EV4030A-S-01B

185VAC~265VAC/50Hz, 30V/520mA Primary-Side Control with Active PFC Offline Dimmable LED Driver Evaluation Board

DESCRIPTION

The EV4030A-S-01B Evaluation Board is designed to demonstrate the capabilities of MP4030A with ripple suppressor. The MP4030A is a primary-side-control offline LED lighting controller which can achieve high power factor and accurate current for Triac dimmable LED lighting application. It works in boundary conduction mode for reducing the MOSFET and Diode switching losses. The ripple suppressor can obviously reduce the output current ripple and escape the flicker or shimmer happened in deep dimming situation.

The EV4030A-S-01B is typically designed for driving a 15W Triac dimmable LED bulb with $30V_{TYP}$, 520mA LED load from 185VAC to 265VAC, 50Hz.

The EV4030A-S-01B 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; primary side over current protection; short-circuit protection, cycle by cycle current limit, etc.

ELECTRICAL SPECIFICATION

Parameter	Symbol	Value	Units
Input Voltage	V_{IN}	185 to 265	VAC
Output Voltage	V_{OUT}	30	V
LED Current	I_{LED}	520	mA
Output Power	P_{OUT}	15	W
Efficiency (full load)	η	>83	%
Power Factor	PF	>0.9	
THD	THD	<20	%

FEATURES

- Fast Start up
- Triac Dimmable, with 1% to 100% dimming range and the dimming curve meets standard SSL6
- Real current control without secondary-feedback circuit
- Unique architecture for superior line regulation
- High power factor>0.9 over 185VAC to 265VAC
- Boundary conduction mode improves efficiency
- Input UVLO
- Cycle-by-cycle current limit
- Over-voltage protection (OVP)
- Short-circuit protection (SCP)
- Primary side over current protection(POCP)
- Over-temperature protection (OTP)
- Fit inside PAR38 bulb enclosure

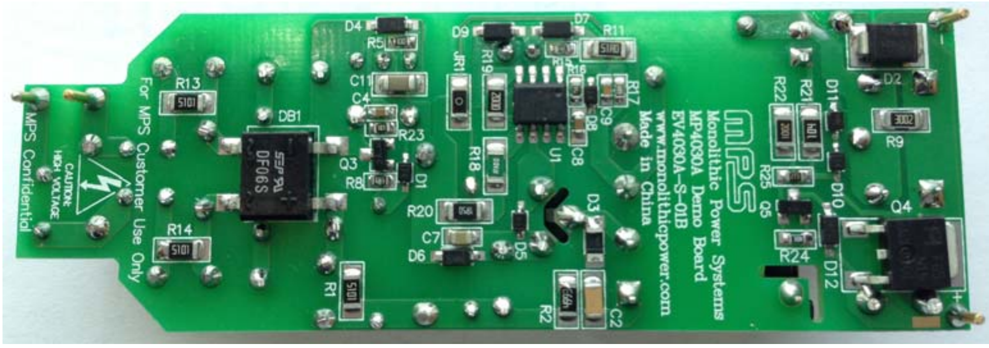
APPLICATIONS

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

High Voltage

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.

EV4030A-S-01B EVALUATION BOARD



(L x W x H) 88mm x 30mm x 23mm

Board Number	MPS IC Number
EV4030A-S-01B	MP4030AGS

EVALUATION BOARD SCHEMATIC

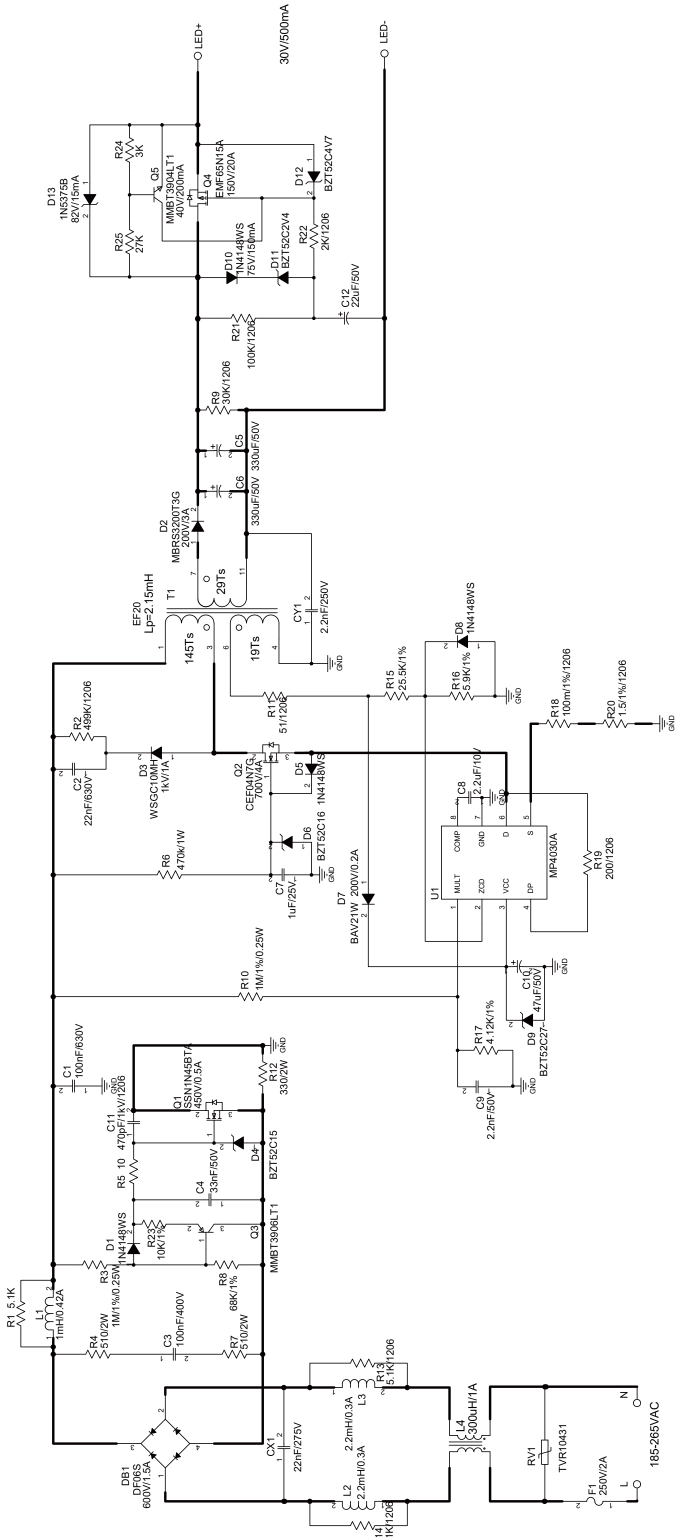


Figure 1—Schematic

PCB LAYOUT (SINGLE-SIDED)

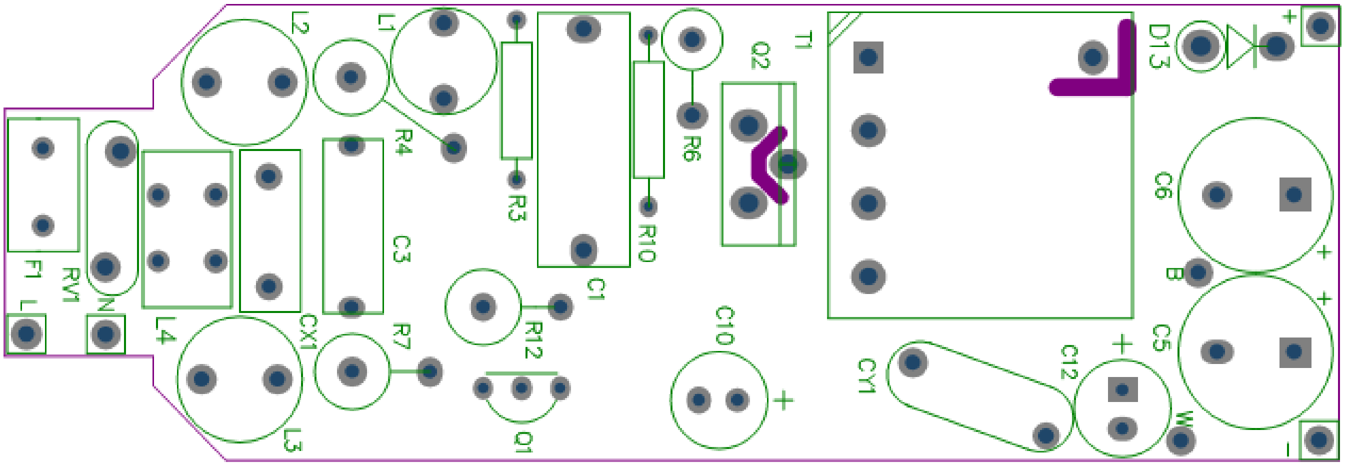


Figure 2—Top Layer

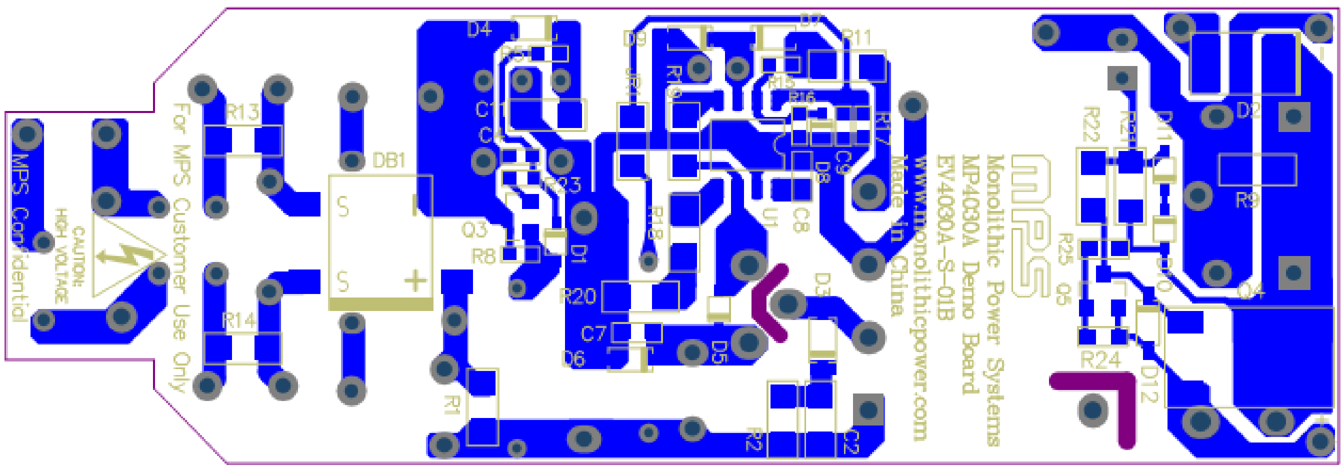


Figure 3—Bottom Layer

CIRCUIT DESCRIPTION

The EV4030A-S-01B 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 accurate LED current.

F1, RV1, L1, L2, L3, L4, R1, R14, R13, CX1, DB1, and C1 compose the input stage. F1 fuses the AC input to protect for the component failure or some excessive short events. RV1 is used for surge test. L1, L2, L3, L4, R1, R14, CX1, R13 and C1 associated with CY1 form the EMI filter which can meet the standard EN55015. The diode rectifier DB1 rectifies the input line voltage. Small bulk CBB capacitor C1 is used for a low impedance path for the primary switching current, to maintain high power factor, the capacitance of C1 should be selected with low value.

R3, R8, R5, R23, C4, C11, D1, D4, Q1, Q3 with R12 compose the damping circuit for reducing the inrush current at the dimmer turning on time. The circuit let the inrush current flow through R12 at first when triac dimmer turns on. Then Q1 turns on and shorts R12, this can save power from R12. Q3 is used to discharge C4 when the triac is off. D4 is used to clamp the gate voltage of Q1 to 15V.

R4, R7, C3 are used as a bleeder circuit which keeping the triac current above the minimum holding current after triac turns on.

R10, R17, C9 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.

R11, D7, C10 and D9 are used to supply the power for MP4030A. A 47μF bulk capacitor C10 is selected to maintain the supply voltage. At start-up, C10 is first charged up through the external MOSFET Q2 and internal charging circuit, when the VCC voltage reaches 10V, the internal charging circuit stops charging and the control logic works. Then the power supply is taken over by the auxiliary winding through R11, D7.

R6, C7, D6 and D5 are used for the gate drive of the external MOSFET Q2.

R15, R16 and D8 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 R15, R16.

R18, R20 are primary sensing resistors for primary side current control. The value of R18, R20 set the output LED current. C2, R2, D3 are used to damp the leakage inductance energy so the drain voltage can be suppressed at a safe level.

Diode D2 rectifies the secondary winding voltage and the capacitor C5, C6 are the output filter. The resistor R9 is placed as pre-load to limit the output voltage rise too high in open load condition.

R21, R22, R24, R25, C12, D10, D11, D12, D13, Q4 and Q5 compose the ripple suppressor. R21 and C12 offer a stable drive voltage to Q4. D10 and D11 compose the fast start up circuit, which help charge C12 quickly at the moment power on. R22 and D12 are used to protect the Q4 from Gate-to-Source over voltage damage when SCP happened. R24, R25 and Q5 are used to protect Q4 from over current damage. D13 are used to protect Q5 from Drain-to-Source over voltage damage cause by Q5 when SCP happened.

EV4030A-S-01B BILL OF MATERIALS

1	C1	100nF/630V	Ceramic Capacitor;630V;10%	DIP	Fala	C312J104K63CC30
1	C2	22nF/630V	Ceramic Capacitor;630V;X7R;1206	1206	TDK	C3216X7R2J223K
1	C3	100nF/400V	Capacitor;400V;CBB	DIP	Panasonic	ECQE4104KF
1	C4	33nF/50V	Ceramic Capacitor;50V;X7R;0603;	0603	muRata	GRM188R71H333KA61D
2	C5, C6	330uF/50V	Electrolytic Capacitor;50V; Electrolytic;DIP	DIP	Jianghai	CD263-50V330
1	C7	1uF/25V	Ceramic Capacitor;25V;X7R;0805	0805	TDK	C2012X7R1E105K
1	C8	2.2uF/10V	Ceramic Capacitor;10V;X7R;0603	0603	muRata	GRM188R71A225KE15D
1	C9	2.2nF/50V	Ceramic Capacitor;50V;X7R;0603;	0603	TDK	C1608X7R1H222K
1	C10	47uF/50V	Electrolytic Capacitor;50V;	DIP	Jianghai	CD281L-50V47
1	C11	470pF/1kV	Ceramic Capacitor;1kV;1206	1206	muRata	GRM31B7U3A471JW31L
2	C12	22uF/50V	Electrolytic Capacitor;50V;	DIP	Jianghai	CD281L-50V22
1	CX1	22nF/275V	Capacitor;275V;10%	DIP	Carli	PX223K3IC39L270D9R
1	CY1	2.2nF/4kV	Capacitor;4000V;20%	DIP	Hongke	JNK12E222MY02N
4	D1, D5, D8, D10	1N4148WS	Diode;75V;0.15A;	SOD-323	Diodes	1N4148WS-7-F
1	D2	MBRS320T3G	Diode;200V;3A	SMB	Qianlongxin	MBRS320T3G
1	D3	WSGC10MH	Diode;1000V;1A	1206	MAXMEGA	WSGC10MH
1	D4	BZT52C15	Zener Diode;15V;5mA/500mW;	SOD-123	Diodes	BZT52C15
1	D6	BZT52C16	Zener Diode;16V;5mA/500mW;	SOD-123	Diodes	BZT52C16
1	D7	BAV21W	Diode;200V;0.2A;	SOD-123	Diodes	BAV21W-7-F
1	D9	BZT52C27	Zener Diode;27V;5mA/500mW;	SOD-123	Diodes	BZT52C27
1	D11	BZT52C2V4S	Zener Diode;2.4V;5mA/500mW;	SOD-323	Diodes	BZT52C2V4S
1	D12	BZT52C4V7	Zener Diode;4.7V;5mA/500mW;	SOD-123	Diodes	BZT52C4V7

EV4030A-S-01B BILL OF MATERIALS *(continued)*

1	D13	1N5375B	Zener Diode, 85V;15mA	DIP	Diodes	1N5375B
1	DB1	DF06S	Diode;600V;1.5A	SMD	Fairchild	DF06S
1	F1	SS-5-2A	Fuse;250V;2A	DIP	COOPER BUSSMANN	SS-5-2A
1	L1	1mH/0.42A	Inductor;1000uH; 2.5 Ohm;0.42A	DIP	Wurth	744743102
2	L2,L3	2.2mH/0.3A	Inductor;1.8mH; 4.73 Ohm;0.3A	DIP	Wurth	7447720222
1	L4	300uH/1A	Inductor;300uH; 33mOhm;1A	DIP	Emei	TP4U300-00
1	Q1	SSN1N45BTA	N-Channel Mosfet450V; 4250/10V;8.5	TO-92	Fairchild	SSN1N45BTA
1	Q2	CEF04N7G	Mosfet;700V;4A	TO-220F	MAXMEGA	CEF04N7G
1	Q3	MMBT3906LT1	Transistor;-40V;-0.2A;	SOT-23	ON Semiconductor	MMBT3906LT1
1	Q5	MMBT3904LT1	Transistor;40V;0.2A;	SOT-23	ON Semiconductor	MMBT3904LT1
1	Q4	EMF65N15A	N-MOS, 20A, 150V	TO-252	Excelliance MOS	EMF65N15A
3	R1, R13,R14	5.1kΩ	Film Resistor;1%;1/4W	1206	Yageo	RC1206FR-075K1L
1	R2	499kΩ/1206	Film Resistor;1%;	1206	Yageo	RC1206FR-07499KL
2	R3, R10	1MΩ/1%/0.25W	Resistor;1%;1/4W	DIP	any	1M Ohm
2	R4, R7	510Ω/2W	Resistor;5%;2W	DIP	any	510 Ohm/2W
1	R5	10Ω	Film Resistor;1%;	0603	Yageo	RC0603FR-0710RL
1	R6	470kΩ/1W	Resistor;5%;1W	DIP	any	100K Ohm
1	R8	68kΩ/1%	Film Resistor;1%	0603	Yageo	RC0603FR-0768KL
1	R9	30kΩ/1206	Resistor;1%	1206	Royalohm	1206F3002T5E
1	R11	51Ω/1206	Film Resistor;1%	1206	Yageo	RC1206FR-0751RL
1	R12	330Ω/2W	Resistor;5%;2W	DIP	any	330 Ohm/ 2W
1	R15	25.5kΩ/1%	Film Resistor;1%;	0603	Yageo	RC0603FR-0725K5L
1	R16	5.9kΩ/1%	Film Resistor;1%	0603	Yageo	RC0603FR-075K9L
1	R17	4.12kΩ/1%	Film Resistor;1%	0603	Yageo	RC0603FR-074K12L
1	R18	100mΩ/1%	Resistor;1%	1206	CYNTEC	RL1632H-R100-FN
1	R19	200Ω/1206	Resistor;1%	1206	Yageo	RC1206FR-07200RL
1	R20	1.5Ω/1%/1206	Resistor;1%	1206	Royalohm	1206F150KT5E
1	R21	100kΩ	Thick Film 5%	1206	Yageo	RC1206JR-07100KL

EV4030A-S-01B BILL OF MATERIALS *(continued)*

1	R22	2kΩ	Thick Film 1%	1206	Royalohm	1206F2001T5E
1	R23	10kΩ/1%	Film Resistor;1%	0603	Yageo	RC0603FR-0710KL
1	R24	2kΩ	Thick Film 1%	0603	Yageo	RC0603FR-072KL
1	R25	27kΩ	Thick Film 1%	0603	Yageo	RC0603FR-0727KL
1	RV1	TVR10431	THERMAL R	DIP	TSK	TVR10431KSY
1	JR1	0Ω	Jumper	1206	Yageo	RC1206FR-070RL
1	T1	EF20	L=2.15mH, Np:Ns:Naux=145:29:19	DIP	Wurth	750341840
1	U1	MP4030A	TRAIC Dimmable, Offline LED Lighting Controller	SOIC8	MPS	MP4030AGS-Z

TRANSFORMER SPECIFICATION

Electrical Diagram

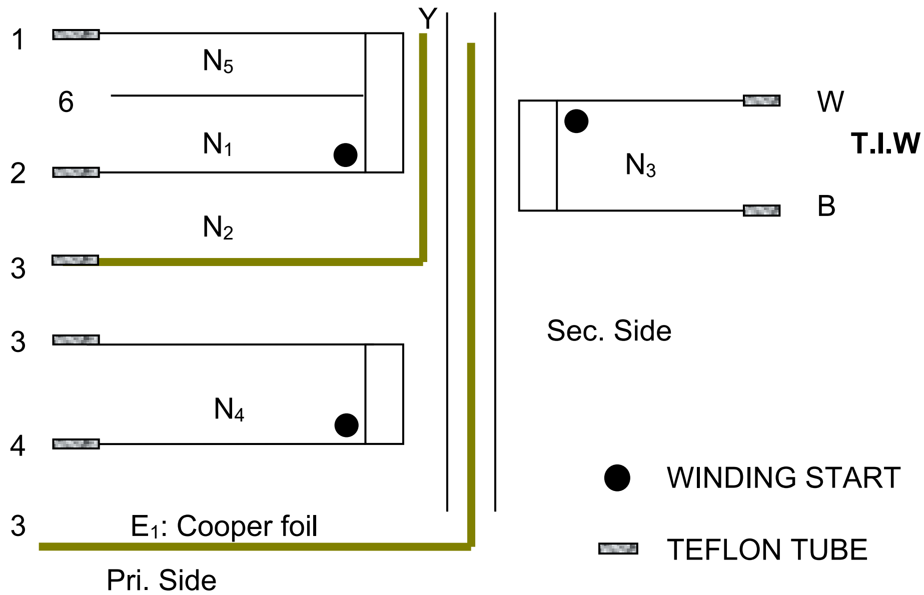


Figure 4—Transformer Electrical Diagram

Notes:

1. Don't connect Y to any pin of Bobbin.
2. W and B are pulled out and marked with different Teflon tube.
3. E_1 is one layer of cooper foil applied to core, and connected to PIN3 by a wire.

Winding Diagram

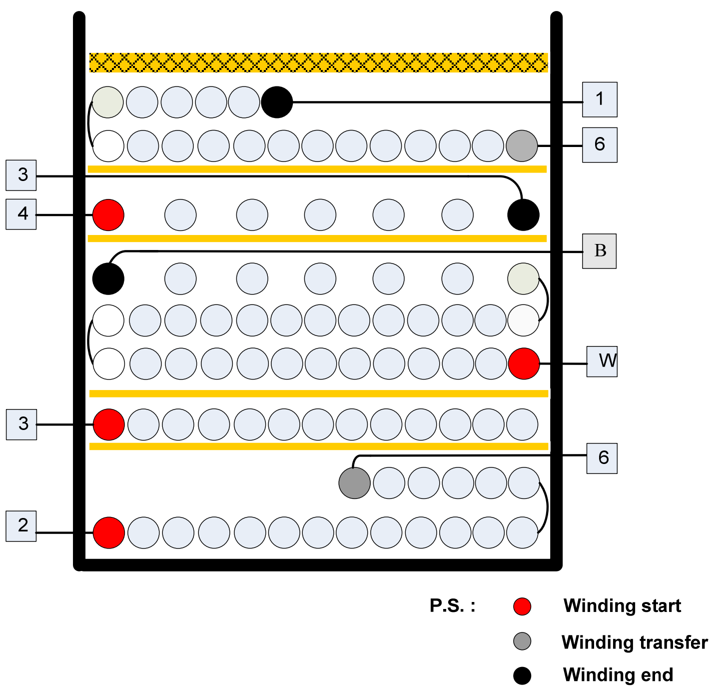


Figure 5—Winding Diagram

Winding Order

Winding No.	Tape Layer Number	Start & End	Magnet WireΦ(mm)	Turns
N_1	2	2→6	0.18mm * 1	73
N_2	2	3→Y	0.15mm * 1	one layer
N_3	2	W→B	0.20mm * 2 (T.I.W)	29
N_4	2	4→3	0.18mm * 1	19
N_5	3	6→1	0.18mm * 1	72
E_1	3		One layer Cooper foil	

Electrical Specifications

Electrical Strength	60 second, 60Hz, from PRI. to SEC.	2500VAC
	60 second, 60Hz, from PRI. to CORE.	1000VAC
	60 second, 60Hz, from SEC. to CORE.	1000VAC
Primary Inductance	Pins 1 - 2, all other windings open, measured at 100kHz, 0.1 VRMS	2.15mH±8%
Primary Leakage Inductance	Pins 1 - 2 with all other pins shorted, measured at 100kHz. 0.1 VRMS	43μH±10%

Materials

Item	Description
1	Core: EF20, UI=2500±25%, AL=1540nH/N^2±25% GAPPED, SUNSHINE SSP-4 or equivalent
2	Bobbin: EF20, 4+4PIN RMMOVE PIN6,7 1SECT T375J UL94V-0 HUAXING HX-2004
3	Wire: Φ0.18mm/Φ0.15mm,, UEW, TAI-I ELECTRIC WIRE&CABLE CO.,LTD or equivalent
4	Triple Insulation Wire: Φ0.20mm,TRW(B) GREAT LEOFLON INDUSTRIAL CO.,LTD or equivalent
5	TFL TUBE: GREAT AWG#18/26/30, CLEAR
6	TFL TUBE: GREAT AWG#18 BLACK, CLEAR
7	COOPER FOIL: 6.0X0.05mm(TH) DIAN QIANG or equivalent
8	Tape: 12.5mm(W)×0.06mm(TH)
9	Varnish: JOHN C. DOLPH CO, BC-346A or equivalent
10	Solder Bar: CHEN NAN: SN99.5/Cu0.5 or equivalent

EVB TEST RESULTS

Performance Data

Efficiency, PF and THD

f (Hz)	Vin(Vac)	Pin(W)	Vo(V)	Io(mA)	Po(W)	Efficiency(%)	PF	THD(%)
50	185	18.61	29.32	527	15.45	83.03	0.986	10.30
	190	18.58	29.32	527	15.45	83.16	0.984	10.40
	200	18.53	29.32	527	15.45	83.39	0.981	11.20
	210	18.49	29.32	526	15.42	83.41	0.977	11.90
	220	18.47	29.32	526	15.42	83.50	0.973	12.10
	230	18.47	29.32	526	15.42	83.50	0.968	12.90
	240	18.47	29.31	526	15.42	83.47	0.965	13.00
	250	18.49	29.31	526	15.42	83.38	0.959	13.10
	260	18.51	29.31	526	15.42	83.29	0.954	13.20
	265	18.53	29.31	526	15.42	83.20	0.953	13.20

Dimming Compatibility (No Flicker with these 21 different Dimmers)

Manufacturer	Part No.	Power Stage	Dimming Type	Imax(mA)	Imin(mA)	Dimming ratio
GIRA	0302 00/I01	60-600W	Leading	533	30	5.63%
MIKA	433/4	60-400W	Leading	531	91	17.14%
Berker	283010	60-400W	Leading	531	43	8.10%
JUNG	225 NV DE	20-500W/VA	Leading	531	22	4.14%
JUNG	225 NV DE	20-500W/VA	Leading	532	105	19.74%
Berker	286610	20-500W	Leading	531	40	7.53%
JUNG	266 GDE	60-600W	Leading	527	33	6.26%
EMC	PROP400U	40-400W	Leading	531	28	5.27%
Busch	2247U	500W/VA	Leading	531	50	9.42%
Busch	2200..	60-400W	Leading	530	54	10.19%
Busch	6513 U-102	420W/VA	Trailing	531	50	9.42%
Grundtyp	ET1_53850	25~300W	Trailing	445	40	8.99%
MIKA	433 HAB	20-315W	Trailing	406	46	11.33%
MIKA?	EIM-585	20-300W	Trailing	458	1	0.22%
Busch	6591U-101	420W/VA	Trailing	462	39	8.44%
Busch	6519U	550W/VA	Trailing	527	50	9.49%
JUNG	225 TDE	20-525W	Trailing	504	44	8.73%
SIEMENS	5TC8 284	20-600W	Trailing	481	30	6.24%
LICHTREGLER	T46s	20~315W	Trailing	514	61	11.87%
JUNG	254 UDIE 1	50-420W/VA	Trailing	527	71	13.47%
Berker	286110	50-420W	Trailing	526	72	13.69%

Electric Strength Test

Primary circuit to secondary circuit electric strength testing was completed according to IEC61347-1 and IEC61347-2-13.

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

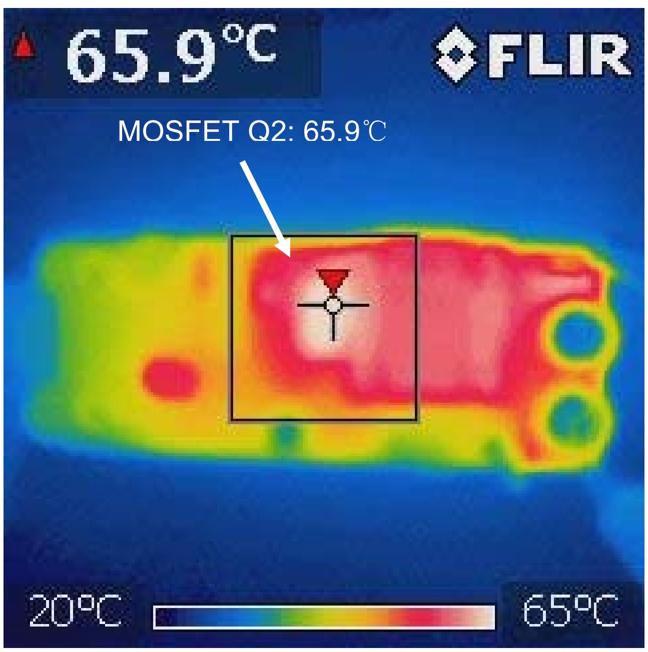
Surge Test

Line to Line 500V and Line to Power Earth 1kV surge testing was completed according to IEC61547. Input voltage was set at 230VAC/50Hz. Output was loaded at full load and operation was verified following each surge event.

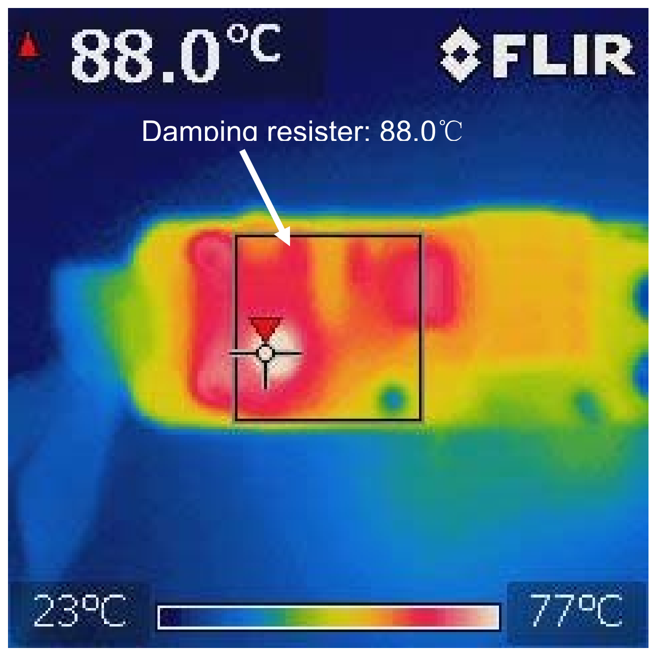
Surge Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Test Result (Pass/Fail)
500	230	L to N	90	Pass
-500	230	L to N	270	Pass
1000	230	L to PE	90	Pass
-1000	230	L to PE	270	Pass
1000	230	N to PE	90	Pass
-1000	230	N to PE	270	Pass

Thermal Test

Test without dimmer and with dimmer at 90% dimming on phase.



Without dimmer

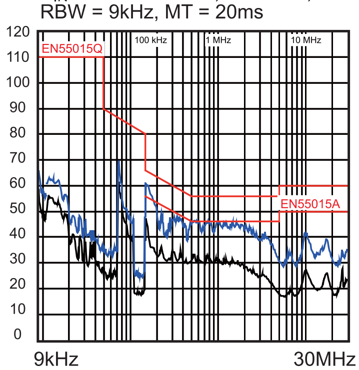


With dimmer at 90% dimming on phase

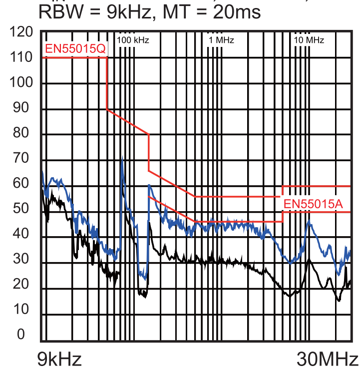
EVB TEST RESULTS

Performance waveforms are tested on the evaluation board.
V_{IN}=230VAC/50Hz, 9 LEDs in series, I_{LED}=520mA, V_{OUT}=30V, L_P=2.15mH, N_P:N_S: N_{AUX} =145:29:19

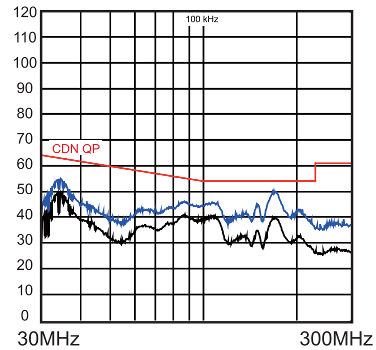
Conducted EMI L-line
V_{IN} = 230VAC/50Hz, Full Load,
RBW = 9kHz, MT = 20ms



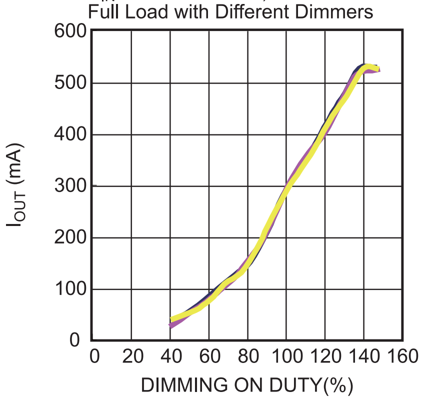
Conducted EMI N-line
V_{IN} = 230VAC/50Hz, Full Load,
RBW = 9kHz, MT = 20ms



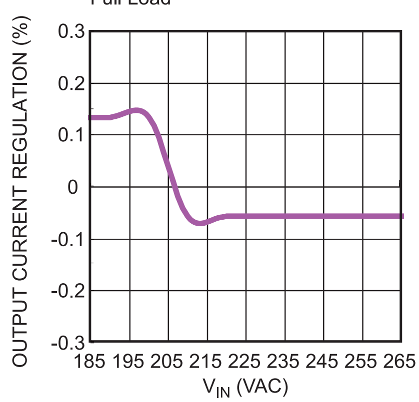
CDN
V_{IN} = 230VAC/50Hz, Full Load



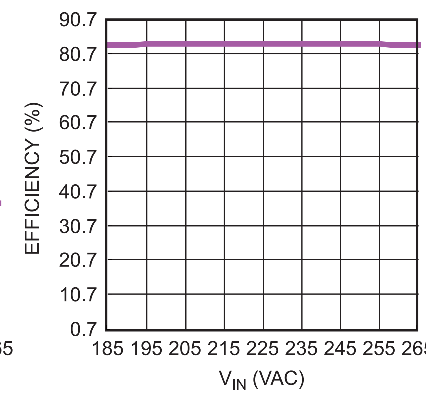
Dimming Curve
V_{IN} = 220VAC/50Hz,
Full Load with Different Dimmers



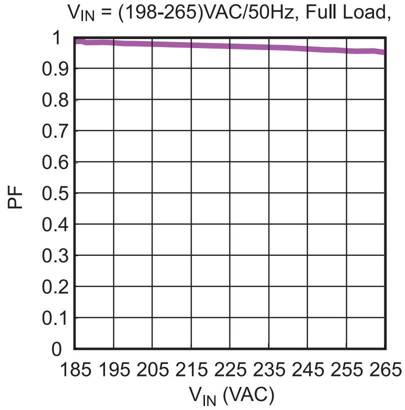
Line Regulation
Full Load



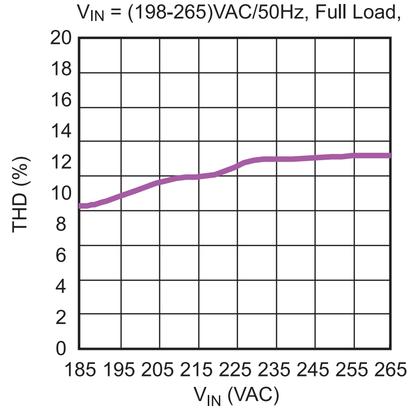
Efficieny vs. V_{IN}



PF vs. V_{IN}
V_{IN} = (198-265)VAC/50Hz, Full Load,



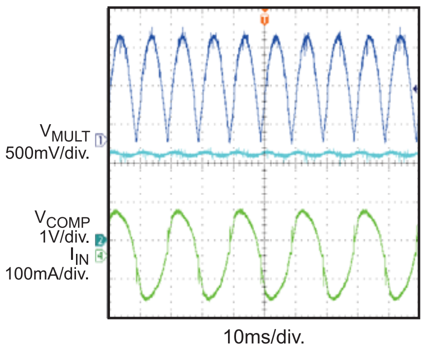
THD vs. V_{IN}
V_{IN} = (198-265)VAC/50Hz, Full Load,



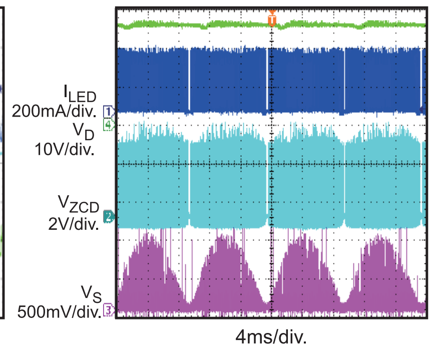
EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.
V_{IN}=220VAC/50Hz, 9 LEDs in series, I_{LED}=520mA, V_{OUT}=30V, L_P=2.15mH, N_P:N_S:N_{AUX} =145:29:19.

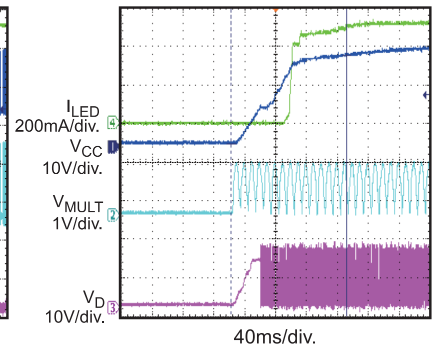
Input Voltage and Current
V_{IN}=230VAC/50Hz, Full Load



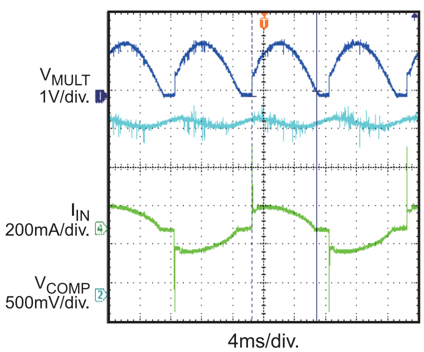
Steady State
V_{IN}=230VAC/50Hz, Full Load



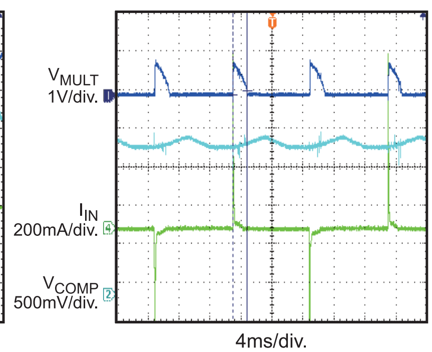
V_{IN} Start Up
V_{IN}=230VAC/50Hz, Full Load



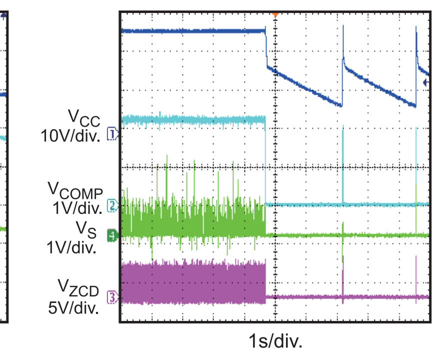
Dimming Performance
Max Dimming on Phase
V_{IN}=230VAC/50Hz, with Dimmer



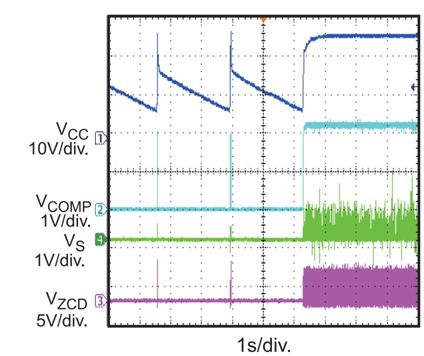
Dimming Performance
Max Dimming on Phase
V_{IN}=230VAC/50Hz, with Dimmer



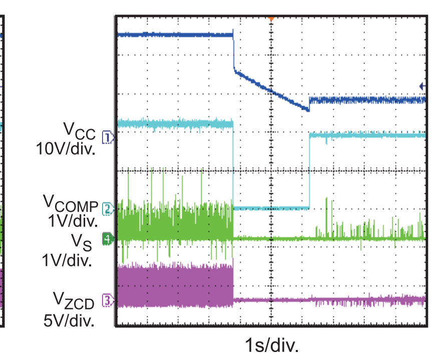
OVP
LED Load Open
at Normal Operation
V_{IN}=230VAC/50Hz, Full Load



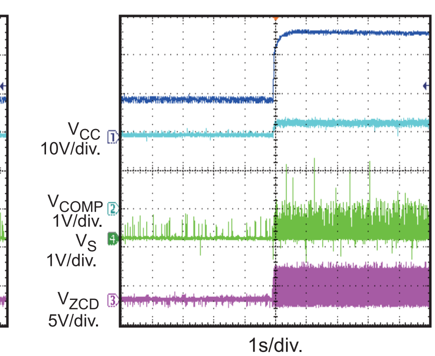
OVP
LED Load Open
then Recovery
V_{IN}=230VAC/50Hz, Full Load



OCP
LED+ Short to LED-
at Normal Operation
V_{IN}=230VAC/50Hz, Full Load



OCP
LED+ Short to LED-
then Recovery
V_{IN}=230VAC/50Hz, Full Load



QUICK START GUIDE

1. Preset AC Power Supply to 185VAC ≤ V_{IN} ≤265VAC.
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_{IN} terminals as shown on the board.
5. Turn AC Power Supply on after making connections.