EVQ8875A-VE-00A

36V, 5A, Single-Channel, Quad-Switch, Synchronous, DC/DC Buck-Boost Converter Evaluation Board

DESCRIPTION

The EVQ8875A-VE-00A is an evaluation board designed to demonstrate the capabilities of the MPQ8875A, a 36V, monolithic, synchronous DC/DC buck-boost converter.

The device's wide 2.2V to 36V input voltage range is ideal for multi-purpose automotive and industrial applications.

Constant-on-time (COT) control and the integrated quad-switch configuration allow the MPQ8875A to flexibly change between the buck, boost, and buck-boost topologies. This optimizes performance and efficiency for input voltages above, below, or equal to the output voltage (V_{OUT}). COT also ensures seamless transitions between the adjacent operational regions.

The MPQ8875A's configurable parameters are set via the I²C interface, and do not require any additional hardware changes.

The switching frequency (f_{SW}) can be configured between 200kHz and 1MHz or synchronized between 250kHz and 1MHz via an external clock signal. To improve EMI performance, the configurable frequency spread spectrum function can dither f_{SW} periodically.

Fault protections include input under-voltage lockout (UVLO), input over-voltage protection (OVP), cycle-by-cycle peak current limiting, output OVP, output short-circuit protection (SCP), and thermal shutdown. The built-in power good (PG) indicator determines whether V_{OUT} is regulated properly.

The EVQ8875A-VE-00A is a fully assembled and tested evaluation board.

ELECTRICAL SPECIFICATIONS

Parameter	Symbol	Value	Units
Input voltage	V_{IN}	4.5 to 36	V
Output voltage	V_{OUT}	11.5	V
Output current	I_{OUT}	0 to 5	A

FEATURES

- Wide 2.2V to 36V Operating Input Range
- Up to 5A Continuous Output Current
- <25µA Shutdown Current
- 180µA Quiescent Current when V_{IN} = 12V
- Single-Channel, Quad-Switch, Synchronous Buck-Boost Configuration:
  - 10mΩ Internal Buck HS-FET
  - 10mΩ Internal Boost LS-FET
  - 25mΩ Internal Boost High-Side (HS) Synchronous Rectifier
  - 25mΩ Internal Buck Low-Side (LS) Synchronous Rectifier
- COT Control for Seamless Transitions
- Internal Soft Start (SS)
- Smart Power Good (PG) Output
- Optimized for Efficiency and EMI Performance:
  - 200kHz to 1MHz Configurable Switching Frequency (f_{SW})
  - 250kHz to 1MHz Synchronized f_{SW}
  - Frequency Spread Spectrum
  - Configurable Switching Speed
- Protection Features:
  - Cycle-by-Cycle Current Limiting
  - Over-Current Protection (OCP)
  - Configurable Input UVLO
  - Output Over-Voltage Protection (OVP)
  - Input OVP
  - Output Short-Circuit Protection (SCP)
  - Over-Temperature Protection (OTP)
- Standard, Configurable via I²C Interface:
  - Converter On/Off
  - Input Range Selection
  - 0.5V to 30V Output Range for Forced Continuous Conduction Mode (FCCM)
  - 5V to 30V Output Range for Discontinuous Conduction Mode (DCM)
  - Synchronized Input and Output
  - Switching Slew Rate
  - f_{SW}
  - Frequency Spread Spectrum
  - Compensation Network
  - Ramp Compensation

FEATURES *(continued)*

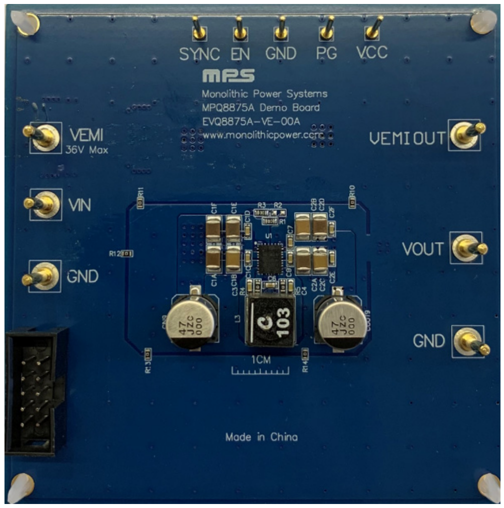
- Soft-Start Time
- Dynamic V_{OUT} with Slew Rate Control
- DCM and FCCM
- COT Control for Boost Switch in Buck-Boost Mode
- Input and Output OVP
- Cycle-by-Cycle Current Limit Threshold
- Reverse Current Limit Threshold
- OCP
- Output SCP
- Thermal Protection
- PG Threshold
- Junction Temperature Reading

- One-Time Programmable (OTP) Default Parameter
- Available in a QFN-34 (4mmx5mm) Package
- Available in a Wettable Flank Package
- Available in AEC-Q100 Grade 1

APPLICATIONS

- Sensor Fusion Systems
- Camera Monitoring Systems
- Infotainment Systems
- Automotive Applications

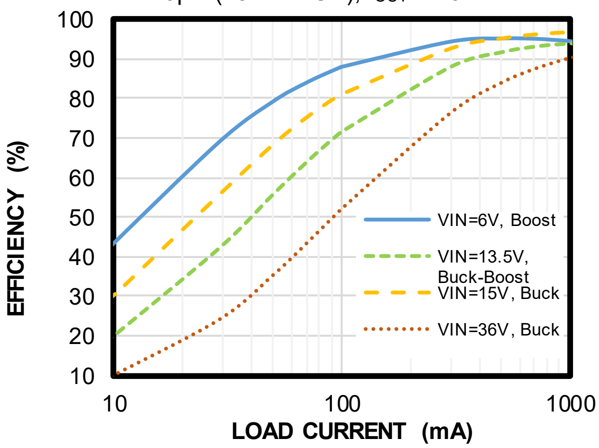
EVQ8875A-VE-00A EVALUATION BOARD



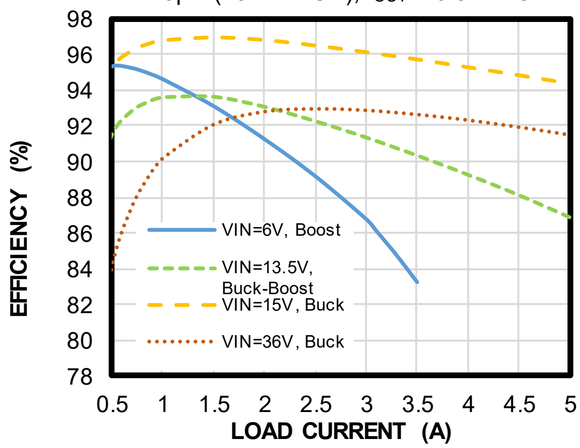
LxWxH (9cmx9cmx1.3cm)

Board Number	MPS IC Number
EVQ8875A-VE-00A	MPQ8875A

Efficiency vs. Load Current
V_{OUT} = 11.5V, f_{SW} = 450kHz, FCCM,
L = 10µH (23mΩ DCR), I_{OUT} = 10mA to 1A



Efficiency vs. Load Current
V_{OUT} = 11.5V, f_{SW} = 450kHz, FCCM,
L = 10µH (23mΩ DCR), I_{OUT} = 0.5A to 5A



QUICK START GUIDE

1. Preset the load current between 0A and 5A, and preset the power supply between 4.5V and 36V. Note that electronic loads represent a negative impedance to the regulator, which can trigger over-current protection (OCP) if the current is set too high.
2. Turn off the power supply. If longer cables (>0.5m total) are being used between the source and the evaluation board, install a damping capacitor at the input terminals. This is critical when V_{IN} exceeds 24V.
3. Connect the power supply terminals to:
    a. Positive (+): VIN
    b. Negative (-): GND
4. For EMI testing, 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. For EMI testing, connect the load terminals to:
    a. Positive (+): VEMI_OUT
    b. Negative (-): GND
7. After making the connections, turn on the power supply. The MPQ8875A should automatically start up. The default V_{OUT} is 11.5V.
8. To use the enable (EN) function, apply a digital input to the EN pin. Drive EN between 1.55V to 5.5V to turn the regulator on; drive EN below 1.4V to turn it off. (1)

Note:

1) For more information and function tests, refer to the MPQ8875A GUI, which can be downloaded from the MPS website.

EVALUATION BOARD SCHEMATIC

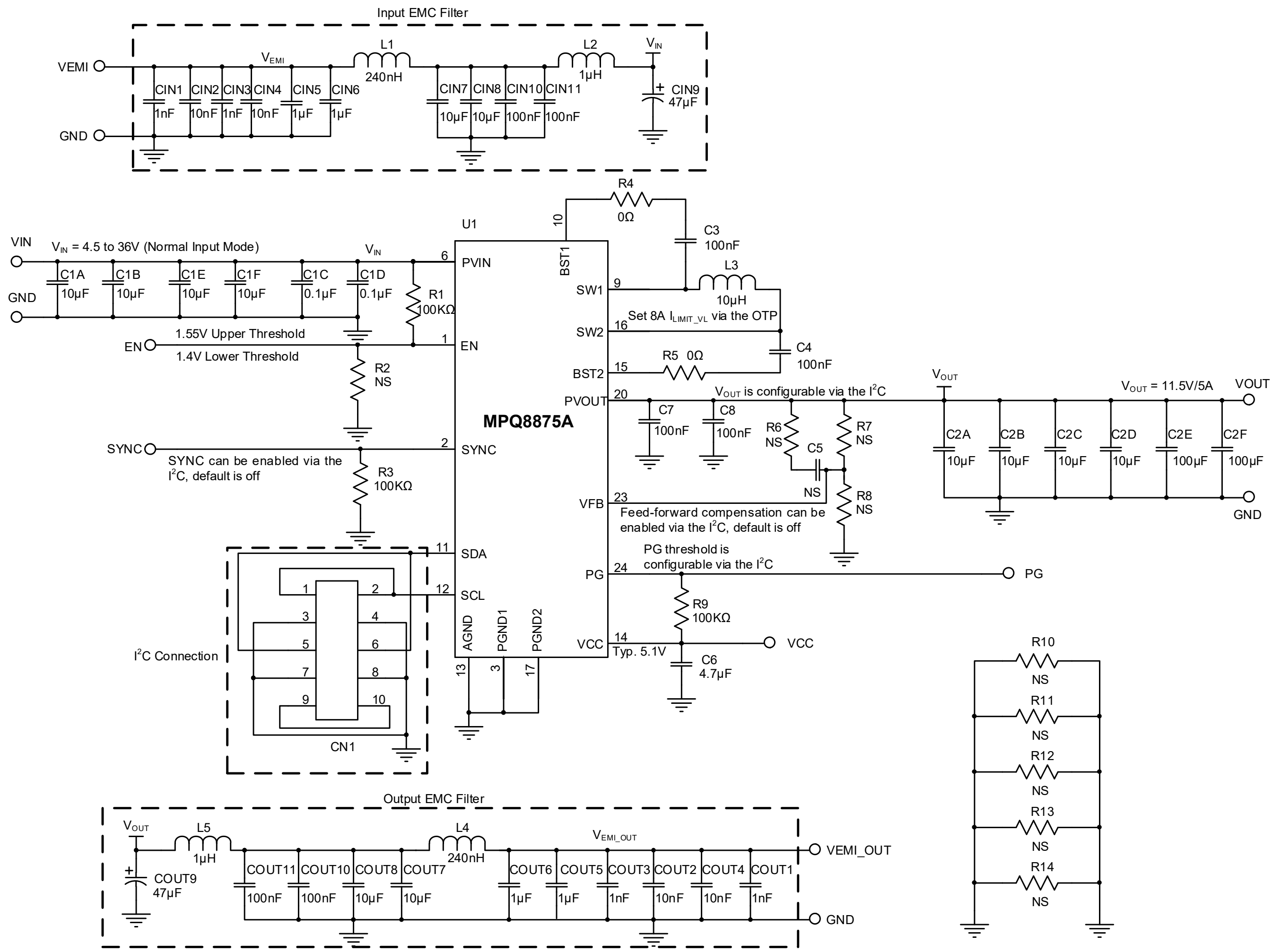


Figure 1: Evaluation Board Schematic

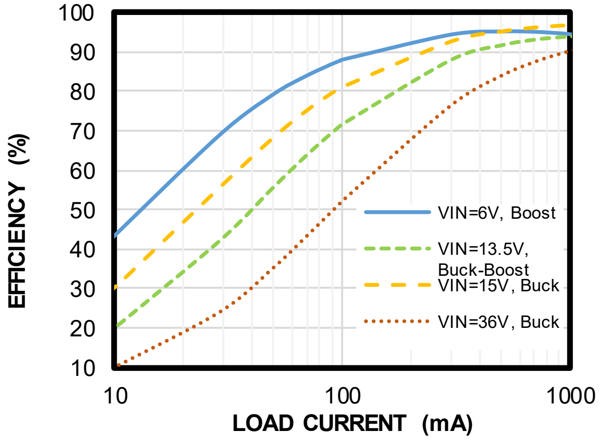
EVQ8875A-VE-00A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
4	CIN1, CIN3, COUT1, COUT3	1nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H102KA01D
4	CIN2, CIN4, COUT2, COUT4	10nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H103KA01D
4	CIN5, CIN6, COUT5, COUT6	1µF	Ceramic capacitor, 50V, X7R	0805	Murata	GRM21BR71H105KA12L
4	CIN7, CIN8, COUT7, COUT8	10µF	Ceramic capacitor, 50V, X5R	1206	Murata	GRM31CR61H106KA12L
2	CIN9, COUT9	47µF	63V, 40mΩ	SMD	Panasonic	EEHZC1J470P
12	CIN10, CIN11, COUT10, COUT11, C1C, C1D, C3, C4, C7, C8, C2E, C2F	0.1µF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H104KA93D
8	C1A, C1B, C1E, C1F, C2A, C2B, 2C, C2D	10µF	Ceramic capacitor, 50V, X7R	1210	Murata	GRM32ER71H106KA12L
0	C5	NS		0603		
1	C6	4.7µF	Ceramic capacitor, 10V, X5R	0603	Murata	GRM188R61A475KE15D
2	L1, L4	240nH	Inductor, 19mΩ, 6.6A	SMD	Toko	DFE201612E-R24M=P2
2	L2, L5	1µH	Inductor, 14.6mΩ, 9.6A	SMD	Coilcraft	XEL4020-102MEB
1	L3	10µH	Inductor, 23.1mΩ, 8.7A	SMD	Coilcraft	XAL8080-103MEB
3	R1, R3, R9	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
0	R2, R6, R7, R8,	NS				
7	R4, R5, R10, R11, R12, R13, R14	0Ω	Film resistor, 5%	0603	Yageo	RC0603JR-070RL
1	U1	MPQ8875A	Quad-switch buck-boost converter	QFN-34 (4mmx5mm)	MPS	MPQ8875AGRE-0000-AEC1
6	VEMI, VIN, GND, VEMI_OUT, VOUT, GND	2mm	Golden pins, test point	DIP	Any	
5	SYNC, VCC, EN, PG, GND	1mm	Golden pin, test point	DIP	Any	
1	CN1	2.54mm	Male box header, 2x5	DIP	Any	

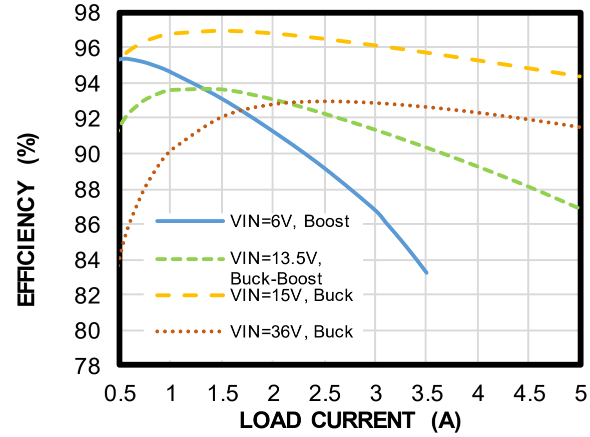
EVB TEST RESULTS

V_{IN} = 13.5V, V_{OUT} = 11.5V, L = 10µH, C_{OUT} = 40µF, f_{SW} = 450kHz, FCCM, T_A = 25°C, unless otherwise noted.

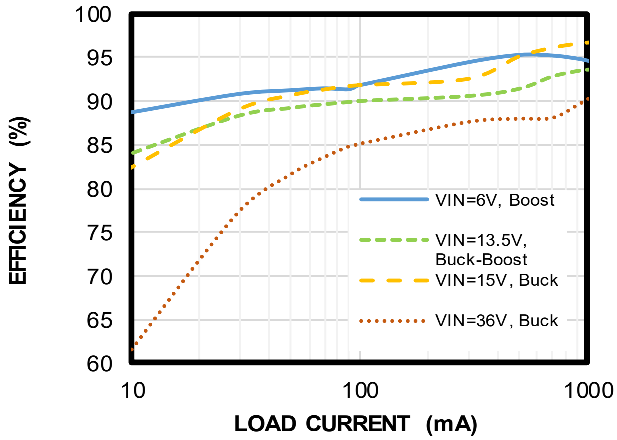
Efficiency vs. Load Current
V_{OUT} = 11.5V, FCCM, I_{OUT} = 10mA to 1A



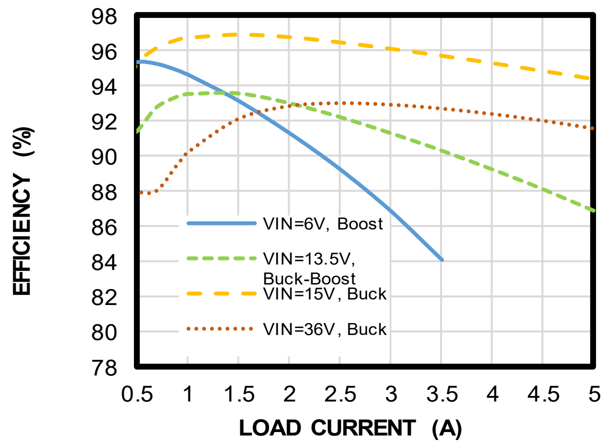
Efficiency vs. Load Current
V_{OUT} = 11.5V, FCCM, I_{OUT} = 0.5A to 5A



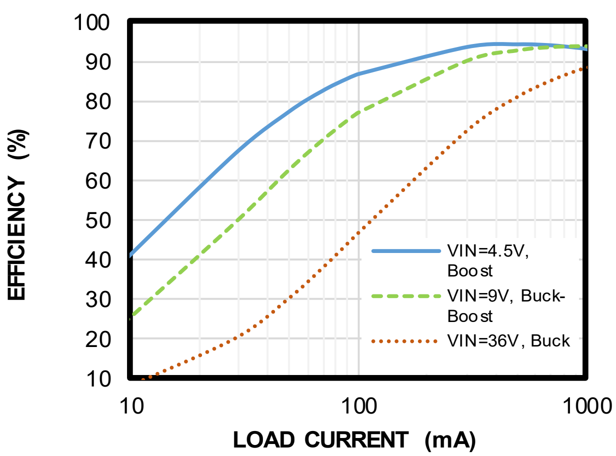
Efficiency vs. Load Current
V_{OUT} = 11.5V, DCM, I_{OUT} = 10mA to 1A



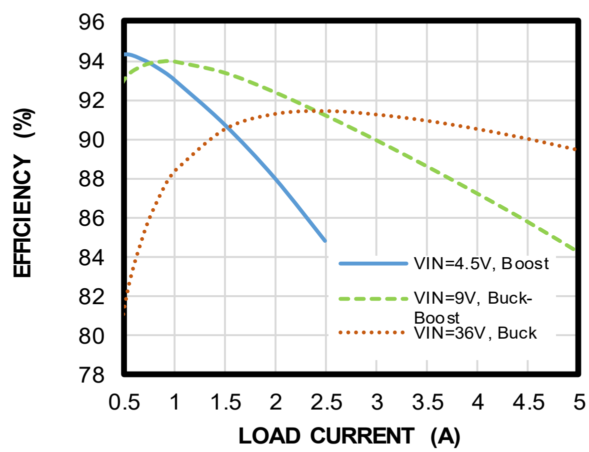
Efficiency vs. Load Current
V_{OUT} = 11.5V, DCM, I_{OUT} = 0.5A to 5A



Efficiency vs. Load Current
V_{OUT} = 9V, FCCM, I_{OUT} = 10mA to 1A



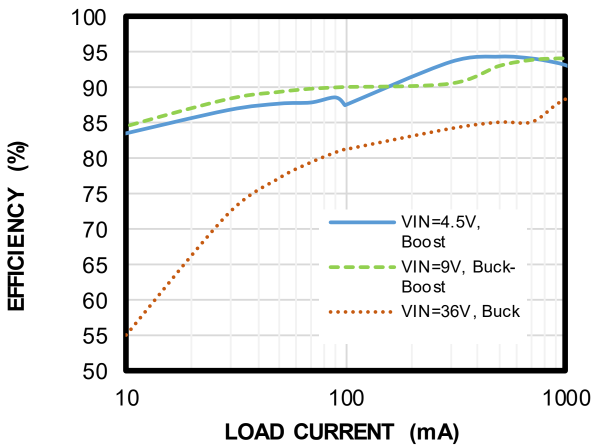
Efficiency vs. Load Current
V_{OUT} = 9V, FCCM, I_{OUT} = 0.5A to 5A



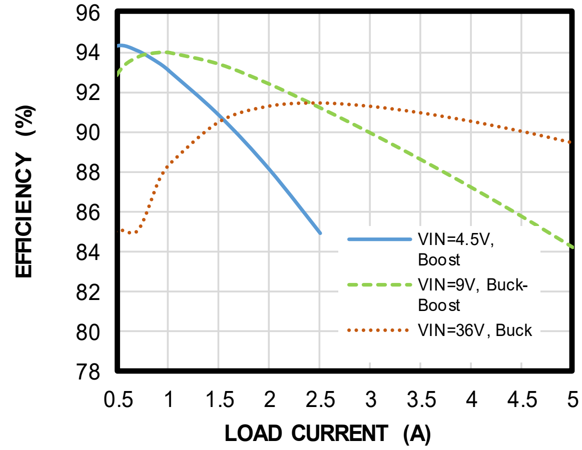
EVB TEST RESULTS *(continued)*

V_{IN} = 13.5V, V_{OUT} = 11.5V, L = 10µH, C_{OUT} = 40µF, f_{SW} = 450kHz, FCCM, T_A = 25°C, unless otherwise noted.

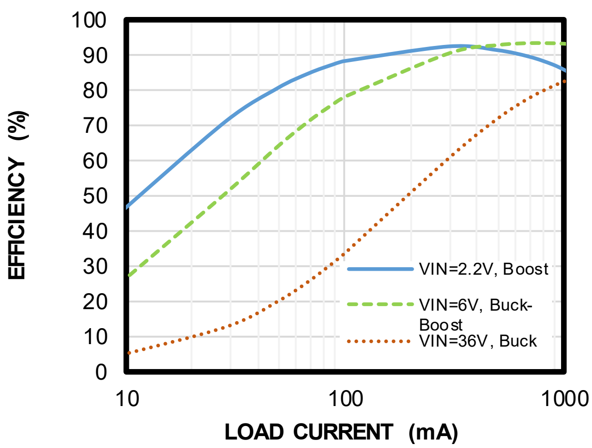
Efficiency vs. Load Current
V_{OUT} = 9V, DCM, I_{OUT} = 10mA to 1A



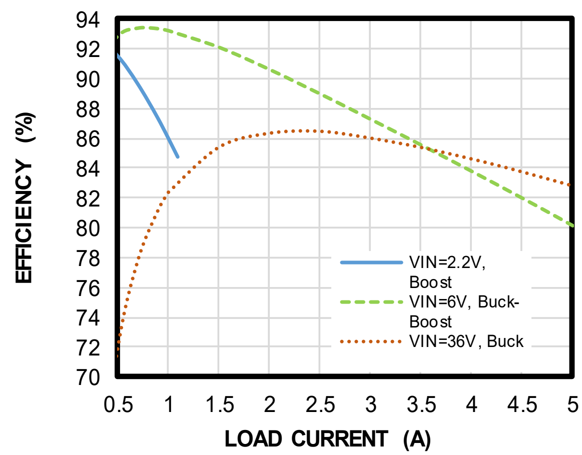
Efficiency vs. Load Current
V_{OUT} = 9V, DCM, I_{OUT} = 0.5A to 5A



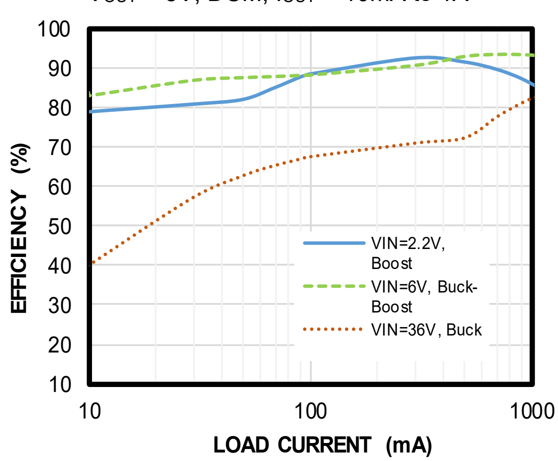
Efficiency vs. Load Current
V_{OUT} = 5V, FCCM, I_{OUT} = 10mA to 1A



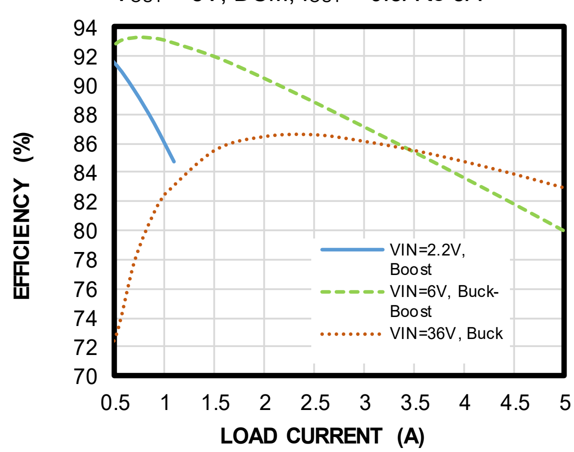
Efficiency vs. Load Current
V_{OUT} = 5V, FCCM, I_{OUT} = 0.5A to 5A



Efficiency vs. Load Current
V_{OUT} = 5V, DCM, I_{OUT} = 10mA to 1A

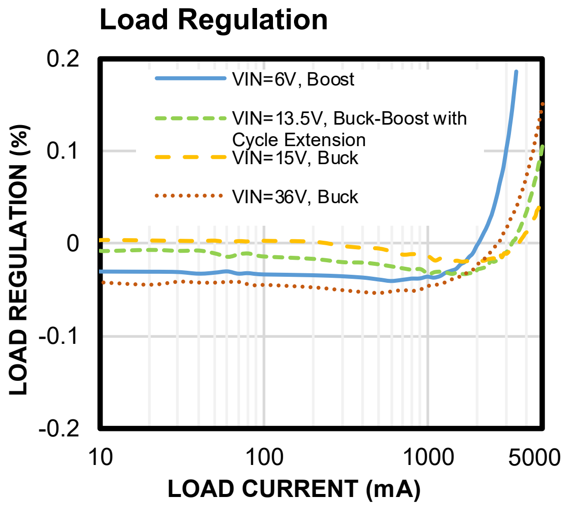


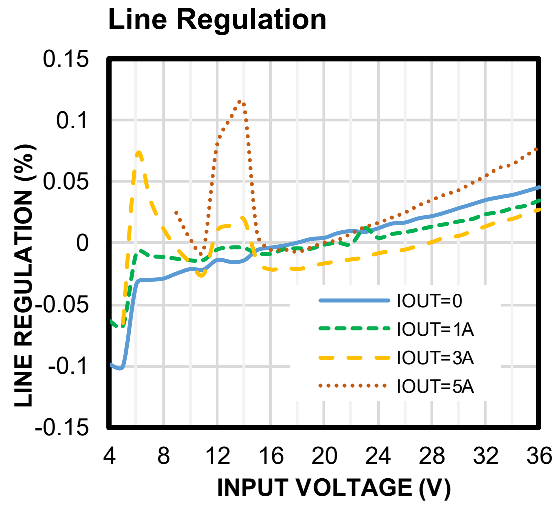
Efficiency vs. Load Current
V_{OUT} = 5V, DCM, I_{OUT} = 0.5A to 5A

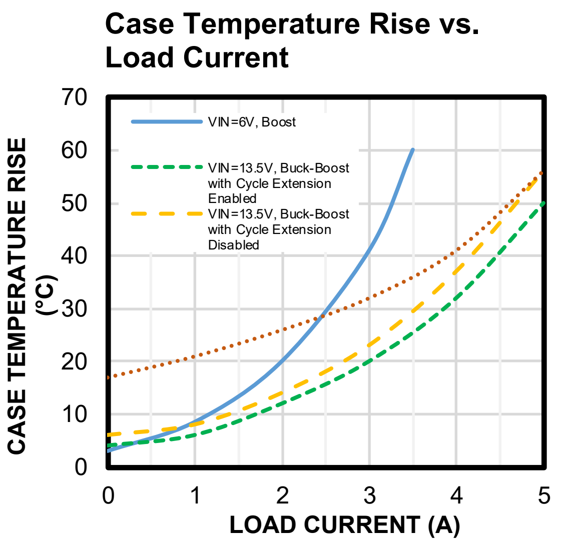


EVB TEST RESULTS *(continued)*

V_{IN} = 13.5V, V_{OUT} = 11.5V, L = 10µH, C_{OUT} = 40µF, f_{SW} = 450kHz, FCCM, T_A = 25°C, unless otherwise noted.





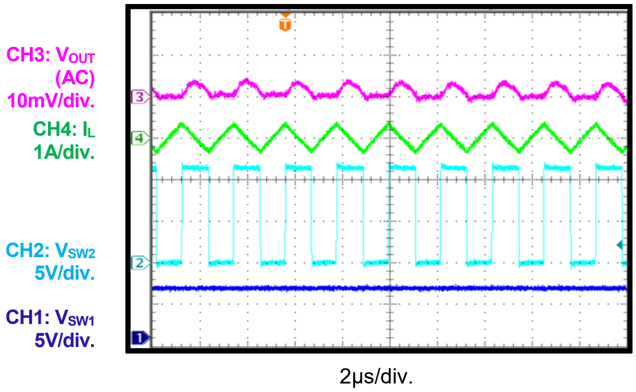


EVB TEST RESULTS *(continued)*

V_{IN} = 13.5V, V_{OUT} = 11.5V, L = 10µH, C_{OUT} = 40µF, f_{SW} = 450kHz, FCCM, T_A = 25°C, unless otherwise noted.

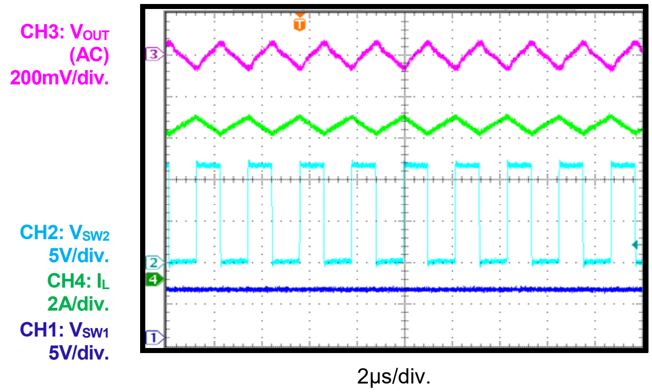
Steady State

V_{IN} = 6V, I_{OUT} = 0A, boost mode



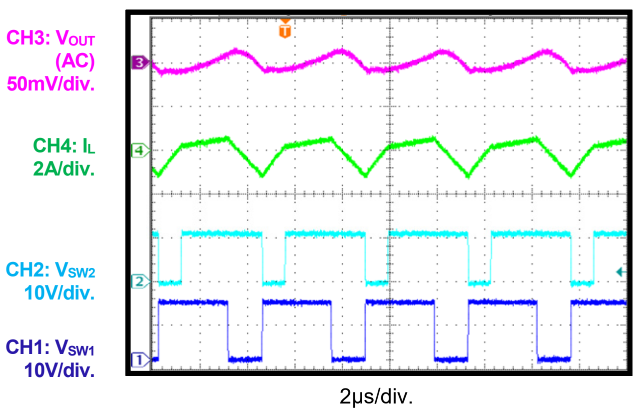
Steady State

V_{IN} = 6V, I_{OUT} = 3.5A, boost mode



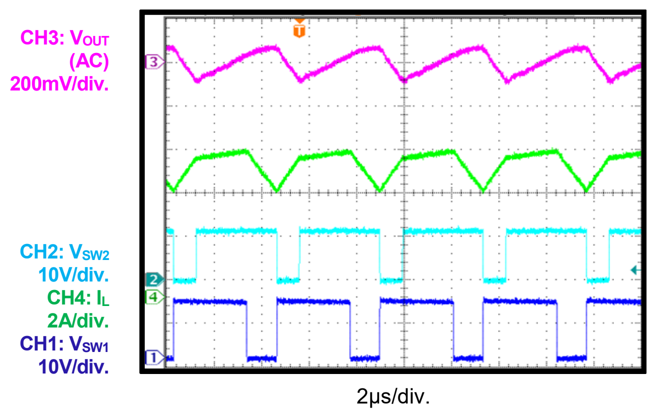
Steady State

V_{IN} = 13.5V, I_{OUT} = 0A, buck-boost mode



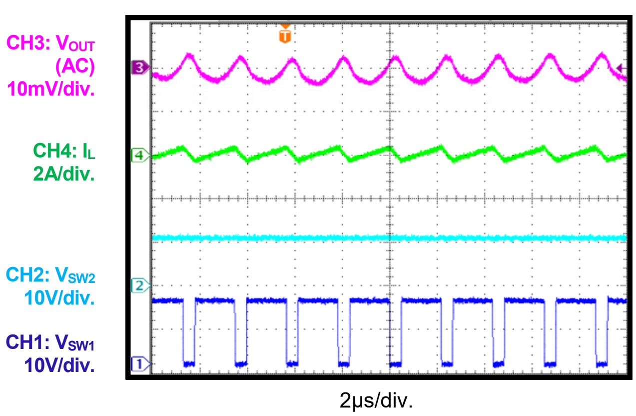
Steady State

V_{IN} = 13.5V, I_{OUT} = 5A, buck-boost mode



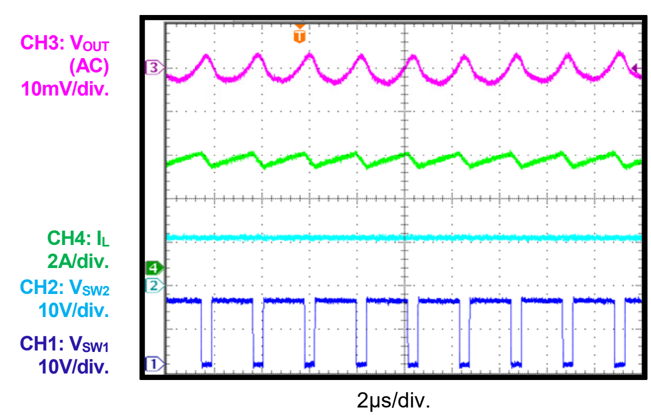
Steady State

V_{IN} = 15V, I_{OUT} = 0A, buck mode



Steady State

V_{IN} = 15V, I_{OUT} = 5A, buck mode

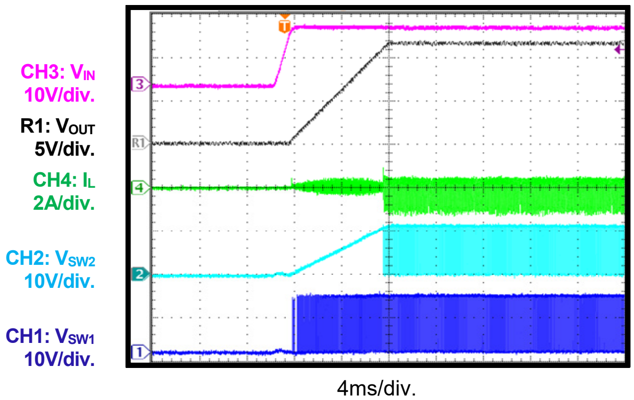


EVB TEST RESULTS *(continued)*

V_{IN} = 13.5V, V_{OUT} = 11.5V, L = 10µH, C_{OUT} = 40µF, f_{SW} = 450kHz, FCCM, T_A = 25°C, unless otherwise noted.

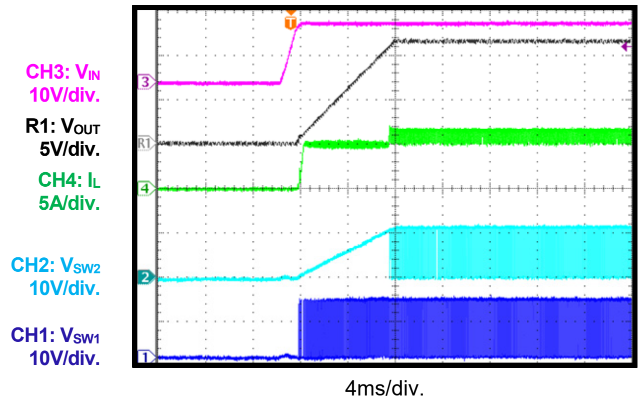
Start-Up through VIN

I_{OUT} = 0A



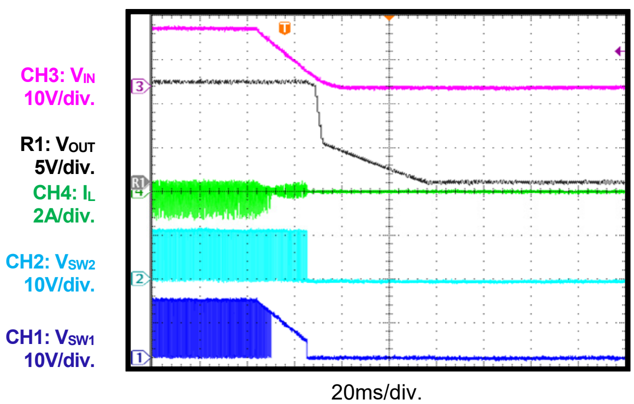
Start-Up through VIN

I_{OUT} = 5A



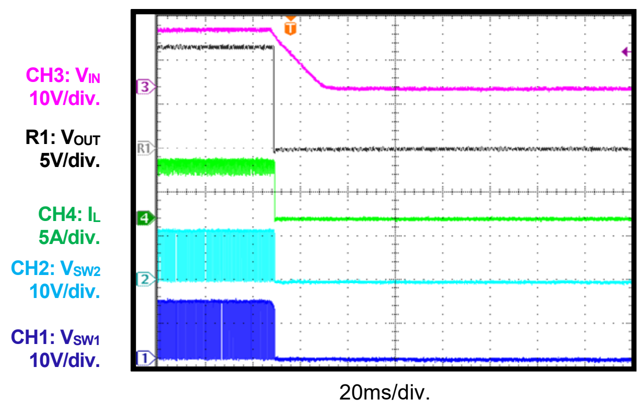
Shutdown through VIN

I_{OUT} = 0A



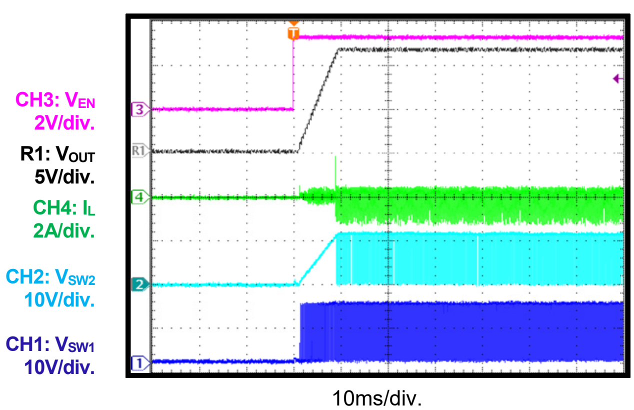
Shutdown through VIN

I_{OUT} = 5A



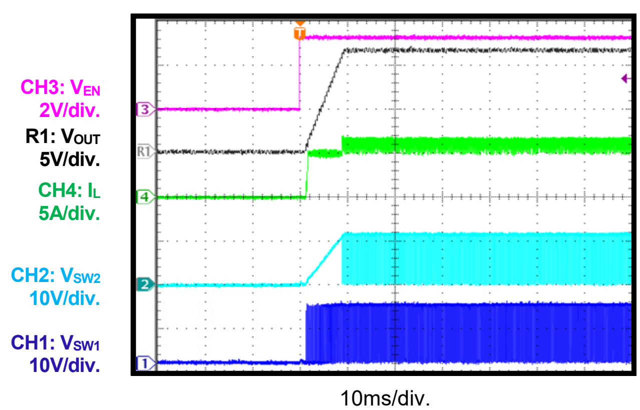
Start-Up through EN

I_{OUT} = 0A



Start-Up through EN

I_{OUT} = 5A

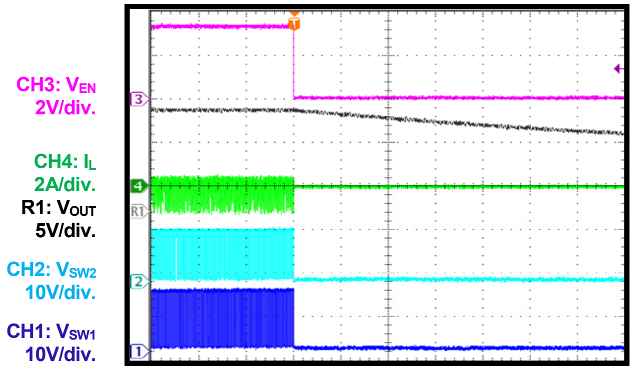


EVB TEST RESULTS *(continued)*

V_{IN} = 13.5V, V_{OUT} = 11.5V, L = 10µH, C_{OUT} = 40µF, f_{SW} = 450kHz, FCCM, T_A = 25°C, unless otherwise noted.

Shutdown through EN

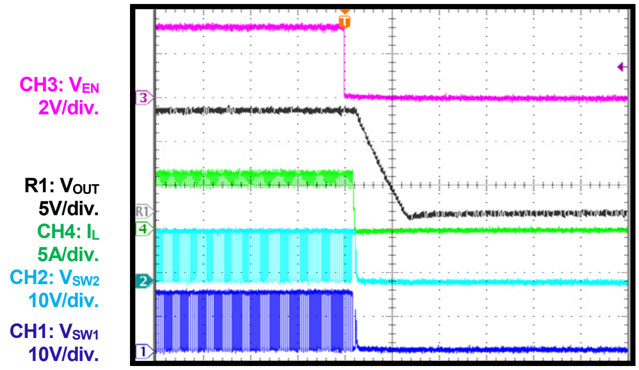
I_{OUT} = 0A



400ms/div.

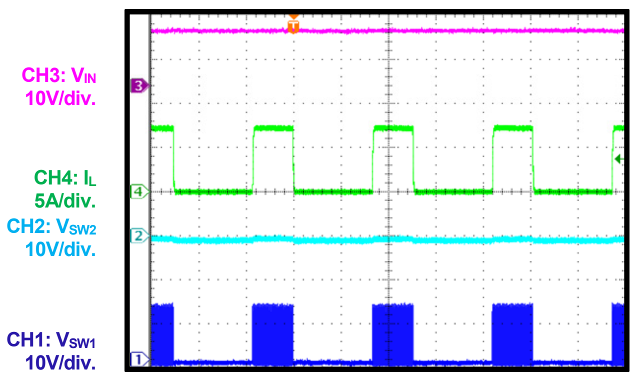
Shutdown through EN

I_{OUT} = 5A



100µs/div.

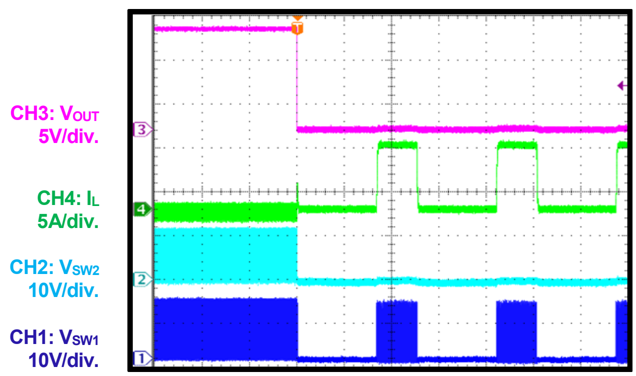
SCP Steady State



10ms/div.

SCP Entry

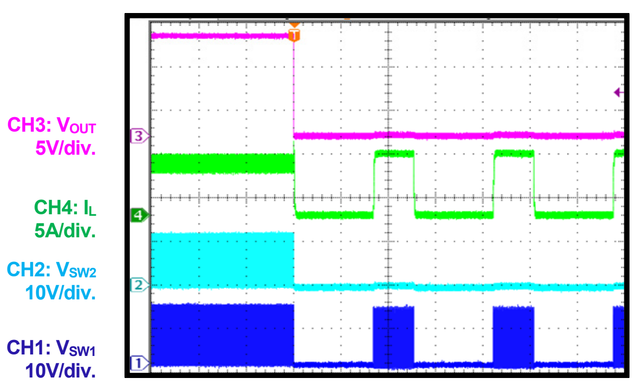
I_{OUT} = 0A to short circuit



10ms/div.

SCP Entry

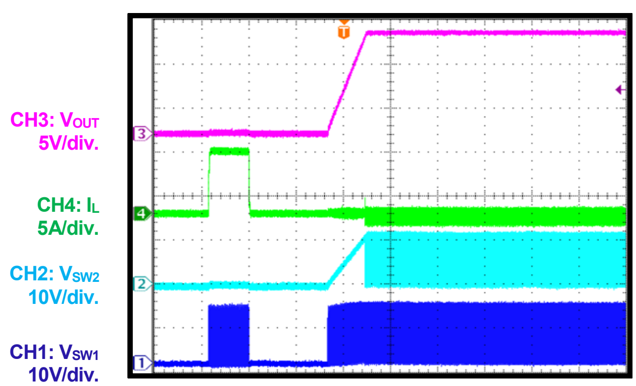
I_{OUT} = 5A to short circuit



10ms/div.

SCP Recovery

Short circuit to I_{OUT} = 0A

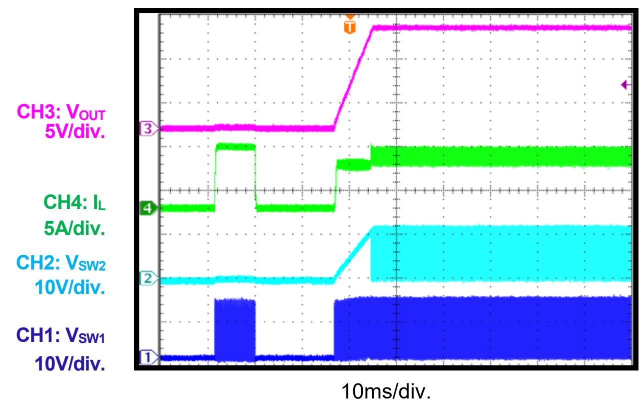


10ms/div.

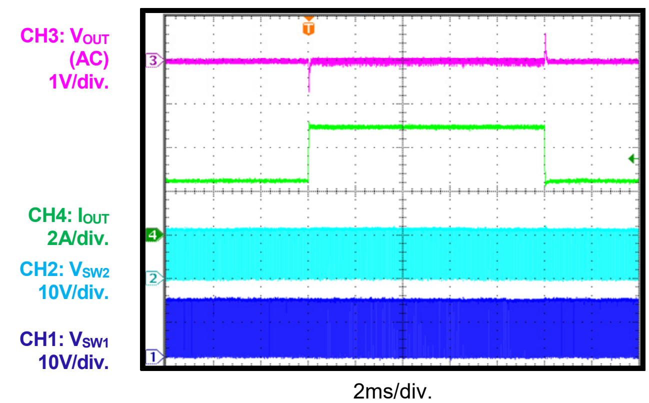
EVB TEST RESULTS *(continued)*

V_{IN} = 13.5V, V_{OUT} = 11.5V, L = 10µH, C_{OUT} = 40µF, f_{SW} = 450kHz, FCCM, T_A = 25°C, unless otherwise noted.

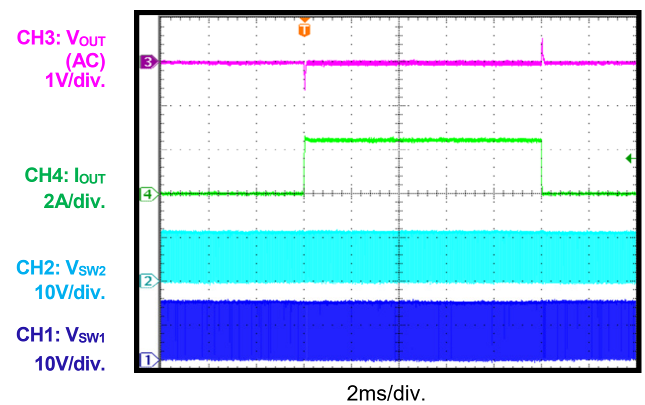
SCP Recovery
Short circuit to I_{OUT} = 5A



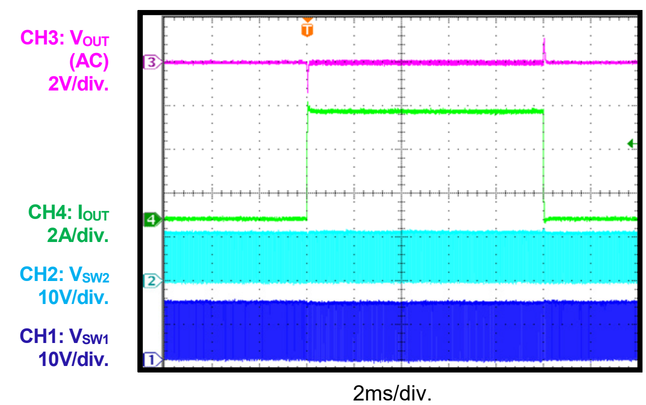
Load Transient
I_{OUT} = 2.5A to 5A, 1.6A/µs



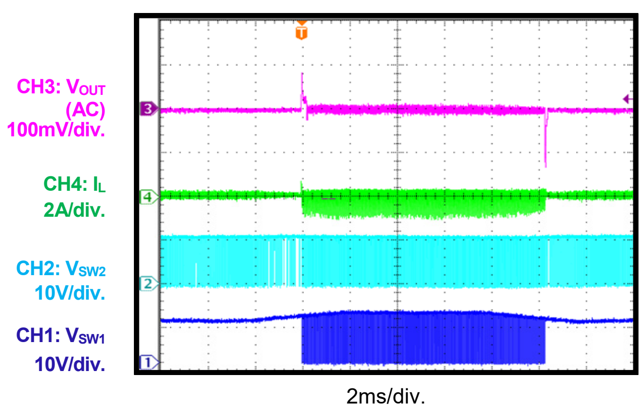
Load Transient
I_{OUT} = 0A to 2.5A, 1.6A/µs



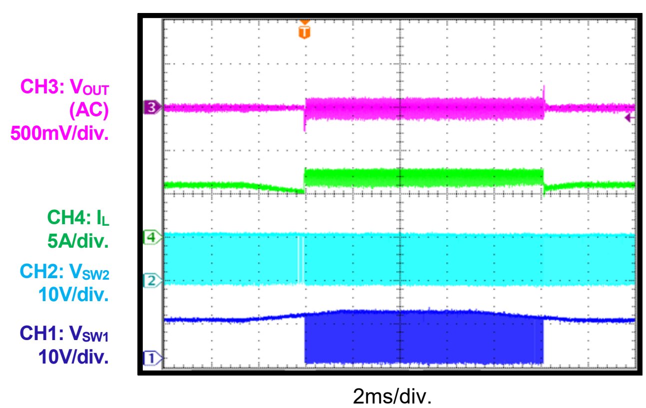
Load Transient
I_{OUT} = 0A to 5A, 1.6A/µs



Mode Transient between Boost and Buck-Boost
V_{IN} = 10V to 12V to 10V, I_{OUT} = 0A



Mode Transient between Boost and Buck-Boost
V_{IN} = 10V to 12V to 10V, I_{OUT} = 5A

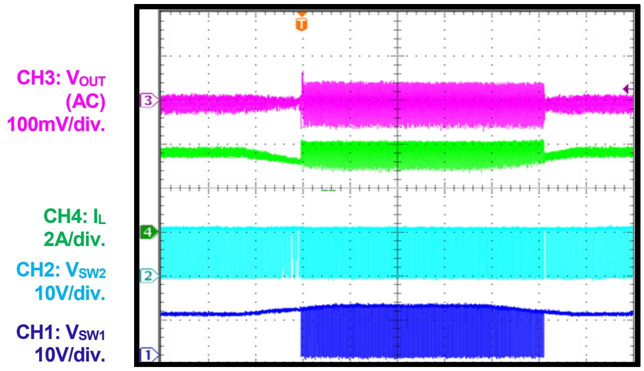


EVB TEST RESULTS *(continued)*

V_{IN} = 13.5V, V_{OUT} = 11.5V, L = 10µH, C_{OUT} = 40µF, f_{SW} = 450kHz, FCCM, T_A = 25°C, unless otherwise noted.

Mode Transient between Boost and Buck-Boost

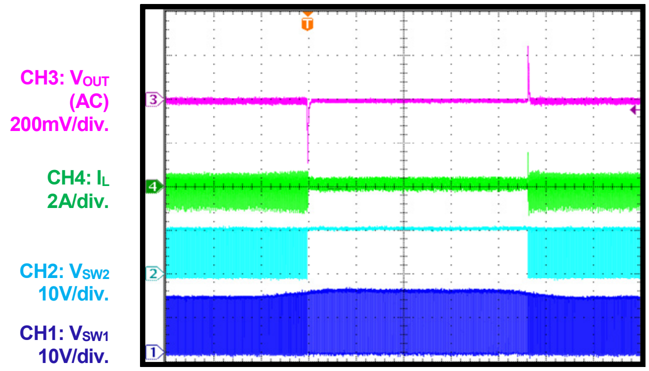
V_{IN} = 10V to 12V to 10V, I_{OUT} = 3A



2ms/div.

Mode Transient between Buck and Buck-Boost

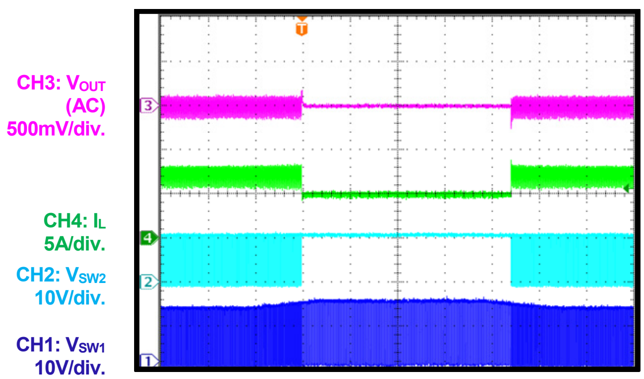
V_{IN} = 13.5V to 15V to 13.5V, I_{OUT} = 0A



2ms/div.

Mode Transient between Buck and Buck-Boost

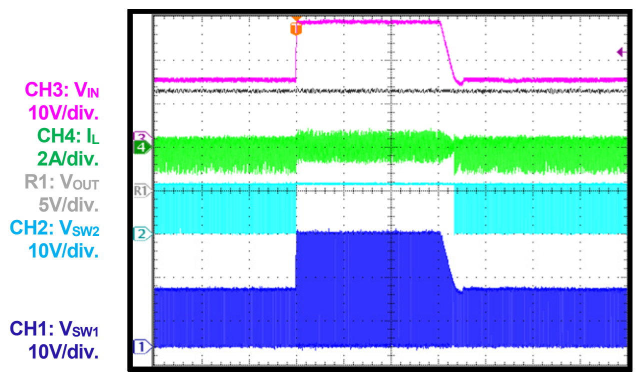
V_{IN} = 13.5V to 15V to 13.5V, I_{OUT} = 5A



2ms/div.

Load Dump

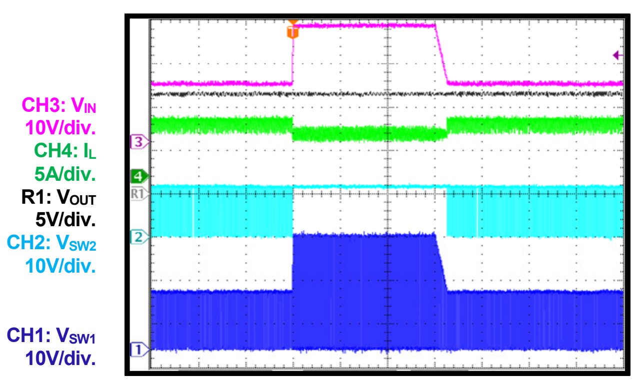
I_{OUT} = 0A



100ms/div.

Load Dump

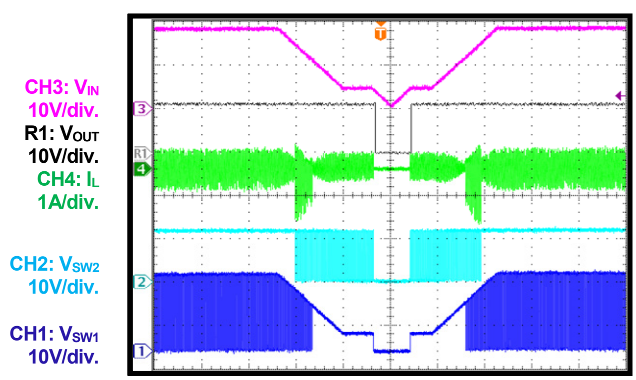
I_{OUT} = 5A



100ms/div.

V_{IN} Ramps Down and Up

I_{OUT} = 0A



10s/div.

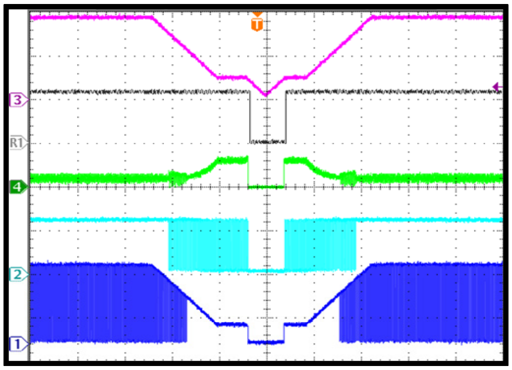
EVB TEST RESULTS *(continued)*

V_{IN} = 13.5V, V_{OUT} = 11.5V, L = 10µH, C_{OUT} = 40µF, f_{SW} = 450kHz, FCCM, T_A = 25°C, unless otherwise noted.

V_{IN} Ramps Down and Up

I_{OUT} = 1A

CH3: V_{IN} 10V/div.
R1: V_{OUT} 10V/div.
CH4: I_L 5A/div.
CH2: V_{SW2} 10V/div.
CH1: V_{SW1} 10V/div.

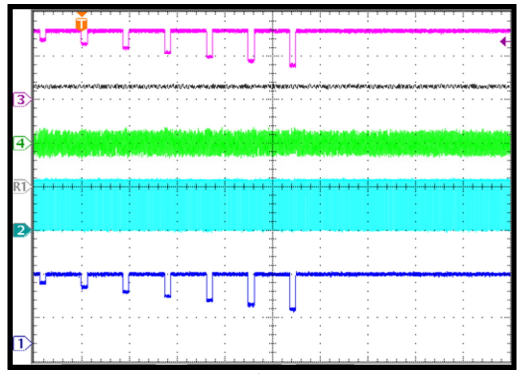


10s/div.

Reset Behavior

I_{OUT} = 0A

CH3: V_{IN} 5V/div.
CH4: I_L 1A/div.
R1: V_{OUT} 5V/div.
CH2: V_{SW2} 10V/div.
CH1: V_{SW1} 5V/div.

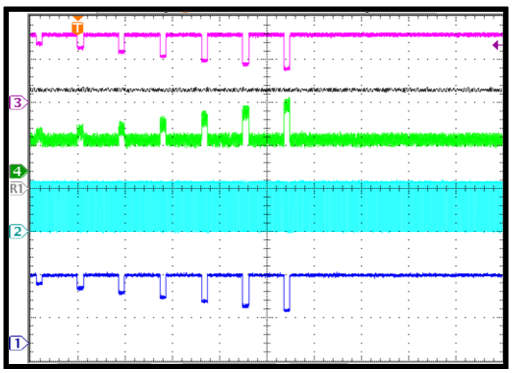


4s/div.

Reset Behavior

I_{OUT} = 1A

CH3: V_{IN} 5V/div.
CH4: I_L 2A/div.
R1: V_{OUT} 5V/div.
CH2: V_{SW2} 10V/div.
CH1: V_{SW1} 5V/div.

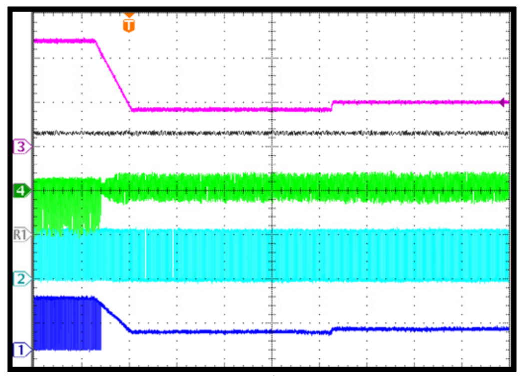


4s/div.

Cold Crank

I_{OUT} = 0A

CH3: V_{IN} 5V/div.
CH4: I_L 1A/div.
R1: V_{OUT} 5V/div.
CH2: V_{SW2} 10V/div.
CH1: V_{SW1} 10V/div.

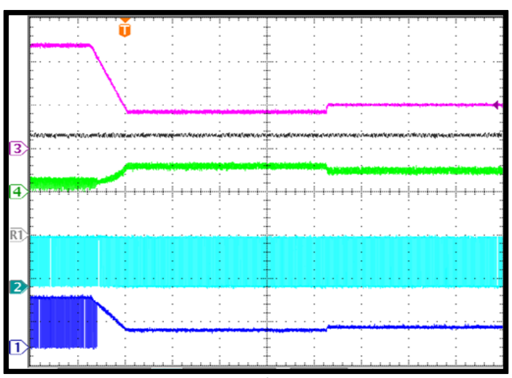


20ms/div.

Cold Crank

I_{OUT} = 1A

CH3: V_{IN} 5V/div.
CH4: I_L 5A/div.
R1: V_{OUT} 5V/div.
CH2: V_{SW2} 10V/div.
CH1: V_{SW1} 10V/div.



20ms/div.

MPQ8875A-0000 DEFAULT REGISTER VALUES

Register Index	Default Value	Description
00h	74h	Reference voltage (V_{REF}): 1.16V
01h	9Ch	Power converter: On V_{OUT} dynamic adjustment step time: 80µs V_{OUT} divider ratio: 1/10
02h	55h	SW1 rising slew rate: 2V/ms SW2 rising slew rate: 2V/ms
03h	09h	Synchronization mode: Off f_{SW}: 450kHz
04h	10h	Frequency spread spectrum: Off Frequency spread spectrum modulation range: 5% x f_{SW} Frequency spread spectrum modulation cycle: 250Hz
05h	FFh	DCM/FCCM: FCCM Reverse current limit: -4.7A Valley current limit: 8A Peak current limit: 9A
06h	03h	R_{FB} compensation network: 50kΩ R_{COMP} compensation network: 420kΩ
07h	F3h	C_{HFP} compensation network: 10pF C_{COMP} compensation network: 100pF
08h	11h	I^2C address: 0x01 Cycle extension in buck-boost mode: Off Boost switch duty in buck-boost mode: 30%
09h	A7h	Hysteresis during buck to buck-boost mode transition: 10% x V_{OUT} Threshold during buck-boost to buck mode transition: 125% x V_{OUT} Hysteresis during boost to buck-boost mode transition: 7.5% x V_{OUT} Threshold during boost to buck-boost mode transition: 90% x V_{OUT}
0Ah	00h	Inductor current-sense gain: 13A/V Inductor current-sense DC bias: 200mV Peak to valley ramp compensation: 0.2V Ramp compensation: 12mV/µs
0Bh	00h	Power good (PG) high-limit hysteresis: 2.5% x V_{OUT} PG high limit: 110% x V_{OUT} PG low-limit hysteresis: 2.5% x V_{OUT} PG low limit: 90% x V_{OUT} Over-current (OC) timer: 32 / f_{SW} Over-current protection (OCP) mode: Hiccup mode
0Ch	60h	Fault recovery delay time: 16ms Under-voltage protection (UVP) feedback (FB) threshold: 50% x V_{REF} Under-voltage (UV) timer: 2 / f_{SW} UVP mode: Hiccup mode

MPQ8875A-0000 DEFAULT REGISTER VALUES *(continued)*

Register Index	Default Value	Description
0Dh	00h	V_{IN} over-voltage protection (OVP) hysteresis: 2.5% x V_{IN} V_{IN} OVP threshold: Off V_{OUT} OVP recovery threshold: 105% x V_{REF} V_{OUT} OVP threshold: 110% x V_{REF} VFB pin connection mode: Disconnected OVP mode: Hiccup mode
0Eh	02h	Thermal shutdown hysteresis: 25°C Thermal shutdown: 170°C

PCB LAYOUT

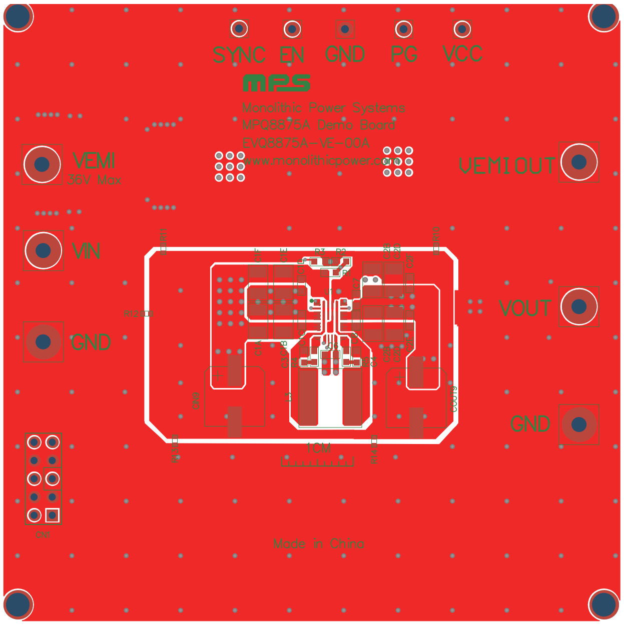


Figure 2: Top Silk and Top Layer

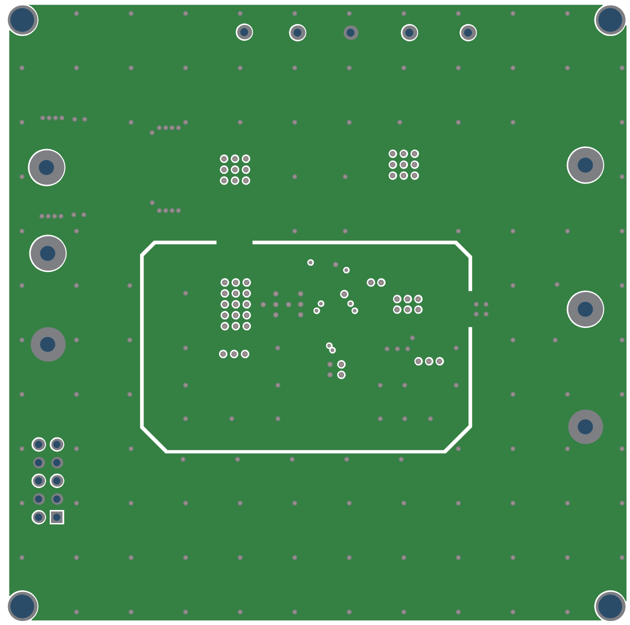


Figure 3: Mid-Layer 1

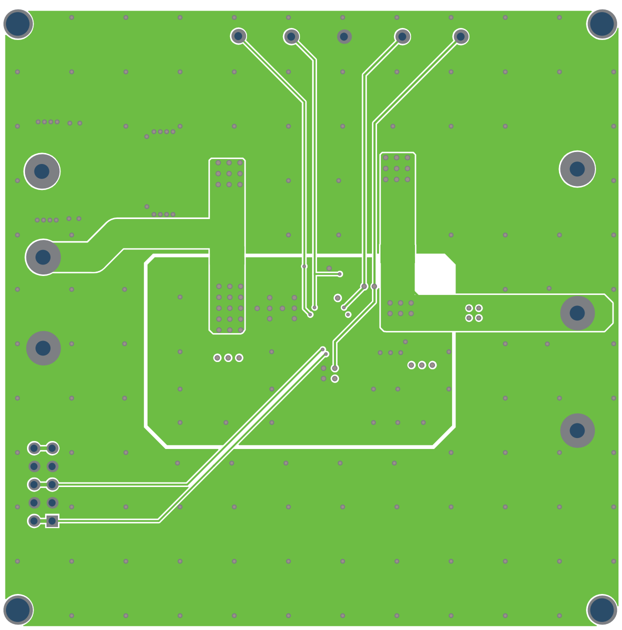


Figure 4: Mid-Layer 2

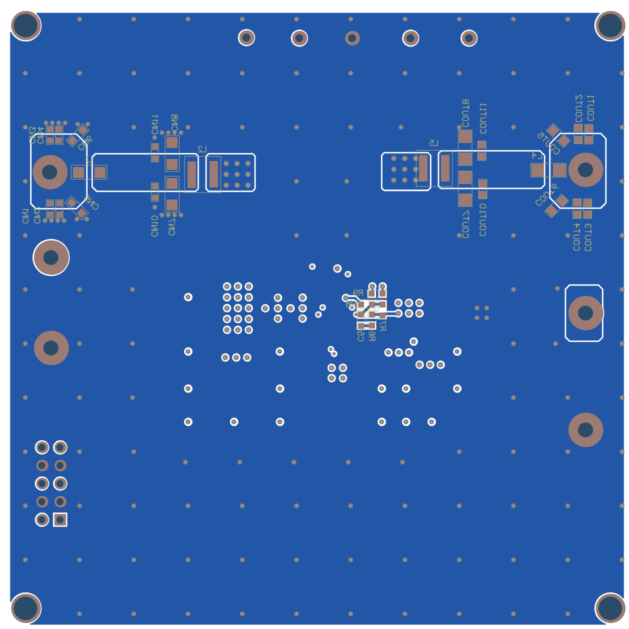


Figure 5: Bottom Layer and Bottom Silk

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	4/9/2021	Initial Release	-