EV44018-S-HR1001-S-00C

12V, 20A, 240W LED Driver and Adapter Evaluation Board

DESCRIPTION

The EV44018-S-HR1001-S-00C is a general-purpose evaluation board designed to demonstrate the capabilities of the MP44018A, HR1001A, MP6924A, and MP174. The evaluation board is recommended for 240W LED driver and adapter applications.

The MP44018A is a critical conduction mode (CrM) and discontinuous conduction mode (DCM), multi-mode PFC controller that provides simple and high-performance active power factor (PF) correction using a minimal number of external components.

The HR1001A is an enhanced LLC controller that features adaptive dead time adjustment (ADTA) and capacitive mode protection (CMP).

The MP6924A is a dual, fast turn-off intelligent rectifier that drives two N-channel power MOSFETs in LLC resonant converters for synchronous rectification applications.

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

The EV44018-S-HR1001-S-00C is designed to evaluate ICs in LED driver and adapter applications with a 12V/20A constant output and 240W rated power. The evaluation board operates from a $90V_{AC}$ to $265V_{AC}$, 50Hz/60Hz input.

The EV44018-S-HR1001-S-00C has excellent efficiency and a high PF. Full protection features include overload protection (OLP), short-circuit protection (SCP), over-voltage protection (OVP), and anti-capacitive mode protection. The device can meet IEC61000-3-2 Class C standards, EN55022 standards, and EN61000-4-5 Level 4 for Surge Immunity (4kV).

High Voltage

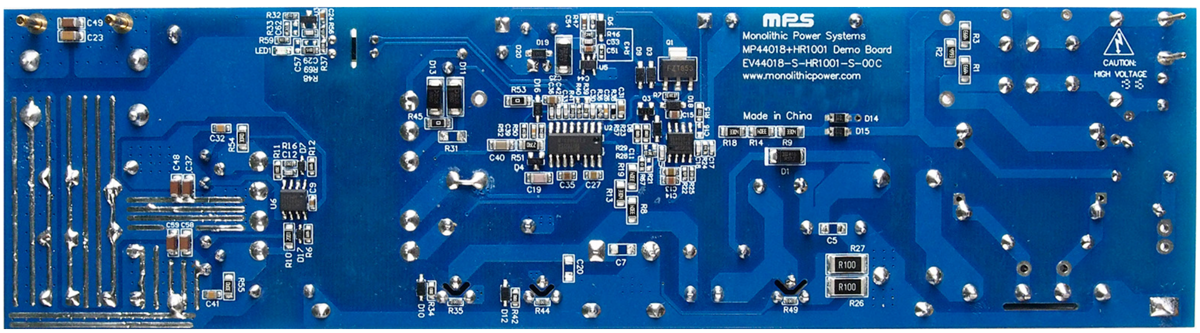
Warning: Although this board is designed to satisfy safety requirements, the engineering prototype has not been agency approved. Therefore, all testing should be performed using an isolation transformer to provide the AC input to the prototype board.

PERFORMANCE SUMMARY (1)

Specifications are at T_A = 25°C, unless otherwise noted.

Parameters	Conditions	Value
Input voltage (V_{IN}) range		$90V_{AC}$ to $265V_{AC}$
Output voltage (V_{OUT})	V_{IN} = $90V_{AC}$ to $265V_{AC}$, I_{OUT} = 0A to 20A	12V
Maximum output current (I_{OUT})	V_{IN} = $90V_{AC}$ to $265V_{AC}$	20A
Typical efficiency	V_{IN} = $220V_{AC}$, V_{OUT} = 12V, I_{OUT} = 20A	93.2%

EV44018-S-HR1001-S-00C EVALUATION BOARD



LxWxH (22.5cmx6cmx3.5cm)

Board Number	MPS IC Number
EV44018-S-HR1001-S-00C	MP44018-AGS
	HR1001AGS
	MP6924AGS
	MP174GJ

QUICK START GUIDE

1. Preset the power supply input voltage (V_{IN}) be between 90V_{AC} and 265V_{AC}.
2. Turn off the power supply.
3. Connect the power supply terminals to:
    a. Line terminal: L port
    b. Neutral terminal: N port
    c. Earth terminal: Earth port (only for 3-wire applications)
4. Connect the load terminals to:
    a. Positive (+): VOUT
    b. Negative (-): GND
5. After making the connections, turn on the power supply.

EVALUATION BOARD SCHEMATIC

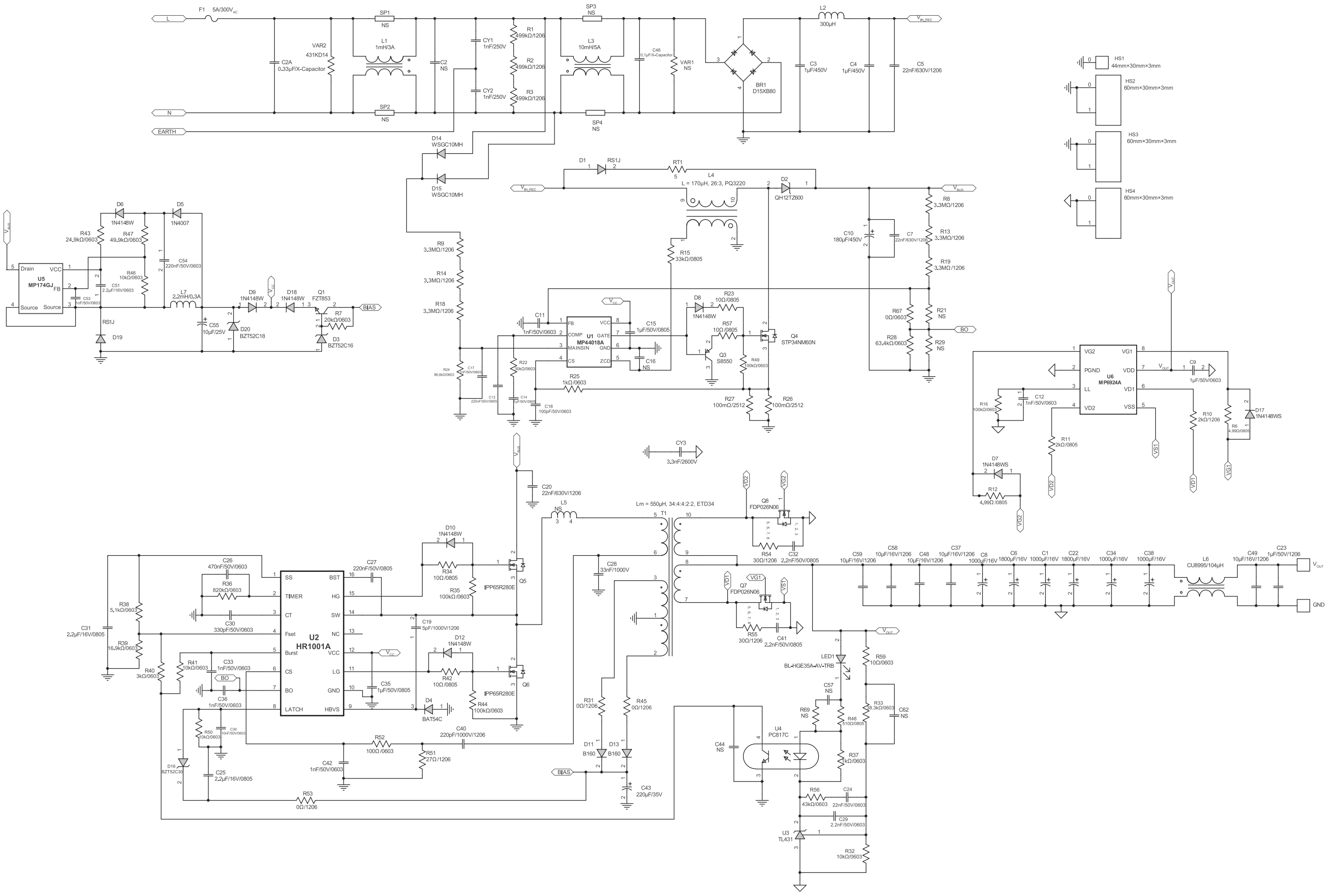


Figure 1: Evaluation Board Schematic

EV44018-S-HR1001-S-00C BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
1	BR1	800V	Bridge rectifier, 15A	DIP	Shinden	D15XB80
4	C1, C8, C34, C38	1000µF	Electrolytic capacitor, 16V	DIP	Jianghai	CD287-16V1000
5	C2, C16, C44, C57, C62	NS				
1	C2A	0.33µF	X-capacitor, 310V	DIP	Vishay	BFC233922334
2	C3, C4	1µF	Capacitor, 450V, CBB	DIP	Carli	TF105K2Y109L270D9R
3	C5, C7, C20	22nF	Ceramic capacitor, 630V, X7R	1206	TDK	C3216X7R2J223K
2	C6, C22	1800µF	Electrolytic capacitor, 16V	DIP	Jianghai	CD283-16V1800uF
1	C9	1µF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R61H105KAAL
1	C10	180µF	Electrolytic capacitor, 450V	DIP	Jianghai	CD261-250V100
7	C11, C12, C17, C33, C36, C42, C53	1nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM1885C1H102JA01D
2	C13, C27	220nF	Ceramic capacitor, 50V, X7R	0805	TDK	C2012X7R1H224K
3	C14, C15, C35	1µF	Ceramic capacitor, 50V, X7R	0805	Wurth	885012207103
1	C18	100pF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM1885C1H101JA01D
1	C19	5pF	Ceramic capacitor, 3000V, NP0	1808	HHEC	C1808N5R0J302T
1	C23	1µF	Ceramic capacitor, 50V, X7R	1206	TDK	C3216X7R1H105K
1	C24	22nF	Ceramic capacitor, 50V, X7R	0603	TDK	C1608X7R1H223K
2	C25, C31	2.2µF	Ceramic capacitor, 16V, X7R	0805	Murata	GRM21BR71C225KA12L
1	C26	470nF	Ceramic capacitor, 50V, X7R	0603	TDK	C1608X7R1H474K
1	C28	33nF	Capacitor, 1000V	DIP	Fala	MMKP82-1000V-333P15JA
1	C29	2.2nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM1885C1H222JA01D
1	C30	330pF	Ceramic capacitor, 50V, COG	0603	Murata	GRM1885C1H331JA01
2	C32, C41	2.2nF	Ceramic capacitor, 50V, X7R	0805	Murata	GRM216R71H222KA01D
5	C37, C48, C49, C58, C59	10µF	Ceramic capacitor, 16V, X7R	1206	TDK	C3216X7R1C106K
1	C39	10nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H103KA01D
1	C40	220pF	Ceramic capacitor, 1000V, COG	1206	Murata	GRM31A7U3A221JW31D
1	C43	220µF	Electrolytic capacitor, 35V	DIP	Jianghai	CD110-35V220
1	C46	0.1µF	X-capacitor, 275V	DIP	Carli	PX104K3ID19L270D9R
1	C51	2.2µF	Ceramic capacitor, 16V, X7R	0603	Murata	GRM188C71C225KE11D
1	C54	220nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H224KA01D

EV44018-S-HR1001-S-00C BILL OF MATERIALS *(continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
1	C55	10µF	Electrolytic capacitor, 50V	DIP	Jianghai	CD287-50V10
2	CY1, CY2	1nF	Y-capacitor, 250V, 20%	DIP	HongKe	JYK08F102ML72N
1	CY3	3.3nF	Y-capacitor, 2600V, 20%	DIP	HongKe	JYK10F332MY72N
2	D1, D19	600V	Diode, 1A	SMA	Diodes, Inc.	RS1J-13-F
1	D2	600V	Diode, 12A	TO-220	Power	QH12TZ600
1	D3	16V	Zener diode, 5mA	SOD-123	Diodes, Inc.	BZT52C16
1	D4	30V	Schottky diode, 0.2A	SOT-23	Diodes, Inc.	BAT54C-7
1	D5	1000V	Diode, 1A	DO-41	Diodes, Inc.	1N4007
6	D6, D8, D9, D10, D12, D18	75V	Diode, 0.15A	SOD-123	Diodes, Inc.	1N4148W
2	D7, D17	75V	Diode, 0.15A	SOD-323	Diodes, Inc.	1N4148WS
2	D11, D13	60V	Schottky diode, 1A	SMA	Diodes, Inc.	B160
2	D14, D15	1000V	Diode, 1A	1206	Zowie	WSGC10MH
1	D16	30V	Zener diode, 5mA	SOD-123	Diodes, Inc.	BZT52C30
1	D20	18V	Zener diode, 5mA	SOD-123	Diodes, Inc.	BZT52C18-F
1	F1	5A	Fuse, SS-5H, 300V_{AC}	DIP	Cooper	SS-5H-5A-APH
1	L1	1mH	Common choke, 3A	DIP	Wurth	744822301
1	L2	330µH	Filter inductor, 3.5A	DIP	Wurth	7447065
1	L3	10mH	Common choke, 5A	DIP	Wurth	744825510
1	L4	170µH	PFC inductor, N1:N2 = 26:3, PQ3220	DIP	Emei	FX0399
1	L5	5mm	Wire jumper instead	DIP	Any	
1	L6	104µH	Common choke, 40A	DIP	Coilcraft	CU8995-AL
1	L7	2.2mH	Inductor, 300mA	DIP	Wurth	7447720222
1	LED1	Blue	LED	0805	Bright LED	BL-HGE35A-AV-TRB
1	Q1	100V	Transistor, 6A	SOT-223	Zetex	FZT853TA
1	Q3	-25V	Transistor, -0.5A	SOT-23	Changjiang Electronics	S8550
1	Q4	600V	N-channel MOSFET, 34A	TO-220	ST	STP34NM60N
2	Q5, Q6	700V	N-channel MOSFET, 29A	TO-220	Infineon	IPP65R280E
2	Q7, Q8	60V	N-channel MOSFET	TO-220	On Semiconductor	FDP025N06
3	R1, R2, R3	499kΩ	Film resistor, 1%	1206	Yageo	RC1206FR-07499KL
2	R6, R12	4.99Ω	Film resistor, 1%	0805	Yageo	RC0805FR-074R99L
1	R7	20kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0720KL

EV44018-S-HR1001-S-00C BILL OF MATERIALS *(continued)*

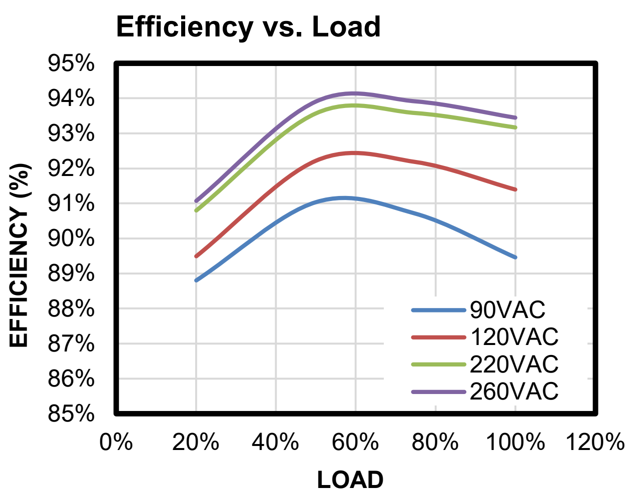
Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
6	R8, R9, R13, R14, R18, R19	3.3MΩ	Film resistor, 1%	1206	Yageo	RC1206FR-073M3L
1	R10	2kΩ	Film resistor, 1%	1206	Yageo	RC1206FR-072KL
1	R11	2kΩ	Film resistor, 1%	0805	Yageo	RC0805FR-072KL
1	R15	33kΩ	Film resistor, 1%	0805	Yageo	RC0805FR-0733KL
4	R16, R35, R44, R49	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
3	R21, R29, R69	NS				
1	R22	30kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0730KL
4	R23, R34, R42, R57	10Ω	Film resistor, 1%	0805	Yageo	RC0805FR-0710RL
1	R24	86.6kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0786K6L
2	R25, R37	1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-071KL
2	R26, R27	100mΩ	Film resistor, 1%	2512	Yageo	RL2512FK-070R1L
1	R28	63.4kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0763K4L
3	R31, R45, R53	0Ω	Film resistor, 1%	1206	Yageo	RC1206FR-070RL
4	R32, R41, R46, R50	10kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0710KL
1	R33	38.3kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0738K3L
1	R36	820kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07820KL
1	R38	5.1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-075K1L
1	R39	16.9kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0716K9L
1	R40	3kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-073KL
1	R43	24.9kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0724K9L
1	R47	49.9kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0749K9L
1	R48	510Ω	Film resistor, 1%	0805	Yageo	RC0805FR-07510RL
1	R51	27Ω	Film resistor, 1%	1206	Yageo	RC1206FR-0727RL
1	R52	100Ω	Film resistor, 1%	0603	Yageo	RC0603FR-07100RL
2	R54, R55	30Ω	Film resistor, 1%	1206	Yageo	RC1206FR-0730RL
1	R56	43kΩ	Film resistor, 1%	0603	Lion	RC0603FR-0743KL
1	R59	10Ω	Film resistor, 1%	0603	Yageo	RC0603FR-0710RL
1	R67	0Ω	Film resistor, 1%	0603	Yageo	RC0603FR-070RL
1	RT1	5Ω	Thermal resistor	DIP	Semitec	5D2-10

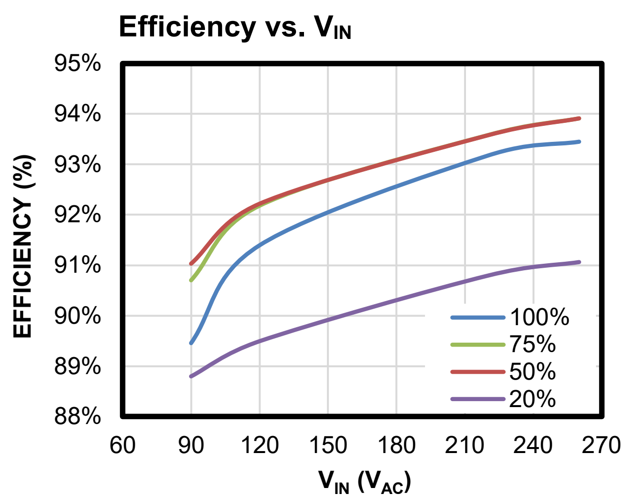
EV44018-S-HR1001-S-00C BILL OF MATERIALS *(continued)*

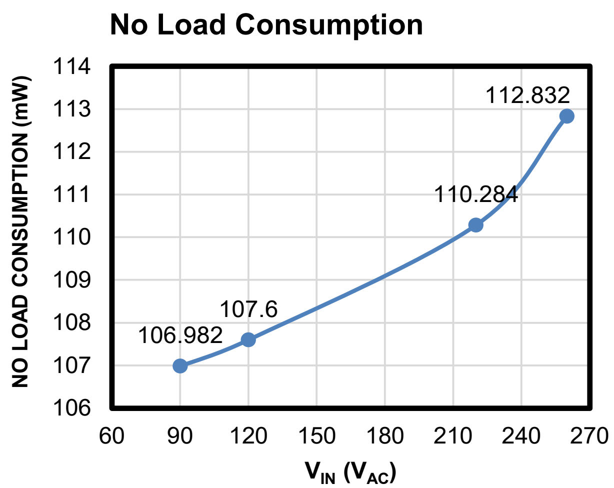
Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
4	SP1, SP2, SP3, SP4	NS				
1	T1	550μH	Transformer, ETD34, N1:N2:N3:N4 = 34:4:4:2:2,	DIP	Emei	FX0501
1	U3	2.5V	Shunt regulator, V_{REF} = 2.5V	SOT-23	Changdian	TL431
1	U4	5000V	Photocoupler, 1-channel	DIP	Sharp	PC817C
1	VAR2	14mm	Zinc oxide varistor	DIP	Thinking	TVR14471KS42Y
1	VAR1	NS				
1	HS1	3mm	Heatsink, 44mmx30mmx3mm	DIP	Any	
3	HS2, HS3, HS4	3mm	Heatsink, 60mmx30mmx3mm	DIP	Any	
2	L, N, Earth	1mm	Connector pin	DIP	Any	
2	VOUT, GND	2mm	Connector pin	DIP	Any	
1	U1	MP44018A	PFC controller	SOIC-8	MPS	MP44018-AGS
1	U2	HR1001A	LLC controller	SOIC-16	MPS	HR1001AGS
1	U5	MP174	700V offline regulator	TSOT23-5	MPS	MP174GJ
1	U6	MP6924A	SR controller	SOIC-8	MPS	MP6924AGS

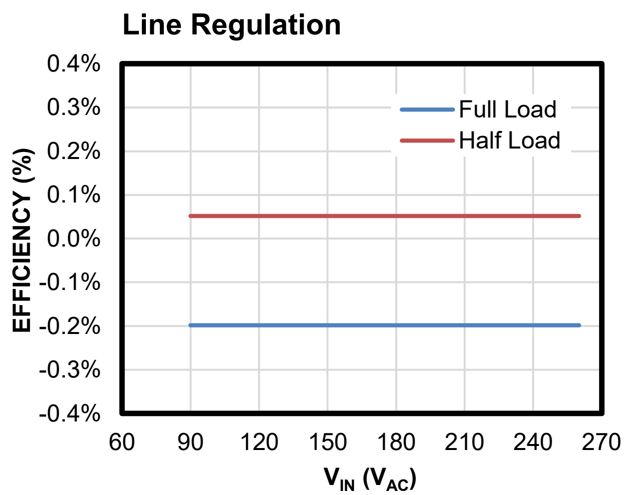
EVB TEST RESULTS

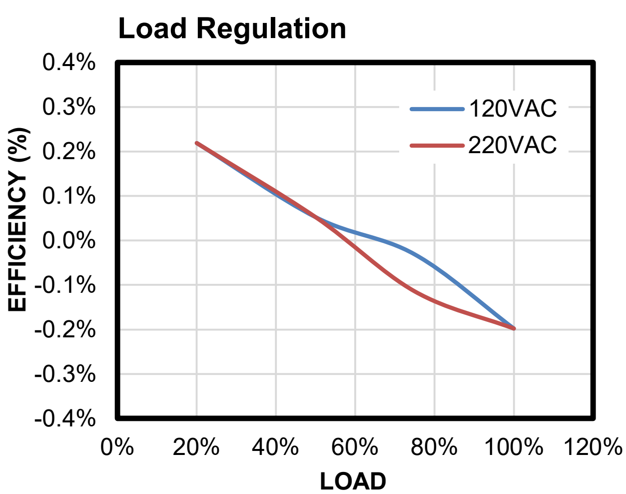
Performance waveforms are tested on the evaluation board. V_{IN} = 90V_{AC} to 265V_{AC}, V_{OUT} = 12V, I_{OUT} = 20A, P_{OUT} = 240W, unless otherwise noted.

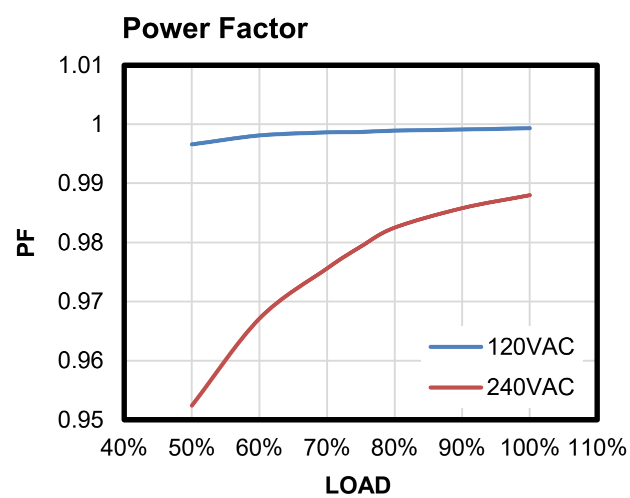






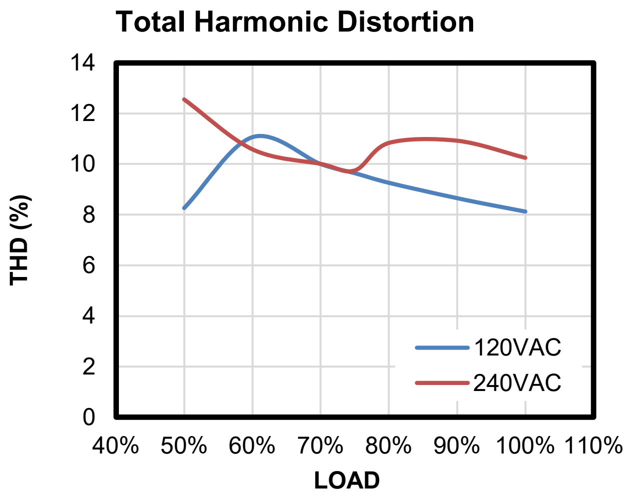




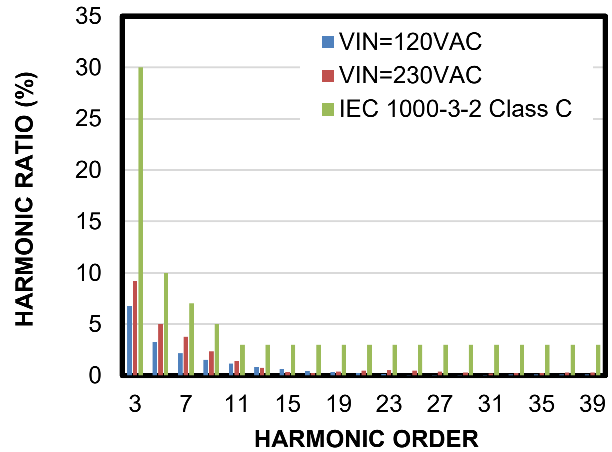


EVB TEST RESULTS *(continued)*

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



Harmonic
V_{IN} = 120V_{AC}/60Hz or 230V_{AC}/50Hz, full load

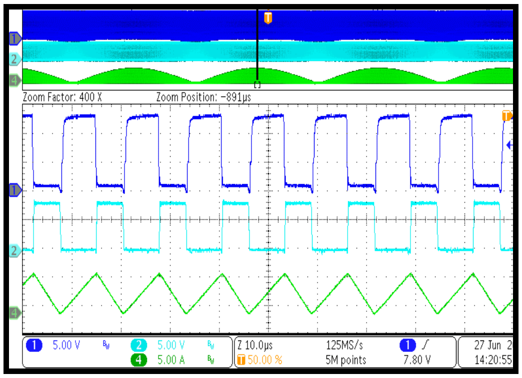


EVB TEST RESULTS *(continued)*

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

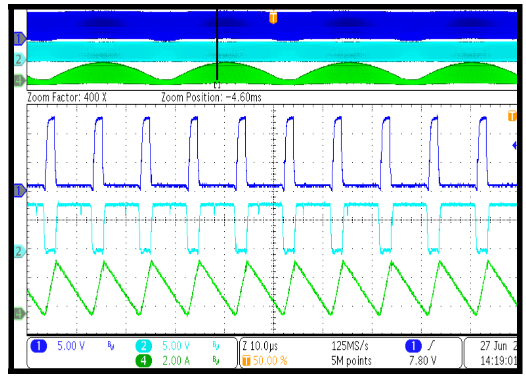
Steady State

PFC stage, V_{IN} = 120V_{AC}, P_{OUT} = 240W



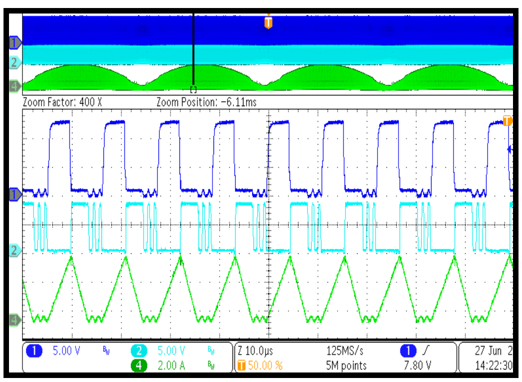
Steady State

PFC stage, V_{IN} = 220V_{AC}, P_{OUT} = 240W



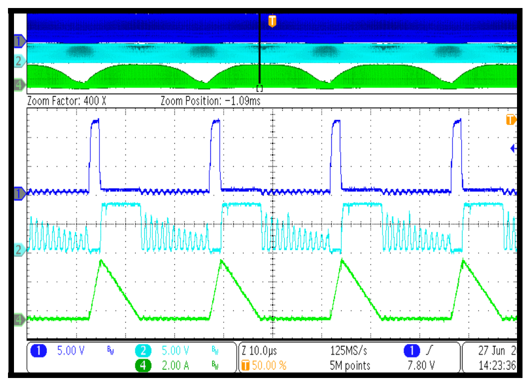
Steady State

PFC stage, V_{IN} = 120V_{AC}, P_{OUT} = 120W



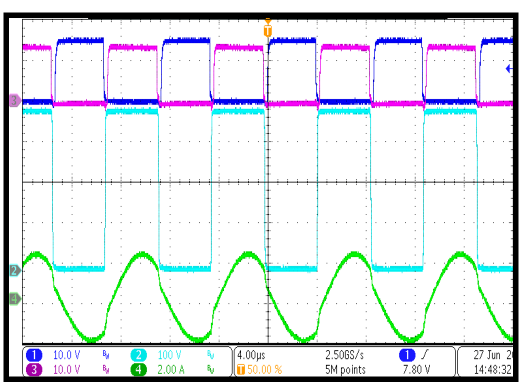
Steady State

PFC stage, V_{IN} = 220V_{AC}, P_{OUT} = 120W



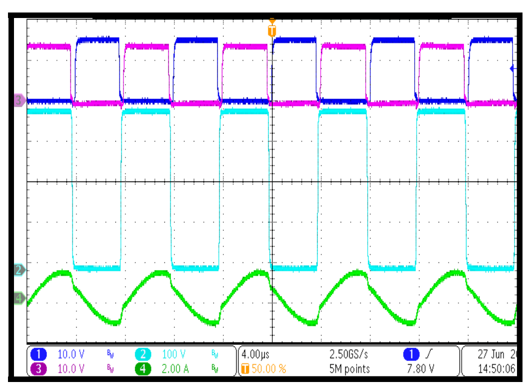
Steady State

LLC stage, P_{OUT} = 240W



Steady State

LLC stage, P_{OUT} = 120W



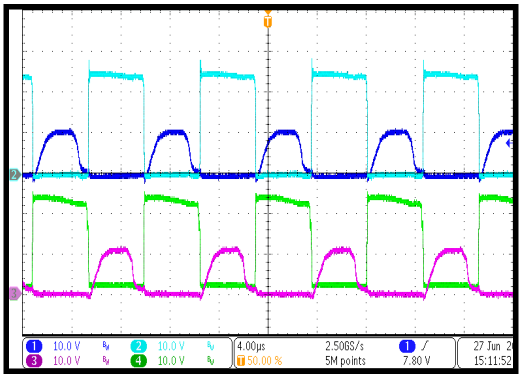
EVB TEST RESULTS *(continued)*

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

Steady State

SR stage, P_{OUT} = 240W

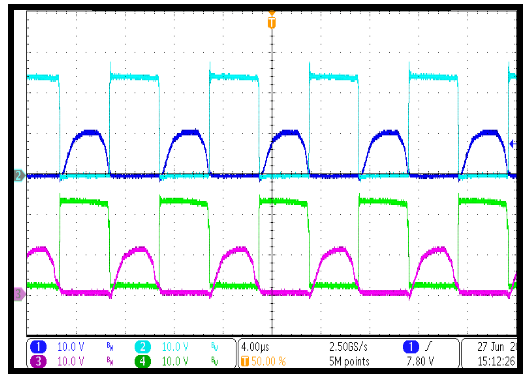
CH2: VDS_Q7
CH1: VGS_Q7
CH3: VGS_Q8
CH4: VDS_Q8



Steady State

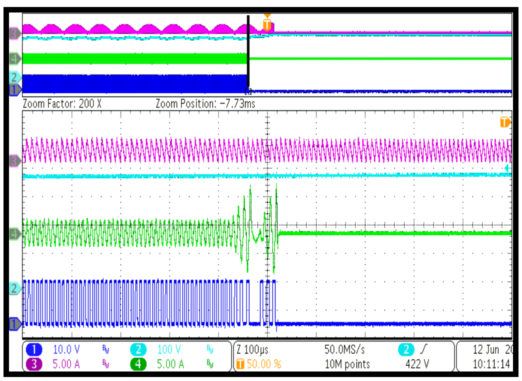
SR stage, P_{OUT} = 120W

CH2: VDS_Q7
CH1: VGS_Q7
CH3: VGS_Q8
CH4: VDS_Q8



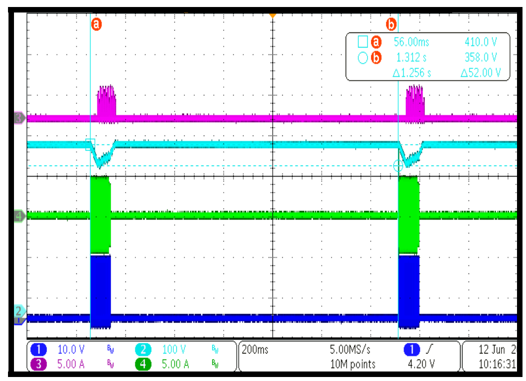
SCP Entry

CH3: IL_PFC
CH4: I_R
CH2: V_{BUS}
CH1: LG



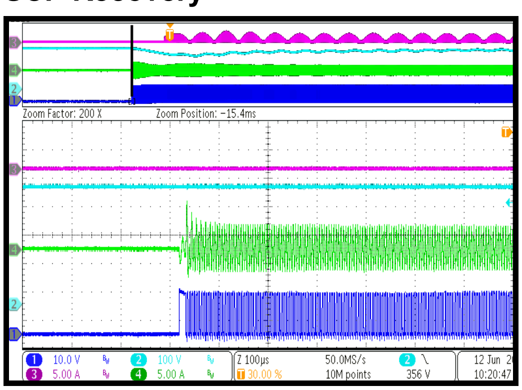
Short-Circuit Protection

CH3: IL_PFC
CH4: I_R
CH2: V_{BUS}
CH1: LG



SCP Recovery

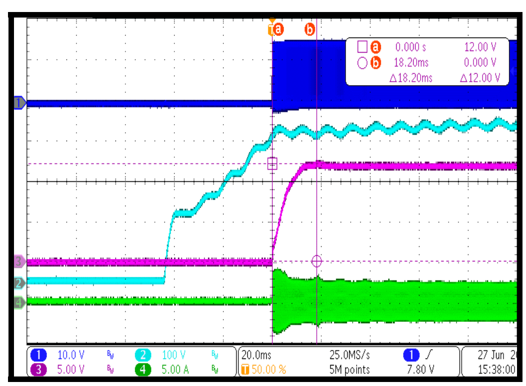
CH3: IL_PFC
CH4: I_R
CH2: V_{BUS}
CH1: LG



Start-Up

V_{IN} = 120V_{AC}, P_{OUT} = 240W

CH1: LG
CH3: V_{OUT}
CH2: V_{BUS}
CH4: I_R

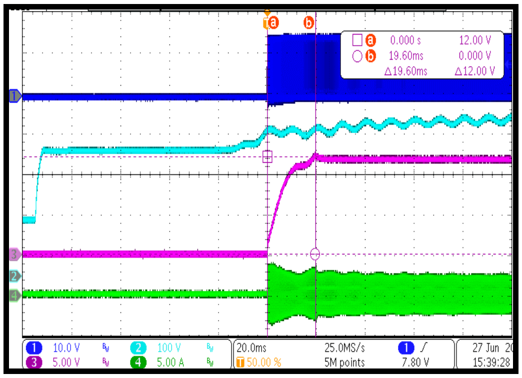


EVB TEST RESULTS *(continued)*

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

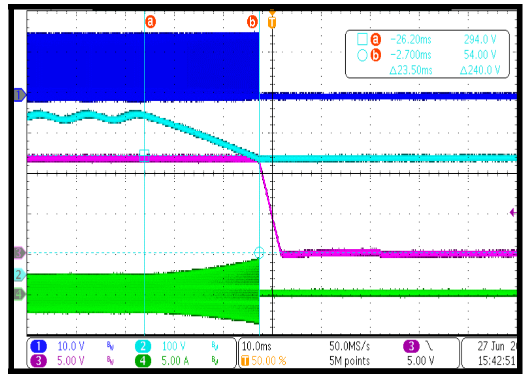
Start-Up

V_{IN} = 220V_{AC}, P_{OUT} = 240W



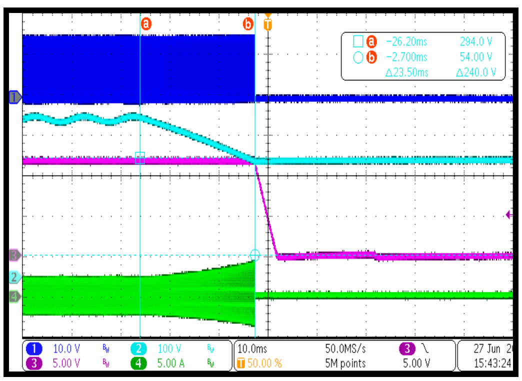
Shutdown

V_{IN} = 120V_{AC}, P_{OUT} = 240W



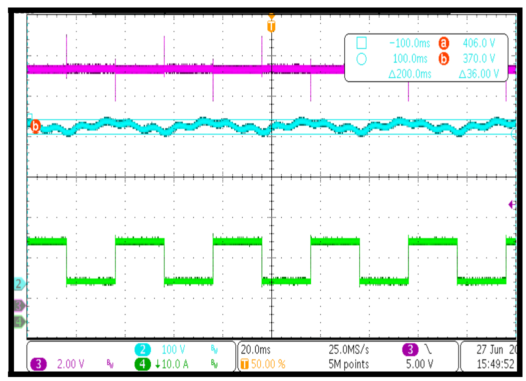
Shutdown

V_{IN} = 220V_{AC}, P_{OUT} = 240W



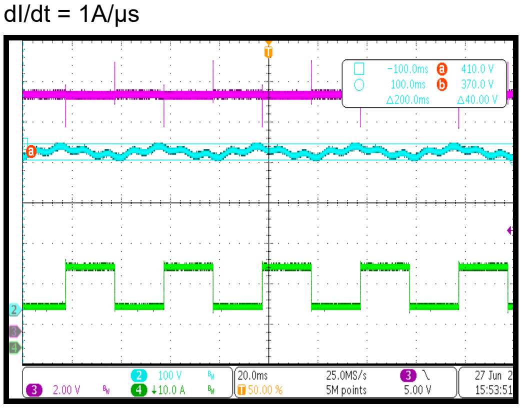
Load Transient

V_{IN} = 120V_{AC}, I_{OUT} transient = 10A to 20A, dI/dt = 1A/μs



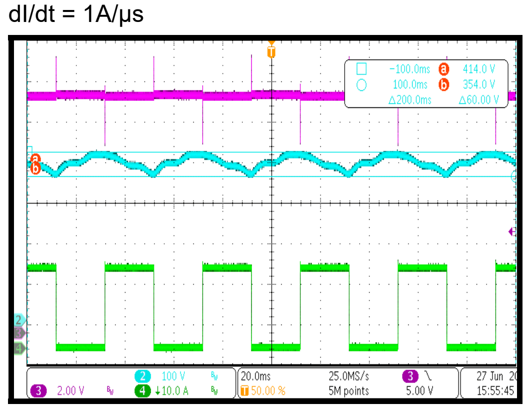
Load Transient

V_{IN} = 220V_{AC}, I_{OUT} transient = 10A to 20A, dI/dt = 1A/μs



Load Transient

V_{IN} = 120V_{AC}, I_{OUT} transient = 0A to 20A, dI/dt = 1A/μs



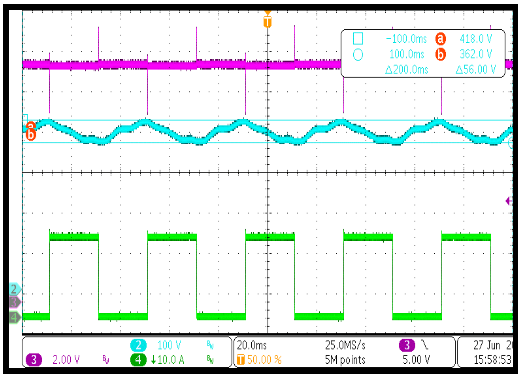
EVB TEST RESULTS *(continued)*

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

Load Transient

V_{IN} = 220V_{AC}, I_{OUT} transient = 0A to 20A, dI/dt = 1A/µs

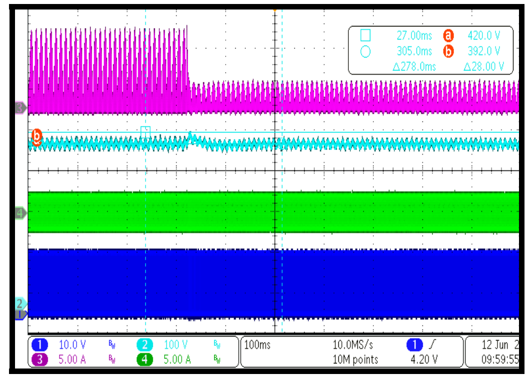
CH2: V_{BUS}
CH3: V_{OUT}
CH4: I_{OUT}



Line Transient

P_{OUT} = 240W, V_{IN} transient = 90V_{AC} to 260V_{AC}

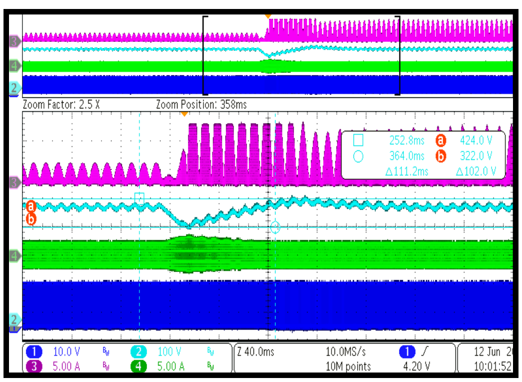
CH3: IL_PFC
CH4: I_R
CH2: V_{BUS}
CH1: LG



Line Transient

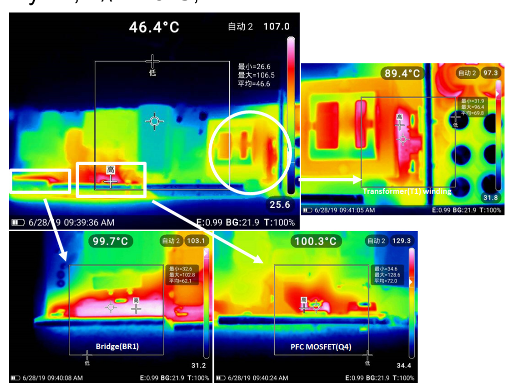
P_{OUT} = 240W, V_{IN} transient = 260V_{AC} to 90V_{AC}

CH3: IL_PFC
CH4: I_R
CH2: V_{BUS}
CH1: LG



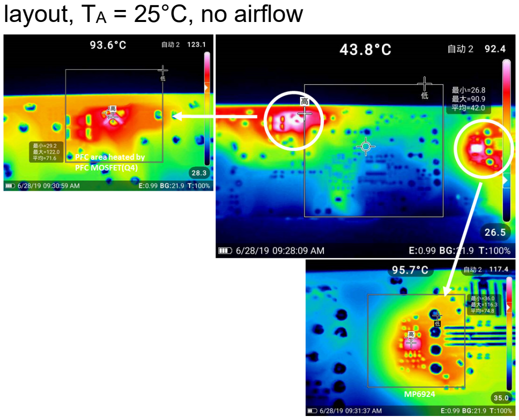
Thermal Performance

V_{IN} = 90V_{AC}, P_{OUT} = 240W, 2oz copper PCB layout, T_A = 25°C, no airflow



Thermal Performance

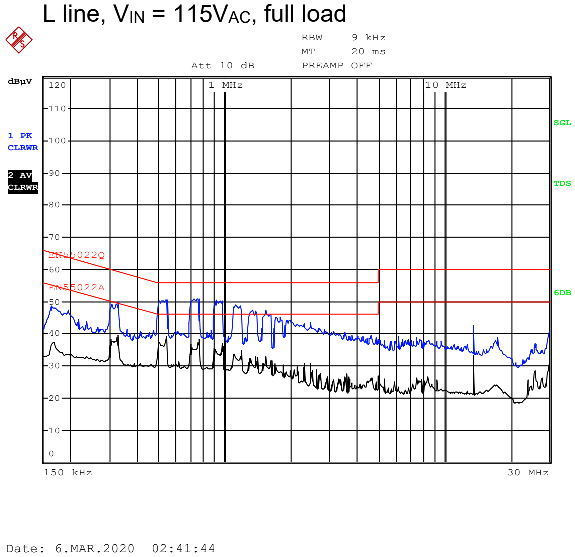
V_{IN} = 90V_{AC}, P_{OUT} = 240W, 2oz copper PCB layout, T_A = 25°C, no airflow



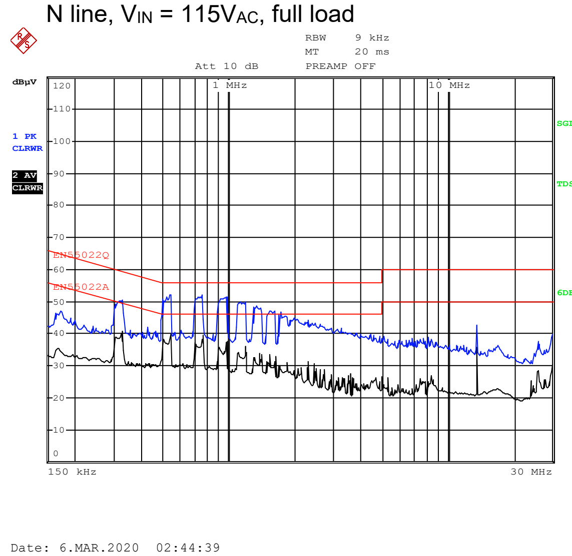
CONDUCTED EMI TEST RESULTS

Conducted EMI is tested at full loads according to EN55022 specifications, V_{IN} = 115V_{AC} or 230V_{AC}.

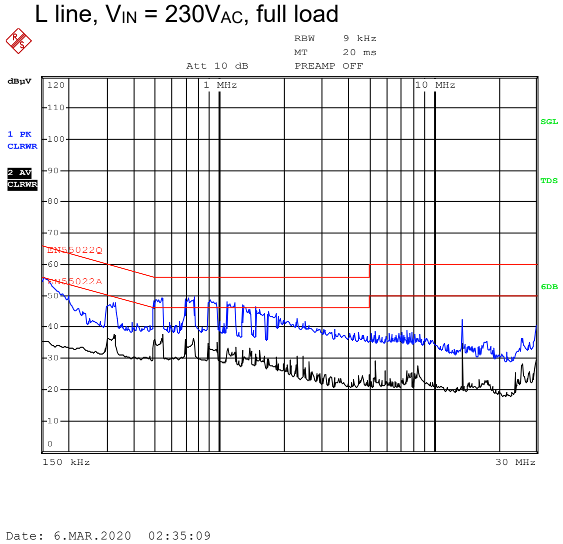
Conducted Emissions
L line, V_{IN} = 115V_{AC}, full load



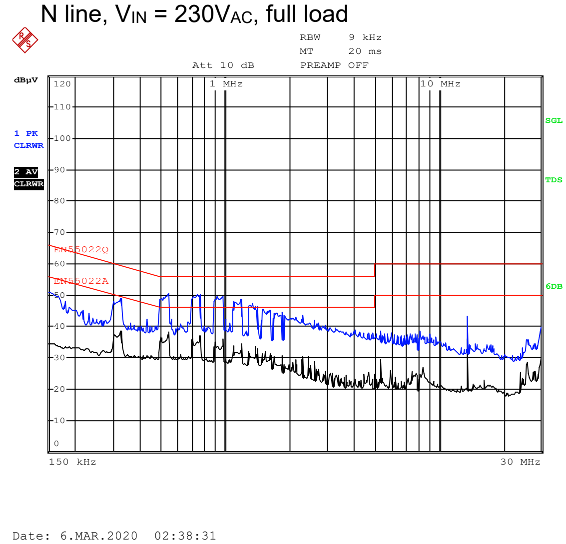
Conducted Emissions
N line, V_{IN} = 115V_{AC}, full load



Conducted Emissions
L line, V_{IN} = 230V_{AC}, full load



Conducted Emissions
N line, V_{IN} = 230V_{AC}, full load



SURGE TEST RESULTS

Line-to-line 4kV and line-to-power earth 4kV surge testing is completed according to EN61000-4-5 Level 4 specifications.

V_{IN} is set to $220V_{AC}$/50Hz, the part is operating under full load conditions, and operation is verified following each surge event (see Table 1).

Table 1: Surge Test Results

Surge Level (V)	V_{IN} (V_{AC})	Injection Location	Injection Phase	Test Result (Pass/Fail)
4000	220	L line to N line	90°	Pass
-4000	220	L line to N line	270°	Pass
4000	220	L line to Earth	90°	Pass
-4000	220	L line to Earth	270°	Pass
4000	220	N line to Earth	90°	Pass
-4000	220	N line to Earth	270°	Pass

PFC INDUCTOR SPECIFICATIONS

Electrical Diagram

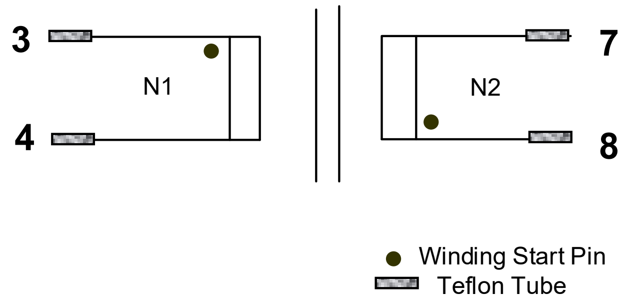


Figure 2: Inductor Electrical Diagram

The core is wrapped with copper foils. Solder the foils to pin 8 with wires (see Figure 3).

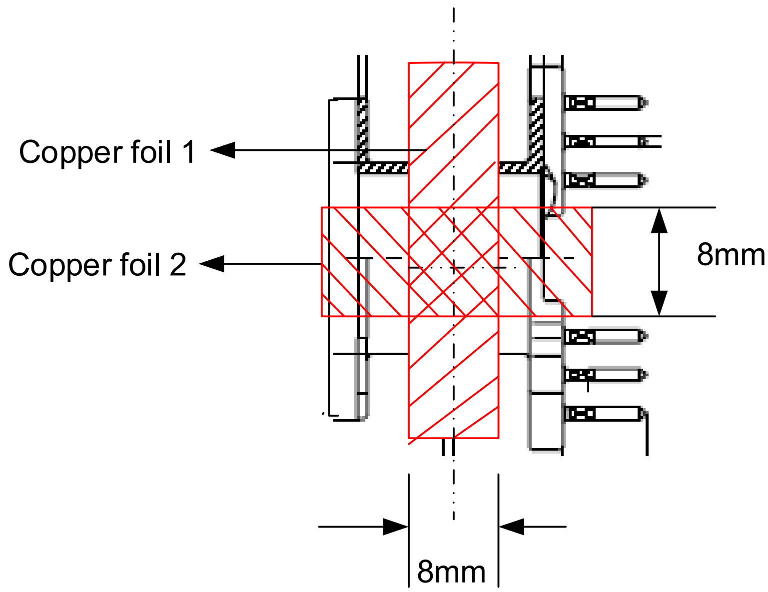


Figure 3: Copper Foil 1 and Copper Foil 2

Winding Diagram

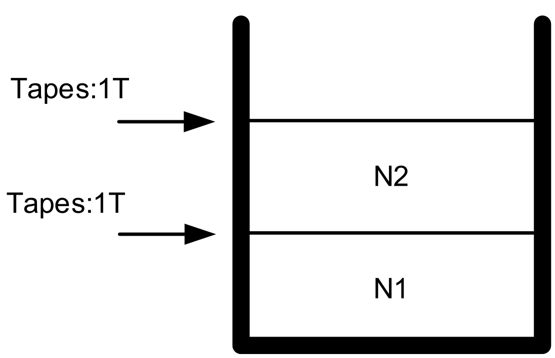


Figure 4: Inductor Winding Diagram

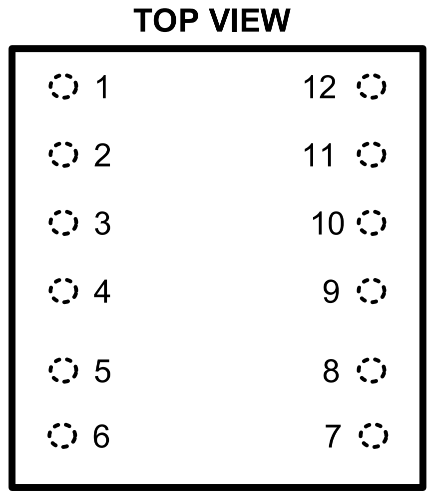


Figure 5: Inductor Bobbin Pin Definition

Table 2: Winding Order

Tape Turns	Winding No.	Start and End	Wire Diameter (Ø)	Turns
1	N1	3 to 4	0.1mm x 100	26
1	N2	8 to 7	0.2mm	3

Table 3: Electrical Specifications

Parameter	Condition	Value/Type
Primary inductance	L (3 to 4)	170µH ± 5%
Core	-	PQ3220
Bobbin	-	PQ3220
Core material	-	DMR40 or equivalent
Turns ratio	N1:N2	26:3

LLC TRANSFORMER SPECIFICATIONS

Electrical Diagram

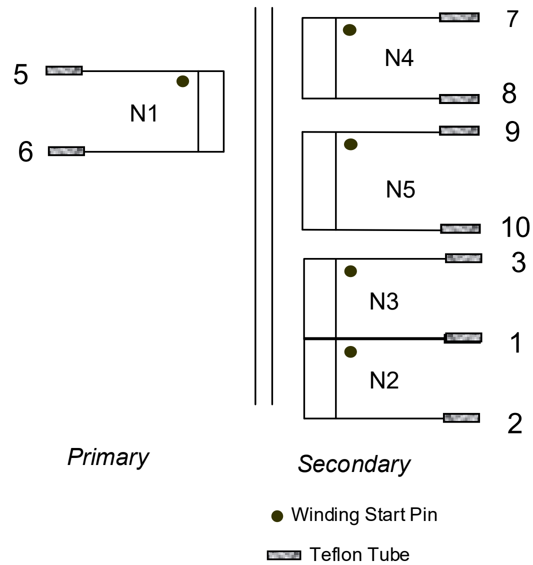


Figure 6: LLC Transformer Electrical Diagram

Winding Diagram

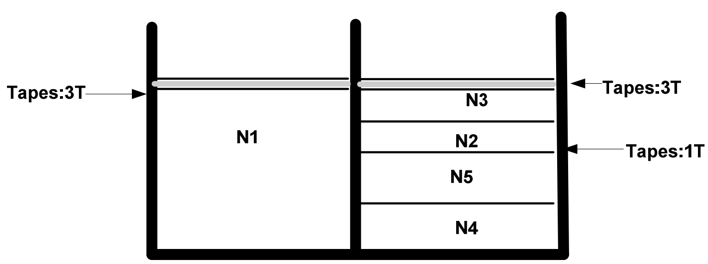


Figure 7: LLC Transformer Winding Diagram

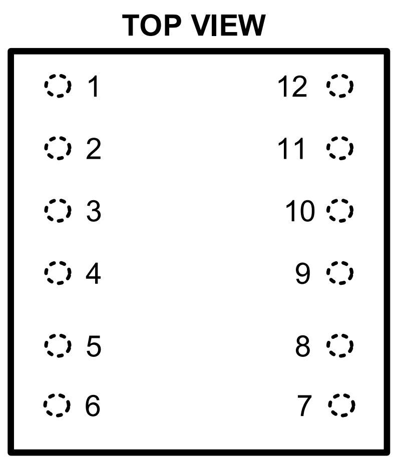


Figure 8: LLC Transformer Bobbin Pin Definition

Table 4: Winding Order

Tape Turns	Winding No.	Start and End	Wire Diameter (Ø)	Turns
3	N1	5 to 6	0.1mm x 50	34
1	N2	1 to 2	0.2mm TIW	4
3	N3	3 to 1	0.2mm TIW	4
1	N4	7 to 8	0.1mm x 240	2
1	N5	9 to 10	0.1mm x 240	2

Table 5: Electrical Characteristics

Parameter	Condition	Value/Type
Primary inductance	L_P (pin 5 to pin 6)	0.55mH ± 5%
Leakage inductance	L_K (pin 5 to pin 6)	55μH ± 20%
Core	-	ETD34
Bobbin	-	ETD34
Core material	-	DMR44 or equivalent
Turns ratio	N1:N2:N3:N4:N5	34:4:4:2:2

PCB LAYOUT

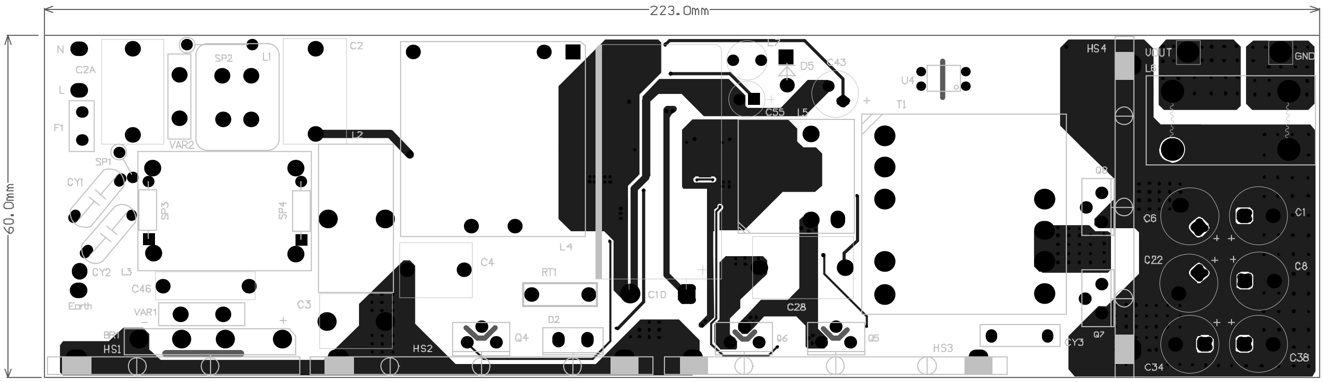


Figure 9: Top Layer

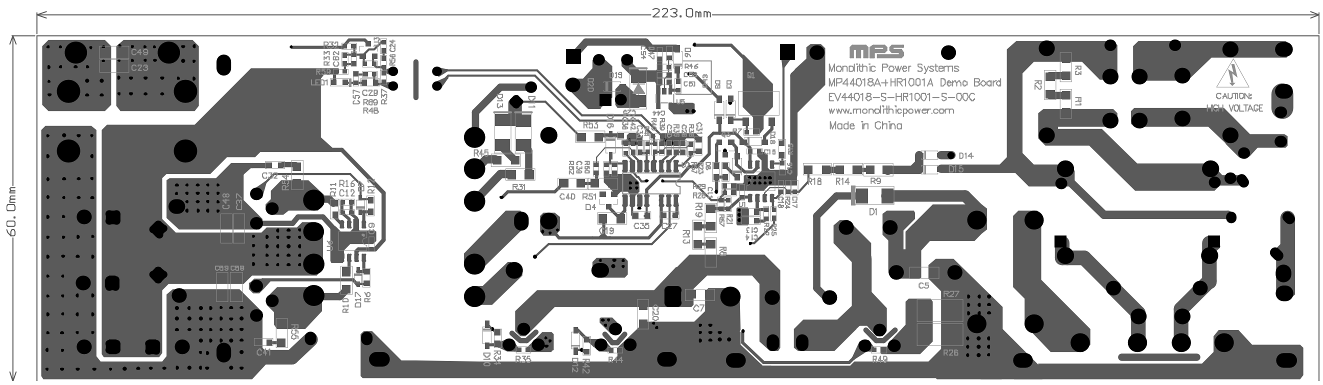


Figure 10: Bottom Layer

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	3/7/2023	Initial Release	-