EVQ4214-U-00A

40V, Synchronous Buck-Boost Controller with I²C and Adjustable OCP via IPWM, AEC-Q100 Qualified

DESCRIPTION

The EVQ4214-U-00A Evaluation Board is designed to demonstrate the capabilities of MPS' MPQ4214GU-AEC1.

The MPQ4214GU-AEC1 is a synchronous, four-switch, buck-boost controller capable of regulating different output voltages with a wide input voltage range and high efficiency. The MPQ4214 provides an I²C interface, which supports V_{OUT} voltage programmability, V_{OUT} slew-rate control and constant output current limit programmability, making the MPQ4214 suitable for USB power delivery (PD) design in USB Type-C power supplies.

The MPQ4214 uses valley-current control in buck mode and peak-current control in boost mode, providing fast load transient response and smooth buck-boost mode transient. The MPQ4214 provides forced continuous conduction mode (FCCM) and programmable average current limit, which supports flexible designs for different applications.

The MPQ4214 also features hiccup over-current protection (OCP), auto retry over-voltage protection (OVP), programmable soft start, and programmable under-voltage lockout (UVLO).

The MPQ4214 is available in a QFN-27 (5mmx5mm) package, and it is available in AEC-Q100 Grade 1.

ELECTRICAL SPECIFICATION

Parameter	Symbol	Value	Units
Input Voltage (1)	VIN	6 – 40	V
Output Voltage (2)	VOUT	Default: 5	V
Output Current	IOUT	0 – 5	A

FEATURES

- 6V to 40V Startup Input Voltage Range
- 5V to 40V Operation Input Voltage Range
- Flexible Reference Voltage Selection:
  - MPQ4214GU: Programmable V_{REF} Voltage
- MPQ4214 Flexible I²C Interface Control for:
  - 0.5V to 36V Output Voltage Range
  - 0.3V to 2.047V Reference Voltage Range with 1mV Steps
  - Selectable V_{OUT} Slew Rate
  - 0.6A Steps Programmable Output Constant Current Limit
- <50mA Steps Output Current Limit Adjusting through IPWM Pin
- Frequency Dithering Function for EMI Optimization
- Integrated V_{OUT} Discharge Function
- Selectable 200kHz, 300kHz, 400kHz, and 600kHz Switching Frequency
- OCP, SCP, and OVP
- Output Enters High Impedance State during EN Shutdown
- Interrupt Indicator for CC, OCP, OVP and OTP
- Available in a QFN-27(5mmx5mm) Package
- Available in AEC-Q100 Grade 1

APPLICATIONS

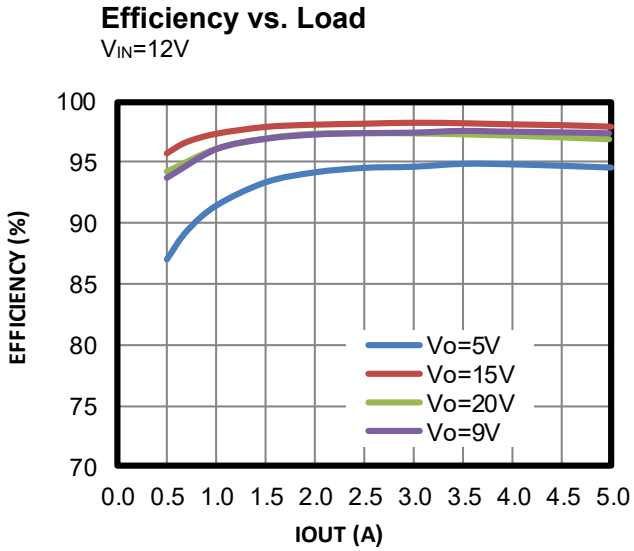
- USB Power Delivery
- Industrial PC Power Supplies
- Wireless Charging
- High Power LED Driver

Notes:
(1) VIN must be 6V or higher to enable this board. After startup, it can work with 5V input voltage.
(2) Using I²C interface can get other output voltage.

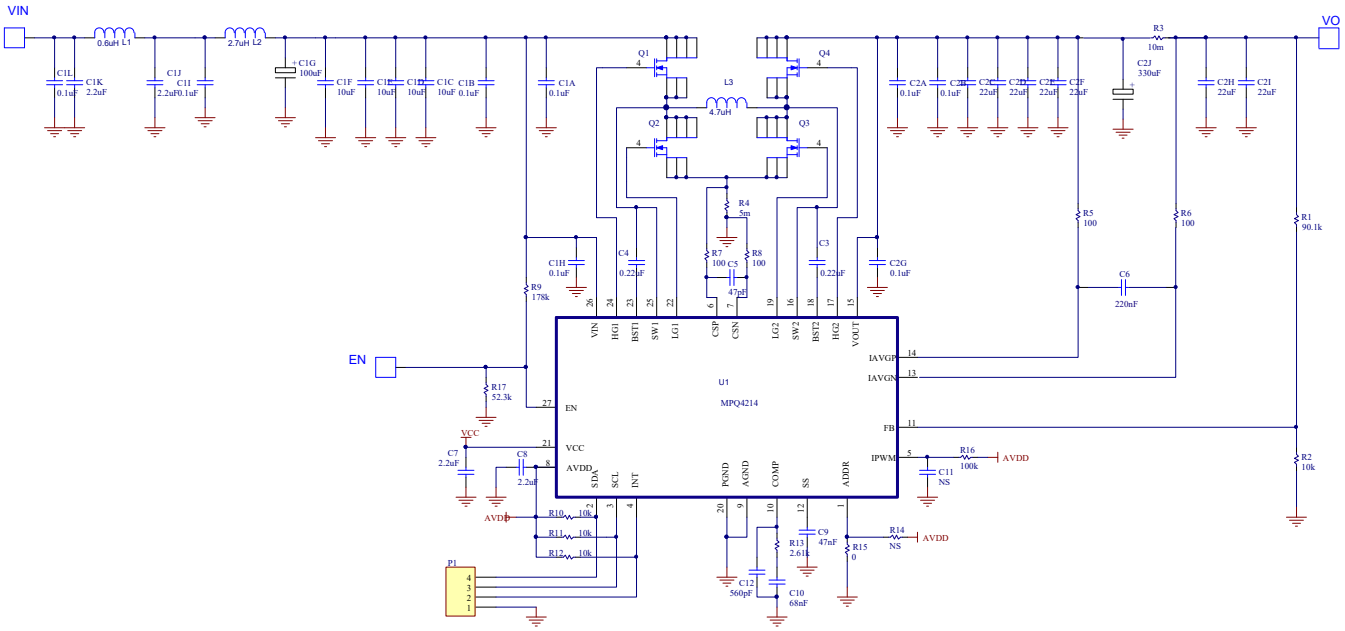
EVQ4214-U-00A EVALUATION BOARD

(L × W) 9.14cm x 6.6cm

Board Number	MPS IC Number
EVQ4214-U-00A	MPQ4214GU-AEC1



EVALUATION BOARD SCHEMATIC



EVQ4214-U-00A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Part Number
8	C1A, C1B, C1H, C1I, C1L, C2A, C2B, C2G	100nF	Ceramic Cap.,50V,X7R	0603	Murata	GRM188R71H104KA93D
4	C1C, C1D, C1E, C1F	10µF	Ceramic Cap.,50V,X7R	1210	Murata	GRM32ER71H106KA12L
1	C1G	100µF	Alum-electrolytic Cap. 50V,460mOhm, 0.35A	SMD	Wurth	865080653016
2	C1J, C1K	2.2µF	Ceramic Cap.,50V,X7R	1210	Murata	GRM32ER71H225KL
6	C2C, C2D, C2E, C2F, C2H, C2I	22µF	Ceramic Cap.,25V,X5R	1210	Murata	GRM32ER61E226KE15L
1	C2J	330µF	330UF/25V,20mOhm	SMD	NIPPON CHEMI-CON	HHXC250A331MJA0G
2	C3, C4	220nF	Ceramic Cap.,16V,X7R	0603	Murata	GRM188R71C224KA01D
1	C5	47pF	Ceramic Cap.,50V,C0G	0603	Murata	GRM1885C1H470JA01D
1	C6	1nF	Ceramic Cap.,16V,X7R	0603	Murata	GRM188R71C102KA01D
1	C7	2.2µF	Ceramic Cap.,16V,X7R	0805	Murata	GRM21BR71C225KA12L
1	C8	2.2µF	Ceramic Cap.,10V,X7R	0603	Murata	GRM188R71A225KE15D
1	C9	47nF	Ceramic Cap.,16V,X7R	0603	Murata	GRM188R71C473KA01D
1	C10	68nF	Ceramic Cap.,50V,X7R	0603	TDK	C1608X7R1H683KT000N
0	C11	NS				
1	C12	560pF	Ceramic Cap.,50V,X7R	0603	Murata	GRM18851C1E561JA01D
1	L3	4.7µH	Ceramic Cap.,25V,C0G		Coilcraft	XAL1010-472MED
1	L1	0.6µH	Inductor, DCR=4.11mΩ,Isat=19.8A	SMD	Coilcraft	XAL5030-601MEC
1	L2	2.7µH	2.7µH inductor	SMD	Coilcraft	XEL6060-272MEC
1	P1	4PINS	4Pins,1 row,straight	DIP	WE	61300411121
4	Q1, Q2, Q3, Q4	28A	60V, 9.5mΩ, N-channel MOSFET	DFN EP (3.3mmx 3.3mm)	AOS	AON7264E
1	R1	90K9	Film Res,1%	0603	YAGEO	RC0603FR-0790K9L
4	R2, R10, R11, R12	10K	Film Res,1%	0603	YAGEO	RC0603FR-0710KL

EVQ4214-U-00A BILL OF MATERIALS *(continued)*

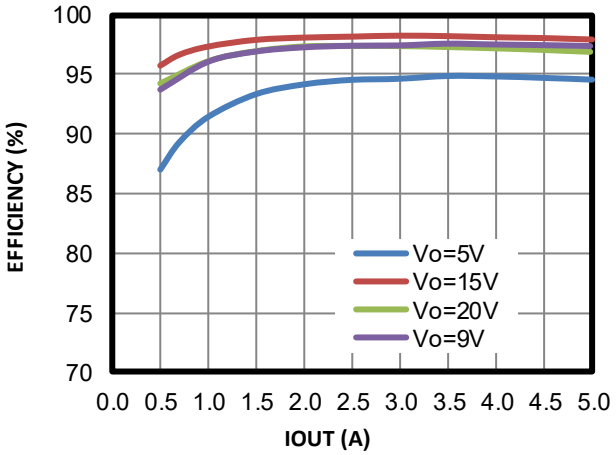
Qty	Ref	Value	Description	Package	Manufacturer	Part Number
1	R3	10m	1%, long side, 1W, current sensing resistor	L1508	Film Tech	RL3720WT-R010-F
1	R4	5m	1%, long side, 1W, current sensing resistor	L1508	Film Tech	RL3720WT-R005-F
4	R5, R6, R7, R8	100R	Film Res,1%	0603	YAGEO	RC0603FR-07100RL
1	R9	178K	Film Res,1%	0603	YAGEO	RC0603FR-07178KL
1	R13	2K61	Film Res,1%	0603	YAGEO	RC0603FR-072K61L
1	R15	0	Film Res,1%	0603	YAGEO	RC0603FR-070L
1	R16	100K	Film Res,1%	0603	YAGEO	RC0603FR-07100kL
1	R17	52.3K	Film Res,1%	0603	YAGEO	RC0603FR-0752K3L
1	U1	MPQ4214	40V Synchronous Buck-Boost Controller with I2C	QFN-27(5x5)	MPS	MPQ4214GU-AEC1

EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board.
V_{IN} = 12V, V_{OUT} = 5V, L = 4.7µH, T_A = +25°C, unless otherwise noted.

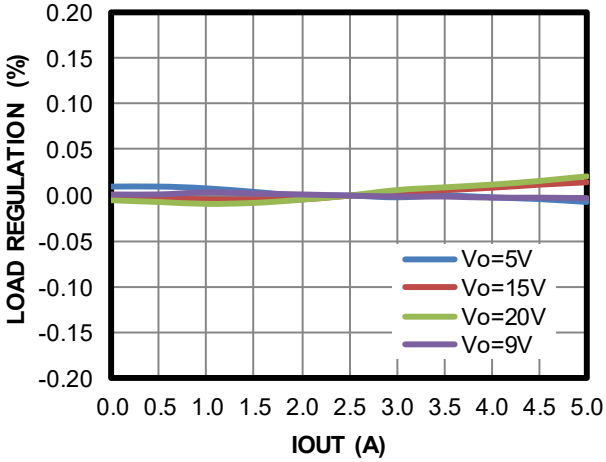
Efficiency vs. Load

V_{IN}=12V



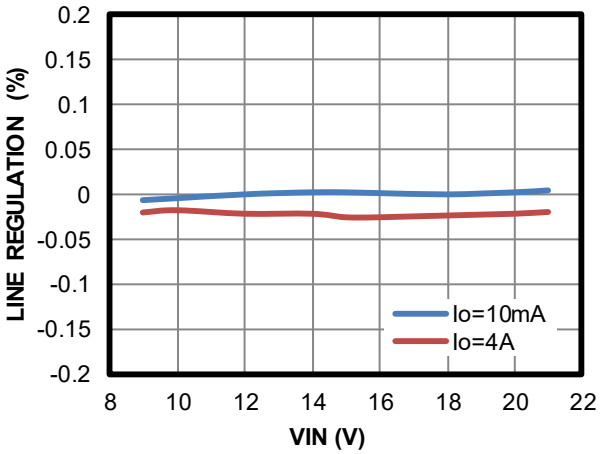
Load Regulation

V_{IN}=12V



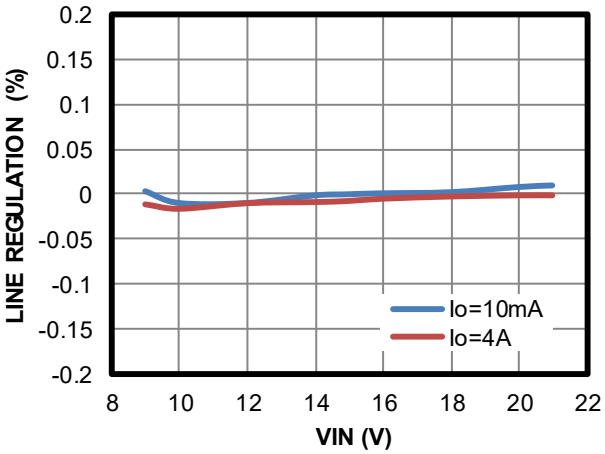
Line Regulation

V_{OUT}=5V



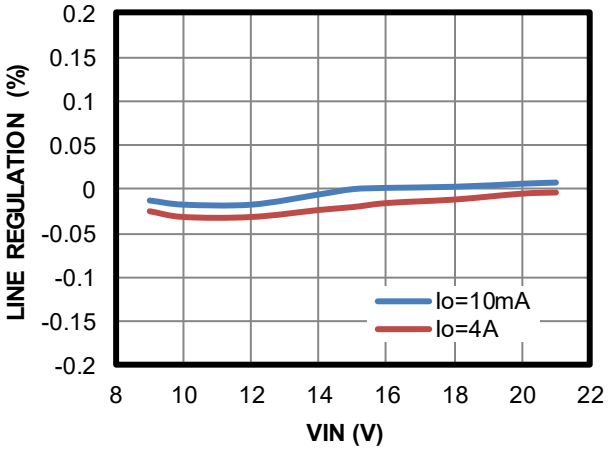
Line Regulation

V_{OUT}=9V



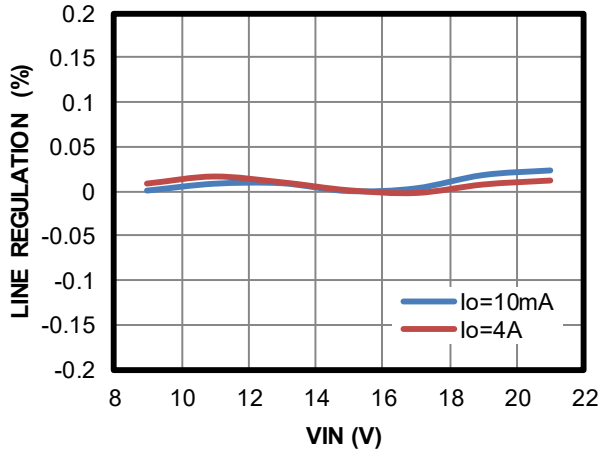
Line Regulation

V_{OUT}=15V



Line Regulation

V_{OUT}=20V

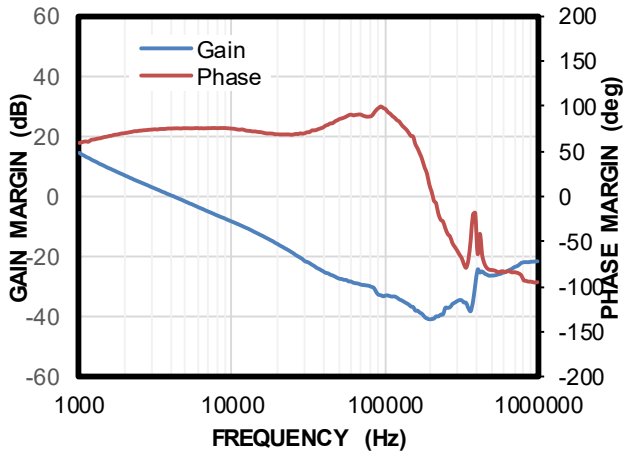


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board.
V_{IN} = 12V, V_{OUT} = 5V, L = 4.7µH, T_A = +25°C, unless otherwise noted.

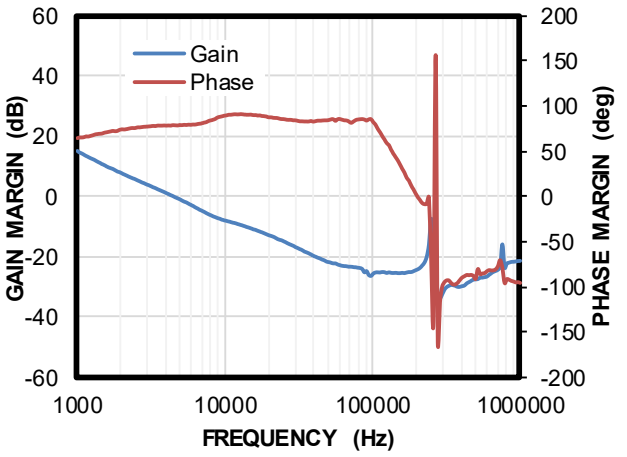
Bode Plot

V_{IN}=12V , V_{OUT}=5V , Io=5A



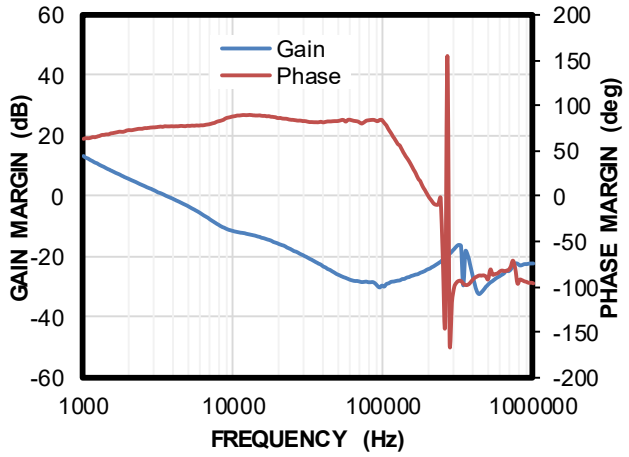
Bode Plot

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



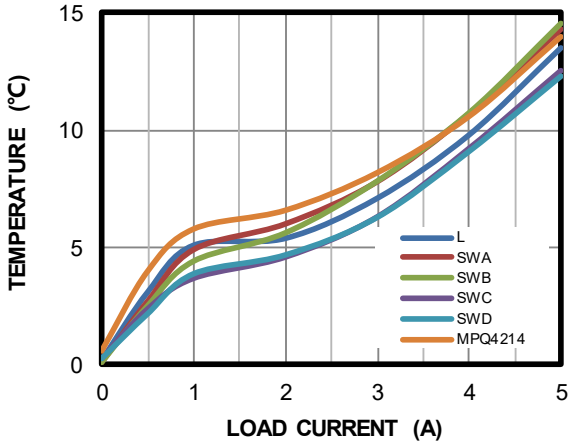
Bode Plot

V_{IN}=12V , V_{OUT}=20V , I_{OUT}=5A



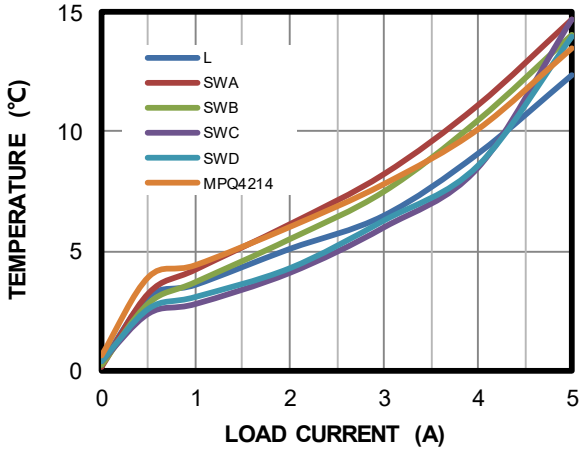
Case Temperature Rise

V_{IN} = 12V, V_{OUT} = 5V, f_{SW} = 400kHz,
based on EVQ4214-U-00A



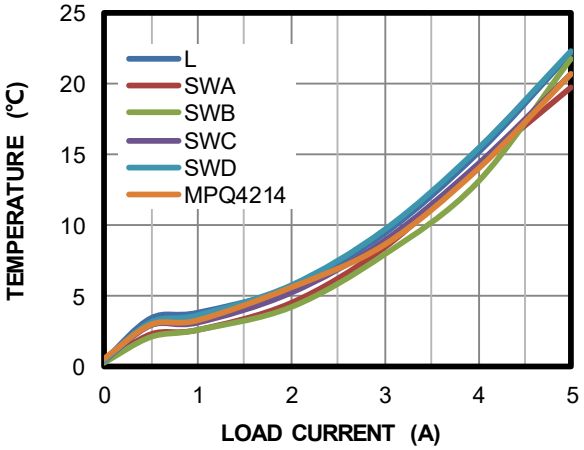
Case Temperature Rise

V_{IN} = 12V, V_{OUT} = 9V, f_{SW} = 400kHz,
based on EVQ4214-U-00A



Case Temperature Rise

V_{IN} = 12V, V_{OUT} = 15V, f_{SW} = 400kHz,
based on EVQ4214-U-00A

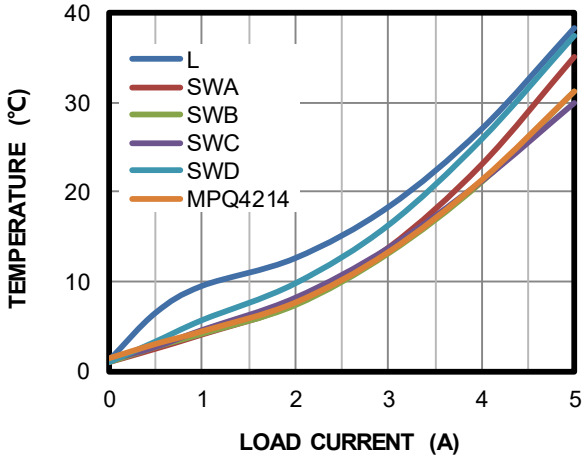


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board.
V_{IN} = 12V, V_{OUT} = 5V, L = 4.7µH, T_A = +25°C, unless otherwise noted.

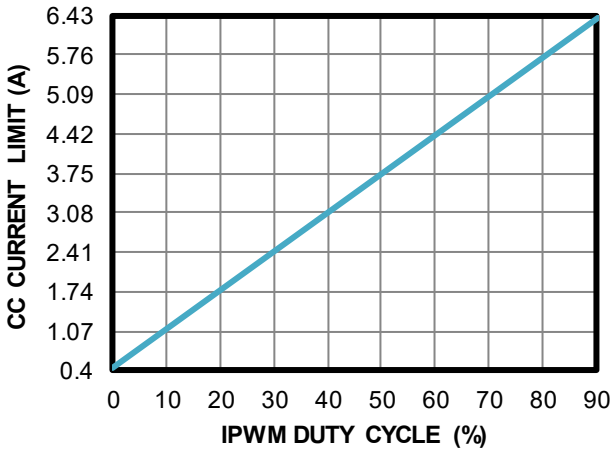
Case Temperature Rise

V_{IN} = 12V, V_{OUT} = 20V, f_{SW} = 400kHz, based on EVQ4214-U-00A



CC Current limit vs. IPWM Duty Cycle

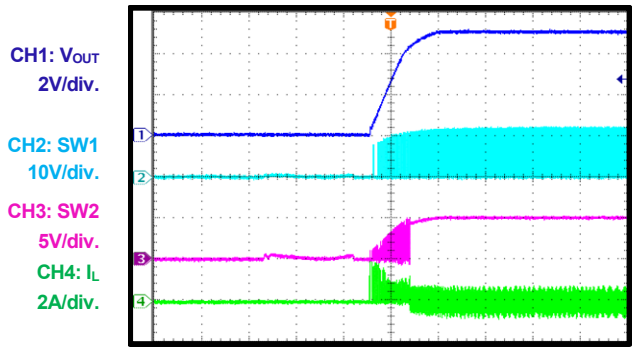
ILIM=111, Rsense=10mΩ



EVB TEST RESULTS *(continued)*

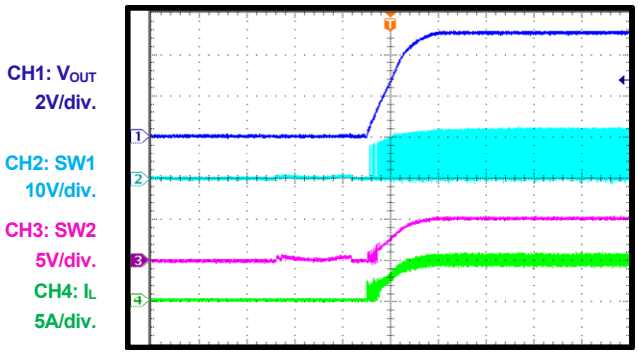
Performance curves and waveforms are tested on the evaluation board.
V_{IN} = 12V, V_{OUT} = 5V, L = 4.7µH, T_A = +25°C, unless otherwise noted.

V_{IN} Start-Up
Load=0A



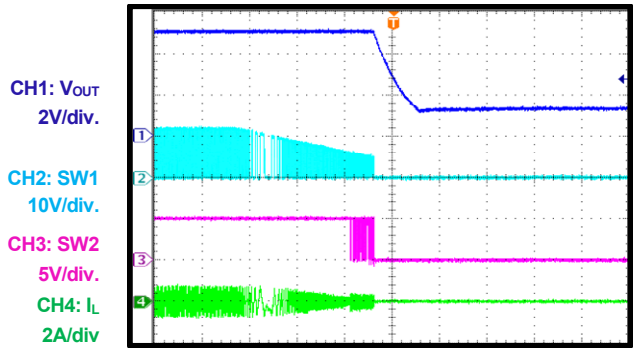
4ms/div.

V_{IN} Startup
Load=5A



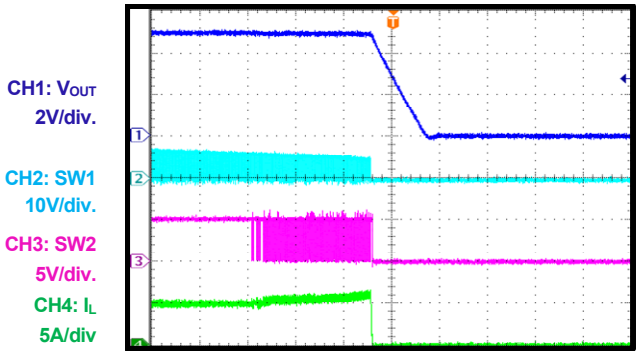
4ms/div.

V_{IN} shutdown
Load=0A



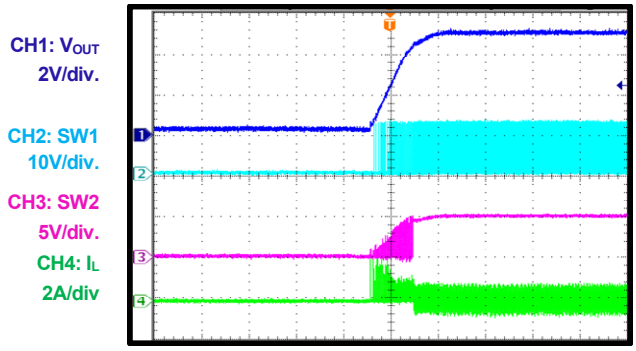
20ms/div.

V_{IN} Shutdown
Load=5A



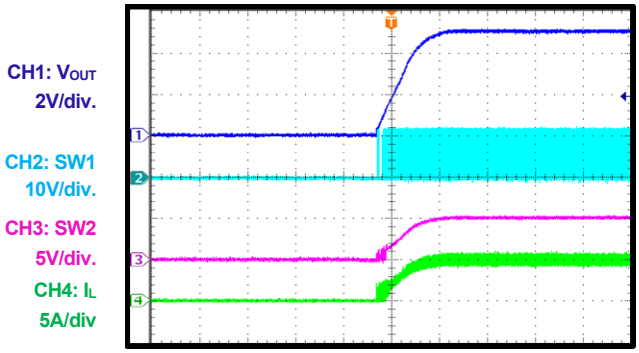
200µs/div.

ENPWR Bit Enable through I2C Command
Load=0A



4ms/div.

ENPWR Bit Enable through I2C Command
Load=5A



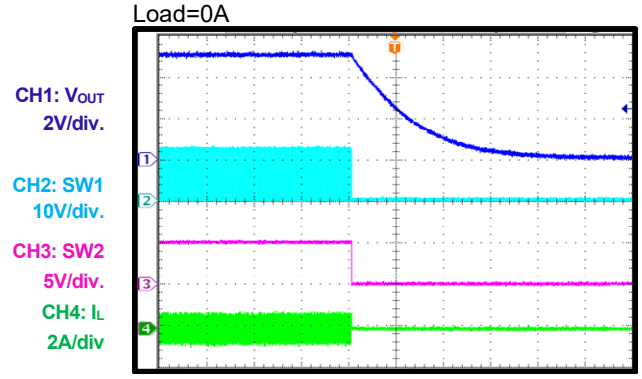
4ms/div.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board.
V_{IN} = 12V, V_{OUT} = 5V, L = 4.7µH, T_A = +25°C, unless otherwise noted.

ENPWR Bit Disable through I2C Command

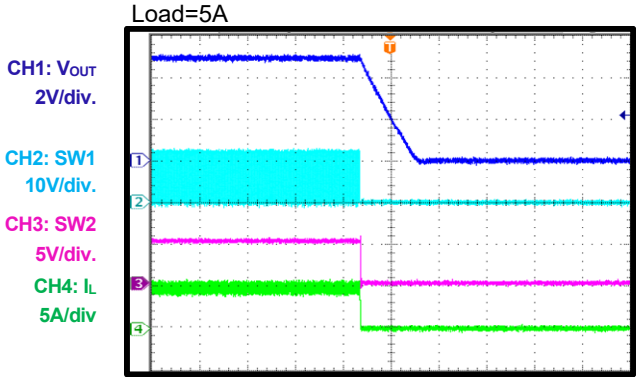
Load=0A



10ms/div.

ENPWR Bit Disable through I2C Command

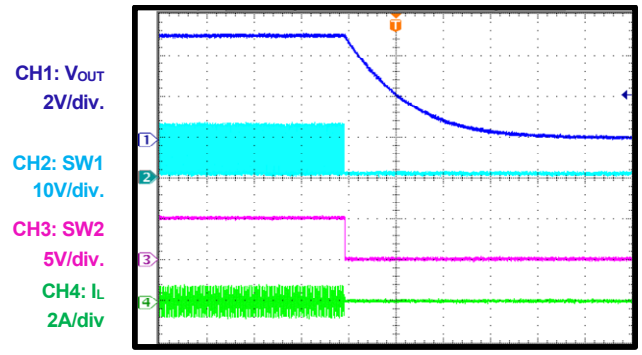
Load=5A



200µs/div

EN Disable through EN Pin

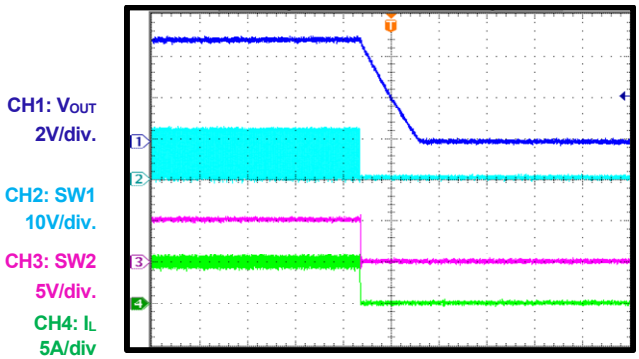
Load=0A



10ms/div.

EN Disable through EN Pin

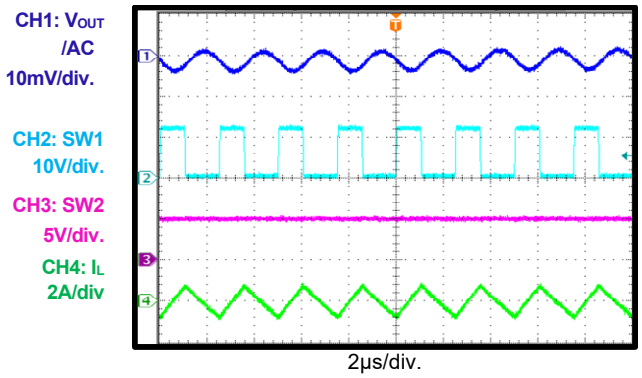
Load=5A



200µs/div.

Steady State

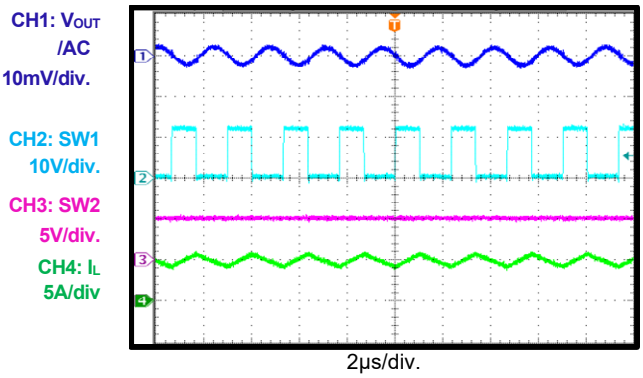
V_{OUT}=5V , Load=0A



2µs/div.

Steady State

V_{OUT}=5V , Load=5A



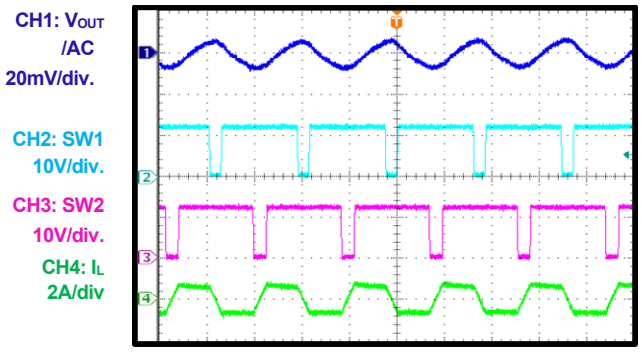
2µs/div.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board.
V_{IN} = 12V, V_{OUT} = 5V, L = 4.7µH, T_A = +25°C, unless otherwise noted.

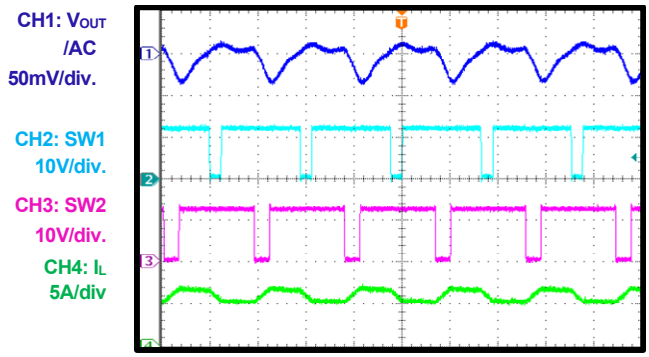
Steady State

V_{OUT}=12V, Load=0A



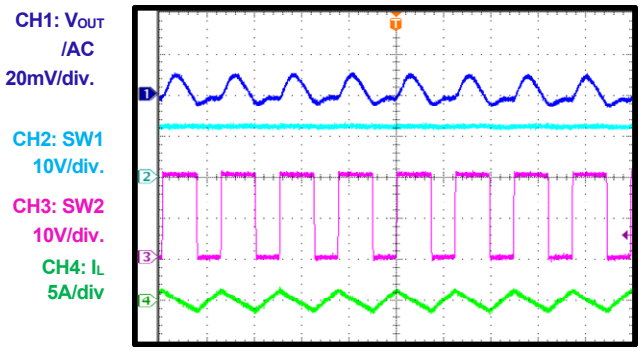
Steady State

V_{OUT}=12V , Load=5A



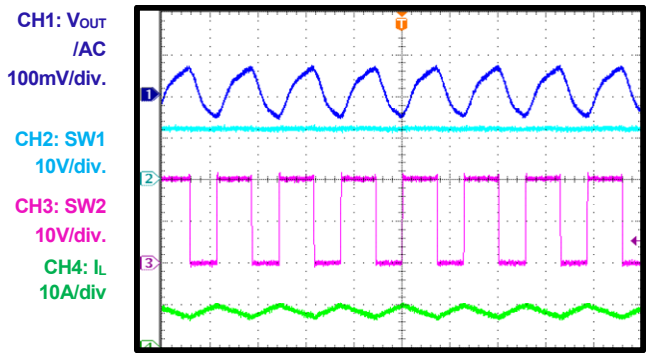
Steady State

V_{OUT}=20V , Load=0A



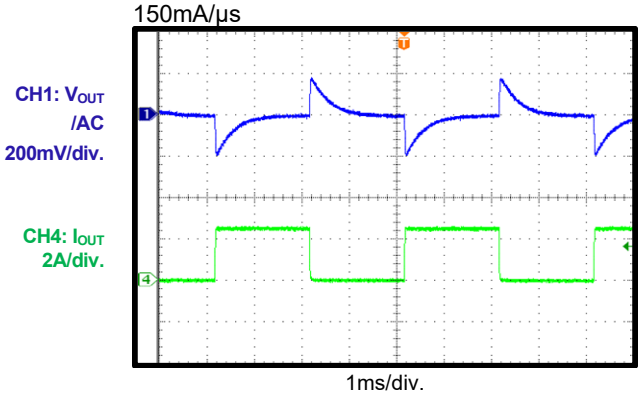
Steady State

V_{OUT}=20V Load=5A



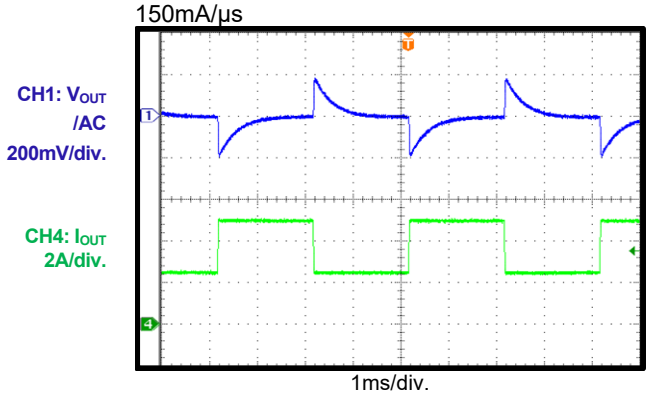
Load Transient

V_{IN}=12V , V_{OUT}=5V , Load=0A to 2.5A , 150mA/µs



Load Transient

V_{IN}=12V , V_{OUT}=5V , Load=2.5A to 5A , 150mA/µs

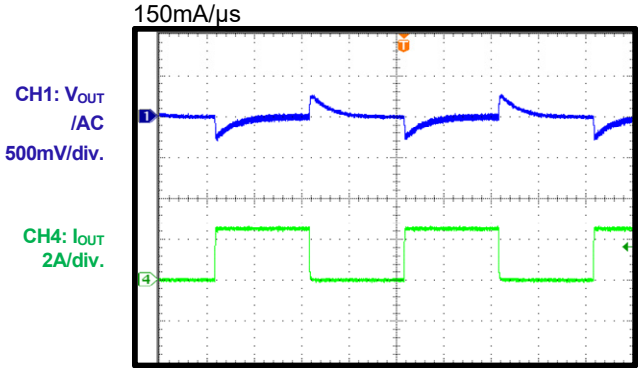


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board.
V_{IN} = 12V, V_{OUT} = 5V, L = 4.7µH, T_A = +25°C, unless otherwise noted.

Load Transient

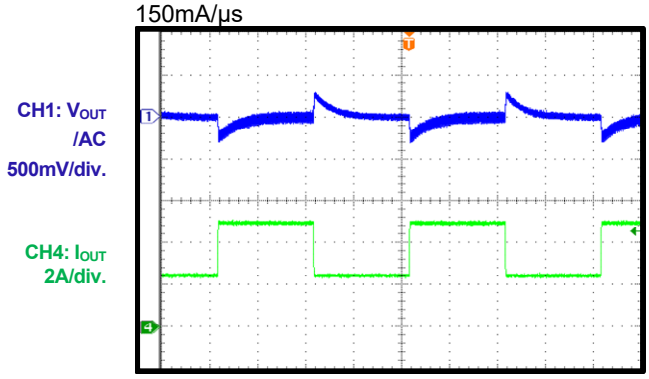
V_{IN}=12V , V_{OUT}=20V , Load=0A to 2.5A , 150mA/µs



1ms/div.

Load Transient

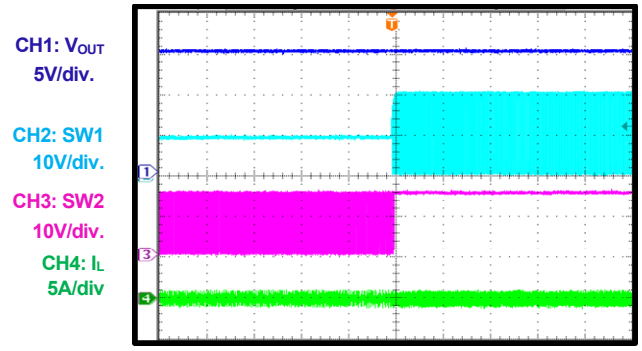
V_{IN}=12V , Vout=20V , Load=2.5A to 5A , 150mA/µs



1ms/div.

Input Voltage Transient

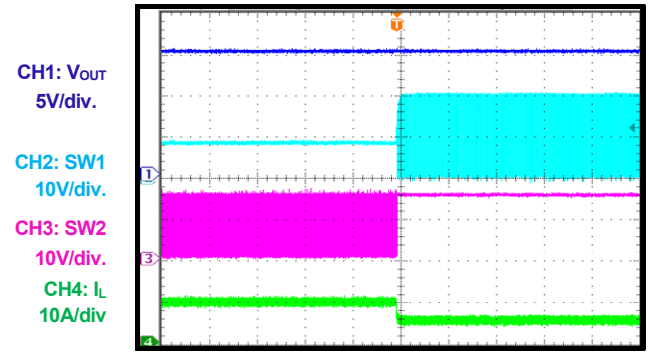
V_{IN}=9V to 20V , V_{OUT}=15V , Load=0A



100ms/div.

Input Voltage Transient

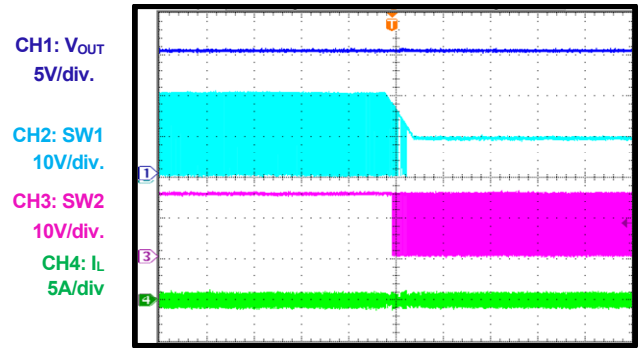
V_{IN}=9V to 20V , V_{OUT}=15V , Load=5A



100ms/div.

Input Voltage Transient

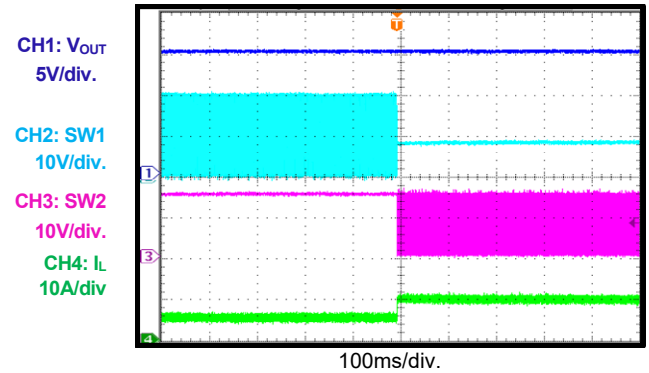
V_{IN}=20V to 9V , V_{OUT}=15V , Load=0A



100ms/div.

Input Voltage Transient

V_{IN}=20V to 9V , V_{OUT}=15V , Load=5A



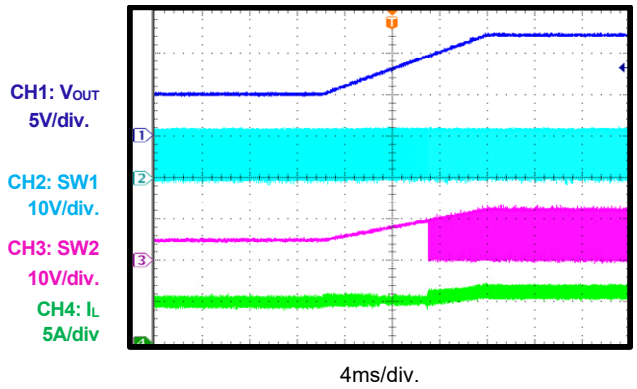
100ms/div.

EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board.
V_{IN} = 12V, V_{OUT} = 5V, L = 4.7µH, T_A = +25°C, unless otherwise noted.

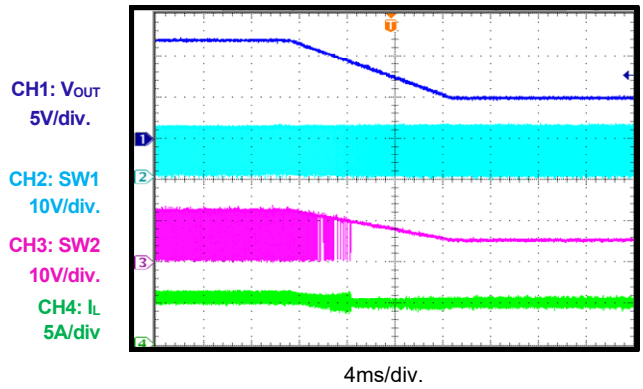
Output Voltage Transient

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



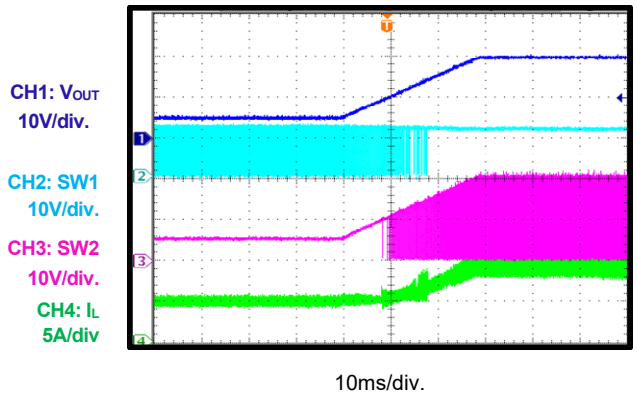
Output Voltage Transient

V_{OUT}=12V to 5V , Load=5A



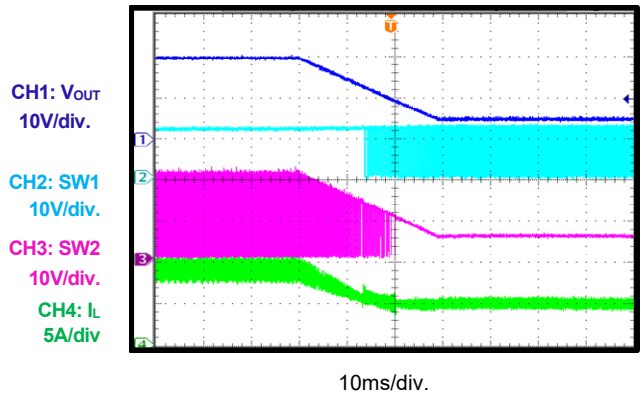
Output Voltage Transient

V_{OUT}=5V to 20V , Load=5A

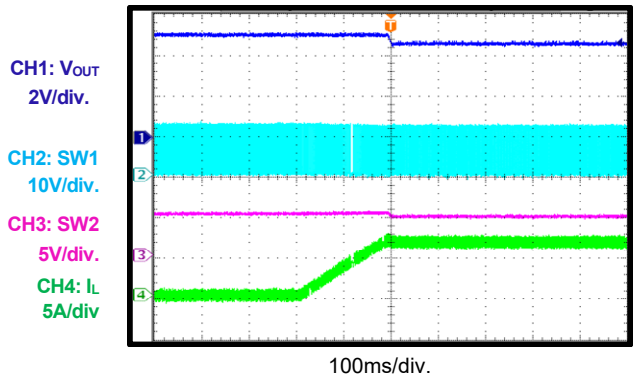


Output Voltage Transient

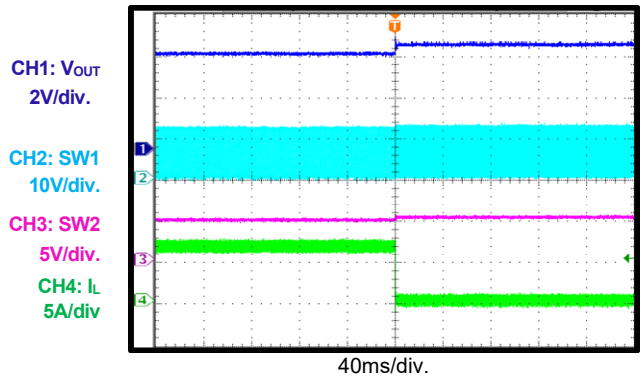
V_{OUT}=20V to 5V , Load=5A



OCP Enter



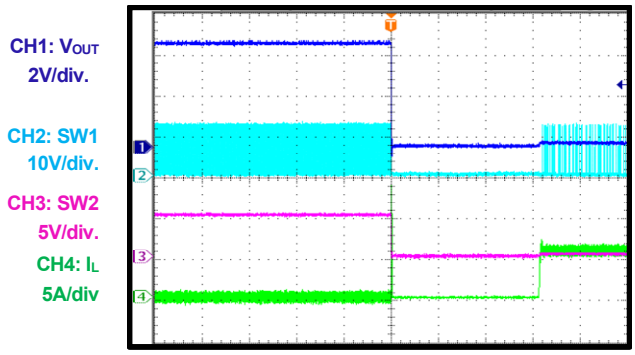
OCP Recover



EVB TEST RESULTS *(continued)*

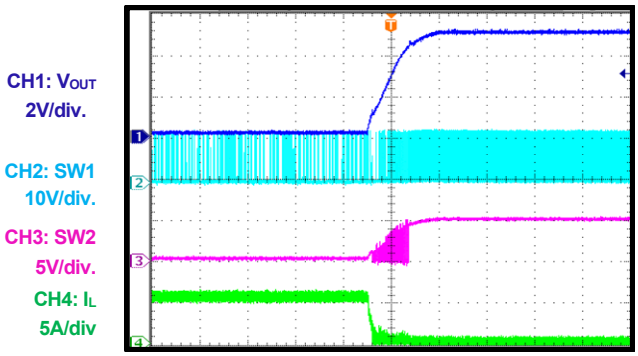
Performance curves and waveforms are tested on the evaluation board.
V_{IN} = 12V, V_{OUT} = 5V, L = 4.7µH, T_A = +25°C, unless otherwise noted.

SCP Enter



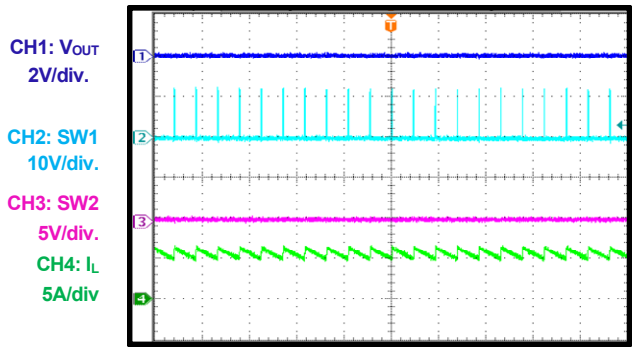
20ms/div.

SCP Recover



4ms/div.

SCP Steady State



40µs/div

PRINTED CIRCUIT BOARD LAYOUT

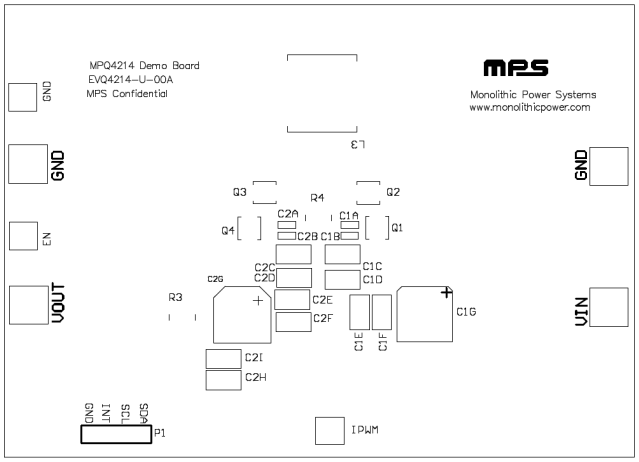


Figure 1: Top Silkscreen Layer

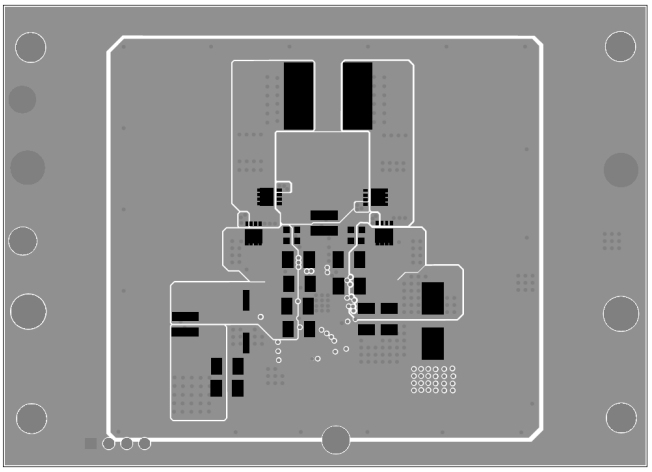


Figure 2: Top Layer

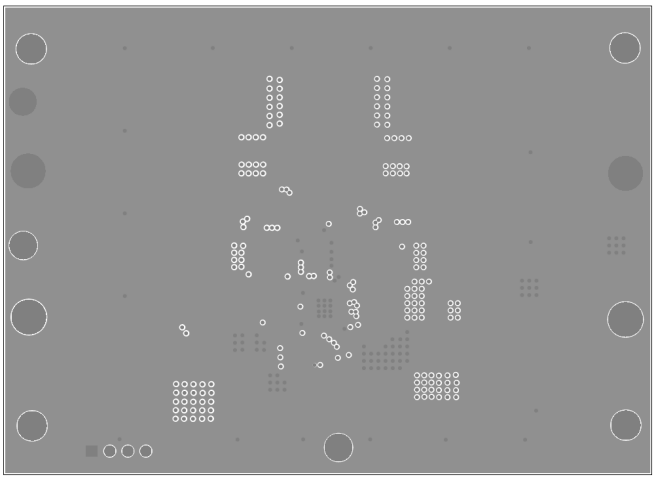


Figure 3: Middle Layer 1

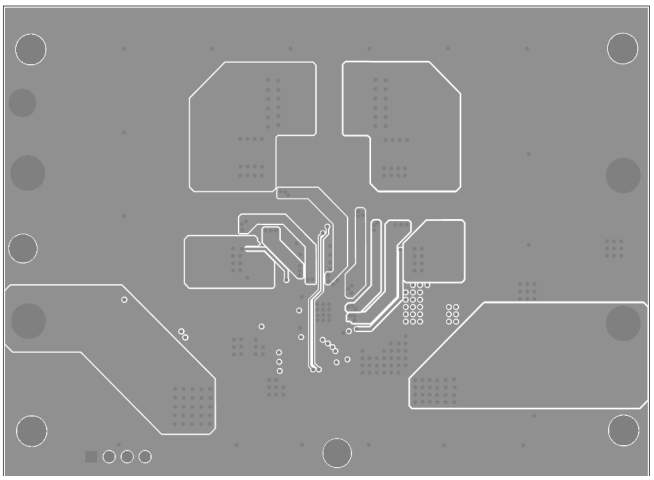


Figure 4: Middle Layer 2

PRINTED CIRCUIT BOARD LAYOUT *(continued)*

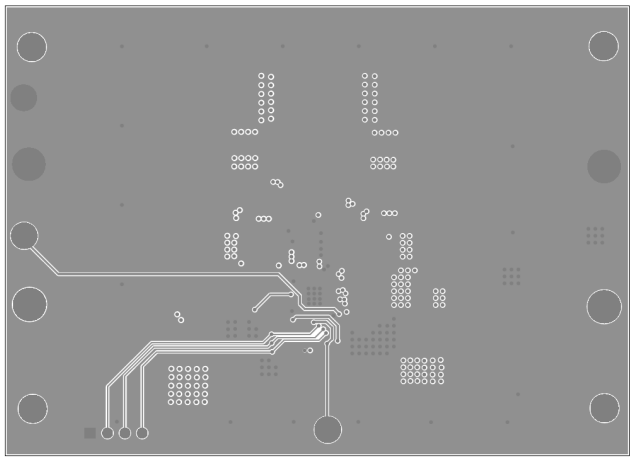


Figure 5: Middle Layer 3

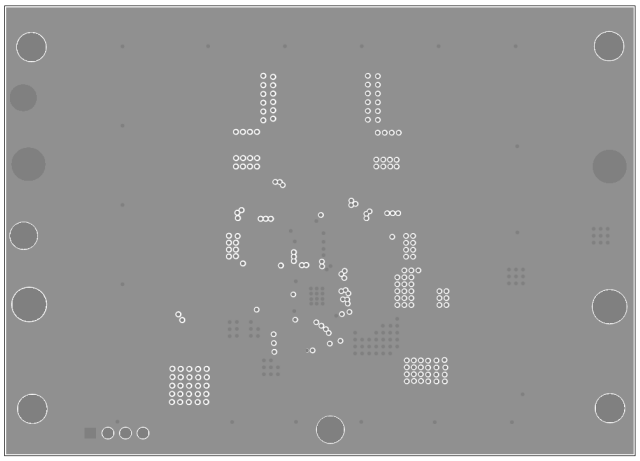


Figure 6: Middle Layer 4

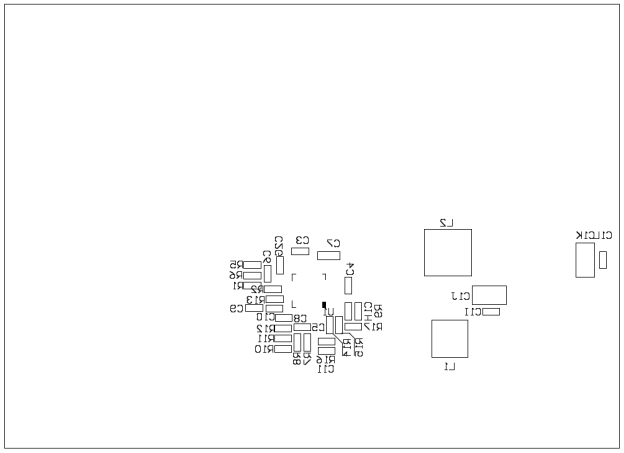


Figure 7: Bottom Silkscreen Layer

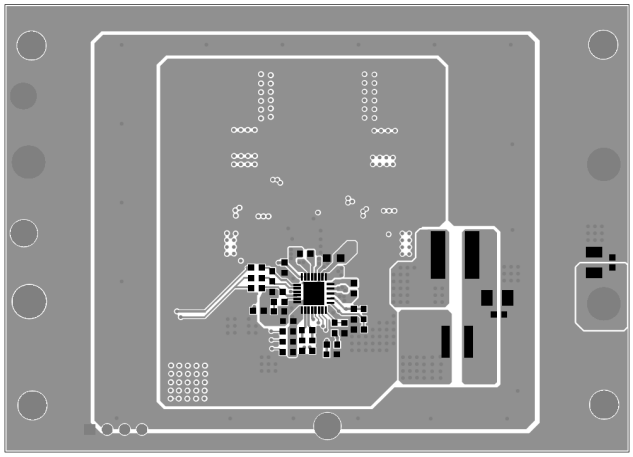


Figure 8: Bottom Layer

QUICK START GUIDE

1. Connect the positive and negative terminals of the load (≤5A) to the VOUT and GND pins, respectively.

2. Preset the power supply output voltage within the range 6V~40V, and then turn off the power supply.

3. Connect the positive and negative terminals of the power supply output to the VIN and GND pins, respectively.

4. Turn on the power supply after making connections, the MPQ4214 will startup automatically. And the output voltage of this board is set to 5V.

Then set MPQ4214 registers through I²C in following step:

a. Connect I2C Cable from host computer to the board, and then launch the MPQ4214 software.

b. Click Detect button on the GUI. Normally the GUI will indicate the connection is OK.

c. If other parameters like output voltage, Frequency spectrum, slew rate, etc. are need be changed, it is OK to modify the corresponding register through MPQ4214 I2C GUI.

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	9/30/2018	Initial Release	-
1.1	9/11/2019	Updated Description, Features, Applications	1–2
		Updated EVB photo	3
		Updated schematic	4–5
		Updated BOM	6–7
		Updated Typical Performance Characteristics	8–13
		Updated Quick Start Guide	22
1.2	2/1/2024	Added “AEC-Q100 Qualified” to the header; updated the Description section to note that the MPQ4214 is available in AEC-Q100 Grade 1; updated “AEC-Q100 Qualification in Progress” to “Available in AEC-Q100 Grade 1” in the Features section	1
		Added “AEC-Q100” to the header	2–18
		Merged the “Q1, Q2” and “Q3, Q4” rows into a single row, updated the corresponding value, and made minor copyedits to its description and package in the Bill of Materials section	6