# EVQ4314-R-01A

## 45V, 4A, Low-$I_Q$, Synchronous Step-Down Converter with Frequency Spread Spectrum Evaluation Board, AEC-Q100 Qualified

## DESCRIPTION

The EVQ4314-R-01A evaluation board is designed to demonstrate the capabilities of the MPQ4314, a synchronous, step-down switching regulator with a configurable frequency and integrated, internal high-side MOSFET (HS-FET) and low-side MOSFET (LS-FET). It provides up to 4A of highly efficient output current ($I_{OUT}$), with current mode control for fast loop response.

The wide 3.3V to 45V input voltage ($V_{IN}$) range accommodates a variety of step-down applications in automotive input environments. A 1.7μA quiescent current ($I_Q$) in shutdown mode allows the device to be used in battery-powered applications. High power conversion efficiency across a wide load range is achieved by scaling down the switching frequency ($f_{SW}$) under light-load conditions to reduce switching and gate driver losses.

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

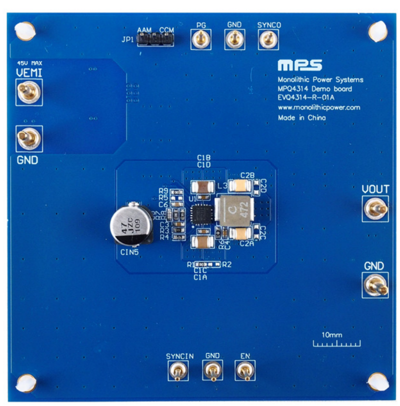
The EVQ4314-R-01A is fully assembled and tested. The MPQ4314-AEC1 is available in a QFN-20 (4mmx4mm) wettable flank package, and is AEC-Q100 Grade 1 qualified.

## PERFORMANCE SUMMARY

Specifications are at $T_A$ = 25°C, unless otherwise noted

| Parameter | Conditions | Value |
|---|---|---|
| Input voltage ($V_{IN}$) range | | 3.3V to 45V |
| Output voltage ($V_{OUT}$) | $V_{IN}$ = 3.3V to 45V, $I_{OUT}$ = 0A to 4A | $V_{OUT}$ = 3.3V |
| Maximum output current ($I_{OUT}$) | $V_{IN}$ = 3.3V to 45V | 4A |
| Typical efficiency | $V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, $I_{OUT}$ = 4A | 93.1% |
| Switching frequency ($f_{SW}$) | | 410kHz |

## EVQ4314-R-01A EVALUATION BOARD



**LxWxH (8.3cmx8.3cmx1.3cm)**

| Board Number | MPS IC Number |
|---|---|
| EVQ4314-R-01A | MPQ4314GRE-AEC1 |

## QUICK START GUIDE

1. Preset the power supply ($V_{IN}$) between 3.3V and 45V. Electronic loads represent a negative impedance to the regulator, and setting a current too high triggers hiccup mode.
2. Turn off $V_{IN}$. If longer cables are used between the source and the evaluation board (>0.5m total), then install a damping capacitor at the input terminals, especially if $V_{IN} \geq 24V$.
3. Connect the power supply terminals to (see Figure 2 on page 3):
   a. Positive (+): VEMI
   b. Negative (-): GND
4. Connect the load terminals to (see Figure 2 on page 3):
   a. Positive (+): VOUT
   b. Negative (-): GND
5. After making the connections, turn on the power supply. The board should automatically start up.
6. 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 the regulator off.
7. The MPQ4314's oscillating (switching) frequency can be configured by an external frequency resistor (R3). R3 can be estimated based on the switching frequency ($f_{SW}$) vs. frequency resistance ($R_{FREQ}$) curve (see Figure 1).

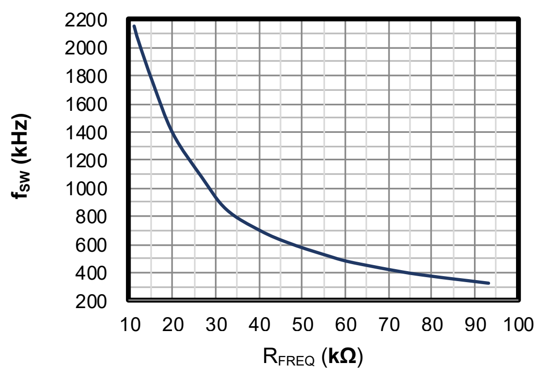



**Figure 1: R3 Frequency Resistance**

8. To use the sync function, apply a 350kHz to 1000kHz external clock to the SYNCIN pin to synchronize the internal clock's rising edge.
9. The output voltage ($V_{OUT}$) is set by the external resistor divider. If R7 = 100kΩ, then R8 can be calculated using Equation (1):

$$R8 = \frac{R7}{\frac{V_{OUT}}{0.815V} - 1} \quad (1)$$

Table 1 shows the recommended R7 and R8 values for common output voltages.

**Table 1: Resistor Selection for Output Voltages**

| $V_{OUT}$ (V) | R7 (kΩ) | R8 (kΩ) |
|---|---|---|
| 3.3 | 100 (1%) | 32.4 (1%) |
| 5 | 100 (1%) | 19.1 (1%) |

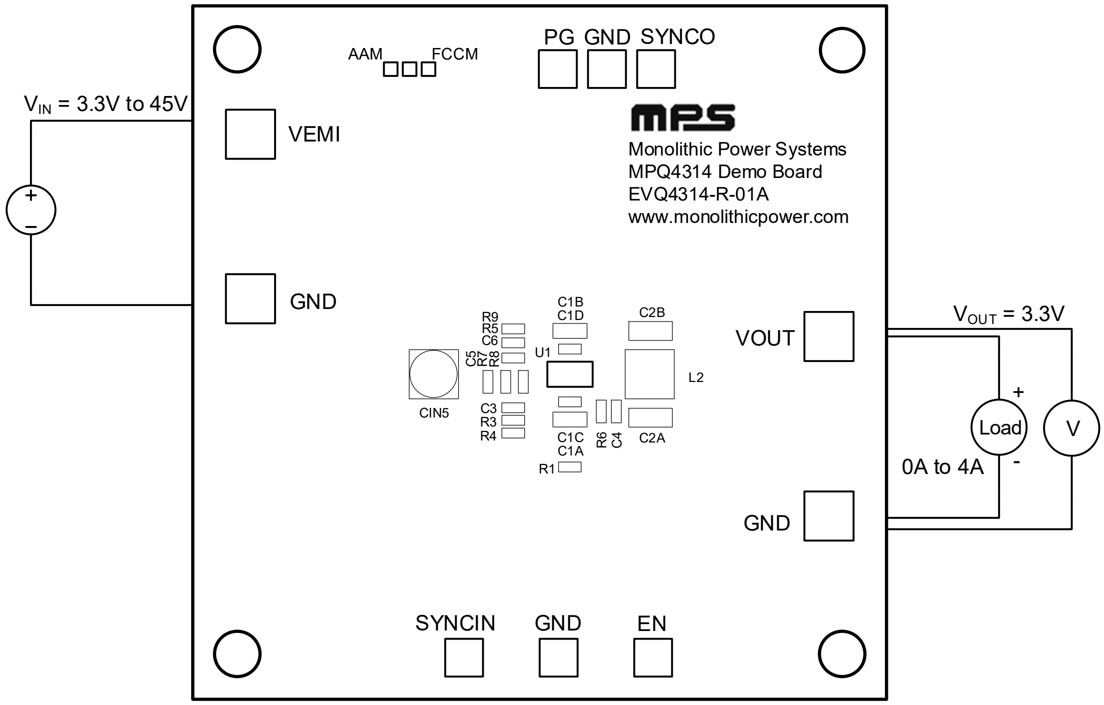
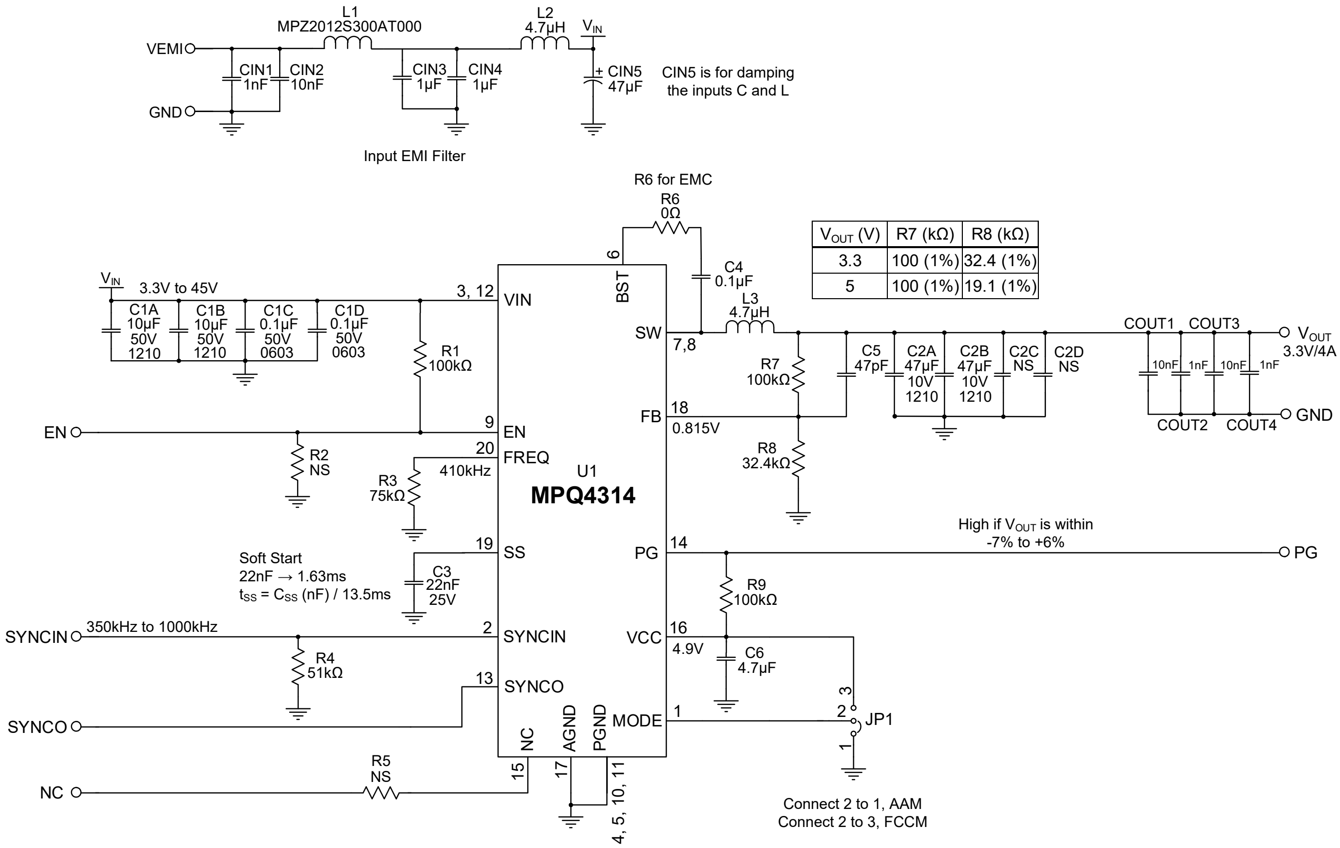



**Figure 2: Measurement Equipment Set-Up**

# EVALUATION BOARD SCHEMATIC



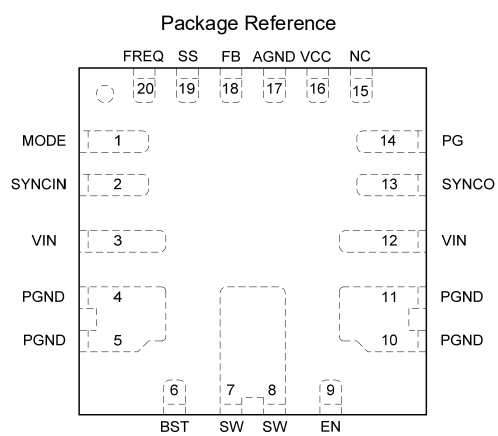




**Figure 3: Evaluation Board Schematic and Package Reference**

## EVQ4314-R-01A BILL OF MATERIALS

| Qty | Ref | Value | Description | Package | Manufacturer | Manufacturer PN |
|---|---|---|---|---|---|---|
| 3 | CIN1, COUT2, COUT4 | 1nF | Ceramic capacitor, 50V, X7R | 0603 | Murata | GRM216R71H102KA01 |
| 3 | CIN2, COUT1, COUT3 | 10nF | Ceramic capacitor, 50V, X7R | 0603 | Murata | GRM188R71H103KA01D |
| 2 | CIN3, CIN4 | 1µF | Ceramic capacitor, 50V, X7R | 1206 | TDK | C3216X7R1H105K |
| 1 | CIN5 | 47µF | Aluminum capacitor, 63V | SMD | Panasonic | EEHZA1J470P |
| 2 | C1A, C1B | 10µF | Ceramic capacitor, 50V, X7R | 1210 | Murata | GRM32ER71H106KA12L |
| 2 | C1C, C1D | 0.1µF | Ceramic capacitor, 50V, X7R | 0603 | Murata | GCJ188R71H104KA12D |
| 2 | C2A, C2B | 47µF | Ceramic capacitor, 10V, X5R | 1210 | Murata | GRM32ER61A476KE20L |
| 1 | C3 | 22nF | Ceramic capacitor, 25V, X7R | 0603 | Murata | GRM188R71E223JA01D |
| 1 | C4 | 0.1µF | Ceramic capacitor, 50V, X7R | 0603 | Murata | GRM188R71H104KA93D |
| 1 | C5 | 47pF | Ceramic capacitor, 50V, C0G | 0603 | TDK | C1608C0G1H470J |
| 1 | C6 | 4.7µF | Ceramic capacitor, 10V, X5R | 0603 | Murata | GRM188R61A475KE15D |
| 1 | L1 | 10mΩ | Magnetic bead, 6A | 0805 | TDK | MPZ2012S300AT000 |
| 1 | L2 | 4.7µH | Inductor, 31.5mΩ, 6A | SMD | Cyntec | VCMT063T-4R7MN5T |
| 1 | L3 | 4.7µH | Inductor, 15.02mΩ, 12.1A | SMD | Coilcraft | XAL6060-472MEC |
| 3 | R1, R7, R9 | 100kΩ | Film resistor, 1% | 0603 | Yageo | RC0603FR-07100KL |
| 1 | R3 | 75kΩ | Film resistor, 1% | 0603 | Yageo | RC0603FR-0775KL |
| 1 | R4 | 51kΩ | Film resistor, 1% | 0603 | Yageo | RC0603FR-0751KL |
| 1 | R6 | 0Ω | Film resistor, 1% | 0603 | Yageo | RC0603FR-070RL |
| 1 | R8 | 32.4kΩ | Film resistor, 1% | 0603 | Yageo | RC0603FR-0732K4L |
| 4 | C2C, C2D, R2, R5 | NS | | | | |
| 1 | JP1 | 2.54mm | Test pin, 3-pin | DIP | Any | |
| 4 | VEMI, GND, VOUT, GND | 2mm | Golden test pin | DIP | Custom (1) | |
| 7 | SYNCIN, ICS, PG, SYNCO, EN, GND, GND | 1mm | Golden test pin | DIP | Custom (1) | |
| 1 | U1 | MPQ4314 | 45V/4A, step-down converter, AEC-Q100 | QFN-20 (4mmx 4mm) | MPS | MPQ4314GRE-AEC1 |

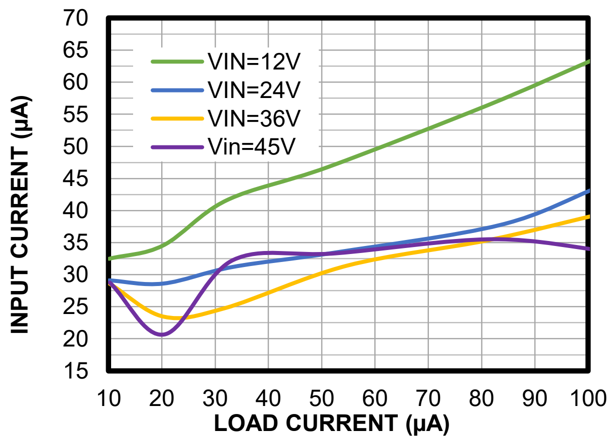
**Note:**

1) Contact an MPS FAE for more information regarding custom pins.

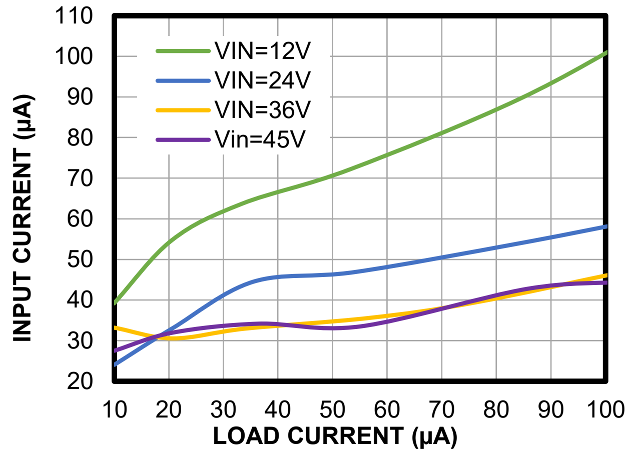
## EVB TEST RESULTS

**Performance curves and waveforms are tested on the evaluation board, $V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, $C_{OUT}$ = 2 x 47µF, L = 4.7µH, $f_{SW}$ = 410kHz, $T_A$ = 25°C, unless otherwise noted.**

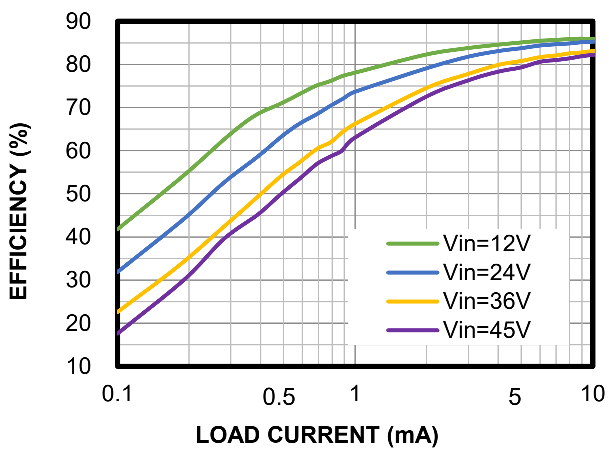
**Input Current vs. Load Current**
AAM mode, $V_{OUT}$ = 3.3V



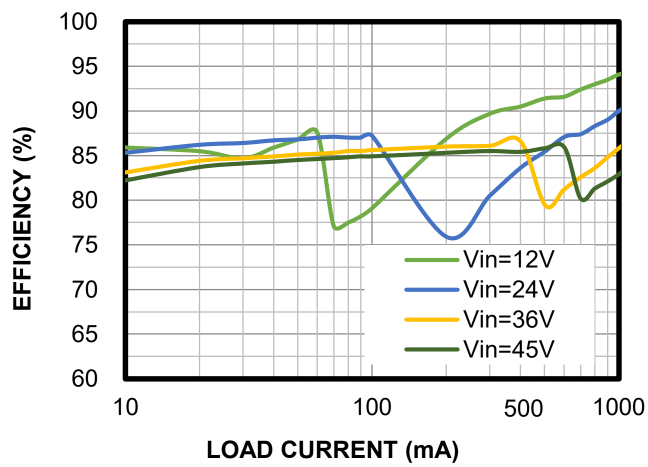

**Input Current vs. Load Current**
AAM mode, $V_{OUT}$ = 5V



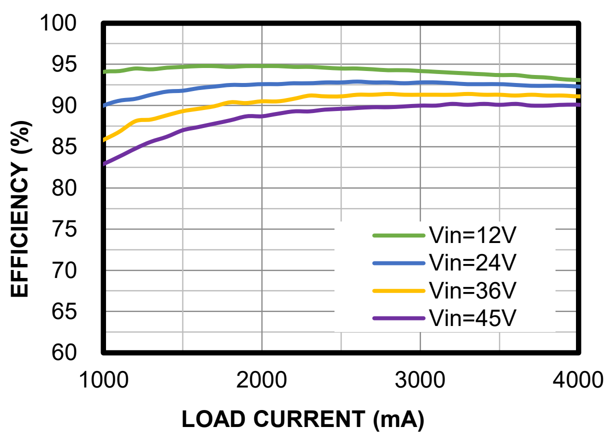

**Efficiency vs. Load Current**
AAM mode, $V_{OUT}$ = 3.3V, 0.1mA to 10mA



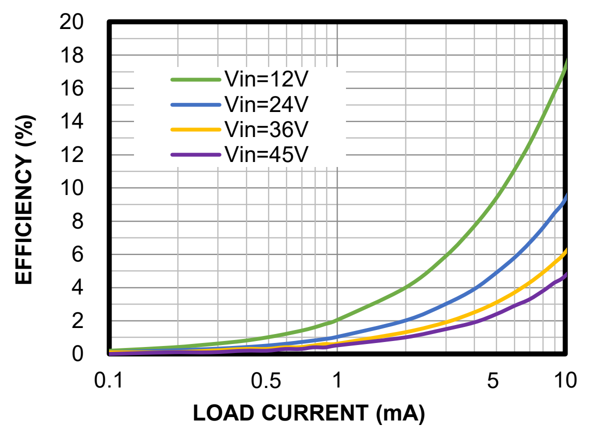

**Efficiency vs. Load Current**
AAM mode, $V_{OUT}$ = 3.3V, 10mA to 1000mA




**Efficiency vs. Load Current**
AAM mode, $V_{OUT}$ = 3.3V. 1A to 4A



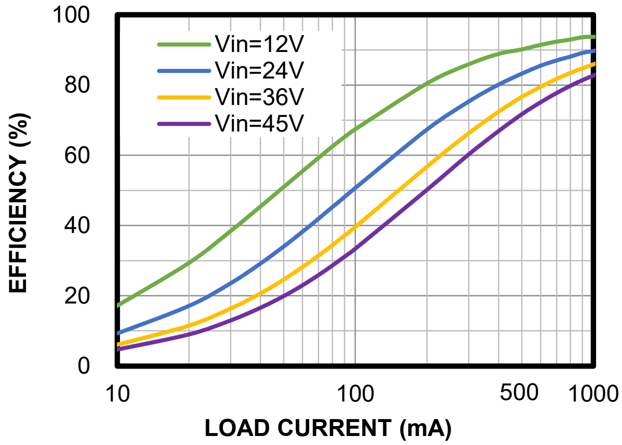

**Efficiency vs. Load Current**
FCCM, $V_{OUT}$ = 3.3V, 0.1mA to 10mA



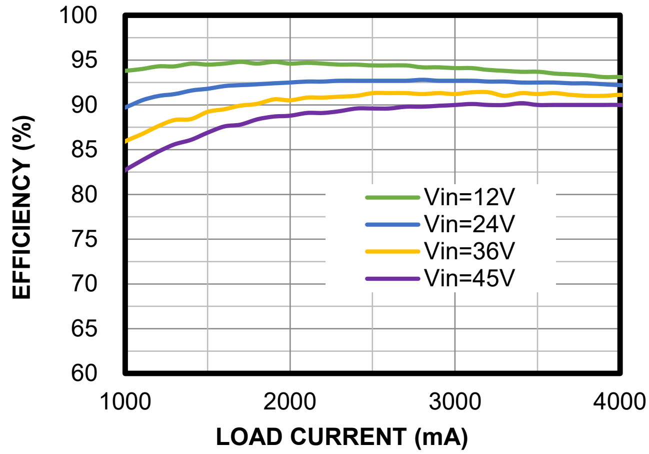
## EVB TEST RESULTS *(continued)*

**Performance curves and waveforms are tested on the evaluation board, $V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, $C_{OUT}$ = 2 x 47μF, L = 4.7μH, $f_{SW}$ = 410kHz, $T_A$ = 25°C, unless otherwise noted.**

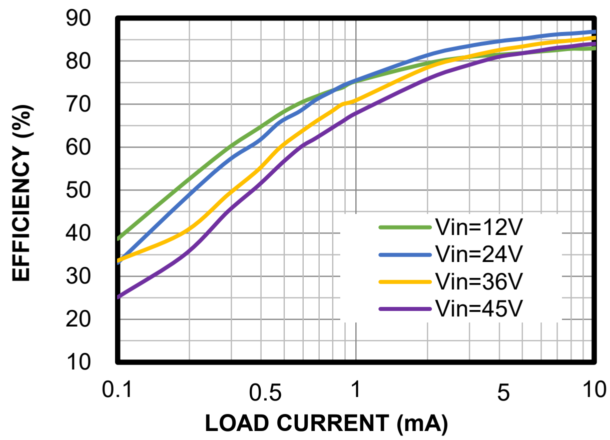
**Efficiency vs. Load Current**
FCCM, $V_{OUT}$ = 3.3V, 10mA to 1000mA



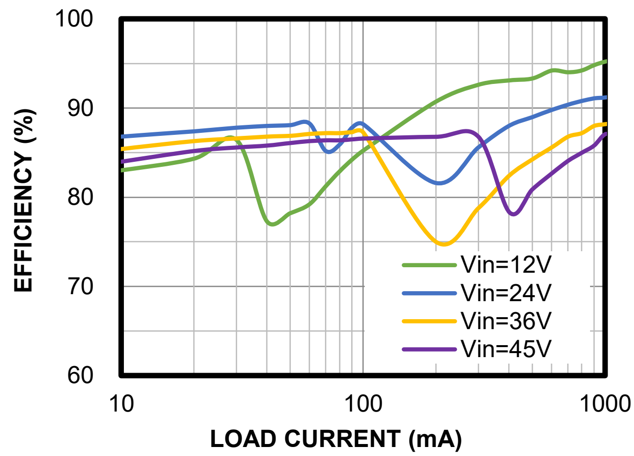

**Efficiency vs. Load Current**
FCCM, $V_{OUT}$ = 3.3V, 1A to 4A



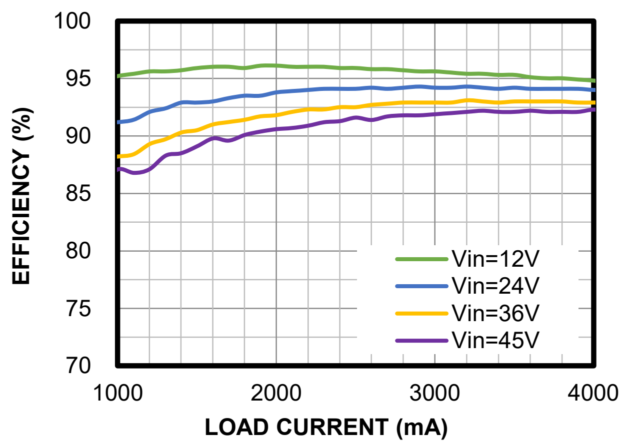

**Efficiency vs. Load Current**
AAM mode, $V_{OUT}$ = 5V, 0.1mA to 10mA



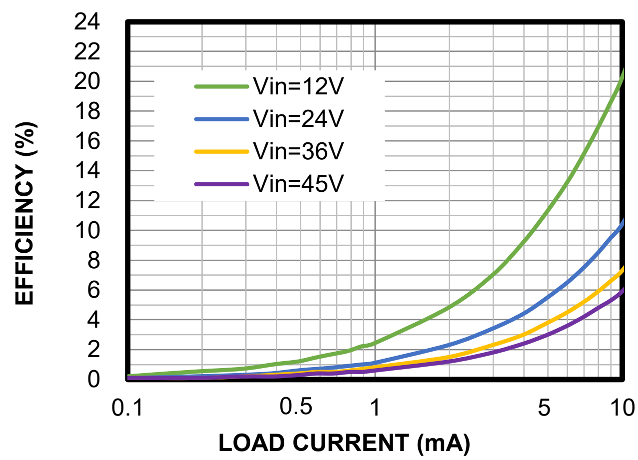

**Efficiency vs. Load Current**
AAM mode, $V_{OUT}$ = 5V, 10mA to 1000mA




**Efficiency vs. Load Current**
AAM mode, $V_{OUT}$ = 5V, 1A to 4A



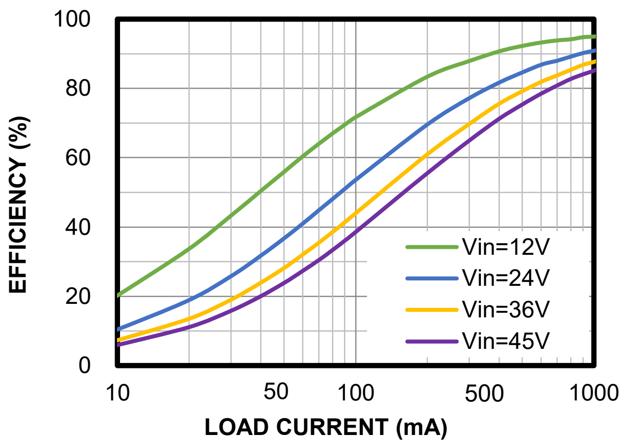

**Efficiency vs. Load Current**
FCCM, $V_{OUT}$ = 5V, 0.1mA to 10mA



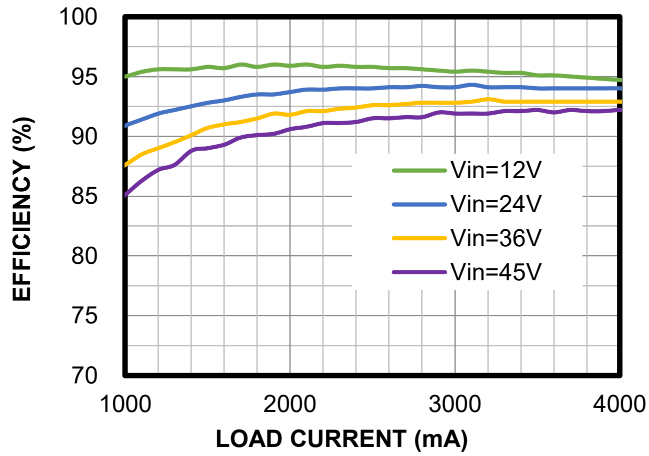
## EVB TEST RESULTS *(continued)*

**Performance curves and waveforms are tested on the evaluation board, $V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, $C_{OUT}$ = 2 x 47µF, L = 4.7µH, $f_{SW}$ = 410kHz, $T_A$ = 25°C, unless otherwise noted.**

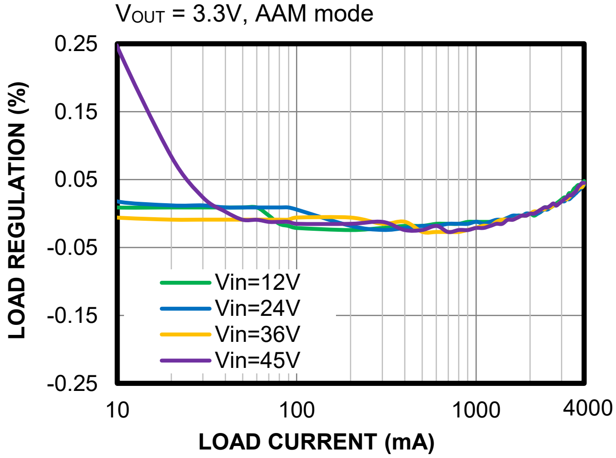
**Efficiency vs. Load Current**
FCCM, $V_{OUT}$ = 5V, 10mA to 1000mA



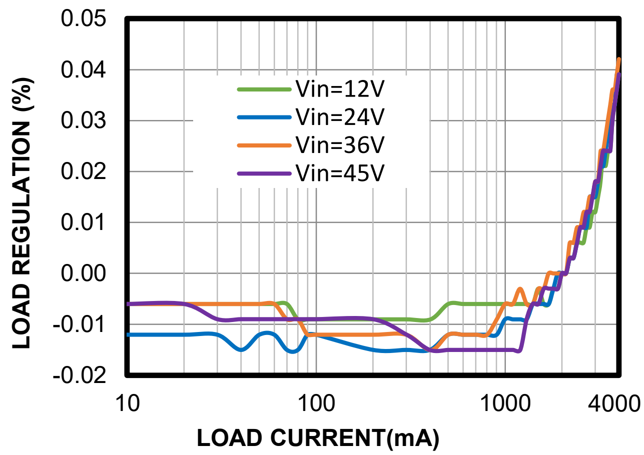

**Efficiency vs. Load Current**
FCCM, $V_{OUT}$ = 5V, 1A to 4A



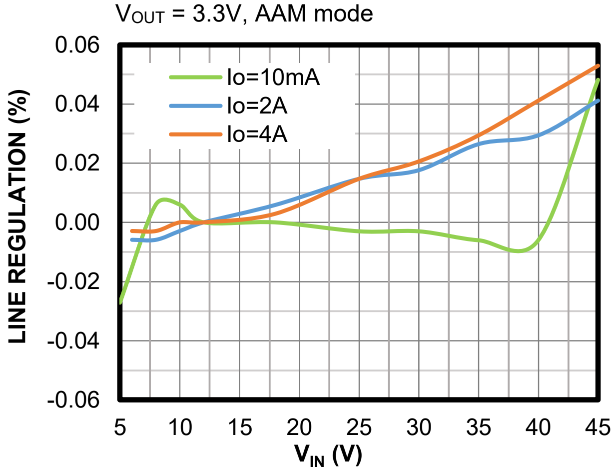

**Load Regulation**
$V_{OUT}$ = 3.3V, AAM mode



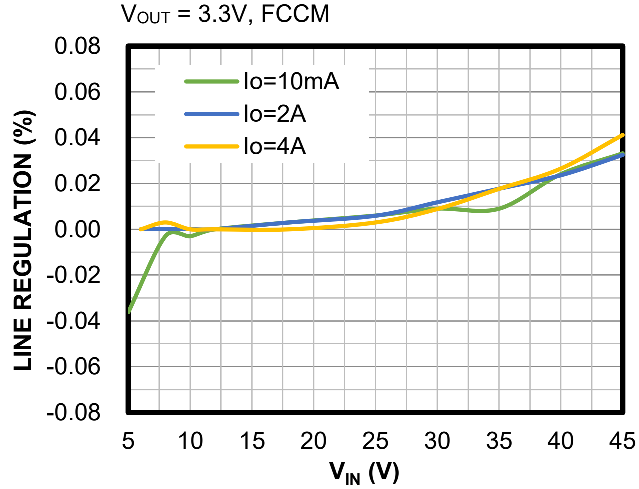

**Load Regulation**
$V_{OUT}$ = 3.3V, FCCM




**Line Regulation**
$V_{OUT}$ = 3.3V, AAM mode

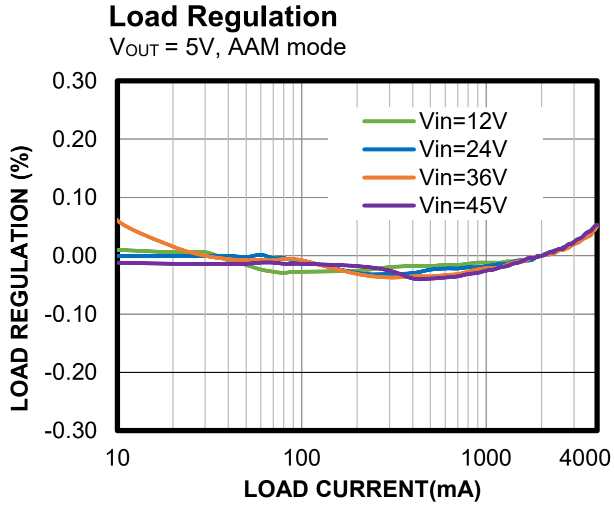


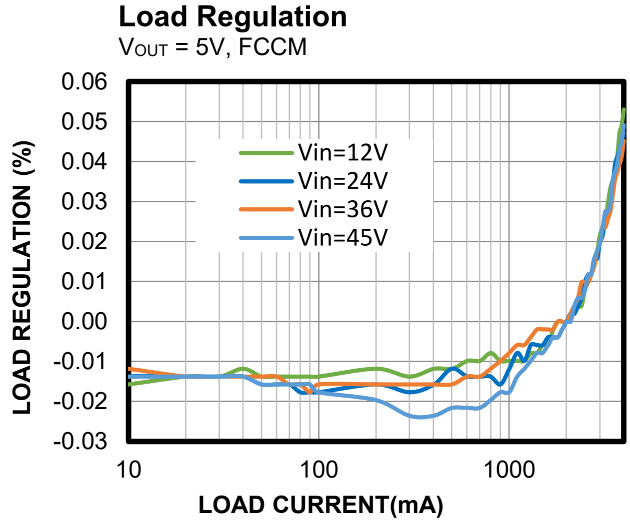

**Line Regulation**
$V_{OUT}$ = 3.3V, FCCM

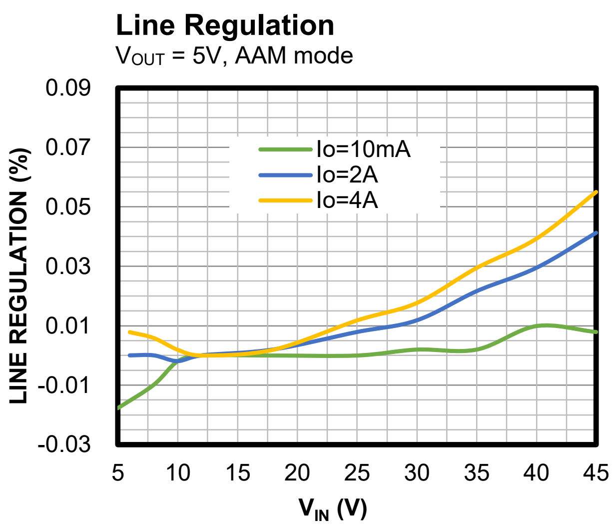


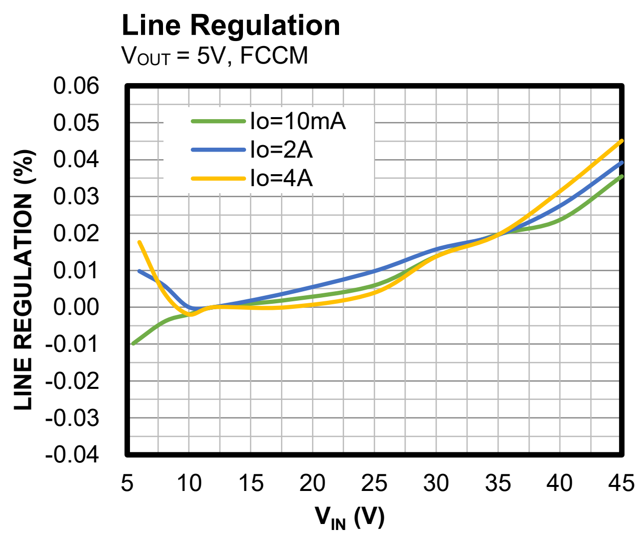
## EVB TEST RESULTS *(continued)*

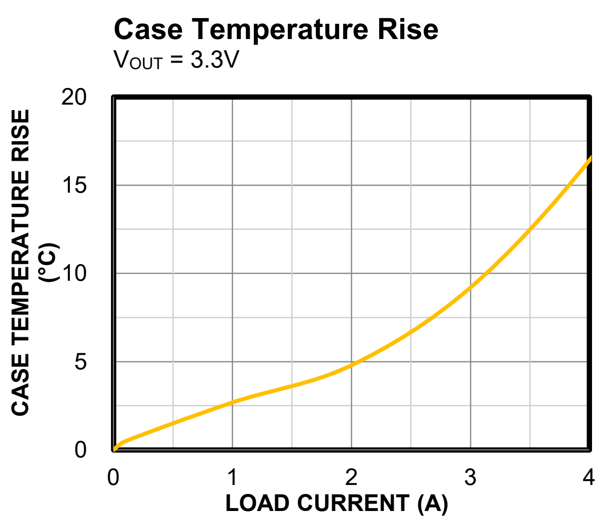
**Performance curves and waveforms are tested on the evaluation board, $V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, $C_{OUT}$ = 2 x 47µF, L = 4.7µH, $f_{SW}$ = 410kHz, $T_A$ = 25°C, unless otherwise noted.**

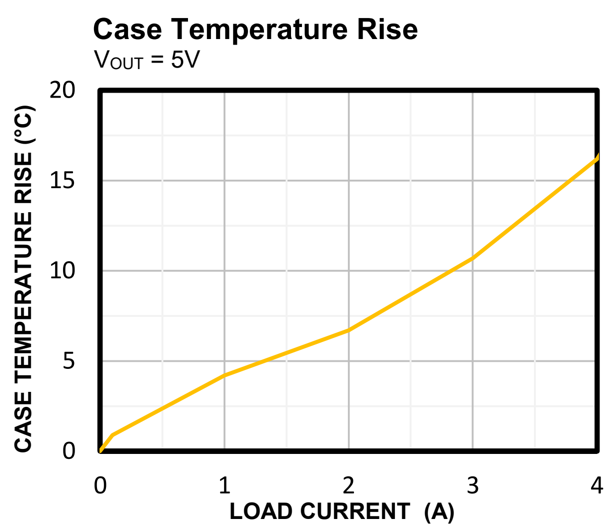


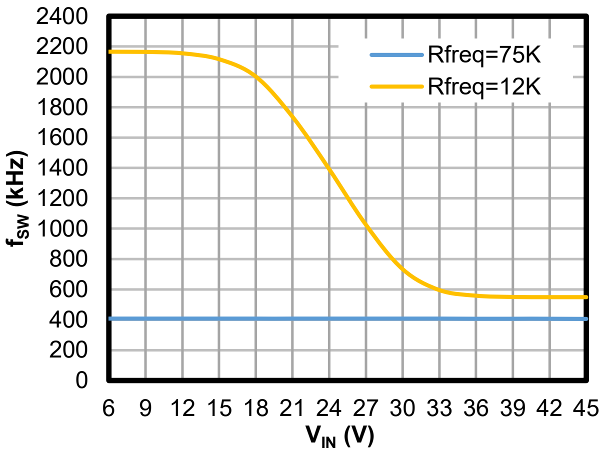



## EVB TEST RESULTS *(continued)*

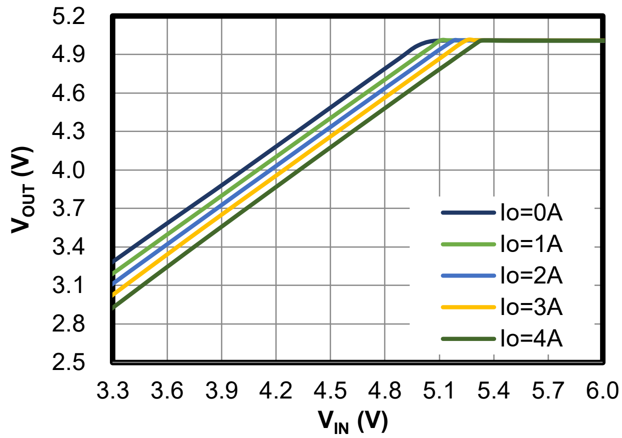
**Performance curves and waveforms are tested on the evaluation board, $V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, $C_{OUT}$ = 2 x 47µF, L = 4.7µH, $f_{SW}$ = 410kHz, $T_A$ = 25°C, unless otherwise noted.**

**$f_{SW}$ vs. $V_{IN}$**




**Low-Dropout Mode**

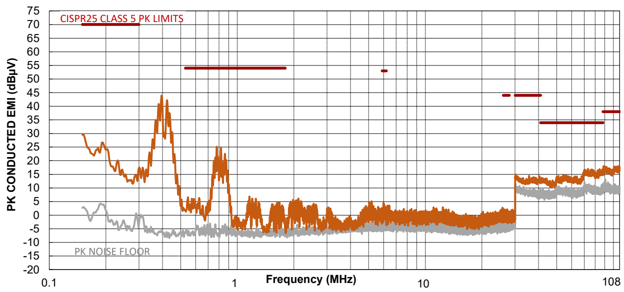
$V_{OUT}$ = 5V



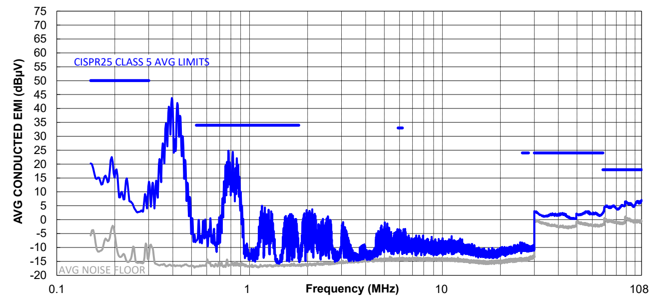
## EVB TEST RESULTS *(continued)*

**Performance curves and waveforms are tested on the evaluation board, $V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, $C_{OUT}$ = 2 x 47µF, L = 4.7µH, $f_{SW}$ = 410kHz, $T_A$ = 25°C, unless otherwise noted.**

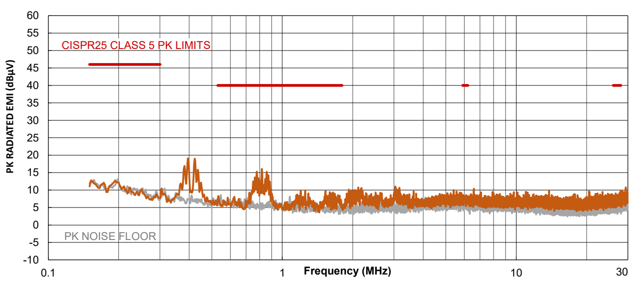
**CISPR25 Class 5 Peak Conducted Emissions**
150kHz to 108MHz



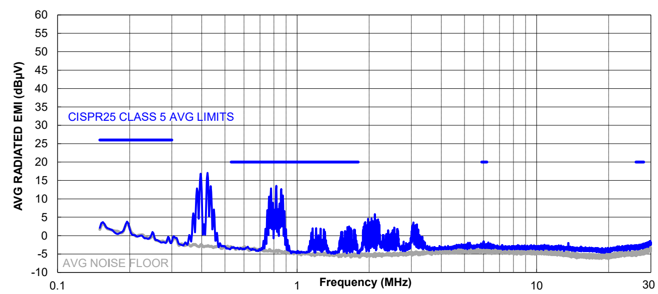

**CISPR25 Class 5 Average Conducted Emissions**
150kHz to 108MHz



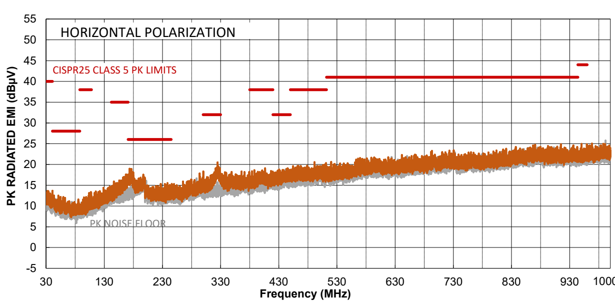

**CISPR25 Class 5 Peak Radiated Emissions**
150kHz to 30MHz



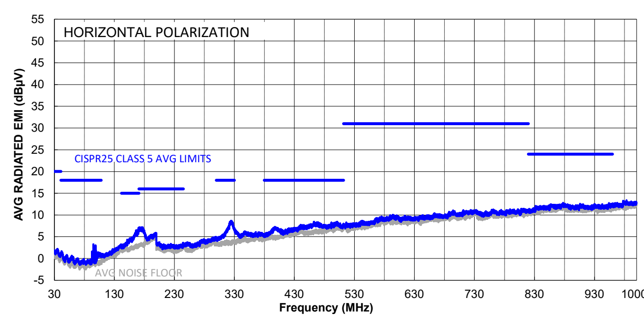

**CISPR25 Class 5 Average Radiated Emissions**
150kHz to 30MHz




**CISPR25 Class 5 Peak Radiated Emissions**
Horizontal, 30MHz to 1GHz




**CISPR25 Class 5 Average Radiated Emissions**
Horizontal, 30MHz to 1GHz

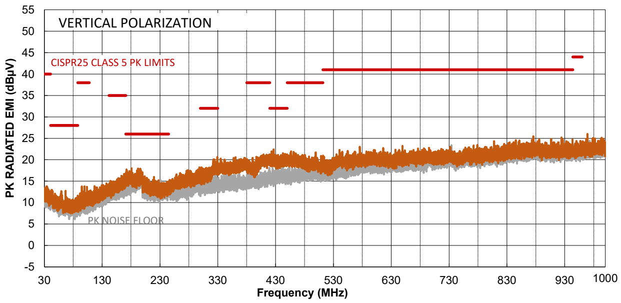


## EVB TEST RESULTS *(continued)*

**Performance curves and waveforms are tested on the evaluation board, $V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, $C_{OUT}$ = 2 x 47µF, L = 4.7µH, $f_{SW}$ = 410kHz, $T_A$ = 25°C, unless otherwise noted.**

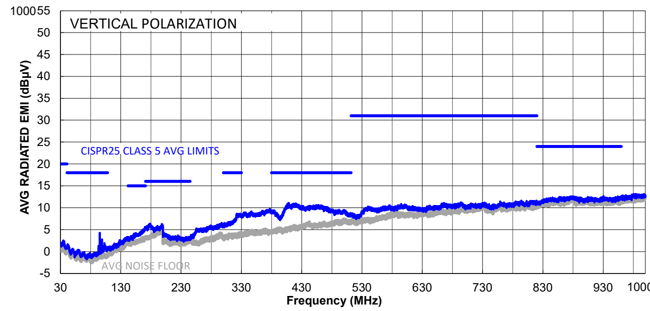
**CISPR25 Class 5 Peak Radiated Emissions**

Vertical, 30MHz to 1GHz




**CISPR25 Class 5 Average Radiated Emissions**

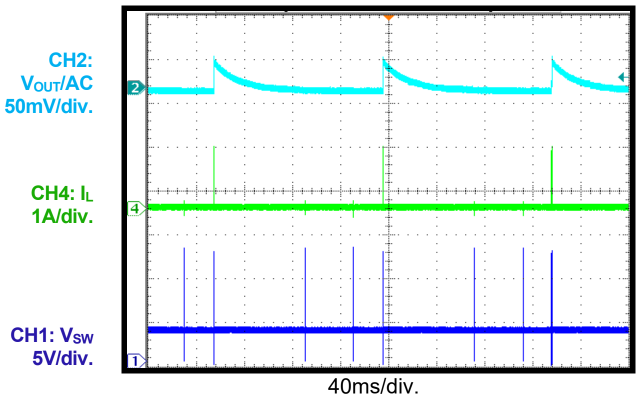
Vertical, 30MHz to 1GHz



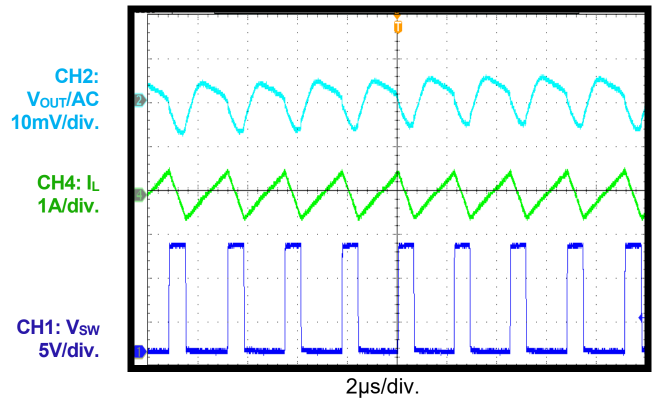
## EVB TEST RESULTS *(continued)*

**Performance curves and waveforms are tested on the evaluation board, $V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, $C_{OUT}$ = 2 x 47μF, L = 4.7μH, $f_{SW}$ = 410kHz, $T_A$ = 25°C, unless otherwise noted.**

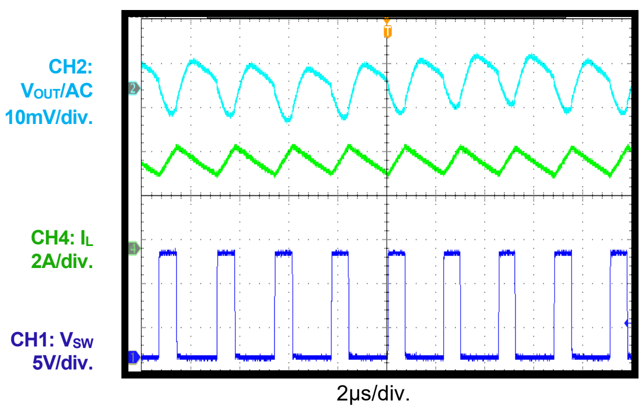
**Steady State**
$I_{OUT}$ = 0A, AAM mode



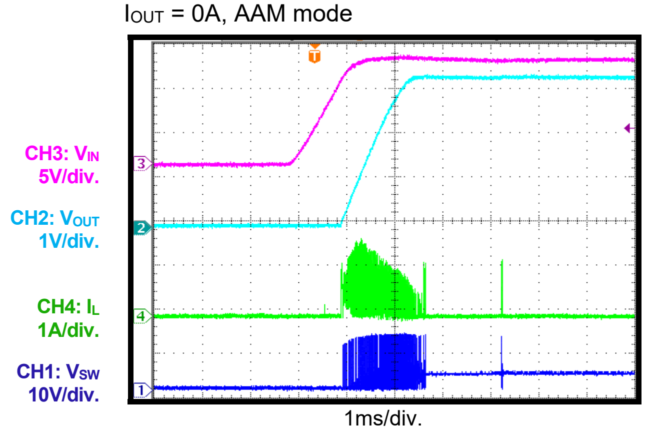

**Steady State**
$I_{OUT}$ = 0A, FCCM



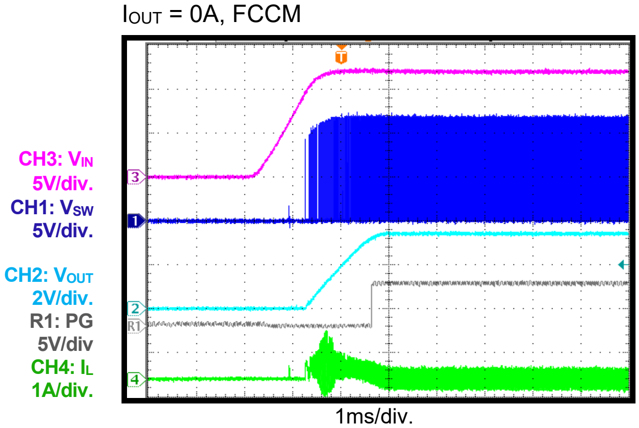

**Steady State**
$I_{OUT}$ = 4A



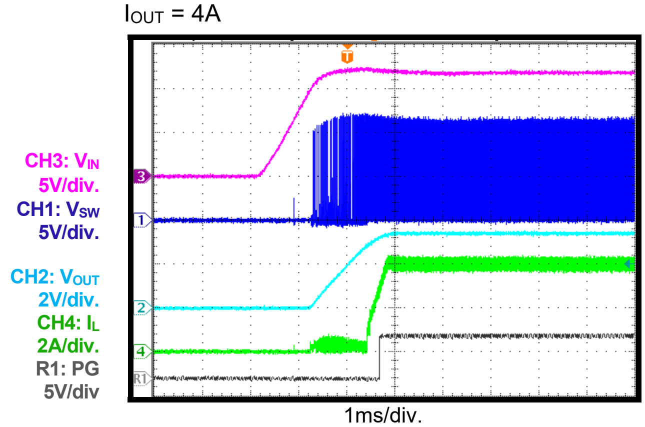

**Start-Up through VIN**
$I_{OUT}$ = 0A, AAM mode




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



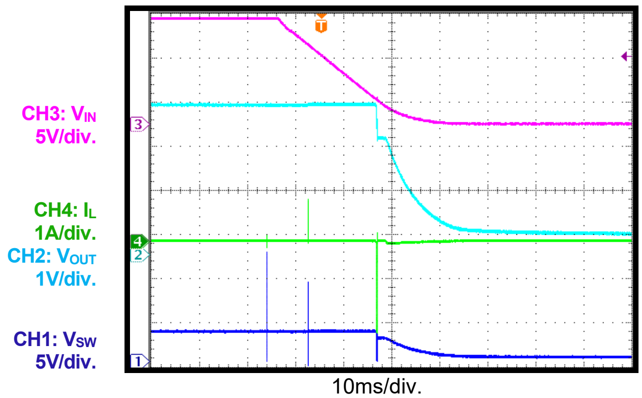

**Start-Up through VIN**
$I_{OUT}$ = 4A



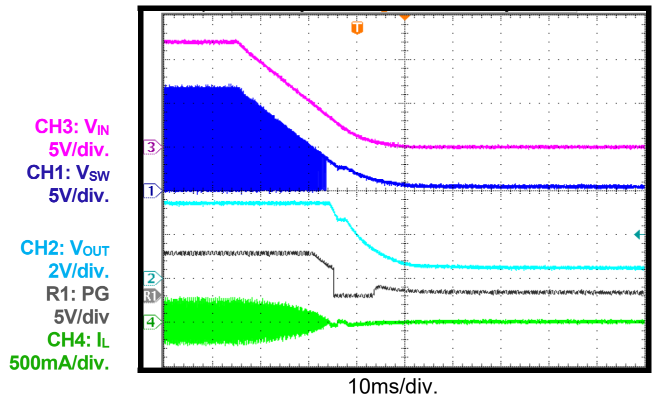
## EVB TEST RESULTS *(continued)*

**Performance curves and waveforms are tested on the evaluation board, $V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, $C_{OUT}$ = 2 x 47µF, L = 4.7µH, $f_{SW}$ = 410kHz, $T_A$ = 25°C, unless otherwise noted.**

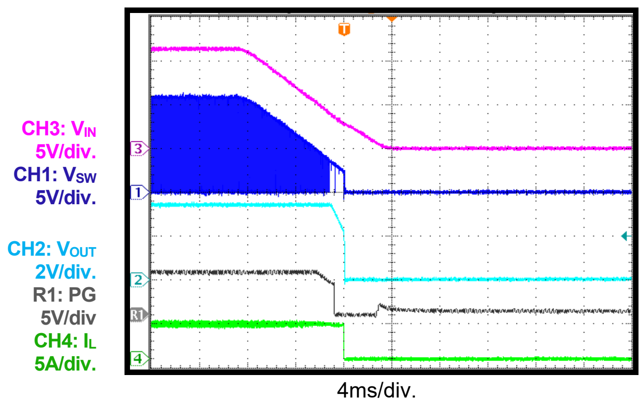
**Shutdown through VIN**
$I_{OUT}$ = 0A, AAM mode



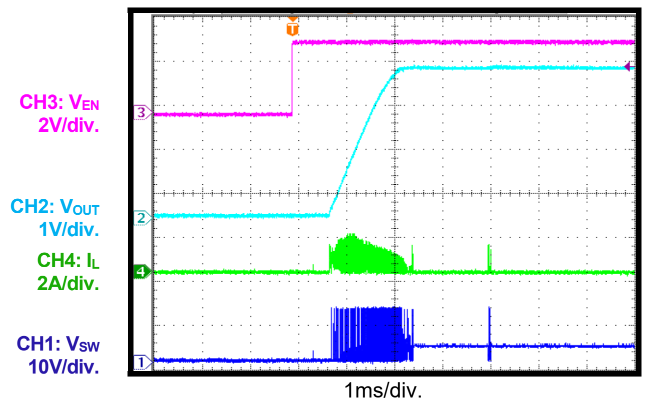

**Shutdown through VIN**
$I_{OUT}$ = 0A, FCCM



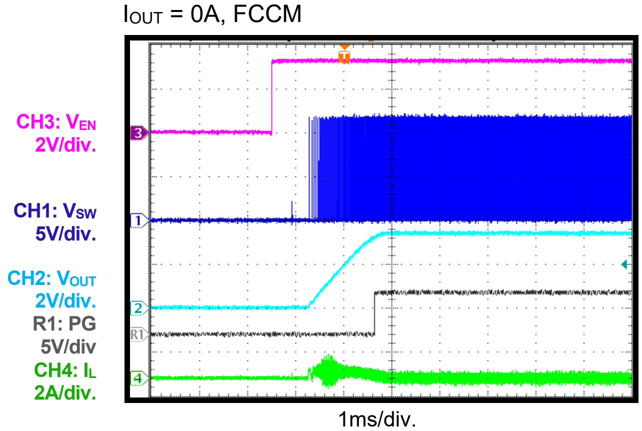

**Shutdown through VIN**
$I_{OUT}$ = 4A



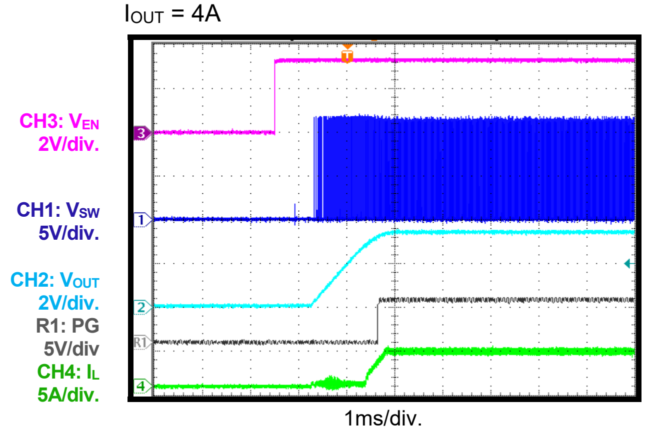

**Start-Up through EN**
$I_{OUT}$ = 0A, AAM mode




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



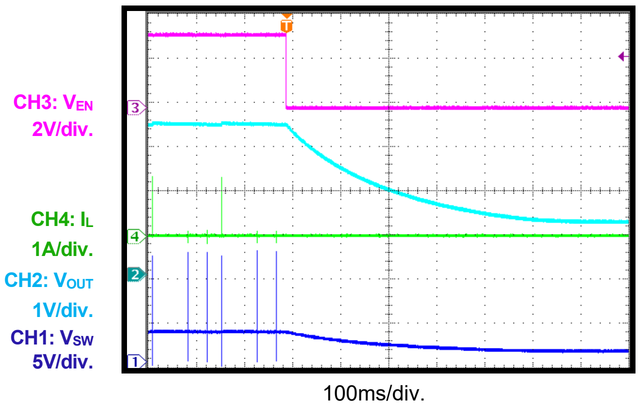

**Start-Up through EN**
$I_{OUT}$ = 4A



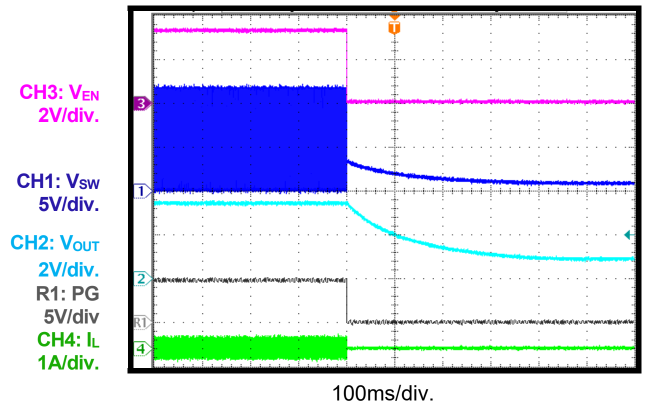
## EVB TEST RESULTS *(continued)*

**Performance curves and waveforms are tested on the evaluation board, $V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, $C_{OUT}$ = 2 x 47μF, L = 4.7μH, $f_{SW}$ = 410kHz, $T_A$ = 25°C, unless otherwise noted.**

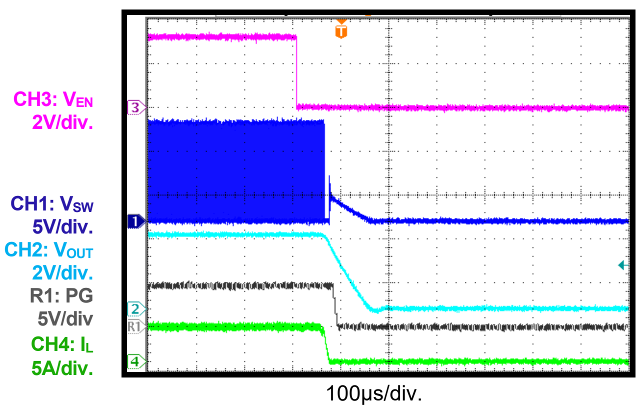
**Shutdown through EN**
$I_{OUT}$ = 0A, AAM mode



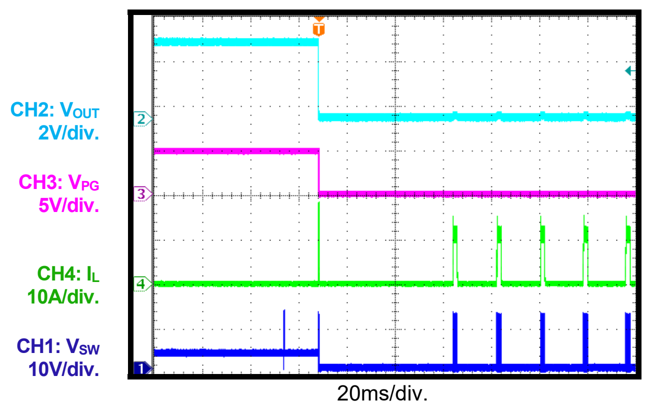

**Shutdown through EN**
$I_{OUT}$ = 0A, FCCM



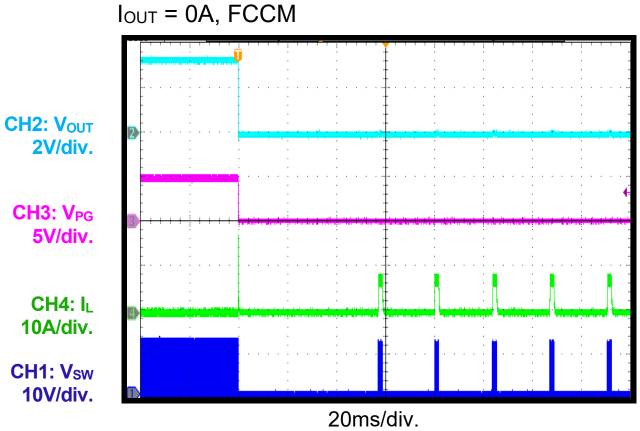

**Shutdown through EN**
$I_{OUT}$ = 4A



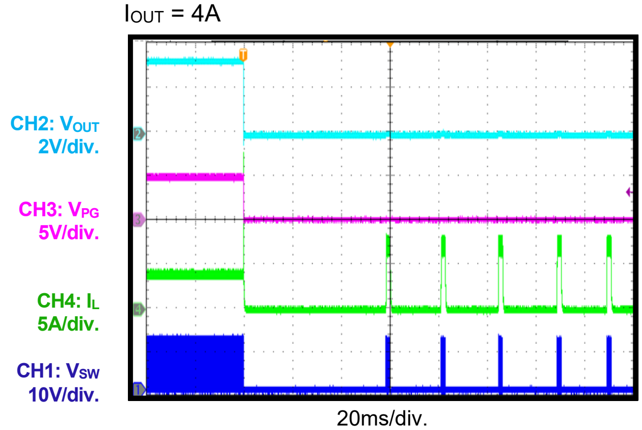

**SCP Entry**
$I_{OUT}$ = 0A, AAM mode




**SCP Entry**
$I_{OUT}$ = 0A, FCCM



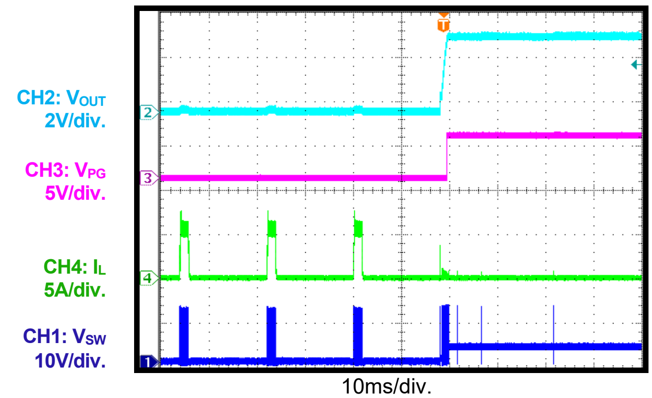

**SCP Entry**
$I_{OUT}$ = 4A



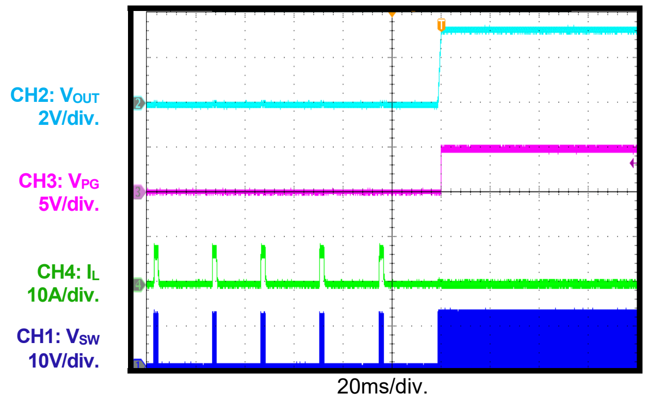
## EVB TEST RESULTS *(continued)*

**Performance curves and waveforms are tested on the evaluation board, $V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, $C_{OUT}$ = 2 x 47µF, L = 4.7µH, $f_{SW}$ = 410kHz, $T_A$ = 25°C, unless otherwise noted.**

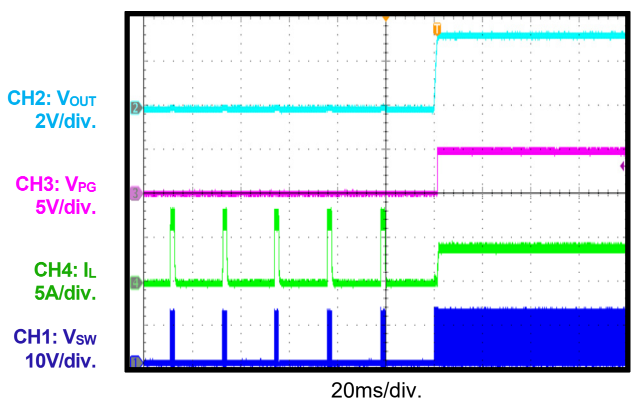
**SCP Recovery**
$I_{OUT}$ = 0A, AAM mode



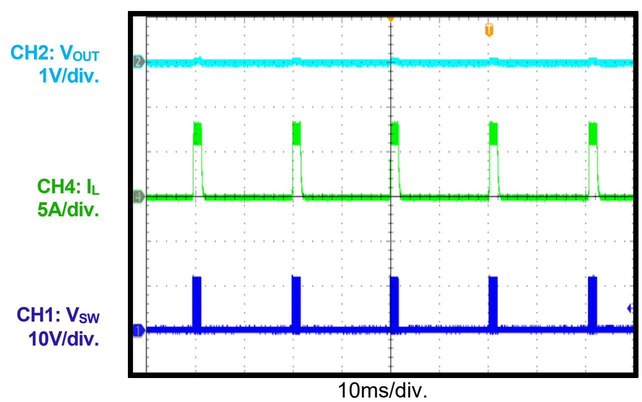

**SCP Recovery**
$I_{OUT}$ = 0A, FCCM



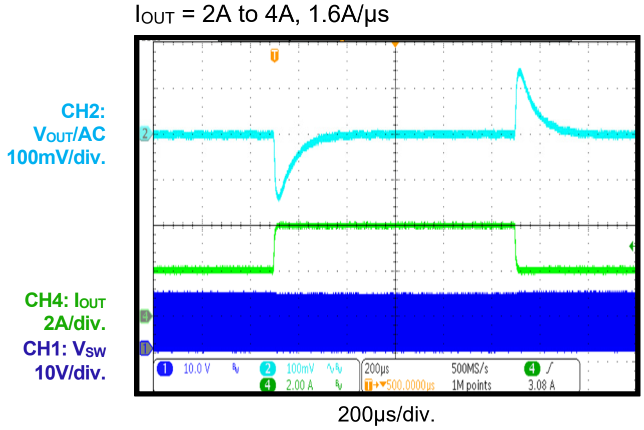

**SCP Recovery**
$I_{OUT}$ = 4A



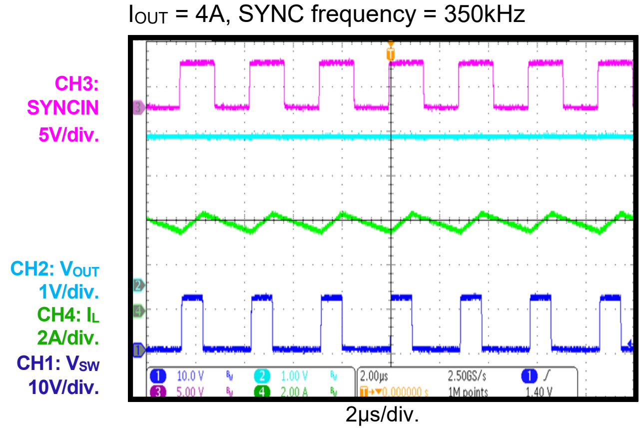

**SCP Steady State**




**Load Transient**
$I_{OUT}$ = 2A to 4A, 1.6A/µs




**SYNC Operation**
$I_{OUT}$ = 4A, SYNC frequency = 350kHz

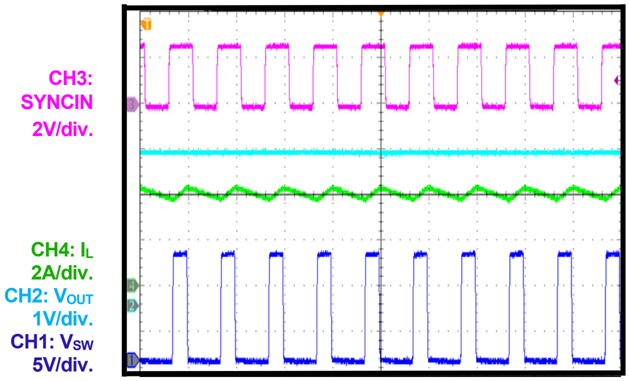


## EVB TEST RESULTS *(continued)*

**Performance curves and waveforms are tested on the evaluation board, $V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, $C_{OUT}$ = 2 x 47µF, L = 4.7µH, $f_{SW}$ = 410kHz, $T_A$ = 25°C, unless otherwise noted.**

**SYNC Operation**

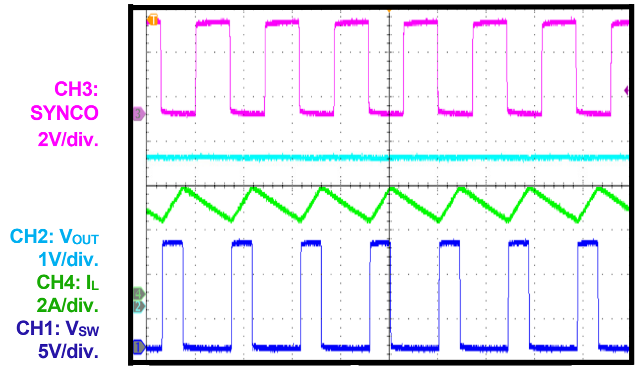
$I_{OUT}$ = 4A, SYNC frequency = 1000kHz




1µs/div.

**SYNCO Operation**

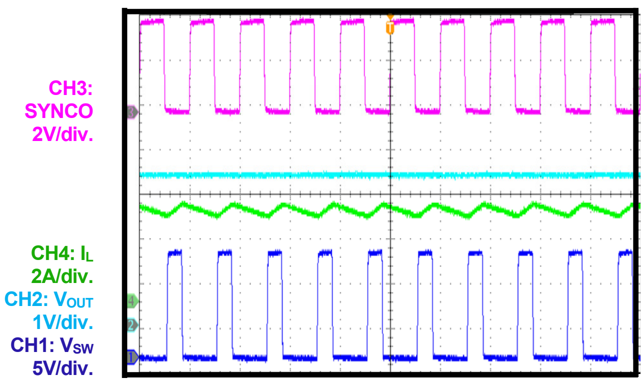
$I_{OUT}$ = 4A, SYNC frequency = 350kHz




2µs/div.

**SYNCO Operation**

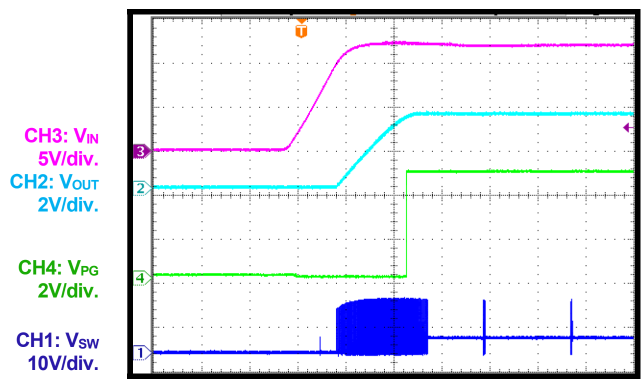
$I_{OUT}$ = 4A, SYNC frequency = 1000kHz




1µs/div.

**PG in Start-Up through VIN**

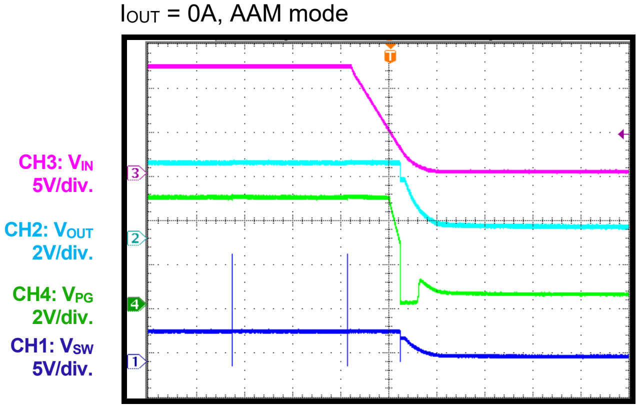
$I_{OUT}$ = 0A, AAM mode




1ms/div.

**PG in Shutdown through VIN**

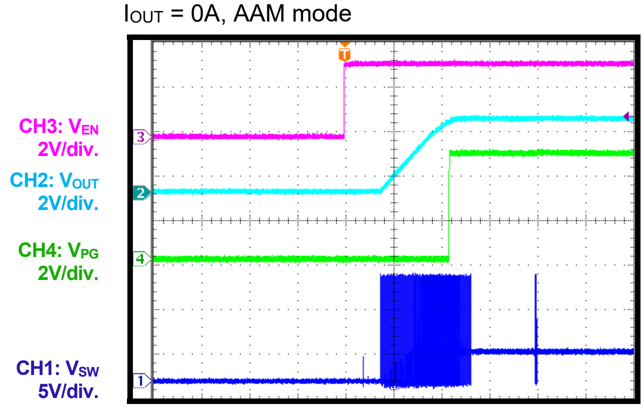
$I_{OUT}$ = 0A, AAM mode




20ms/div.

**PG in Start-Up through EN**

$I_{OUT}$ = 0A, AAM mode




1ms/div.

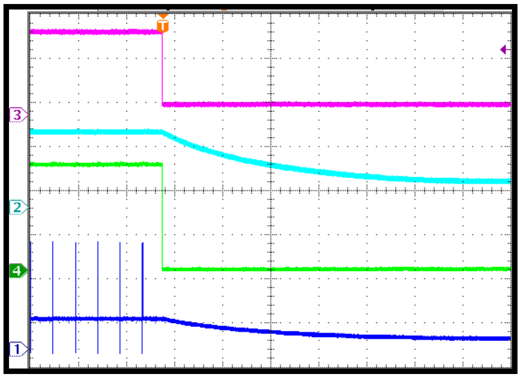
## EVB TEST RESULTS *(continued)*

**Performance curves and waveforms are tested on the evaluation board, $V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, $C_{OUT}$ = 2 x 47µF, L = 4.7µH, $f_{SW}$ = 410kHz, $T_A$ = 25°C, unless otherwise noted.**

### PG in Shutdown through EN

$I_{OUT}$ = 0A, AAM mode

CH3: $V_{EN}$ 2V/div.
CH2: $V_{OUT}$ 2V/div.
CH4: $V_{PG}$ 2V/div.
CH1: $V_{SW}$ 5V/div.

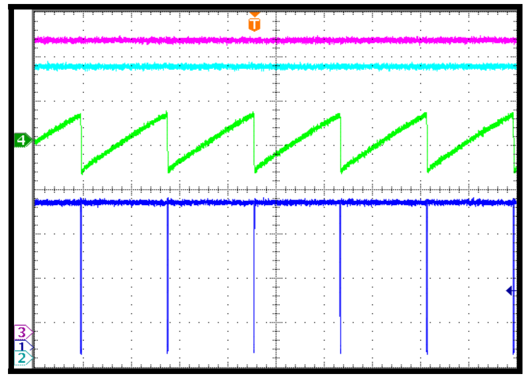


100ms/div.

### Low-Dropout Mode

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

CH4: $I_L$ 50mA/div.
CH3: $V_{IN}$ 500mV/div.
CH1: $V_{SW}$ 1V/div.
CH2: $V_{OUT}$ 500mV/div.

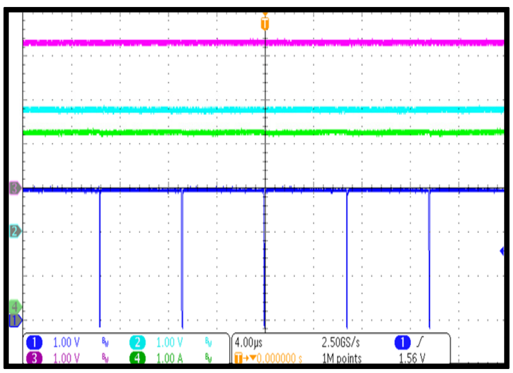


4µs/div.

### Low-Dropout Mode

$V_{IN}$ = 3.3V, $V_{OUT}$ set to 3.3V, $I_{OUT}$ = 4A

CH3: $V_{IN}$ 1V/div.
CH2: $V_{OUT}$ 1V/div.
CH4: $I_L$ 1A/div.
CH1: $V_{SW}$ 1V/div.

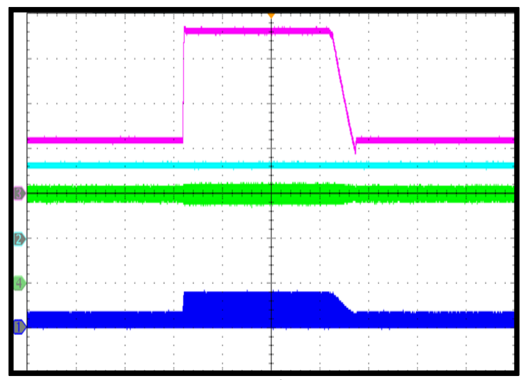


4µs/div.

### Load Dump

$V_{IN}$ = 12V to 36V, $I_{OUT}$ = 4A

CH3: $V_{IN}$ 10V/div.
CH2: $V_{OUT}$ 2V/div.
CH4: $I_L$ 2A/div.
CH1: $V_{SW}$ 50V/div.

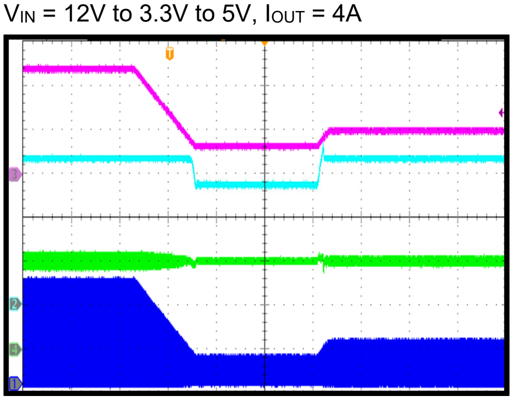


100ms/div.

### Cold Crank

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

CH3: $V_{IN}$ 5V/div.
CH2: $V_{OUT}$ 1V/div.
CH4: $I_L$ 2A/div.
CH1: $V_{SW}$ 5V/div.

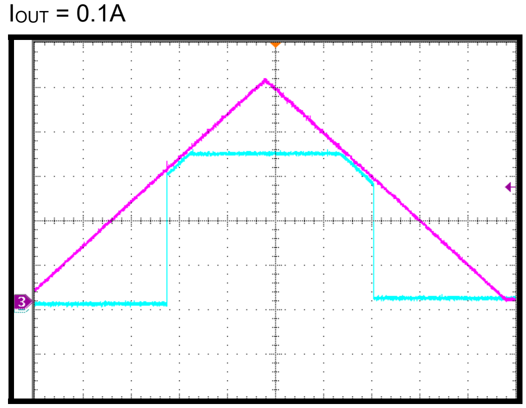


4ms/div.

### $V_{IN}$ Ramping Up and Down

$I_{OUT}$ = 0.1A

CH3: $V_{IN}$ 1V/div.
CH2: $V_{OUT}$ 1V/div.



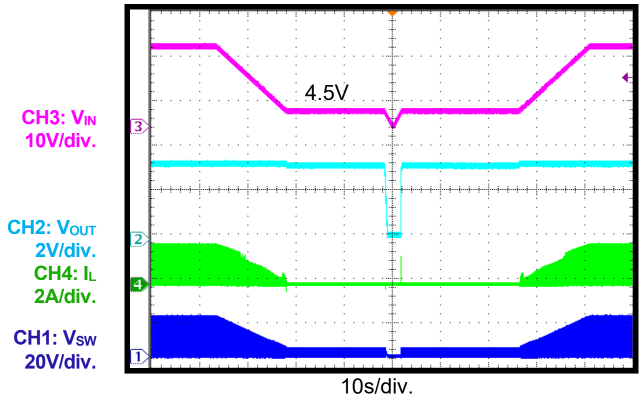
1s/div.

## EVB TEST RESULTS *(continued)*

**Performance curves and waveforms are tested on the evaluation board, $V_{IN}$ = 12V, $V_{OUT}$ = 3.3V, $C_{OUT}$ = 2 x 47µF, L = 4.7µH, $f_{SW}$ = 410kHz, $T_A$ = 25°C, unless otherwise noted.**

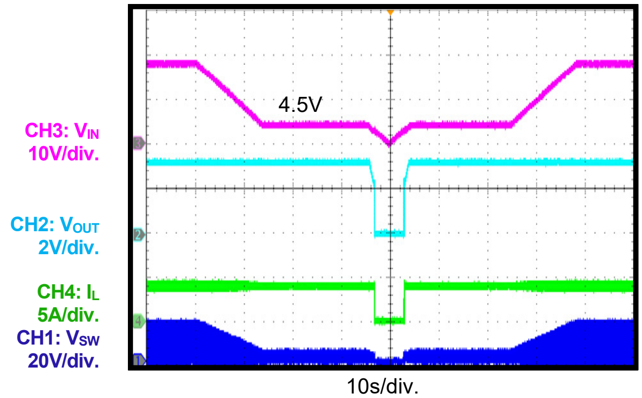
**$V_{IN}$ Ramping Down and Up**

$I_{OUT}$ = 1mA




**$V_{IN}$ Ramping Down and Up**

$I_{OUT}$ = 4A



## PCB LAYOUT (2)

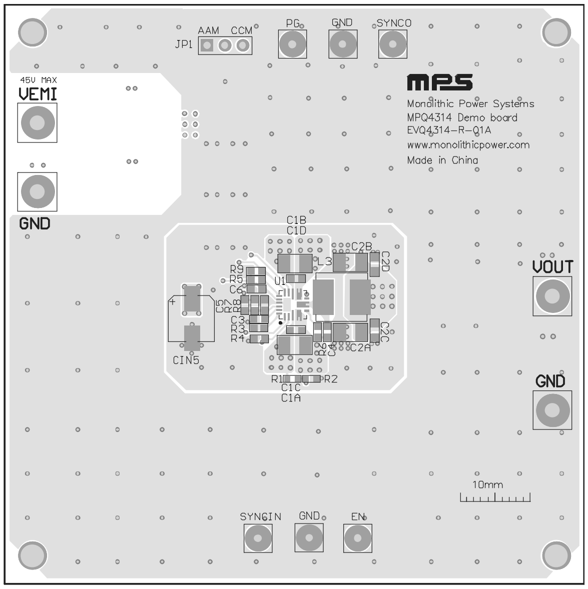



Figure 4: Top Silk and Top Layer

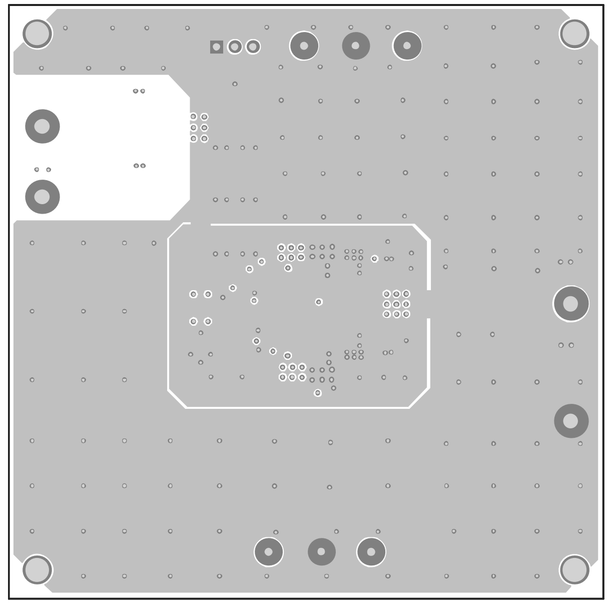


Figure 5: Mid-Layer 1

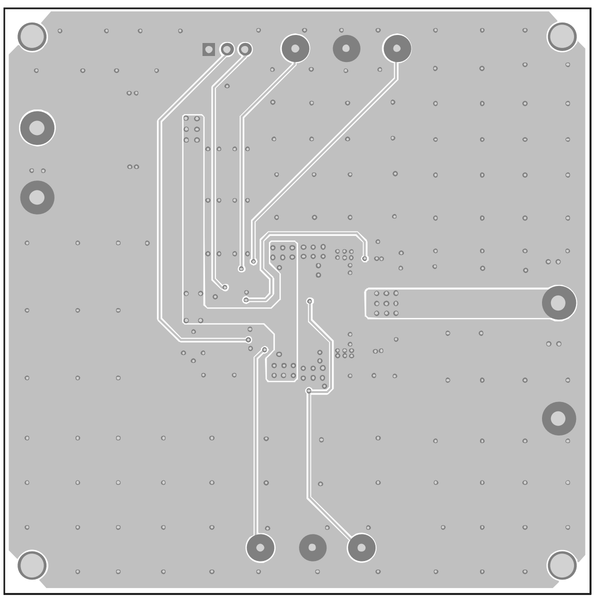


Figure 6: Mid-Layer 2

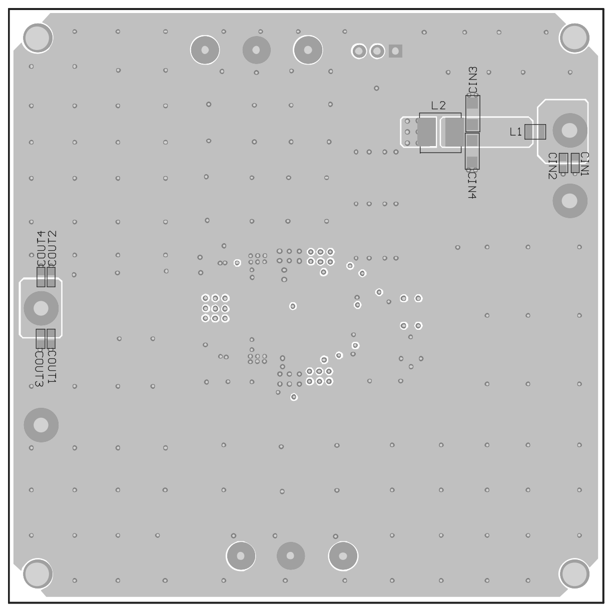



Figure 7: Bottom Layer and Bottom Silk

**Note:**

2) The copper thickness is 2oz.

## REVISION HISTORY

| Revision # | Revision Date | Description | Pages Updated |
|---|---|---|---|
| 1.0 | 3/21/2022 | Initial Release | - |

**Notice:** The information in this document is subject to change without notice. Please contact MPS for current specifications. Users should warrant and guarantee that third-party Intellectual Property rights are not infringed upon when integrating MPS products into any application. MPS will not assume any legal responsibility for any said applications.