EV44014-S+HR1001-S-00A

240W LED Driver&Adapters Evaluation Board

The Future of Analog IC Technology®

DESCRIPTION

The EV44014-S+HR1001-S-00A is a general purpose evaluation board of MP44014, HR1001, MP6922 and MP174 for 240W LED driver & Adapters application.

The MP44014 is a boundary conduction mode PFC controller which can provide simple and high performance active power factor correction using minimum external components.

The HR1001 is an enhanced LLC controller which provides new features of adaptive dead time adjustment (ADTA) and capacitive mode protection (CMP).

The MP6922 is a dual fast turn-off intelligent rectifier to drive two N-CH power MOSFETs in LLC resonant converters for synchronous rectification.

The MP174 is a primary-side regulator that provides accurate constant voltage (CV) regulation without opto-coupler.

Typically, the EV44014-S+HR1001-S-00A is designed for LED driver &adapters with a 12 V, 20 A constant voltage output and 240W rated power, from 90 VAC to 265 VAC, 50 Hz/60 Hz.

The EV44014-S+HR1001-S-00A has excellent efficiency and high power factor. Besides, the EV44014-S+HR1001-S-00A has output fault protections, such as over load protection, short circuit protection, over voltage protection and anti-capacitive mode protection. It also can meet the Class C standard of IEC61000-3-2 and EN55022 standard.

ELECTRICAL SPECIFICATIONS

Parameter	Symbol	Value	Units
Input AC Voltage	V_{IN_AC}	90 to 265	V
Output Current	I_{OUT}	20	A
Output Voltage	V_{OUT}	12	V
Output Power	P_{OUT}	240	W

FEATURES

- Wide Operating Input Range(from 90V to 265V)
- 240W Rated Power and Constant Voltage Output
- High efficiency up to 93%
- Meet Class C Standard of IEC61000-3-2
- Meet EN55022 Standard
- Meet EN61000-4-5 Level 4 for Surge Immunity (4kV)
- High Power Factor
- Over load protection (Hiccup Mode)
- Short Circuit Protection (Latch Mode)
- Over Voltage Protection
- Anti-capacitive Mode Protection

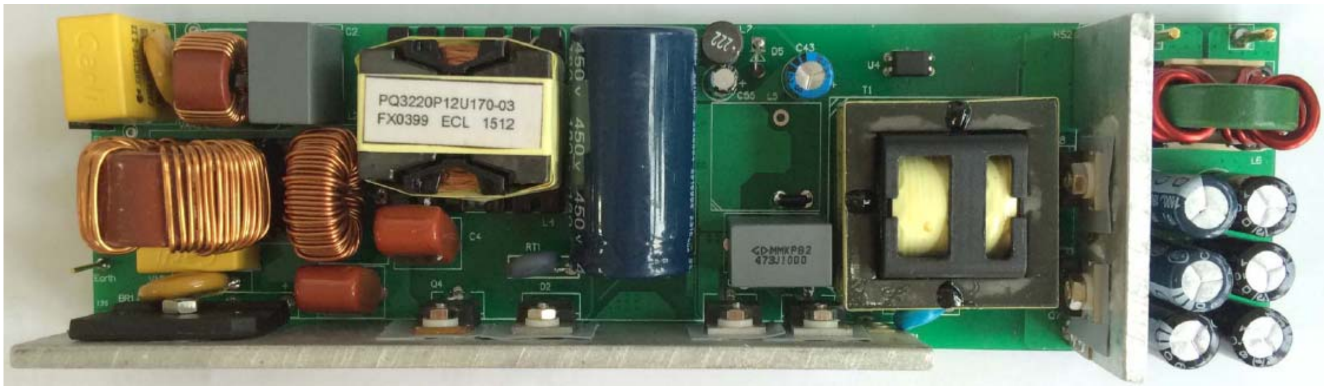
APPLICATIONS

- LED Driver Application
- Adapters Application

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.

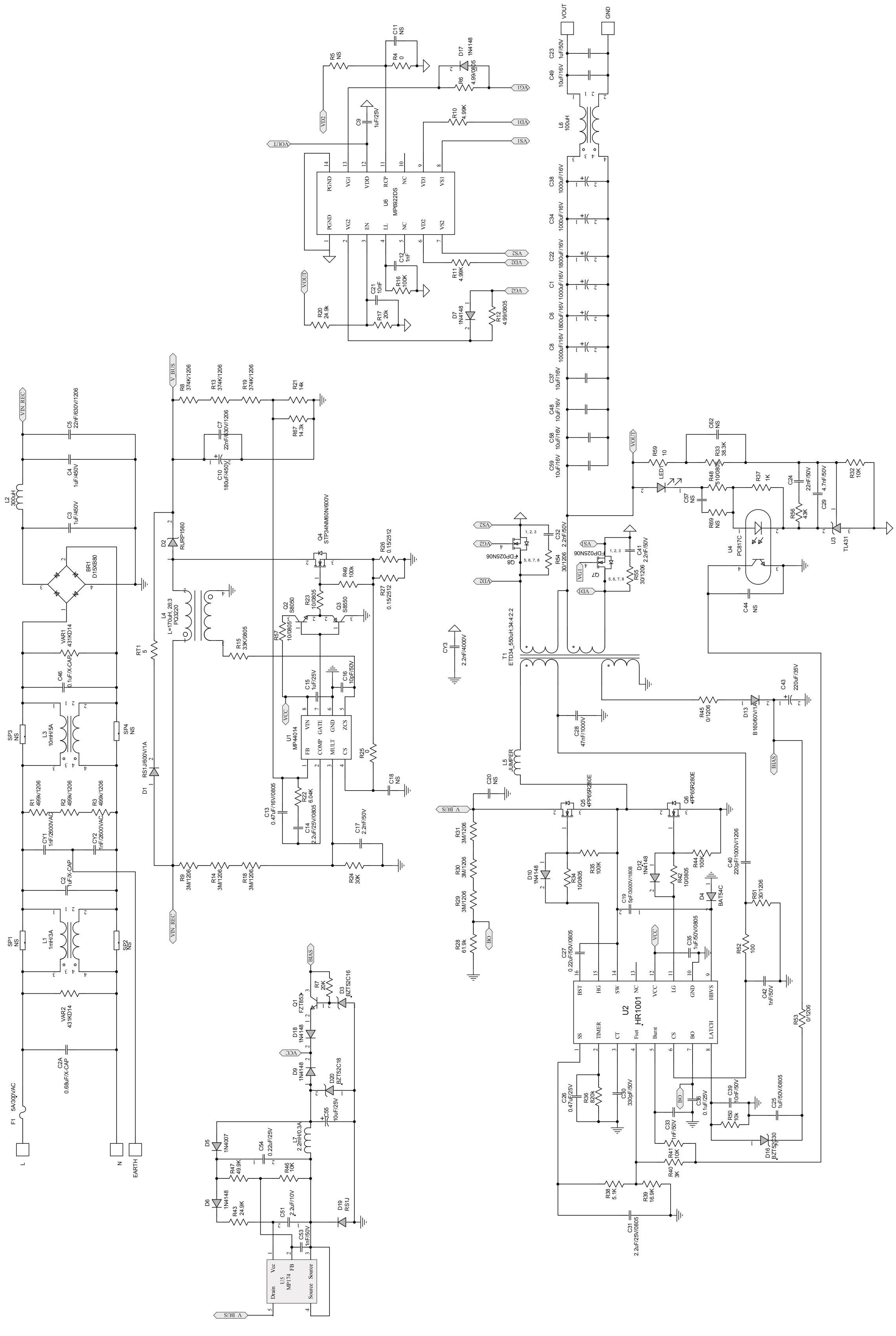
EV44014-S+HR1001-S-00A EVALUATION BOARD



(L x W x H) (21.75cm x 6.0cm x 3.5cm)

Board Number	MPS IC Number
EV44014-S+HR1001-S-00A	MP44014GS
	HR1001GS
	MP6922DS
	MP174GJ

EVALUATION BOARD SCHEMATIC



EV44014-S+HR1001-S-00A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer_P/N
2	CY1, CY2	1nF	Y Capacitor;2600V;20%	DIP	HongKe	JYK08F102ML72N
1	CY3	2.2nF	Y Capacitor;4000V;20%	DIP	HongKe	JNK12E222MY02N
4	C1,C8, C34,C38	1000µF	Electrolytic Capacitor;16V	DIP	JIANGHAI	C287-16V1800
1	C2A	0.68µF	X-CAP;310V	DIP	CARLI	PX684K2WD69H200D9R
1	C2	1µF	X-CAP;310V	DIP	FALA	C42Q2105M6FC000
2	C3,C4	1µF	Capacitor;450V;CBB	DIP	CARLI	TF105K2Y109L270D9R
2	C5,C7	22nF	Ceramic Capacitor; 630V;X7R	1206	TDK	C3216X7R2J223K
2	C6,C22	1800µF	Electrolytic Capacitor;16V	DIP	JIANGHAI	CD283-16V1800
2	C9,C15	1µF	Ceramic Capacitor; 25V;X7R	0603	Murata	GRM188R71E105KA01D
1	C10	180µF	Electrolytic Capacitor;450V	DIP	JIANGHAI	CD263-450V180
0	C11,C18, C20,C44, C57,C62	NS				
4	C12,C33, C42,C53	1nF	Ceramic Capacitor; 50V;X7R	0603	Murata	GRM188R71H102KA01D
1	C13	0.47µF	Ceramic Capacitor; 16V;X7R	0805	Murata	GRM21BR71C474KA01L
2	C14,C31	2.2µF	Ceramic Capacitor; 25V;X7R	0805	Murata	GRM21BR71E225KA73L
1	C16	10pF	Ceramic Capacitor; 50V;COG	0603	TDK	C1608COG1H100D
1	C17	2.2nF	Ceramic Capacitor; 50V;X7R	0603	Murata	GRM188R71H222KA01D
1	C19	5pF	Ceramic Capacitor; 3000V;NP0	1808	HHEC	C1808N5R0J302T
2	C21,C39	10nF	Ceramic Capacitor; 50V;X7R	0603	Murata	GRM188R71H103KA01D
1	C23	1µF	Ceramic Capacitor; 50V;X7R	1206	TDK	C3216X7R1H105K
1	C24	22nF	Ceramic Capacitor; 50V;X7R	0603	Murata	GRM188R71H223KA01D
2	C25,C35	1µF	Ceramic Capacitor; 50V;X7R	0805	Murata	GRM21BR71H105KA12L
1	C26	0.47µF	Ceramic Capacitor; 25V;X7R	0603	Murata	GRM188R71E474KA12
1	C27	0.22µF	Ceramic Capacitor; 50V;X7R	0805	TDK	C2012X7R1H224K
1	C28	47nF	Capacitor;1000V	DIP	FaLa	MMKP82-1000V-473P15JA
1	C29	4.7nF	Ceramic Capacitor; 50V;X7R	0603	Murata	GRM188R71H472KA01D
1	C30	330pF	Ceramic Capacitor; 50V;X7R	0603	Murata	GRM188R71H331KA01

EV44014-S+HR1001-S-00A BILL OF MATERIALS *(continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer_P/N
2	C32,C41	2.2nF	Ceramic Capacitor; 50V;X7R	0805	Murata	GRM21BR71H222KA01D
1	C36	0.1uF	Ceramic Capacitor;25V;X7R	0603	Murata	GRM188R71E104KA01D
5	C37,C48, C49,C58, C59	10μF	Ceramic Capacitor; 16V;X7R	1206	Murata	C3216X7R1C106K
1	C40	220pF	Ceramic Capacitor; 1000V;C0G	1206	TDK	C3216C0G3A221J
1	C43	220μF	Electrolytic Capacitor;35V	DIP	JIANGHAI	CD110-35V220
1	C46	0.1μF	X-CAP;275V	DIP	CARLI	PX104K3ID19L270D9R
1	C51	2.2μF	Ceramic Capacitor;10V;X7R	0603	Murata	GRM188R71A225KE15D
1	C54	0.22μF	Ceramic Capacitor;25V;X7R	0603	TDK	C1608X7R1E224K
1	C55	10μF	Electrolytic Capacitor;50V	DIP	JIANGHAI	CD287-50V10
3	R1,R2,R3	499k	Film Resistor;1%;	1206	Yageo	RC1206FR-07499KL
2	R4,R25	0	Film Resistor;1%;	0603	Yageo	RC0603JR-070RL
0	R5,R69	NS				
2	R6,R12	4.99	Film Resistor;1%;	0805	Yageo	RC0805FR-074R99L
2	R7,R17	20k	Film Resistor;1%;	0603	Yageo	RC0603FR-0720KL
3	R8,R13, R19	374k	Film Resistor;1%;	1206	Yageo	RC1206FR-07374KL
6	R9,R14, R18,R29, R30,R31	3M	Film Resistor;1%;	1206	Yageo	RC1206FR-073ML
2	R10,R11	4.99k	Film Resistor;1%;	0603	Yageo	RC0603FR-074K99L
1	R15	33k	Film Resistor;1%;	0805	Yageo	RC0805FR-0733KL
4	R16,R35, R44,R49	100k	Film Resistor;1%;	0603	Yageo	RC0603FR-07100KL
2	R20,R43	24.9k	Film Resistor;1%;	0603	Yageo	RC0603FR-0724K9L
1	R21	14k	Film Resistor;1%;	0603	Yageo	RC0603FR-0714KL
1	R22	6.04k	Film Resistor;1%;	0603	Yageo	RC0603FR-076K04L
4	R23,R34, R42,R57	10	Film Resistor;1%;	0805	Yageo	RC0805FR-0710RL
1	R24	30k	Film Resistor;1%;	0603	Yageo	RC0603FR-079K1L
2	R26, R27	0.15	Film Resistor;1%;	2512	Yageo	RL2512FK-070R15L
1	R28	61.9k	Film Resistor;1%;	0603	Yageo	RC0603FR-0711KL
4	R32,R41, R46,R50	10k	Film Resistor;1%;	0603	Yageo	RC0603FR-0710KL
1	R33	38.3k	Film Resistor;1%;	0603	Yageo	RC0603FR-0738K3L
1	R36	820k	Film Resistor;1%;	0603	Yageo	RC0603FR-07820KL
1	R37	1k	Film Resistor;1%;	0603	Yageo	RC0603FR-071KL
1	R38	5.1k	Film Resistor;1%;	0603	Yageo	RC0603FR-075K1L
1	R39	16.9k	Film Resistor;1%;	0603	Yageo	RC0603FR-0716K9L
1	R40	3k	Film Resistor;1%;	0603	Yageo	RC0603FR-073KL

EV44014-S+HR1001-S-00A BILL OF MATERIALS *(continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer_P/N
2	R45,R53	0	Film Resistor;1%;	1206	Yageo	RC1206JR-070RL
1	R47	49.9k	Film Resistor;1%;	0603	Yageo	RC0603FR-0749K9L
1	R48	510	Film Resistor;1%;	0805	Yageo	RC0805FR-07510RL
3	R51,R54, R55	30	Film Resistor;1%;	1206	Yageo	RC1206FR-0730RL
1	R52	100	Film Resistor;1%;	0603	Yageo	RC0603FR-07100RL
1	R56	43k	Film Resistor;1%;	0603	Yageo	RC0603FR-0743KL
1	R59	10	Film Resistor;1%;	0603	Yageo	RC0603FR-0710RL
1	R67	14.3k	Film Resistor;1%;	0603	Yageo	RC0603FR-0714K3L
1	RT1	5	Thermal 'Resistor	DIP	Semitec	5D2-10
2	VAR1, VAR2	431KD14	MOV;	DIP	Thinking	TVR14431KS42Y
1	BR1	D15XB80	BRIDGE RECTIFIER; 800V;15A	DIP	Diodes	D15XB80
2	D1,D19	RS1J	Diode;600V;1A;	SMA	Diodes	RS1J
1	D2	RURP1560	Diode;600V;15A;	TO-220	Fairchild	RURP1560
1	D3	BZT52C16	Zener Diode;16V;5mA	SOD-123	Diodes	BZT52C16
1	D4	BAT54C	Schottky Diode;30V;0.2A;	SOT23	Diodes	BAT54C
1	D5	1N4007	Diode;1000V;1A;	DO-41	Diodes	1N4007
7	D6,D7, D9,D10, D12,D17, D18	1N4148W	Diode;75V;0.15A;	SOD-123	Diodes	1N4148W
1	D13	B160	Schottky Diode;60V;1A;	SMA	Diodes	B160
1	D16	BZT52C30	Zener Diode;30V;5mA	SOD-123	Diodes	BZT52C30
1	D20	BZT52C18	Zener Diode;18V;5mA	SOD-123	Diodes	BZT52C18
1	F1	5A/300VAC	FUSE-SS-5H	DIP	COOPER BUSSMANN	SS-5H-5N-APH
1	L1	1mH	Common Choke,1mH,3A	DIP	Wurth	744822301
1	L2	300μH	Filter Inductor;300μH	DIP	Wurth	7447065
1	L3	10mH	Common Choke, 10mH,5A	DIP	Wurth	744825510
1	L4	170μH	PFC Inductor, L=170μH, N1:N2=26:3,PQ3220	DIP	Emei	FX0399
1	L5		Wire jumper	DIP		
1	L6	100μH	Common Choke, 100μH,40A	DIP	COILCRAFT	CU8995-AL
1	L7	2.2mH	Inductor,2.2mH,300mA	DIP	Wurth	7447720222
1	Q1	FZT853	Transistor;100V;6A	SOT-223	Zetex	FZT853TA
1	Q2	S8050	Transistor;25V;0.5A	SOT-23	Changjiang Electronics	S8050
1	Q3	S8550	Transistor;-25V;-0.5A	SOT-23	Changjiang Electronics	S8550

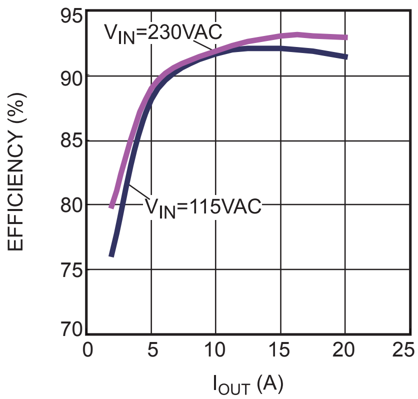
EV44014-S+HR1001-S-00A BILL OF MATERIALS *(continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer_P/N
1	Q4	STP34NM60 N	N-Channel Mosfet; 600V;34A	TO220	ST	STP34NM60N
2	Q5,Q6	IPP65R280E	N-Channel Mosfet; 700V;29A	TO220	Infineon	IPP65R280E
2	Q7,Q8	FDP025N06	N-Channel Mosfet; 60V;To-220	TO220	Fairchild	FDP025N06
0	SP1,SP2, SP3,SP4	NS				
1	T1	0.55mH	Transformer,Lp=0.55mH N1:N2:N3:N4=34:4:2:2 ETD34	DIP	Emei	FX0400
1	U1	MP44014	PFC controller	SOIC8	MPS	MP44014HS
1	U2	HR1001	LLC controller	SOIC16	MPS	HR1001GS
1	U3	TL431	Shunt regulator, Vref=2.5V	SOT-23	Changjiang Electronics	TL431
1	U4	PC817C	Photocoupler;1-Channel	DIP	SHARP	PC817C
1	U5	MP174	700V off-line regulator	TSOT23-5	MPS	MP174GJ
1	U6	MP6922	SR controller	SOIC8	MPS	MP6922DS
1	LED1	HL-PSC-2012H203BC	LED, Blue	0805	BRIGHT LED	HL-PSC-2012H203BC
2	VOUT,GND		2mm Connector Pin			
3	L,N,Earth		1mm 'Connector Pin			
1	HS1		Heatsink, 150mm*30mm			
1	HS2		Heatsink, 58mm*30mm			

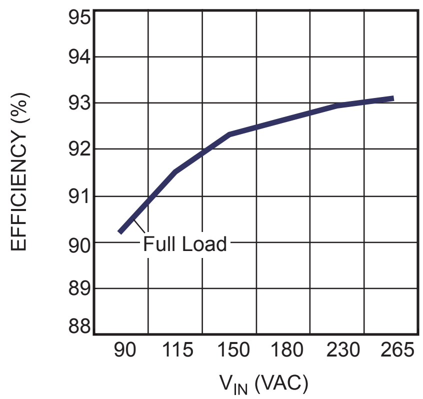
EVB TEST RESULTS

Performance waveforms are tested on the evaluation board.
V_{IN_AC}=90V to 265V, V_{OUT}=12V, I_{OUT}=20A, P_{OUT}=240W

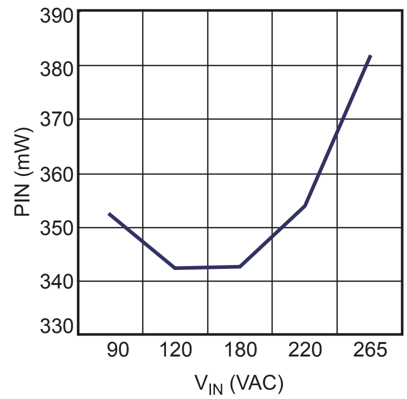
Efficiency



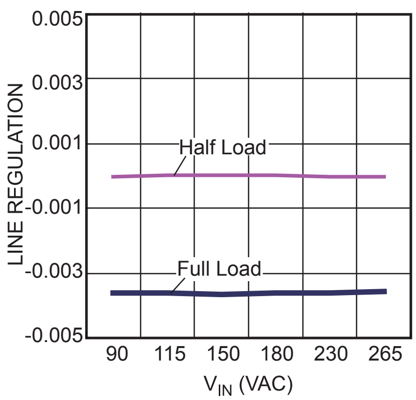
Efficiency vs. V_{IN}



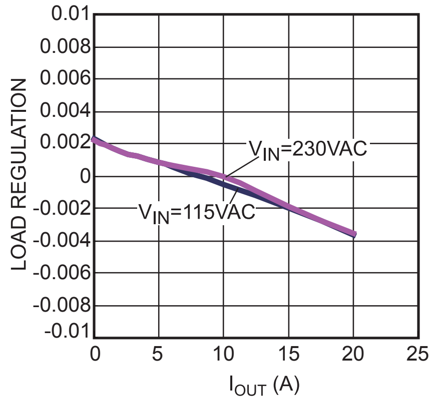
No Load Consumption



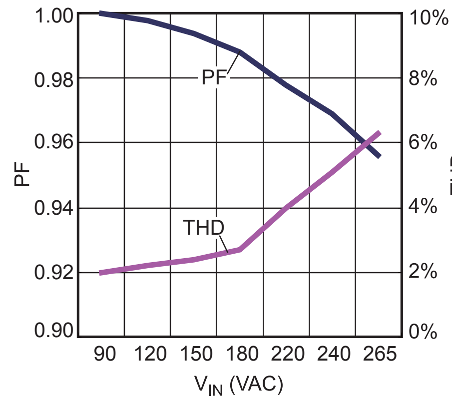
Line Regulation



Load Regulation

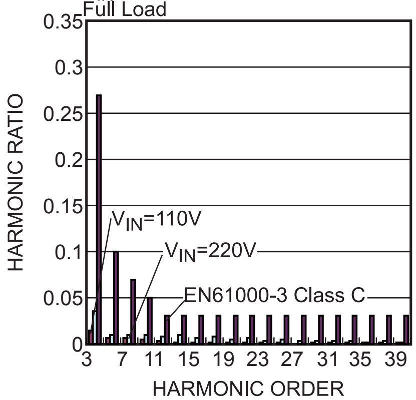


PF & THD



Harmonic

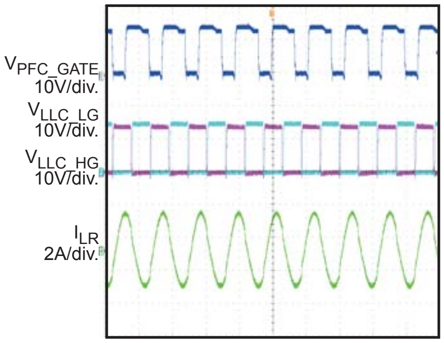
V_{IN}=115VAC/60Hz & 230VAC/50Hz, Full Load



EVB TEST RESULTS *(continued)*

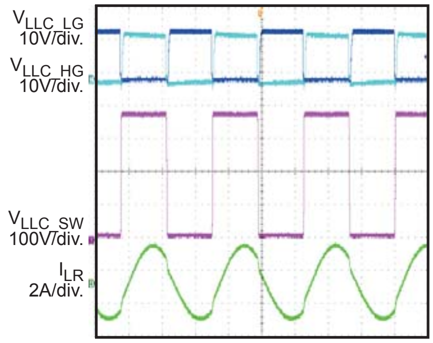
Performance waveforms are tested on the evaluation board.
V_{IN_AC}=90V to 265V, V_{OUT}=12V, I_{OUT}=20A, P_{OUT}=240W

Steady State



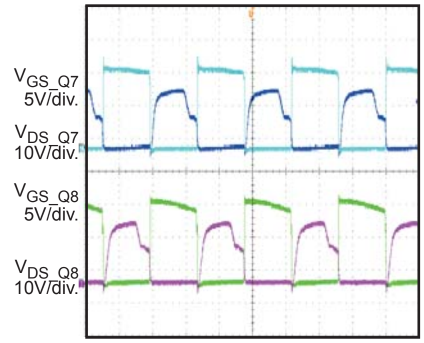
10μs/div.

LLC Stage



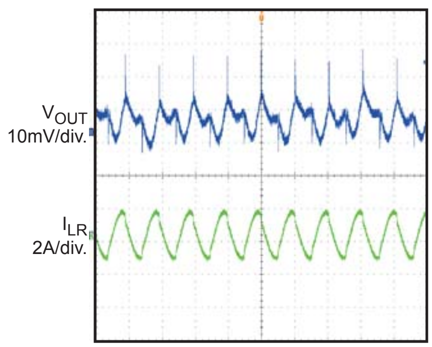
4μs/div.

SR Operation



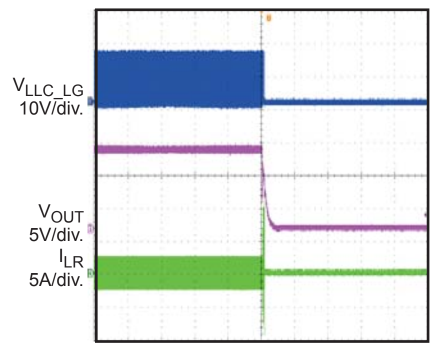
4μs/div.

Output Ripple



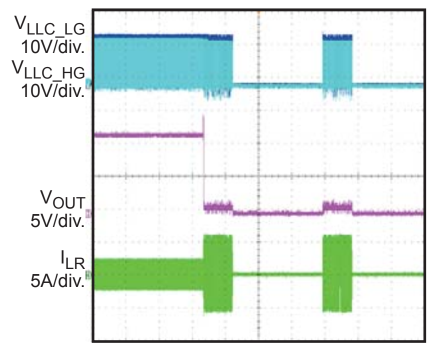
10μs/div.

SCP Latch



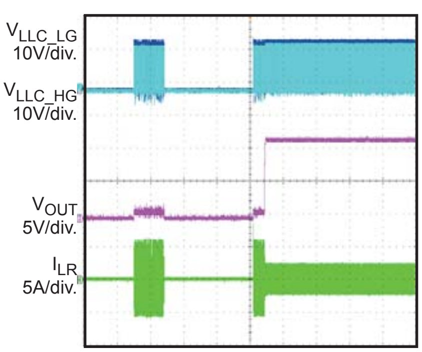
2ms/div.

OCP Enter



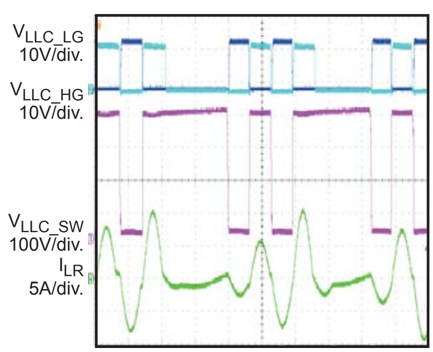
400ms/div.

OCP Recovery



400ms/div.

CMP in Short

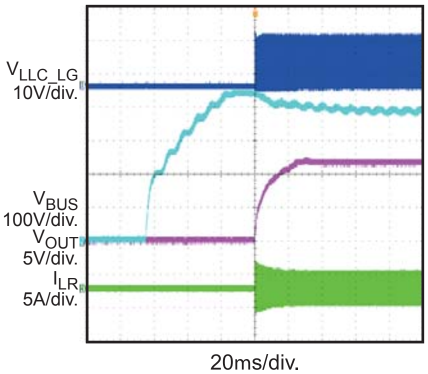


10μs/div.

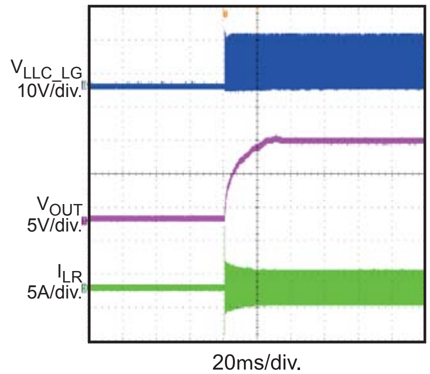
EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.
V_{IN_AC}=90V to 265V, V_{OUT}=12V, I_{OUT}=20A, P_{OUT}=240W

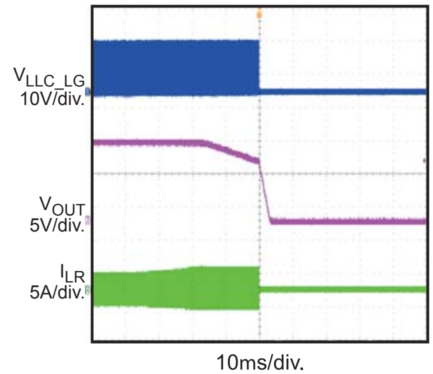
Start-Up
V_{IN} = 115VAC



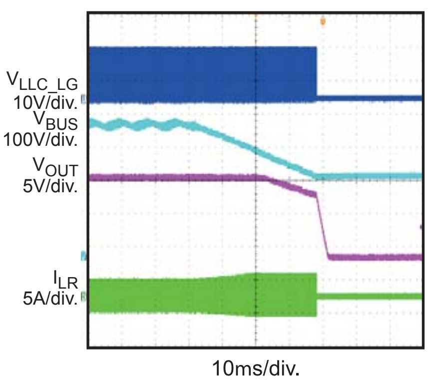
Output Rise Time
V_{IN} = 115VAC



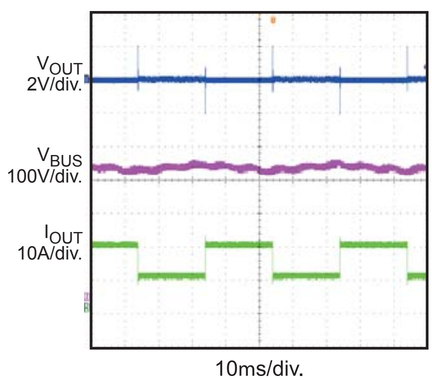
Shutdown
V_{IN} = 115VAC



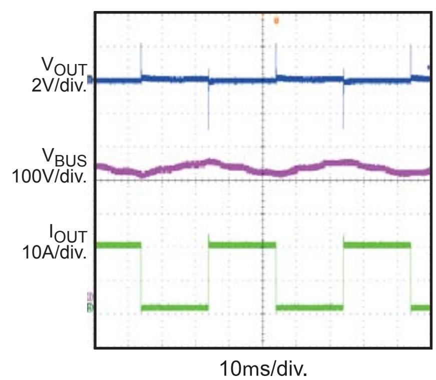
Hold Up Time
V_{IN} = 115VAC



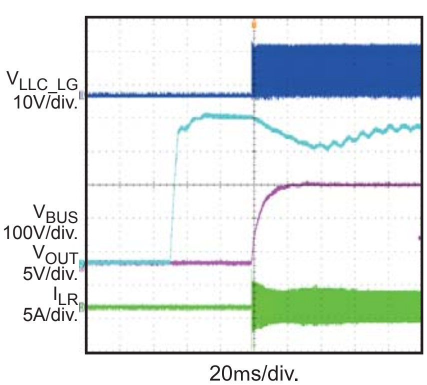
Load Transient
V_{IN} = 115VAC,
10A-20A, 1A/μs



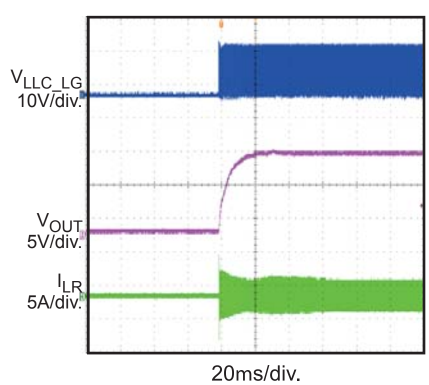
Load Transient
V_{IN} = 115VAC,
0A-20A, 1A/μs



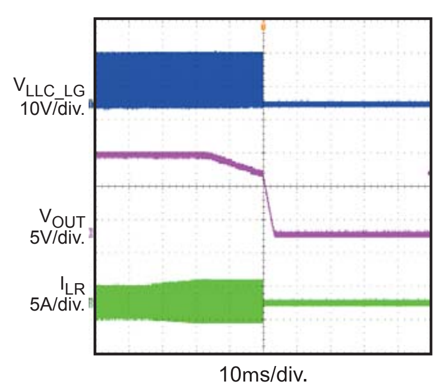
Start-Up
V_{IN} = 230VAC



Output Rise Time
V_{IN} = 230VAC



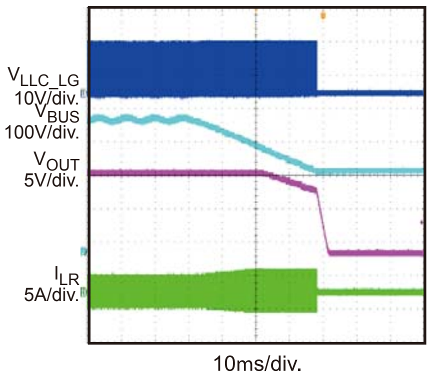
Shutdown
V_{IN} = 230VAC



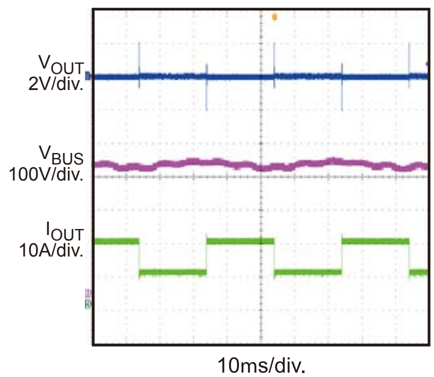
EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.
V_{IN_AC}=90V to 265V, V_{OUT}=12V, I_{OUT}=20A, P_{OUT}=240W

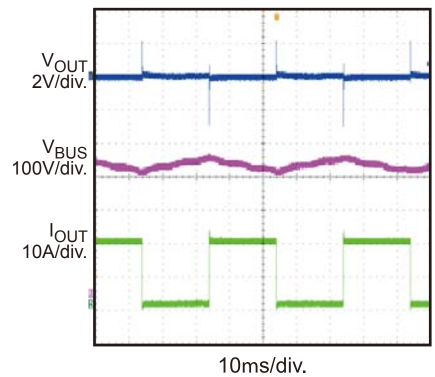
Hold Up Time
V_{IN} = 230VAC



Load Transient
V_{IN} = 230VAC,
10A-20A, 1A/μs



Load Transient
V_{IN} = 230VAC,
0A-20A, 1A/μs



PRINTED CIRCUIT BOARD LAYOUT

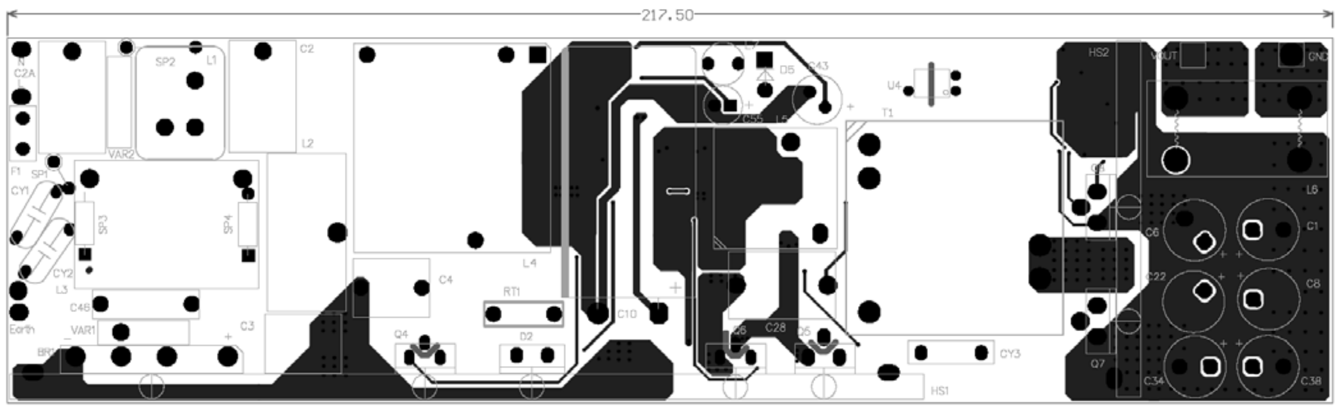


Figure 1—Top Layer

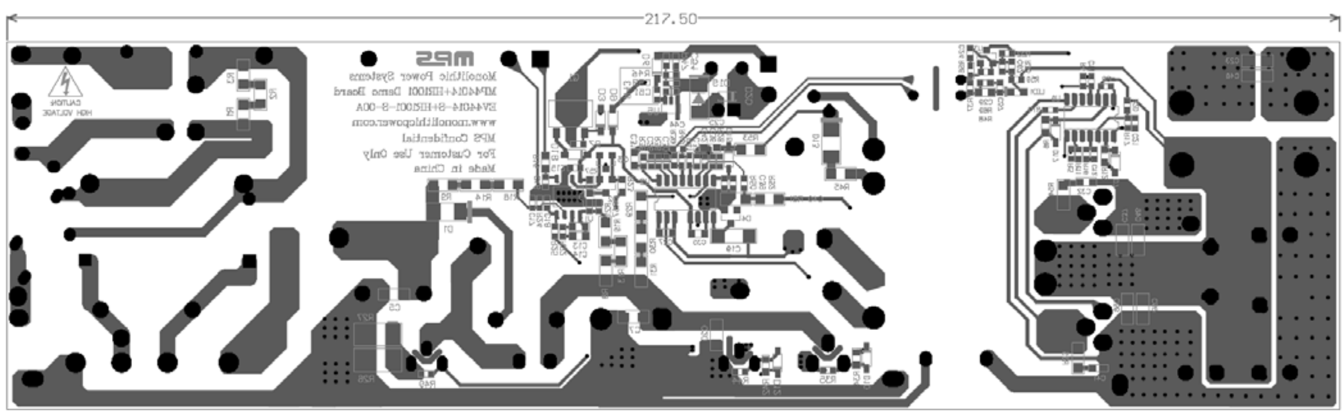


Figure 2—Bottom Layer

SURGE TEST

Line-to-line 4 kV and line-to-power earth 4 kV surge testing was completed according to EN61000-4-5 Level 4.
The input voltage was set at 220 VAC/50 Hz. The output was loaded at full load, and operation was verified following each surge event (see Table 1).

Table 1—Surge test results

Surge Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Test Result (Pass/Fail)
4000	220	L to N	90	Pass
-4000	220	L to N	270	Pass
4000	220	L to PE	90	Pass
-4000	220	L to PE	270	Pass
4000	220	N to PE	90	Pass
-4000	220	N to PE	270	Pass

CONDUCTED EMI TEST

Tested with 115VAC input and full load condition.

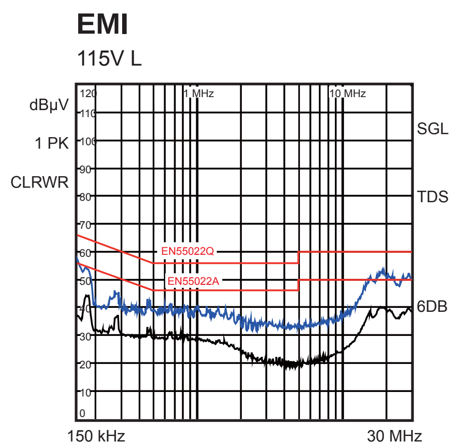


Figure 3—115 VAC, 60 Hz, maximum load, L line, EN55022 limits

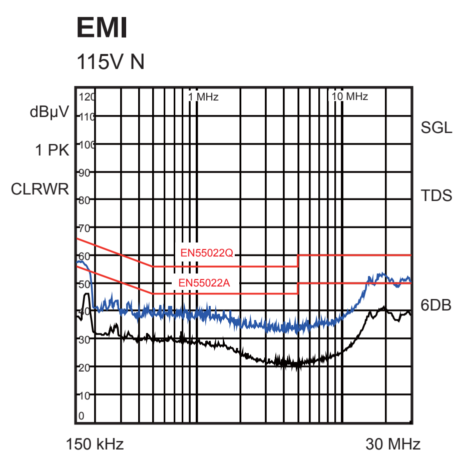


Figure 4—115 VAC, 60 Hz, maximum load, N line, EN55022 limits

Conducted EMI Test *(continued)*

Tested with 230 VAC input and full load condition.

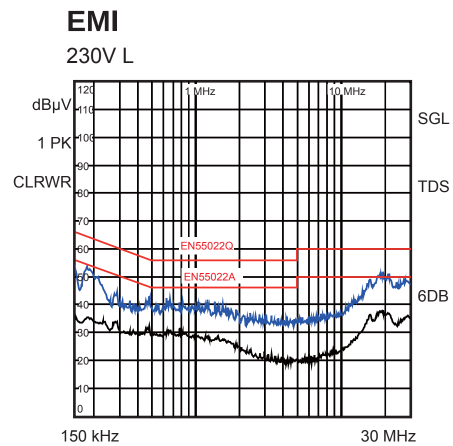


Figure 5—230 VAC, 50 Hz, maximum load, L line, EN55022 limits

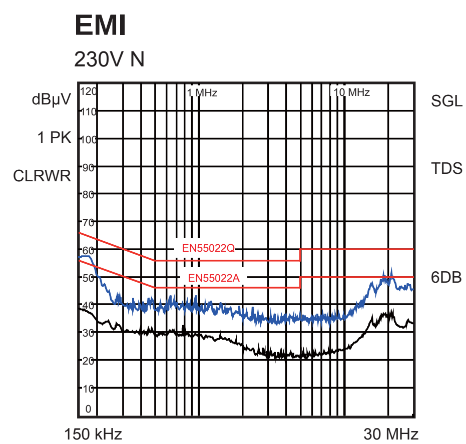
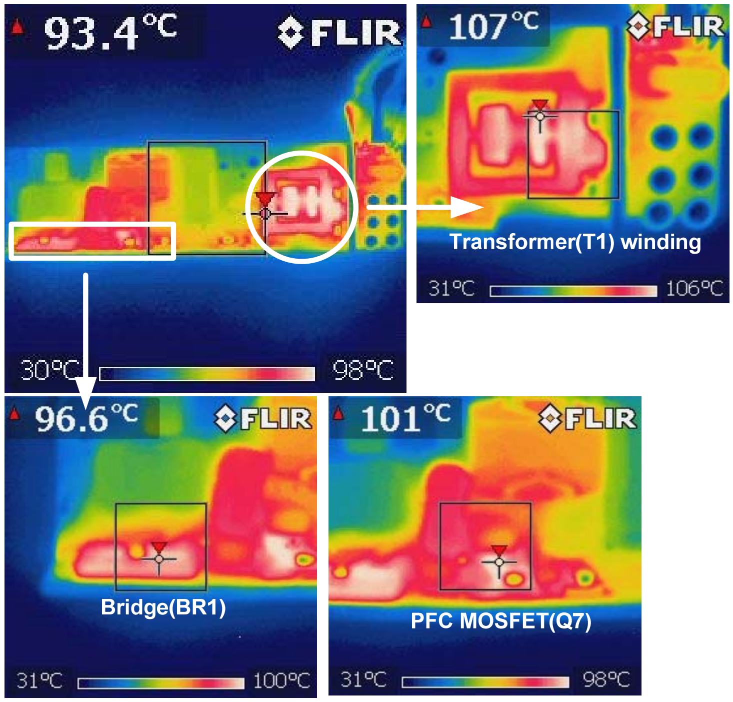


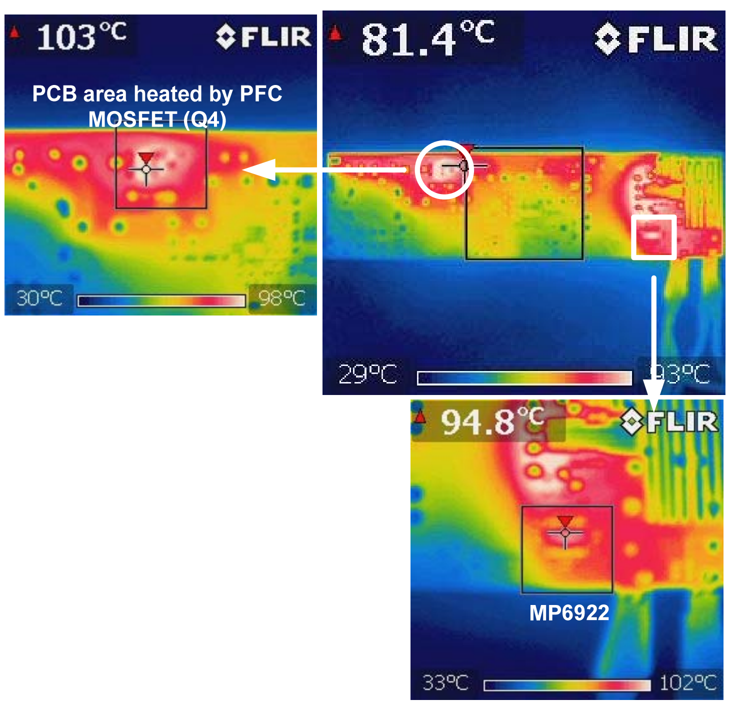
Figure 6—230 VAC, 50 Hz, maximum load, N line, EN55022 limits

THERMAL TEST

Tested with 90 VAC input and full load condition. PCB layout is with 2 oz copper. Ambient temperature is 33°C and without air flow.



Top Layer



Bottom Layer

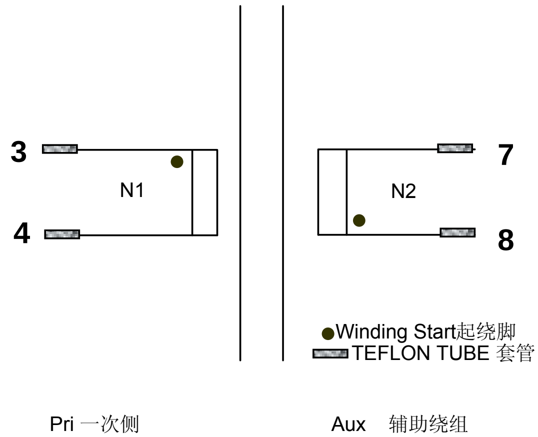
Figure 7—Temperature chamber test

QUICK START GUIDE

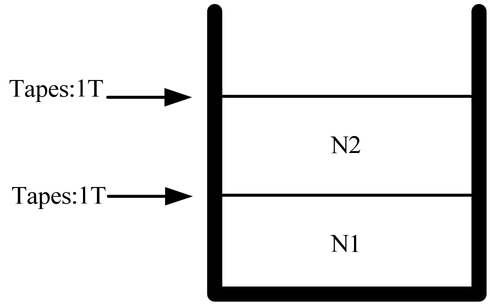
1. Pre-set the power supply to 90 VAC ≤ V_{IN} ≤ 265 VAC.
2. Turn the power supply off.
3. Connect the line and neutral terminals of the power supply output to the L and N ports. For three-wire input application, connect earth terminal to the Earth port.
4. Connect Load to:
    a. Positive (+): VOUT
    b. Negative (–): GND
5. Turn the power supply on after making the connections.

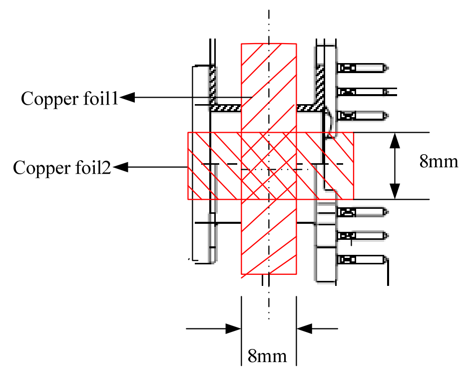
APPENDIX1: PFC INDUCTOR SPECIFICATION

Electrical Diagram



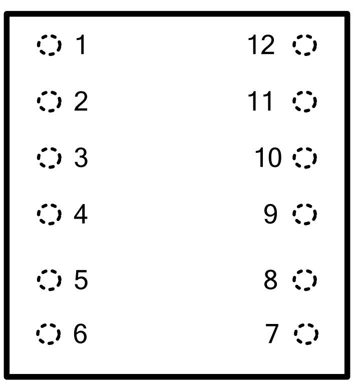
Winding Diagram





Pin Definition of Bobbin

Pin out



View from the top

Note: ***Core is wrapped with copper foils as below. Connect the foils to Pin 8 with wires.***

Table 1—Electrical Characteristic

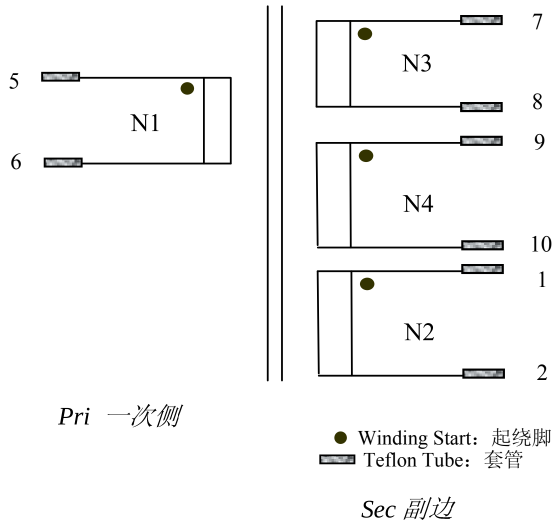
Parameter	Condition	Value
Primary Inductance	L（3—4）	170µH±10%
Core		PQ3220
Bobbin		PQ3220
Core Material		DMR40 or equivalent
Turn Ratio	N1:N2	26:3

Table 2—Winding Specification

Tape Turns	Winding No.	Margin Tapes	Start& End	Wire Diameter (mm)	Turns
1	N1		3→4	0.1×100	26
1	N2		8→7	0.2×1	3

APPENDIX2: LLC TRANSFORMER SPECIFICATION

Electrical Diagram



Winding Diagram

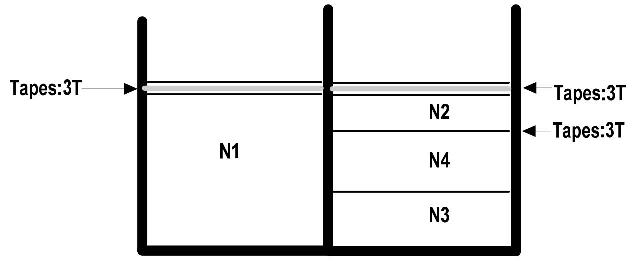
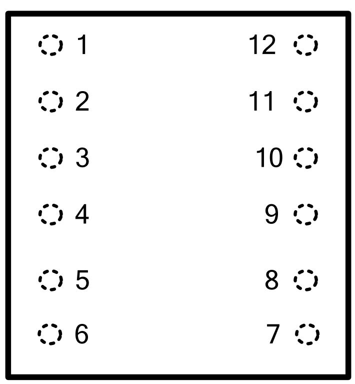


Table 1—Electrical Characteristic

Parameter	Condition	Value
Primary Inductance	Lp (5-6)	0.55mH±5%
Leakage Inductance	Lk (5-6)	55µH±20%
Core		ETD34
Bobbin		ETD34
Core Material		DMR44 or equivalent
Turn Ratio	N1:N2:N3:N4	34:4:2:2

Pin Definition of Bobbin

Pin out



View from the top

Table 2—Winding Specification

Tape Turns	Winding No.	Margin Tapes	Start& End	Wire Diameter (mm)	Turns
3	N1		5→6	0.1×50	34
	N3		7→8	0.1×240	2
3	N4		9→10	0.1×240	2
3	N2		1→2	0.2TIW×1	4