EVQ4321-D-00A

36V, 1A, Low-I_Q, Synchronous Step-Down Converter in a QFN-12 Package Evaluation Board, AEC-Q100 Qualified

DESCRIPTION

The EVQ4321-D-00A evaluation board is designed to demonstrate the capabilities of the MPQ4321, a 350kHz to 2.5MHz configurable-frequency, synchronous, step-down switching regulator with integrated, internal high-side MOSFETs (HS-FETs) and low-side MOSFETs (LS-FETs).

The MPQ4321 provides 1A of highly efficient output current (I_{OUT}) with peak current control mode. The wide 3.3V to 36V input voltage (V_{IN}) range and 42V load dump tolerance accommodates a variety of step-down applications in automotive input environments. A 1µA 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, which reduces the 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 helps prevent 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.

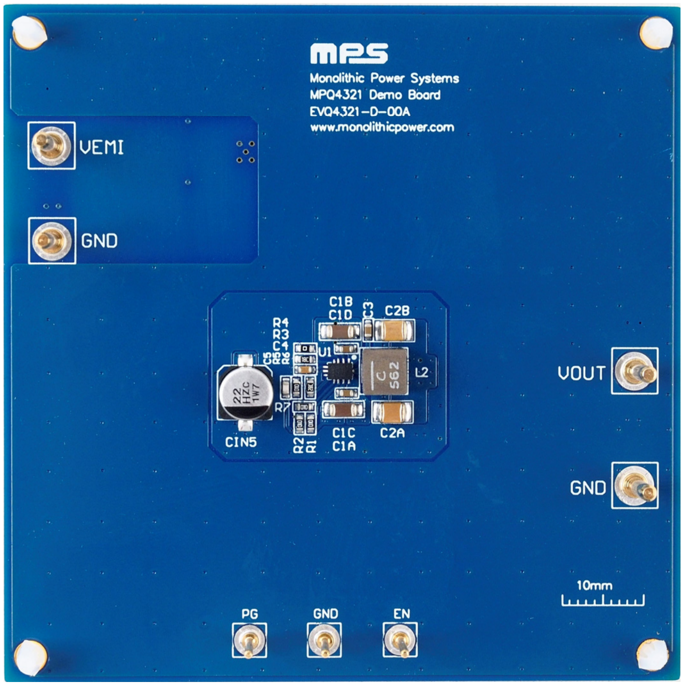
The EVQ4321-D-00A is fully assembled and tested. The MPQ4321 is available in a QFN-12 (2mmx3mm) package with wettable flanks. It is available in AEC-Q100 Grade 1.

PERFORMANCE SUMMARY

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

Parameters	Conditions	Value
Input voltage (V_{IN}) range		3.3V to 36V
Output voltage (V_{OUT})	V_{IN} = 6V to 36V, I_{OUT} = 0A to 1A	V_{OUT} = 5V
Maximum output current (I_{OUT})	V_{IN} = 3.3V to 36V	1A
Typical efficiency	V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 1A	92.6%
Peak efficiency	V_{IN} = 8V, V_{OUT} = 5V, I_{OUT} = 1A	94.4%
Switching frequency (f_{SW})		2.2MHz

EVQ4321-D-00A EVALUATION BOARD



LxWxH (8.3cmx8.3cmx0.58cm)

Board Number	MPS IC Number
EVQ4321-D-00A	MPQ4321GDE-AEC1

QUICK START GUIDE

The EVQ4321-D-00A evaluation board is easy to set up and use to evaluate the MPQ4321's performance. For proper measurement equipment set-up, refer to Figure 2 on page 4 and follow the steps below:

1. Preset the power supply between 6V and 36V, then turn off the power supply.
2. Set the load current between 0A and 1A. Electronic loads represent a negative impedance to the regulator, and setting a current too high may trigger hiccup mode.
3. If longer cables are used between the source and the evaluation board (>0.5m total), 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.
7. To use the enable 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 the regulator 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}), which ranges between 350kHz and 2.5MHz.
9. The external resistor divider sets the output voltage (V_{OUT}) (see Figure 1).

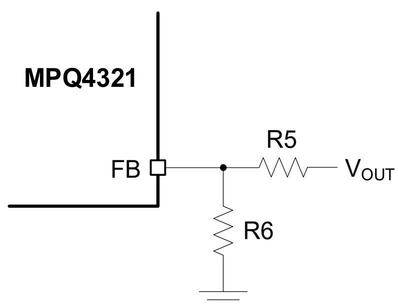


Figure 1: Feedback Divider Network with Adjustable Output

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

$$R6 = \frac{R5}{\frac{V_{OUT}}{0.8V} - 1} \quad (1)$$

Refer to the Application Information section in the MPQ4321 datasheet to calculate the inductance and output capacitance for different V_{OUT} values.

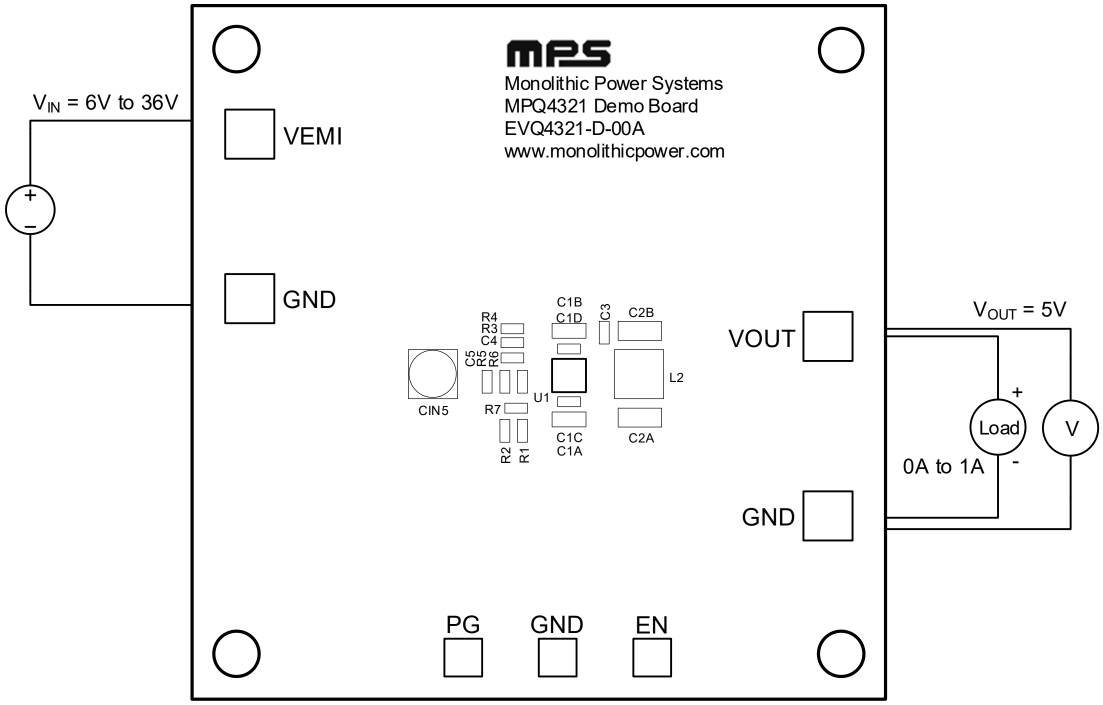
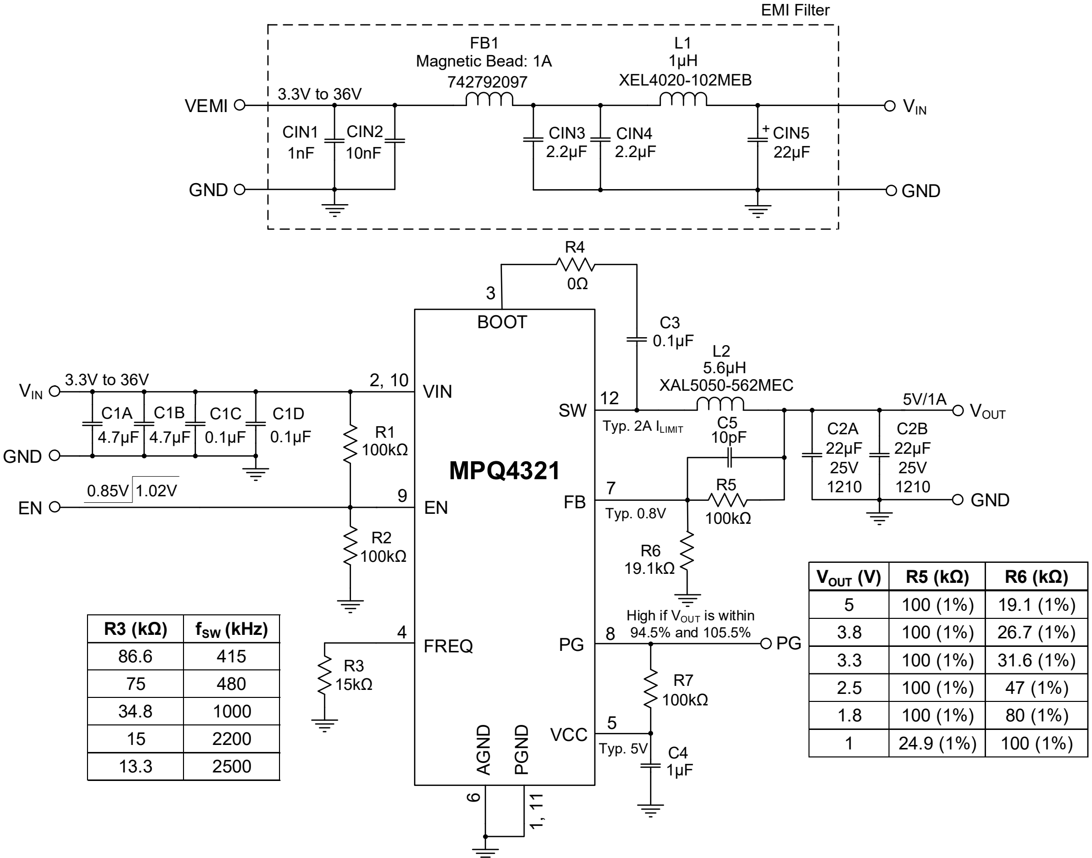


Figure 2: Measurement Equipment Set-Up

EVALUATION BOARD SCHEMATIC

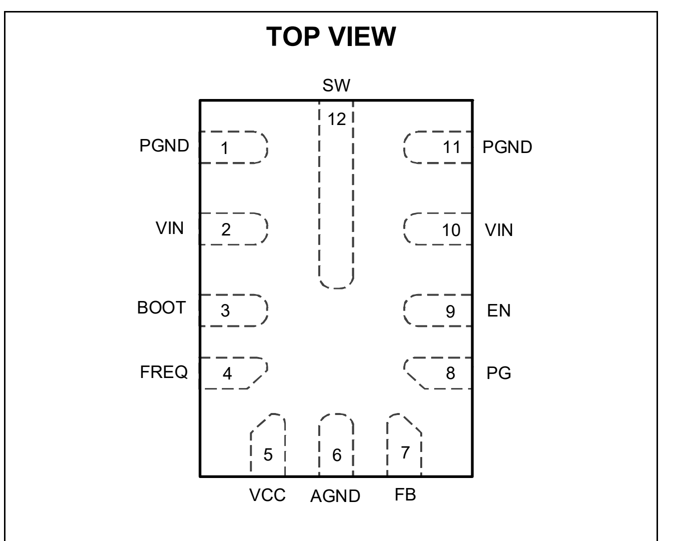


R3 (kΩ)	f_{SW} (kHz)
86.6	415
75	480
34.8	1000
15	2200
13.3	2500

V_{OUT} (V)	R5 (kΩ)	R6 (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)

EVQ4321-D-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	TDK	CGA4J3X7R1H225KT000N
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	GRM32ER71E226KE15L
1	C5	10pF	Ceramic capacitor, 50V, NP0	0603	Wurth	885012006051
1	C4	1µF	Ceramic capacitor, 25V, X7R	0603	Murata	GCM188R71E105KA64D
1	FB1	1A	Magnetic bead	0805	Wurth	742792097
1	L1	1µH	Inductor, 14.6mΩ, 9.6A	SMD	Coilcraft	XEL4020-102MEB
1	L2	5.6µH	Inductor, 25.8mΩ, 5.3A	SMD	Coilcraft	XAL5050-562MEC
4	R1, R5, R7, R2	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
1	R6	19.1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0719K1L
1	R3	15kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0715KL
1	R4	0Ω	Film resistor, 5%	0603	Yageo	RC0603JR-070RL
4	VEMI, GND, GND, VOUT	2mm	Golden pin	DIP	Custom (1)	
3	PG, EN, GND	1mm	Golden pin	DIP	Custom (1)	
1	U1	MPQ4321	36V, 1A, low-I_Q, synchronous step-down converter, AEC-Q100	QFN-12 (2mmx 3mm)	MPS	MPQ4321GDE-AEC1

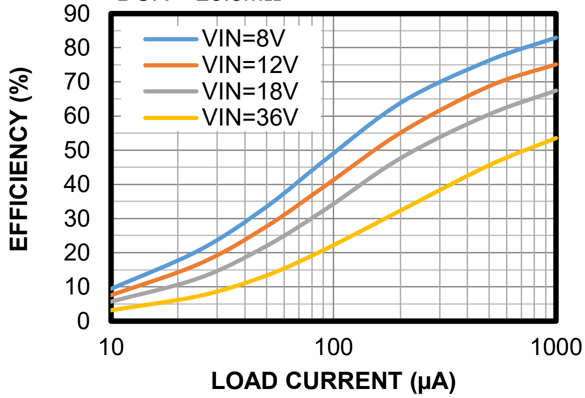
Note:

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

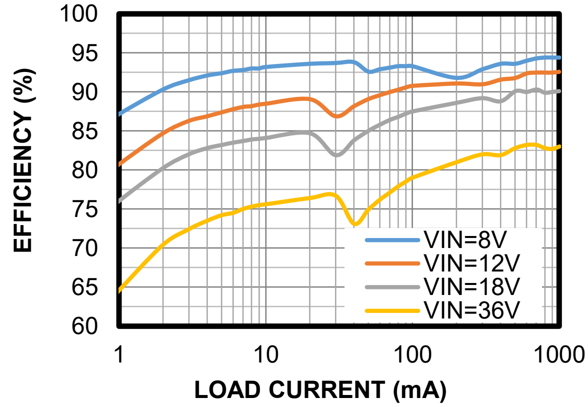
EVB TEST RESULTS

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

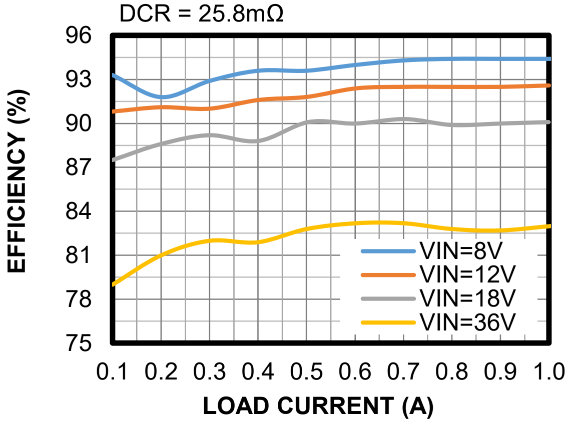
Efficiency vs. Load Current
R_{FB1} = 100kΩ, R_{FB2} = 19.1kΩ,
DCR = 25.8mΩ



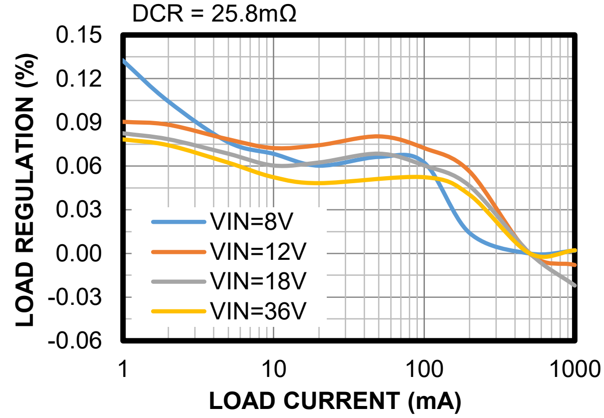
Efficiency vs. Load Current
DCR = 25.8mΩ



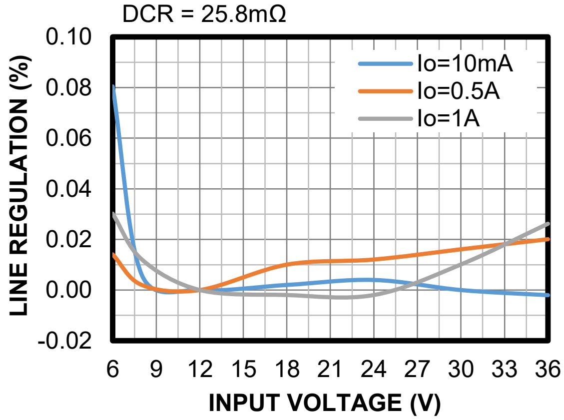
Efficiency vs. Load Current
DCR = 25.8mΩ



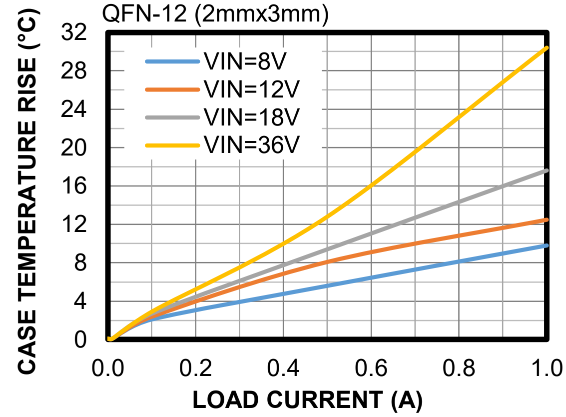
Load Regulation
DCR = 25.8mΩ



Line Regulation
DCR = 25.8mΩ

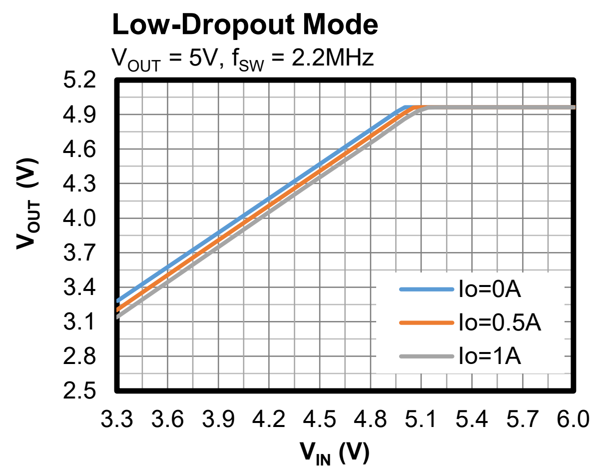


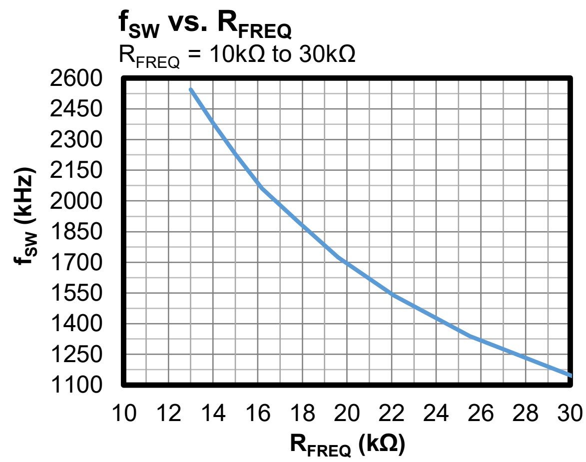
Case Temperature Rise
V_{OUT} = 5V, f_{SW} = 2.2MHz,
QFN-12 (2mmx3mm)

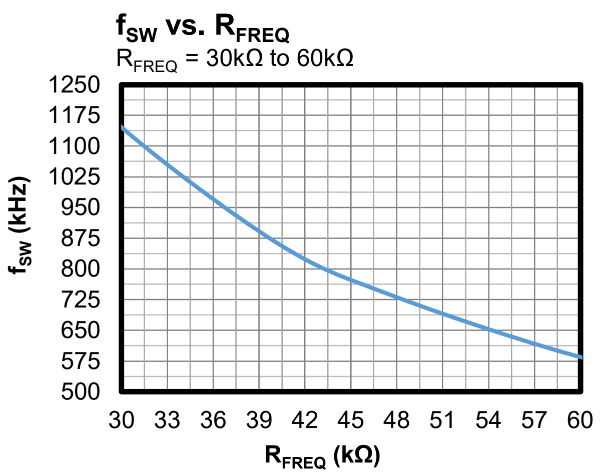


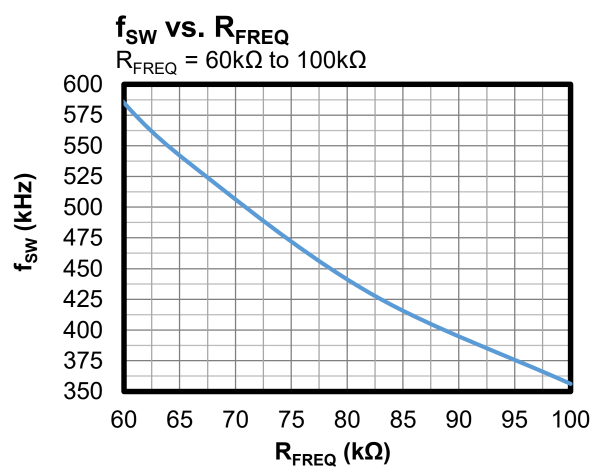
EVB TEST RESULTS *(continued)*

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







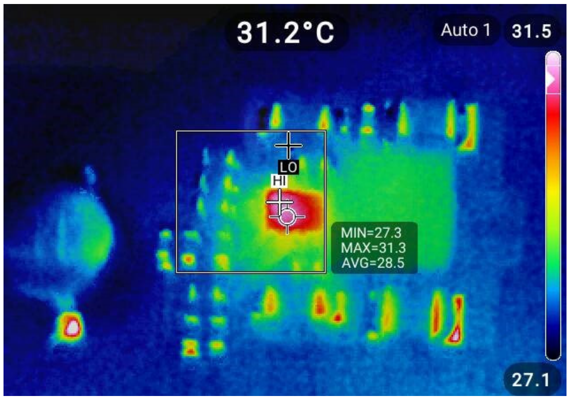


EVB TEST RESULTS *(continued)*

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

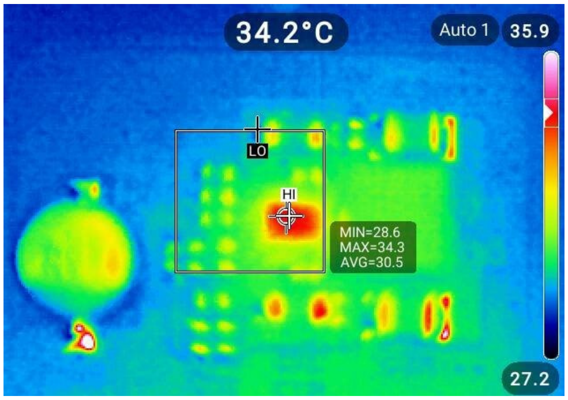
Thermal Performance

I_{OUT} = 0.5A, no forced airflow, T_{CASE} = 31.2°C



Thermal Performance

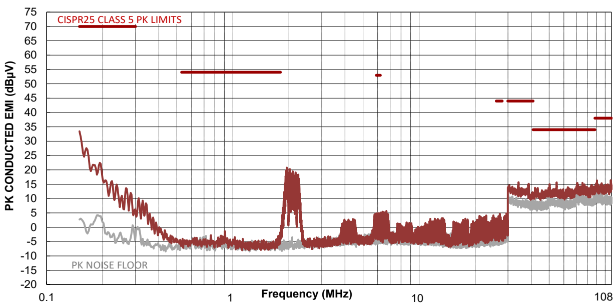
I_{OUT} = 1A, no forced airflow, T_{CASE} = 34.2°C



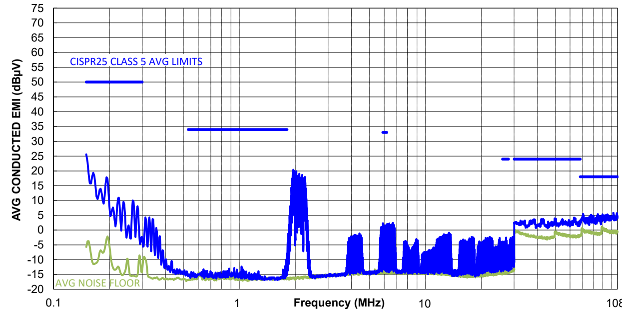
EVB TEST RESULTS *(continued)*

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

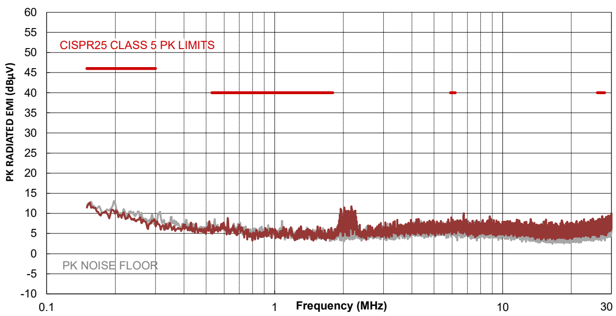
CISPR25 Class 5 Peak Conducted Emissions
150kHz to 108MHz



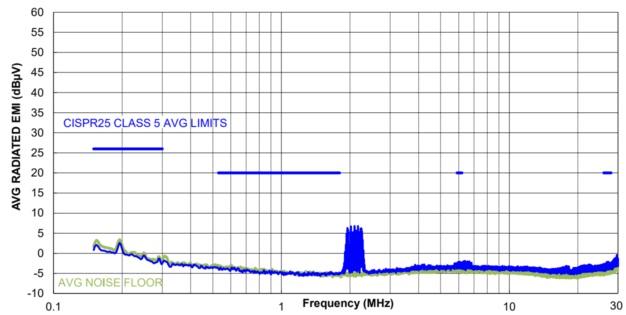
CISPR25 Class 5 Average Conducted Emissions
150kHz to 108MHz



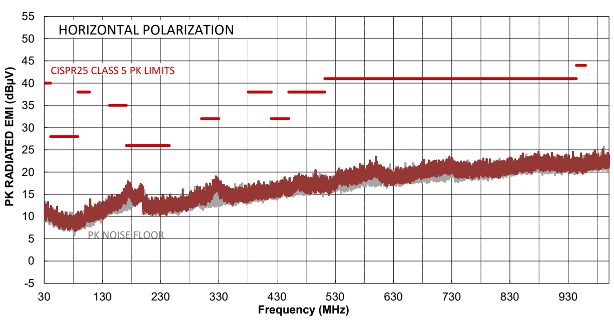
CISPR25 Class 5 Peak Radiated Emissions
150kHz to 30MHz



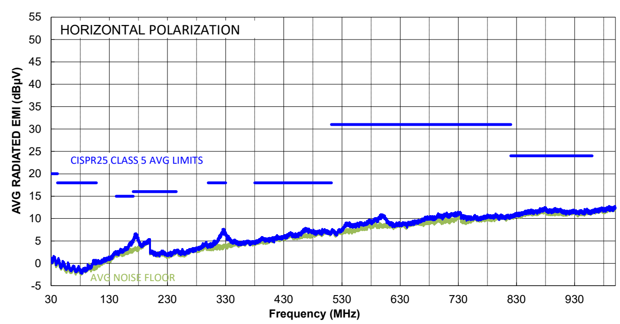
CISPR25 Class 5 Average Radiated Emissions
150kHz to 30MHz



CISPR25 Class 5 Peak Radiated Emissions
Horizontal, 30MHz to 1GHz



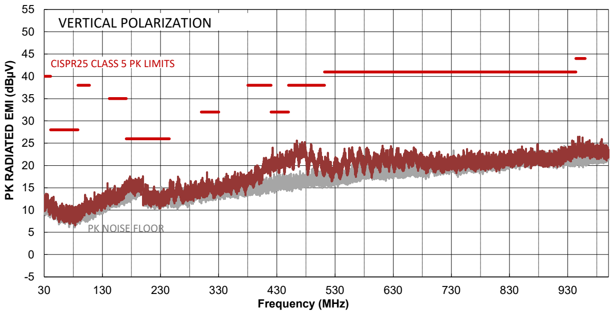
CISPR25 Class 5 Average Radiated Emissions
Horizontal, 30MHz to 1GHz



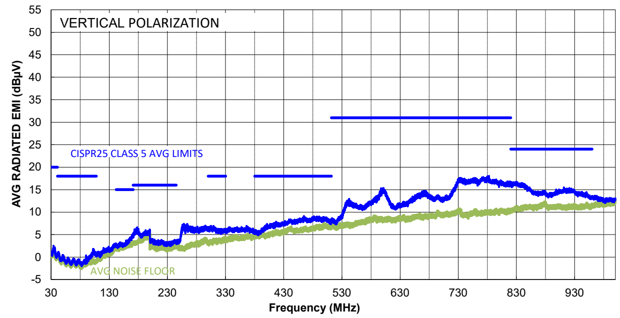
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, 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



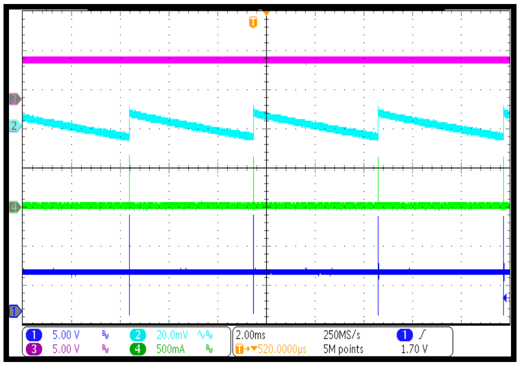
EVB TEST RESULTS *(continued)*

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

Steady State

I_{OUT} = 0A

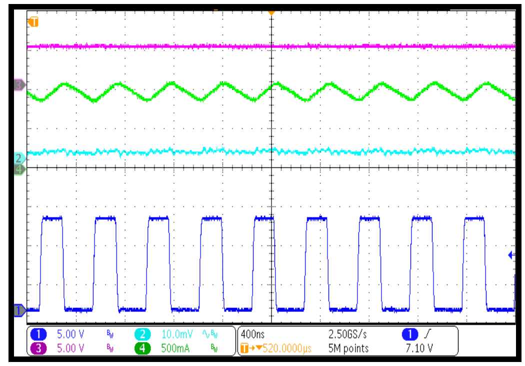
CH3: PG
CH2: V_{OUT}/AC
CH4: I_L
CH1: V_{SW}



Steady State

I_{OUT} = 1A

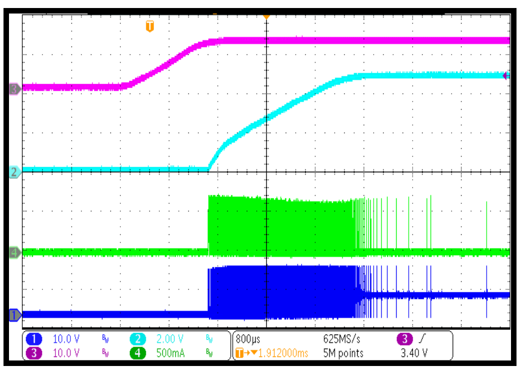
CH3: PG
CH2: V_{OUT}/AC
CH4: I_L
CH1: V_{SW}



Start-Up through VIN

I_{OUT} = 0A

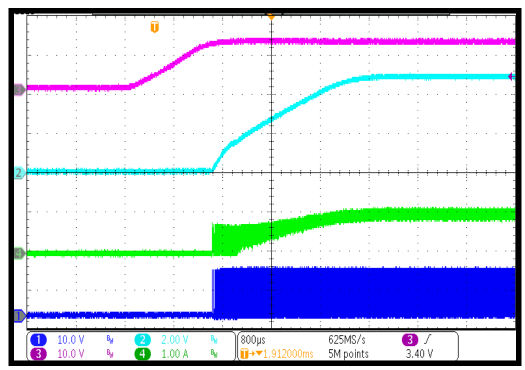
CH3: V_{IN}
CH2: V_{OUT}
CH4: I_L
CH1: V_{SW}



Start-Up through VIN

I_{OUT} = 1A

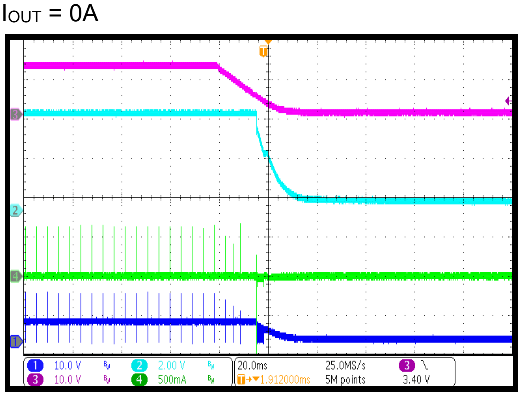
CH3: V_{IN}
CH2: V_{OUT}
CH4: I_L
CH1: V_{SW}



Shutdown through VIN

I_{OUT} = 0A

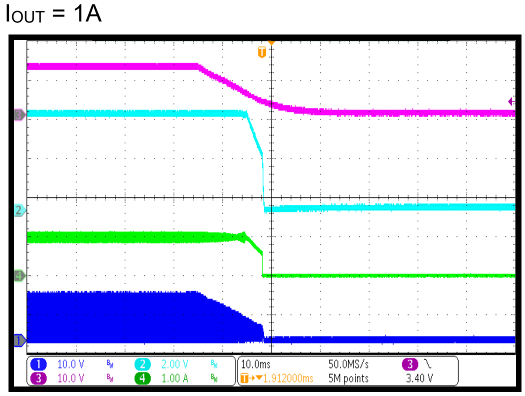
CH3: V_{IN}
CH2: V_{OUT}
CH4: I_L
CH1: V_{SW}



Shutdown through VIN

I_{OUT} = 1A

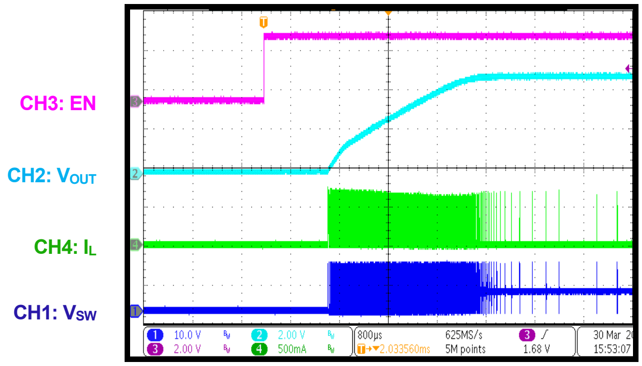
CH3: V_{IN}
CH2: V_{OUT}
CH4: I_L
CH1: V_{SW}



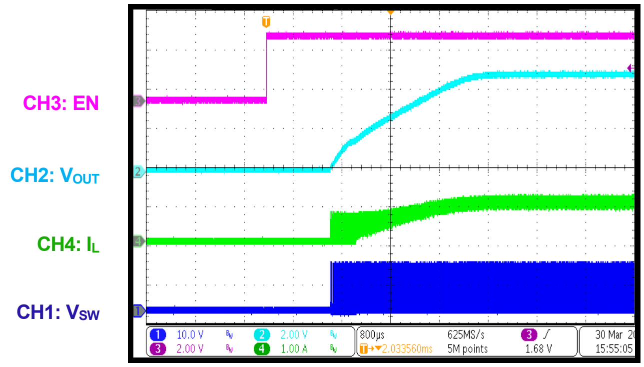
EVB TEST RESULTS *(continued)*

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

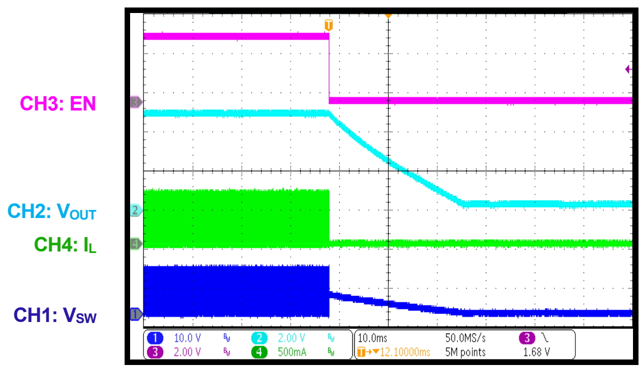
Start-Up through EN
I_{OUT} = 0A



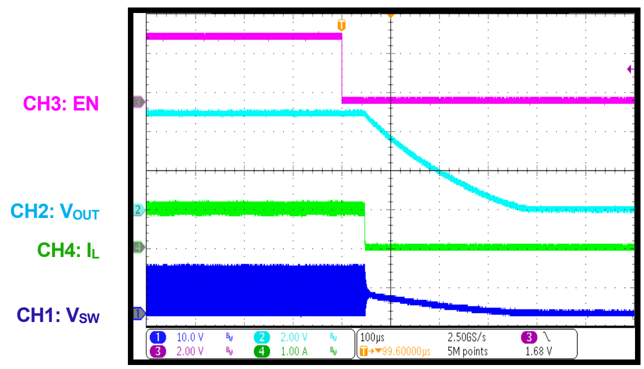
Start-Up through EN
I_{OUT} = 1A



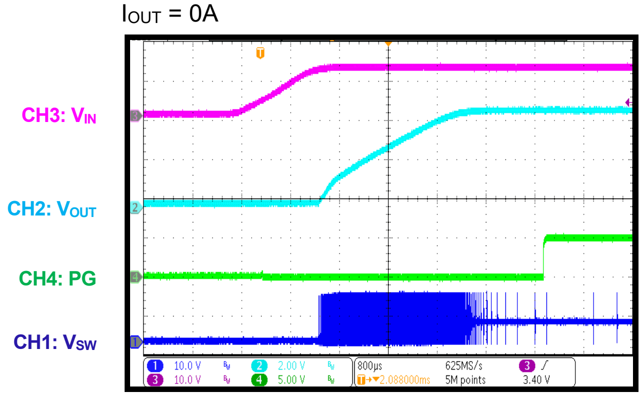
Shutdown through EN
I_{OUT} = 0A



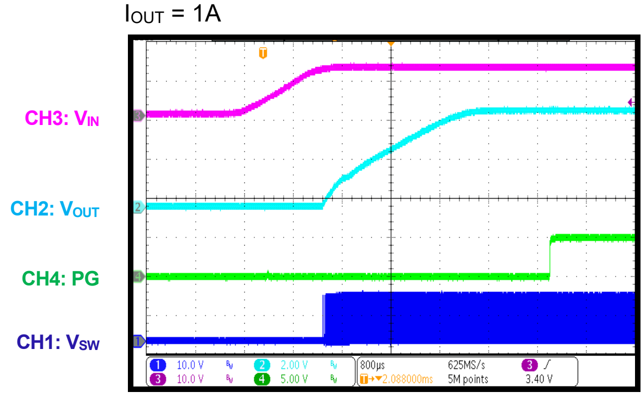
Shutdown through EN
I_{OUT} = 1A



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



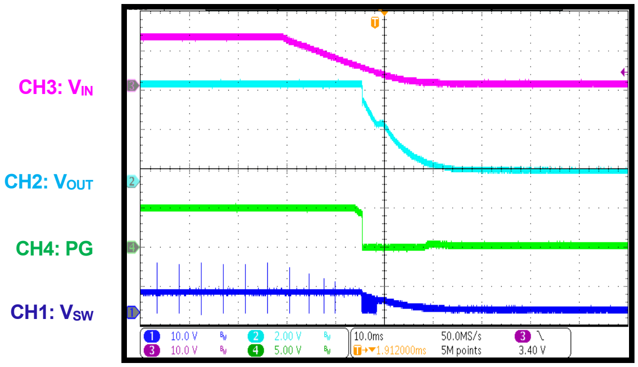
PG in Start-Up through VIN
I_{OUT} = 1A



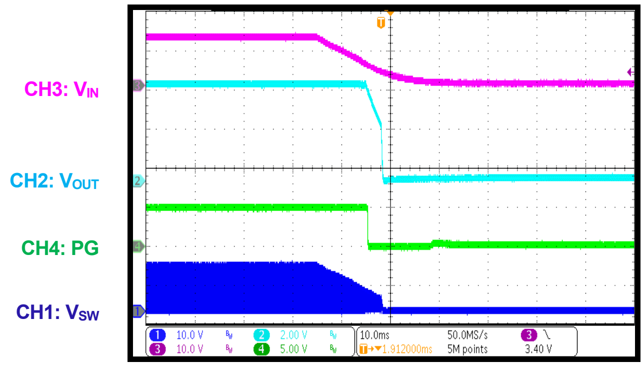
EVB TEST RESULTS *(continued)*

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

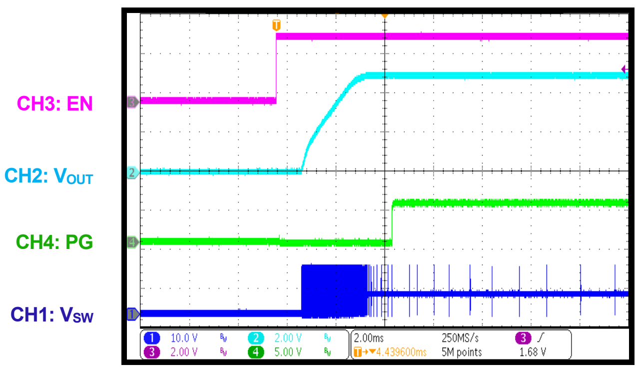
PG in Shutdown through VIN
I_{OUT} = 0A



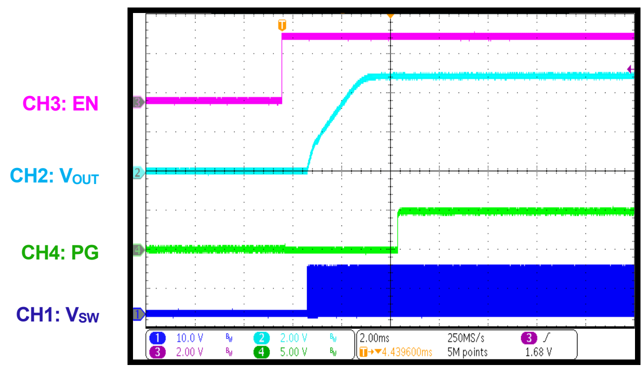
PG in Shutdown through VIN
I_{OUT} = 1A



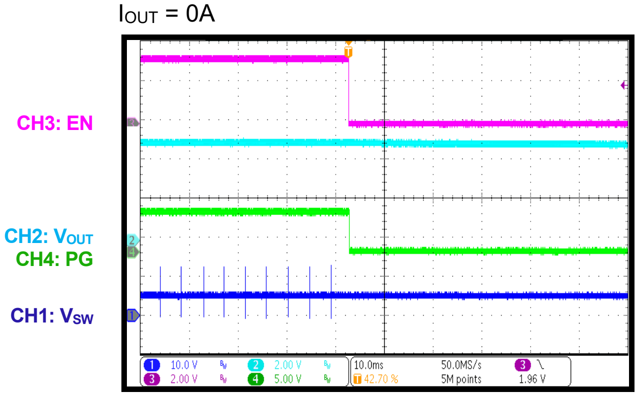
PG in Start-Up through EN
I_{OUT} = 0A



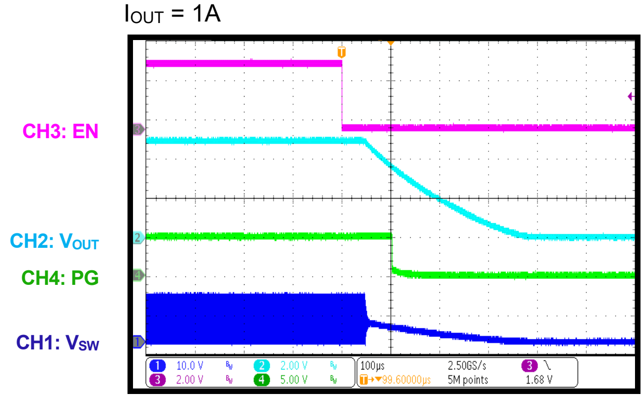
PG in Start-Up through EN
I_{OUT} = 1A



PG in Shutdown through EN
I_{OUT} = 0A



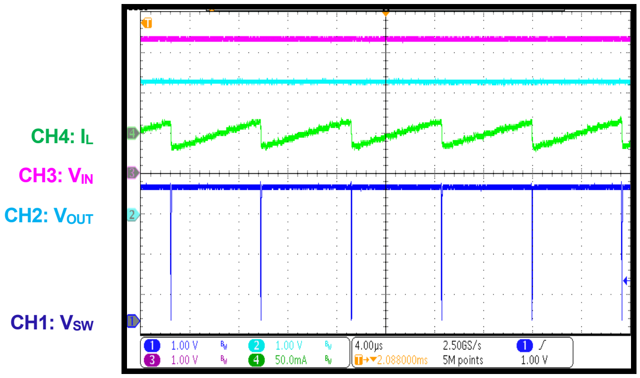
PG in Shutdown through EN
I_{OUT} = 1A



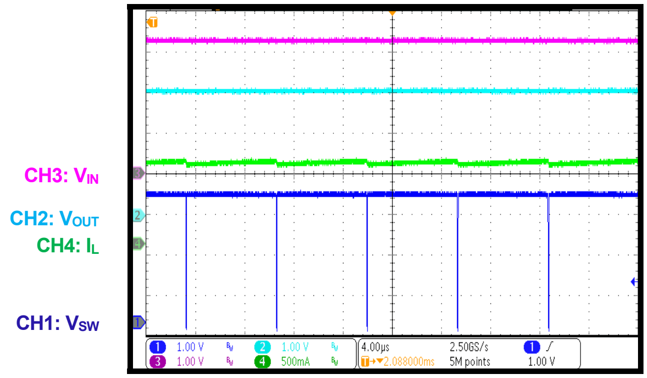
EVB TEST RESULTS *(continued)*

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

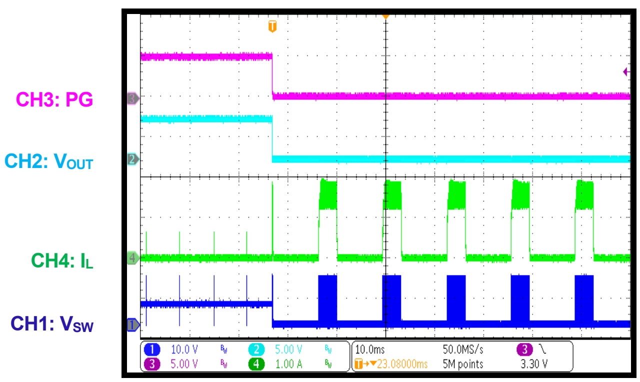
Low-Dropout Mode
I_{OUT} = 0A, V_{IN} = 3.3V



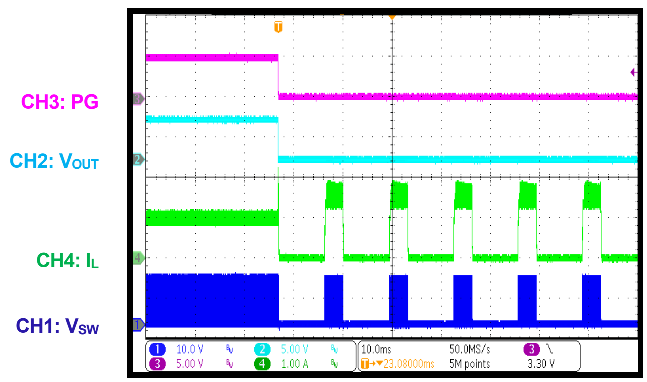
Low-Dropout Mode
I_{OUT} = 1A, V_{IN} = 3.3V



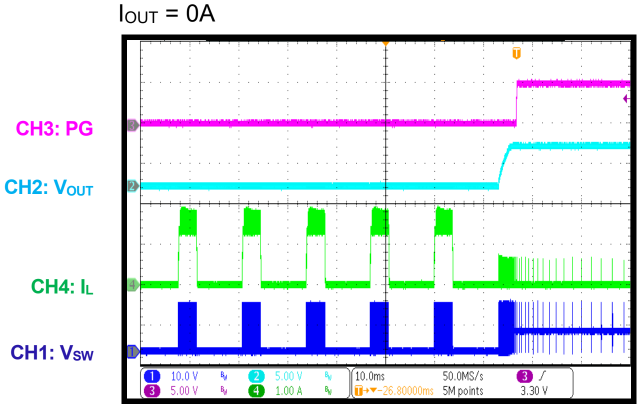
SCP Entry
I_{OUT} = 0A



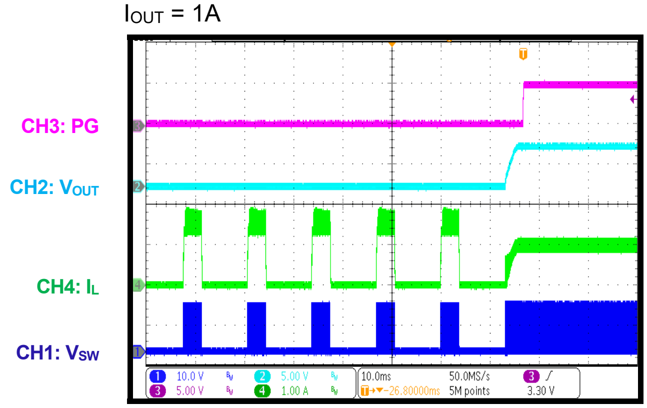
SCP Entry
I_{OUT} = 1A



SCP Recovery
I_{OUT} = 0A



SCP Recovery
I_{OUT} = 1A

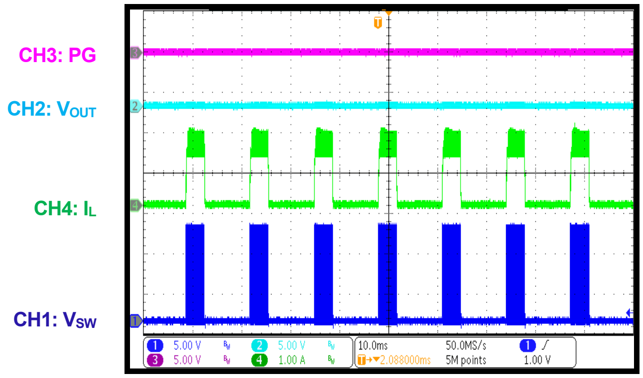


EVB TEST RESULTS *(continued)*

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

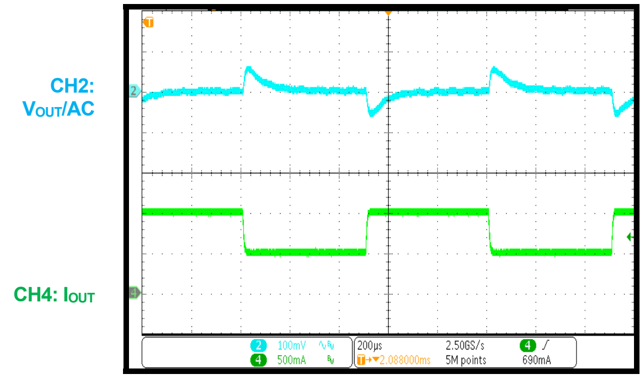
SCP Steady State

I_{OUT} = 0A



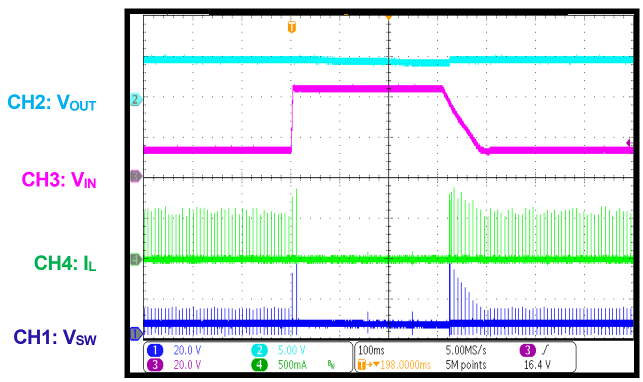
Load Transient

I_{OUT} = 0.5A to 1A, 1.6A/μs



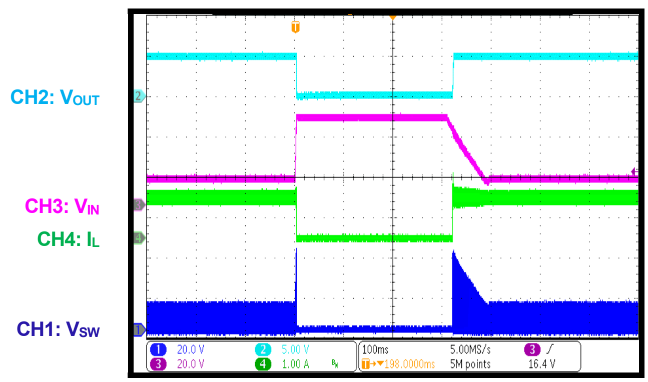
Load Dump

V_{IN}= 12V to 42V, I_{OUT} = 0A



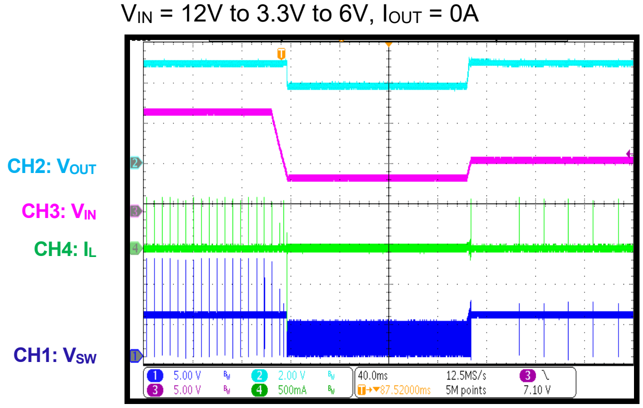
Load Dump

V_{IN} = 12V to 42V, I_{OUT} = 1A



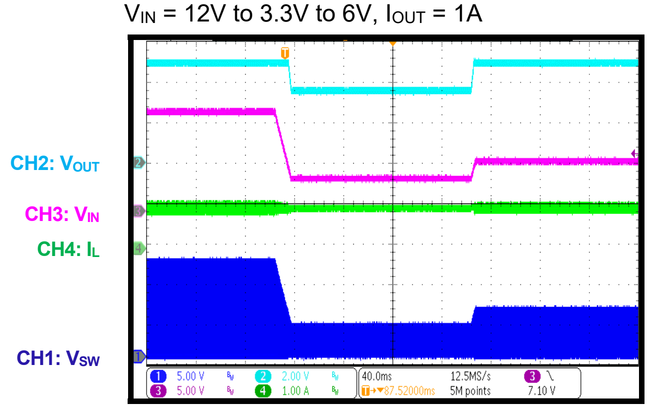
Cold Crank

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



Cold Crank

V_{IN} = 12V to 3.3V to 6V, I_{OUT} = 1A

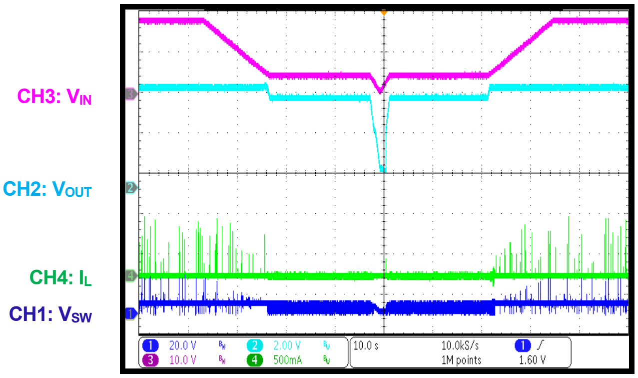


EVB TEST RESULTS *(continued)*

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

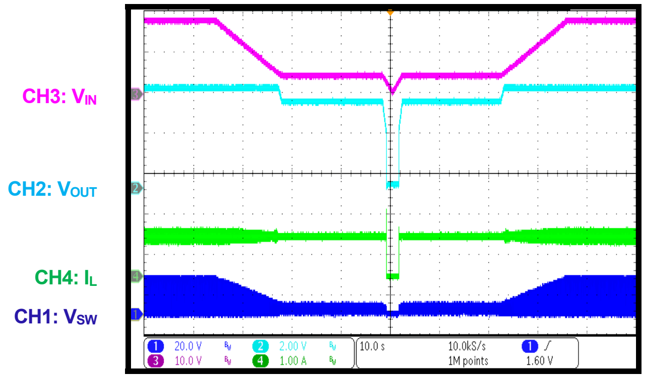
V_{IN} Ramping Down and Up

V_{IN} = 18V to 4.5V to 0V to 4.5V to 18V,
I_{OUT} = 0A



V_{IN} Ramping Down and Up

V_{IN} = 18V to 4.5V to 0V to 4.5V to 18V,
I_{OUT} = 1A



PCB LAYOUT (2)

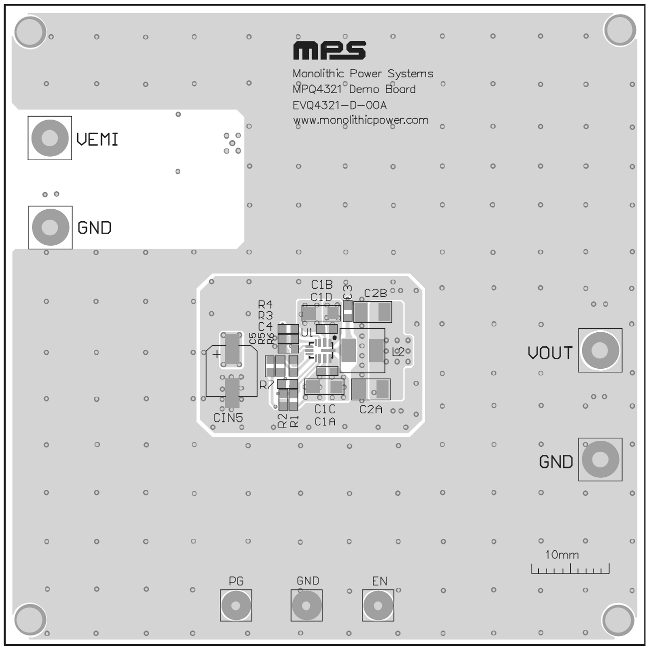


Figure 4: Top Silk and Top Layer

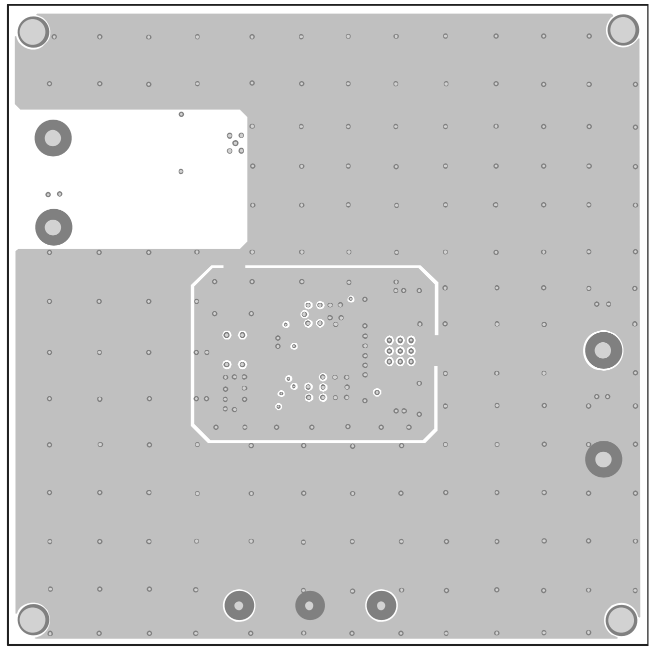


Figure 5: Mid-Layer 1

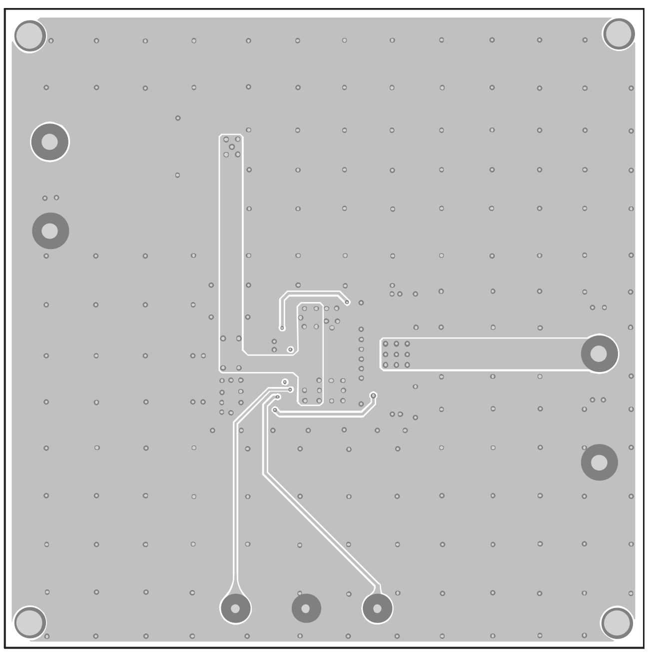


Figure 6: Mid-Layer 2

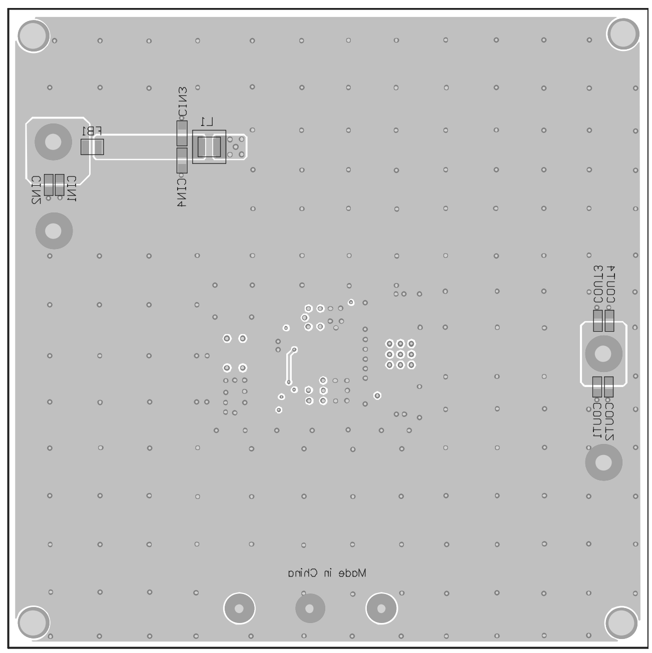


Figure 7: Bottom Layer and Bottom Silk

Note:

2) The copper thickness is 2oz.

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	8/8/2022	Initial Release	-