EVQ4328-R-00A

36V, 4A, Low Quiescent Current, Synchronous Step-Down Converter Evaluation Board, AEC-Q100 Qualified

DESCRIPTION

The EVQ4328-R-00A evaluation board is designed to demonstrate the capabilities of the MPQ4328, a synchronous, step-down switching converter with a configurable frequency and integrated internal high-side MOSFET (HS-FET) and low-side MOSFET (LS-FET). The MPQ4328 provides up to 4A of highly efficient output current (I_{OUT}) with current mode control for fast loop response.

The wide 3.3V to 36V input voltage (V_{IN}) range with 42V load dump support accommodates a variety of step-down applications in automotive input environments. A 1µA shutdown mode quiescent current allows the device to be used in battery-powered applications.

High power conversion efficiency across the wide load range is achieved by scaling down the switching frequency (f_{SW}) under light-load conditions to reduce the switching and gate driving losses.

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

Thermal shutdown provides reliable, fault-tolerant operation. A high duty cycle and low-dropout mode are provided for automotive cold-crank conditions.

The EVQ4328-R-00A is a fully assembled and tested evaluation board. The MPQ4328 is available in a QFN-14 (4mmx4mm) package with wettable flanks. It is available in AEC-Q100 Grade 1.

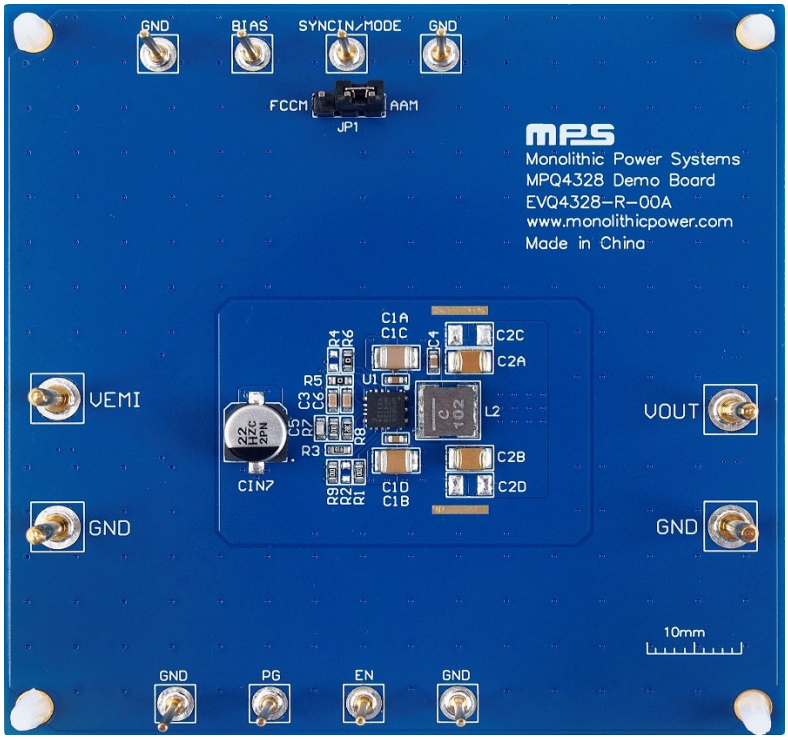
PERFORMANCE SUMMARY

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} = 3.3V to 36V, I_{OUT} = 0A to 4A	5V
Maximum output current (I_{OUT})	V_{IN} = 3.3V to 36V	4A
Typical efficiency	V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 4A	93.9%
Peak efficiency	V_{IN} = 8V, V_{OUT} = 5V, I_{OUT} = 1.6A	96%
Switching frequency (f_{SW})		2.2MHz

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EVQ4328-R-00A EVALUATION BOARD



LxWxH (8.3cmx8.3cmx1.3cm)

Board Number	MPS IC Number
EVQ4328-R-00A	MPQ4328GRE-AEC1

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QUICK START GUIDE

The EVQ4328-R-00A evaluation board is easy to set up and use to evaluate the MPQ4328's performance. For proper measurement equipment set-up, refer to Figure 3 on page 5 and follow the steps below:

1. Preset the power supply to be between 3.3V 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 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, especially when V_{IN} ≥ 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 automatically start up.
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 the enable function is not used, EN can be connected directly to VIN.
8. The MPQ4328's switching frequency (f_{SW}) can be configured by R3, which is the FREQ pin's resistor (R_{FREQ}). R3 can be estimated based on the relationship between f_{SW} and R_{FREQ}. Figure 1 shows the relationship between f_{SW} and R_{FREQ} when f_{SW} is between 200kHz and 1000kHz.

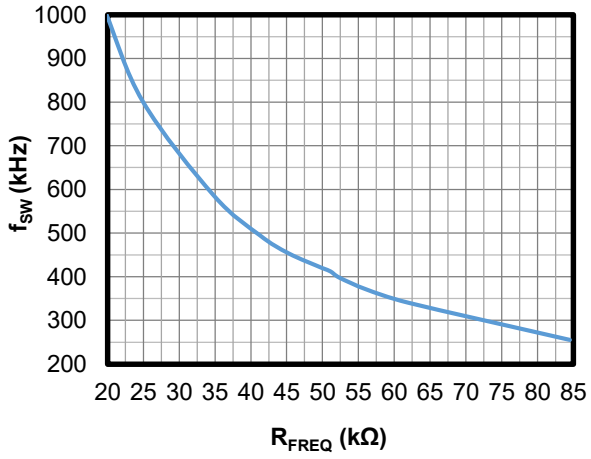


Figure 1: f_{SW} vs. R_{FREQ} (f_{SW} = 200kHz to 1000kHz)

Figure 2 on page 4 shows the relationship between f_{SW} and R_{FREQ} when f_{SW} is between 1000kHz and 2500kHz.

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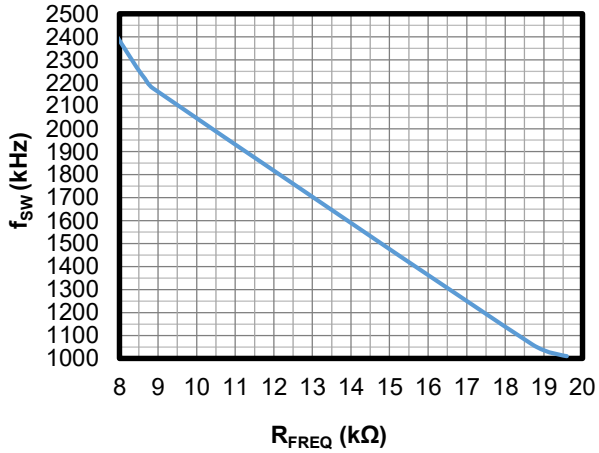


Figure 2: f_{SW} vs. R_{FREQ} (f_{SW} = 1000kHz to 2500kHz)

Table1 shows some common f_{SW} and R_{FREQ} values for a quick reference to select f_{SW}.

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

R_{FREQ} (kΩ)	f_{SW} (kHz)
7.87	2500
8.66	2200
14.3	1500
18.7	1060
19.6	1000
24.9	800
34.8	590
43.2	470
49.9	410
52.3	400
56.2	370
62	340
84.5	255
100	210

9. The output voltage (V_{OUT}) is set by the external resistor divider (R7 and R8). If R7 = 100kΩ, then R8 can be calculated with Equation (1):

$$R8 = \frac{R7}{\frac{V_{OUT}}{0.8V} - 1} \quad (1)$$

Table 2 shows the recommended R7 and R8 values for common output voltages.

Table 2: Resistor Selection for Output Voltages

V_{OUT} (V)	R7 (kΩ)	R8 (kΩ)
3.3	100 (0.1%)	31.6 (0.1%)
5	100 (0.1%)	19.1 (0.1%)

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10. When the SYNC/MODE pin is used as the SYNC input pin (SYNCIN), f_{SW} can be synchronized to the rising edge of a clock signal applied to the SYNC/MODE pin. The recommended SYNCIN frequency range is between 90% and 110% of f_{SW}. When the SYNCIN/MODE pin is used for mode selection (MODE), pulling this pin high forces the device to operate in forced continuous conduction mode (FCCM), while pulling it low forces the device to work in advanced asynchronous modulation (AAM) mode (see Table 3).

Table 3: Mode Selection

SYNC/MODE Input	Operation
<0.4V	AAM mode
>1.4V	FCCM
External clock in	FCCM

Refer to the Application Information section in the MPQ4328's datasheet to calculate the inductance and output capacitance.

Figure 3 shows the measurement equipment set-up.

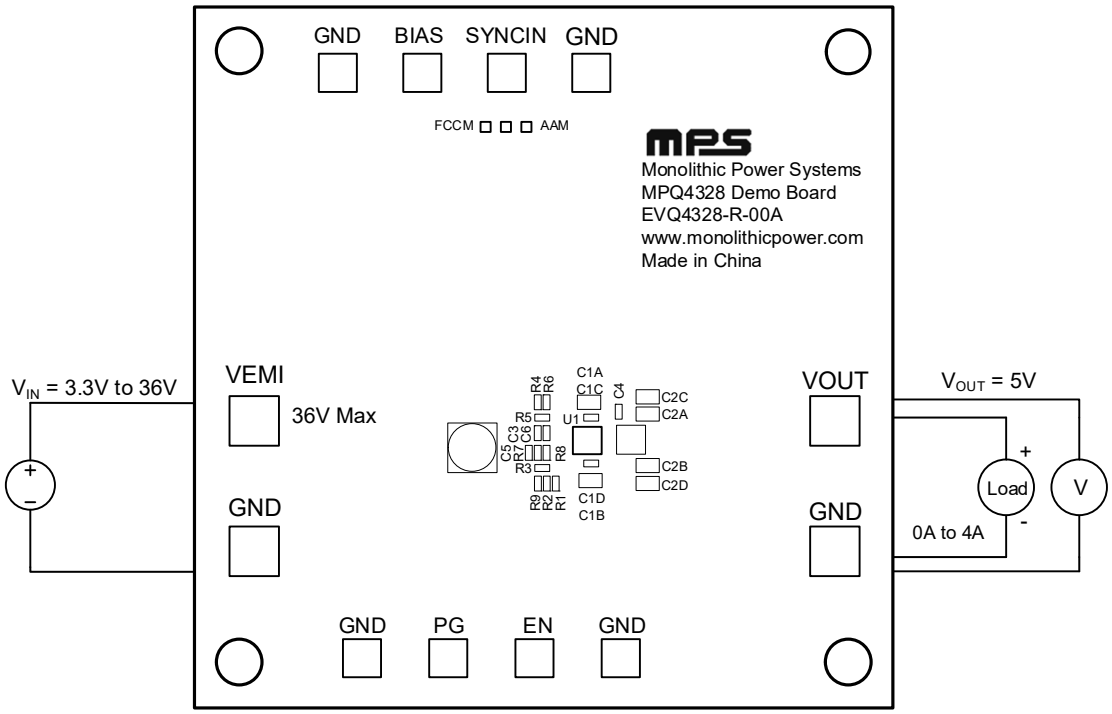


Figure 3: Measurement Equipment Set-Up

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EVALUATION BOARD SCHEMATIC

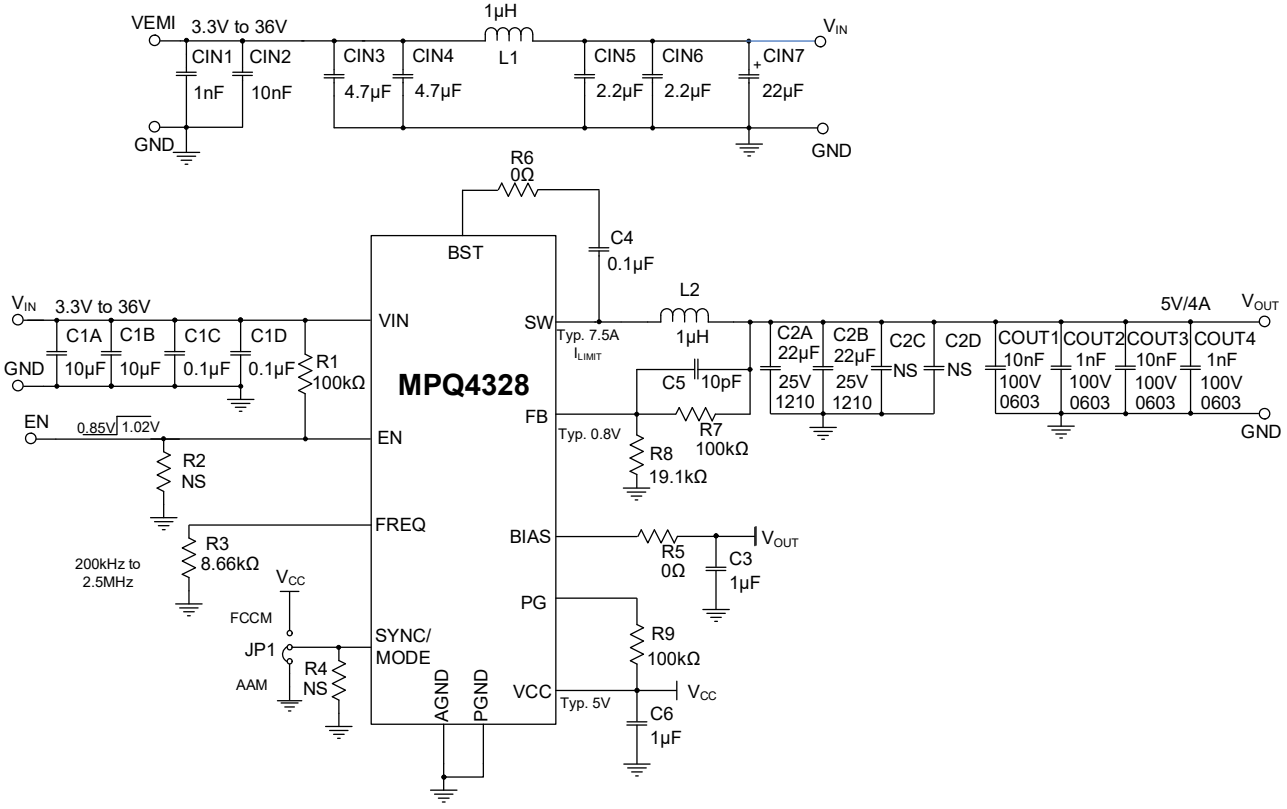
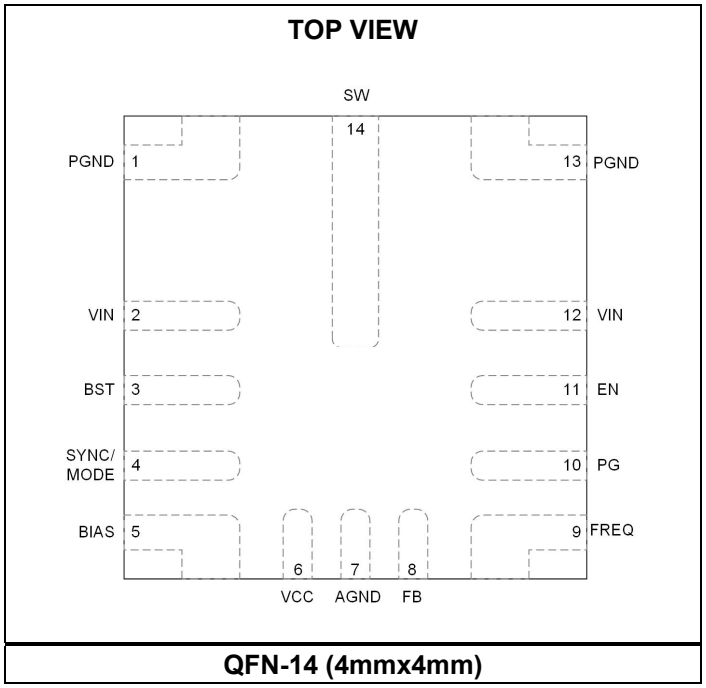


Figure 4: Evaluation Board Schematic

PACKAGE REFERENCE



QFN-14 (4mmx4mm)

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EVQ4328-R-00A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
3	CIN1, COUT2, COUT4	1nF	Ceramic capacitor, 100V, X7R	0603	Murata	GRM188R72A102KA01D
3	CIN2, COUT1, COUT3	10nF	Ceramic capacitor, 100V, X7R	0603	Murata	GRM188R72A103KA01D
2	CIN3, CIN4	4.7μF	Ceramic capacitor, 50V, X7R	1206	Murata	GRM31CR71H475KA12L
2	CIN5, CIN6	2.2μF	Ceramic capacitor, 50V, X7R	1206	Murata	GCM31CR71H225KA55L
1	CIN7	22μF	Aluminum polymer capacitor, 50V	SMD	Panasonic	EEHZC1H220P
2	C1A, C1B	10μF	Ceramic capacitor, 50V, X7R	1210	Murata	GRM32ER71H106KA12L
3	C1C, C1D, C4	0.1μF	Ceramic capacitor, 100V, X7R	0603	Murata	GRM188R72A104KA35D
1	C5	10pF	Ceramic capacitor, 100V, C0G	0603	Murata	GCM1885C2A100JA16D
2	C2A, C2B	22μF	Ceramic capacitor, 25V, X7R	1210	Murata	GRM32ER71E226KE15L
2	C3, C6	1μF	Ceramic capacitor, 25V, X7R	0603	Murata	GCM188R71E105KA64D
1	L1	1μH	Inductor, 9.6A	SMD	Coilcraft	XEL4020-102MEB
1	L2	1μH	Inductor, 9.4mΩ, 11.1A	SMD	Coilcraft	XAL5030-102MEB/C
3	R1, R7, R9	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
1	R8	19.1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0719K1L
1	R3	8.66kΩ	Film resistor, 1%	0603	Yageo	0603SAF8661T5E
2	R5, R6	0Ω	Film resistor, 5%	0603	Yageo	RC0603JR-070RL
2	R2, R4	NS				
4	C2C, C2D, C2E, C2F	NS				
1	JP1	2.54mm	Test pin, 3-pin	DIP	Any	
4	VEMI, GND, VOUT, GND	2mm	Golden pin	DIP	Custom (1)	
8	PG, EN, BIAS, SYNCIN, GND	1mm	Golden pin	DIP	Custom (1)	
1	U1	MPQ4328	36V/4A, step-down converter, AEC-Q100	QFN-14 (4mmx 4mm)	MPS	MPQ4328GRE-AEC1

Note:

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

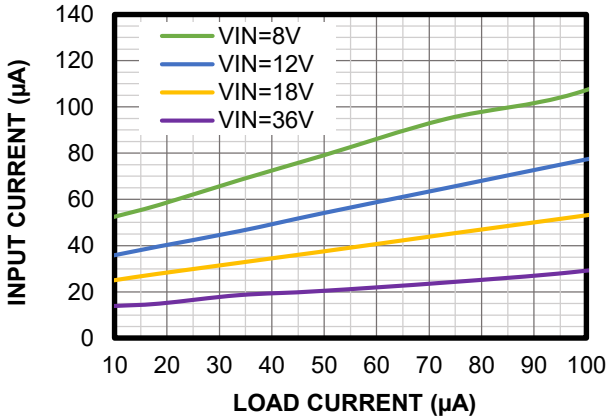
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EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

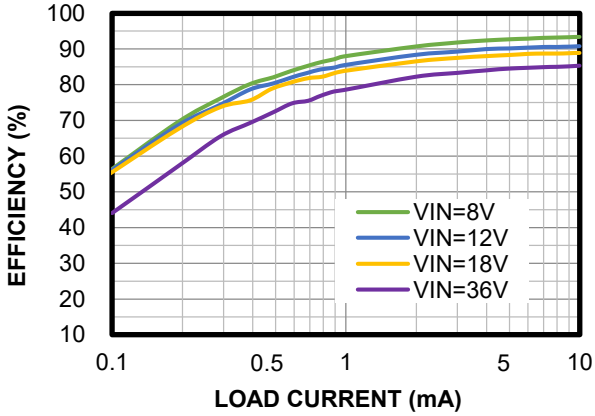
Input Current vs. Load Current

AAM mode, 10µA to 100µA



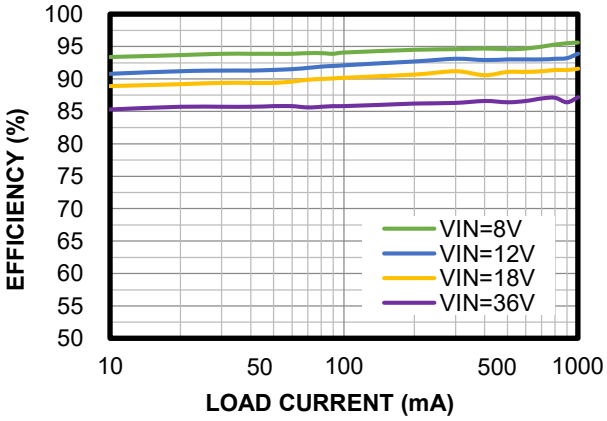
Input Current vs. Load Current

AAM mode, 0.1mA to 10mA



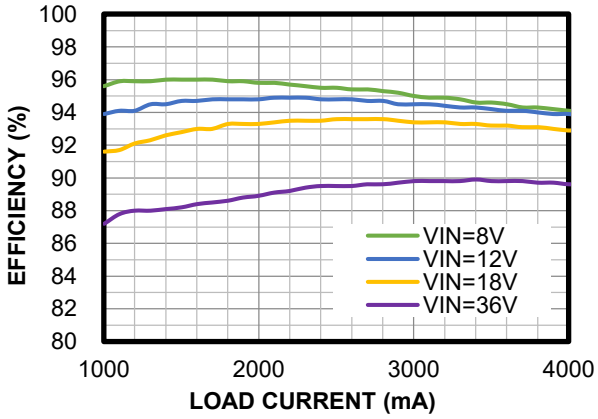
Efficiency vs. Load Current

AAM mode, 10mA to 1000mA



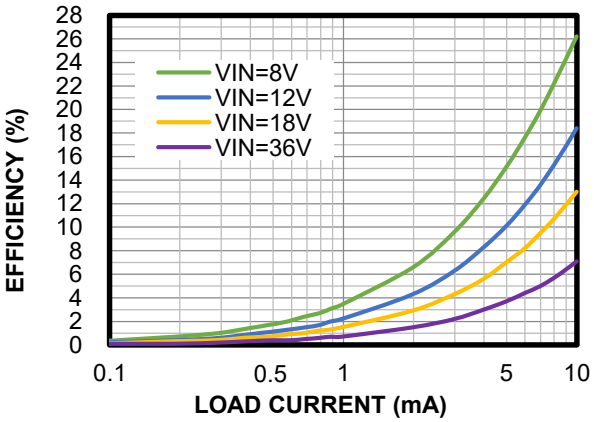
Efficiency vs. Load Current

AAM mode, 1A to 4A



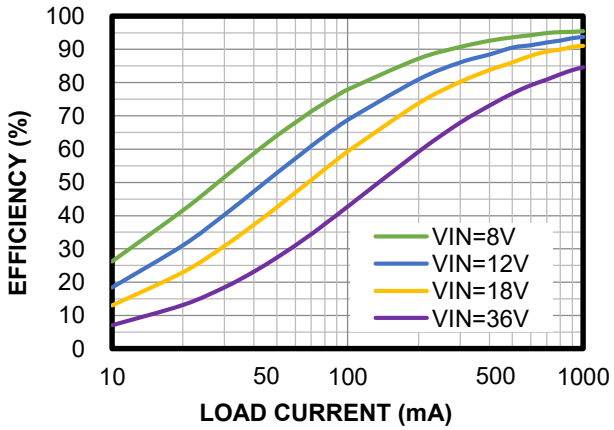
Efficiency vs. Load Current

FCCM, 0.1mA to 10mA



Efficiency vs. Load Current

FCCM, 10mA to 1000mA



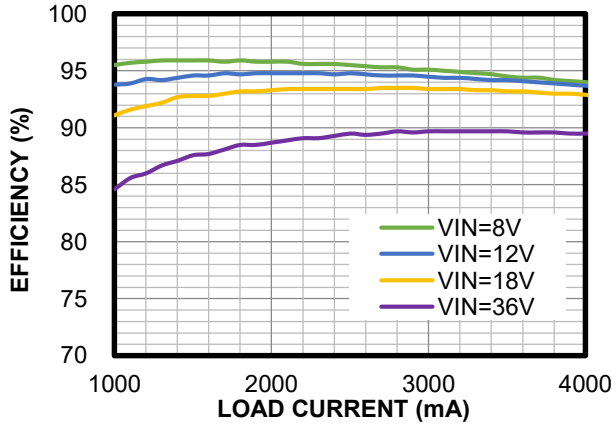
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EVB TEST RESULTS *(continued)*

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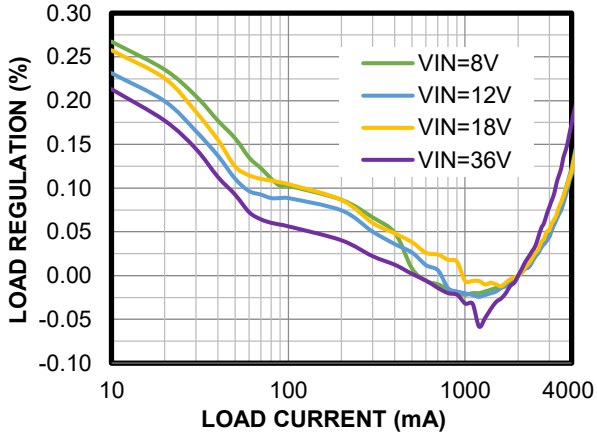
Efficiency vs. Load Current

FCCM, 1A to 4A



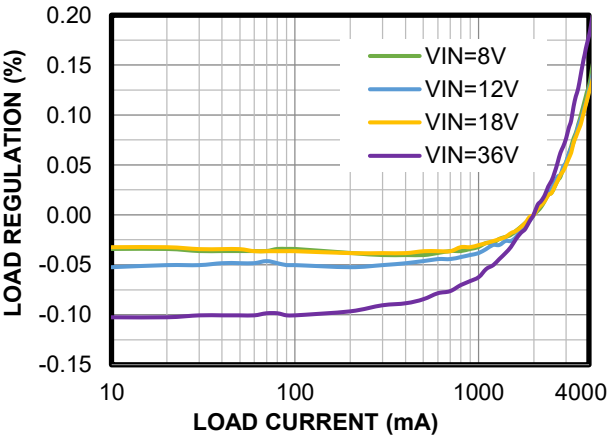
Load Regulation

AAM mode



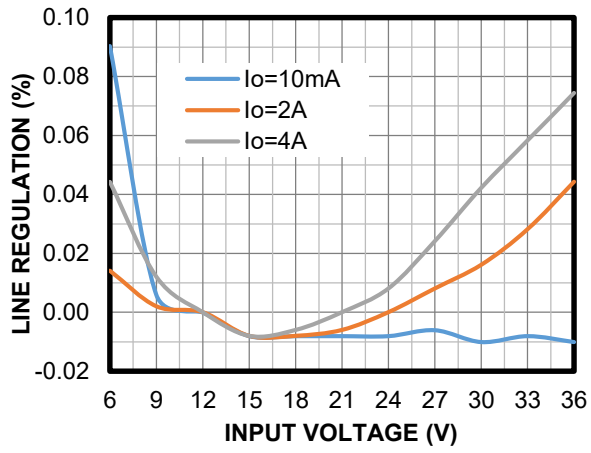
Load Regulation

FCCM



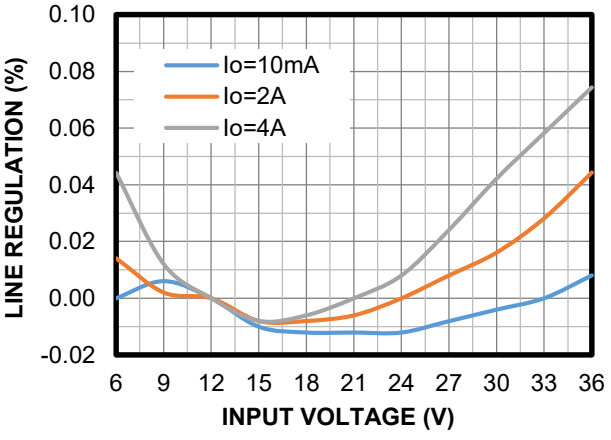
Line Regulation

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



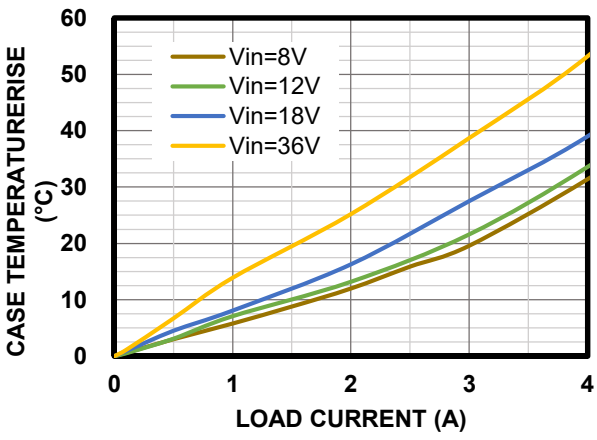
Line Regulation

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



Case Temperature Rise

AAM mode



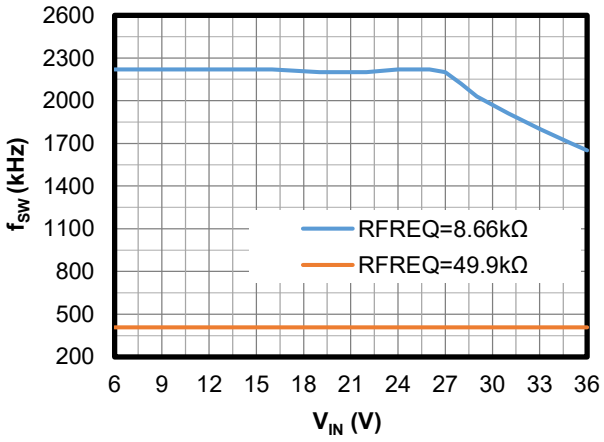
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EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

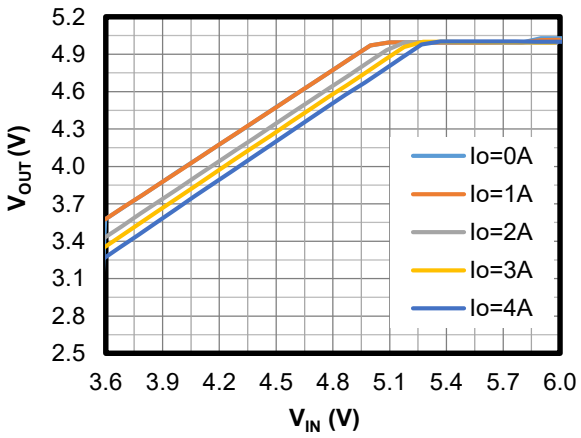
f_{SW} vs. V_{IN}

FCCM, V_{OUT} = 3.3V



Low-Dropout Mode

FCCM



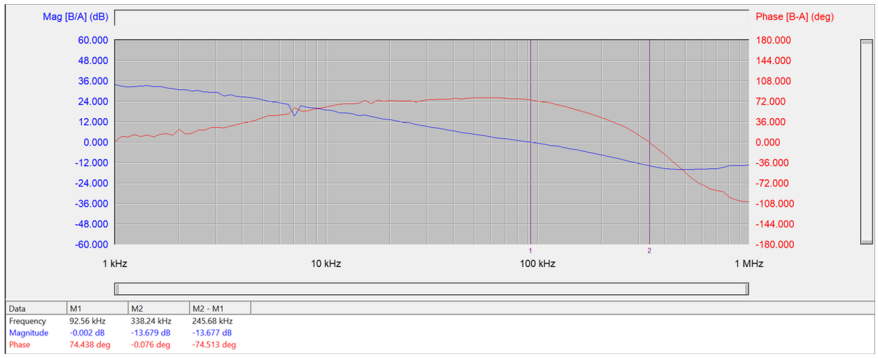
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EVB TEST RESULTS *(continued)*

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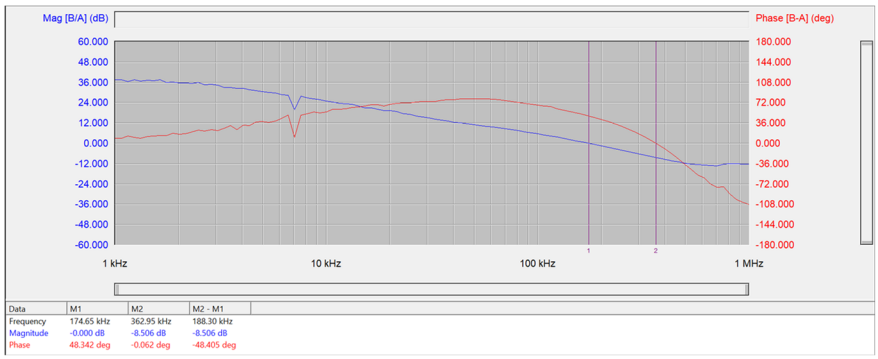
Loop Performance

I_{OUT} = 4A, T_A = 25°C



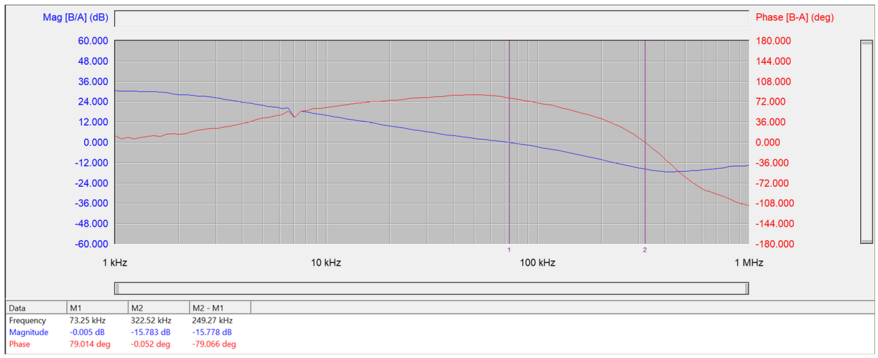
Loop Performance

I_{OUT} = 4A, T_A = -40°C



Loop Performance

I_{OUT} = 4A, T_A = 120°C (2)



Note:

2) Ambient temperatures exceeding 120°C may trigger over-temperature protection (OTP).

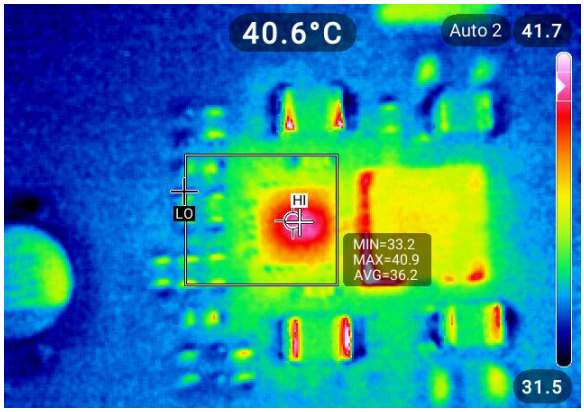
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EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

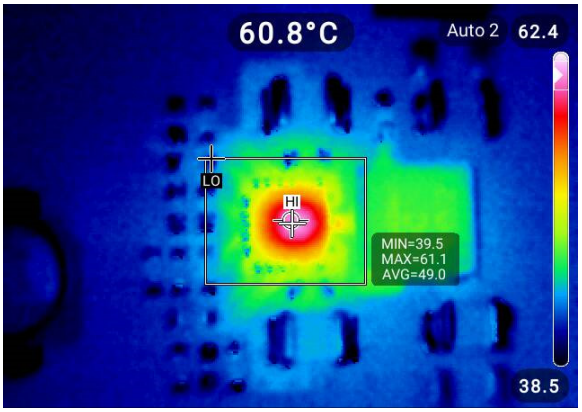
Thermal Performance

I_{OUT} = 2A, no forced airflow, T_{CASE} = 40.9°C



Thermal Performance

I_{OUT} = 4A, no forced airflow, T_{CASE} = 61.1°C



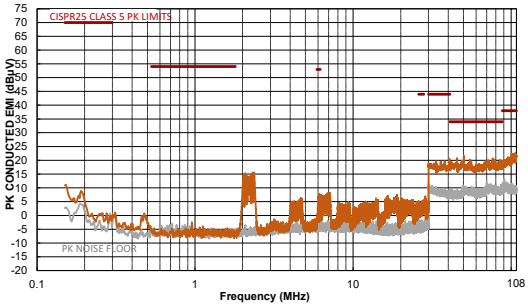
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EVB TEST RESULTS *(continued)*

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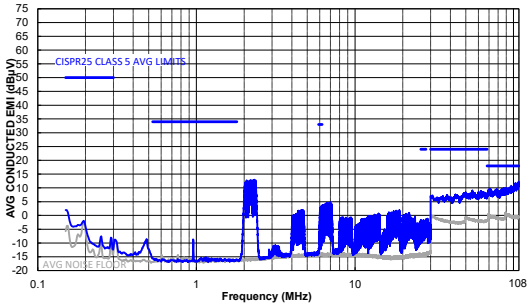
CISPR25 Class 5 Peak Conducted Emissions

150kHz to 108MHz



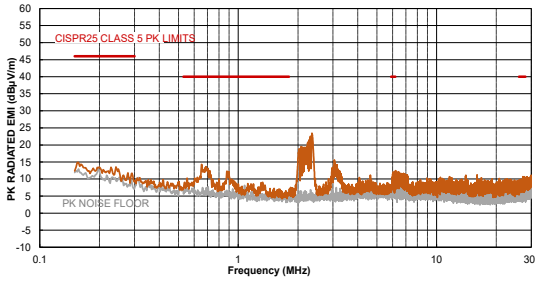
CISPR25 Class 5 Average Conducted Emissions

150kHz to 108MHz



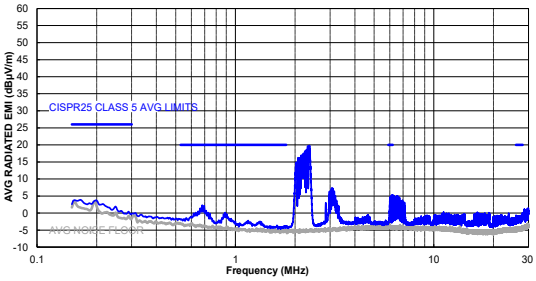
CISPR25 Class 5 Peak Radiated Emissions

150kHz to 30MHz



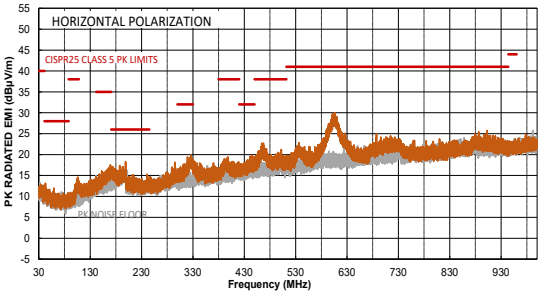
CISPR25 Class 5 Average Radiated Emissions

150kHz to 30MHz



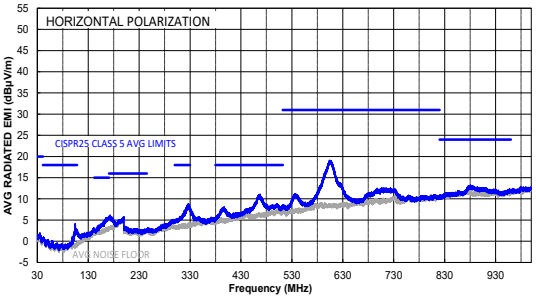
CISPR25 Class 5 Peak Radiated Emissions

Horizontal, 30MHz to 1GHz



CISPR25 Class 5 Average Radiated Emissions

Horizontal, 30MHz to 1GHz



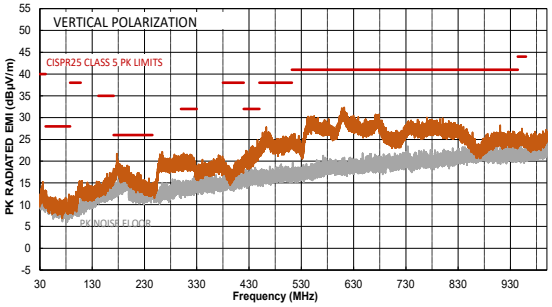
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EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

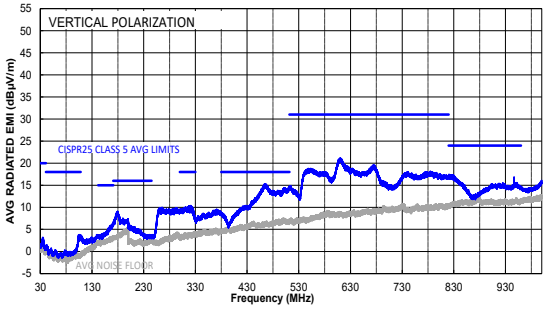
CISPR25 Class 5 Peak Radiated Emissions

Vertical, 30MHz to 1GHz



CISPR25 Class 5 Average Radiated Emissions

Vertical, 30MHz to 1GHz

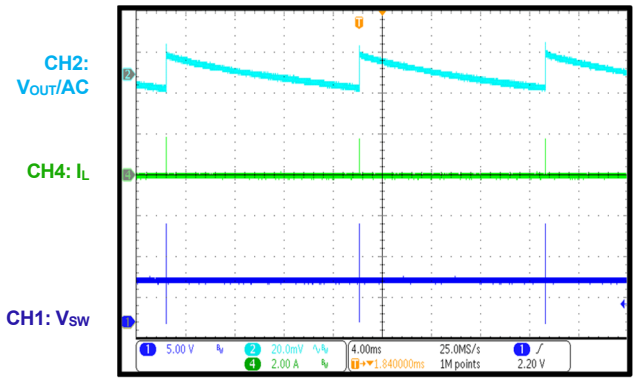


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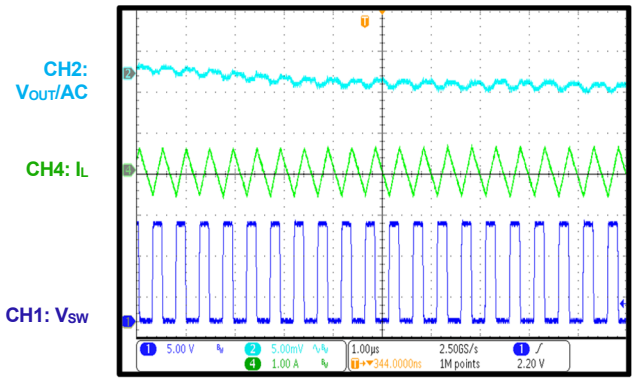
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

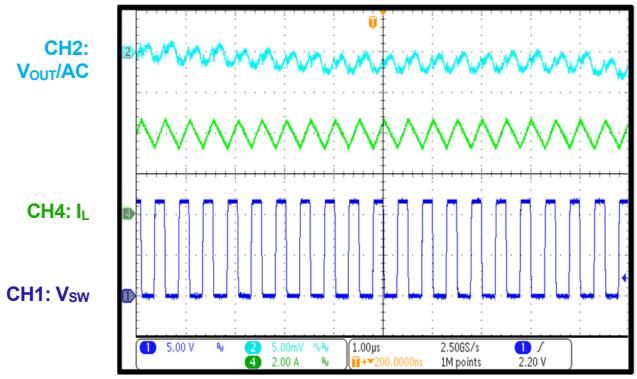
Steady State
I_{OUT} = 0A, AAM mode



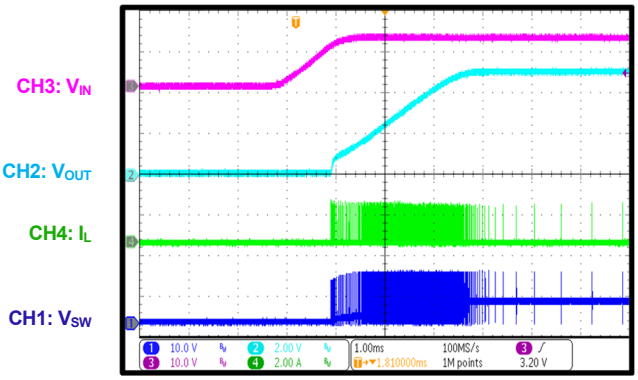
Steady State
I_{OUT} = 0A, FCCM



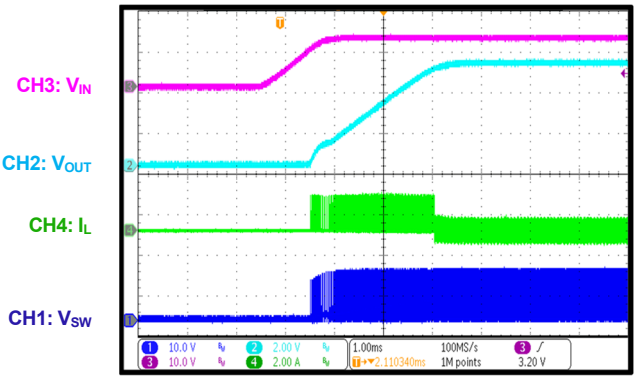
Steady State
I_{OUT} = 4A



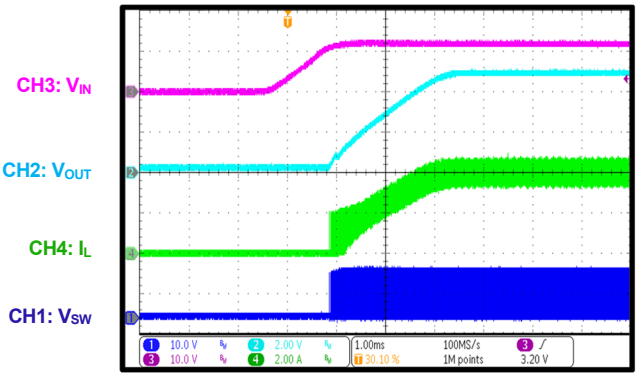
Start-Up through VIN
I_{OUT} = 0A, AAM mode



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



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

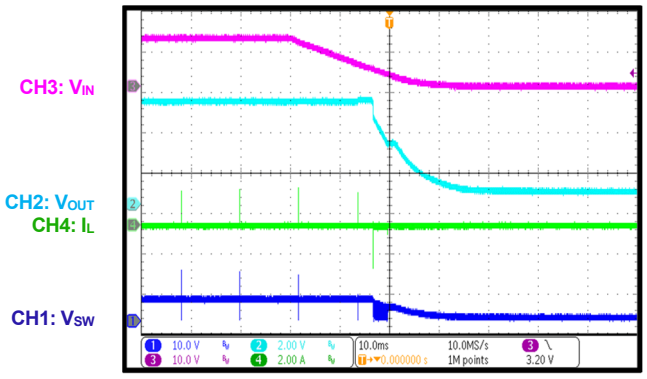


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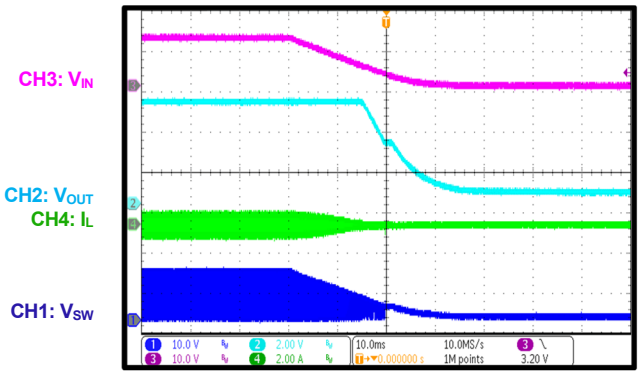
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

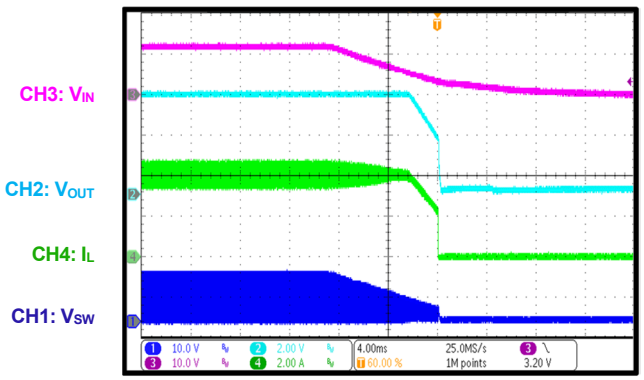
Shutdown through VIN
I_{OUT} = 0A, AAM mode



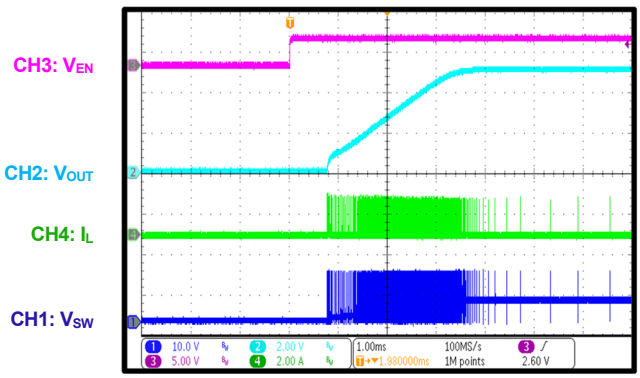
Shutdown through VIN
I_{OUT} = 0A, FCCM



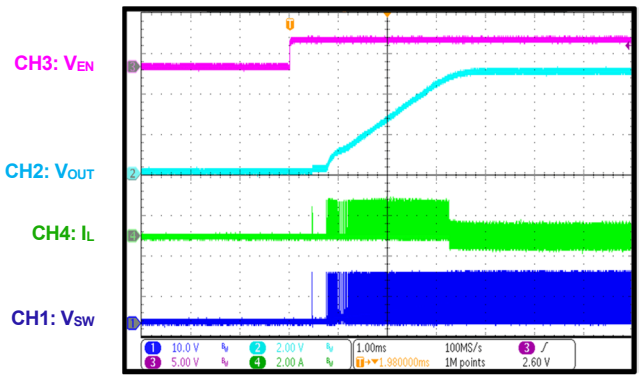
Shutdown through VIN
I_{OUT} = 4A



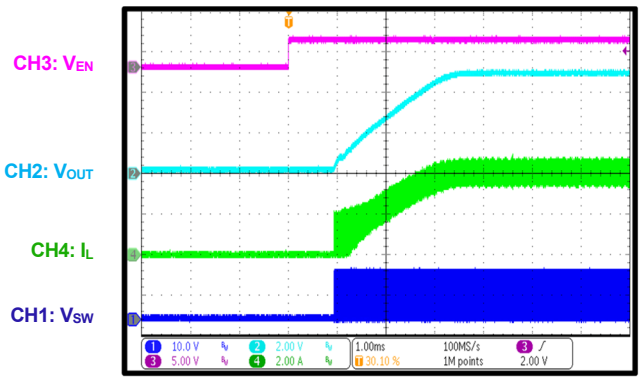
Start-Up through EN
I_{OUT} = 0A, AAM mode



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



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

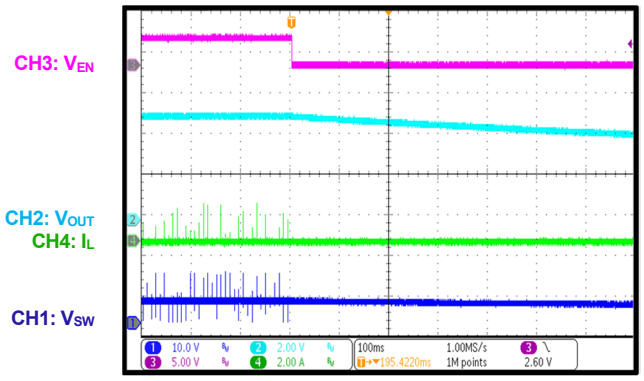


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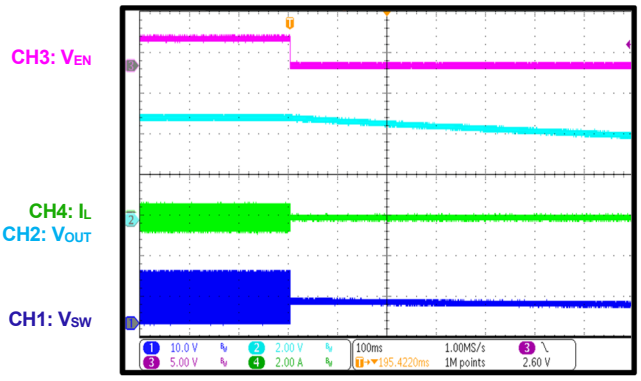
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

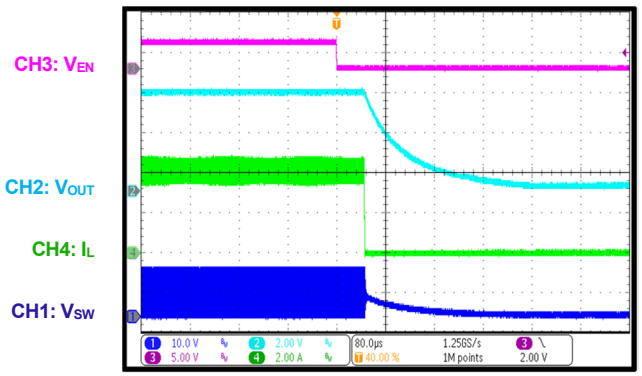
Shutdown through EN
I_{OUT} = 0A, AAM mode



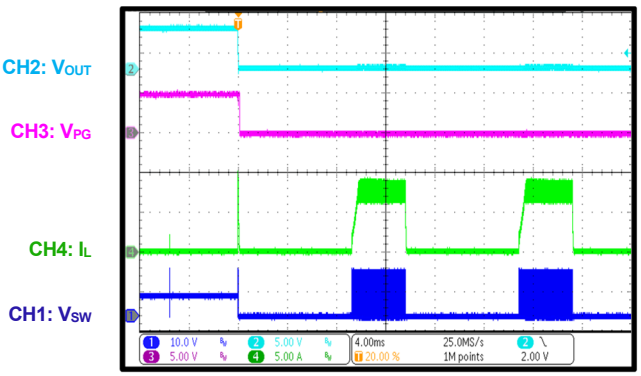
Shutdown through EN
I_{OUT} = 0A, FCCM



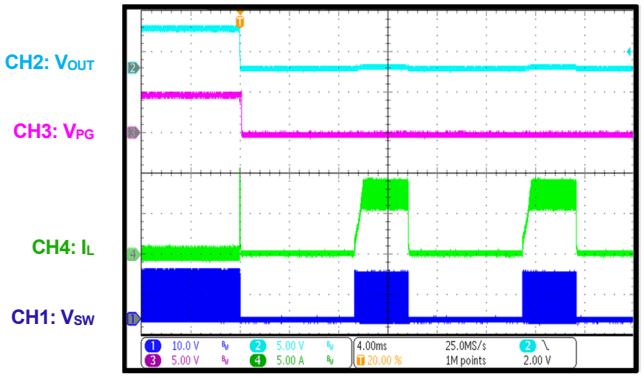
Shutdown through EN
I_{OUT} = 4A



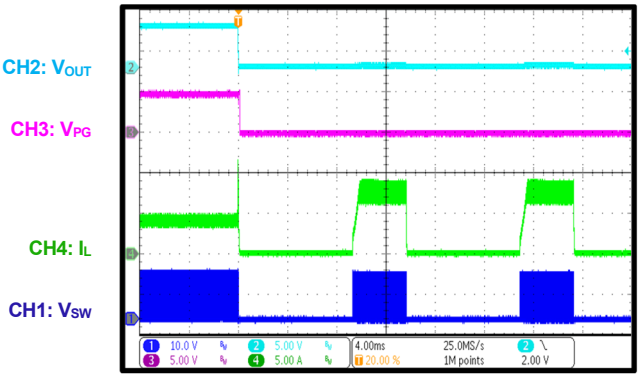
SCP Entry
I_{OUT} = 0A, AAM mode



SCP Entry
I_{OUT} = 0A, FCCM



SCP Entry
I_{OUT} = 4A

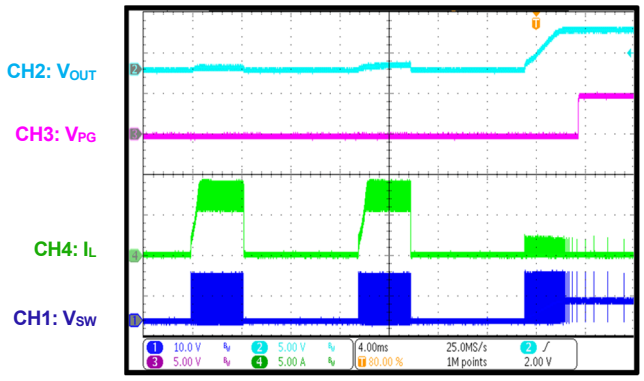


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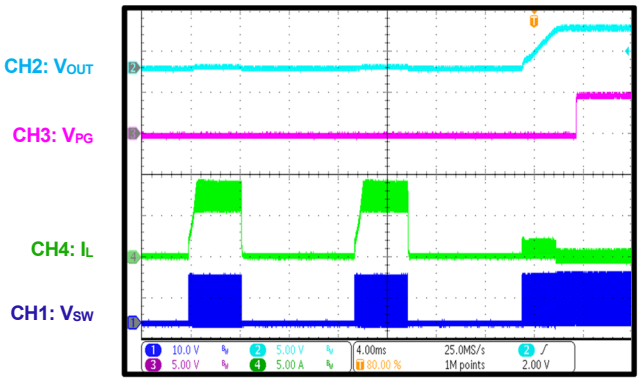
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

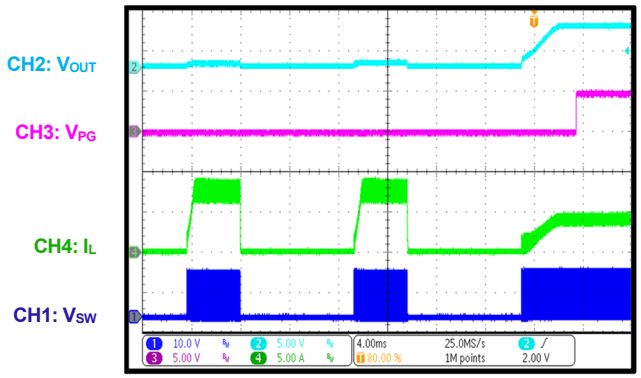
SCP Recovery
I_{OUT} = 0A, AAM mode



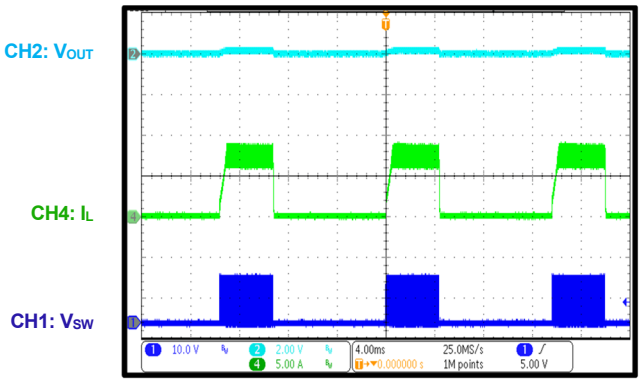
SCP Recovery
I_{OUT} = 0A, FCCM



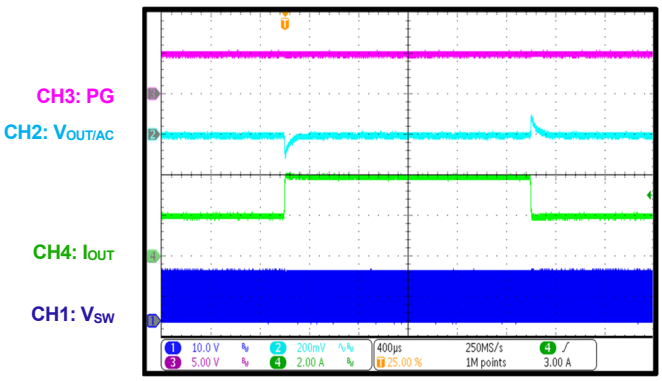
SCP Recovery
I_{OUT} = 4A



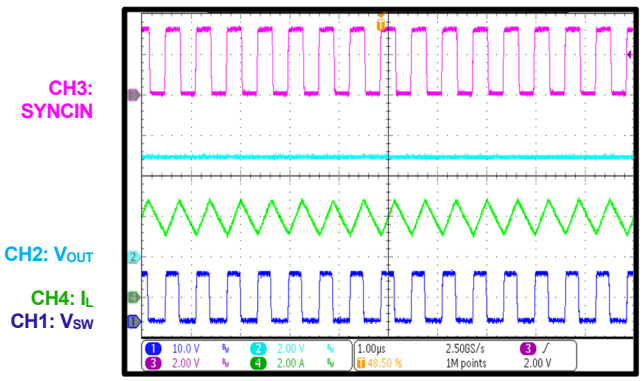
SCP Steady State



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



SYNCIN Operation
I_{OUT} = 4A, SYNC frequency = 1600kHz



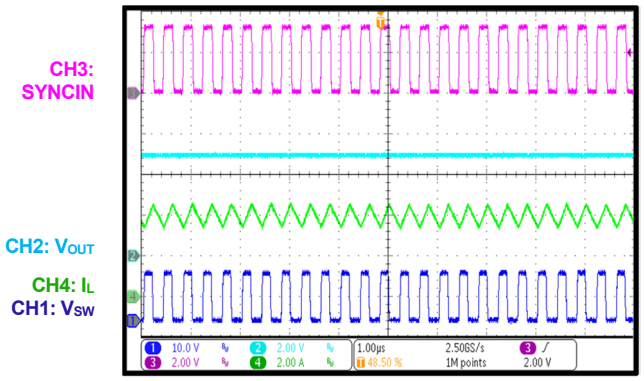
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EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

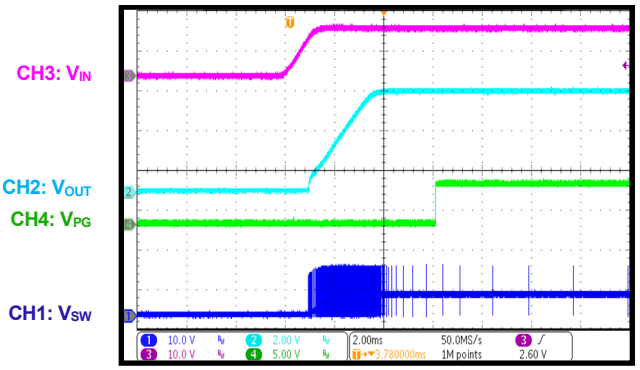
SYNCIN Operation

I_{OUT} = 4A, SYNC frequency = 2500kHz



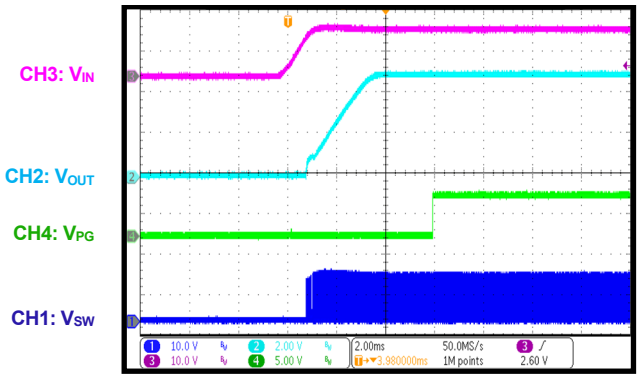
PG in Start-Up through VIN

I_{OUT} = 0A, AAM mode



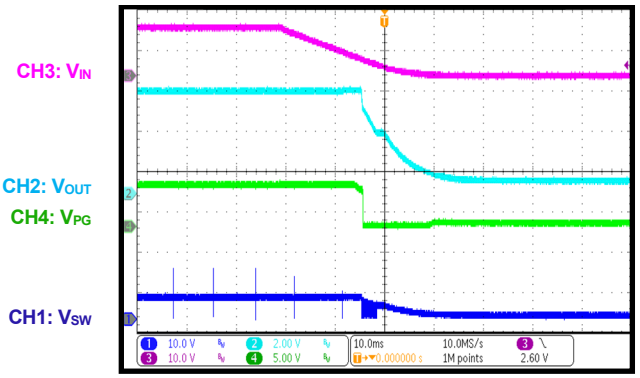
PG in Start-Up through VIN

I_{OUT} = 4A



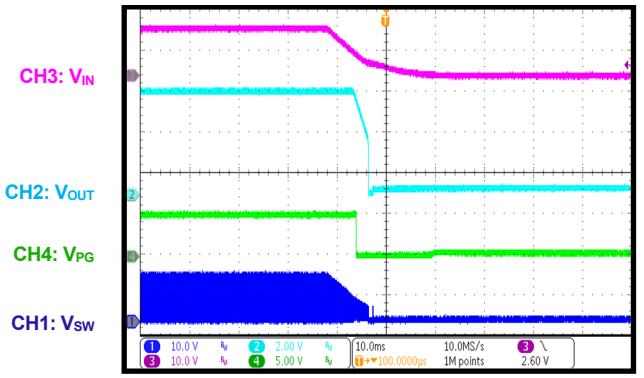
PG in Shutdown through VIN

I_{OUT} = 0A, AAM mode



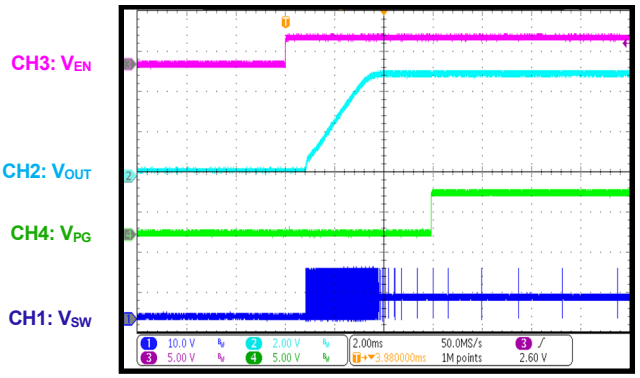
PG in Shutdown through VIN

I_{OUT} = 4A



PG in Start-Up through EN

I_{OUT} = 0A



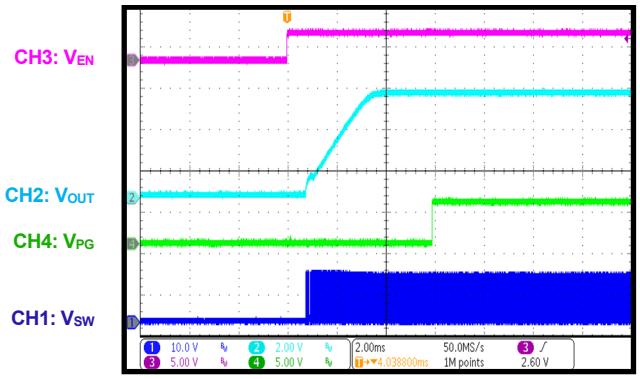
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EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 5V, C_{OUT} = 2 x 22µF, L = 1µH, T_A = 25°C, unless otherwise noted.

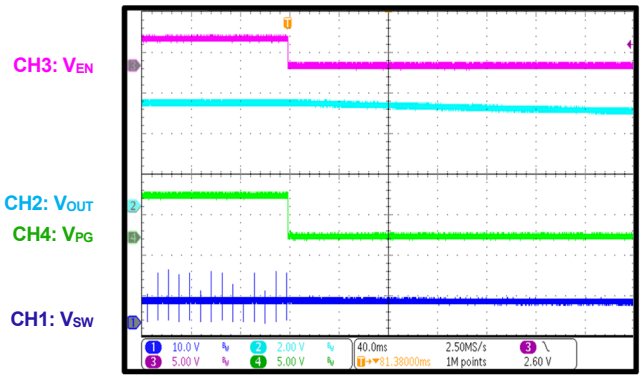
PG in Start-Up through EN

I_{OUT} = 4A



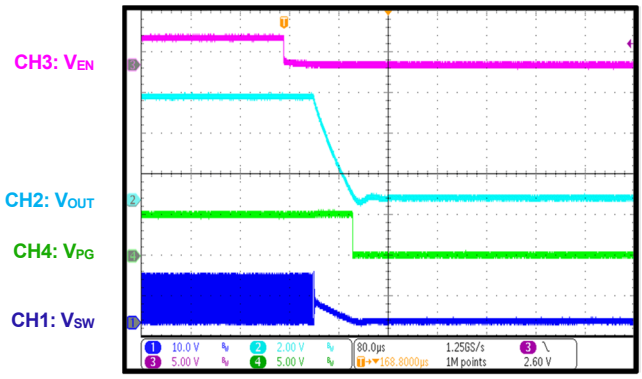
PG in Shutdown through EN

I_{OUT} = 0A



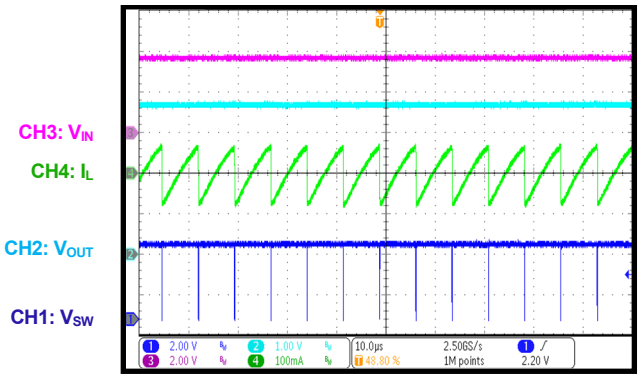
PG in Shutdown through EN

I_{OUT} = 4A



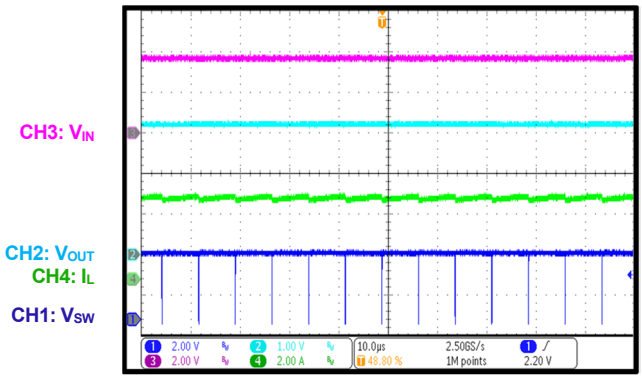
Low-Dropout Mode

V_{IN} = 3.7V, I_{OUT} = 0A



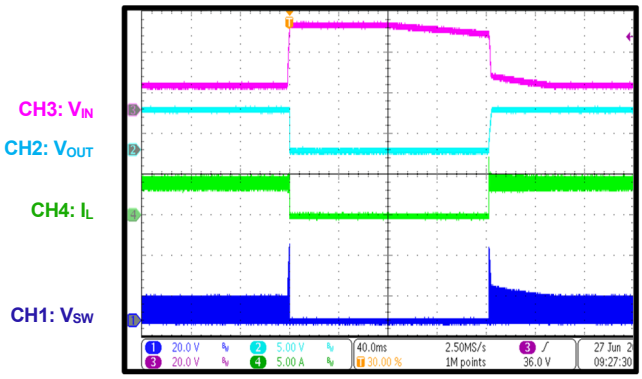
Low-Dropout Mode

V_{IN} = 3.7V, I_{OUT} = 4A



Load Dump

V_{IN} = 12V to 42V, I_{OUT} = 4A



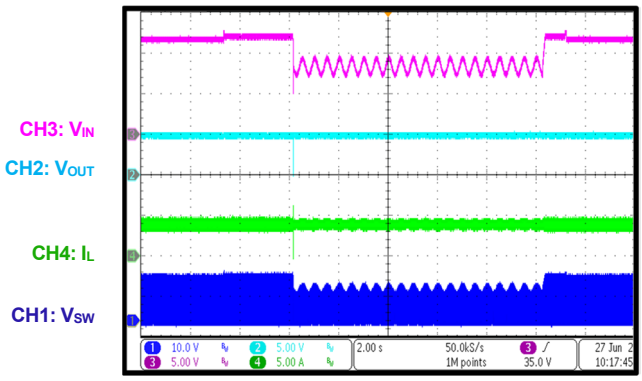
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EVB TEST RESULTS *(continued)*

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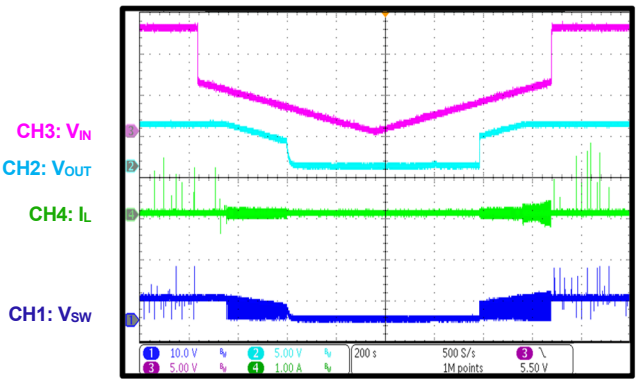
Cold Crank

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



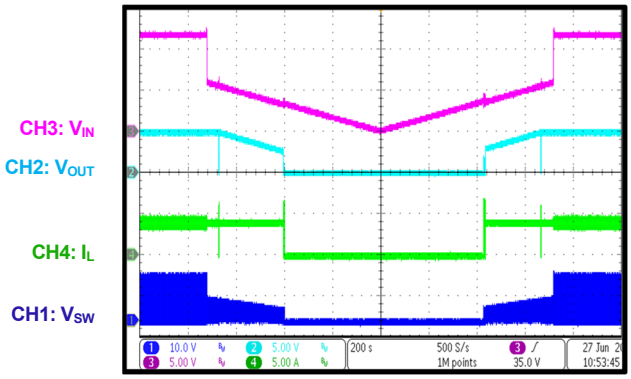
V_{IN} Ramping Down and Up

I_{OUT} = 0A, AAM mode



V_{IN} Ramping Down and Up

I_{OUT} = 4A



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PCB LAYOUT (3)

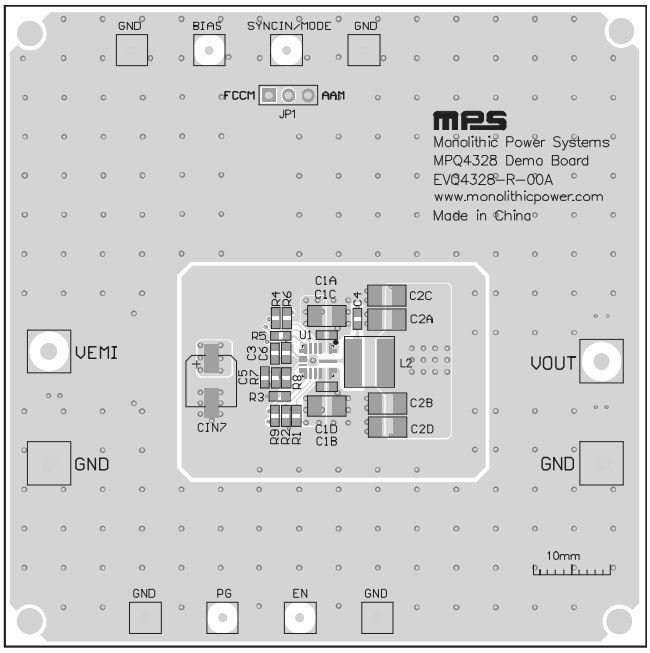


Figure 5: Top Silk and Top Layer

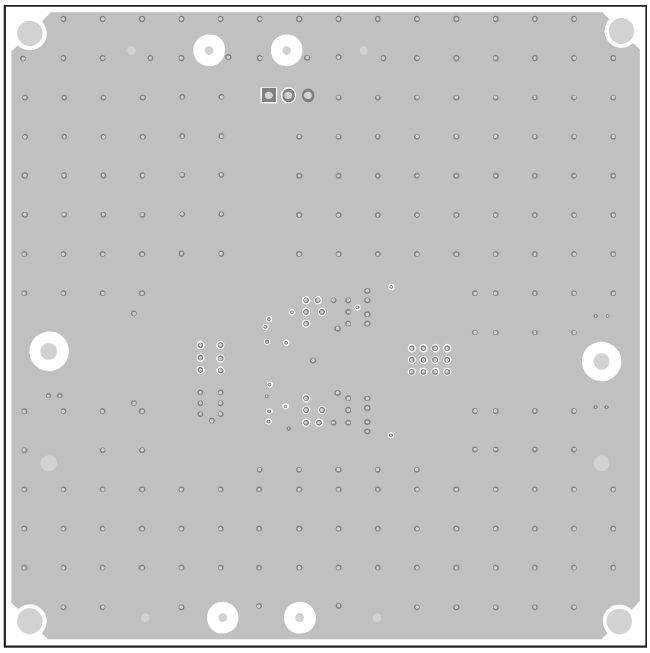


Figure 6: Mid-Layer 1

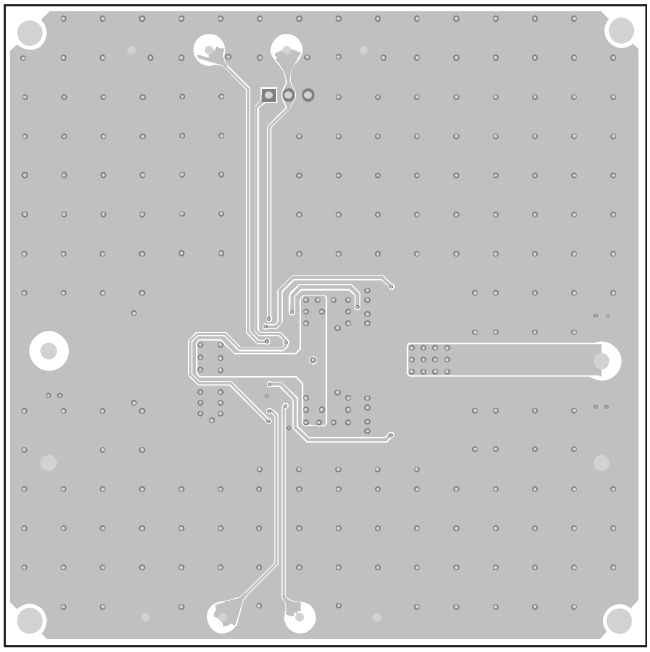


Figure 7: Mid-Layer 2

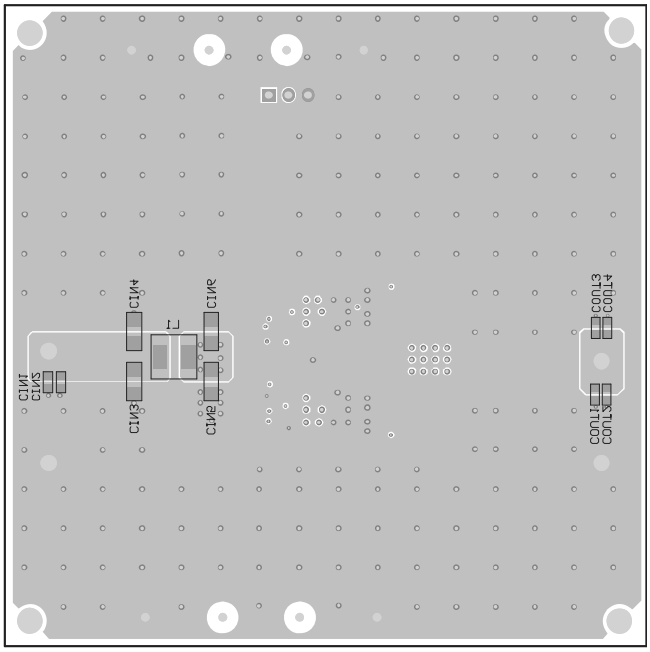


Figure 8: Bottom Layer and Bottom Silk

Note:

3) The copper thickness is 2oz.

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REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	1/31/2024	Initial Release	-
1.01	4/11/2024	Reformatted Package Reference	6

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