EVQ4573-QB-00A

60V, 2.5A, High-Efficiency, Synchronous Buck Converter Evaluation Board, AEC-Q100

DESCRIPTION

The EVQ4573-QB-00A is an evaluation board designed to demonstrate the capabilities of the MPQ4573-AEC1, a fully integrated, fixed-frequency, synchronous step-down converter. It can achieve up to 2.5A of continuous output current (I_{OUT}) with peak current control for excellent transient response.

Advanced asynchronous modulation (AAM) mode achieves high efficiency under light-load conditions by scaling down the frequency to reduce switching and gate driver losses.

The EVQ4573-QB-00A is a fully assembled and tested evaluation board that generates up to 5V of output voltage (V_{OUT}) and up to 2.5A of load current across a wide 5V to 60V input voltage range.

The MPQ4573-AEC1 is available in a QFN-12 (2.5mmx3mm) package.

ELECTRICAL SPECIFICATIONS

Parameter	Symbol	Value	Units
Input voltage	V_{EMI}	5 to 60	V
Output voltage	V_{OUT}	5	V
Output current	I_{OUT}	2.5	A

FEATURES

- Wide 5V to 60V Operating Input Range
  2.5A Continuous Output Current (I_{OUT})
- High-Efficiency, Synchronous Mode Control
- 250mΩ/45mΩ Internal Power MOSFETs
- Up to 2.2MHz Configurable Switching Frequency (f_{SW})
- 180° Out-of-Phase SYNCO Clock
- 40μA Quiescent Current (I_Q)
- Low 2μA Shutdown Current
- Selectable Advanced Asynchronous Modulation (AAM) Mode or Forced Continuous Conduction Mode (FCCM) during Light-Load Operation
- 0.45ms Internal Soft Start (SS)
- Remote Enable (EN) Control
- Power Good (PG) Indicator
- Low-Dropout (LDO) Mode
- Over-Current Protection (OCP)
- Thermal Shutdown
- Available in a QFN-12 (2.5mmx3mm) Package
- Available in AEC-Q100 Grade 1

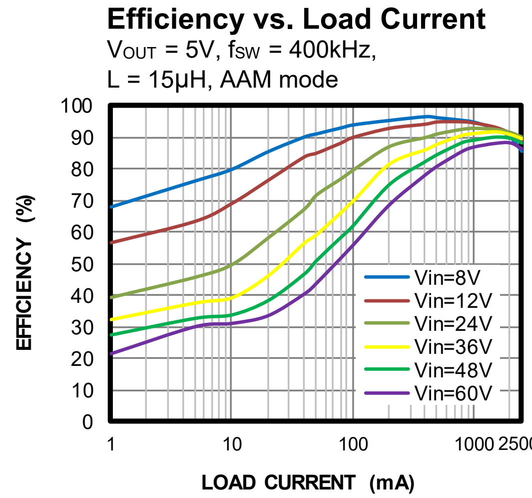
APPLICATIONS

- Automotive Systems
- Industrial Power Systems

EVQ4573-QB-00A EVALUATION BOARD

LxWxH (8.9cmx8.9cmx1.3cm)

Board Number	MPS IC Number
EVQ4573-QB-00A	MPQ4573GQBE-AEC1



QUICK START GUIDE

1. Preset the power supply between 5V and 60V. Be aware that electronic loads represent a negative impedance to the converter, which can trigger hiccup mode if the current exceeds 3.9A.
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 (+): VEMI
    b. Negative (-): GND
4. Connect the load terminals to:
    a. Positive (+): VOUT
    b. Negative (-): GND
5. After making the connections, turn on the power supply. The board should start up automatically.
6. To use the enable (EN) function, apply a digital input to the EN pin. Drive EN above 1.45V to turn the converter on; drive EN below 1.12V to turn it off.
7. An external frequency resistor (R_{FREQ}) sets the switching frequency (f_{SW}). R_{FREQ} can be estimated with Equation (1):

$$R_{FREQ}(M\Omega) = \frac{30}{f_{sw}(kHz)} \tag{1}$$

A bench test may be required to fine-tune the calculated resistance.

8. An external feedback resistor divider (R6 + R4) sets the output voltage (V_{OUT}). R6 + R4 also sets the loop bandwidth via an internal compensation capacitor. Choose R4 to be about 40kΩ. Then R5 can be calculated with Equation (2):

$$R5 = \frac{R4}{\frac{V_{OUT}}{0.8} - 1} \tag{2}$$

Figure 1 shows the feedback resistor network.

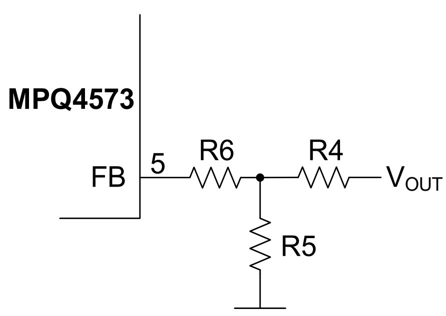


Figure 1: Feedback Resistor Network

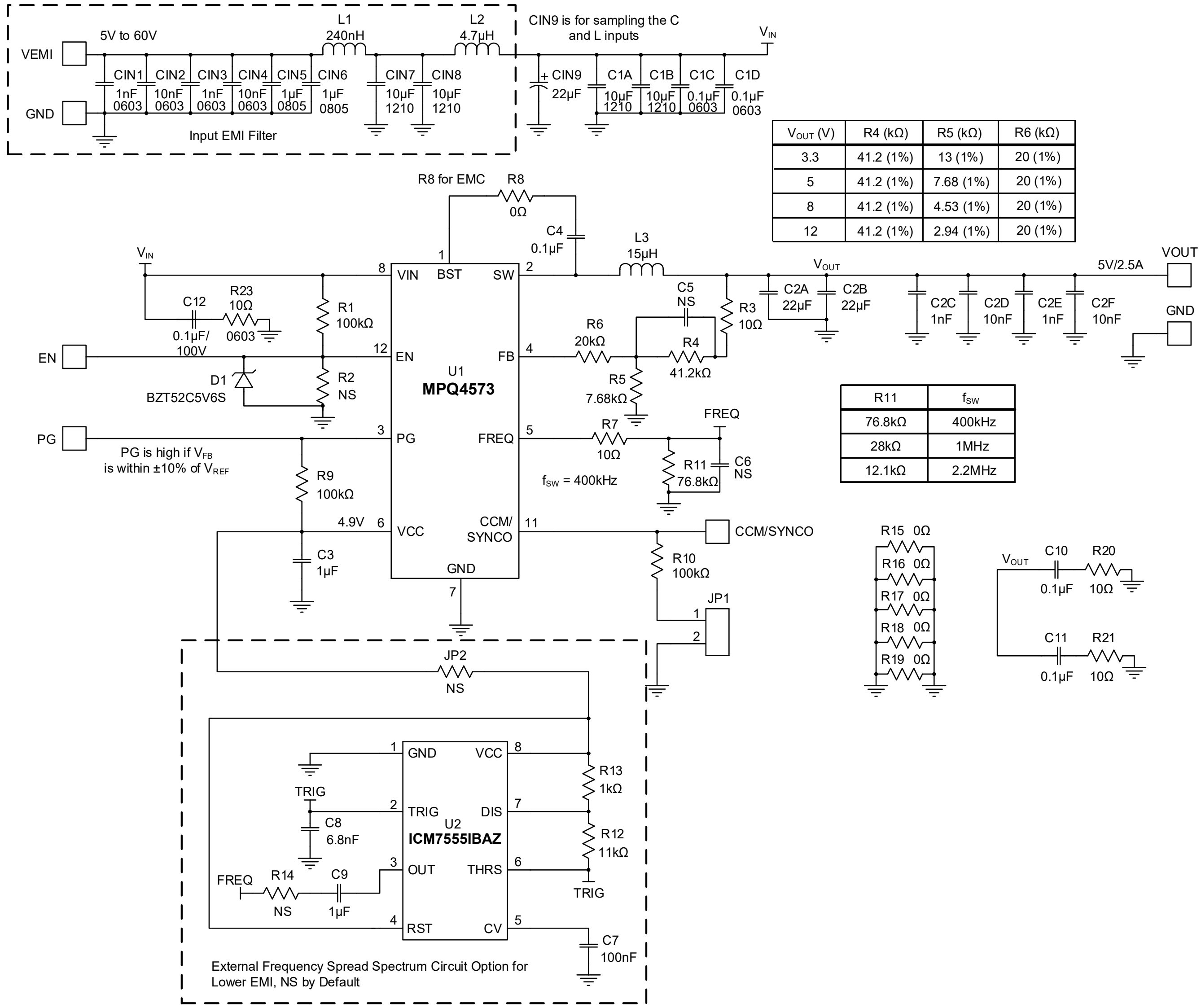
Table 1 lists the recommended feedback resistor values for common output voltages.

Table 1: Recommended Resistor Values

V_{OUT} (V)	R4 (kΩ)	R5 (kΩ)	R6 (kΩ)
3.3	41.2 (1%)	13 (1%)	20 (1%)
8	41.2 (1%)	4.53 (1%)	20 (1%)
5	41.2 (1%)	7.68 (1%)	20 (1%)
12	41.2 (1%)	2.94 (1%)	20 (1%)

9. Jumper points JP3 and JP4 can added for external shielding above the inductor and IC. JP3 and JP4 are not stuffed by default.

EVALUATION BOARD SCHEMATIC



V_{OUT} (V)	R4 (kΩ)	R5 (kΩ)	R6 (kΩ)
3.3	41.2 (1%)	13 (1%)	20 (1%)
5	41.2 (1%)	7.68 (1%)	20 (1%)
8	41.2 (1%)	4.53 (1%)	20 (1%)
12	41.2 (1%)	2.94 (1%)	20 (1%)

R11	f_{SW}
76.8kΩ	400kHz
28kΩ	1MHz
12.1kΩ	2.2MHz

Figure 2: Evaluation Board Schematic

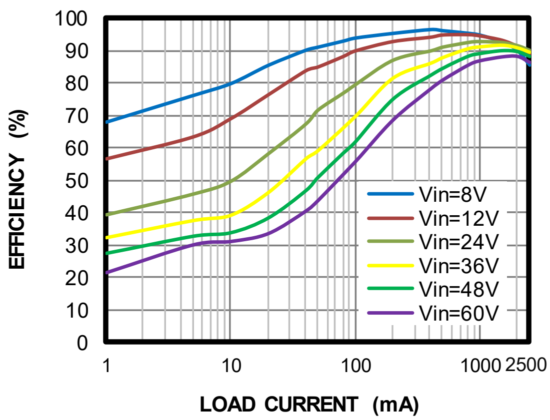
EVQ4573-QB-00A BILL OF MATERIALS

Qty	Designator	Value	Description	Package	Manufacturer	Manufacturer PN
4	CIN1, C1N3, C2C, C2E	1nF	Ceramic capacitor, 100V, X7R	0603	Murata	GRM188R72A102KA01D
4	CIN2, CIN4, C2D, C2F	10nF	Ceramic capacitor, 100V, X7R	0603	Murata	GRM188R72A103KA01D
2	CIN5, CIN6	1µF	Ceramic capacitor, 100V, X7S	0805	Murata	GRM21BC72A105KE01L
4	CIN7, CIN8, C1A, C1B	10µF	Ceramic capacitor, 100V, X7S	1210	Murata	GRM32EC72A106KE05L
1	CIN9	22µF	Electrical capacitor, 80V, SMD	SMD	Panasonic	EEHZC1K220P
3	C1C, C1D, C12	0.1µF	Ceramic capacitor, 100V, X7R	0603	Murata	GRM188R72A104KA35D
2	C2A, C2B	22µF	Ceramic capacitor, 25V, X7R	1210	Murata	GRM32ER71E226KE15L
2	C3, C9	1µF	Ceramic capacitor, 25V, X7R	0603	Murata	GRM188R71E105KA12D
2	C4, C7	0.1µF	Ceramic capacitor, 16V, X7R	0603	Murata	GRM188R71C104KA01D
1	C8	6.8nF	Ceramic capacitor, 50V, X7R	0603	TDK	C1608X7R1H682K
2	C10, C11	0.1µF	Ceramic capacitor, 16V, X7R	0402	Murata	GRM155R71C104KA88D
2	C5, C6	NS				
1	L1	240nH	Inductor, 19mΩ, 6.6A	SMD	Toko	DFE201612E-R24M
1	L2	4.7µH	Inductor, 83mΩ, 3.6A	SMD	Toko	FDSD0402-H-4R7M
1	L3	15µH	Inductor, 40mΩ, 5.8A	SMD	Coilcraft	XAL6060-153MEB
3	R1, R9, R10	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
3	R2, JP2, R14	NS				
3	R3, R7, R23	10Ω	Film resistor, 1%	0603	Yageo	RC0603FR-0710RL
1	R4	41.2kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0741K2L
1	R5	7.68kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-077K68L
1	R6	20kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0720KL
1	R8	0Ω	Film resistor, 1%	0603	Yageo	RC0603FR-070RL
1	R11	76.8kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0776K8L
1	R12	11kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0711KL
1	R13	1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-071KL
5	R15, R16, R17, R18, R19	0Ω	Film resistor, 1%	0402	Yageo	RC0402FR-070RL
2	R20, R21	10Ω	Film resistor, 1%	0402	Yageo	RC0402FR-0710RL
1	D1	5.6V	Zener diode	SOD323	Diodes, Inc.	BZT52C5V6WS
1	U2	1MHz	Single timer/oscillator IC	SOIC-8	Intersil (Renesas)	ICM7555IBAZ
1	JP1	2.54mm	Test pin	DIP	Custom	
4	VEMI, GND, GND, VOUT	2mm	2 golden pins	DIP	Custom	
5	CCM/SYNCO, PG, GND, EN, GND	1mm	1 golden pin	DIP	Custom	
2	JP3, JP4	NS				
1	U1	MPQ4573-AEC1	Synchronous, step-down converter, 60V, 2.5A	QFN-12 (2.5mmx 3mm)	MPS	MPQ4573GQBE-AEC1

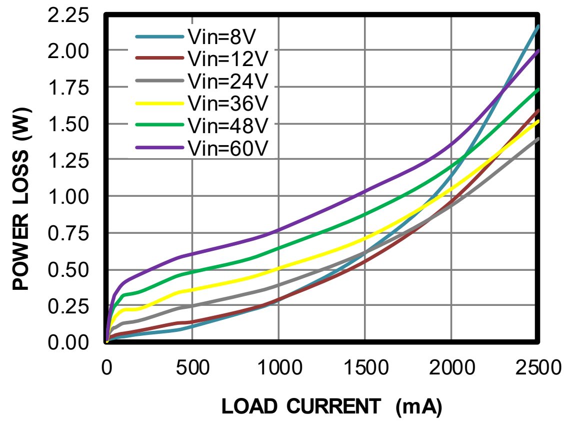
EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, L = 15µH, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

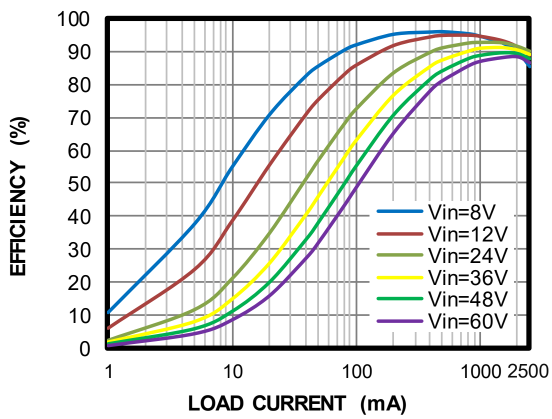
Efficiency vs. Load Current
f_{SW} = 400kHz, L = 15µH (1), AAM mode



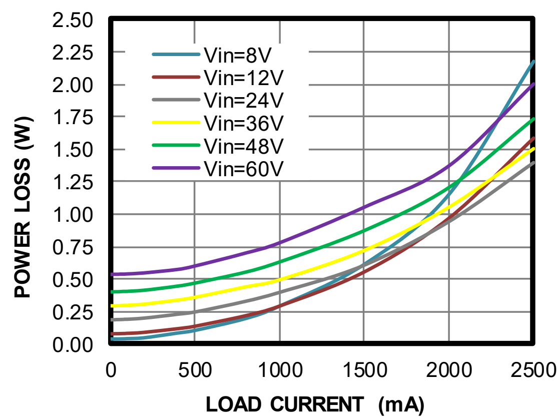
Power Loss vs. Load Current
f_{SW} = 400kHz, L = 15µH (1), AAM mode



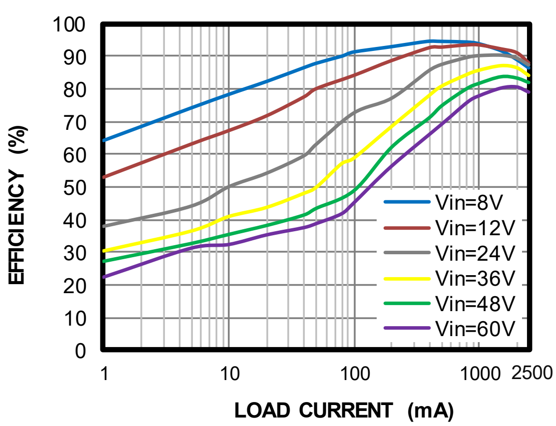
Efficiency vs. Load Current
f_{SW} = 400kHz, L = 15µH (1), FCCM



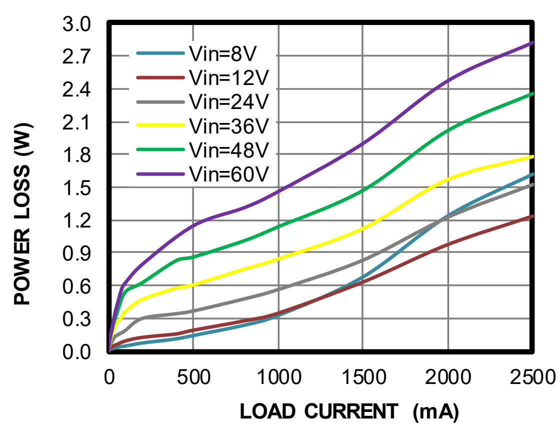
Power Loss vs. Load Current
f_{SW} = 400kHz, L = 15µH (1), FCCM



Efficiency vs. Load Current
f_{SW} = 1MHz, L = 10µH (2), AAM mode



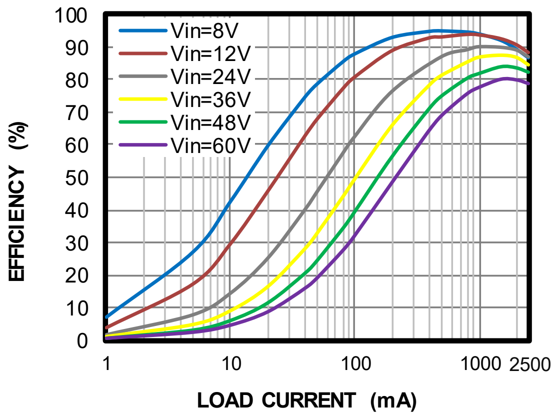
Power Loss vs. Load Current
f_{SW} = 1MHz, L = 10µH (2), AAM mode



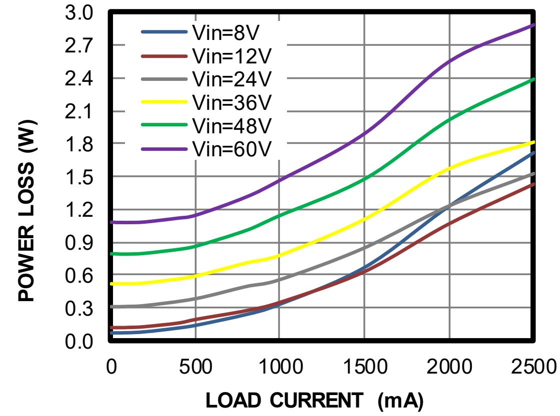
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, L = 15µH, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

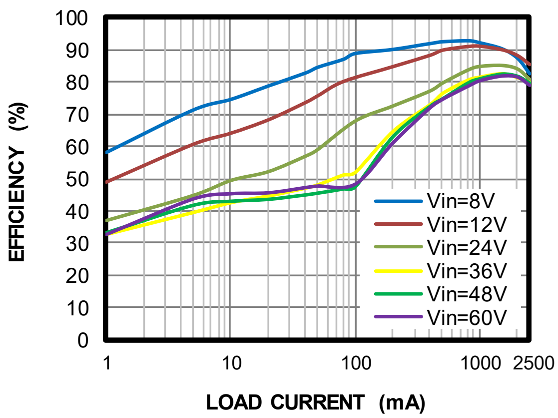
Efficiency vs. Load Current
f_{SW} = 1MHz, L = 10µH (2), FCCM



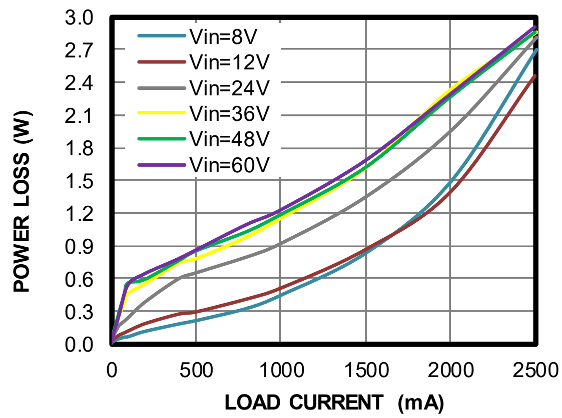
Power Loss vs. Load Current
f_{SW} = 1MHz, L = 10µH (2), FCCM



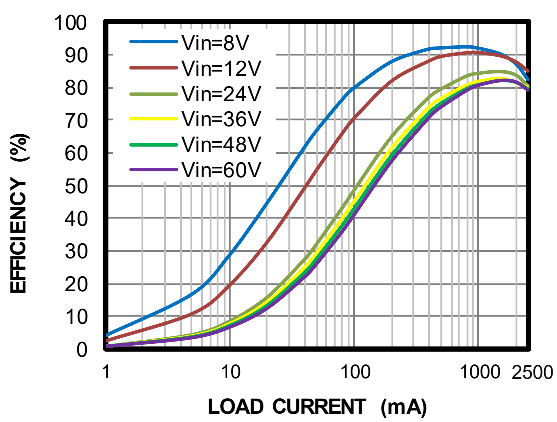
Efficiency vs. Load Current
f_{SW} = 2.2MHz, L = 4.7µH (3), AAM mode



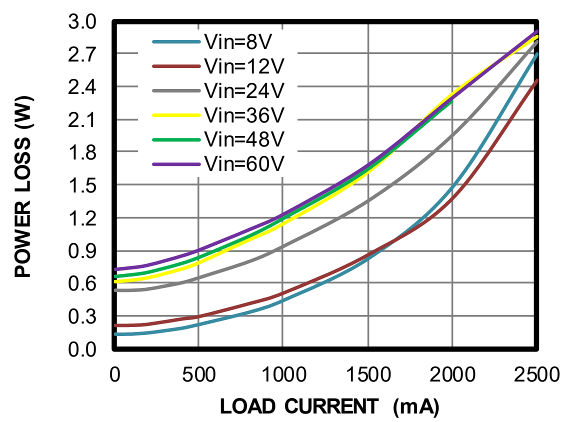
Power Loss vs. Load Current
f_{SW} = 2.2MHz, L = 4.7µH (3), AAM mode



Efficiency vs. Load Current
f_{SW} = 2.2MHz, L = 4.7µH (3), FCCM



Power Loss vs. Load Current
f_{SW} = 2.2MHz, L = 4.7µH (3), FCCM



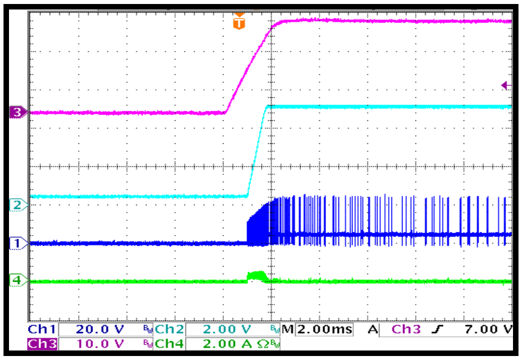
Notes:

1) Inductor part number: XAL6060-153MEB/C; DCR = 43.75mΩ.
2) Inductor part number: XAL6060-103MEB/C; DCR = 29.82mΩ.
3) Inductor part number: XAL5030-472MEB/C; DCR = 36mΩ.

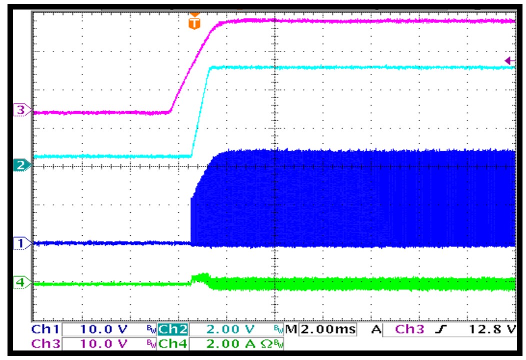
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, L = 15µH, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

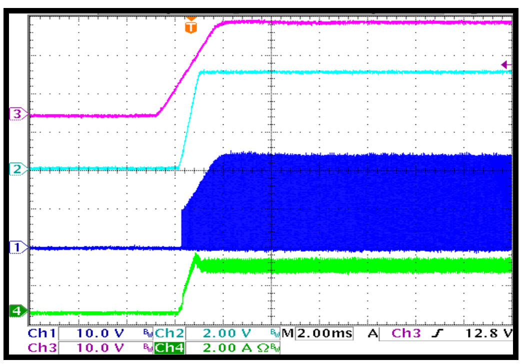
Start-Up through VIN
I_{OUT} = 0A, AAM mode



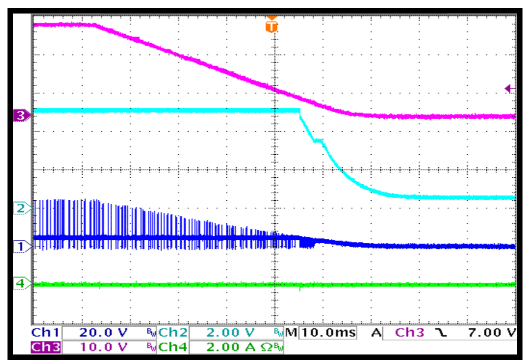
Start-Up through VIN
I_{OUT} = 0A, FCCM



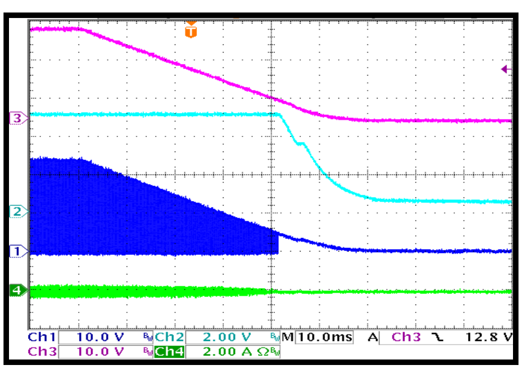
Start-Up through VIN
I_{OUT} = 2.5A



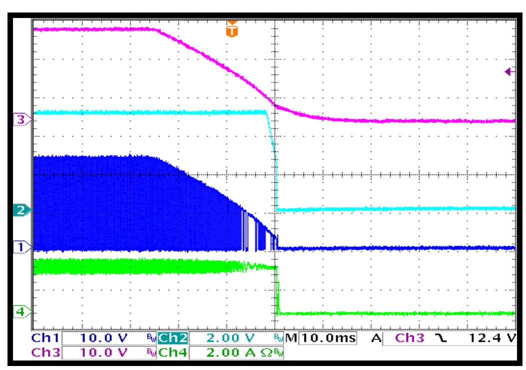
Shutdown through VIN
I_{OUT} = 0A, AAM mode



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



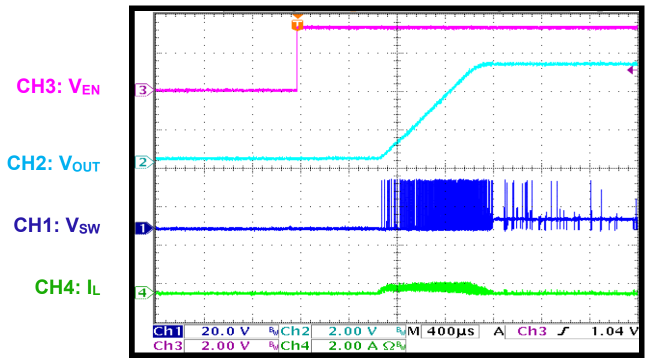
Shutdown through VIN
I_{OUT} = 2.5A



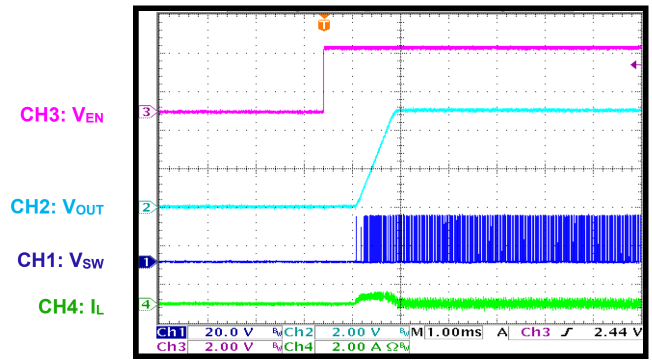
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, L = 15µH, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

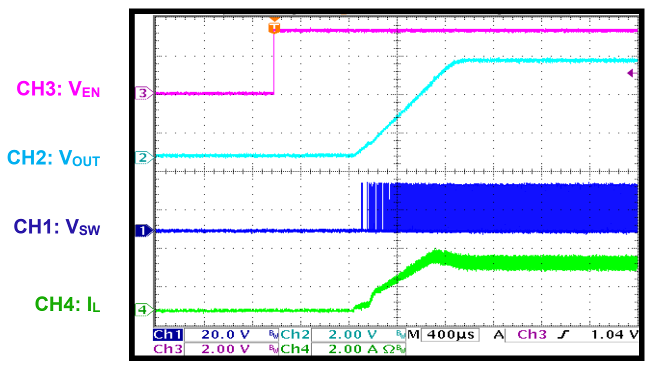
Start-Up through EN
I_{OUT} = 0A, AAM mode



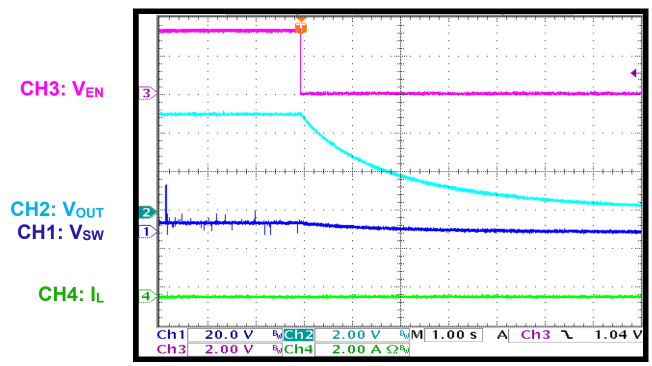
Start-Up through EN
I_{OUT} = 0A, FCCM



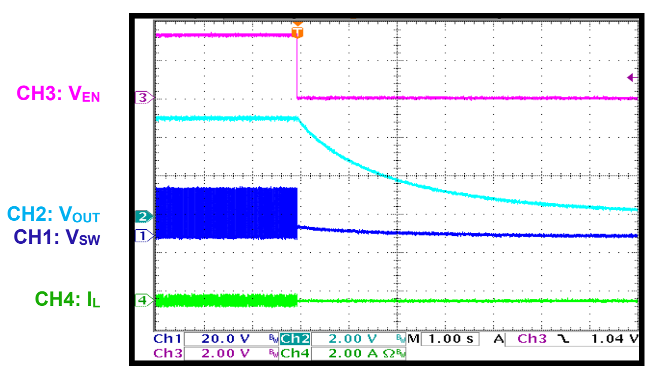
Start-Up through EN
I_{OUT} = 2.5A



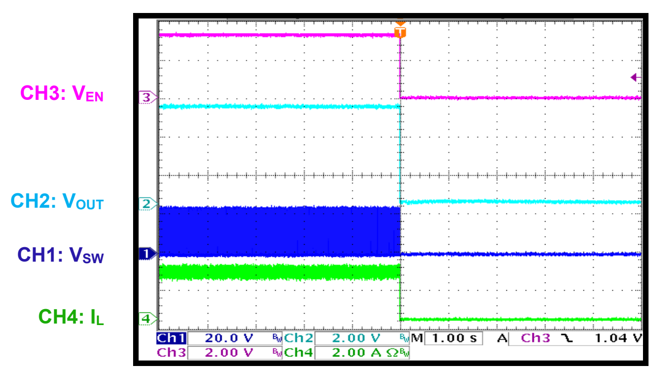
Shutdown through EN
I_{OUT} = 0A, AAM mode



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



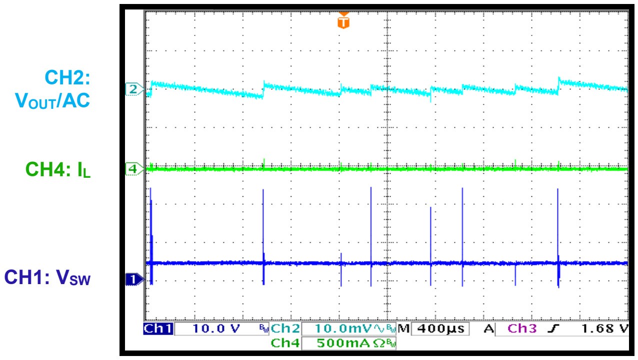
Shutdown through EN
I_{OUT} = 2.5A



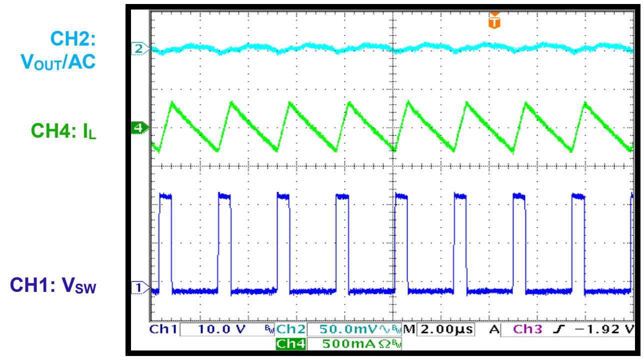
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, L = 15µH, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

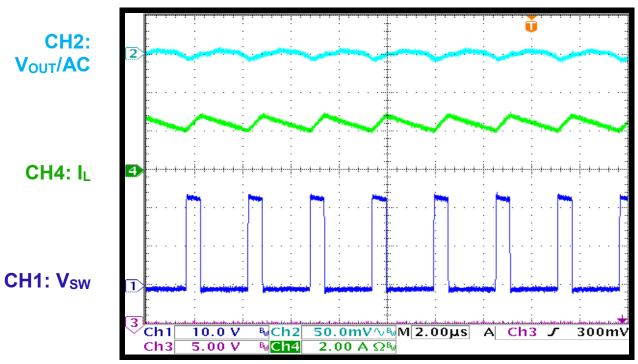
Output Ripple
I_{OUT} = 0A, AAM mode



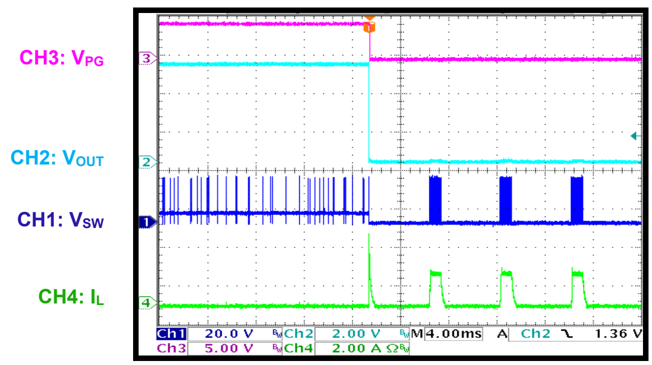
Output Ripple
I_{OUT} = 0A, FCCM



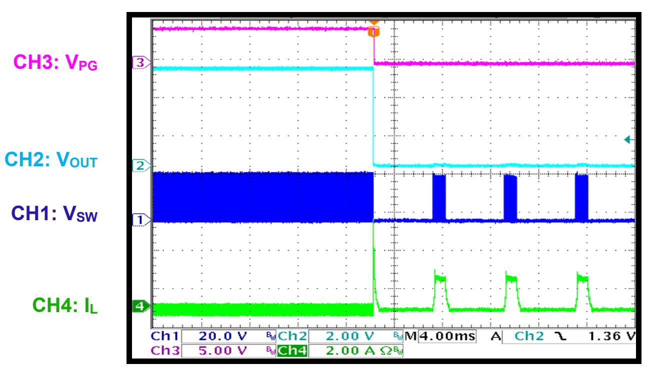
Output Ripple
I_{OUT} = 2.5A



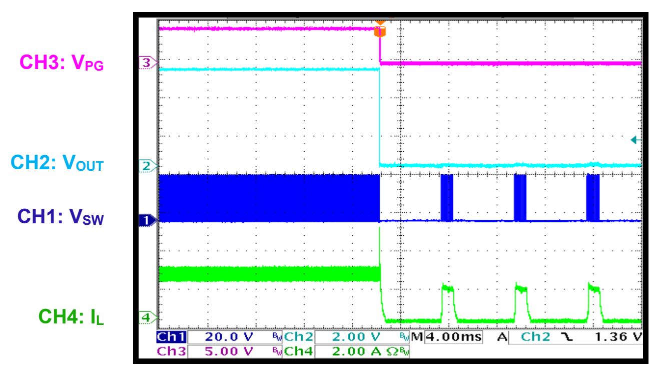
SCP Entry
I_{OUT} = 0A, AAM mode



SCP Entry
I_{OUT} = 0A, FCCM



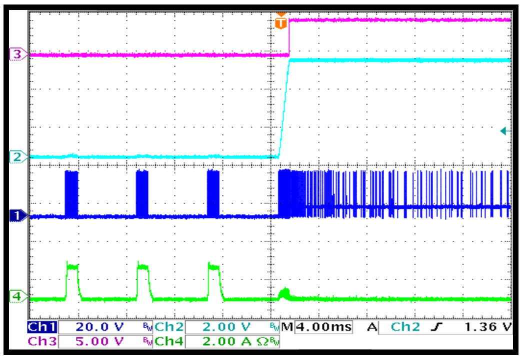
SCP Entry
I_{OUT} = 2.5A



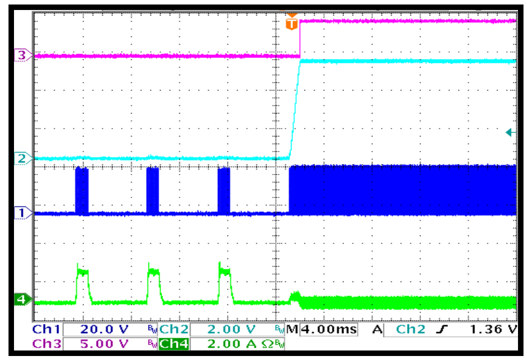
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, L = 15µH, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

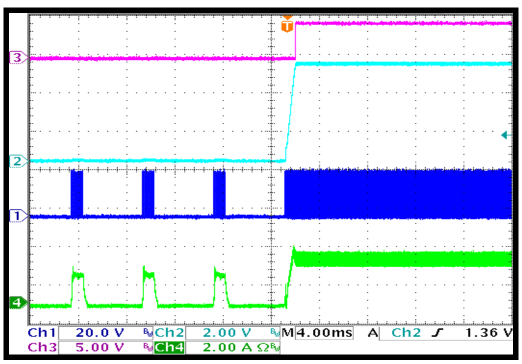
SCP Recovery
I_{OUT} = 0A, AAM mode



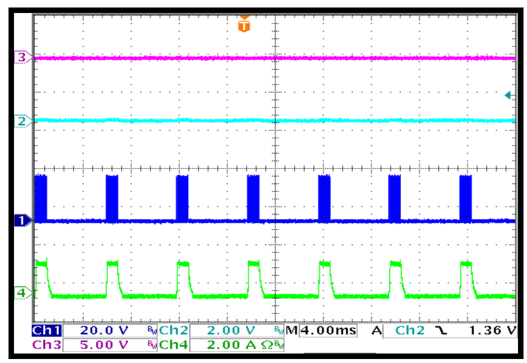
SCP Recovery
I_{OUT} = 0A, FCCM



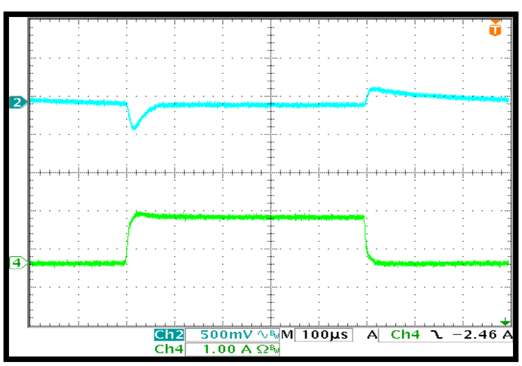
SCP Recovery
I_{OUT} = 2.5A



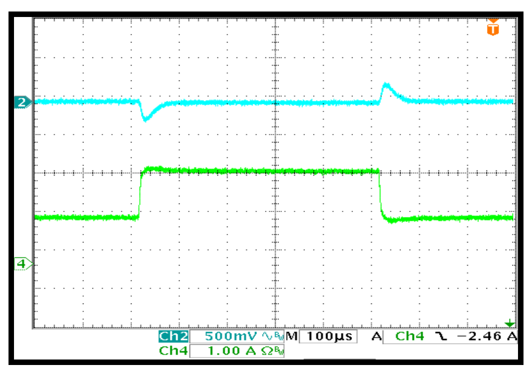
SCP Steady State



Load Transient
I_{OUT} = 0A to 1.5A, AAM mode



Load Transient
I_{OUT} = 1A to 2.5A, AAM mode

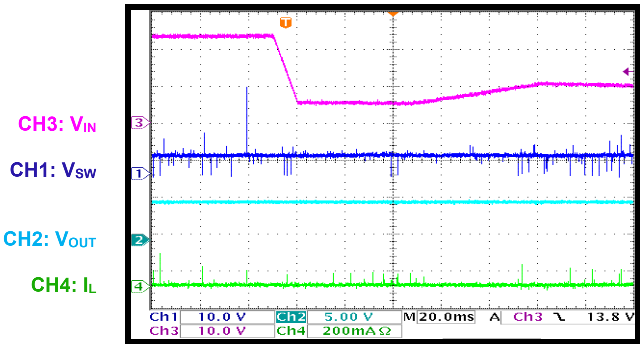


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 24V, V_{OUT} = 5V, L = 15µH, f_{SW} = 400kHz, T_A = 25°C, unless otherwise noted.

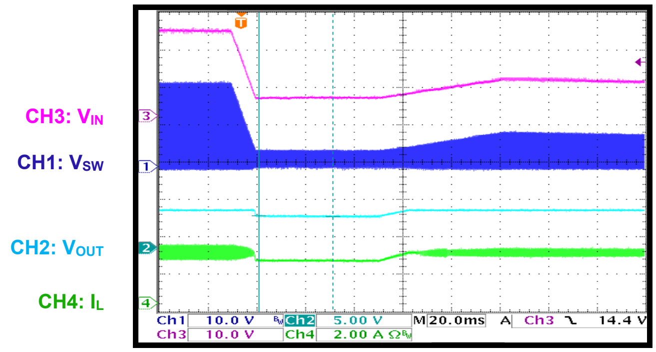
Cold Crank

V_{IN} = 24V to 6V to 10V, I_{OUT} = 0A



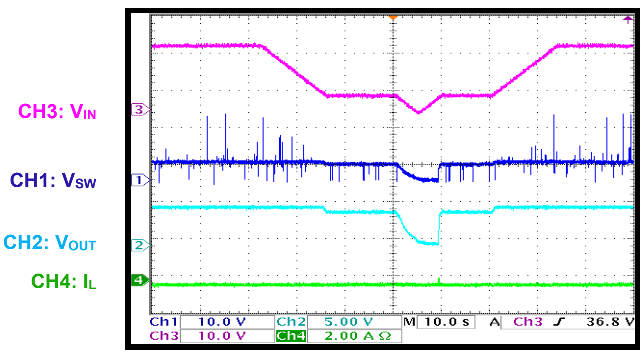
Cold Crank

V_{IN} = 24V to 6V to 10V, I_{OUT} = 2.5A



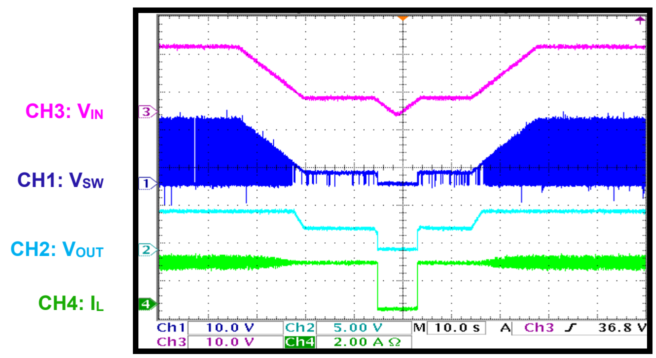
VIN Ramps Down and Up

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



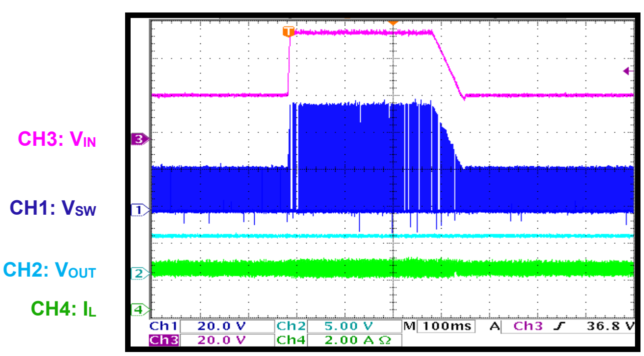
VIN Ramps Down and Up

V_{IN} = 18V to 4.5V to 0V to 4.5V to 18V, I_{OUT} = 2.5A



Load Dump

V_{IN} = 24V to 58V to 24V, I_{OUT} = 2.5A



PCB LAYOUT

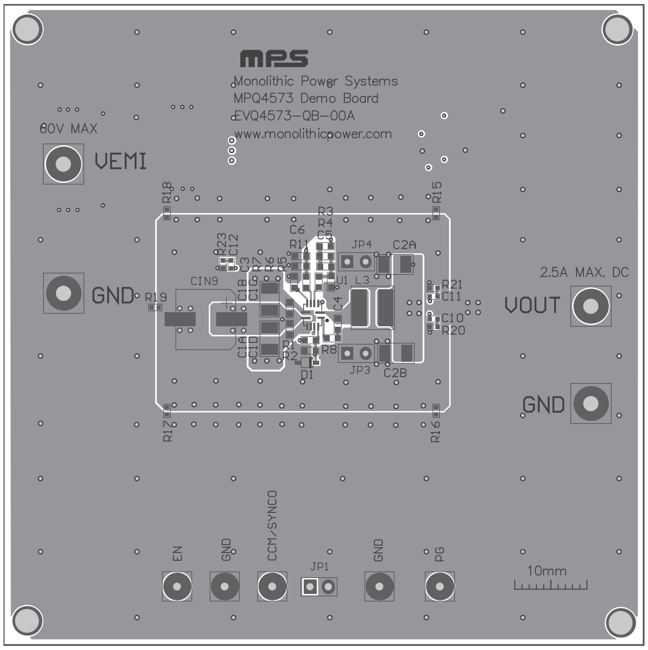


Figure 3: Top Silk and Top Layer

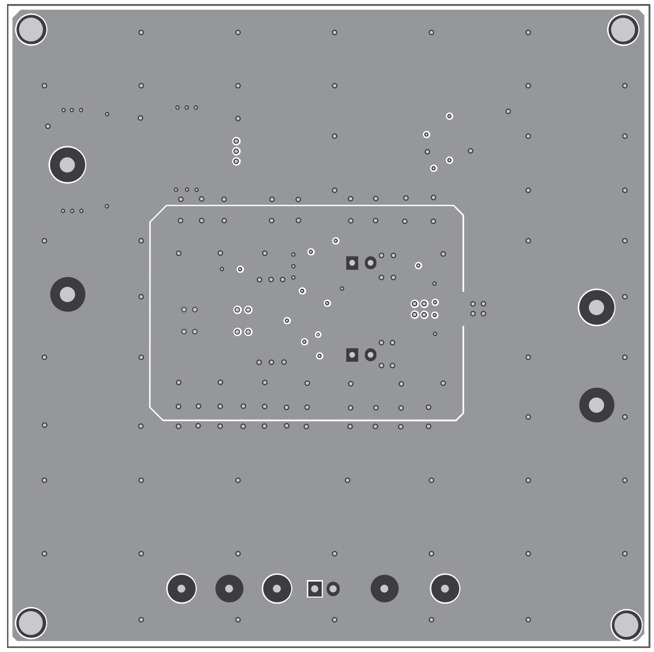


Figure 4: Mid-Layer 1

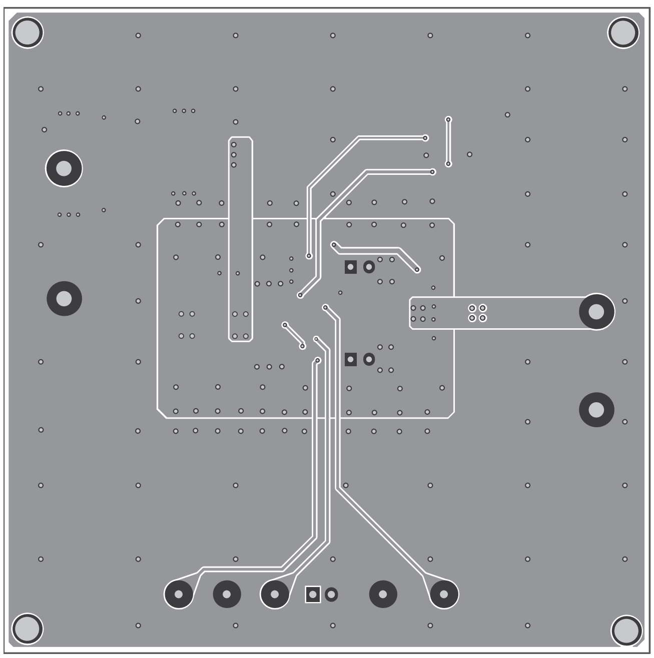


Figure 5: Mid-Layer 2

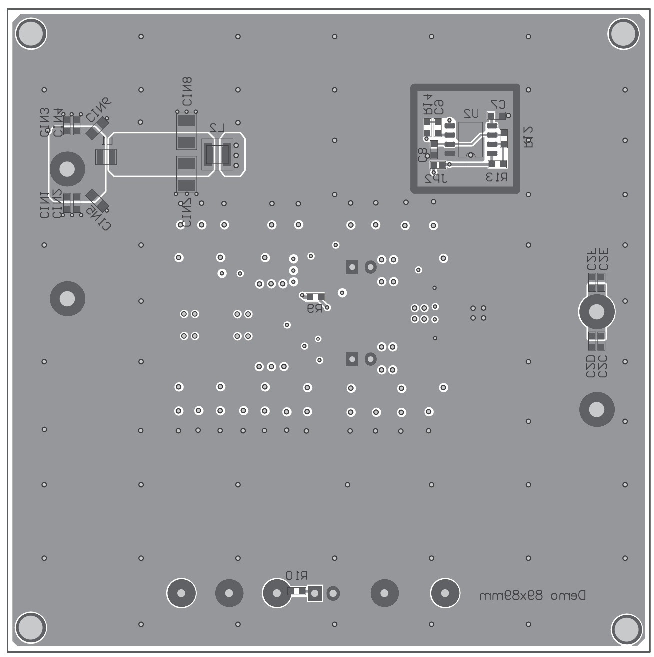


Figure 6: Bottom Layer and Bottom Silk

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	5/25/2021	Initial Release	-