EVQ4436A-R-00A

45V, 6A, Low I_Q, Synchronous, Step-Down Converter Evaluation Board

DESCRIPTION

The EVQ4436A-R-00A evaluation board is designed to demonstrate the capabilities of MPS's MPQ4436A-AEC1 and MPQ4436A.

The MPQ4436A is a frequency-configurable, synchronous, step-down, switching regulator with integrated, internal high-side and low-side power MOSFETs. It provides up to 6A of highly efficient output, with current mode control for fast loop response.

The wide 3.3V to 45V input range accommodates a variety of step-down applications in an automotive input environment. A 1.7μA shutdown mode quiescent current allows the part to be used in battery-powered applications.

High power conversion efficiency over a wide load range is achieved by scaling down the switching frequency under light-load conditions to reduce switching and gate driver losses.

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

ELECTRICAL SPECIFICATIONS

Parameter	Symbol	Value	Units
Input voltage	V_{EMI}	3.3 to 45	V
Output voltage	V_{OUT}	3.3	V
Output current	I_{OUT}	6	A

FEATURES

- Wide 3.3V to 45V Operating Voltage Range
- 6A Continuous Output Current
- 1.7μA Low Shutdown Supply Current
- 18μA Sleep Mode Quiescent Current
- Internal 48mΩ High-Side and 20mΩ Low-Side MOSFETs
- 350kHz to 530kHz Programmable Switching Frequency for Car Battery Applications
- Synchronize to External Clock
- Multi-Phase Capability
- Out-of-Phase Synchronized Clock Output
- Frequency Spread Spectrum (FSS) for Low EMI
- Symmetric V_{IN} for Low EMI
- Power Good Output
- External Soft Start
- 100ns Minimum On Time
- Selectable Advanced Asynchronous Mode (AAM) or Forced Continuous Conduction Mode (FCCM)
- Low-Dropout Mode
- Hiccup Over-Current Protection
- Available in a QFN-20 (4mmx4mm) Wettable Flank Package
- Available in AEC-Q100 Grade 1

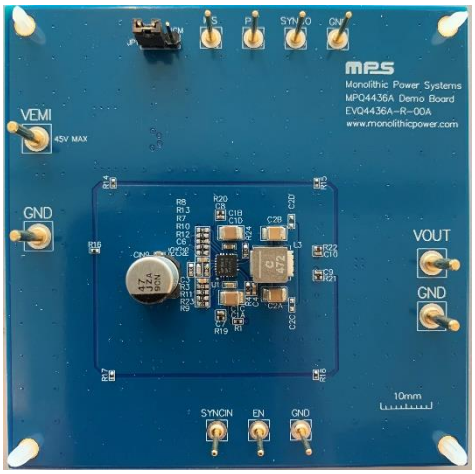
APPLICATIONS

- Infotainment
- Clusters
- Advanced Driver Assistance Systems (ADAS)
- Industrial Power Systems

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EVQ4436A-R-00A EVALUATION BOARD

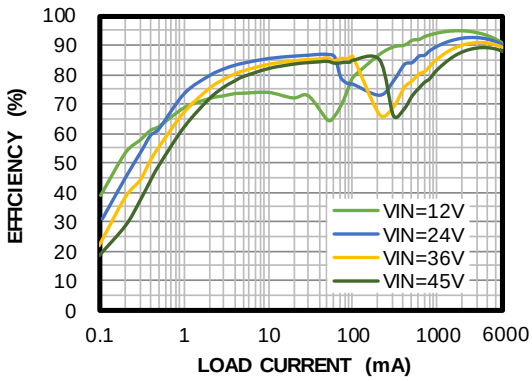


(LxWxH) 9cmx9cmx1.3cm

Board Number	MPS IC Number
EVQ4436A-R-00A	MPQ4436AGR-AEC1

Efficiency vs. Load Current

V_{OUT} = 3.3V, AAM, f_{SW} = 470kHz



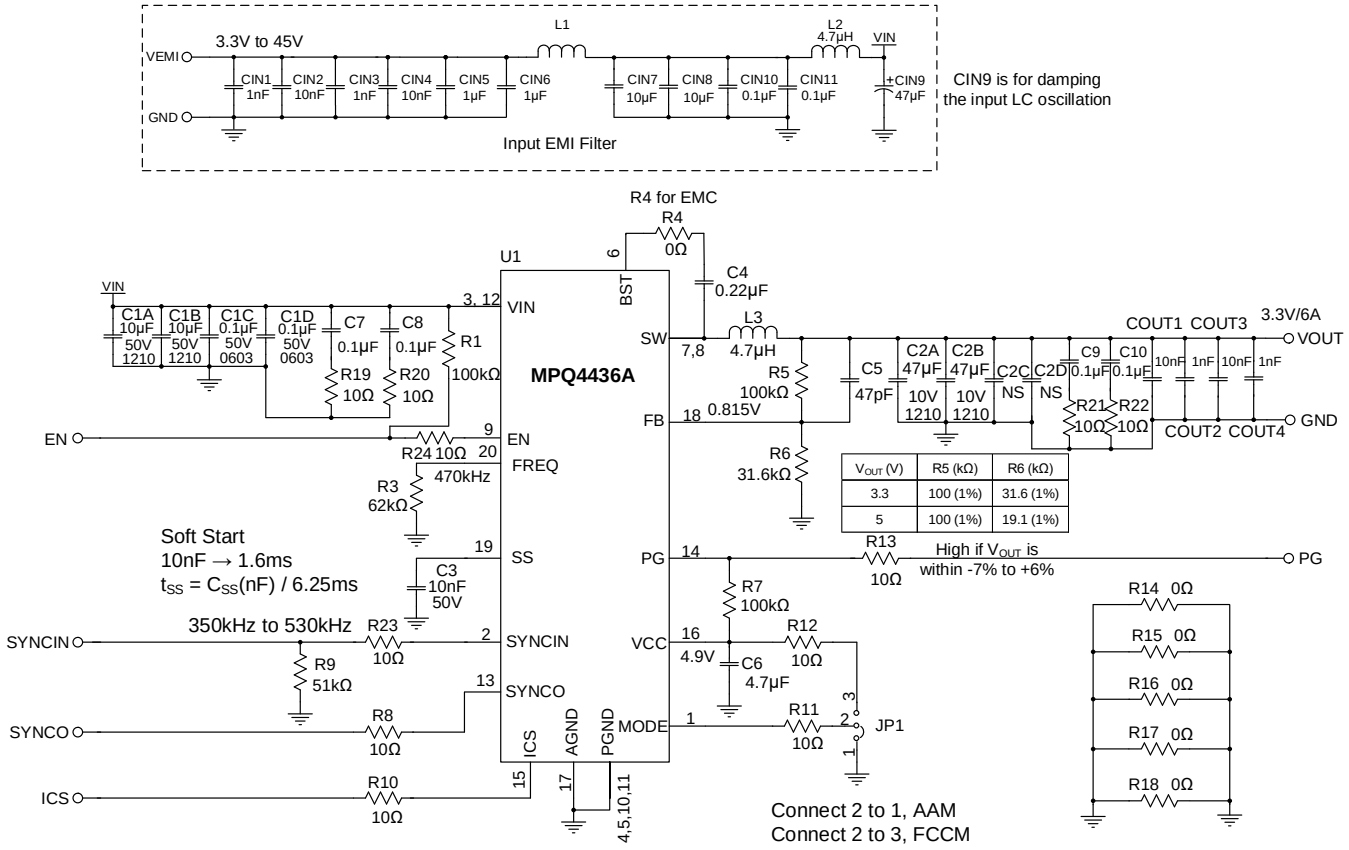
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QUICK START GUIDE

1. Connect the load terminals to:
   a. Positive (+): VOUT
   b. Negative (-): GND
2. Set the load current between 0A and 6A. Electronic loads represent a negative impedance to the regulator. If they are set to an exceedingly high current, it may trigger over-current protection (OCP) or short current protection (SCP).
3. Preset the power supply output between 3.3V and 45V, then turn it off.
4. If long cables (>0.5m total) are used between the source and the EVB, install a damping capacitor at the input terminals. This is highly recommended when V_{EMI} ≥ 24V.
3. Connect the power supply output terminals to:
   a. Positive (+): VEMI
   b. Negative (-): GND
4. Turn the power supply on. The board should automatically start up. The default V_{OUT} is 3.3V.
5. To use the enable function, apply a digital input to the EN pin. Drive EN above 1V to turn the regulator on; drive EN below 0.85V to turn it off.
6. To use the sync function, apply a 350kHz to 530kHz external clock to the SYNCIN pin to synchronize the internal clock's rising edge.
7. JP1 selects forced continuous conduction mode (FCCM) or advanced asynchronous mode (AAM). Connect pin 2 (mode) to pin 3 (VCC) of JP1 to force the MPQ4436A into FCCM. Connect pin 1 (GND) to pin 2 (mode) of JP1 to force the MPQ4436A into AAM.

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EVALUATION BOARD SCHEMATIC



VOUT (V)	R5 (kΩ)	R6 (kΩ)
3.3	100 (1%)	31.6 (1%)
5	100 (1%)	19.1 (1%)

Package Reference

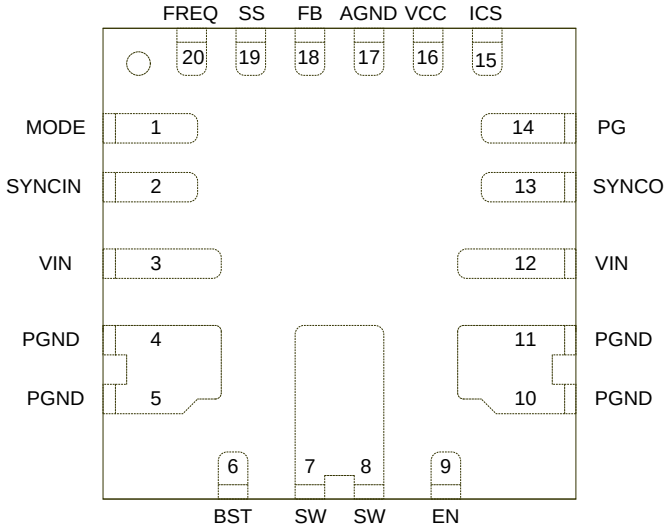


Figure 1: Evaluation Board Schematic

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EVQ4436A-R-00A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
4	CIN1, CIN3, COUT2, COUT4	1nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM216R71H102KA01
5	CIN2, CIN4, C3, COUT1, COUT3	10nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H103KA01D
2	CIN5, CIN6	1µF	Ceramic capacitor, 50V, X7R	0805	Murata	GRM21BR71H105KA12L
2	CIN7, CIN8	10µF	Ceramic capacitor, 50V, X5R	1206	Murata	GRM31CR61H106KA12L
1	CIN9	47µF	Aluminum capacitor, 63V	SMD	Panasonic	EEHZA1J470P
2	C1A, C1B	10µF	Ceramic capacitor, 50V, X7R	1210	Murata	GRM32ER71H106KA12L
4	CIN10, CIN11, C1C, C1D	0.1µF	Ceramic capacitor, 50V, X7R	0603	Murata	GCJ188R71H104KA12D
2	C2A, C2B	47µF	Ceramic capacitor, 10V, X5R	1210	Murata	GRM32ER61A476KE20L
1	C4	0.22µF	Ceramic capacitor, 16V, X7R	0603	Murata	GRM188R71C122KA01D
1	C5	47pF	Ceramic capacitor, 50V, COG	0603	TDK	C1608C0G1H470J
1	C6	4.7µF	Ceramic capacitor, 10V, X5R	0603	Murata	GRM188R61A475KE15D
4	C7, C8, C9, C10	0.1µF	Ceramic capacitor, 50V, X7R	0402	Murata	GRM155R71H104KE14D
2	C2C, C2D	NS				
1	L1		Magnetic bead, 6A	1806	Murata	BLM41PG600SN1L
1	L2	4.7µH	Inductor, 4.7µH, 31.5mΩ, 6A	SMD	Cyntec	VCMT063T-4R7MN5T-99
1	L3	4.7µH	Inductor, 4.7µH, 14.4mΩ, 11A	SMD	Coilcraft	XAL6060-472ME
1	R1	100kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-07100KL
1	R3	62kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-062KL
1	R4	0Ω	Film resistor, 5%	0603	Yageo	RC0603JR-070RL
2	R5, R7	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
1	R6	32.4kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0732K4L
7	R8, R10, R11, R12, R13, R23, R24	10Ω	Film resistor, 1%	0603	Yageo	RC0603FR-0710RL
1	R9	51kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0751KL
5	R14, R15, R16, R17, R18	0Ω	Film resistor, 1%	0402	Yageo	RC0402FR-070RL

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EVQ4436A-R-00A BILL OF MATERIALS *(continued)*

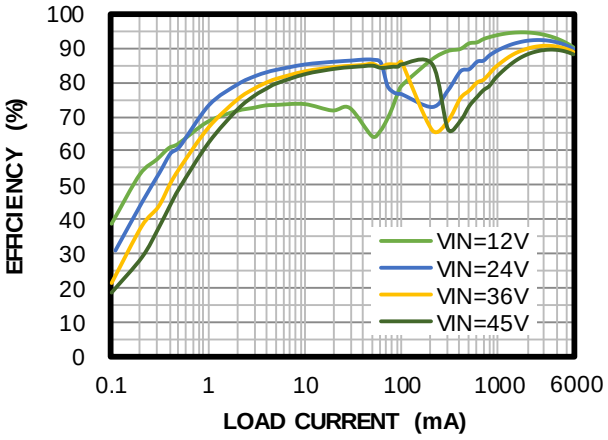
Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
4	R19, R20, R21, R22	10Ω	Film resistor, 5%	0402	Yageo	RC0402FR-0710RL
1	U1	MPQ4436A	Step-down converter	QFN-20 (4mmx 4mm)	MPS	MPQ4436AGR-AEC1
1	JP1		3-pin connector, 2.54mm		Any	
4	VEMI, GND, VOUT, GND	Test point	2.0 golden pin		Custom	
7	SYNCIN, EN, GND, ICS, PG, SYNCO, GND	Test point	1.0 golden pin		Custom	

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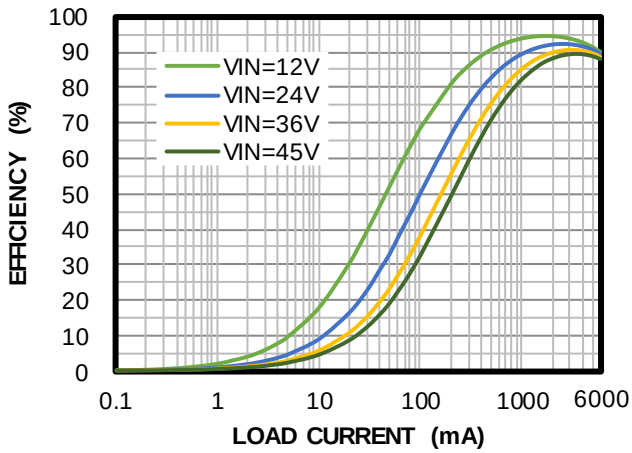
EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, L = 4.7µH, f_{SW} = 470kHz, T_A = 25°C, unless otherwise noted.

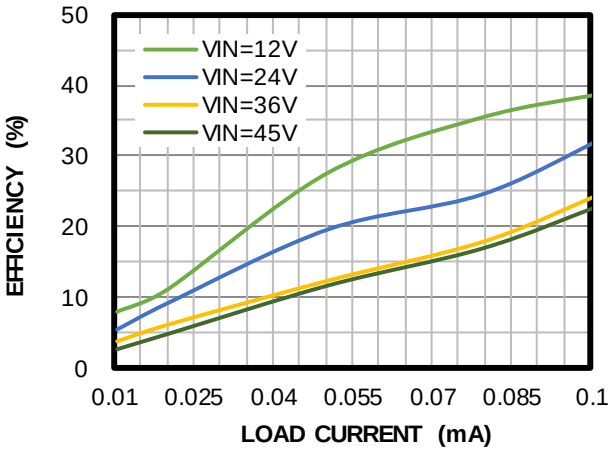
Efficiency vs. Load Current
AAM



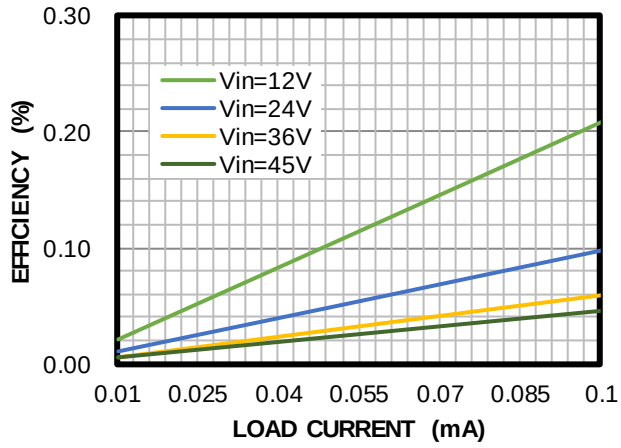
Efficiency vs. Load Current
CCM



Efficiency vs. Load Current
(Extreme light loads) AAM



Efficiency vs. Load Current
(Extreme light loads) FCCM

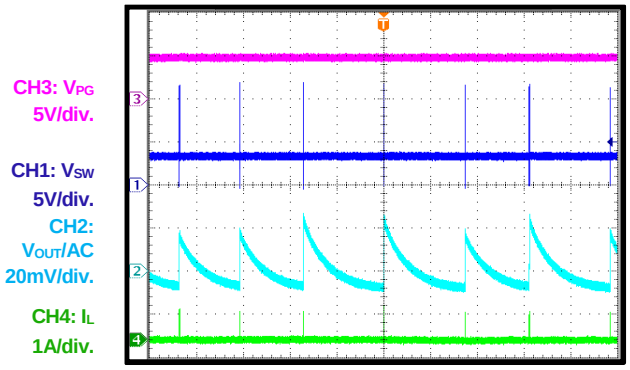


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EVB TEST RESULTS *(continued)*

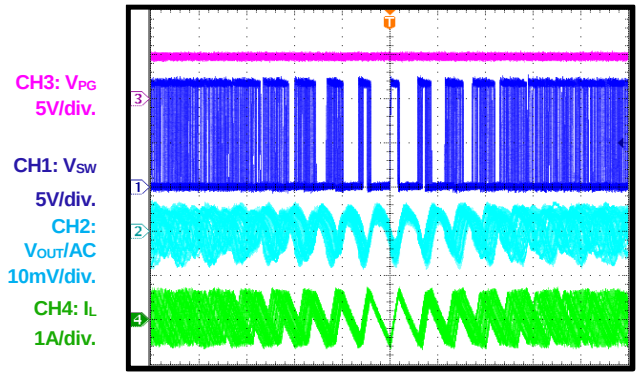
Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, L = 4.7µH, f_{SW} = 470kHz, AAM, T_A = 25°C, unless otherwise noted.

Steady State
I_{OUT} = 0A, AAM



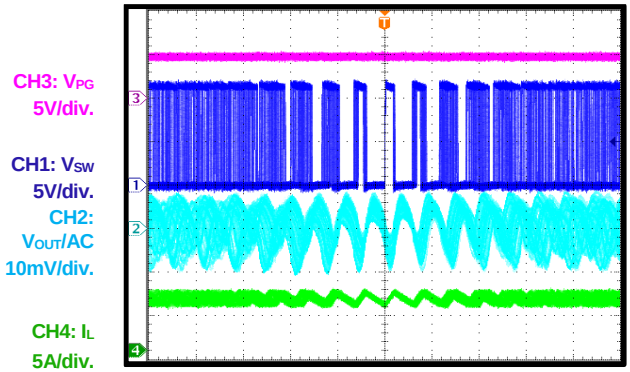
40ms/div.

Steady State
I_{OUT} = 0A, FCCM



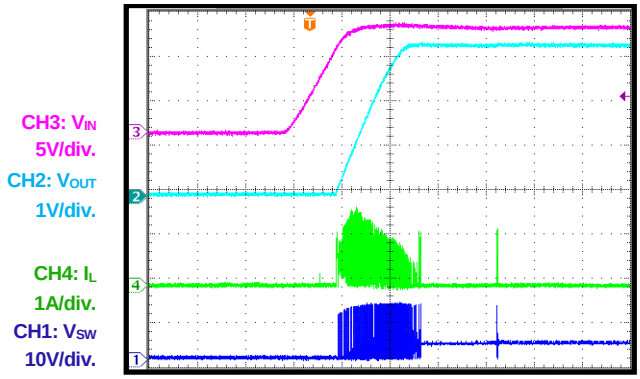
4µs/div.

Steady State
I_{OUT} = 6A



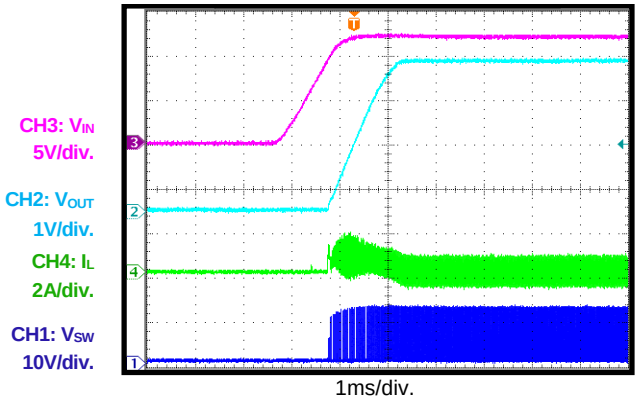
4µs/div.

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



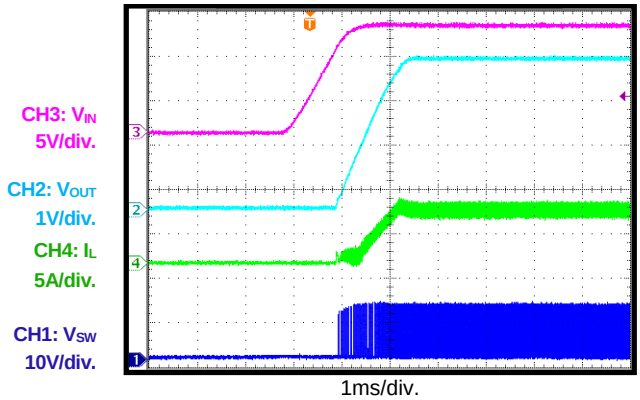
1ms/div.

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



1ms/div.

Start-Up through VIN
I_{OUT} = 6A



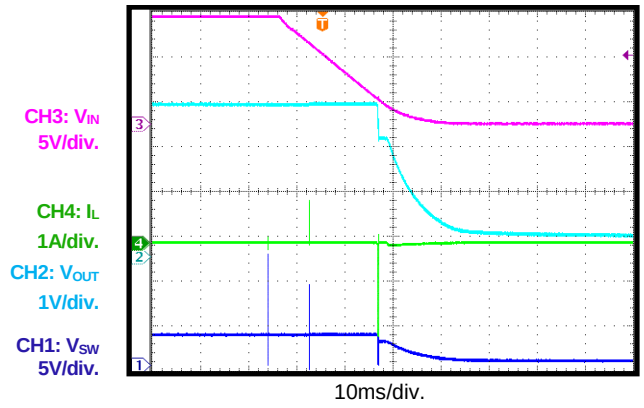
1ms/div.

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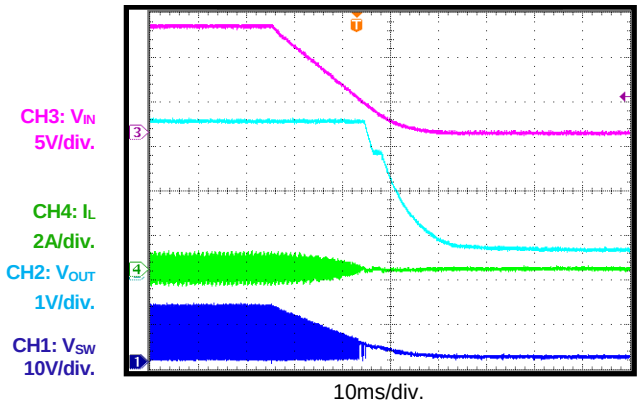
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, L = 4.7µH, f_{SW} = 470kHz, AAM, T_A = 25°C, unless otherwise noted.

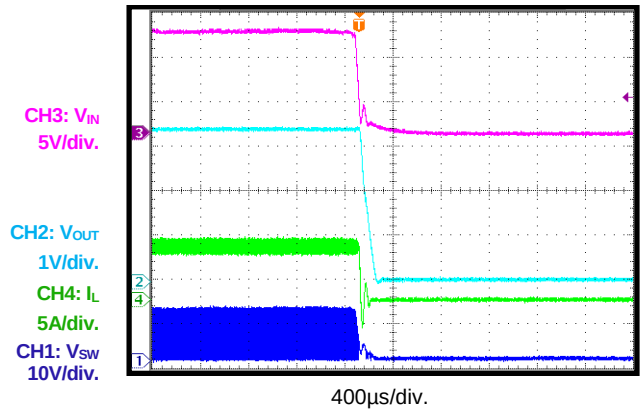
Shutdown through VIN
I_{OUT} = 0A, AAM



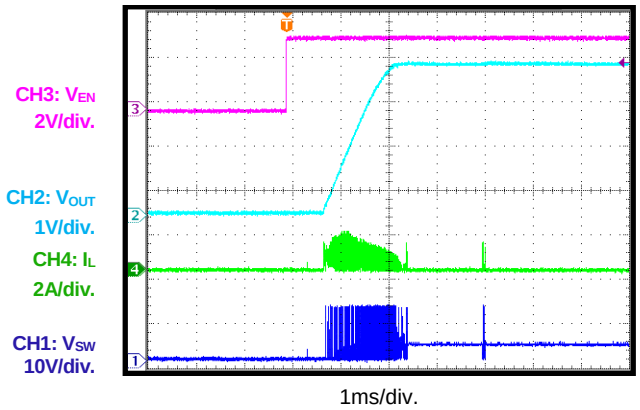
Shutdown through VIN
I_{OUT} = 0A, FCCM



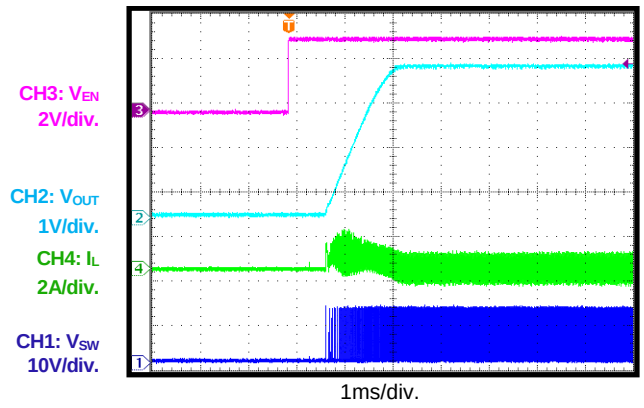
Shutdown through VIN
I_{OUT} = 6A



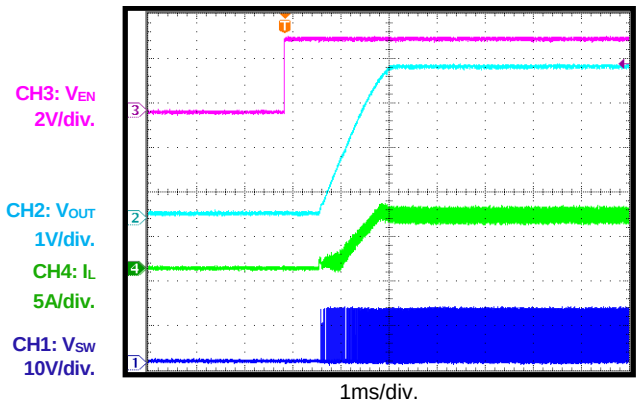
Start-Up through EN
I_{OUT} = 0A, AAM



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



Start-Up through EN
I_{OUT} = 6A



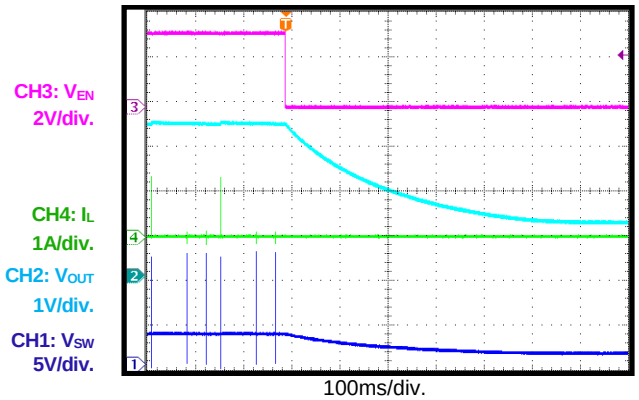
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EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, L = 4.7µH, f_{SW} = 470kHz, AAM, T_A = 25°C, unless otherwise noted.

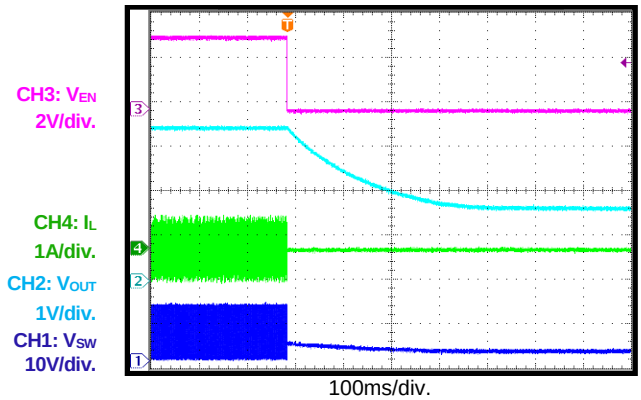
Shutdown through EN

I_{OUT} = 0A, AAM



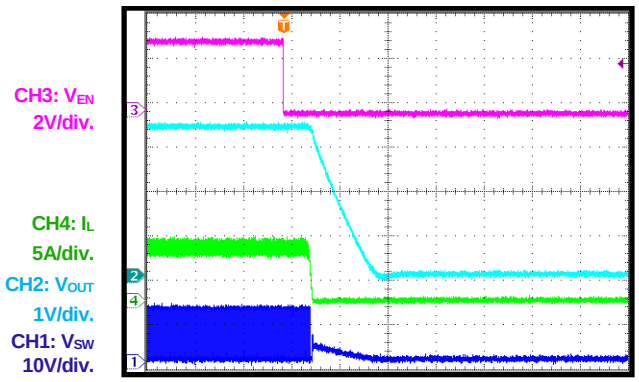
Shutdown through EN

I_{OUT} = 0A, FCCM



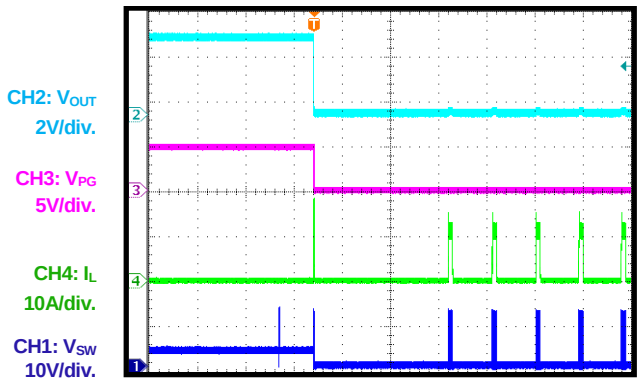
Shutdown through EN

I_{OUT} = 6A



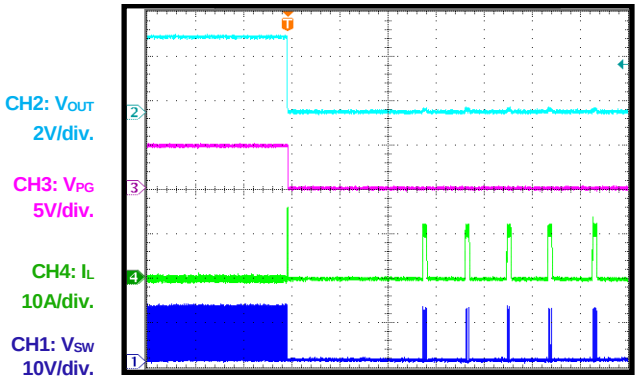
SCP Entry

I_{OUT} = 0A, AAM



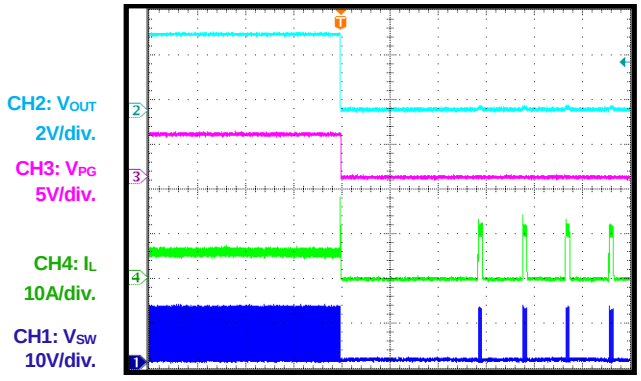
SCP Entry

I_{OUT} = 0A, FCCM



SCP Entry

I_{OUT} = 6A

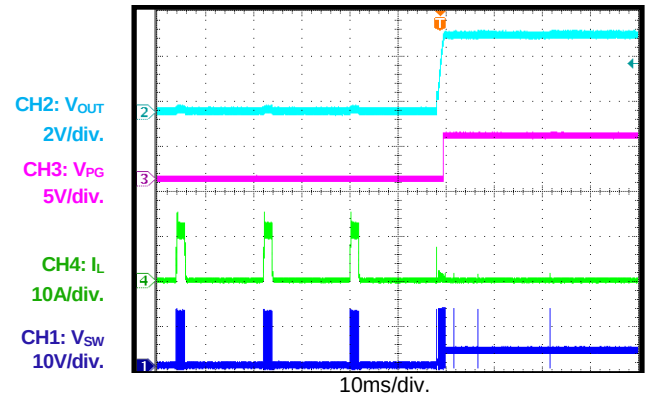


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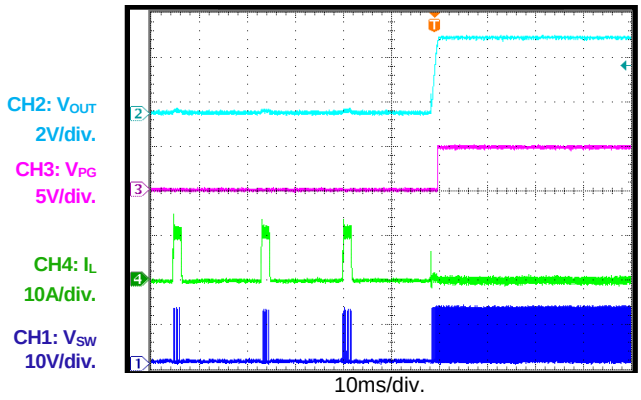
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, L = 4.7µH, f_{SW} = 470kHz, AAM, T_A = 25°C, unless otherwise noted.

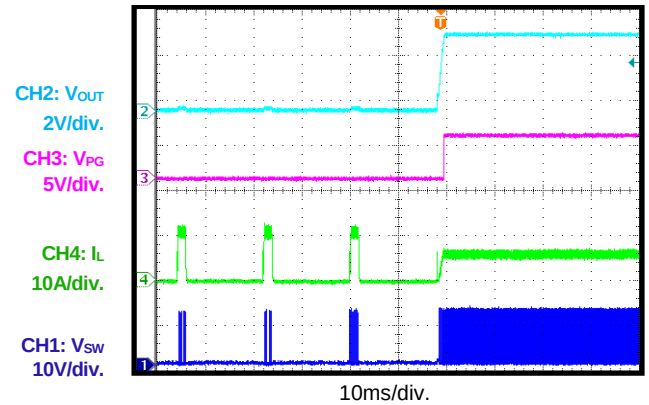
SCP Recovery
I_{OUT} = 0A, AAM



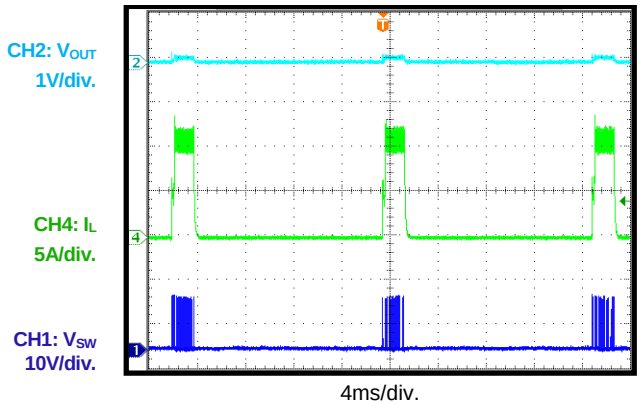
SCP Recovery
I_{OUT} = 0A, FCCM



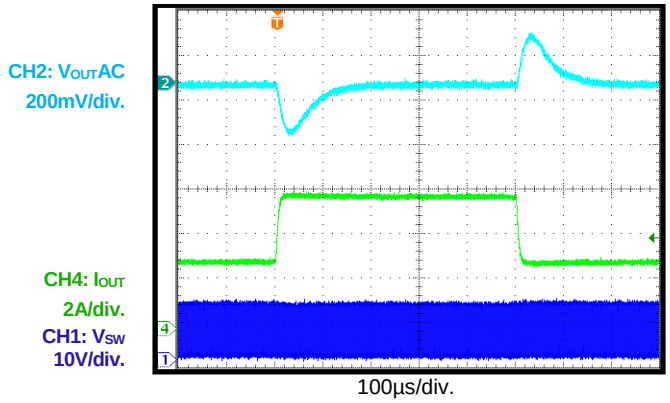
SCP Recovery
I_{OUT} = 6A



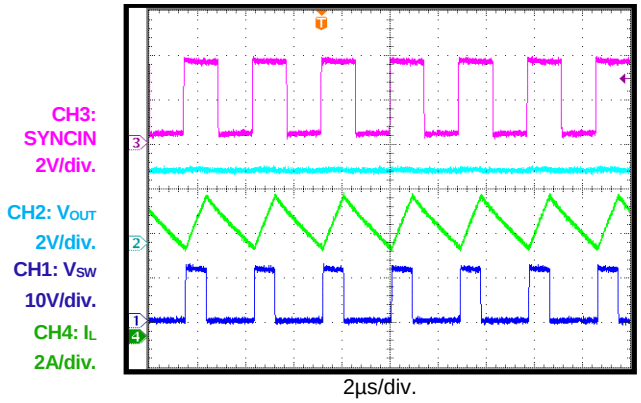
SCP Steady State



Load Transient
I_{OUT} = 3A to 6A



SYNC Operation
I_{OUT} = 6A, SYNC frequency = 350kHz



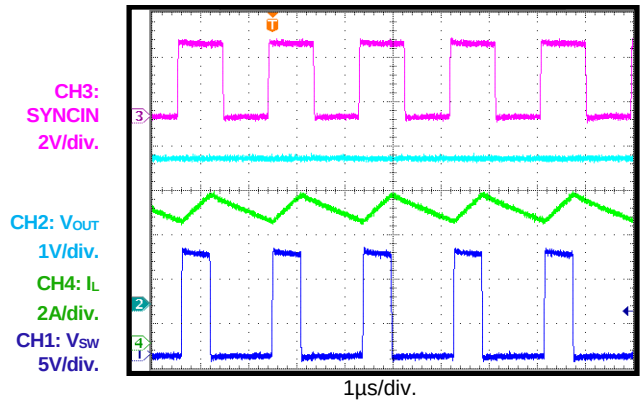
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EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, L = 4.7µH, f_{SW} = 470kHz, AAM, T_A = 25°C, unless otherwise noted.

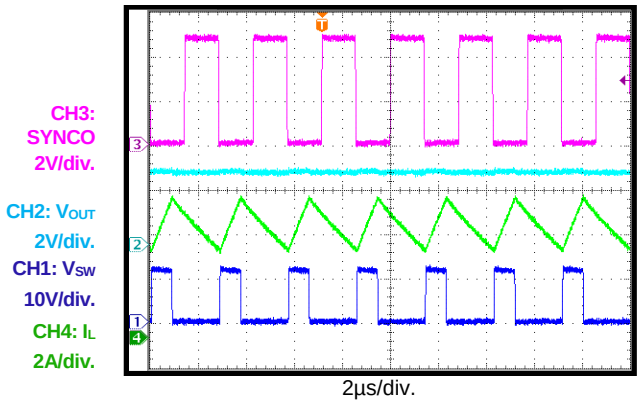
SYNC Operation

I_{OUT} = 6A, SYNC frequency = 530kHz



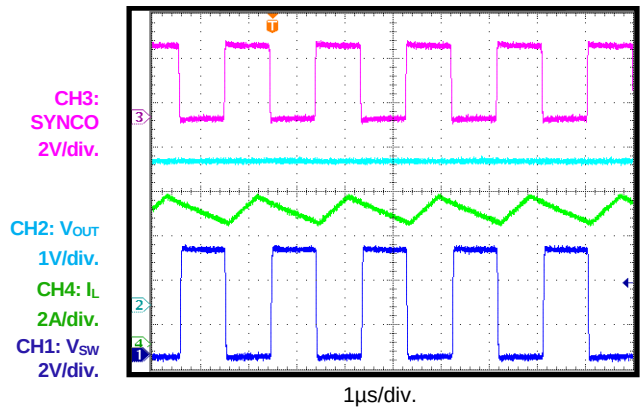
SYNCO Operation

I_{OUT} = 6A, SYNC frequency = 350kHz



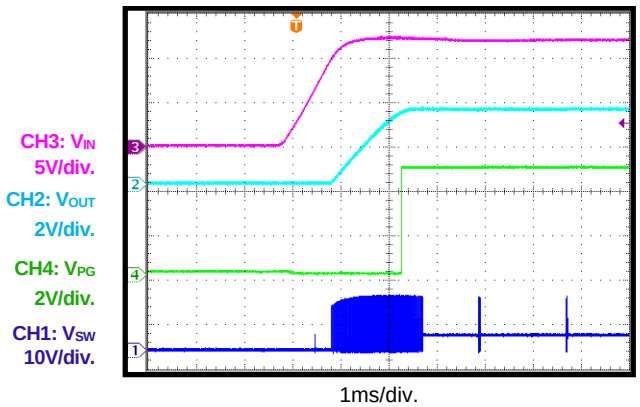
SYNCO Operation

I_{OUT} = 6A, SYNC frequency = 530kHz



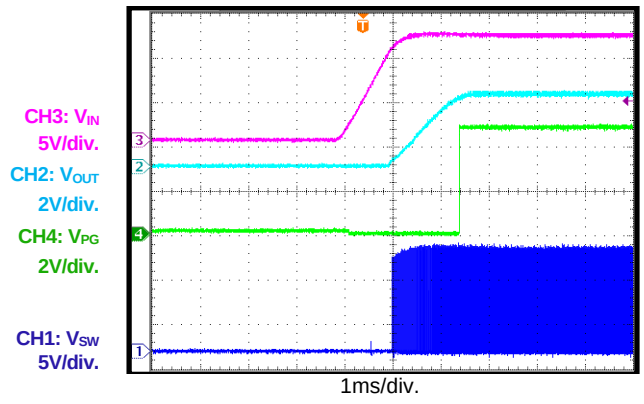
PG Start-Up through VIN

I_{OUT} = 0A



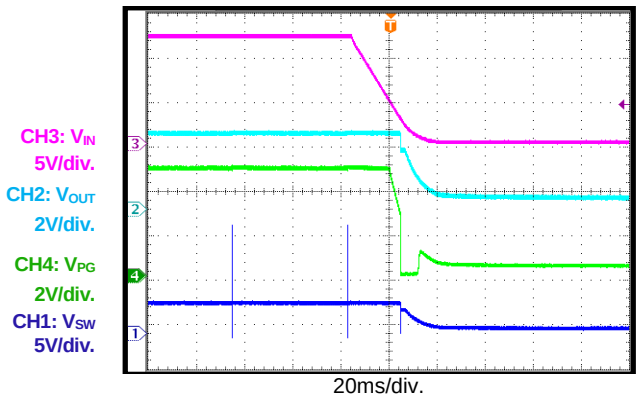
PG Start-Up through VIN

I_{OUT} = 6A



PG Shutdown through VIN

I_{OUT} = 0A



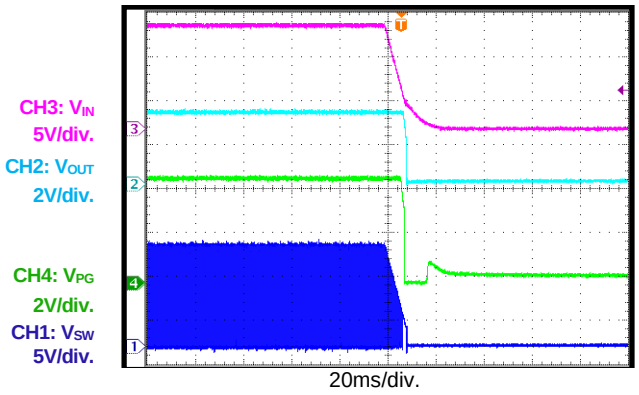
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EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, L = 4.7µH, f_{SW} = 470kHz, AAM, T_A = 25°C, unless otherwise noted.

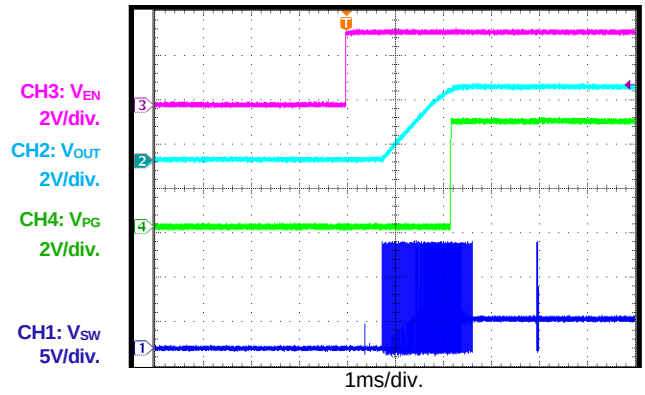
PG Shutdown through VIN

I_{OUT} = 6A



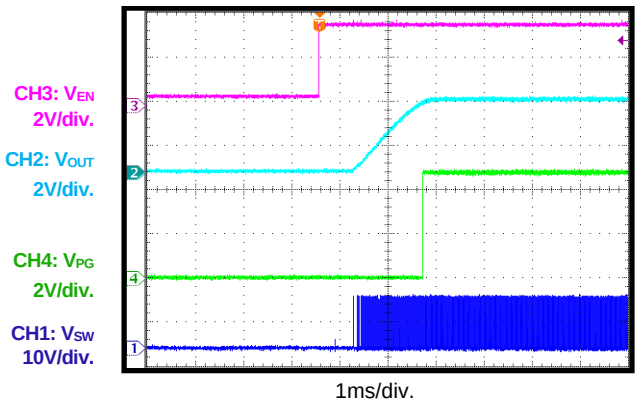
PG Start-Up through EN

I_{OUT} = 0A



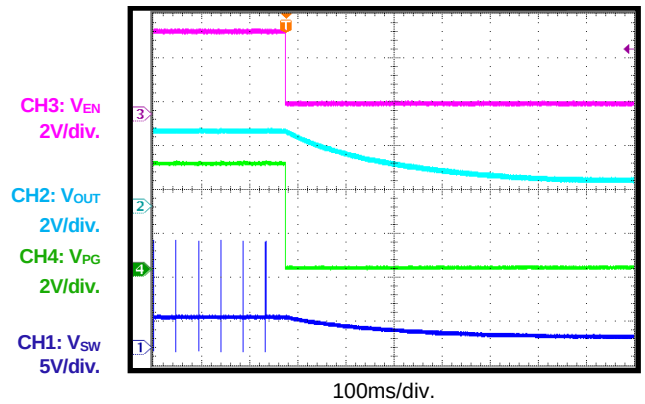
PG Start-Up through EN

I_{OUT} = 6A



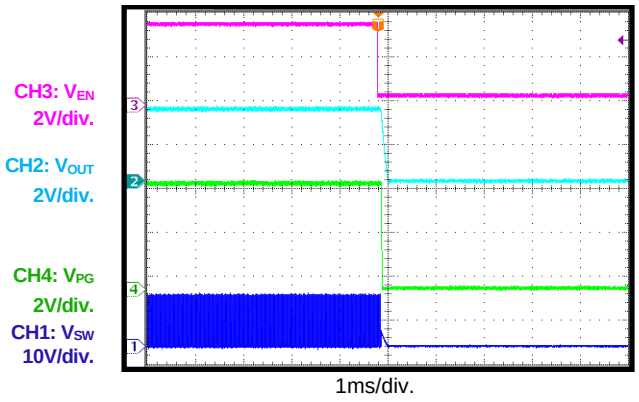
PG Shutdown through EN

I_{OUT} = 0A



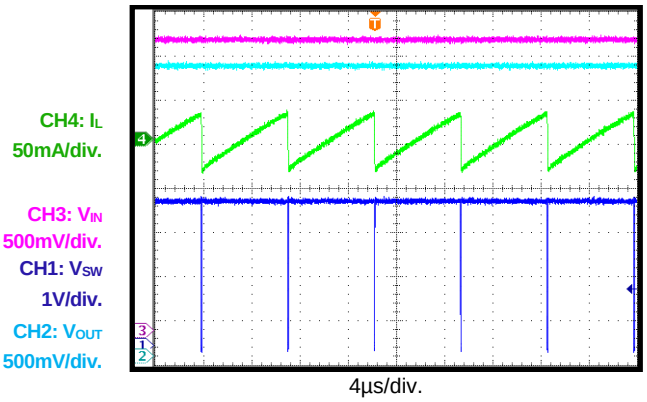
PG Shutdown through EN

I_{OUT} = 6A



Low-Dropout Mode

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



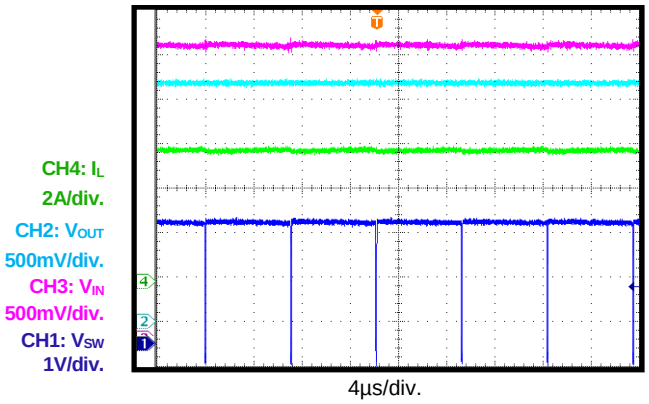
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EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 3.3V, L = 4.7µH, f_{SW} = 470kHz, AAM, T_A = 25°C, unless otherwise noted.

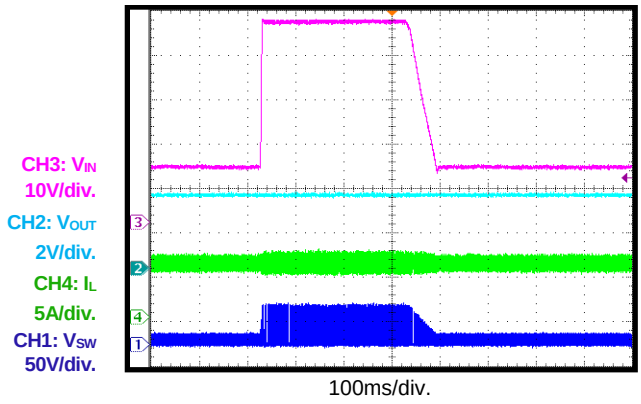
Low-Dropout Mode

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



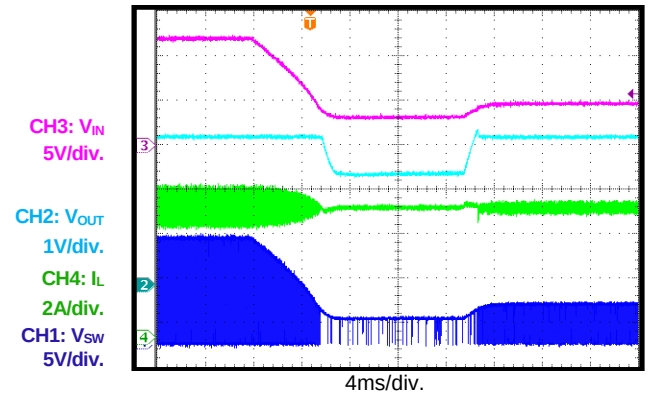
Load Dump

V_{IN} = 12V to 36V, I_{OUT} = 6A



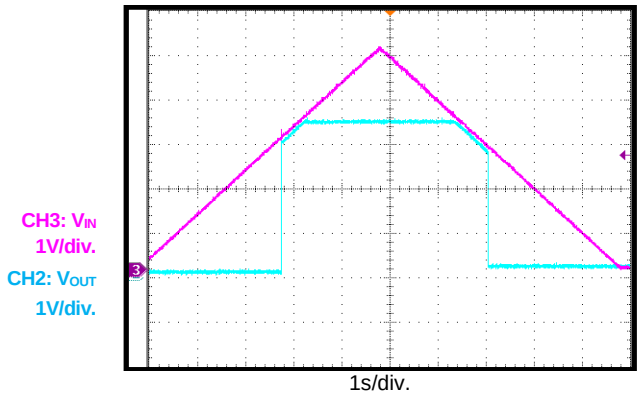
Cold Crank

V_{IN} = 12V to 3.3V to 5V, I_{OUT} = 6A



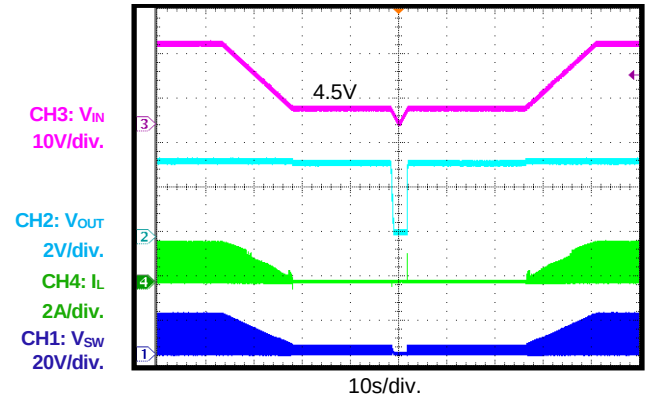
V_{IN} Ramp Up and Down

I_{OUT} = 0.1A



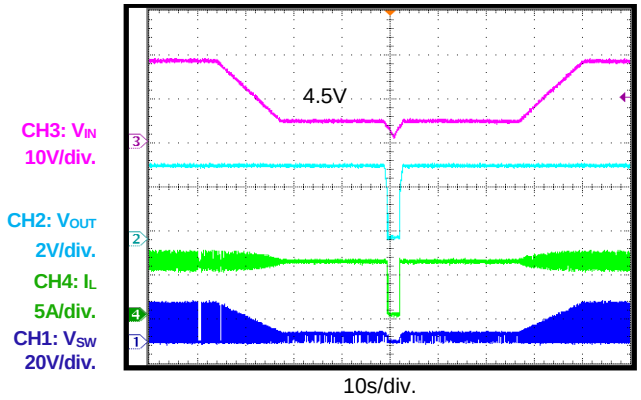
V_{IN} Ramp Down and Up

I_{OUT} = 1mA



V_{IN} Ramp Down and Up

I_{OUT} = 6A



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PCB LAYOUT

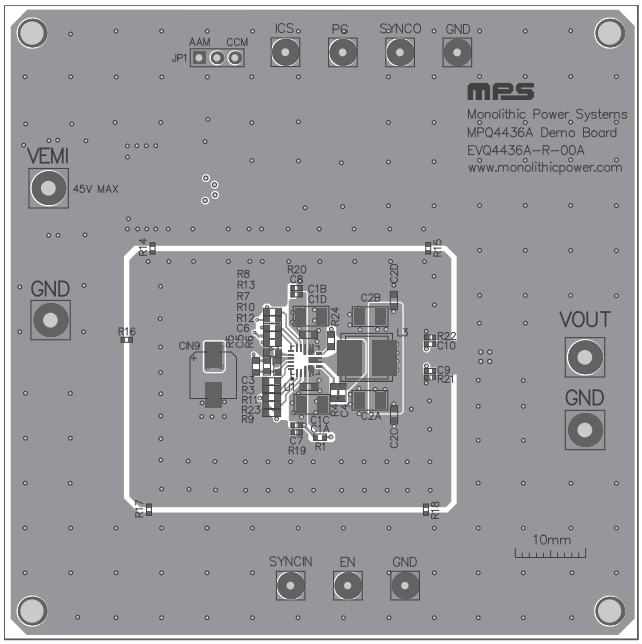


Figure 2: Top Silk Layer and Top Layer

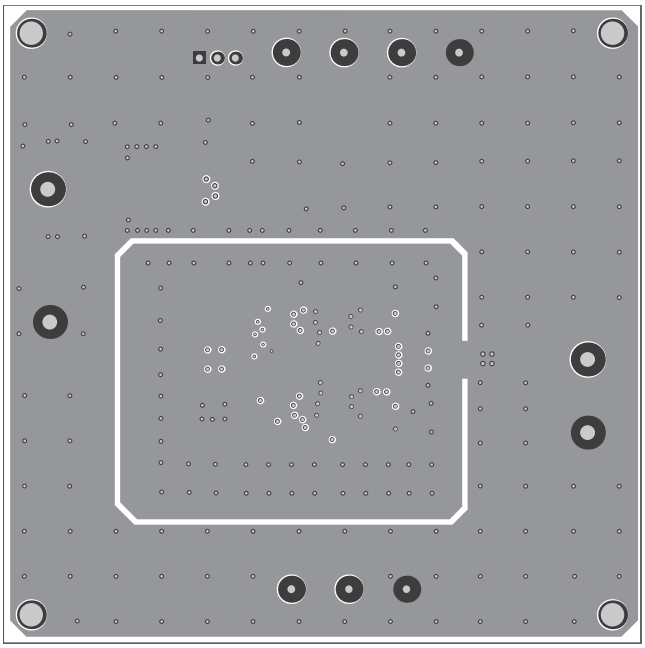


Figure 3: Mid-Layer 1

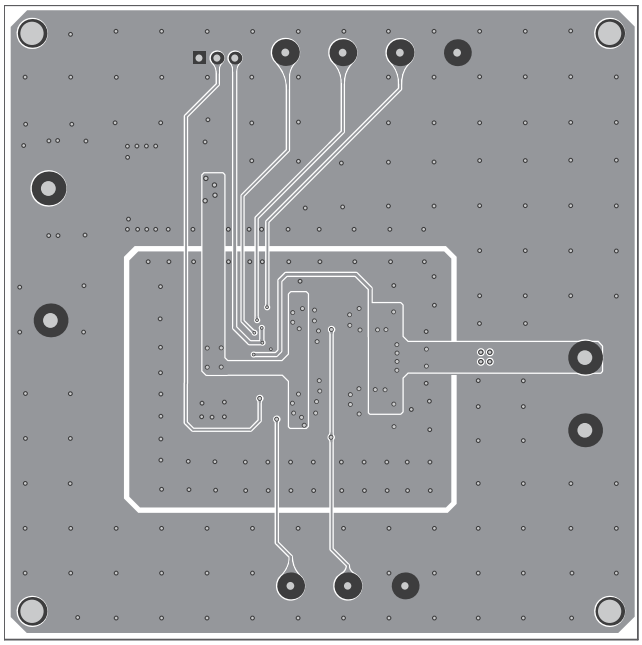


Figure 4: Mid-Layer 2

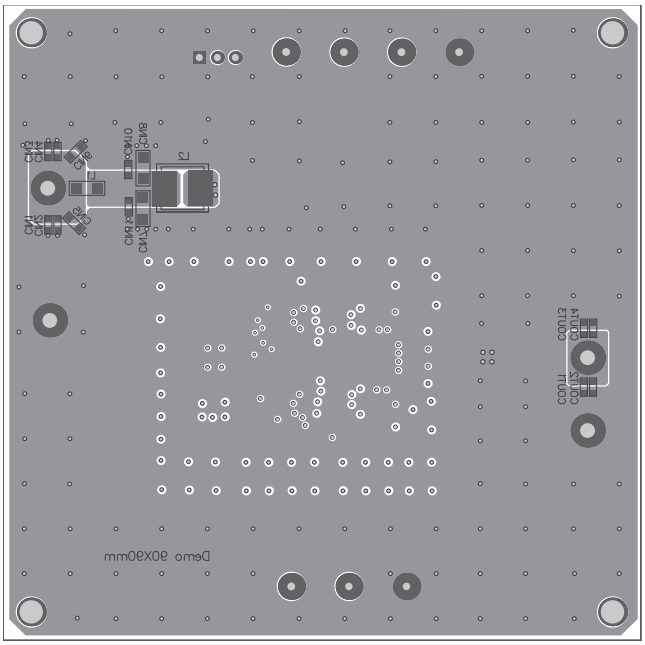


Figure 5: Bottom Silk Layer and Bottom Layer

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REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	12/21/2020	Initial Release	-

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