EV44010-S+HR1000A-S-00D

100W LED Driver Evaluation Board

The Future of Analog IC Technology®

DESCRIPTION

The EV44010-S+HR1000A-S-00D is a general purpose evaluation board of MP44010, HR1000A, MP6922 and MP150 for 100W LED driver application.

MP44010 is a boundary conduction mode PFC controller which can provide simple and high performance active power factor correction with minimum external components.

HR1000A is a controller specific for the resonant half-bridge topology with two channels of 50% complementary duty cycle outputs driving signals.

The MP6922 is a dual fast turn-off intelligent rectifier to drive two N-CH power MOSFETs in LLC resonant converters for synchronous rectification.MP6922 has a light-load function to latch-off the gate driver at light load condition.

MP150 supports high-side buck converter which features as integrated 500V MOSFET, accurate voltage regulation, minimum external components. There features makes it a good candidate for standby power supply for Vcc.

The EV44010-S+HR1000A-S-00D provides up to 100W output power and operates with ultra wide input range from 90V to 305V. Besides, the EV44010-S+HR1000A-S-00D has output fault protections, such as short circuit protection, over voltage protection. It also can meet the Class C standard of IEC61000-3-2 and EN55015 standard.

ELECTRICAL SPECIFICATIONS

Parameter	Symbol	Value	Units
Input AC Voltage	V_{AC}	90 to 305	V
Output Current	I_{OUT}	4.16	A
Output Voltage	V_{OUT}	24	V
Output Power	P_{OUT}	100	W

FEATURES

- Ultra Wide Operating Input Range(from 90V to 305V)
- High efficiency up to 92%
- Meet Class C Standard of IEC61000-3-2
- Meet EN55015 Standard
- High Power Factor
- Short Circuit Protection (Latch Mode)
- Over Current Protection
- Over Voltage Protection

APPLICATIONS

- LED Driver Application

All MPS parts are lead-free and adhere to the RoHS directive. For MPS green status, please visit MPS website under Quality Assurance. "MPS" and "The Future of Analog IC Technology", are Registered Trademarks of Monolithic Power Systems, Inc.

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.

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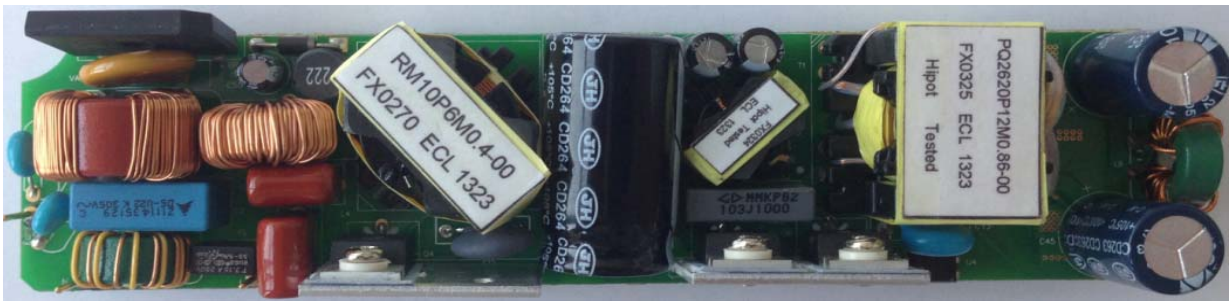
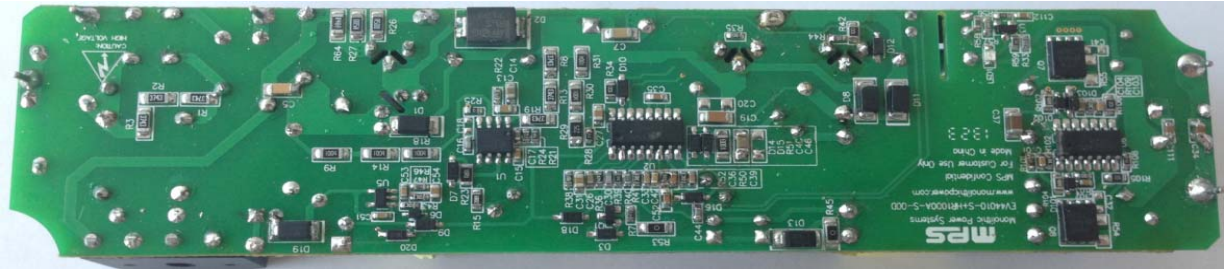
EV44010-S+HR1000A-S-00D EVALUATION BOARD





(L x W x H) (16.2cm x 3.8cm x 2.5cm)

Board Number	MPS IC Number
EV44010-S+HR1000A-S-00D	MP44010HS
	HR1000AGS
	MP6922GS
	MP150GJ

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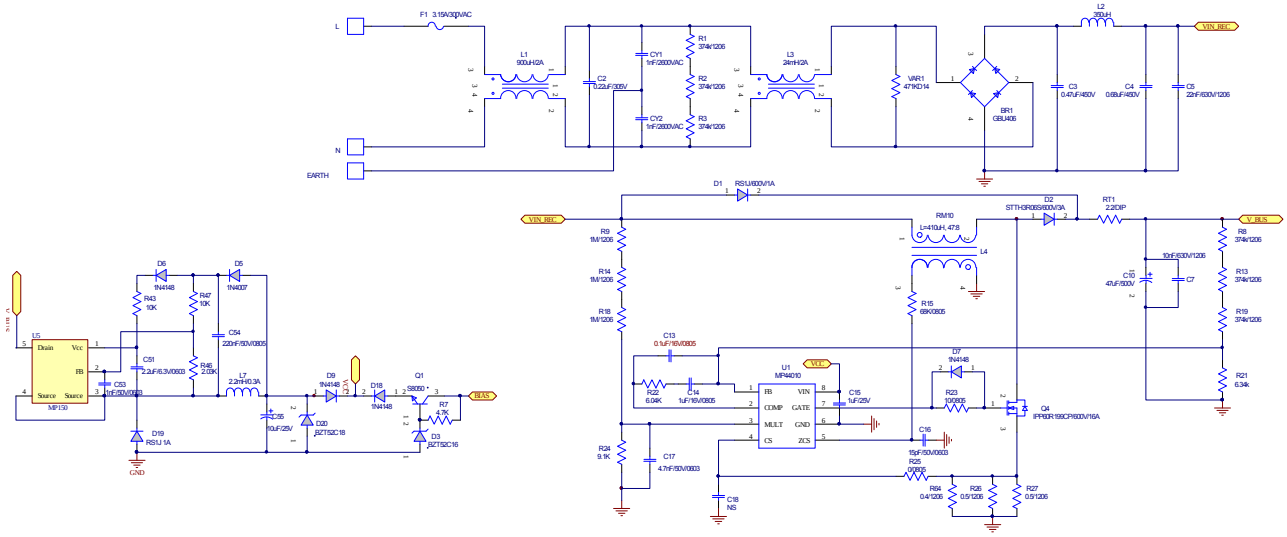
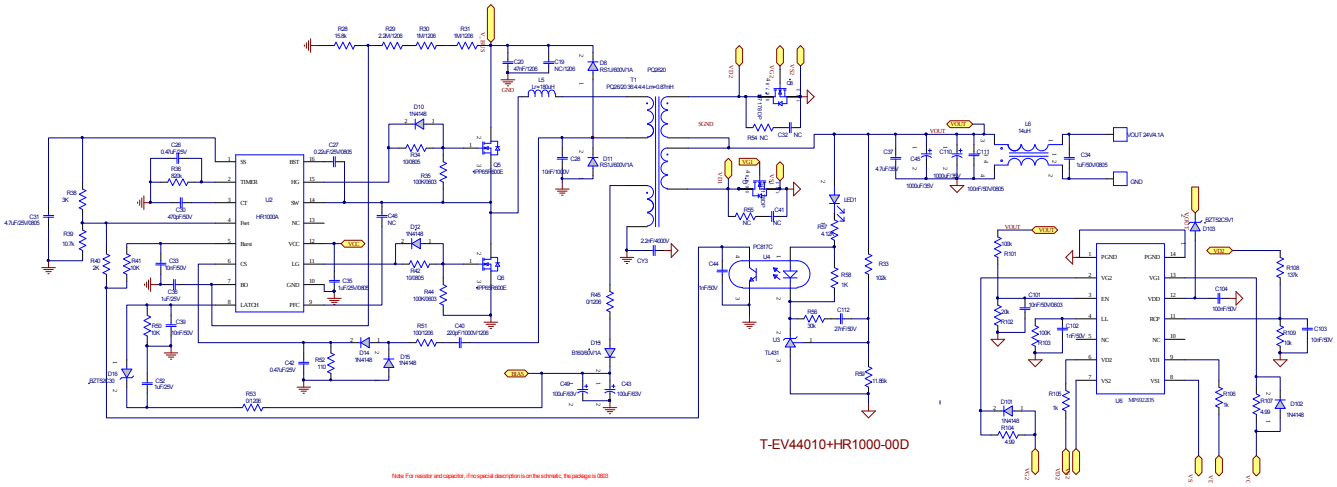
EVALUATION BOARD SCHEMATIC



PFC Stage



LLC Stage

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EV44010-S+HR1000A-S-00D BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Part Number
2	CY1, CY2	1nF	Y Capacitor;2600V;20%	DIP	Panasonic	JYK08F102ML72N
1	CY3	2.2nF	Y Capacitor;4000V;20%	DIP		JNK12E222MY02N
1	C2	0.22μF	X-CAP;305V	DIP	EPCOS	B32922C3224K
1	C3	0.47μF	Capacitor;450V;CBB	DIP	CARLI	TF474K2Y10BL270D9R
1	C4	0.68μF	Capacitor;450V;CBB	DIP	CARLI	TF684K2Y10BL270D9R
1	C5	22nF	Ceramic Capacitor;630V;X7R	1206	TDK	C3216X7R2J223K
1	C10	47μF	Electrolytic Capacitor;500V	DIP	Rubycon	500BXC47M
1	C7	10nF	Ceramic Capacitor;630V;X7R	1206	TDK	C3216X7R2J103K
2	C27, C54	0.22μF	Ceramic Capacitor;50V;X7R	0805	TDK	C0805X224K025T
1	C13	0.1μF	Ceramic Capacitor;16V;X7R	0805	Murata	GRM21BR71H104KA01L
1	C51	2.2μF	Ceramic Capacitor;6.3V;X5R	0603	Murata	GRM188R71E225KA01D
3	C53, C102, C44	1nF	Ceramic Capacitor;50V;X7R	0603	Murata	GRM188R71H102KA01D
1	C14	2.2μF	Ceramic Capacitor;16V;X7R	0805	Murata	GRM21BR71H225KA01L
1	C15	1μF	Ceramic Capacitor;25V;X7R	0603	Murata	GRM188R71E105KA01D
2	C35, C52	1μF	Ceramic Capacitor;25V;X7R	0805	Murata	GRM21BR71E105KA01D
1	C55	10μF	Electrolytic Capacitor;50V	DIP	Rubycon	50BXC10M
1	C16	15pF	Ceramic Capacitor;50V;X7R	0603	TDK	C1608X7R1H150K
1	C17	4.7nF	Ceramic Capacitor;50V;X7R	0603	Murata	GRM188R71H472KA01D
1	C19	47nF	Ceramic Capacitor;630V;X7R	1206	Murata	GRM31CR71H473KA01D
0	C18,C46, C41,C32, C20	NS				
1	C37	4.7μF	Ceramic Capacitor;50V;X7R	1206	Murata	GRM31CR71H475KA01D
2	C26,C42	0.47μF	Ceramic Capacitor;25V;X5R	0603	TDK	GRM188R71E474KA12
2	C45, C110	1000μF	Electrolytic Capacitor;35V	DIP	JIANGHAI	CD263-35V1000
1	C104	0.1μF	Ceramic Capacitor;50V;X7R	0603	Murata	GRM188R71H104KA01D
1	C111	0.1μF	Ceramic Capacitor;50V;X7R	0805	Murata	GRM21BR71H104KA01D
1	C34	1μF	Ceramic Capacitor;50V;X7R	0805	Murata	GRM21BR71H105KA01D
1	C28	10nF	Capacitor;1000V	DIP	FaLa	MMKP82-1000V-103P15JA
1	C30	470pF	Ceramic Capacitor;50V;X7R	0603	Murata	GRM1885C1H471JA01
1	C31	4.7μF	Ceramic Capacitor;25V;X5R	0805	Murata	GRM21BR61E475KA88
4	C33, C101, C39, C103	10nF	Ceramic Capacitor;50V;X7R	0603	Murata	GRM188R71H103KA01D
1	C36	1μF	Ceramic Capacitor;25V;X7R	0603	Murata	GRM188R71H105KA01D

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EV44010-S+HR1000A-S-00D BILL OF MATERIALS *(continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Part Number
1	C112	27nF	Ceramic Capacitor;50V;X7R	0603	Murata	GRM1885C1H273JA01
1	C40	220pF	Ceramic Capacitor;1000V;C0G	1206	TDK	C3216C0G3A221J
2	C43,C49	100µF	Electrolytic Capacitor;35V	DIP	Sanyo	CD287-35V100
6	R1, R2, R3,R8, R13,R19	374k	Film Resistor;1%;	1206	Yageo	RC1206FR-07374KL
5	R9,R14, R18,R30, R31	1M	Film Resistor;1%;	1206	Yageo	RC1206FR-071ML
4	R43,R47, R41,R109	10k	Film Resistor;1%;	0603	Yageo	RC0603FR-0710KL
1	R28	15.8k	Film Resistor;1%;	0603	Yageo	RC0603FR-0715K8L
1	R29	2.2M	Film Resistor;1%;	1206	Yageo	RC1206FR-072M2L
1	R15	68k	Film Resistor;1%;	0805	Yageo	RC0805FR-0768KL
1	R46	2.05k	Film Resistor;1%	0603	Yageo	RC0603FR-072K05L
1	R21	6.34k	Film Resistor;1%;	0603	Yageo	RC0603FR-076K34L
1	R22	6.04k	Film Resistor;1%;	0603	Yageo	RC0603FR-0720KL
1	R23	10	Film Resistor;1%;	0805	Yageo	RC0805FR-0710RL
1	R7	4.7k	Film Resistor;1%;	0603	Yageo	RC0603FR-074K7L
1	R24	9.1k	Film Resistor;1%;	0603	Yageo	RC0603FR-079K1L
1	R25	0	Film Resistor;1%;	603	Yageo	RC0603FR-070RL
2	R26, R27	0.5	Film Resistor;1%;	1206	Yageo	RC1206FR-070R5L
1	R64	0.4	Film Resistor;1%;	1206	Yageo	RC1206FR-070R4L
0	R54,R55	NS				
2	R34,R42	10	Film Resistor;1%;	0805	Yageo	RC0805FR-0710RL
1	R36	820k	Film Resistor;1%;	0603	Yageo	RC0603FR-07820KL
4	R35,R101, R44,R103	100k	Film Resistor;1%;	0603	Yageo	RC0603FR-07100KL
1	R38	3k	Film Resistor;1%;	0603	Yageo	RC0603FR-073KL
1	R39	10.7k	Film Resistor;1%;	0603	Yageo	RC0603FR-0710K7L
1	R58	1k	Film Resistor;1%;	0603	Yageo	RC0603FR-071KL
2	R105, R106	1k	Film Resistor;1%;	0805	Yageo	RC0805FR-071KL
1	R40	2k	Film Resistor;1%;	0603	Yageo	RC0603FR-072KL
1	R57	4.12k	Film Resistor;1%;	0805	Yageo	RC0805FR-074K12L
1	R33	102k	Film Resistor;1%;	0603	Yageo	RC0603FR-07102KL
1	R108	137k	Film Resistor;1%;	0603	Yageo	RC0603FR-07137KL
2	R45,R53	0	Film Resistor;1%;	1206	Yageo	RC1206FR-070RL
1	R56	30k	Film Resistor;1%;	0603	Yageo	RC0603FR-0730KL
1	R102	20k	Film Resistor;1%;	0603	Yageo	RC0603FR-0720KL
1	R50	10k	Film Resistor;1%;	0603	Yageo	RC0603FR-0710KL

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EV44010-S+HR1000A-S-00D BILL OF MATERIALS *(continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Part Number
1	R51	100	Film Resistor;1%;	1206	Yageo	RC1206FR-07100RL
1	R52	110	Film Resistor;1%;	0603	Yageo	RC0603FR-07110RL
1	R59	11.8k	Film Resistor;1%;	0603	Yageo	RC0603FR-0711K8L
2	R107, R104	4.99	Film Resistor;1%;	0805	Yageo	RC0805FR-075R1L
1	RT1	2	Resistor	DIP	Semitec	5D2-10
1	VAR1	471KD14	MOV	DIP	Thinking	TVR14471KS42Y
1	BR1	GBU406	BRIDGE RECTIFIER/DF02S; 600V;4A	DIP	Diodes	GBU406
3	D1,D11, D8	RS1J	Diode;600V;1A;	SMA	Diodes	RS1J
1	D2	STTH3R06S	Diode;600V;3A;	SMC	ST	STTH3R06S
1	D5	1N4007	Diode;1000V;1A;	DO-41	Diodes	1N4007
7	D12, D7, D9, D10, D14, D15, D18	1N4148W	Diode;75V;0.15A;	SOD-123	Diodes	1N4148W
3	D6,D102, D101	1N4148WS	Diode;75V;0.15A;	SOD-323	Diodes	1N4148WS
2	D3,D20	BZT52C16	Zener Diode;16V;5mA	SOD-123	Diodes	BZT52C16
1	D19	US1G	Diode;400V;1A;		Mic	US1G
1	D103	BZT52C5V1	Zener Diode;5.1V;5mA	SOD-123	Diodes	BZT52C5V1
1	D13	B160	Schottky Diode;60V;1A;	SMA	Diodes	B160
1	D16	BZT52C30	Zener Diode;30V;5mA	SOD-123	Diodes	BZT52C30
1	F1	3.15A/300VAC	FUSE-SS-5H	DIP	COOPER BUSSMANN	SS-5H-3.15A
1	L1	900uH	Common Choke,900μH,2A	DIP	DEKELONG	T12.7*7.92*5.08
1	L2	300uH	Filter Inductor;300μH	DIP	DEKELONG	T60-26
1	L3	20mH	Common Choke,20mH,2A	DIP	Wurth	744823220
1	L4	410uH	PFC Inductor, L=410μH, N1:N2=47:8,RM10	DIP	Emei	FX0323
1	L7	2.2mH	2.2mH,0.3A	DIP	Wurth	7447720222
1	L5	180uH	Resonant Inductor, L=180μH,RM6	DIP	Emei	FX0324
1	L6	14uH	Common Choke,14μH,4A	DIP	Wurth	744841414
1	Q1	S8050	Transistor;25V;0.5A	SOT-23	Changjiang Electronics	S8050
1	Q4	IPP60R199CP	N-Channel Mosfet; 650V;16A	TO220	Infineon	IPP60R199CP
2	Q5,Q6	IPP65R600E	N-Channel Mosfet; 700V;18A	TO220	Infineon	IPP65R600E

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EV44010-S+HR1000A-S-00D BILL OF MATERIALS *(continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Part Number
2	Q8,Q7	SI7178DP	N-Channel Mosfet;100V;60A	Powerpak	Vishay	SI7178DP
1	T1	0.86mH	Transformer, Lp=0.86mH N1:N2:N3:N4 =36:4:4:4 PQ26-20	DIP	Emei	FX0325
1	U5	MP150	buck regulator	SOIC8	MPS	MP150GJ
1	U1	MP44010	PFC controller	SOIC8	MPS	MP44010HS
1	U2	HR1000A	LLC controller	SOIC16	MPS	HR1000AGS
1	U4	PC817C	Photocoupler; 1-Channel	DIP	SHARP	PC817C
1	U3	TL431	Vref=2.5V	SOT-23	Changjiang Electronics	TL431
1	U6	MP6922	SR controller	SOIC8	MPS	MP6922GS
1	LED1	HL-PSC-2012H203BC	LED Blue	0805	BRIGHT LED	HL-PSC-2012H203BC
6	0-10V DIMMING, GND, LED+, LED-,L, N		Connector			Connector
2	HEATSINK		HEATSINK			HEATSINK

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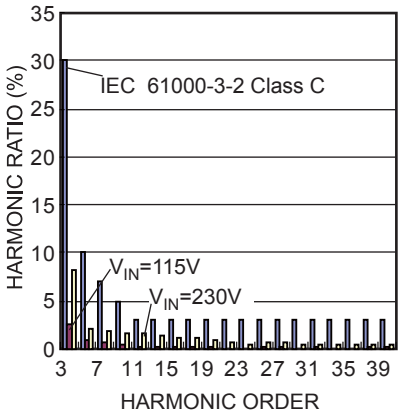
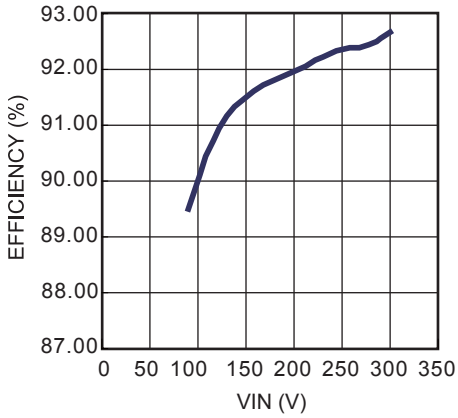
EVB TEST RESULTS

Performance waveforms are tested on the evaluation board.
V_{AC}=90V to 305V, I_{OUT}=4.16A, P_{OUT}=100W

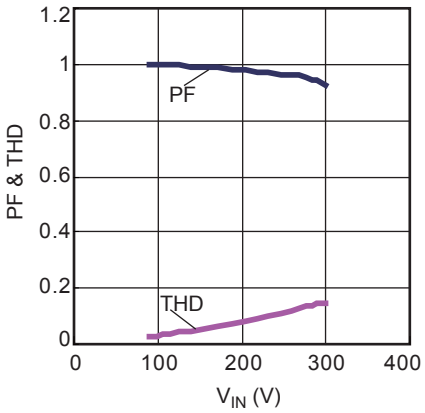
Harmonic
VAC=115V & 230V, full load



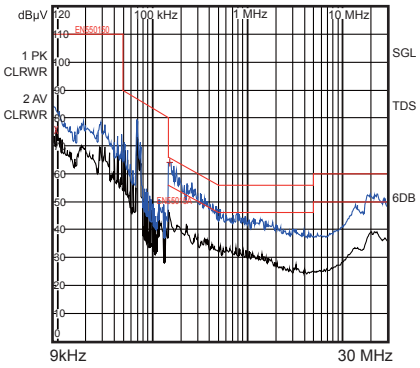
Efficiency vs. V_{AC}



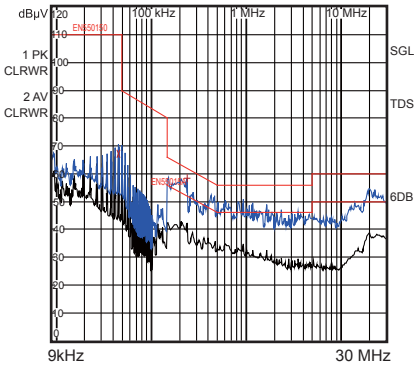
PF & THD vs. V_{AC}



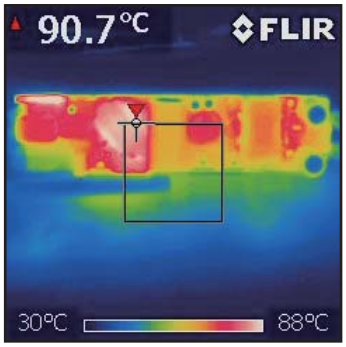
Conducted EMI
VAC=115V, full load



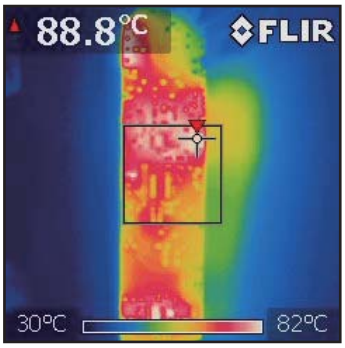
Conducted EMI
VAC=230V, full load



Thermal Figure
VAC=90V, full load, T_A=35°C
Top view



Thermal Figure
VAC=90V, full load, T_A=35°C
Bottom view



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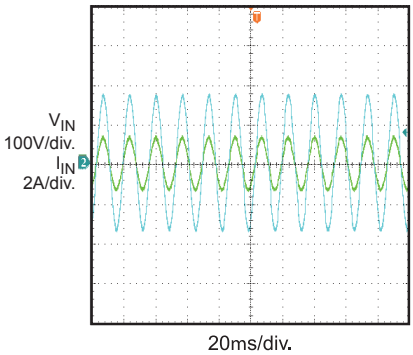
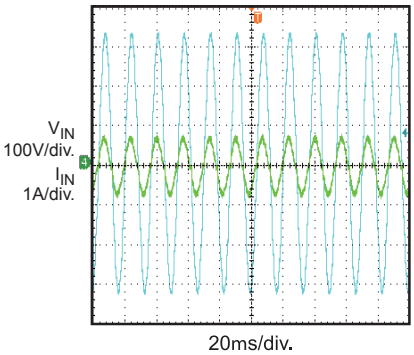
EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.
V_{AC}=90V to 305V, I_{OUT}=4.16A, P_{OUT}=100W

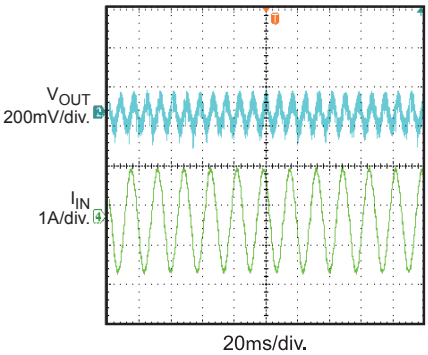
Input Voltage and Current
V_{IN} = 120VAC/60Hz, full load



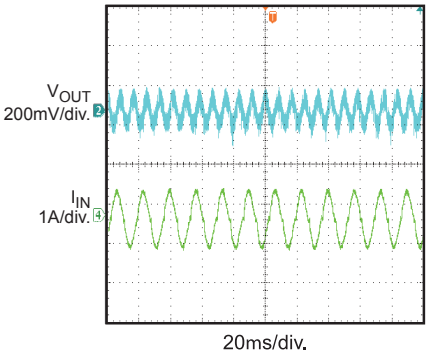
Input Voltage and Current
V_{IN} = 230VAC/60Hz, full load



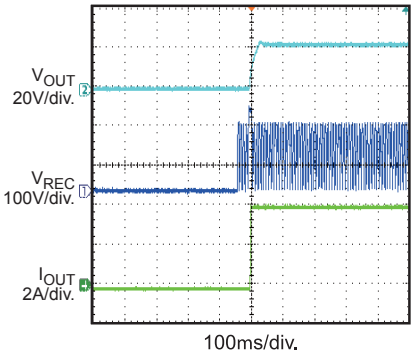
Steady State
V_{IN} = 120VAC/60Hz, full load



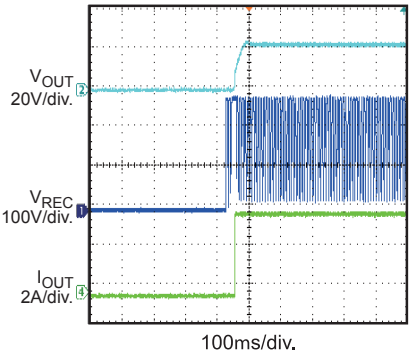
Steady State
V_{IN} = 230VAC/60Hz, full load



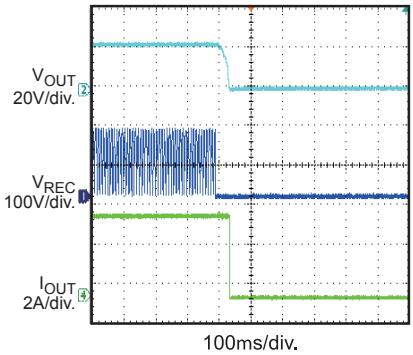
Start Up
V_{IN} = 120VAC/60Hz, full load



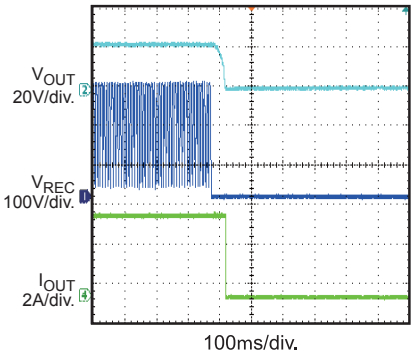
Start Up
V_{IN} = 230VAC/60Hz, full load



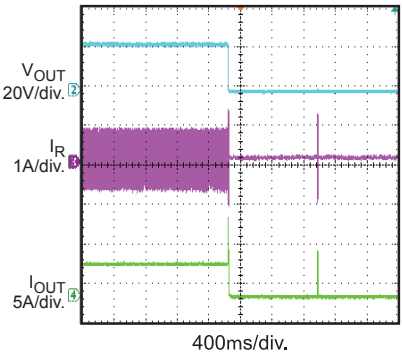
Shut Down
V_{IN} = 120VAC/60Hz, full load



Shut Down
V_{IN} = 230VAC/60Hz, full load



SCP Entry
V_{IN} = 120VAC/60Hz, full load



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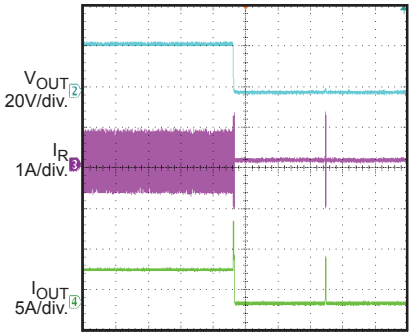
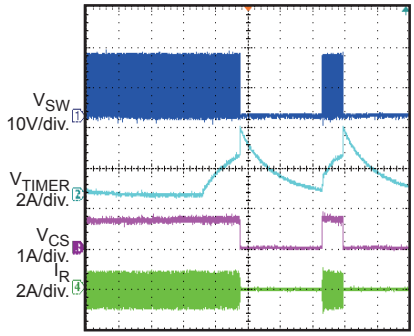
EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.
V_{AC}=90V to 305V, I_{OUT}=4.16A, P_{OUT}=100W

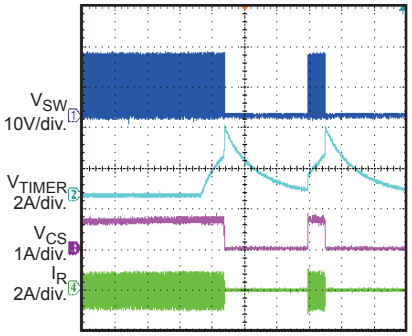
SCP Entry
V_{IN} = 230VAC/60Hz, full load



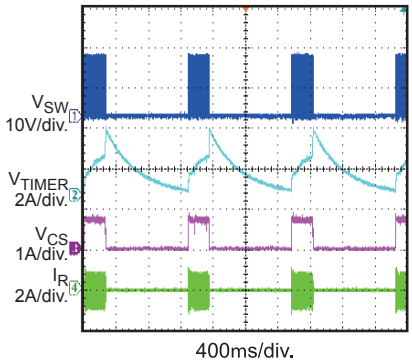
OCP Entry
V_{IN} = 120VAC/60Hz, full load



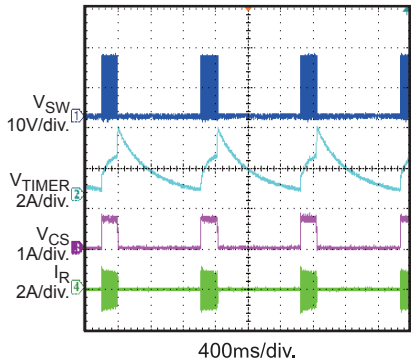
OCP Entry
V_{IN} = 230VAC/60Hz, full load



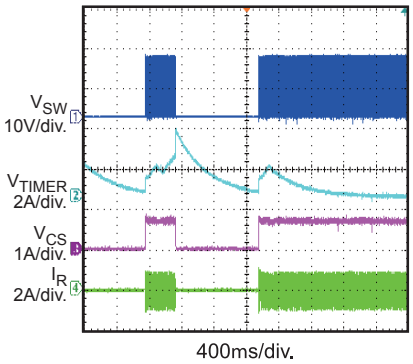
OCP Steady State
V_{IN} = 120VAC/60Hz, 5A load



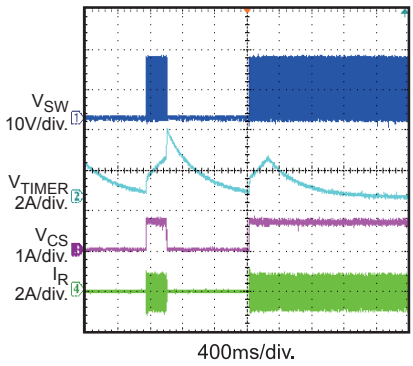
OCP Steady State
V_{IN} = 230VAC/60Hz, 5A load



OCP Recovery
V_{IN} = 120VAC/60Hz, 5A load



OCP Recovery
V_{IN} = 230VAC/60Hz, 5A load



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PRINTED CIRCUIT BOARD LAYOUT

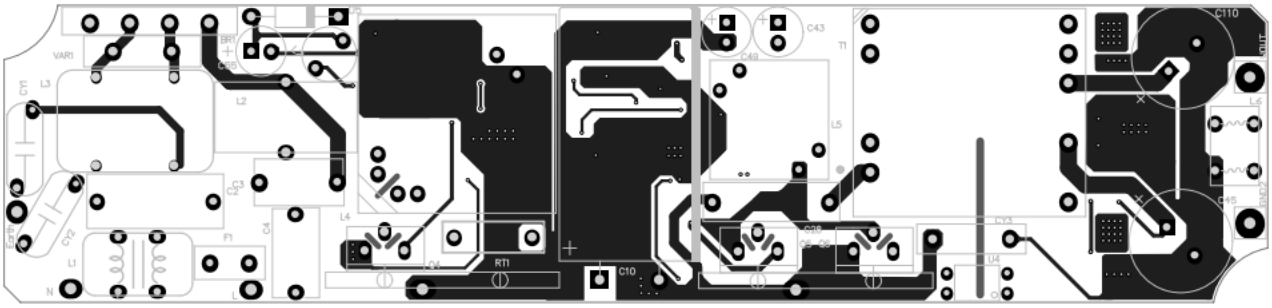

Figure 1—Top Layer

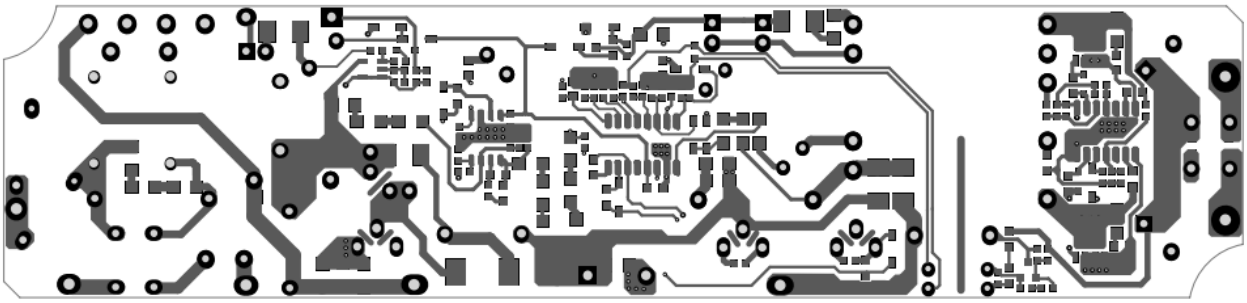

Figure 2—Bottom Layer

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QUICK START GUIDE

1. Preset AC input voltage between 90V and 305V. Then turn off AC power supply.
2. Connect the output pins, VOUT & GND to the output load.
3. Connect the Line and Neutral terminals of the power supply output to AC input pins, L & N.
4. Turn on the power supply. The board will start up automatically.

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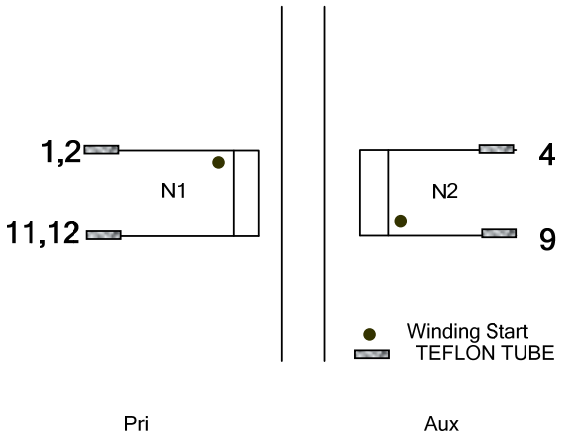
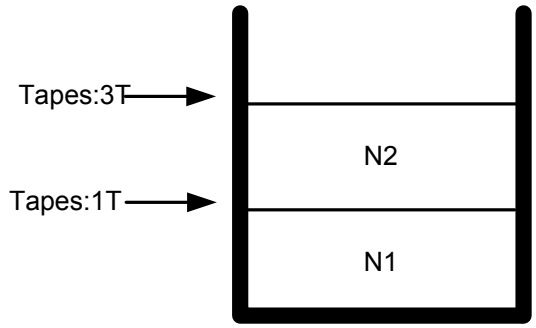
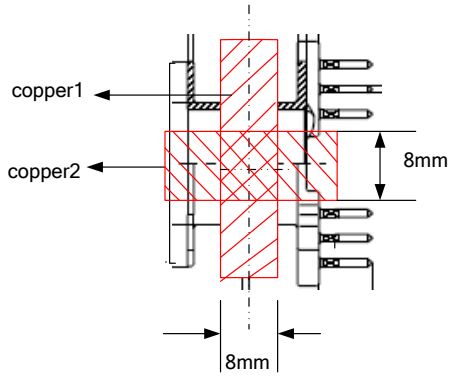
APPENDIX1: PFC INDUCTOR SPECIFICATION

Electrical Diagram



Winding Diagram

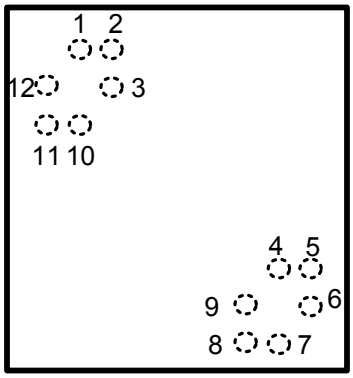




Note: use copper wires to connect copper1 & copper2 with pin 9 of bobbin.

Pin Definition of Bobbin

Pin out



View from the top

Table 1—Electrical Characteristic

Parameter	Condition	Value
Primary Inductance	L（1,2—11,12）	410μH±5%
Core		RM10
Bobbin		RM10
Core Material		PC40
Turn Ratio	N1:N2	47:8

Table 2—Winding Specification

Tape Turns	Winding No.	Margin Tapes	Start& End	Wire Diameter (mm)	Turns
1	N1		1&2→11&12	0.33×5	47
3	N2		9→4	0.2×1	8

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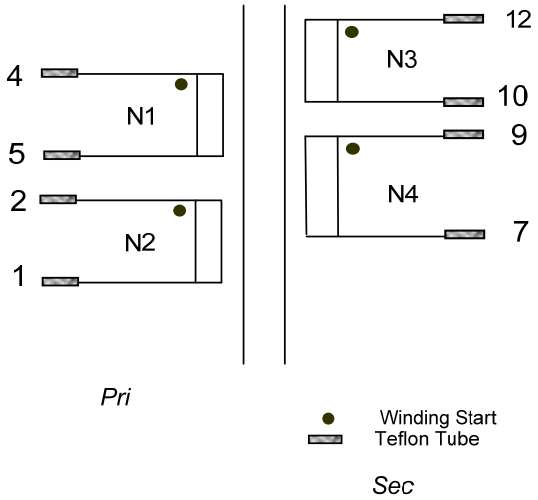
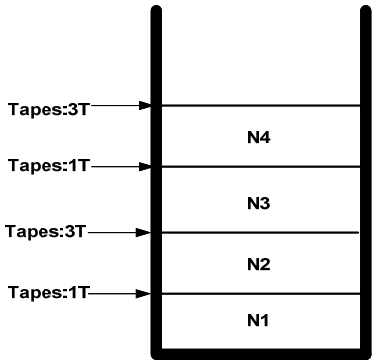
APPENDIX2: LLC TRANSFORMER SPECIFICATION

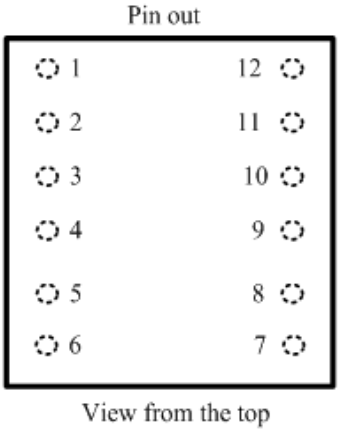
Electrical Diagram

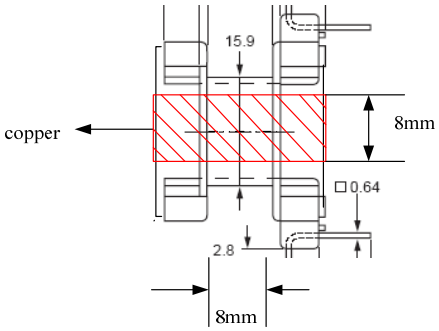


Winding Diagram



Pin Definition of Bobbin





Note: use a copper wire to connect copper with pin 2 of bobbin.

Table 1—Electrical Characteristic

Parameter	Condition	Value
Primary Inductance	L(4-5)	860uH±5%
Core		PQ26-20
Bobbin		PQ26-20
Core Material		PC40
Turn Ratio	N1:N2:N3:N4	36:4:4:4

Table 2—Winding Specification

Tape Turns	Winding No.	Start& End	Wire Diameter (mm)	Turns
1	N1	4→5	0.22×2	36
3	N2	2→1	0.2×8	4
1	N3	12→10	0.7TIW×2	4
3	N4	9→7	0.7TIW×2	4

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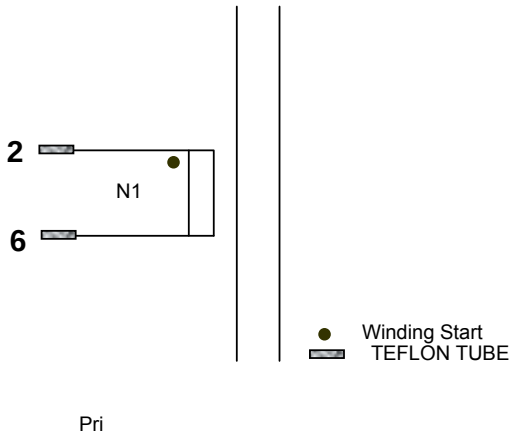
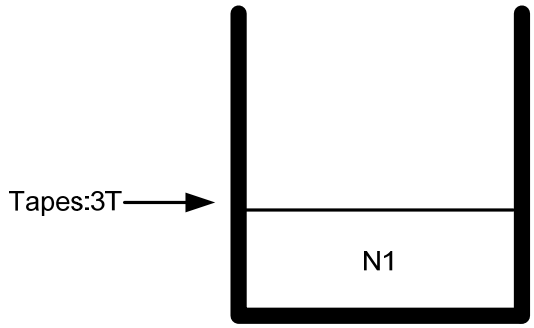
APPENDIX3: LLC RESONANT INDUTOR SPECIFICATION

Electrical Diagram



Winding Diagram



Pin Definition of Bobbin

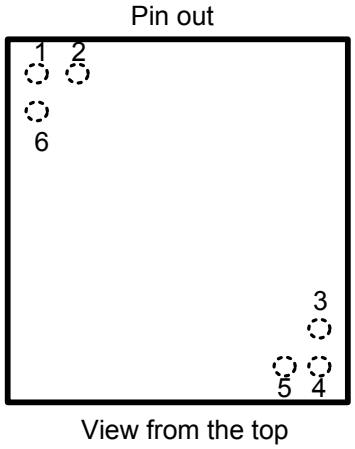


Table 1—Electrical Characteristic

Parameter	Condition	Value
Primary Inductance	L(2-6)	180μH±5%
Core		RM6
Bobbin		RM6
Core Material		PC40
Turn Ratio	N1	40

Table 2—Winding Specification

Tape Turns	Winding No.	Margin Tapes	Start& End	Wire Diameter (mm)	Turns
3	N1		2→6	0.25×3	40

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