# EV020-5-S-00C

**85VAC~265VAC/50Hz, 12V/0.3A, 5V/0.1A Off-line Primary-side-Regulator, Dual Outputs Evaluation Board for Small Appliances**

## DESCRIPTION

The EV020-5-S-00C Evaluation Board is designed to demonstrate the capabilities of MP020-5. The MP020-5 is a primary-side-control regulator which can eliminates secondary feedback components.

The EV020-5-S-00C is typically designed for small appliances which output 12V/0.3A and 5V/0.1A load from 85VAC to 265VAC, 50HZ/60HZ.

The EV020-5-S-00C has an excellent efficiency and meets IEC61000-4-5 surge immunity and EN55022 conducted EMI requirements. It has multi-protection function as open circuit protection, short-circuit protection, cycle by cycle current limit and over-temperature protection, etc.

## ELECTRICAL SPECIFICATION

| Parameter | Symbol | Value | Units |
|---|---|---|---|
| Input Voltage | $V_{IN}$ | 85 to 265 | VAC |
| Output Voltage 1 | $V_{OUT1}$ | 12 | V |
| Output Current 1 | $I_{OUT1}$ | 0.3 | A |
| Output Voltage 2 | $V_{OUT2}$ | 5 | V |
| Output Current 2 | $I_{OUT2}$ | 0.1 | A |
| Output Power | $P_{OUT}$ | 4.1 | W |
| Efficiency (full load) | η | >70 | % |

## FEATURES

- Primary-Side–Control without Opto-Coupler or Secondary Feedback Circuit
- Precise Constant Voltage Control (CV)
- Integrated 700V MOSFET with Minimal External Components
- Variable, Off-Time, Peak-Current Control
- 550μA High-Voltage Current Source
- Programmable Cable Compensation (By adding 1μF/25V ceramic cap at CP pin)
- Multiple Protections: OVP, OCP, OCkP, OTP, and VCC UVLO
- Natural Spectrum Shaping for Improved EMI Signature
- Low Cost and Simple External circuit

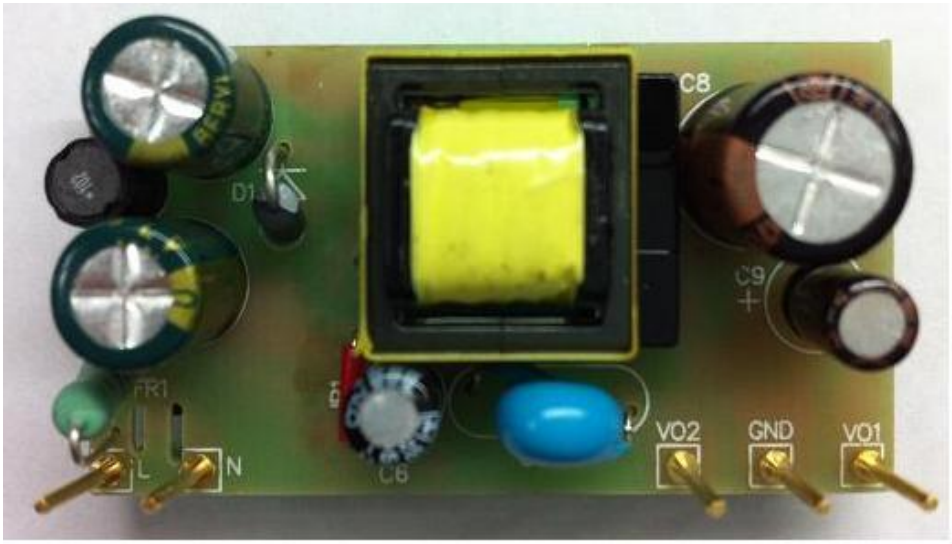
## APPLICATIONS

- Small Appliances




**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.

## EV020-5-S-00C EVALUATION BOARD




**TOP VIEW**


**BOTTOM VIEW**

**(L x W x H) 50mm x 28mm x 17mm**

| Board Number | MPS IC Number |
|---|---|
| EV020-5-S-00C | MP020-5GS |

## EVALUATION BOARD SCHEMATIC

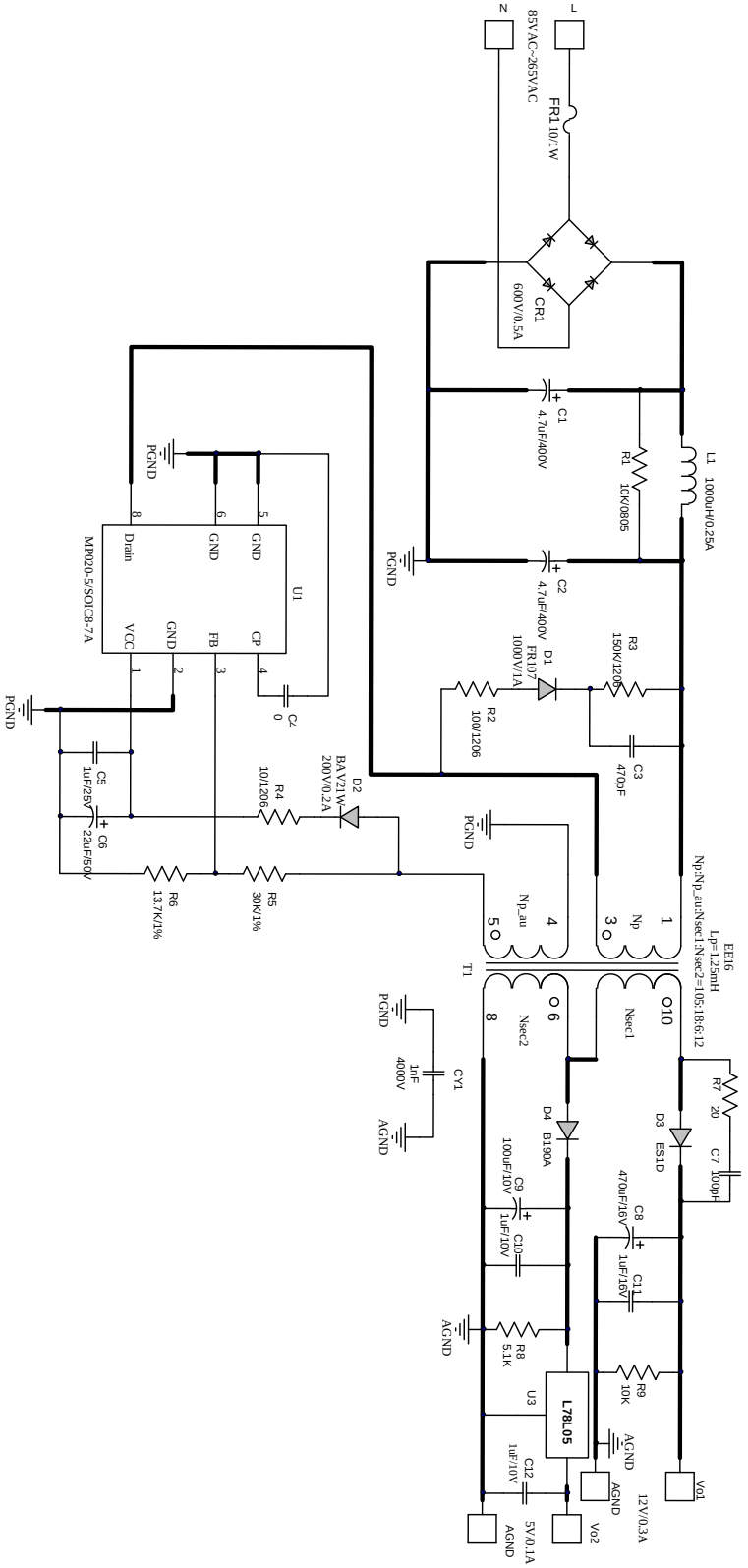



**Figure 1—Schematic**

## PCB LAYOUT (SINGLE-SIDED)

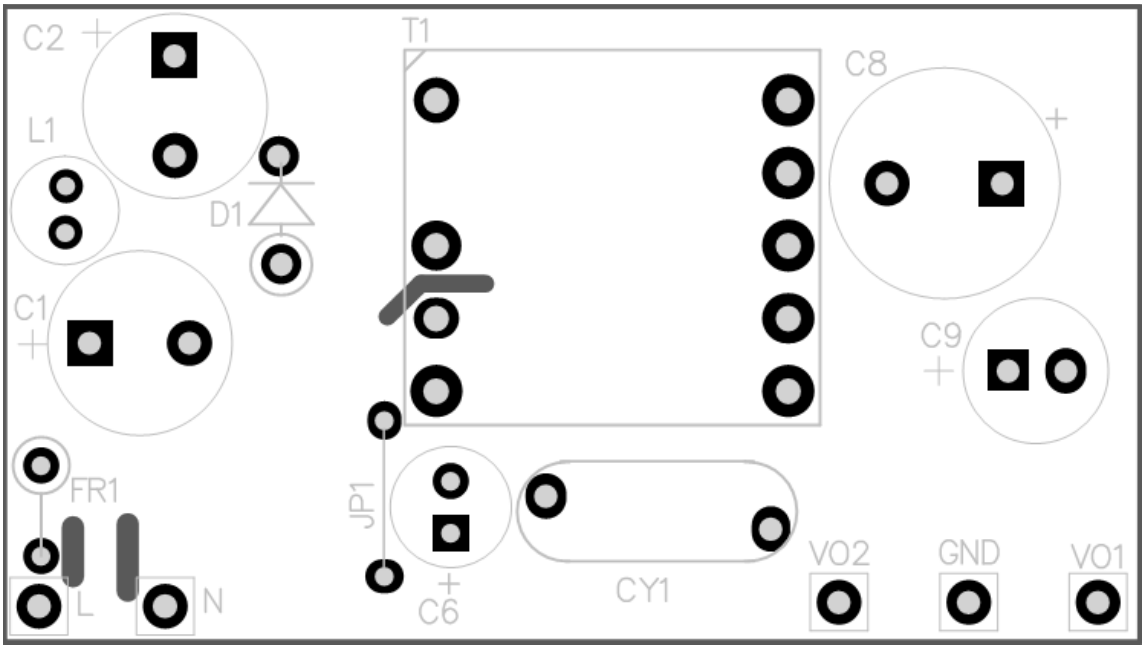



**Figure 2—Top Layer**

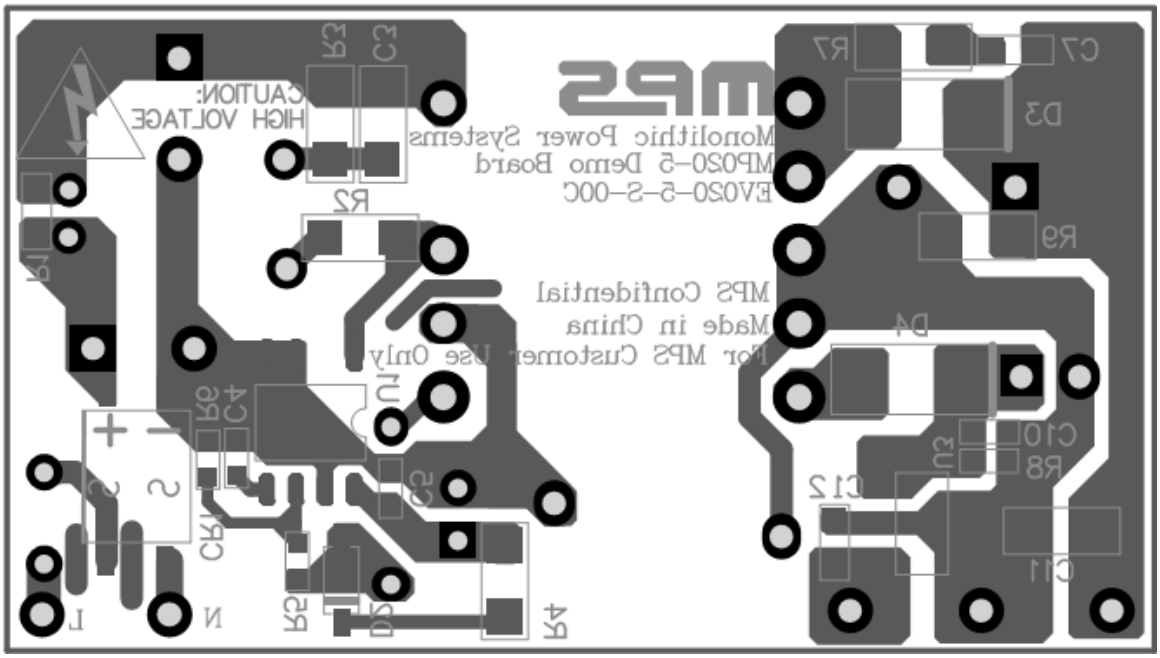



**Figure 3—Bottom Layer**

## CIRCUIT DESCRIPTION

The EV020-5-S-00C is configured in a single-stage Flyback topology, it uses primary-side-control which can mostly simplify the schematic and get a cost effective BOM. It can also achieve accurate constant voltage and acceptable cross regulation.

FR1 and CR1 compose the input stage. FR1 is used to protect for the component failure or some excessive short events, also it can restrain the inrush current.

C1, L1 and C2 compose π filter to guarantee the conducted EMI meet standard EN55022. R1 paralleled with L1 is used to damp resonant between L1 and C1, C2. R2, R3, D1 and C3 compose the snubber circuit to reduce drain-source voltage spike.

R4, C5, C6 and D2 are used as Vcc power supply. C5 is high frequency decoupling capacitor and should be placed with Vcc pin as near as possible.

R5 and R6 are resistor divider for detecting output voltage by sampling voltage on primary auxiliary winding.

CY1 is Y capacitor lowering common mode noise to make sure there is enough EMI margin. T1 is power transformer, the structure of which is also very important to pass EMI test.

D3 is rectifier for 12V output. Schottky diode is recommended for better efficiency and regulation.C7 and R7 are composed snubber for D3, which is to restrain the voltage spike between D3.

C8 and C11 are output capacitors for 12V output. C8 should be low ESR electrolytic capacitor for better load regulation. C11 is ceramic capacitor to reduce high frequency voltage ripple. R9 is dummy load to lower the output voltage of 12V rail at no load condition.

D4 is rectifier for 5V output. Schottky diode is recommended for better efficiency and regulation. Due to the output current is low at this rail and there is no obvious spike on D4, so no RC snubber is needed.

C9 and C10 are output capacitors for 5V output. C9 should be low ESR electrolytic capacitor for better load regulation. C10 is ceramic capacitor to reduce high frequency voltage ripple. R8 is dummy load to lower the output voltage of 5V rail at no load condition.

U3 is three terminals voltage regulator for precise 5V output. C12 is output capacitor for U3.

## EV020-5-S-00C BILL OF MATERIALS

| Qty | Ref | Value | Description | Package | Manufacturer | Manufacturer_P/N |
|---|---|---|---|---|---|---|
| 2 | C1, C2 | 4.7μF | Capacitor;400V;20% | DIP | Beryl | 4.7μF/400V |
| 1 | C3 | 470pF | Ceramic Capacitor; 1000V;U2J; | 1206 | muRata | GRM31B7U3A471JW31L |
| 1 | C4 | 0Ω | Shorted with 0Ω resistor | 0603 | Yageo | RC0603JR-070RL |
| 1 | C5 | 1μF | Ceramic Capacitor; 25V;X7R; | 0603 | muRata | GRM188R71E105KA12D |
| 1 | C6 | 22μF | Electrolytic Capacitor; 50V;Electrolytic; | DIP | Jianghai | CD281L-50V22 |
| 1 | C7 | 100pF | Ceramic Capacitor; 250V;COG | 0805 | Murata | GRM21A5C2E101JW01D |
| 1 | C8 | 470μF | Electrolytic Capacitor; 16V;Electrolytic; | DIP | Lelon | RXW471M1CBK-1012P |
| 1 | C9 | 100μF | Electrolytic Capacitor; 10V;Electrolytic; | DIP | Lelon | RXW101M1ABK-0511P |
| 2 | C10, C12 | 1μF | Ceramic Capacitor; 10V;X7R | 0603 | Murata | GRM188R71A105KA61D |
| 1 | C11 | 1μF | Ceramic Capacitor; 25V;X7R; | 1206 | TDK | C3216X7R1E105K |
| 1 | CR1 | MB6F | Diode;600V;0.5A | SOP-4 | Taiwan Semiconductor | MB6F |
| 1 | CY1 | 1nF | Y Capacitor;4000V;20% | DIP | Hongke | JN09E102MY02N |
| 1 | D1 | FR107 | Diode;1000V;1A | DO-41 | Diodes | FR107 |
| 1 | D2 | BAV21W | Diode;200V;0.2A; | SOD-123 | Diodes | BAV21W-7-F |
| 1 | D3 | ES1D | Diode;200V;1A; | SMA | Taiwan Semiconductor | ES1D |
| 1 | D4 | B190A | Schottky Diode;90V;1A; | SMA | Diodes | B190A |
| 1 | FR1 | FKN1WSJT -52-10R | Fusible Resistor ;10Ω/1W | DIP | Yageo | FKN1WSJT-52-10R |
| 1 | L1 | 1000μH/ 0.25A | Inductor;1000μH;6 Ohm;0.25A | DIP | Wurth | 7447462102 |
| 1 | R1 | 10kΩ | Film Resistor;5%; | 0805 | Yageo | RC0805JR-0710KL |
| 1 | R2 | 100Ω | Film Resistor;5%;1/4W | 1206 | Yageo | RC1206JR-07100RL |
| 1 | R3 | 150kΩ | Film Resistor;1%; | 1206 | Panasonic | ERJ8ENF1503V |
| 1 | R4 | 10Ω | Film Resistor;5% | 1206 | Yageo | RC1206JR-0710R |
| 1 | R5 | 30kΩ | Film Resistor;1%; | 0603 | Yageo | RC0603FR-0730KL |
| 1 | R6 | 13.7kΩ | Film Resistor;1% | 0603 | Yageo | RC0603FR-0713K7L |
| 1 | R7 | 20Ω | Film Resistor;5%;1/4W | 1206 | | 1206J0200T5E |
| 1 | R8 | 5.1kΩ | Film Resistor;5%; | 0603 | Yageo | RC0603JR-075K1L |
| 1 | R9 | 10kΩ | Resistor;5%; | 1206 | Yageo | RM12JTN103 |
| 1 | T1 | | EE16 Transformer, Lp=1.25mH Np:Np_au:Nsec1:Nsec2= 105:18:6:12 | EE16 | | FX0295 |
| 1 | U1 | MP020-5 | Primary Side Regulator | SOIC8-7A | MPS | MP020-5GS R3 |
| 1 | U3 | L78L05 | Three-Terminal Voltage Regulator | SOT-89 | STMicroelectronics | L78L05ACUTR |

# TRANSFORMER SPECIFICATION

## Electrical Diagram

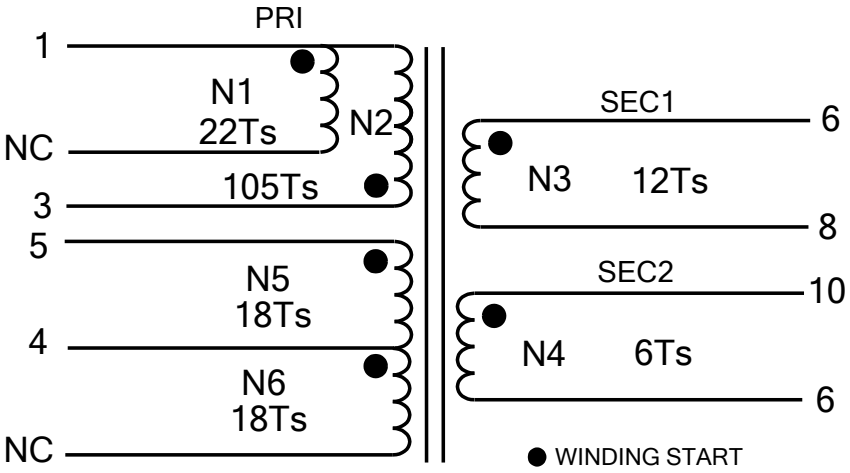



**Figure 4—Transformer Electrical Diagram**

**Notes:**
1. N1 is with 2 wires which are paralleled together.
2. N3 and N4 are both triple insulation wires.
3. One layer tape is between each layer winding. 3 layers tape is at the outside of last winding

## Winding Diagram

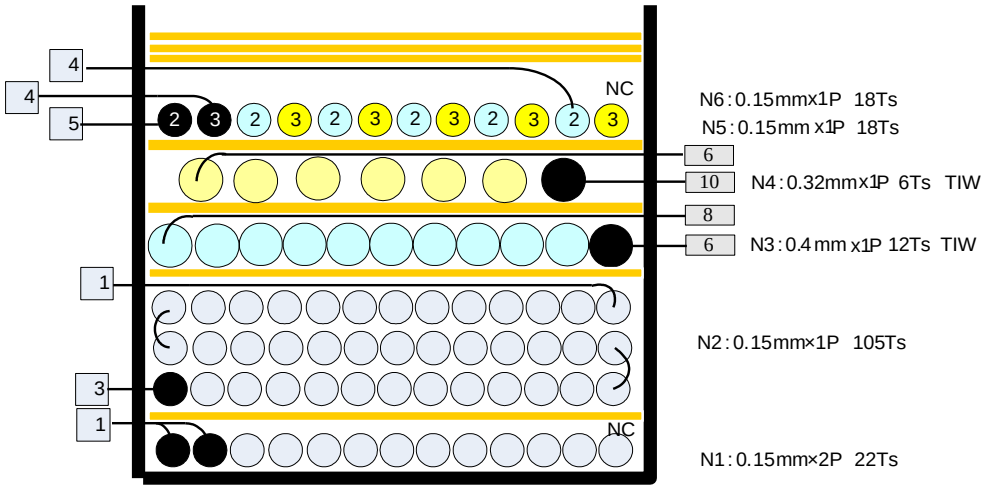



**Figure 5—Winding Diagram**

## Winding Order

| Tapes (T) | Winding | Start-End | Wire Diameter (Ø) | Turns ( T ) | Tube |
|---|---|---|---|---|---|
| 0 | N1 | 1—〉NC | 0.15mm*2 | 22 | None |
| 1 | N2 | 3—〉1 | 0.15mm*1 | 105 | None |
| 1 | N3 | 6—〉8 | 0.4mm*1 TIW | 12 | None |
| 1 | N4 | 10—〉6 | 0.32mm*1 TIW | 6 | None |
| 3 | N5,<br>N6 | 5—〉4<br>4—〉NC | 0.15mm*1<br>0.15mm*1 | 18<br>18 | None |

## Electrical Specifications

| | | |
|---|---|---|
| **Electrical Strength** | 60 second, 60Hz, from PRI. to SEC. | 3000VAC |
| | 60 second, 60Hz, from PRI. to CORE. | 500VAC |
| | 60 second, 60Hz, from SEC. to CORE. | 3000VAC |
| **Primary Inductance** | Pins 1 - 3, all other windings open, measured at 60kHz, 0.1 VRMS | 1.25mH±10% |
| **Primary Leakage Inductance** | Pins 1 - 3 with all other pins shorted, measured at 60kHz. 0.1 VRMS | 50μH±10% |

## Materials

| Item | Description |
|---|---|
| 1 | Core: EE16, UI=2300±25%, AL=73.2.4nH/$N^2$±3% GAPPED, or equivalent |
| 2 | Bobbin: EE16, 5+5PIN 1 SECT TH, UL94V-0 |
| 3 | Wire:Φ0.15mm,, 2UEW, Class B |
| 4 | Triple Insulation Wire: Φ0.40mm, TIW |
| 5 | Triple Insulation Wire: Φ0.32mm TIW |
| 6 | Tape: 8.0mm(W)×0.06mm(TH) |
| 7 | Varnish: JOHN C. DOLPH CO, BC-346A or equivalent |
| 8 | Solder Bar: CHEN NAN: SN99.5/Cu0.5 or equivalent |

# EVB TEST RESULTS

## Performance Data

**Ta=25℃, unless otherwise noted.**

**Efficiency and Load/Line Regulation (Test at the end of board)**

| | Pin (W) | $V_{OUT1}$ (V) | $I_{OUT1}$ (A) | $V_{OUT2}$ (V) | $I_{OUT2}$ (A) | Efficiency | $V_{OUT1}$ Regulation | $V_{OUT2}$ Regulation |
|---|---|---|---|---|---|---|---|---|
| Vin=85Vac/60Hz | 0.06293 | 11.9 | 0 | 5 | 0 | 0.00% | -0.83% | 0.00% |
| | 5.5626 | 11.75 | 0.3 | 5 | 0.1 | 72.36% | -2.08% | 0.00% |
| | 1.4909 | 11.89 | 0.03 | 5 | 0.1 | 57.46% | -0.92% | 0.00% |
| | 0.56577 | 11.72 | 0.03 | 5 | 0.005 | 66.56% | -2.33% Δ | 0.00% |
| | 4.5994 | 11.79 | 0.3 | 5 | 0.005 | 77.44% | -1.75% | 0.00% |

| | Pin (W) | $V_{OUT1}$ (V) | $I_{OUT1}$ (A) | $V_{OUT2}$ (V) | $I_{OUT2}$ (A) | Efficiency | $V_{OUT1}$ Regulation | $V_{OUT2}$ Regulation |
|---|---|---|---|---|---|---|---|---|
| Vin=115Vac/60Hz | 0.06221 | 11.89 | 0 | 5 | 0 | 0.00% | -0.92% | 0.00% |
| | 5.4373 | 11.76 | 0.3 | 5 | 0.1 | 74.08% | -2.00% | 0.00% |
| | 1.4935 | 11.89 | 0.03 | 5 | 0.1 | 57.36% | -0.92% | 0.00% |
| | 0.5646 | 11.72 | 0.03 | 5 | 0.005 | 66.70% | -2.33% Δ | 0.00% |
| | 4.5104 | 11.72 | 0.3 | 5 | 0.005 | 78.51% | -2.33% Δ | 0.00% |

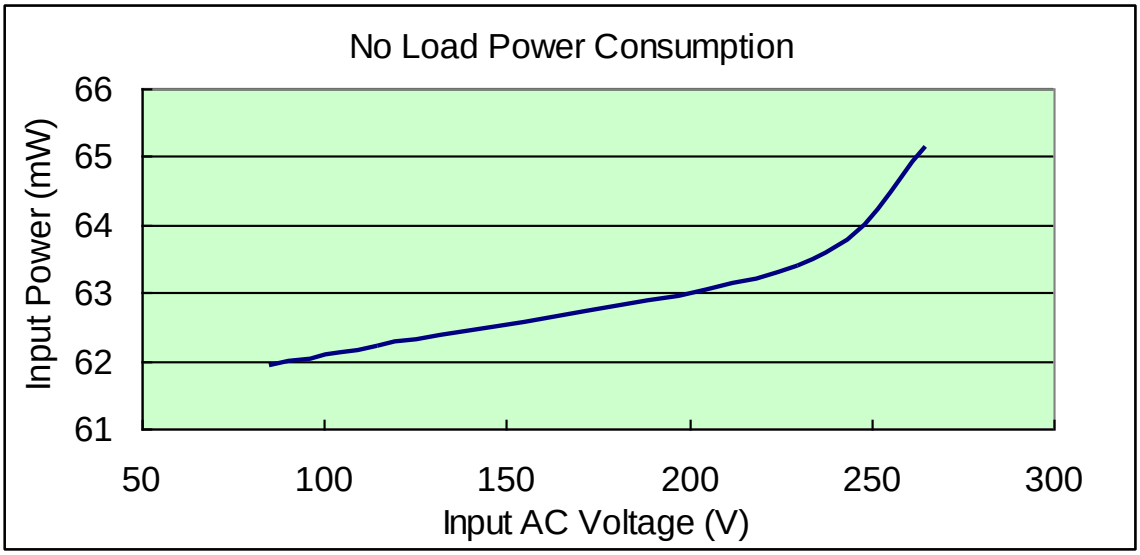
| | Pin (W) | $V_{OUT1}$ (V) | $I_{OUT1}$ (A) | $V_{OUT2}$ (V) | $I_{OUT2}$ (A) | Efficiency | $V_{OUT1}$ Regulation | $V_{OUT2}$ Regulation |
|---|---|---|---|---|---|---|---|---|
| Vin=230Vac/50H | 0.06338 | 11.94 | 0 | 5 | 0 | 0.00% | -0.50% | 0.00% |
| | 5.475 | 11.77 | 0.3 | 5 | 0.1 | 73.63% | -1.92% | 0.00% |
| | 1.5214 | 11.89 | 0.03 | 5 | 0.1 | 56.31% | -0.92% | 0.00% |
| | 0.57955 | 11.74 | 0.03 | 5 | 0.005 | 65.08% | -2.17% | 0.00% |
| | 4.5556 | 11.74 | 0.3 | 5 | 0.005 | 77.86% | -2.17% | 0.00% |

| | Pin (W) | $V_{OUT1}$ (V) | $I_{OUT1}$ (A) | $V_{OUT2}$ (V) | $I_{OUT2}$ (A) | Efficiency | $V_{OUT1}$ Regulation | $V_{OUT2}$ Regulation |
|---|---|---|---|---|---|---|---|---|
| Vin=265Vac/50Hz | 0.06514 | 11.98 | 0 | 5 | 0 | 0.00% | -0.17% | 0.00% |
| | 5.5176 | 11.77 | 0.3 | 5 | 0.1 | 73.06% | -1.92% | 0.00% |
| | 1.5205 | 11.9 | 0.03 | 5 | 0.1 | 56.36% | -0.83% | 0.00% |
| | 0.58397 | 11.75 | 0.03 | 5 | 0.005 | 64.64% | -2.08% | 0.00% |
| | 4.5994 | 11.75 | 0.3 | 5 | 0.005 | 77.18% | -2.08% | 0.00% |

**Notes:**

1. The red triangle means the worst case in table.

**No Load Consumption**




**Electric Strength Test**

Primary circuit to secondary circuit electric strength testing was completed according to IEC61000-4-2.

Input and output was shorted respectively. 3000VAC/50Hz sine wave applied between input and output for 1min, and operation was verified.

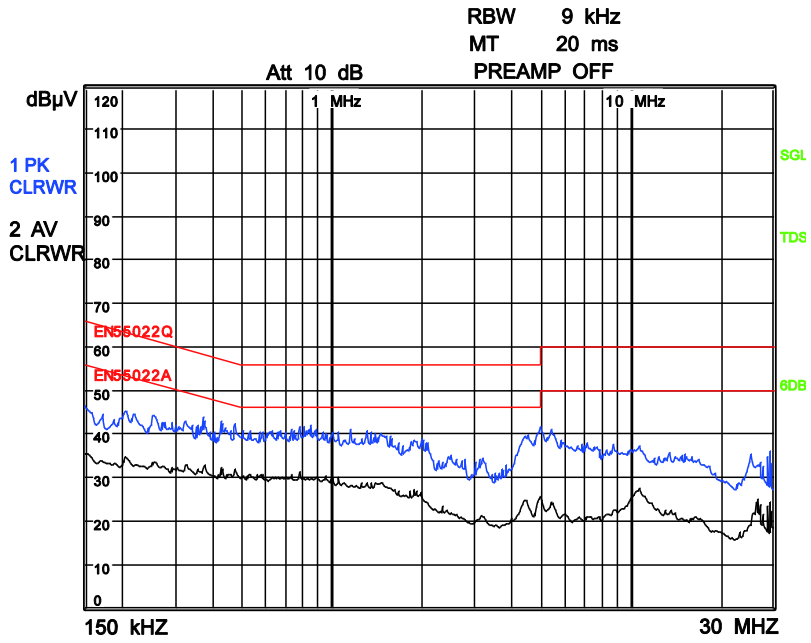
**Surge Test**

Line to Line 1kV and Line to Power Earth 1kV surge testing was completed according to IEC61000-4-5. Input voltage was set at 230VAC/50Hz. Output was loaded at full load and operation was verified following each surge event.

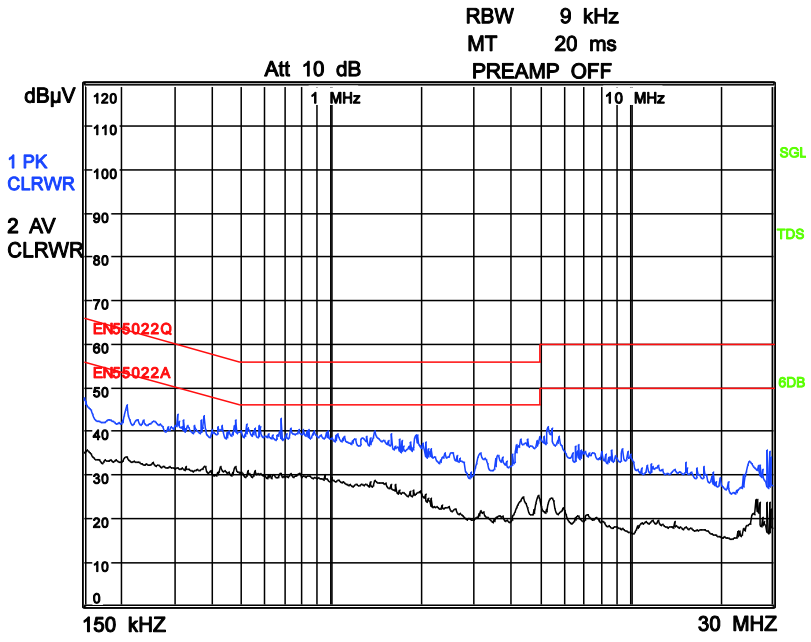
| Surge Level (V) | Input Voltage (VAC) | Injection Location | Injection Phase (°) | Test Result (Pass/Fail) |
|---|---|---|---|---|
| 1000 | 230 | L to N | 90 | Pass |
| -1000 | 230 | L to N | 270 | Pass |
| 1000 | 230 | L to PE | 90 | Pass |
| -1000 | 230 | L to PE | 270 | Pass |
| 1000 | 230 | N to PE | 90 | Pass |
| -1000 | 230 | N to PE | 270 | Pass |

## Conducted EMI Test

Test with 230Vac input and full load condition



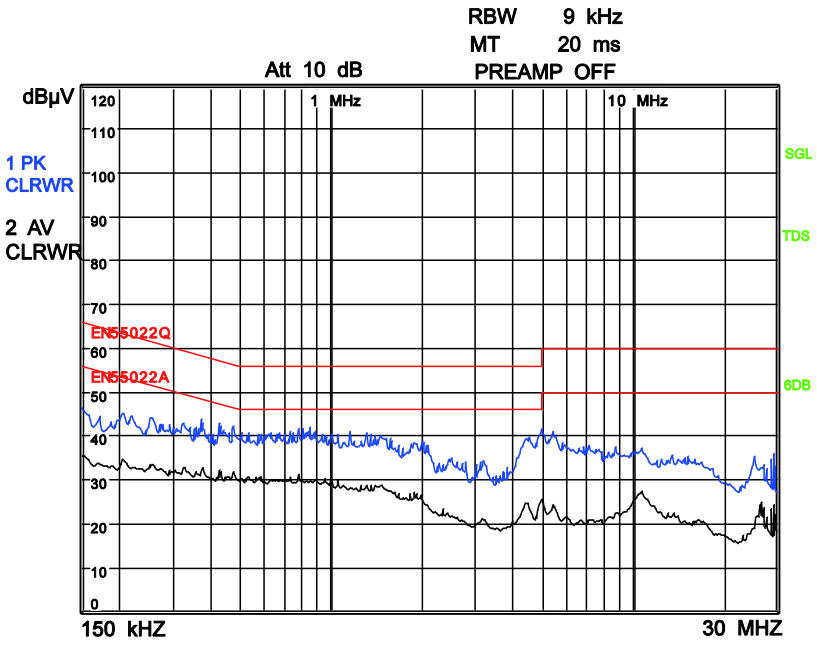

**230Vac, 50Hz, Maximum Load, L Line, Output GND floats, EN55022 Limits**



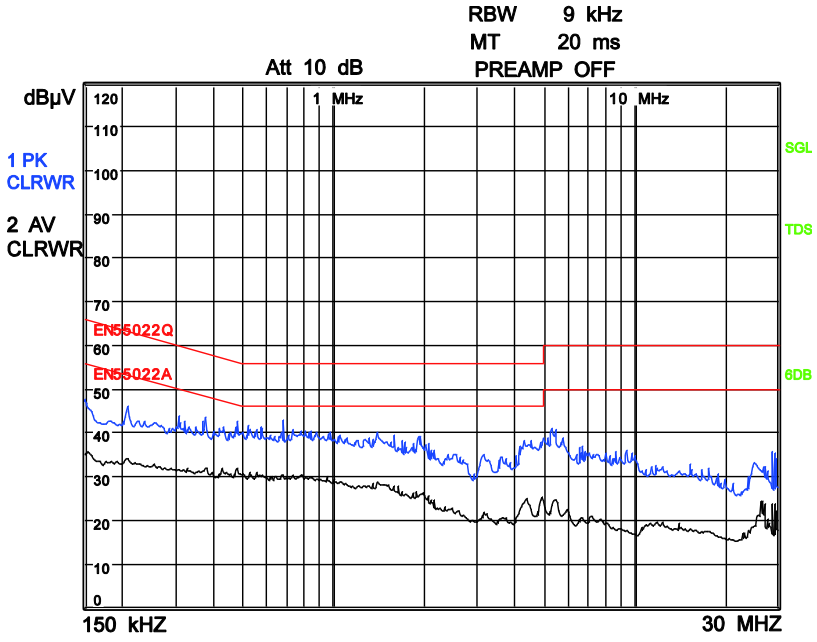

**230Vac, 50Hz, Maximum Load, N Line, Output GND floats, EN55022 Limits**

## Conducted EMI Test *(continued)*

Test with 115Vac input and full load condition



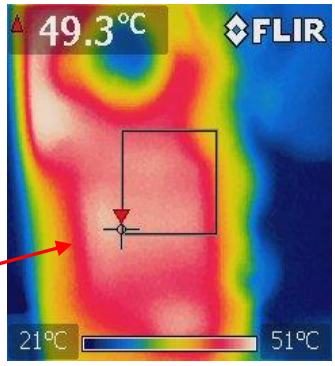

**115Vac, 60Hz, Maximum Load, L Line, Output GND floats, EN55022 Limits**



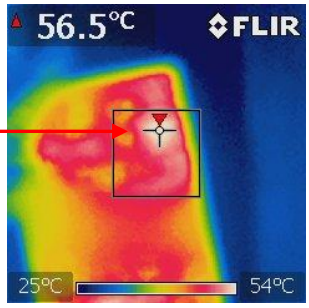

**115Vac, 60Hz, Maximum Load, N Line, Output GND floats, EN55022 Limits**

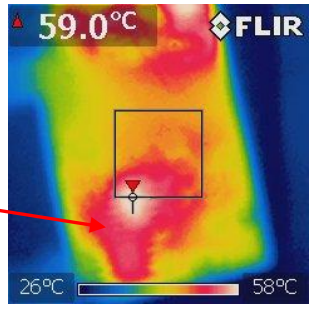
**Thermal Test**

Test is conducted at ambient temperature of 25°C, 85Vac/60Hz input.




**Top Layer**



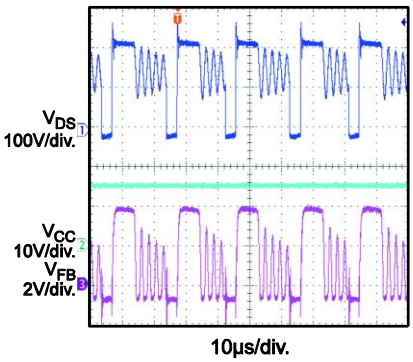




**Bottom Layer**

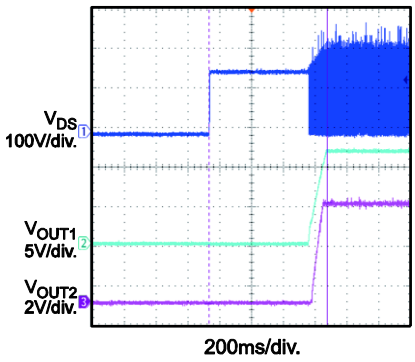
## EVB TEST RESULTS

**Performance waveforms are tested on the evaluation board.**
**$V_{IN}$=115VAC/60Hz, $V_{OUT1}$=12V, $I_{OUT1}$=0.3A, $V_{OUT2}$=5V, $I_{OUT2}$=0.1A, CC Mode Load, Ta=25℃**

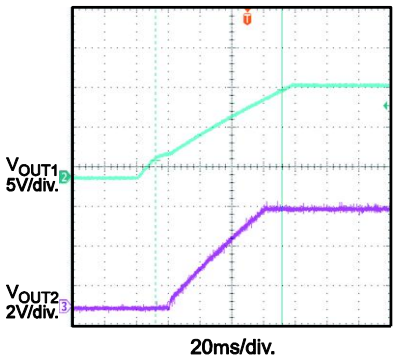
**Steady State**



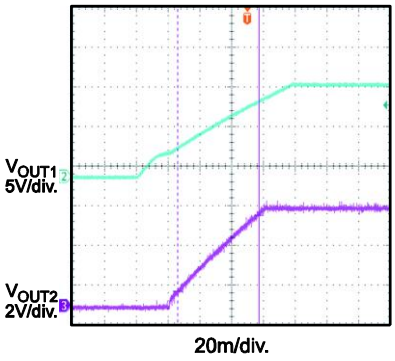

**Turn On Delay**



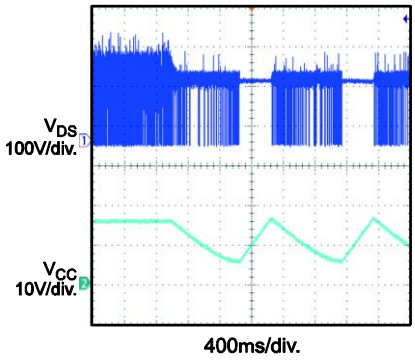

**Output1 Rise Time**



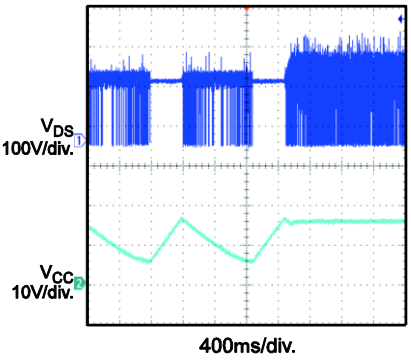

**Output2 Rise Time**



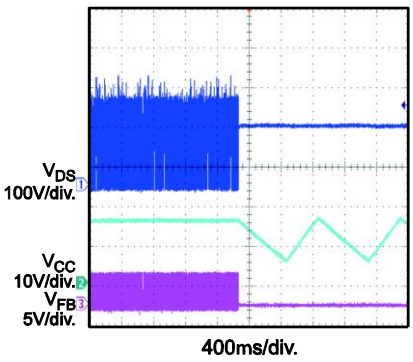

**OCP Entry**



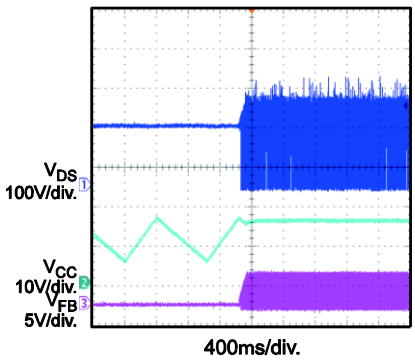

**OCP Recovery**



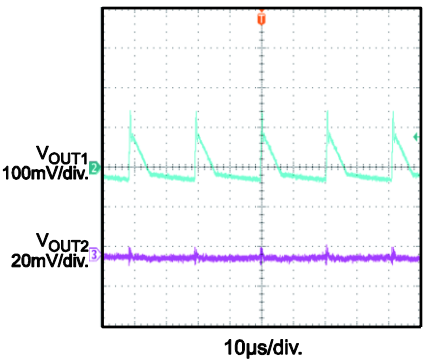

**OCkP Entry**




**OCkP Recovery**



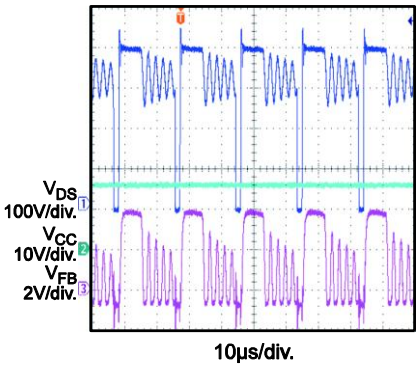

**Output Voltage Ripple**



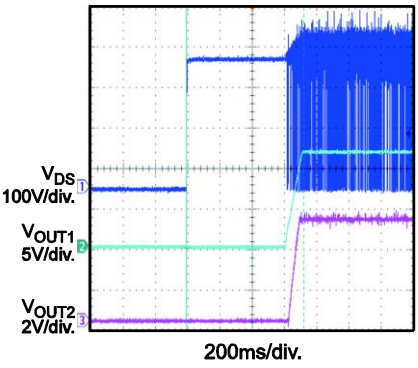
## EVB TEST RESULTS *(continued)*

**Performance waveforms are tested on the evaluation board.**
**$V_{IN}$=230VAC/50Hz, $V_{OUT1}$=12V, $I_{OUT1}$=0.3A, $V_{OUT2}$=5V, $I_{OUT2}$=0.1A, CC Mode Load, Ta=25℃**

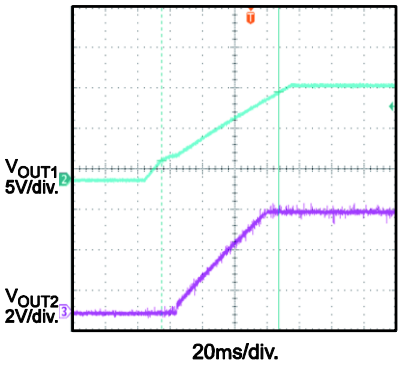
**Steady State**



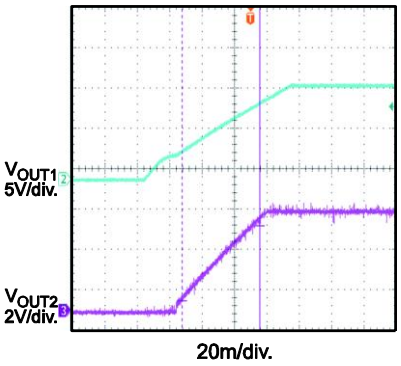

**Turn On Delay**



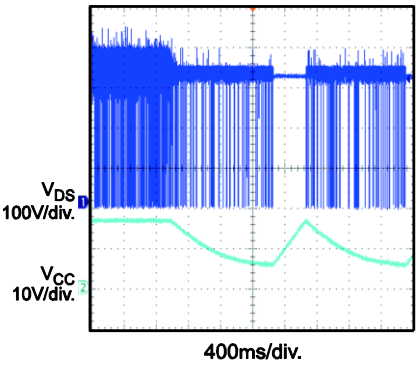

**Output1 Rise Time**



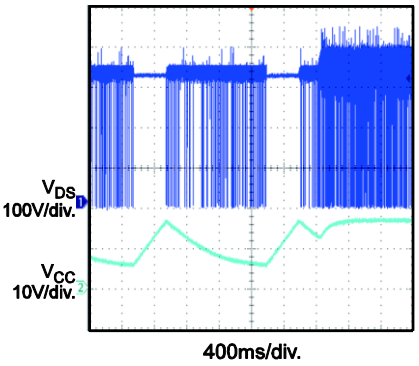

**Output2 Rise Time**



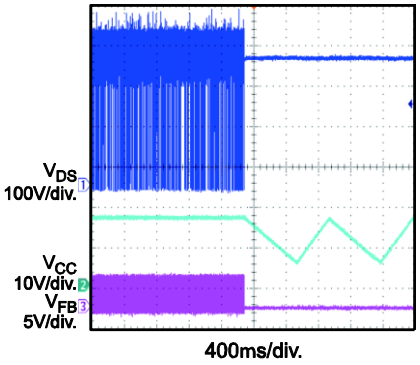

**OCP Entry**



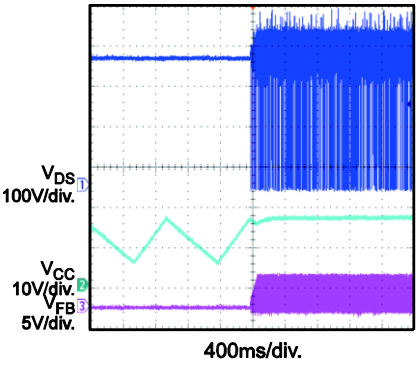

**OCP Recovery**



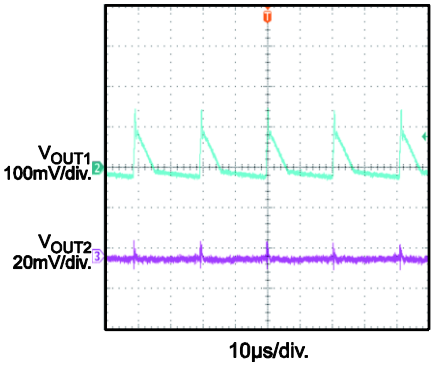

**OCkP Entry**




**OCkP Recovery**




**Output Voltage Ripple**



## QUICK START GUIDE

1. Preset Power Supply to 85VAC ≤ $V_{IN}$ ≤ 265VAC.
2. Turn Power Supply off.
3. Connect the Line and Neutral terminals of the power supply output to L and N port. For three-wire input application, make OUTPUT GND connected to Earth.
4. Connect Different Load to Corresponding Outputs :
    a. Positive 1 (+): 12V OUT
    b. Positive 2 (+): 5V OUT
    c. Negative (–): GND
5. Turn Power Supply on after making connections.