EV4020GS-00B

85V-265V$_{AC}$, 15W Evaluation Board
Primary-side-control with Active PFC
Off-line WLED Driver with Triac Dimming

The Future of Analog IC Technology

PRELIMINARY SPECIFICATIONS SUBJECT TO CHANGE

MPS CONFIDENTIAL AND PROPRIETARY INFORMATION – ARVHITECT USE ONLY

DESCRIPTION

The EV4020GS-00B Evaluation Board is designed to demonstrate the capabilities of MP4020. The MP4020 is a primary-side-control offline LED lighting controller. It can achieve high power factor and flicker-free triac dimmable LED current for an isolate lighting application in a single stage converter. It works in boundary conduction mode for reducing the MOSFET and Diode switching losses.

The EV4020GS-00B is typically designed for driving a 15W LED Tube with 30V$_{TYP}$ LED load at universal input (85V~265V, 50/60Hz). And the max LED current is 450mA at 220Vin with max triac dimming phase.

The EV4020GS-00B has an excellent efficiency and meets IEC61000-3-2 Class C harmonics, EN55015 conducted EMI. It has multi-protection function as over-voltage protection, short-circuit protection, cycle by cycle current limit, etc.

FEATURES

- Real Current Control Without Secondary-feedback Circuit
- Flicker-free Phase-controlled TRIAC Dimming
- Accurate Constant Current Output
- Boundary Conduction Mode Operation
- Ultra-low (10μA) Start Up Current
- Low (1mA) Quiescent Current
- Input UVLO
- Cycle-by-cycle Current Limit
- Over-voltage Protection
- Short-circuit Protection
- Over-temperature Protection
- Available in a 8 Pin SOIC Package

APPLICATIONS

- Solid State Lighting
- Industrial and Commercial Lighting
- Residential Lighting

ELECTRICAL SPECIFICATION

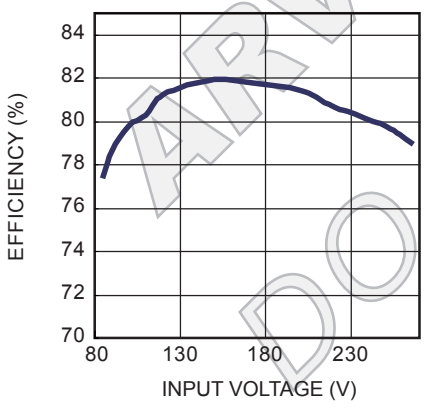
Parameter	Symbol	Value	Units
Input Voltage	V_{IN}	85 ~ 265	V
Output Voltage Output Current Output Power	V_O $I_{O(max)}$ P_O	30 450 15	V mA W
Efficiency (full load)	η	77-81	%

For MPS green status, please visit MPS website under Quality Assurance.

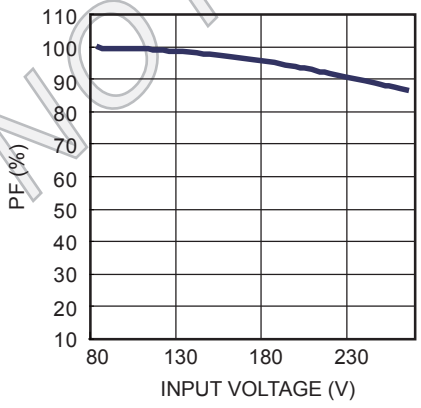
The MP4020 is under patent pending.

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.

Efficiency

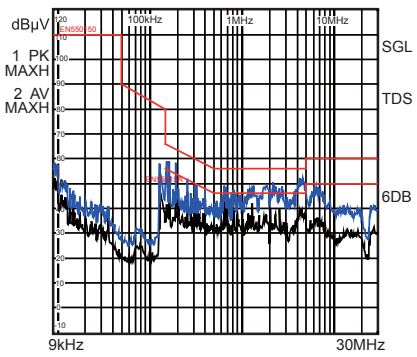


PF vs. V_{IN}

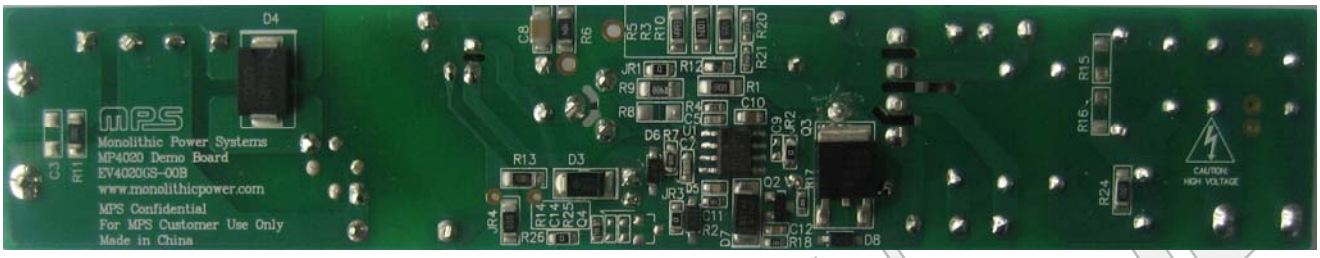


Conducted EMI

V_{IN}=220V



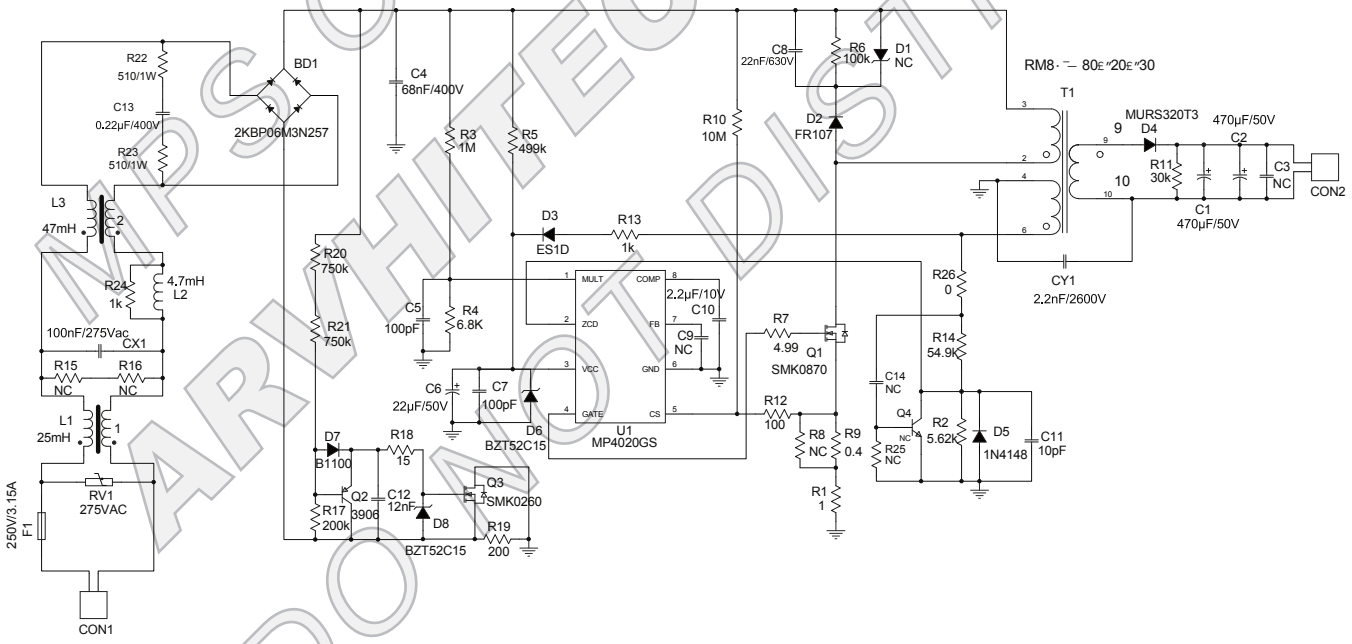
EV4020GS-00B EVALUATION BOARD



(L x W x H) 149mm x 26mm x 18.4mm

Board Number	MPS IC Number
EV4020GS-00B	MP4020GS

EVALUATION BOARD SCHEMATIC



CIRCUIT DESCRIPTION

The EV4020GS-00B 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 high power factor and flicker-free triac dimmable LED current.

F1, CX1, L1, L2, L3, C4, R24 and BD1 compose the input stage. F1 fuses the AC input to protect for the component failure or some excessive short events. CX1, L1, L2, L3, R24 associated with CY1 form the EMI filter which can meet the requirement for universal input. The diode rectifier BD1 rectifies the input line voltage. Small bulk CBB capacitor C4 is used for a low impedance path for the primary switching current. To maintain high power factor, the capacitance of C4 should be selected with low value.

R20, R21, R17, R18, C12, D7, D8, Q2, Q3 with R19 compose the damping circuit for reducing the inrush current at the dimmer turning on time. The circuit let the inrush current flow through R19 at first when triac dimmer turn on. Then Q3 turns on and shorts R19, this can save power from R19. Q2 is used to discharge C13 when the triac is off. D8 is used to clamp the gate voltage to 15V on Q3.

R22, R23, C13 are used as a bleeder circuit which keeping the triac current above the minimum holding current after triac turns on.

R3, R4, C5 provide sine wave reference for the primary peak current to get an active PFC function. The divided voltage should be lower than the max voltage rating of MULT pin.

R5, C6, C7, D6, R13, D3 are used to supply the power for MP4020. A 22uF bulk capacitor C6 is selected to maintain the supply voltage. The small decoupling cap C7 is used for reducing the noise. Zener diode D6 is used to clamp the max voltage for VCC at OVP condition. At start-up, C6 is first charged up by the start resistor R5 from the line voltage, when the VCC voltage passes the UVLO threshold the IC starts to work and the gate begins to switch, then the VCC power supply is taken over by the auxiliary winding through R13, D3.

R14, R2, D5, C11 are used to detect the auxiliary winding to get the transformer magnetizing current zero crossing signal for realizing the boundary conduction operation, and also monitor the output OVP condition. The OVP voltage is set by the divider ratio of R14 and R2. D5, C11 are used to reduce the noise by clamping the negative voltage and decoupling the high frequency du/dt influence on ZCD pin. R26, R25, C14, Q4 are option for external ZCD blanking time.

R8, R9, R1 are primary sensing resistor for primary side current control. The value of R8, R9 and R1 sets the output LED current. C8, R6, D2 are used to damp the leakage inductance energy so the drain voltage can be suppressed at a safe level.

Diode D4 rectifies the secondary winding voltage and the capacitor C1, C2 are the output filter. The resistor R11 is placed as pre-load to limit the output voltage rise too high in open load condition

EV4020GS-00B BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacture	Manufacture_PN
1	BD1	2KBP06M3N257	2KBP06M3N257	DIP	Vishay	2KBP06M
2	C1, C2	470μF/50V	Electrolytic Capacitor;50V, 470μF	DIP	Panasonic	ECQV1J474JM
1	C3	NC				
1	C4	68nF/400V	CBB,400V	DIP	Panasonic	ECQE400VDC683K
2	C5, C7	100pF	Ceramic Cap,50V,X7R	0603	LION	0603B10K500T
1	C6	22μF/50V	Electrolytic Capacitor;50V; Electrolytic	DIP	Jianghai	CD281L-50V22
1	C8	22nF/630V	Ceramic Cap, 630V，X7R	1210	muRata	GRM32QR72J223KW01
1	C9	NC				
1	C10	2.2μF/10V	Ceramic Capacitor;10V; X7R;0805	0805	Murata	GRM21BR71A225KAO1
1	C11	10pF	Ceramic Cap,50V,COG	0603	Murata	GRM1885C1H100JAO1
1	C12	12nF	Ceramic Cap,50V,X7R	0603	muRata	GRM188R71H123KA01D
1	C13	220nF/400V	CBB,400V	DIP	Panasonic	ECQE4224KF
1	C14	NC				
1	CX1	100nF	Film Capacitor, X2,275V	DIP	carli	PX104K3ID19L270D9R
1	CY1	2.2nF	Y Capacitor,	DIP	Hongke	JYK09F222ML72N
1	D1	NC				
1	D2	FR107	Diode, 1A,1000V	DO-41	Diodes	FR107
1	D3	ES1D	Diode, 1A,200V	SMA	Taiwan Semeconductor	ES1D
1	D4	MURS320T3	Diode,3A,200V	SMC	ON Semi	MURS320T3
1	D5	1N4148W	DIODES/SOD-123	SOD-123	Diodes	1N4148W
2	D6, D8	BZT52C15	DIODES/SOD-123	SOD-123	Diodes	BZT52C15
1	D7	B1100	schottky diode	SMA	Diodes	B1100-13-F
1	F1	250V/3.15A	SS-5-3.15A	DIP	COOPER BUSSMANN	SS-5-3.15A
1	L1	common chock, 25mH	common chock, 25mH	DIP		
1	L2	Inductor,4.7mH	Inductor,4.7mH	DIP		
1	L3	Common chock, 47mH	common chock, 47mH	DIP		
1	Q1	SMK0870F	SMK0870F	TO-220	AUK	SMK0870F
1	Q2	MMBT3906LT1	PNP,transistor	SOT-23	ON Semiconductor	MMBT3906LT1

EV4020GS-00B BILL OF MATERIALS *(continued)*

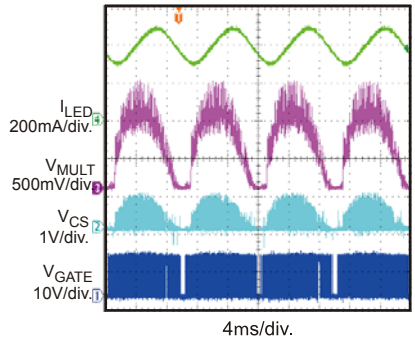
Qty	Ref	Value	Description	Package	Manufacture	Manufacture_PN
1	Q3	SMK0260D	MOSFET, 600V	TO-252	AUK	SMK0260D
1	Q4	NC				
1	R1	1	Film RES,1%	1206	Royalohm	1206F100KT5E
1	R2	5.62k	Film RES, 1%	0603	Yageo	RC0603FR-075K62L
1	R3	1M	Film RES, 1%	1206	Yageo	RC1206FR-071ML
1	R4	6.8k	Film RES, 1%	0603	Yageo	RC0603FR-076K8L
1	R5	499k	Film RES, 1%	1206	Panasonic	ERJ8EF4993V
1	R6	100k	Film RES, 5%	1206	Yageo	RM12JTN104
1	R7	4.99	Film RES, 1%	0805	Yageo	RC0805FR-074R99L
1	R8	NC				
1	R9	0.4	Film RES,1%	1206	Yageo	RL1206FR-070R4L
1	R10	10M	Film RES,1%	1206	Royalohm	12061005T5E
1	R11	30k	Film RES,1%	1206	Royalohm	12063002T5E
1	R12	100	Film RES,1%	0603	Yageo	RC0603FR-07100RL
4	R13, R24	1k	Film RES,1%	1206	Royalohm	1206F1001T5E
1	R14	54.9k	Film RES,1%	0603	Yageo	RC0603FR-0754K9L
2	R15, R16	NC				
1	R17	200k	Film RES,1%	0603	Yageo	RC0603FR-07200KL
1	R18	15	Film RES,1%	0603	Yageo	RC0603FR-0715RL
1	R19	200	DIP, 2W	DIP		
2	R20, R21	750k	Film RES,1%	0603	Yageo	RC0603FR-07750KL
2	R22,R 23	510	DIP,1W RESISTOR	DIP		
1	R25	NC				
4	R26, JR1, JR2, JR3	0	Film RES, 1%	0805		0805S8J0000T5E
1	JR4	0	Film RES, 5%	1206	Yageo	RC1206JR-070RL
1	JP1					
1	RV1	NC				
1	T1	FX0164	RM8 磁芯 Np:Ns:Naux=80：20：30, Lp=1.03mH	RM8		
1	U1	MP4020GS	MP4020GS	SOIC8	MPS	MP4020GS

EVB TEST RESULTS

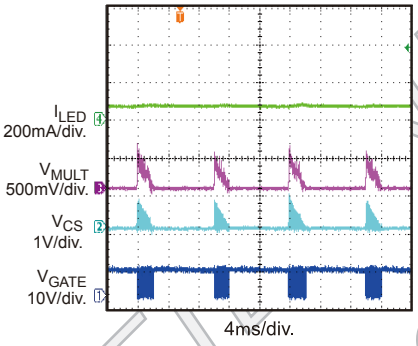
Performance waveforms are tested on the evaluation board.
V_{IN} =110VAC, 9 LEDs in series, I_{OUT_max}=380mA, V_{OUT}=30V, Lm=1.03mH, Np:Ns:Naux =80:20:30

Panasonic's dimmer, WMS549 (40-400W, 220V, 50-60Hz, made in china)

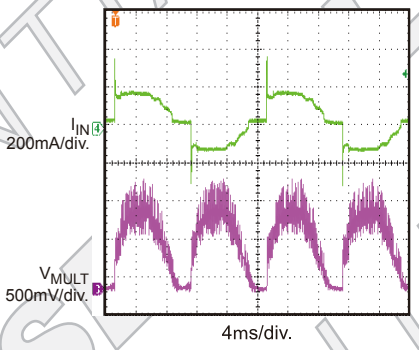
Steady State, Max Dimming Phase



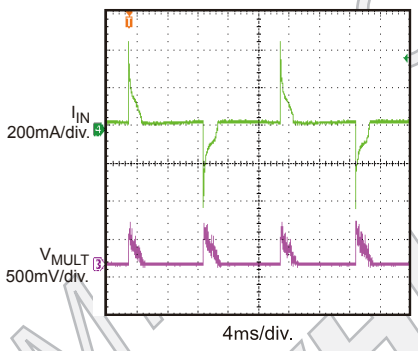
Steady State, Min Dimming Phase



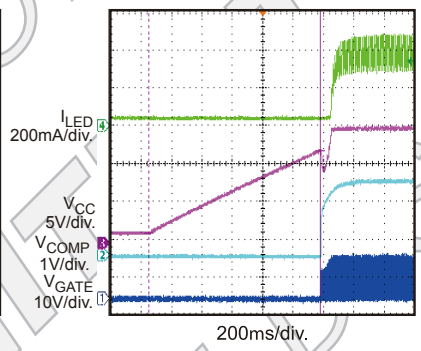
Input Voltage and Current, Max Dimming Phase



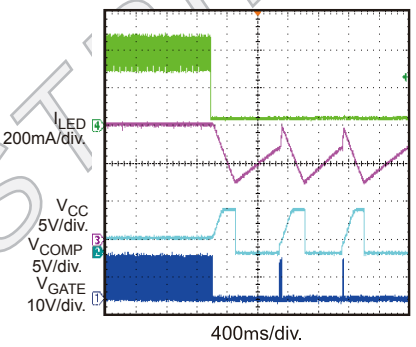
Input Voltage and Current, Min Dimming Phase



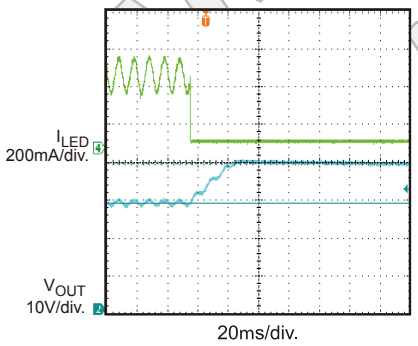
Vin Start Up



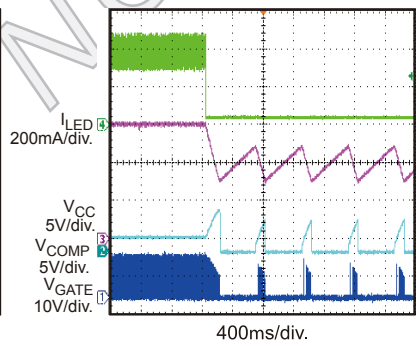
OVP, LED Load Open when working



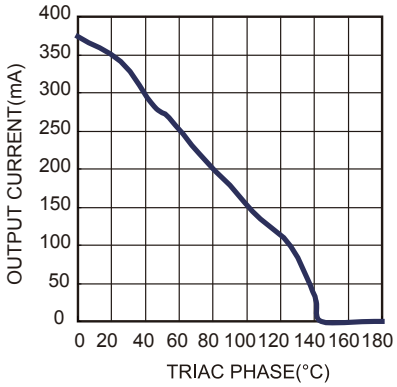
OVP, LED Load Open when working



OCP, LED+ Short to LED- when working



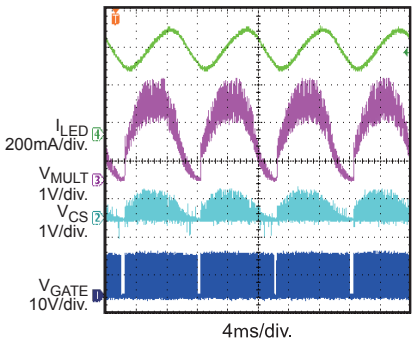
110V Triac Regulation



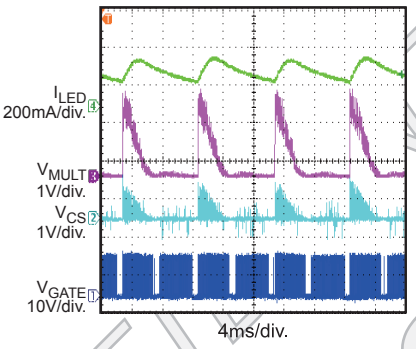
EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.
V_{IN} =220VAC, 5 LEDs in series, I_{OUT_max}=450mA, V_{OUT}=16V, Lm=2.2mH, Np:Ns:Naux =120:20:30
Panasonic's dimmer, WMS549 (40-400W, 220V, 50-60Hz, made in china)

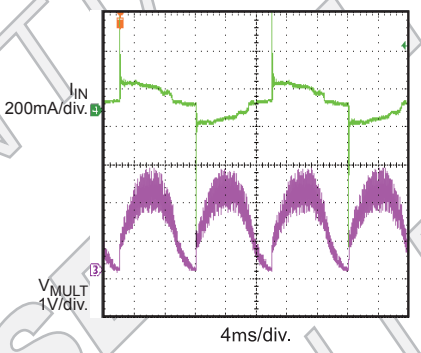
Steady State,Max Dimming Phase



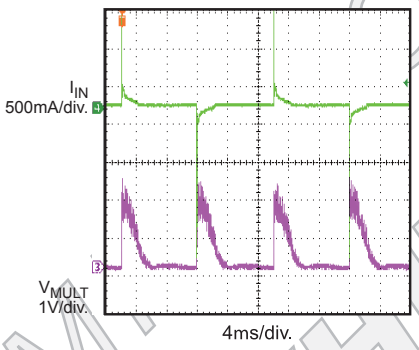
Steady State,Min Dimming Phase



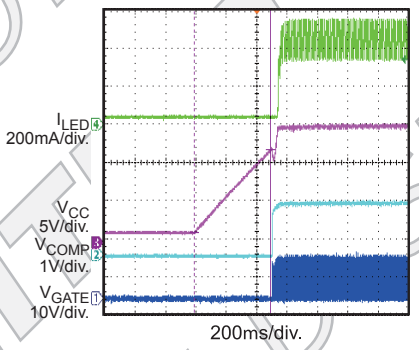
Input Voltage and Current, Max Dimming Phase



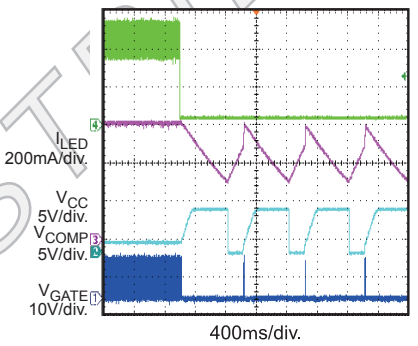
Input Voltage and Current, Min Dimming Phase



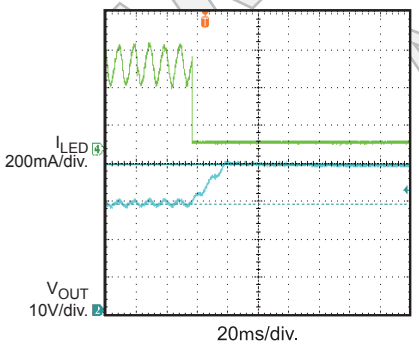
Vin Start Up



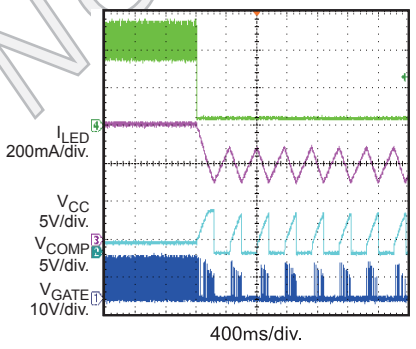
OVP, LED Load Open when Working



OVP, LED Load Open when Working

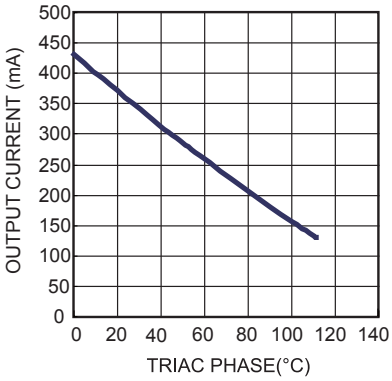


OCP, LED+ Short to LED -when Working



220V Triac Regulation

The max triac phase is 110□, so the min current is limited by the dimmer



RINTED CIRCUIT BOARD LAYOUT

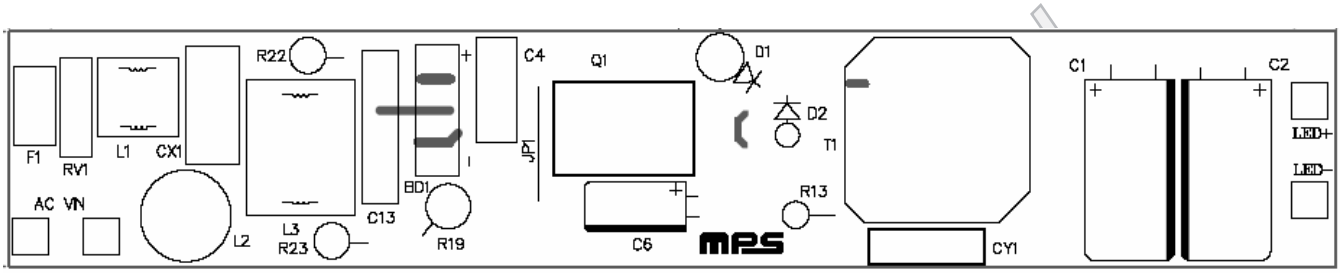


Figure 1—Top Silk Layer

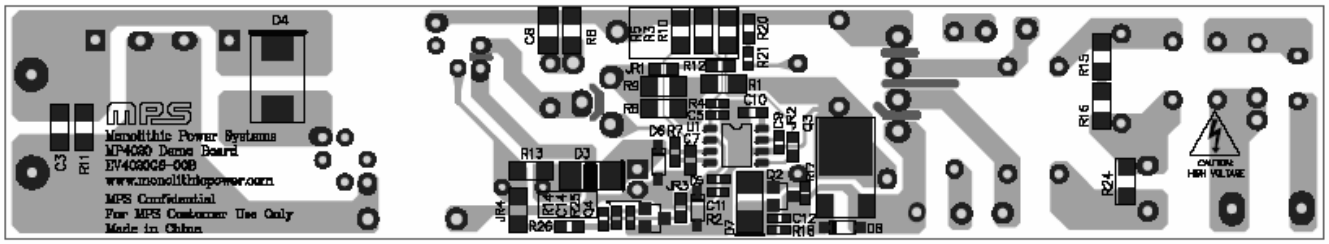


Figure 2—Bottom Layer

QUICK START GUIDE

1. Preset AC Power Supply to 85V ≤ V_{IN} ≤265V.
2. Turn Power Supply off.
3. Connect the LED string between ”LED+”(anode of LED string) and “-”(cathode of LED string).
4. Connect Triac dimmer between Power Supply terminals and AC VIN terminals as shown on the board.
5. Turn AC Power Supply on after making connections, then regulate the Triac dimmer.