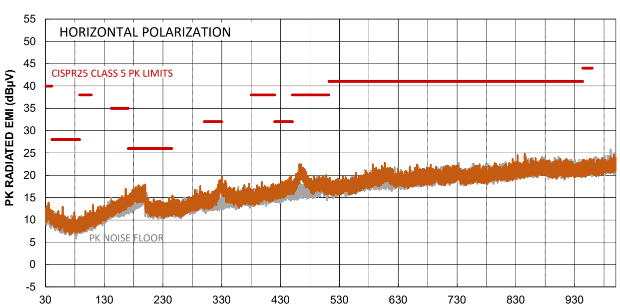
CISPR 25 Class 5 Average Radiated Emissions

150kHz to 30MHz



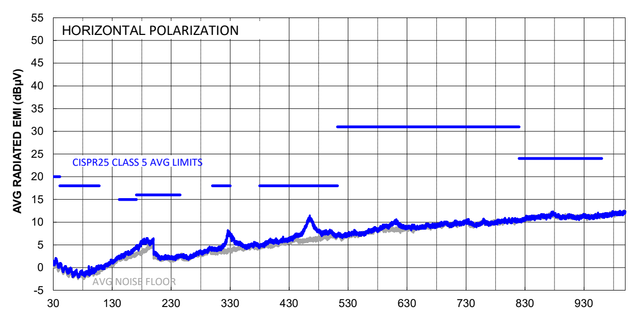
CISPR 25 Class 5 Peak Radiated Emissions

Horizontal, 30MHz to 1GHz



CISPR 25 Class 5 Average Radiated Emissions

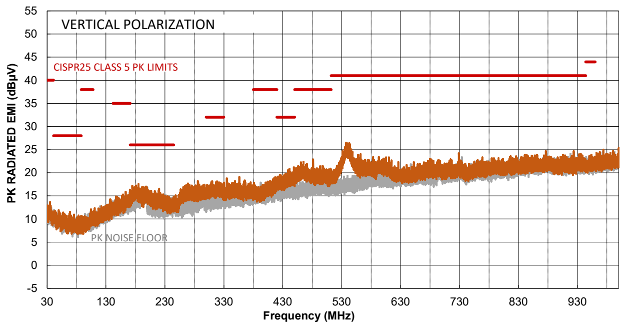
Horizontal, 30MHz to 1GHz



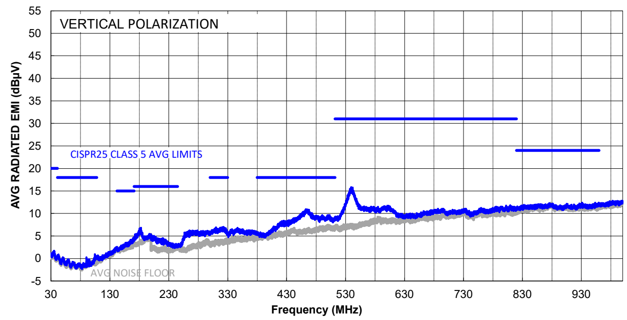
EVB TEST RESULTS *(continued)*

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



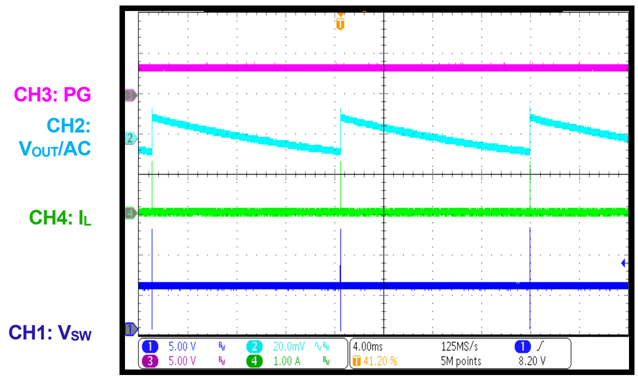
CISPR 25 Class 5 Average Radiated Emissions
Vertical, 30MHz to 1GHz



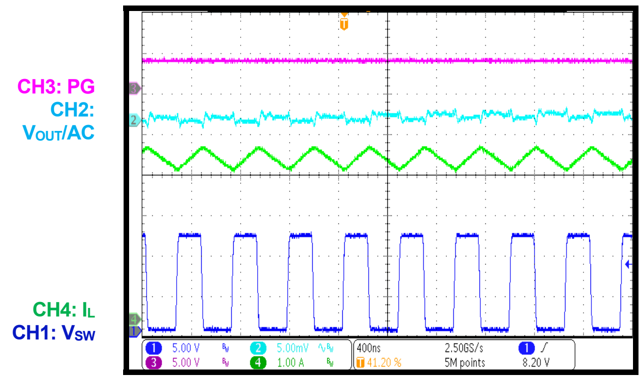
EVB TEST RESULTS *(continued)*

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

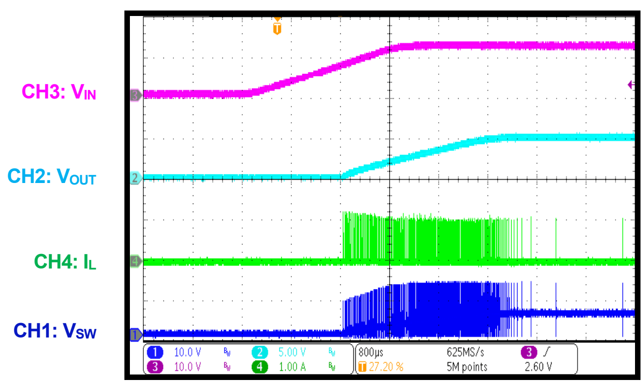
Steady State
I_{OUT} = 0A



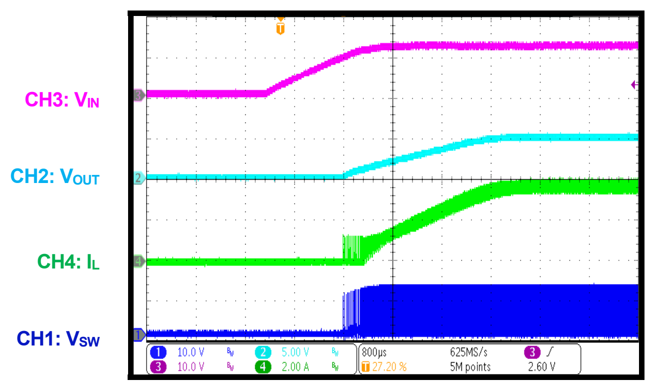
Steady State
I_{OUT} = 4A



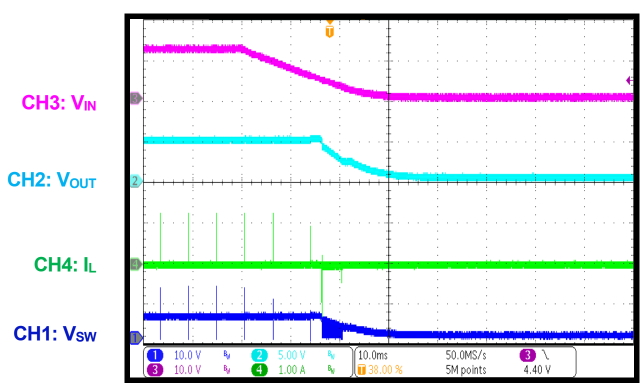
Start-Up through VIN
I_{OUT} = 0A



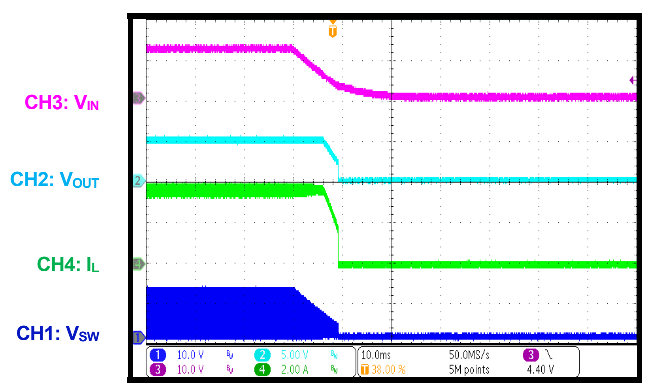
Start-Up through VIN
I_{OUT} = 4A



Shutdown through VIN
I_{OUT} = 0A



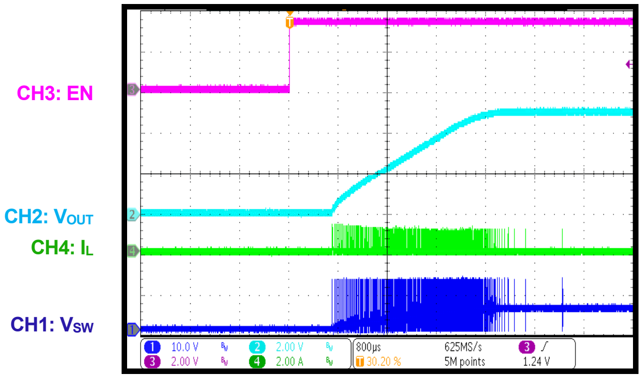
Shutdown through VIN
I_{OUT} = 4A



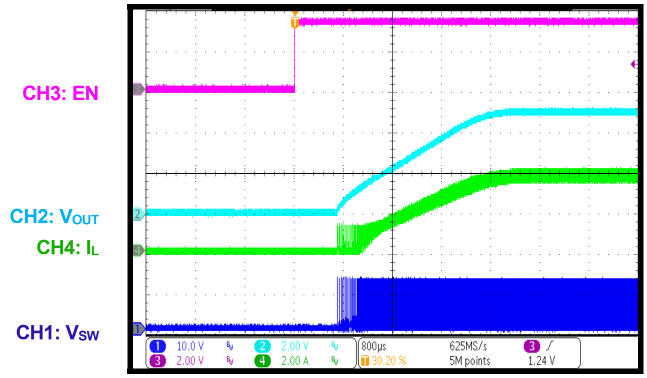
EVB TEST RESULTS *(continued)*

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

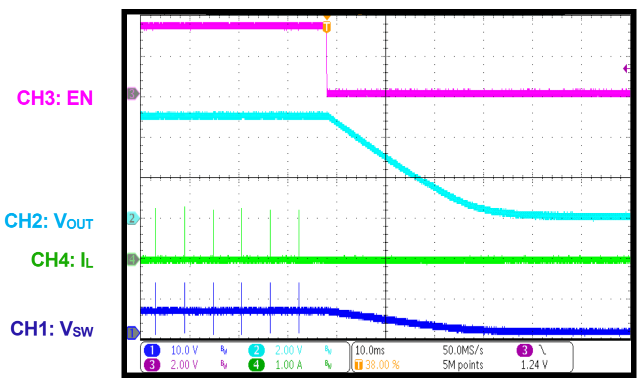
Start-Up through EN
I_{OUT} = 0A



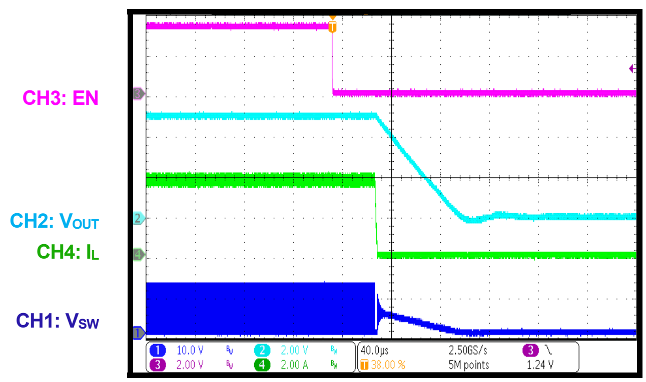
Start-Up through EN
I_{OUT} = 4A



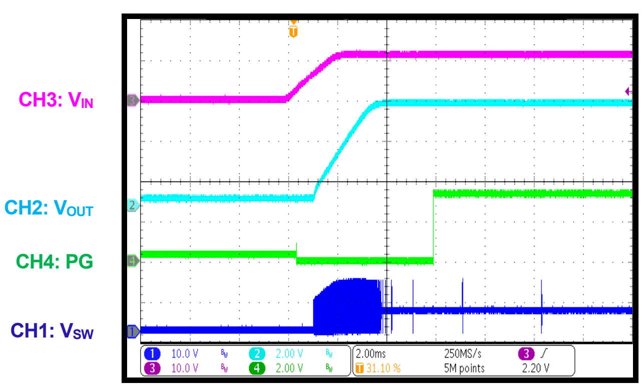
Shutdown through EN
I_{OUT} = 0A



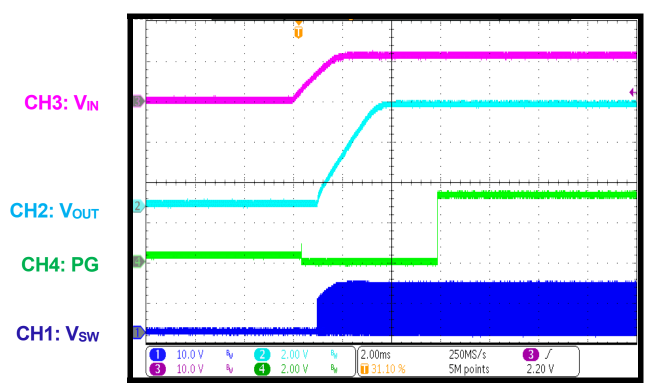
Shutdown through EN
I_{OUT} = 4A



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



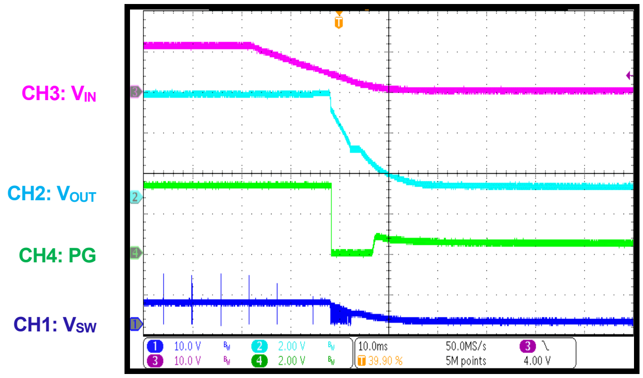
PG Start-Up through VIN
I_{OUT} = 4A



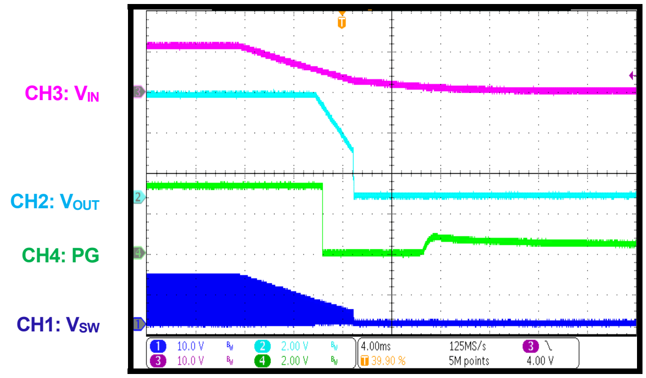
EVB TEST RESULTS *(continued)*

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

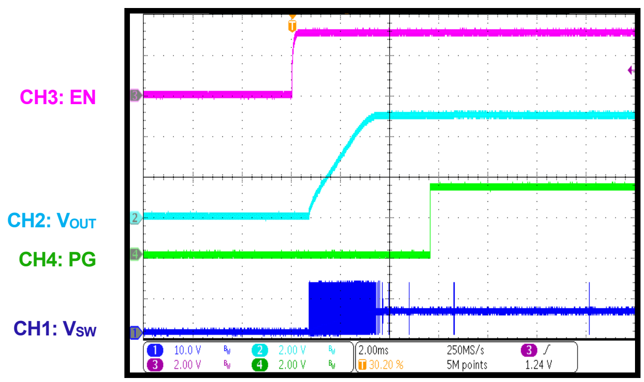
PG Shutdown through VIN
I_{OUT} = 0A



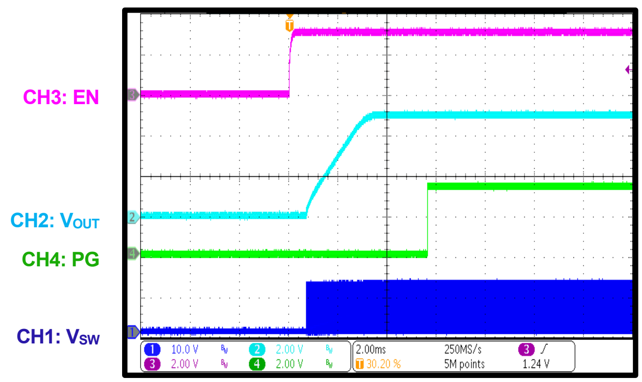
PG Shutdown through VIN
I_{OUT} = 4A



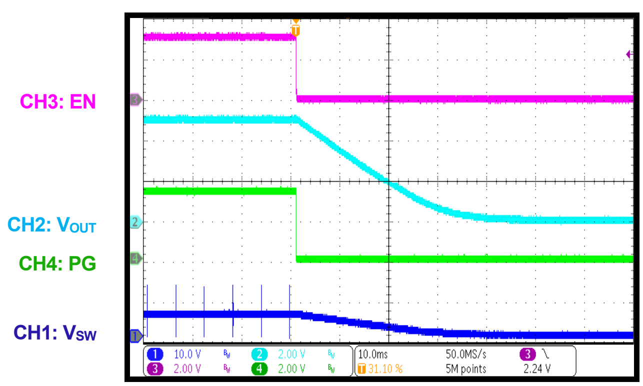
PG Start-Up through EN
I_{OUT} = 0A



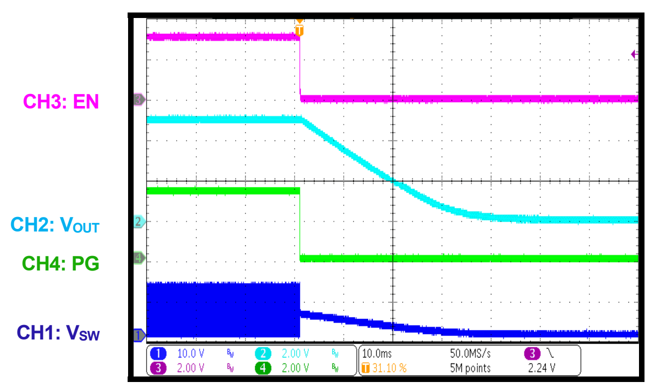
PG Start-Up through EN
I_{OUT} = 4A



PG Shutdown through EN
I_{OUT} = 0A



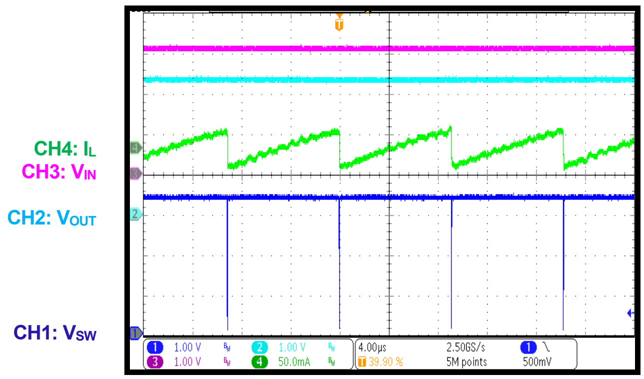
PG Shutdown through EN
I_{OUT} = 4A



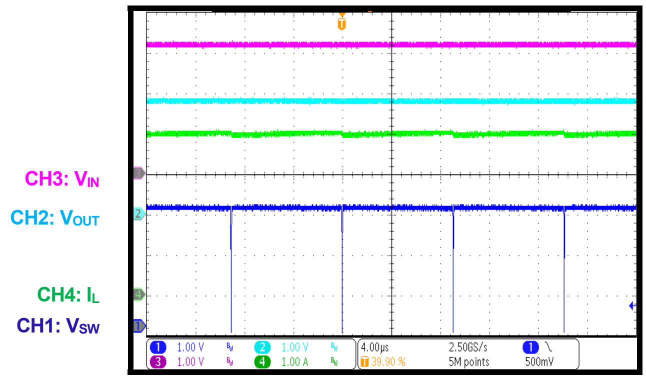
EVB TEST RESULTS *(continued)*

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

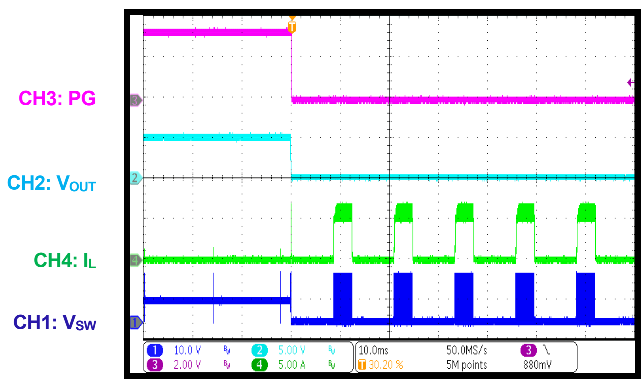
Low-Dropout Mode
I_{OUT} = 0A, V_{IN} = 3.3V



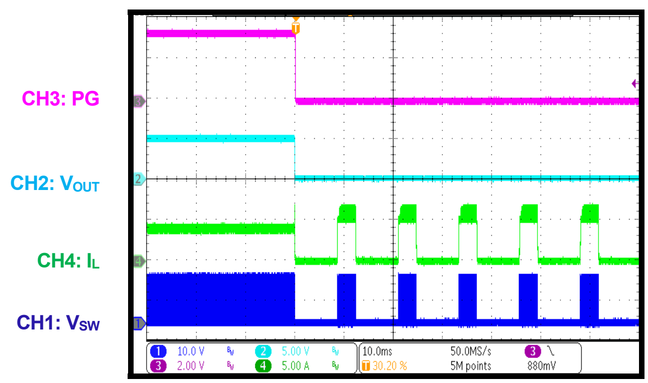
Low-Dropout Mode
I_{OUT} = 4A, V_{IN} = 3.3V



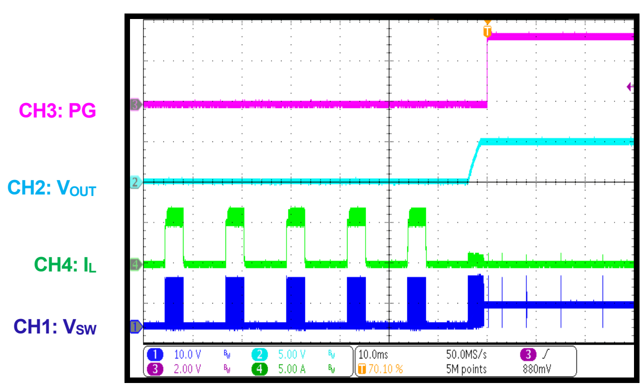
SCP Entry
I_{OUT} = 0A



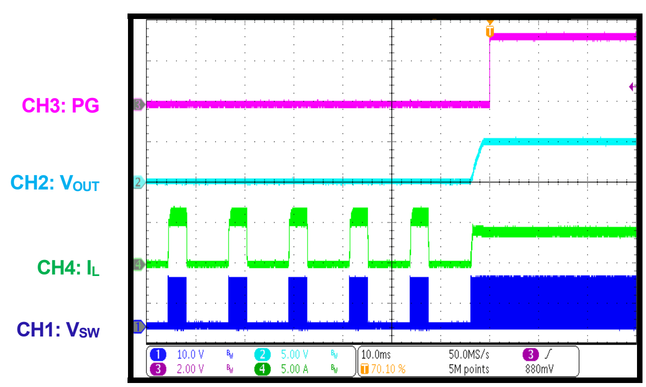
SCP Entry
I_{OUT} = 4A



SCP Recovery
I_{OUT} = 0A



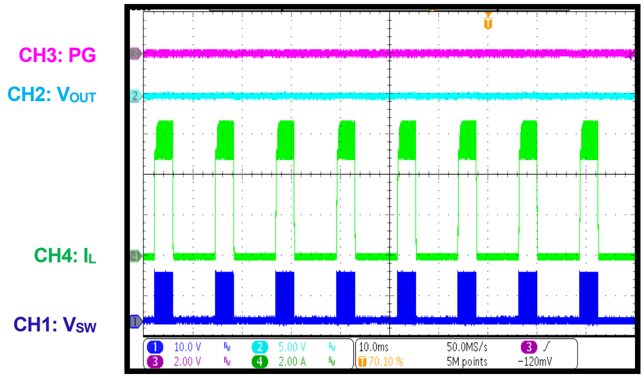
SCP Recovery
I_{OUT} = 4A



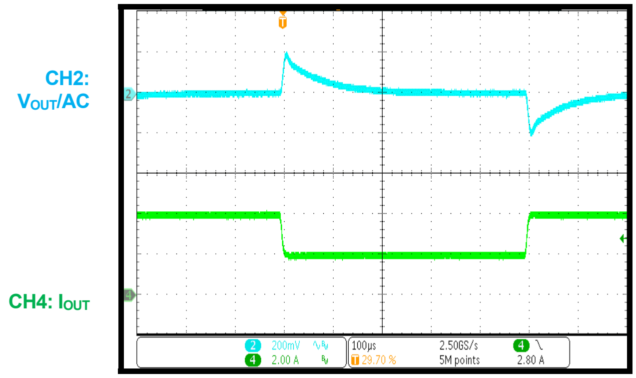
EVB TEST RESULTS *(continued)*

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

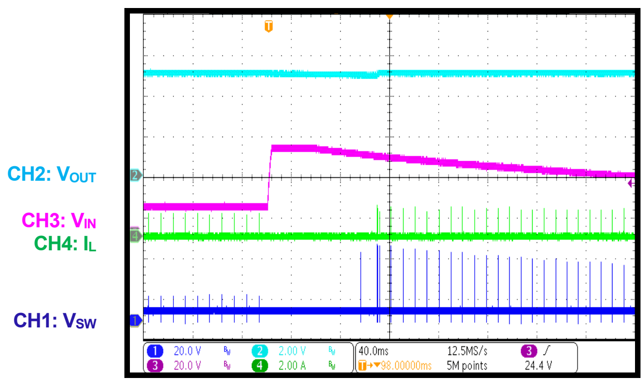
SCP Steady State
I_{OUT} = 0A



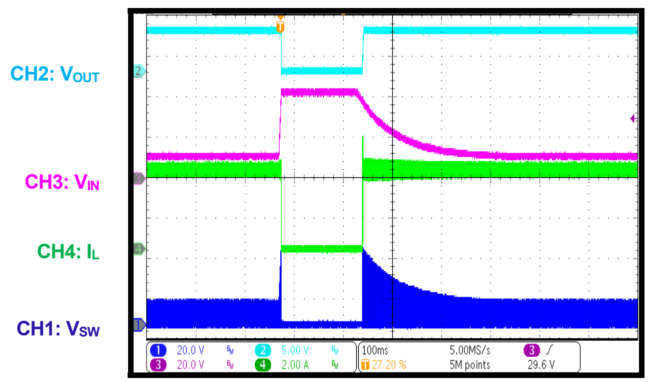
Load Transient
I_{OUT} = 2A to 4A, 1.6A/μs



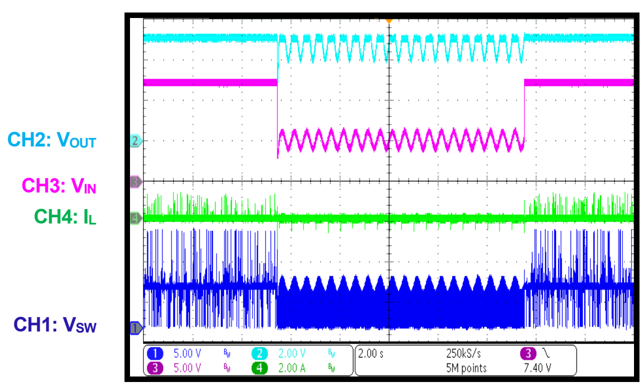
Load Dump
V_{IN} = 12V to 40V, I_{OUT} = 0A



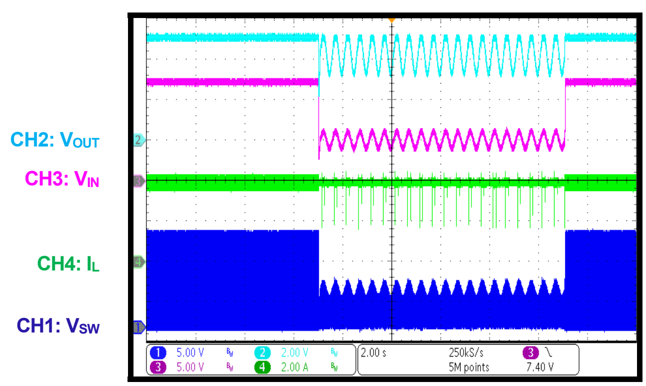
Load Dump
V_{IN} = 12V to 40V, I_{OUT} = 4A



Cold Crank
I_{OUT} = 0A



Cold Crank
I_{OUT} = 4A

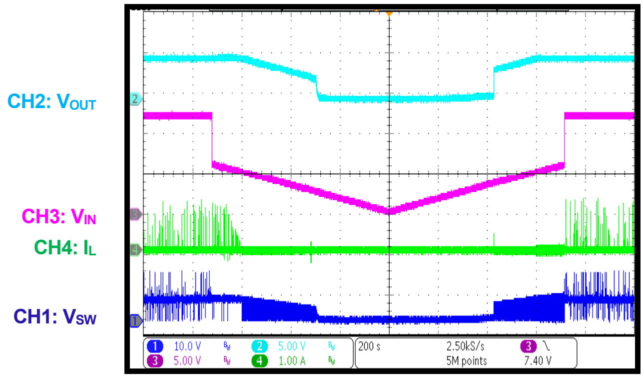


EVB TEST RESULTS *(continued)*

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

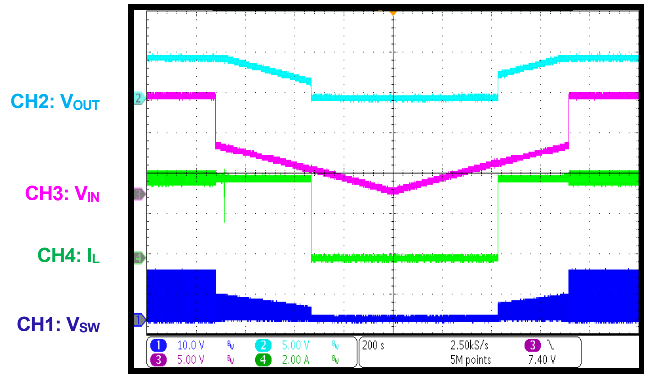
V_{IN} Ramping Down and Up

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



PCB LAYOUT (2)

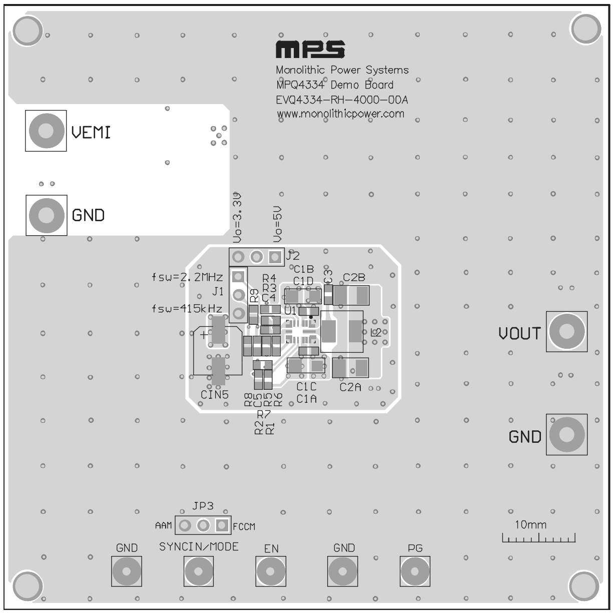


Figure 4: Top Silk and Top Layer

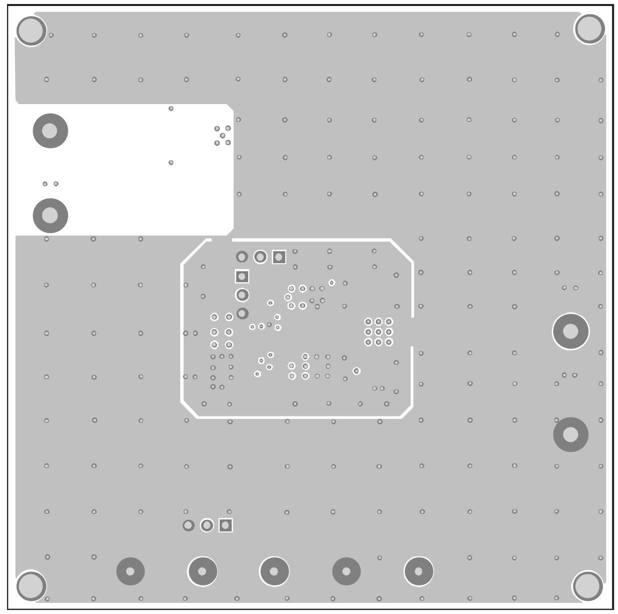


Figure 5: Mid-Layer 1

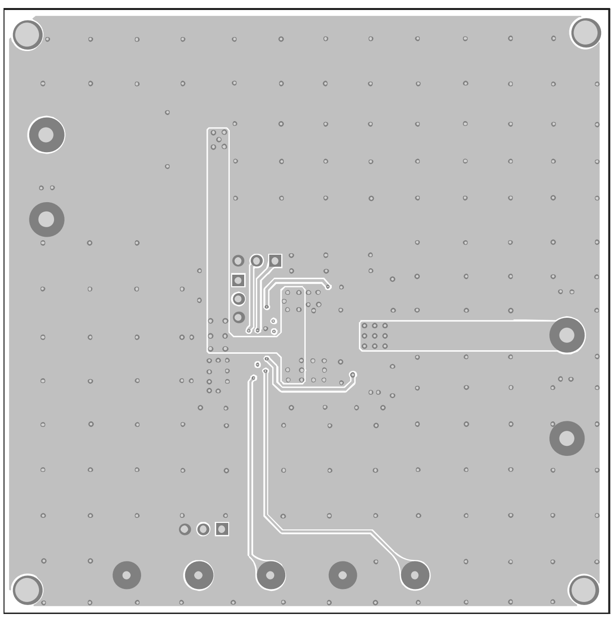


Figure 6: Mid-Layer 2

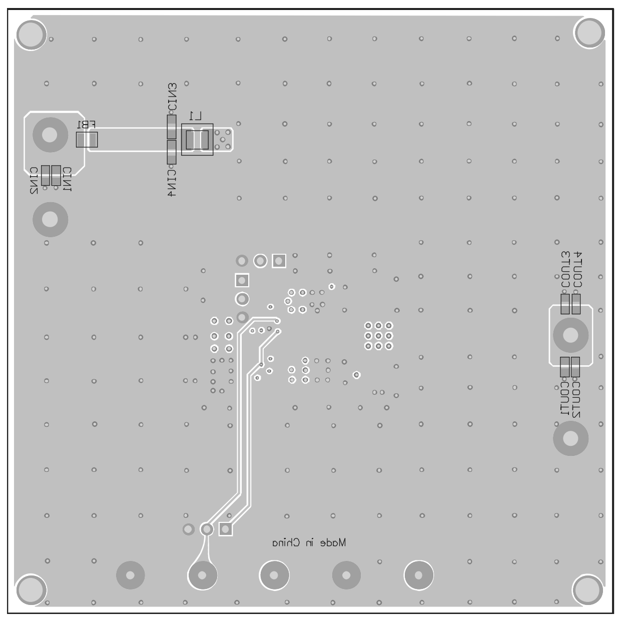


Figure 7: Bottom Layer and Bottom Silk

Note:

2) The copper thickness is 2oz.

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	6/3/2025	Initial Release	-