

## DESCRIPTION

The EV4068-N-00A Evaluation Board is designed to demonstrate the capabilities of MP4068. The MP4068 is a highly integrated TRIAC dimmable LED driver with high power factor. It is specifically designed for low-line input (120VAC), no-isolated, TRIAC-dimmable LED lighting applications, especially for the low cost and small form factor applications.

The integrated 500V MOSFET ensures the system to withstand 500V surge test without MOV or TVS. Only a single winding inductor is required to realize the solution. It features MPS's proprietary hybrid operation mode which is designed to achieve good dimming performance.

The EV4068-N-00A is typically designed for driving an 8W TRIAC dimmable LED bulb with 50V<sub>TYP</sub>, 160mA LED load from 108VAC to 132VAC, 60Hz.

The EV4068-N-00A has an excellent efficiency and meets IEC61547 surge immunity, IEC61000-3-2 Class C harmonics and EN55015 conducted EMI requirements. It has multi-protection function as over-voltage protection; output short-circuit protection, thermal shut down, etc.

## ELECTRICAL SPECIFICATION

| Parameter              | Symbol           | Value      | Units |
|------------------------|------------------|------------|-------|
| Input Voltage          | V <sub>IN</sub>  | 108 to 132 | VAC   |
| Output Voltage         | V <sub>OUT</sub> | 50         | V     |
| LED Current            | I <sub>LED</sub> | 160        | mA    |
| Output Power           | P <sub>OUT</sub> | 8          | W     |
| Efficiency (full load) | η                | >86        | %     |
| Power Factor           | PF               | >0.88      |       |
| THD                    | THD              | <46        | %     |

## FEATURES

- Excellent TRIAC Dimming Performance
- Lowest Cost BOM
- Constant Current LED Driver
- Good LED Current Accuracy
- 500V MOSFET Integrated
- Internal HV Fast Start-Up
- Single Winding Inductor
- High Power Factor(>0.88)
- High Efficiency (>86%)
- LED Current Foldback at High Temperature
- Thermal Shutdown (Auto Restart with Hysteresis)
- VCC Under Voltage Lockout with Hysteresis (UVLO)
- Programmable Over Voltage Protection
- Output Short Circuit Protection
- Fit inside GU10 Bulb Enclosure

## APPLICATIONS

- Solid State Lighting
- Industrial & Commercial Lighting
- Residential Lighting

All MPS parts are lead-free, halogen free, and adhere to the RoHS directive. For MPS green status, please visit MPS website under Quality Assurance.

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**Warning:** Although this board is designed to satisfy safety requirements, the engineering prototype has not been agency approved. Therefore, all testing should be performed using an isolation transformer to provide the AC input to the prototype board.

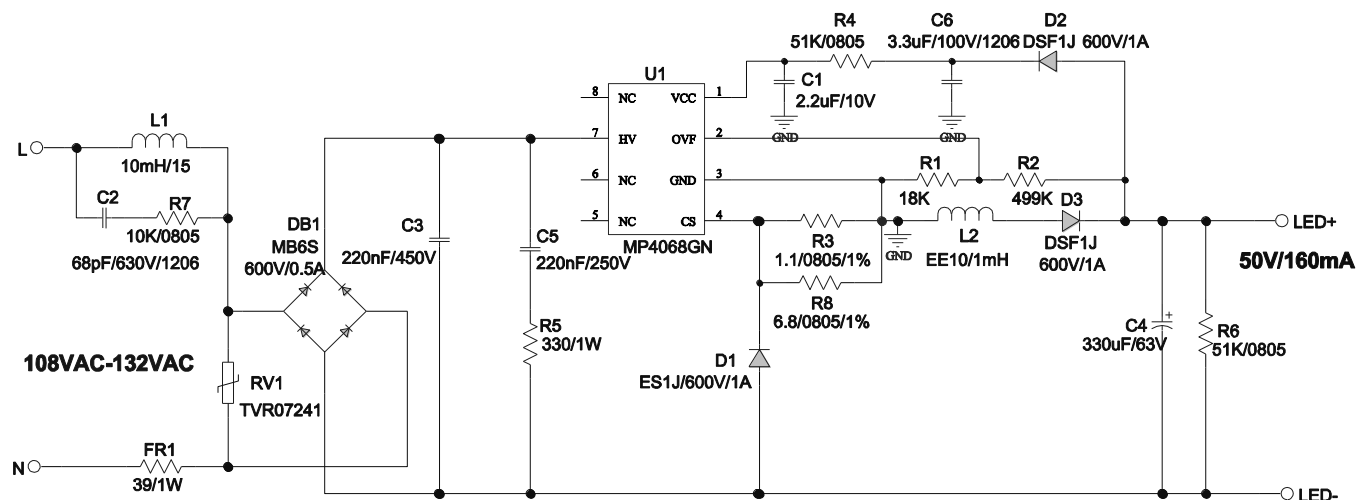
# EV4068-N-00A EVALUATION BOARD



**(L x W x H) 35mm x 23mm x 15mm**

| Board Number | MPS IC Number |
|--------------|---------------|
| EV4068-N-00A | MP4068GN      |

## EVALUATION BOARD SCHEMATIC



### Figure 1—Schematic

## PCB LAYOUT (SINGLE-SIDED)

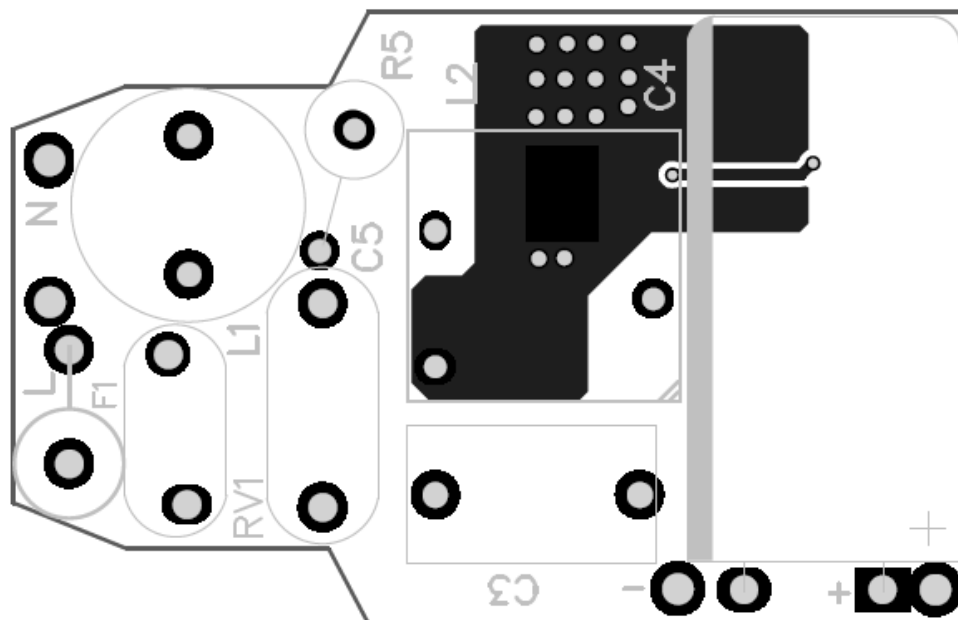


Figure 2—Top Layer

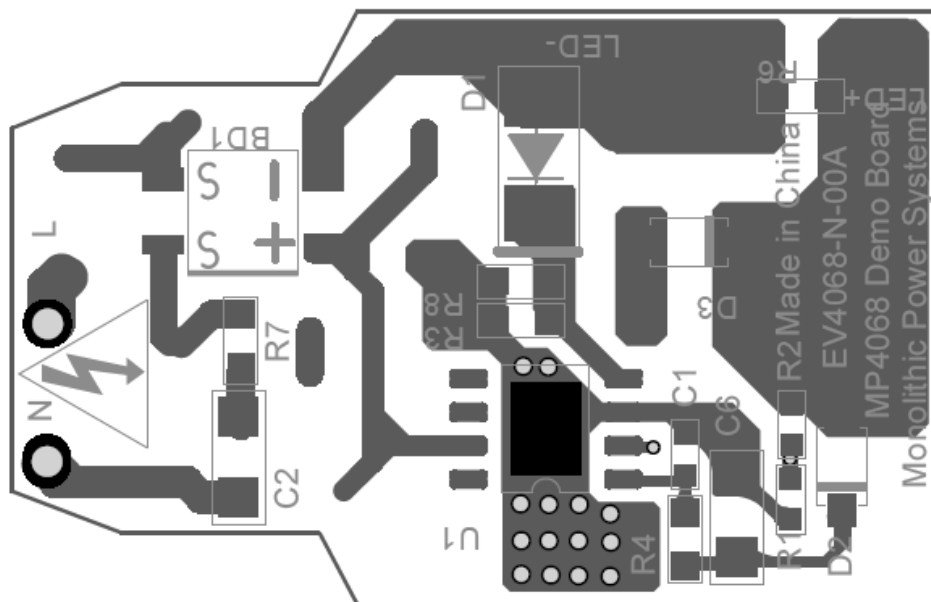


Figure 3—Bottom Layer

## CIRCUIT DESCRIPTION

The EV4068-N-00A is configured in a single-stage Buck topology and gets a cost effective BOM. It also achieves high power factor and excellent TRIAC dimming performance.

FR1, RV1, L1, R7, C2, and BD1 compose the input stage. The fusible resistor FR1 fuses the AC input to protect for the component failure or some excessive short events, its resistance is also used as a passive damper of dimming. RV1 is used for surge test. L1, R7 and C2 associated with C3 form an EMI filter. The diode rectifier BD1 rectifies the input line voltage.

R5, C5 are used as a bleeder circuit which keeping the TRIAC current above the minimum holding current after TRIAC turns on.

R4, D2, C1 and C6 are used to supply the power for MP4068. At normal work, the power is charged by the internal high voltage regulator from HV pin. But in deep dimming condition, the

power may not be enough supplied only by the high voltage regulator, the diode D2 connected to output will help maintain the power supply voltage .

R1 and R2 are used to monitor the output OVP condition. The OVP voltage is set by the divider ratio of R1 and R2.

R3, R8 are sensing resistors for LED current control. The value of R3 and R8 set the output LED current.

Diode D1 is the Buck fly-wheel diode, the inductor L2 and the capacitor C4 are the output filter. The resistor R6 is placed as a dummy load to consume the output power in open load condition. The diode D3 is used to prevent the output current flowing back to IC when input Sine voltage drops lower than output voltage.

**EV4068-N-00A BILL OF MATERIALS**

| Qty | Ref            | Value      | Description                            | Package   | Manufacturer         | Manufacture_P/N    |
|-----|----------------|------------|----------------------------------------|-----------|----------------------|--------------------|
| 1   | C1             | 2.2μF/10V  | Ceramic Cap, 10V, X7R                  | 0603      | muRata               | GRM188R71A225KE15D |
| 1   | C2             | 68pF/630V  | Ceramic Cap, 630V, C0G                 | 1206      | muRata               | GRM31A7U2J680JW31D |
| 1   | C3             | 220nF/450V | CBB, 450V                              | DIP       | Fara                 | C222S224K31C000    |
| 1   | C4             | 330μF/63V  | Electrolytic Capacitor, 63V            | DIP       | Jianghai             | CD263-63V330       |
| 1   | C5             | 220nF/250V | CBB, 250V                              | DIP       | Fara                 | C222E224K30C000    |
| 1   | C6             | 3.3μF/100V | Ceramic Cap, 100V, X7S                 | 1206      | TDK                  | C3216X7S2A335K     |
| 1   | BD1            | MB6S       | Rectifier Bridge, 600V, 0.5A           | SOIC-4    | Taiwan Semiconductor | MB6S               |
| 1   | D1             | ES1J       | Diode, 1A, 600V                        | SMA       | Taiwan Semiconductor | ES1J               |
| 2   | D2, D3         | DSF1J      | Diode, 1A, 600V                        | SOD-123FL | SXY                  | DSF1J              |
| 1   | F1             | 39Ω/1W     | Fusible Res, 5%, 1W                    | DIP       | Yageo                | FKN1WSJT-52-39R    |
| 1   | L1             | 10mH       | Inductor                               | DIP       | Hulsin               | HDR0810-103K-N5    |
| 1   | L2             | 1mH        | Inductor, Φ0.23mm, 180 turns           | EE10      | Emei                 |                    |
| 1   | R1             | 18kΩ       | Thick Film Chip Res, 1%                | 0603      | Yageo                | RC0603FR-0718KL    |
| 1   | R2             | 499kΩ      | Thick Film Chip Res, 1%                | 0603      | Yageo                | RC0603FR-07499KL   |
| 1   | R3             | 1.1Ω       | Thick Film Chip Res, 1%                | 0805      | Yageo                | RC0805FR-071R1L    |
| 1   | R8             | 6.8Ω       | Thick Film Chip Res, 1%                | 0805      | Yageo                | RC0805FR-076R8L    |
| 2   | R4, R6         | 51kΩ       | Thick Film Chip Res, 5%                | 0805      | Yageo                | RC0805JR-0751KL    |
| 1   | R5             | 330Ω/1W    | Metal Film Res, 1W, 5%                 | DIP       | Any                  | Any                |
| 1   | R7             | 10kΩ       | Thick Film Chip Res, 5%                | 0805      | Yageo                | RC0805JR-0710KL    |
| 1   | RV1            | TVR07241   | MOV                                    | DIP       | TKS                  | TVR07241           |
| 1   | U1             | MP4068GN   | Triac-dimmable LED Lighting Controller | SOIC-8 EP | MPS                  | MP4068N-CU10 R4    |
| 4   | L,N,L ED+, LED | 1.0 公针     |                                        |           |                      | 1.0 公针             |

## TRANSFORMER SPECIFICATION

### Electrical Diagram

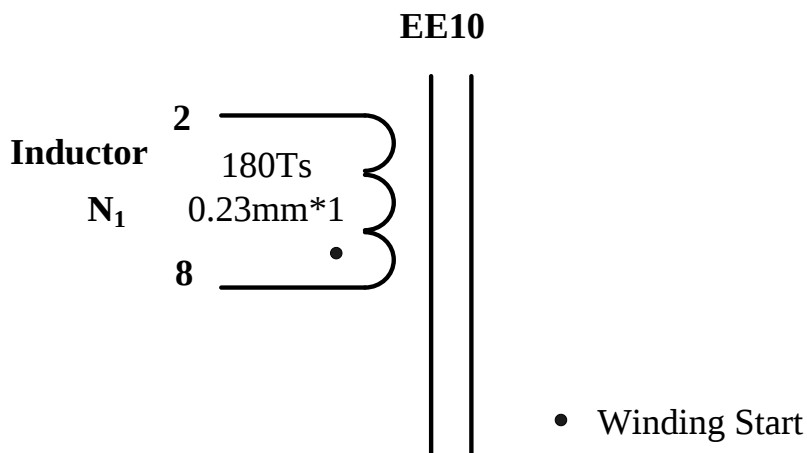


Figure 4—Transformer Electrical Diagram

### Winding Diagram

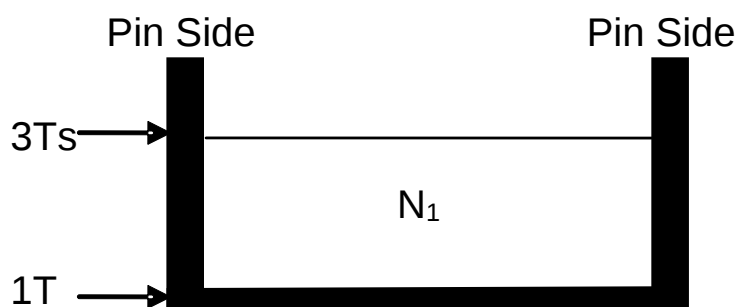


Figure 5—Winding Diagram

## Winding Order

| Winding No. | Tape Layer Number | Start & End | Magnet Wire $\Phi$ (mm) | Turns |
|-------------|-------------------|-------------|-------------------------|-------|
|             | 1                 |             |                         |       |
| N           | 3                 | 8→2         | 0.23mm * 1              | 180   |

## Electrical Specifications

|                     |                                                                   |         |
|---------------------|-------------------------------------------------------------------|---------|
| Electrical Strength | 60 second, 60Hz, from Winding to CORE.                            | 1000VAC |
| Primary Inductance  | Pins 2 - 8, all other windings open, measured at 100kHz, 0.1 VRMS | 1mH±8%  |

## Materials

| Item | Description                                                                       |
|------|-----------------------------------------------------------------------------------|
| 1    | Core: EE10, UI=2500±25%, AL=221.5H/N <sup>2</sup> ± 2% GAP, ACME P4 or equivalent |
| 2    | Bobbin: EE10, 4+4PIN RMMOVE PIN1,3,4,5,7                                          |
| 3    | Wire: $\Phi$ 0.23mm, 2UEW, CLASS F or equivalent                                  |
| 4    | Tape: 6.5mm(W)×0.06mm(TH)                                                         |
| 5    | Varnish: JOHN C. DOLPH CO, BC-346A or equivalent                                  |
| 6    | Solder Bar: CHEN NAN: SN99.5/Cu0.5 or equivalent                                  |

## EVB TEST RESULTS

### Performance Data

#### Efficiency, PF and THD

| f (Hz) | Vin(V) | Pin(W) | Vo(V) | Io (mA) | Po(W) | Efficiency (%) | PF    | THD (%) |
|--------|--------|--------|-------|---------|-------|----------------|-------|---------|
| 60     | 108    | 8.84   | 49.4  | 155     | 7.66  | 86.6           | 0.931 | 34.9    |
|        | 120    | 9.31   | 49.5  | 163     | 8.07  | 86.7           | 0.908 | 40.2    |
|        | 132    | 9.67   | 49.6  | 170     | 8.43  | 87.2           | 0.882 | 45.7    |

#### Dimming Compatibility (No Flicker with these 30 different Dimmers)

| Dimmer No. | Manufacturer | Part No.       | Power Stage                   | I <sub>max</sub> (mA) | I <sub>min</sub> (mA) |
|------------|--------------|----------------|-------------------------------|-----------------------|-----------------------|
| 1          | LUTRON       | Q-600P-IV      | 600W Incandescent             | 150                   | 9                     |
| 2          | LUTRON       | CN-600P        | 600W                          | 131                   | 2                     |
| 3          | LUTRON       | AY-600P        | 600W                          | 131                   | 2                     |
| 4          | LUTRON       | SLV-600P       | 600W                          | 132                   | 2                     |
| 5          | LUTRON       | LG-600P        | 600W                          | 132                   | 2                     |
| 6          | LUTRON       | 6B38-Q-600P    | 600W                          | 133                   | 2                     |
| 7          | LUTRON       | GL-600H-DK     | 600W Incandescent             | 144                   | 1                     |
| 8          | LEVITON      | 1G40O5         | 600W                          | 133                   | 0                     |
| 9          | LEVITON      | 1I20O5         | 600W                          | 156                   | 0                     |
| 10         | LEVITON      | 6633-P         | 600W                          | 153                   | 0                     |
| 11         | LUTRON       | 6B38-S-600P    | 600W                          | 127                   | 2                     |
| 12         | LUTRON       | CT-600P        | 600W                          | 127                   | 3                     |
| 13         | LUTRON       | 6B38-S-603PG   | 600W                          | 100                   | 2                     |
| 14         | LUTRON       | 6B38-DV-600P   | 600W                          | 126                   | 3                     |
| 15         | LUTRON       | DVCL-153P      | 600W                          | 119                   | 34                    |
| 16         | LUTRON       | 6B38-DVLV-600P | 600W                          | 129                   | 4                     |
| 17         | LEVITON      | 1L10O5         | 600W                          | 133                   | 2                     |
| 18         | LUTRON       | GLS01-C06570   | 600W                          | 99                    | 0                     |
| 19         | LUTRON       | DV-600P-BR     | 600W Incandescent             | 127                   | 3                     |
| 20         | LEVITON      | 6613-PL        | 600W Magnetic low voltage     | 151                   | 1                     |
| 21         | LEVITON      | C20-6684-IW    | 600W Incandescent             | 160                   | 0                     |
| 22         | LUTRON       | AY-600P-LA     | 600W Incandescent             | 133                   | 3                     |
| 23         | LUTRON       | TG-600PH-WH    | 600W                          | 130                   | 3                     |
| 24         | LUTRON       | TG-603GH-WH    | 600W                          | 93                    | 3                     |
| 25         | LUTRON       | S-600          | 600W                          | 141                   | 2                     |
| 26         | LUTRON       | DVPDC-203P-WH  | 200W for Philips dimmable CFL | 138                   | 50                    |
| 27         | LUTRON       | S-600P         | 600W                          | 126                   | 2                     |
| 28         | LUTRON       | 6B38-DV-603PG  | 600W                          | 99                    | 3                     |
| 29         | LUTRON       | DNG-603PH-WH   | 400W                          | 120                   | 0                     |
| 30         | COOPER       | 6B28           | 600W                          | 137                   | 0                     |

### Electric Strength Test

Input and output was shorted respectively. 3750VAC/50Hz sine wave applied between input and output for 1min, and operation was verified.

### Surge Test

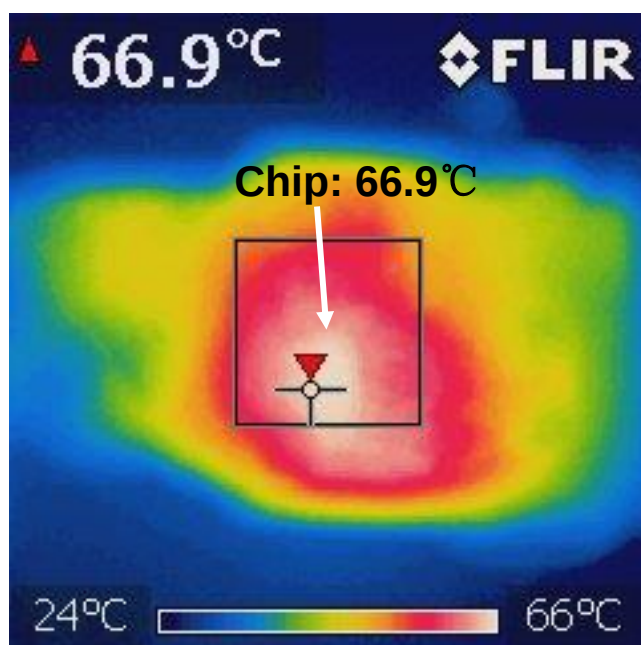
Line to Line 500V surge testing was completed according to IEC61547.

Input voltage was set at 120VAC/60Hz. Output was loaded at full load and operation was verified following each surge event.

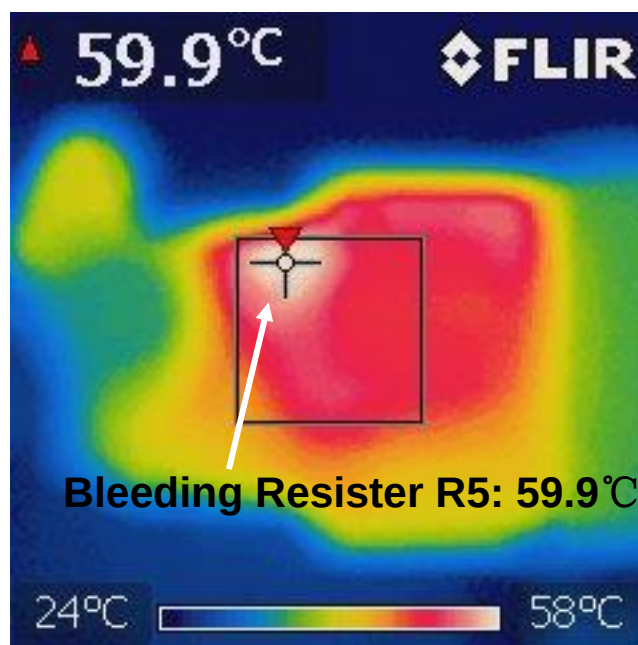
| Surge Level (V) | Input Voltage (VAC) | Injection Location | Injection Phase (°) | Test Result (Pass/Fail) |
|-----------------|---------------------|--------------------|---------------------|-------------------------|
| 500             | 120                 | L to N             | 90                  | Pass                    |
| -500            | 120                 | L to N             | 270                 | Pass                    |

### Thermal Test

Test without dimmer and with dimmer at 50% dimming on phase.



**Without dimmer**



**With dimmer at 50% dimming on phase**

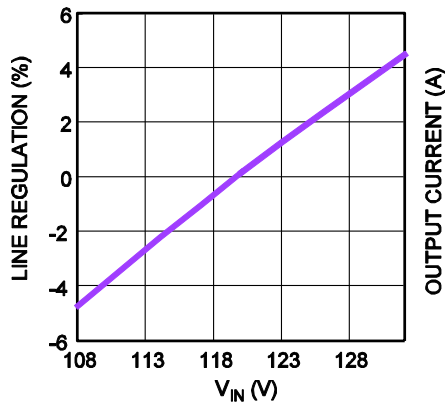
## EVB TEST RESULTS

Performance waveforms are tested on the evaluation board.

$V_{IN}=120V_{AC}/60Hz$ , 16 LEDs in series,  $I_{LED}=160mA$ ,  $V_{OUT}=50V$ ,  $L=1mH$ .

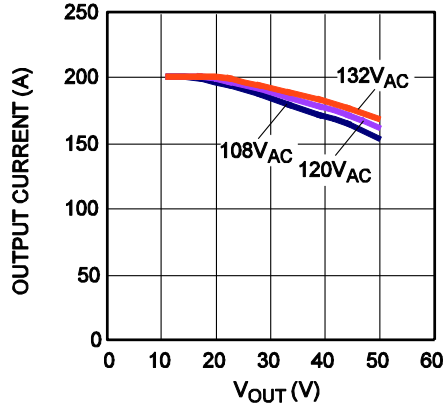
### Line Regulation

$V_{IN}=(108-132)V_{AC}/60Hz$ , Full Load



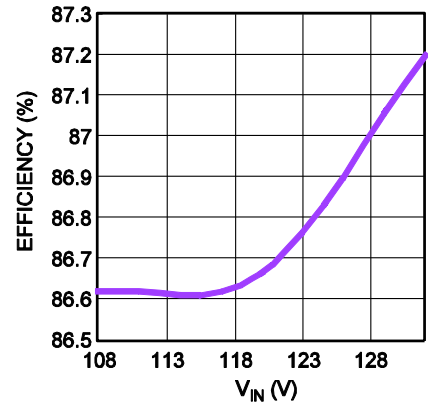
### Load Regulation

$V_{IN}=(108-132)V_{AC}/60Hz$



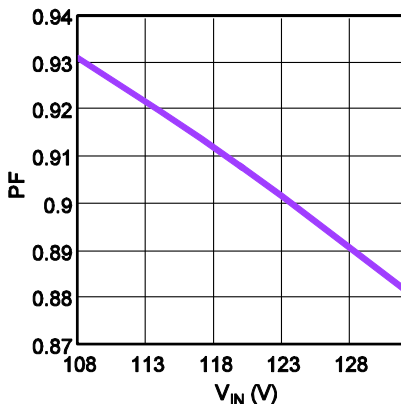
### Efficiency

$V_{IN}=(108-132)V_{AC}/60Hz$ , Full Load



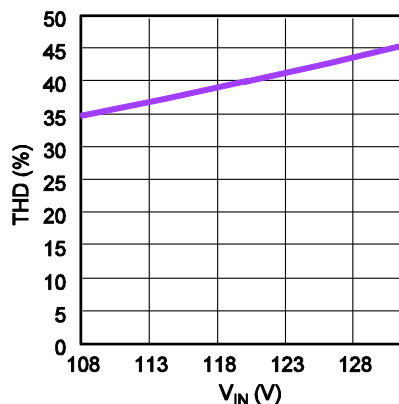
### PF vs. $V_{IN}$

$V_{IN}=(108-132)V_{AC}/60Hz$ , Full Load



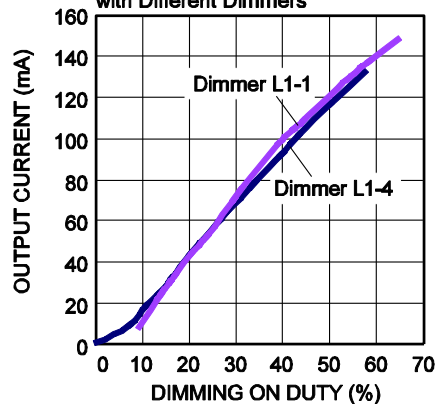
### THD vs. $V_{IN}$

$V_{IN}=(108-132)V_{AC}/60Hz$ , Full Load



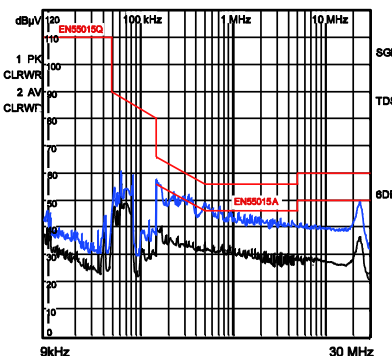
### Dimming Curve

$V_{IN}=120V_{AC}/60Hz$ , Full Load, with Different Dimmers



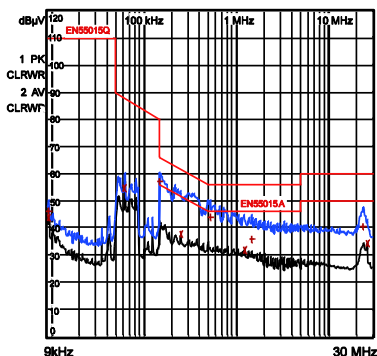
### Conducted EMI, L-Line

$V_{IN}=115V_{AC}/60Hz$ , RBW=9kHz, MT=20ms



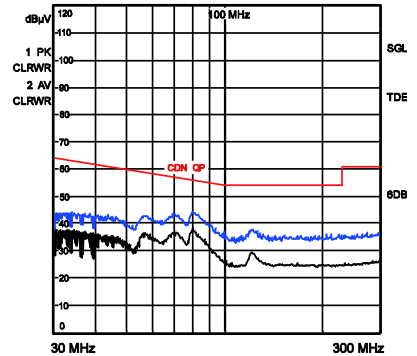
### Conducted EMI, N-Line

$V_{IN}=115V_{AC}/60Hz$ , RBW=9kHz, MT=20ms



### CDN Test

$V_{IN}=115V_{AC}/60Hz$ , RBW=120kHz, MT=1ms



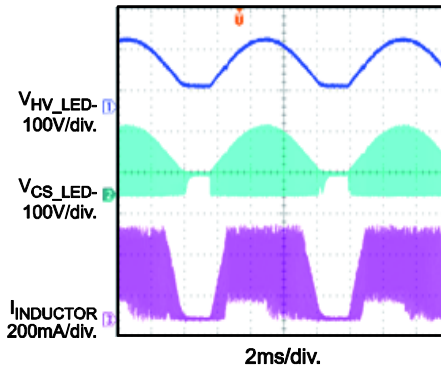
## EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

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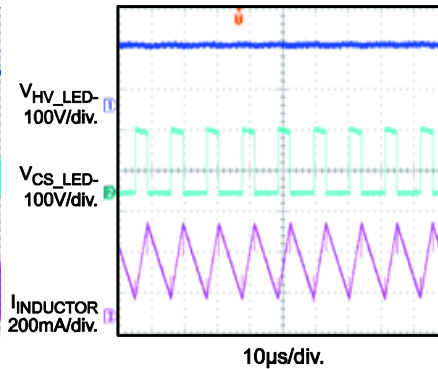
### Steady State

$V_{IN}=120V_{AC}/60Hz$ , Full Load



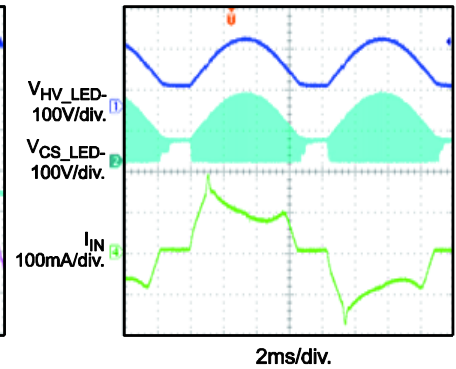
### Steady State

$V_{IN}=120V_{AC}/60Hz$ , Full Load



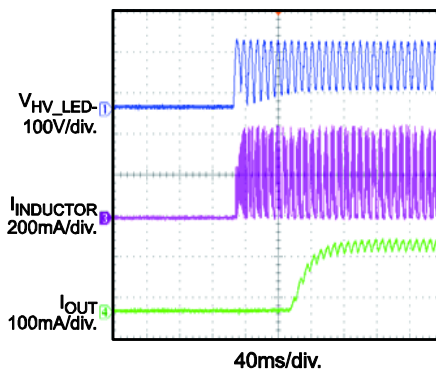
### Steady State

$V_{IN}=120V_{AC}/60Hz$ , Full Load



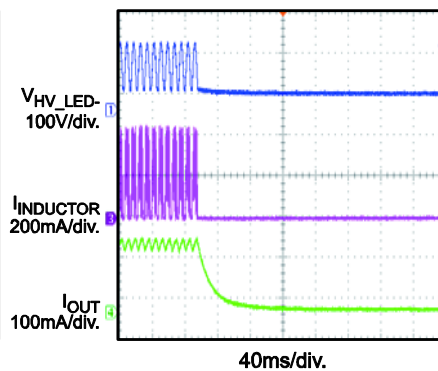
### $V_{IN}$ Start-Up

$V_{IN}=120V_{AC}/60Hz$ , Full Load



### $V_{IN}$ Shutdown

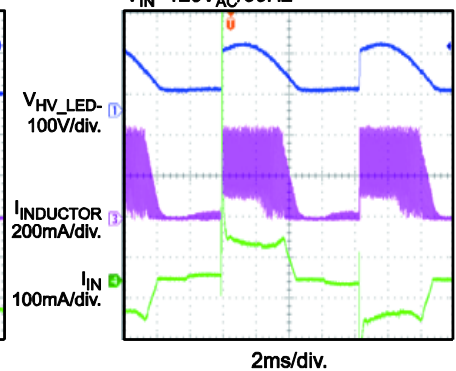
$V_{IN}=120V_{AC}/60Hz$ , Full Load



### Dimming Performance

Max Dimming on Phase with Leading-Edge Dimmer

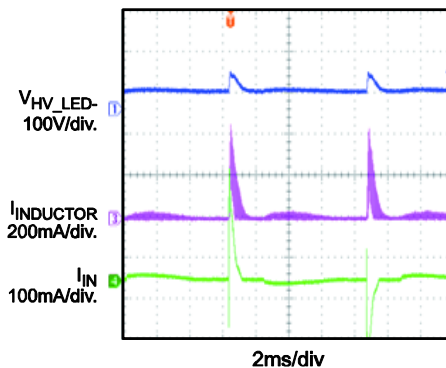
$V_{IN}=120V_{AC}/60Hz$



### Dimming Performance

Min Dimming on Phase with Leading-Edge Dimmer

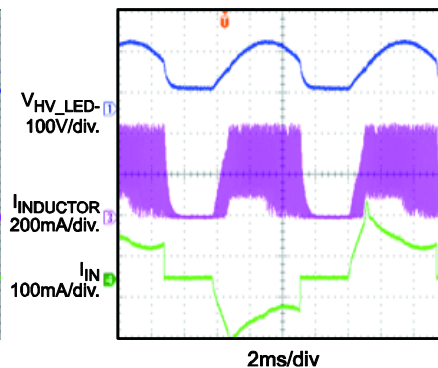
$V_{IN}=120V_{AC}/60Hz$



### Dimming Performance

Max Dimming on Phase with Trailing-Edge Dimmer

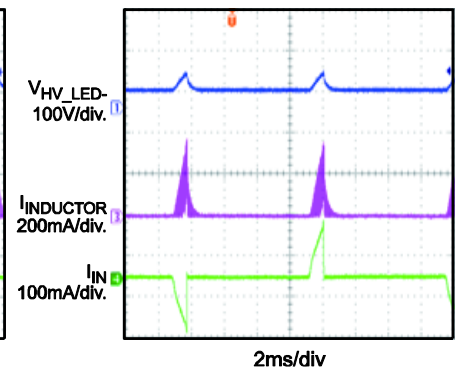
$V_{IN}=120V_{AC}/60Hz$



### Dimming Performance

Min Dimming on Phase with Trailing-Edge Dimmer

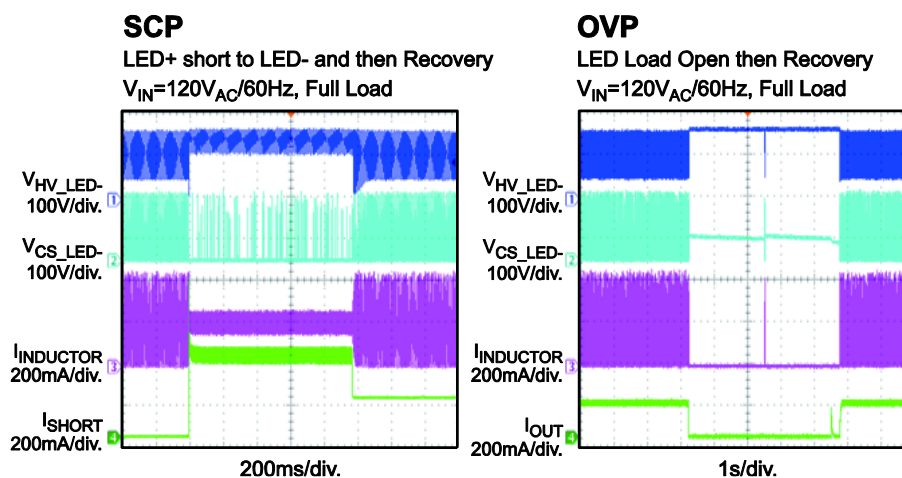
$V_{IN}=120V_{AC}/60Hz$



## EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

$V_{IN}=120V_{AC}/60Hz$ , 16 LEDs in series,  $I_{LED}=160mA$ ,  $V_{OUT}=50V$ ,  $L=1mH$ .



## QUICK START GUIDE

1. Preset AC Power Supply to  $108\text{VAC} \leq V_{\text{IN}} \leq 132\text{VAC}$ .
2. Turn Power Supply off.
3. Connect the LED string between “LED+” (anode of LED string) and “LED-” (cathode of LED string).
4. Connect Power Supply terminals to AC  $V_{\text{IN}}$  terminals (“L” and “N”) as shown on the board.
5. Turn AC Power Supply on after making connections.

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