EVHR1204-S-00A

400W Battery Charger for Power Tools Evaluation Board

DESCRIPTION

The EVHR1204-S-00A is a 21V/18A 400W Battery charger for power tools.

This reference design is a complete battery charger design for cordless power tool, which is widely used in drilling, grinding, cutting, polishing, and various garden tools. The design can be used in Li-ion and Li-poly chemistry battery with a voltage range from 10V to 21V. The maximum current can support up to 18A. The charger provides constant voltage and constant current control with programmable voltage and current.

The HR1204 integrates a digital PFC controller and a half-bridge resonant controller into a single chip. It uses very low power at no load or ultra-light load.

The PFC of the HR1204 employs a patented average current control scheme, which can operate in continuous conduction mode (CCM) and discontinuous conduction mode (DCM) according to the instantaneous condition of the input voltage and output load.

The half-bridge LLC converter achieves high efficiency with zero-voltage switching (ZVS). The HR1204 implements an adaptive dead-time adjustment (ADTA) function so the LLC converter can easily achieve ZVS from heavy load to light load. Additionally, the HR1204 can prevent the LLC converter from operating in capacitive mode, making it more robust and easier to design.

The EVHR1204-S-00A has excellent efficiency and a high power factor for the entire load range. Full protection features include overload protection; short-circuit protection (SCP), over-voltage protection (OVP), and anti-capacitive mode protection. The EVHR1204-S-00A also meets 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}	18	A
Output voltage	V_{OUT}	10-21	V
Output power	P_{OUT}	400	W
Efficiency@120V	η	>90	%
Output Current Ripple	Δ Iout	± 10	%

FEATURES

- Wide Operating Input Range (from 90V to 265V)
- Designed to Charge Wide Range of Battery in the Voltage Range of 10 to 21 V
- Delivers up to 18 A of Continuous Charging Current for Fast Charging of Batteries
- High Efficiency up to 90%
- Low Standby Power of < 250 mW When Battery is Not Connected
- Meets Class A Standard of IEC61000-3-2
- Meets EN55022 Standard
- Meets EN61000-4-5 Level 4 for Surge Immunity (4kV)
- High Power Factor (PF)
- Overload Protection (Auto-Restart Mode)
- Short-Circuit Protection (SCP) (Auto-Restart Mode)
- Over-Voltage Protection (OVP)
- Anti-Capacitive Mode Protection

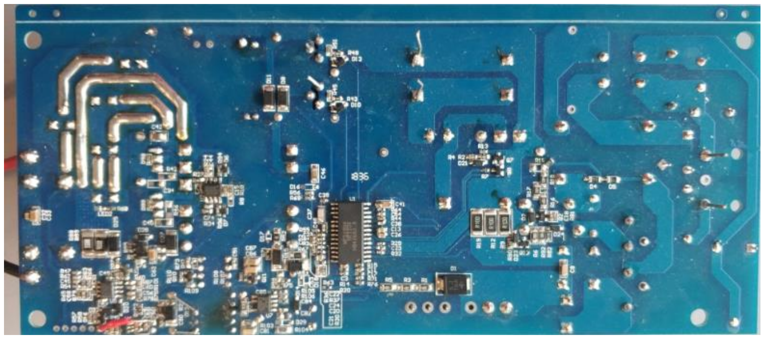
APPLICATIONS

- Cordless Power Tools
- Cordless Garden Tools
- Battery Chargers for
  – Vacuum Cleaner
  – Robotic Mower
  – E-Bike, E-Cycle

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 AC input to the prototype board.

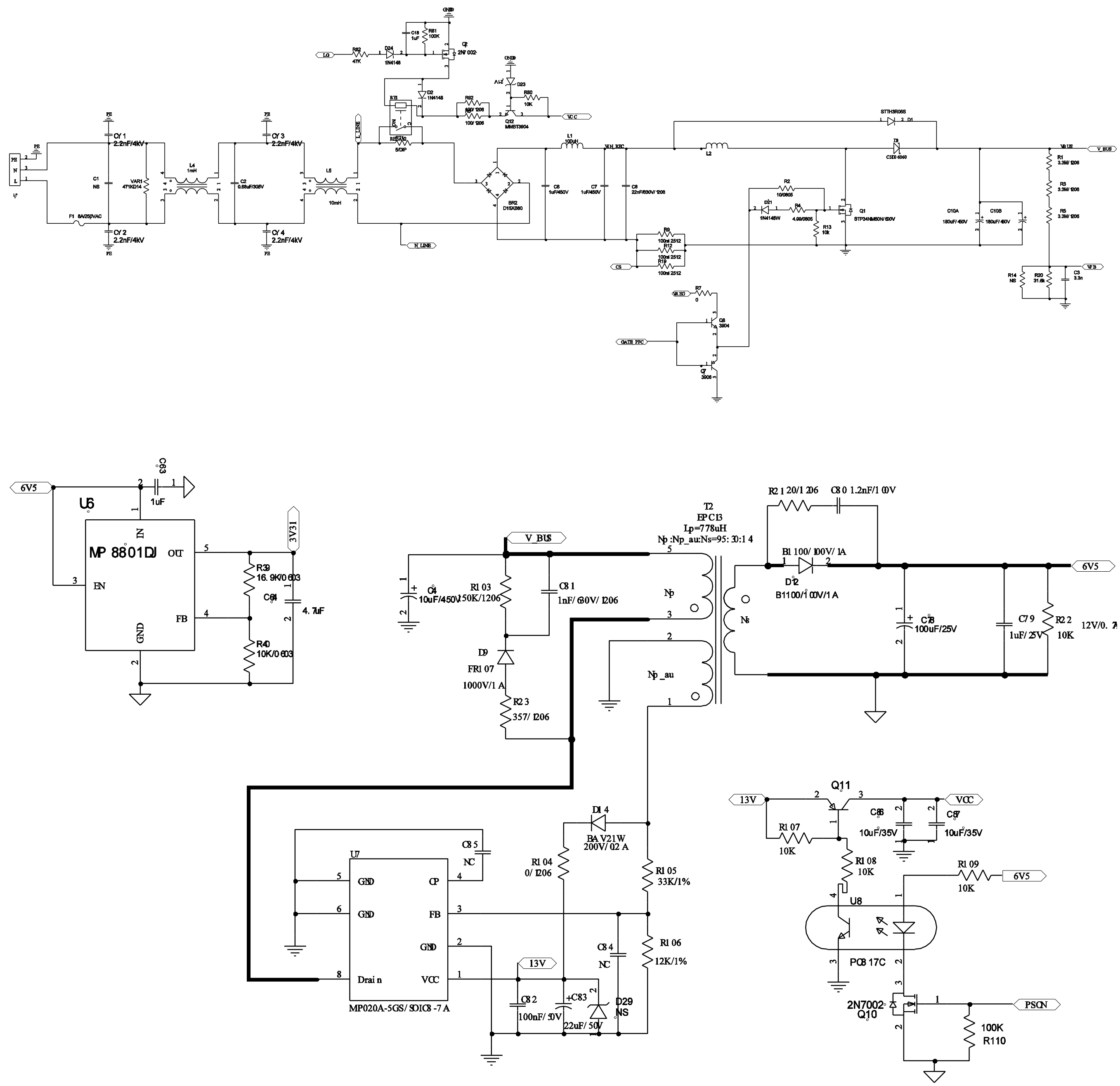
EVHR1204-S-00A EVALUATION BOARD

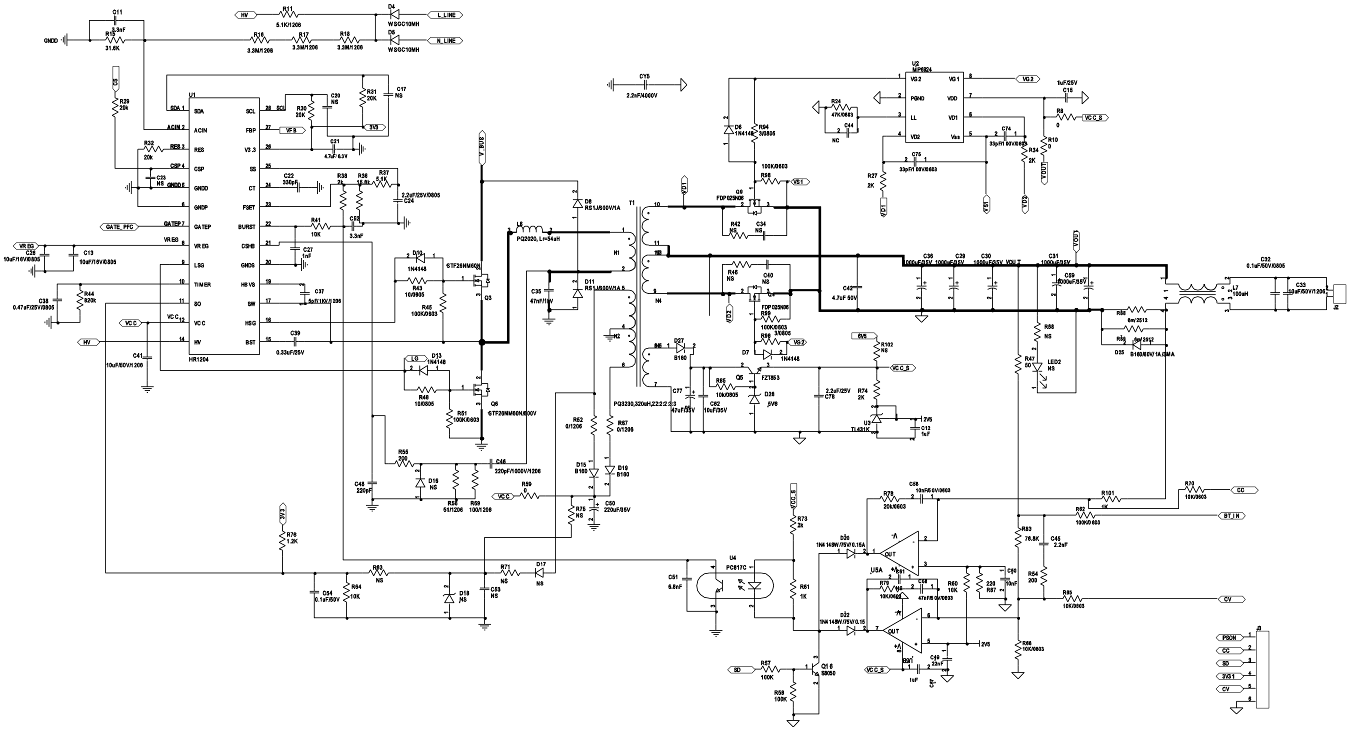


(L x W x H) (21.4cm x 9cm x 3.5cm)

Board Number	MPS IC Number
EVHR1204-S-00A	HR1204GM
	MP6924DS
	MP020A-5GS
	MP8801DJ

EVALUATION BOARD SCHEMATIC





EVHR1204-S-00A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer P/N
1	BR2	D15XB 80	Bridge rectifier, 800V, 15A	DIP	SHINDEN	D15XB80
10	C1, C17, C20, C23, C34, C40, C53, C44, C84, C85	NS				
1	C49	22nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H223KA01D
2	C12, C45	2.2nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H222KA01D
1	C2	0.68uF	X-capacitor, 310V	DIP	CARLI	PX684K2WD69H200D9R
1	C8	22nF	Ceramic capacitor, 630V, X7R	1206	TDK	C3216X7R2J223K
1	C81	1nF	Ceramic capacitor, 630V, X7R	1206	Murata	GRM31A7U2J102JW31D
2	C6, C7	1uF	Capacitor, 450V, CBB	DIP	CARLI	TF684K2Y10BL270D9R
2	C10A, C10B	180uF	Electrolytic capacitor, 450V	DIP	JIANGHAI	CD263-450V180
2	C3, C11	3.3nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H332KA01D
2	C13, C26	10uF	Ceramic capacitor, 16V, X7R	0805	Murata	GRM21BR61C106KE15L
6	C15, C57, C18, C12, C63, C79	1uF	Ceramic capacitor, 50V, X5R	0603	Murata	GRM188R61H105KAAL
2	C21, C64	4.7uF	Ceramic capacitor, 6.3V, X7R	0603	Murata	GRM188R60J475ME19D
1	C22	330pF	Ceramic capacitor, 50V, COG	0603	Murata	C1608COG1H331J
2	C24,C76	2.2uF	Ceramic capacitor, 25V, X7R	0805	Murata	GRM21BR71E225KA73L
2	C27,C48	1nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H102KA01D
5	C29, C30, C31, C59, C36	1000uF	Electrolytic capacitor, 35V	DIP	JIANGHAI	CD287-35V1000
1	C32	0.1uF	Ceramic capacitor, 50V, X7R	0805	Murata	GRM21BR71H104KA01L
4	C33, C41, C86, C87	10uF	Ceramic capacitor, 50V, X5R	1206	Murata	GRM31CR61H106KA12L
1	C60	10nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H103KA01D
1	C35	47nF	Capacitor, 1000V	DIP	FaLa	MMKP82-1000V-473P
1	C37	5pF	Ceramic capacitor, 3000V, NP0	1206	HHEC	C1206N5R0J302T

EVHR1204-S-00A BILL OF MATERIALS (*continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer P/N
1	C38	470nF	Ceramic capacitor, 25V, X7R	0603	Murata	GRM188R71E474KA12D
1	C39	330nF	Ceramic capacitor, 25V, X7R	0603	Murata	GRM188R71E334KA12D
1	C46	220pF	Ceramic capacitor, 1000V, U2J	1206	Murata	GMR31A7U3A221JW31D
1	C50	220μF	Electrolytic capacitor, 35V	DIP	JIANGHAI	CD110-35V220
2	C51, C52	6.8nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H682KA01D
1	C42	4.7uF	Ceramic capacitor, 50V, X7R	1210	Murata	GRM32ER71H475KA88L
1	C54, C82	100nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H104KA93D
1	C56	12nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H123KA01D
1	C58	47nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H473KA01D
2	C74, C75	33pF	Ceramic capacitor, 100V, X7R	0603	Murata	GRM1885C1H330JA01D
1	C77	47uF	Electrolytic capacitor, 50V	DIP	JIANGHAI	CD287-50V47
1	C78	100uF	Electrolytic capacitor, 25V	DIP	Rubycon	25YXF100M6.3X11
1	C4	10uF	Electrolytic capacitor, 450V	DIP	永铭	LKM_450V_10uF_10*14
1	C62	10uF	Ceramic capacitor, 35V, X7R	1206	TDK	C3216X7R2V106K
1	C80	1.2nF	Ceramic capacitor, 100V, X7R	0603	Murata	GRM188R72A122KA01D
1	C83	22uF	Electrolytic capacitor, 50V	DIP	JIANGHAI	CD281L-50V22
5	CY1, CY2, CY3, CY4, CY5	2.2nF/2600V	Y-capacitor, 2600V, 20%	DIP	鸿科	JYK09F222MY72N
2	D8, D11	RS1J	Diode, 600V, 1A	SMA	Diodes	RS1J-13-F
1	D1	S5J	Diode, 600V, 5A	SMC	邦达园	S5J
1	D3	C3D06060	Diode, 600V, 6A	TO-220	CREE	C3D06060
2	D4, D5	WSRGC10MH	Diode, 1000V, 1A	1206	ZOWIE	WSRGC10MH
8	D2, D10, D13, D20, D21, D22, D24,D26	1N4148W	Diode, 75V, 0.15A	SOD-123	Diodes	1N4148W
2	D6,D7	1N4148WS	Diode, 75V, 0.15A	SOD-323	Diodes	1N4148WS-7
1	D12	B1100	Schottky diode, 100V, 1A	SMA	Diodes	B1100-13-F

EVHR1204-S-00A BILL OF MATERIALS (*continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer P/N
1	D14	BAV21 W	Diode, 200V, 0.2A	SOD-123	Diodes	BAV21W-7-F
4	D15, D19, D25,D27	B160	Schottky diode, 60V, 1A	SMA	Diodes	B160
4	D16, D17, D18, D29	NS				
1	D23	BZT52 C22	Zener diode, 22V, 5mA/500mW	SOD-123	Diodes	BZT52C22
1	D28	BZT52 C5V6	Zener diode, 22V, 5mA/500mW	SOD-123	Diodes	BZT52C5V6
1	D9	FR107	Diode, 1000V, 1A	DO-41	MIC	FR107
1	F1	021600 8.MXE P	Fuse, 250V, 8A	DIP	Little	0216008.MXEP
1	L1	300µH	Filter inductor, 300µH, 3A	DIP	Wurth	7447065
1	L2	300uH	PFC inductor, L = 300µH, PQ3230	DIP	Emei	FX0538
1	L4	1mH	Common choke, 1mH, 3A	DIP	Wurth	744822301
1	L5	10mH	Common choke, 10mH, 5A	DIP	Wurth	744825510
1	L6	54uH	Resonant inductor, PQ2020	DIP	Emei	FX0539
1	L7	104uH	Common choke, 104uH, 40A	DIP	CoilCraft	CU8995-AL
1	LED2	NS				
1	Q1	STW26 NM60	N-channel MOSFET, 600V, 30A	TO-247	ST	STW26NM60
2	Q4, Q9	FDP02 5N06	N-channel MOSFET, 600V, 25A	TO-220-3	Faichild	FDP025N06
2	Q3, Q6	STF26 NM60	N-channel MOSFET, 600V, 20A	TO-220F	ST	STF26NM60
4	Q12, Q8, Q16, Q5	MMBT3 904LT1 G	Transistor, 40V, 0.2A	SOT-23	Onsemi	MMBT3904LT1G
1	Q5	BCX55 10TA	Transistor, 60V, 1A	SOT-89-3	Diodes	BCX5510TA
2	Q7, Q11	MMBT3 906LT1 G	Transistor, -40V, 0.2A	SOT-23	Onsemi	MMBT3906LT1G
3	Q2, Q13, Q10	2N7002 MTF	N-channel MOSFET, 60V, 115mA	SOT-23	Faichild	2N7002MTF
3	R52, R67, R104	0	Film resistor, 1%	1206	Yageo	RC1206FR-070RL
6	R1, R3, R5, R16, R17, R18	3.3M	Film resistor, 1%	1206	Yageo	RC1206FR-073M3L
1	R11	5.1K	Film resistor, 1%	1206	Yageo	RL1206FR-075K1L

EVHR1204-S-00A BILL OF MATERIALS (*continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer P/N
3	R9, R12, R19	100m	Film resistor, 1%	2512	Yageo	RL2512FK-070R1L
12	R40, R41, R64, R79, R66, R65, R70, R60, R107, R108, R109, R22	10K	Film resistor, 1%	0603	Yageo	RC0603FR-0710KL
10	R14, R42, R46, R63, R68, R71, R75, R97, R8, R61	NS				
2	R15, R20	31.6K	Film resistor, 1%	0603	Yageo	RC0603FR-0731K6L
15	R13, R45, R51, R81, R86, R97, R98, R99, R110, R84, R62, R57, R58, R86, R80	100K	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
1	R24	47K	Film resistor, 1%	0603	Yageo	RC0603FR-0747KL
1	R23	357	Film resistor, 1%	1206	Yageo	RC1206FR-07357RL
3	R27, R34,R74	2K	Film resistor, 1%	0805	Yageo	RC0805FR-072KL
1	R29	20K	Film resistor, 1%	0805	Yageo	RC0805FR-0720KL
4	R30, R31, R32, R78	20K	Film resistor, 1%	0603	Yageo	RC0603FR-0720KL
1	R36	15.8K	Film resistor, 1%	0603	Yageo	RC0603FR-0715K8L
1	R37	5.1K	Film resistor, 1%	0603	Yageo	RC0603FR-075K1L
1	R38	2K	Film resistor, 1%	0603	Yageo	RC0603FR-072KL
1	R39	16.9K	Film resistor, 1%	0603	Yageo	RC0603FR-0716K9L
1	R87	220	Film resistor, 1%	0603	Yageo	RC0603FR-07220RL
3	R2, R43, R48	10	Film resistor, 1%	0805	Yageo	RC0805FR-0710RL
1	R21	20	Film resistor, 1%	1206	Yageo	RL1206FR-0720RL
1	R4	4.99	Film resistor, 1%	0805	Yageo	RC0805FR-074R99L
1	R44	820K	Film resistor, 1%	0603	Yageo	RC0603FR-07820KL
1	R47	50	Film resistor, 1%	0603	Yageo	RC0603FR-0750RL
2	R54, R55	200	Film resistor, 1%	0603	Yageo	RC0603FR-07200RL
1	R56	51	Film resistor, 1%	0603	Yageo	RC0603FR-0751RL
1	R69	100	Film resistor, 1%	0603	Yageo	RC0603FR-07100RL
4	R59, R7, R102, R10	0	Film resistor, 1%	0603	Yageo	RC0603FR-07oRL

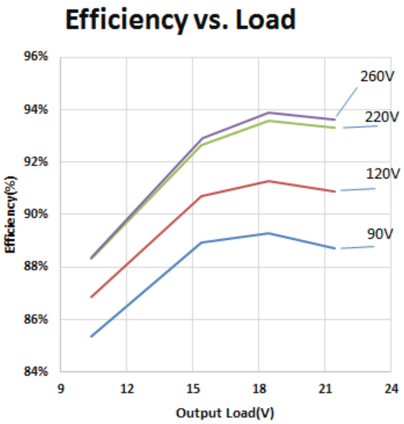
EVHR1204-S-00A BILL OF MATERIALS *(continued)*

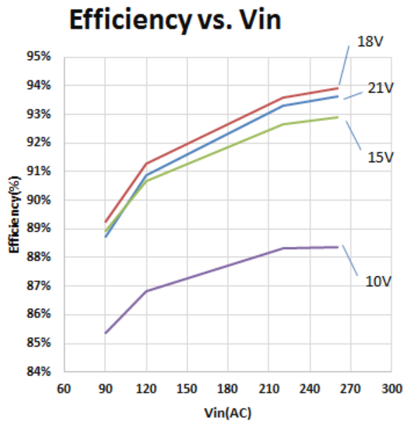
Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer P/N
2	R101	1K	Film resistor, 1%	0603	Yageo	RC0603FR-071KL
4	R6, R92, R72, R91	10	Film resistor, 1%	1206	Yageo	RL1206FR-0710RL
1	R73	1.5K	Film resistor, 1%	0603	Yageo	RC0603FR-071K5L
1	R76	1.2K	Film resistor, 1%	0805	Yageo	RC0805FR-071K2L
1	R82	47K	Film resistor, 1%	0603	Yageo	RC0603FR-0747KL
1	R83	76.8K	Film resistor, 1%	0603	Yageo	RC0603FR-0776K8L
1	R103	150K	Film resistor, 1%	1206	Yageo	RL1206FR-076K8L
1	R85	10K	Film resistor, 1%	0805	Yageo	RC0805FR-0710KL
2	R88, R89	6m	Film resistor, 1%	2512	旺诠	LR2515-22R006F4
2	R94, R96	3	Film resistor, 1%	0805	Yageo	RC0805FR-073RL
1	R105	33K	Film resistor, 1%	0603	Yageo	RC0603FR-0733KL
1	R106	12K	Film resistor, 1%	0603	Yageo	RC0603FR-0712KL
1	RT1	5	Thermal resistor	DIP	江苏兴顺	5D2-10
2	RY1,RY2	OJE-SS-112HMF	Electric relay	DIP	TYCO	OJE-SS-112HMF
1	T1	316uH	Transformer, Lp = 316uH N1:N2:N3:N4:N5 = 22:2:2:3:3, PQ3230	DIP	Emei	FX0537
1	T2	778uH	Transformer, Lp = 778uH N1:N2:N3 = 95:30:14, EPC13	DIP	Emei	
1	U1	HR1204	PFC + LLC combo controller	SOIC-28	MPS	HR1204GY-0001-Z
1	U2	MP6924	SR controller	SOIC-8	MPS	MP6924AGS-Z
2	U4, U8	PC817C	Photocoupler, 1-channel	DIP	Sharp	PC817C
1	U5	LM358	Dual Operational Amplifiers	SOIC-8	TI	LM358ADR
1	U3	TL431	Shunt regulator, V_{REF} = 2.5V	SOT-23	TI	TL431AIDBZR
1	U6	MP8801	Linear regulator	SOT-23	MPS	MP8801DJ-3.3-LF-Z
1	U7	MP020A	Flyback controller	SOIC8-7A	MPS	MP020A-5GS
2	VAR1, VAR2	471KD14	MOV	DIP	TKS	TVR14471KS42Y
1	HS1		Heatsink for BRIDGE	DIP		
1	HS2		Heatsink for PFC rectifier DIODE	DIP		
1	HS3		Heatsink for LLC primary MOSFETs	DIP		
1	HS4		Heatsink for SR MOSFETs	DIP		

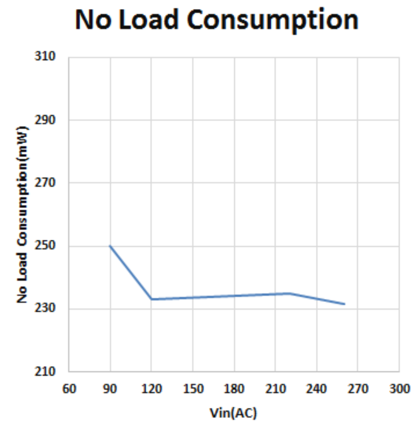
EVB TEST RESULTS

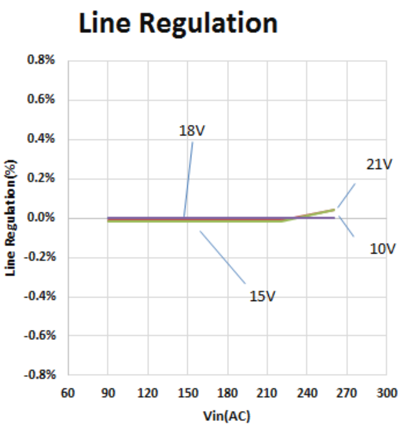
Performance waveforms are tested on the evaluation board.

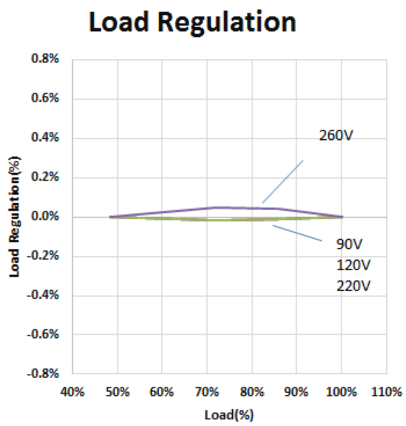
V_{IN_AC} = 90V to 265V, V_{OUT} = 21V, I_{OUT} = 18A, P_{OUT} = 400W

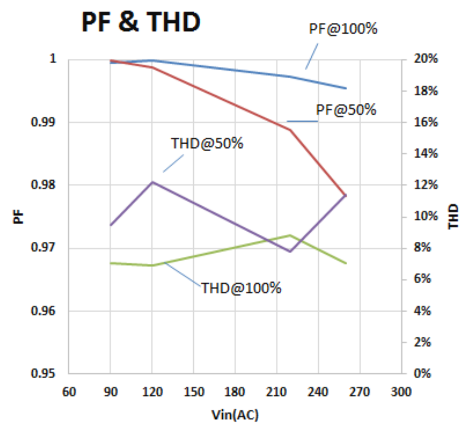


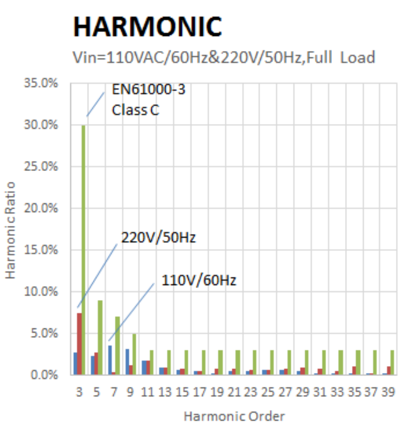


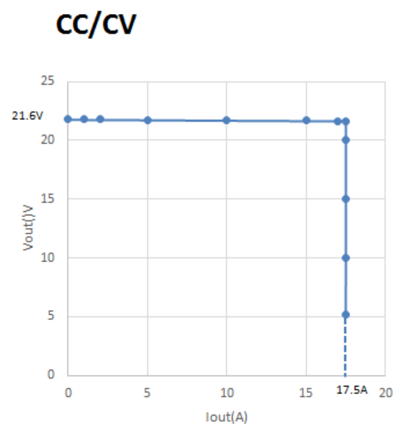












EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

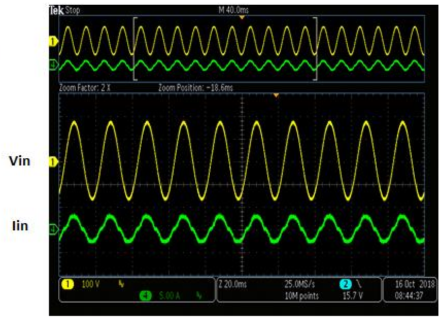
V_{IN_AC} = 90V to 265V, V_{OUT} = 21V, I_{OUT} = 18A, P_{OUT} = 400W, CV Load

Input Voltage & Current

Vin=120VAC, Vo=21V,Io=18A

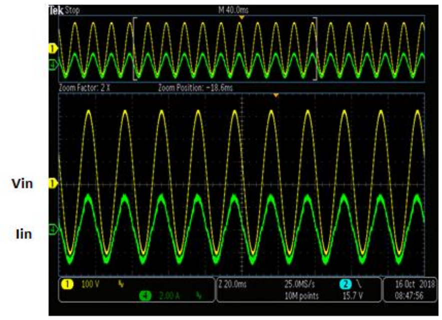
Input Voltage & Current

Vin=120VAC, Vo=10V,Io=18A



Input Voltage & Current

Vin=220VAC, Vo=21V,Io=18A



Input Voltage & Current

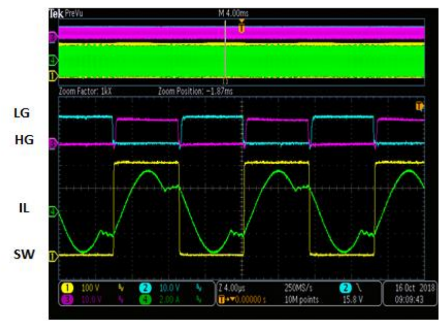
Vin=220VAC, Vo=10V,Io=18A

Steady State

Vin=120VAC, Vo=21V,Io=18A

LLC Stage

Vin=120VAC, Vo=21V,Io=18A



SR Operation

Vin=120VAC, Vo=21V,Io=18A

EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

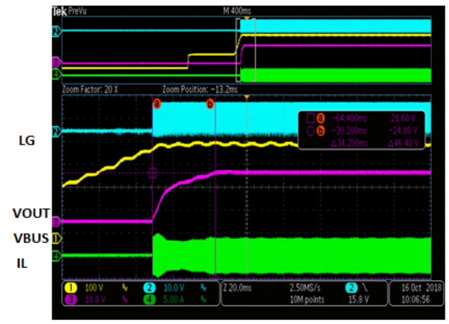
V_{IN_AC} = 90V to 265V, V_{OUT} = 21V, I_{OUT} = 18A, P_{OUT} = 400W, CV Load

Start-Up

Vin=120VAC, Vo=21V,Io=18A

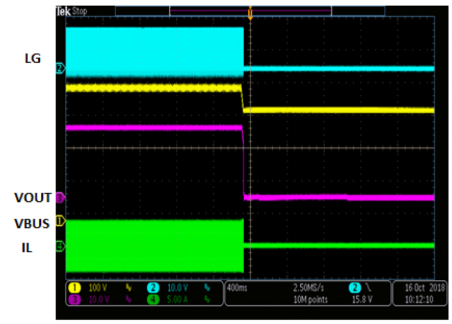
Output Rise Time

Vin=120VAC, Vo=21V,Io=18A



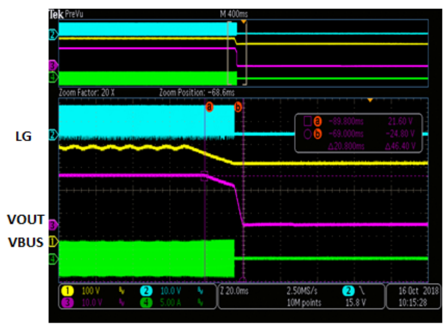
Shutdown

Vin=120VAC, Vo=21V,Io=18A



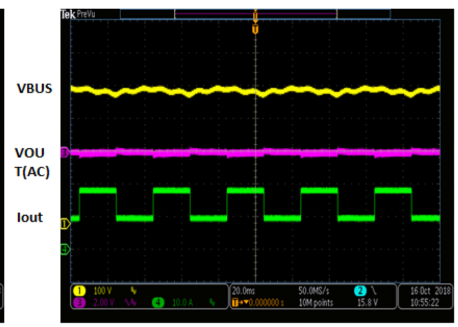
Hold up time

Vin=120VAC, Vo=21V,Io=18A



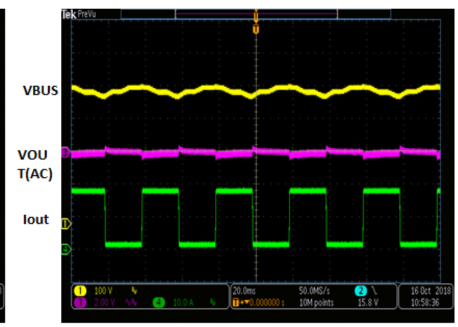
Load Transient

Vin=120VAC, 9A-18A



Load Transient

Vin=120VAC, 1A-18A



Start-up

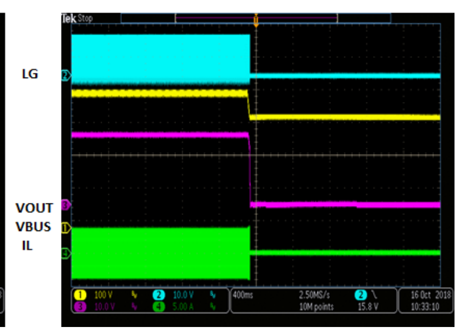
Vin=220VAC, Vo=21V,Io=18A

Output Rise time

Vin=220VAC, Vo=21V,Io=18A

Shutdown

Vin=220VAC, Vo=21V,Io=18A



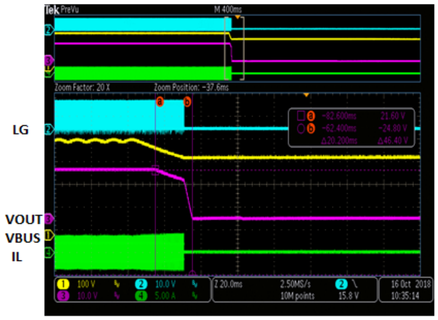
EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

V_{IN_AC} = 90V to 265V, V_{OUT} = 21V, I_{OUT} = 18A, P_{OUT} = 400W, CV Load

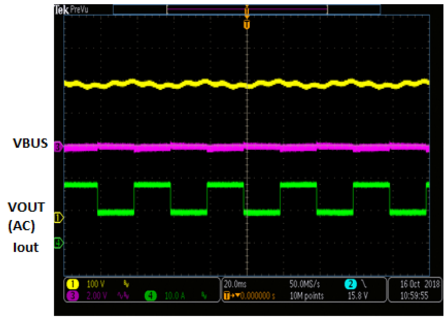
Hold up time

Vin=220VAC, Vo=21V,Io=18A



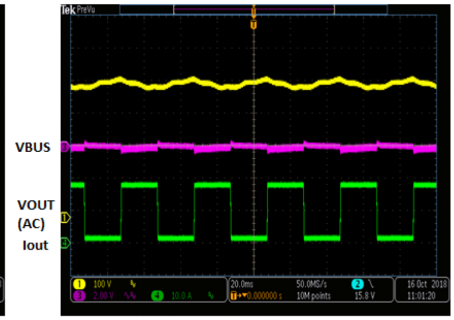
Load Transient

Vin=220VAC, 9A-18A



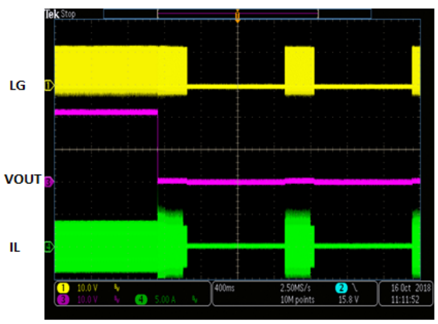
Load Transient

Vin=220VAC, 9A-18A



SCP Entry

Vin=120VAC, Vo=21V,Io=18A

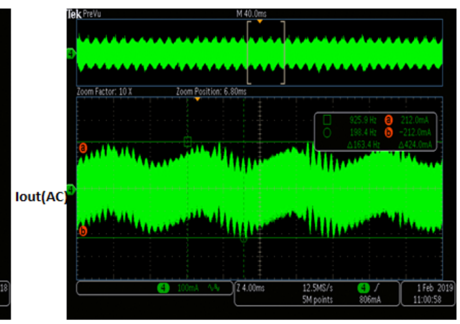


SCP Recovery

Vin=120VAC, Vo=21V,Io=18A

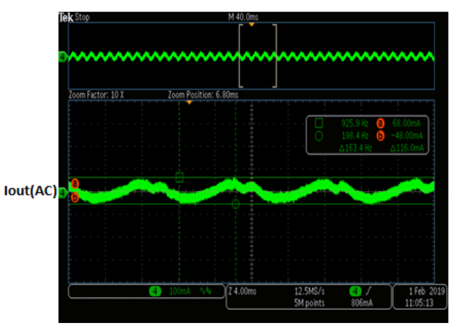
Output Current Ripple

Vin=120VAC, Vo=21V,Io=18A



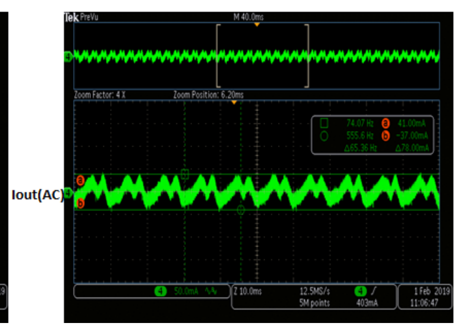
Output Current Ripple

Vin=120VAC, Vo=15V,Io=18A



Output Current Ripple

Vin=120VAC, Vo=10V,Io=18A



PRINTED CIRCUIT BOARD LAYOUT

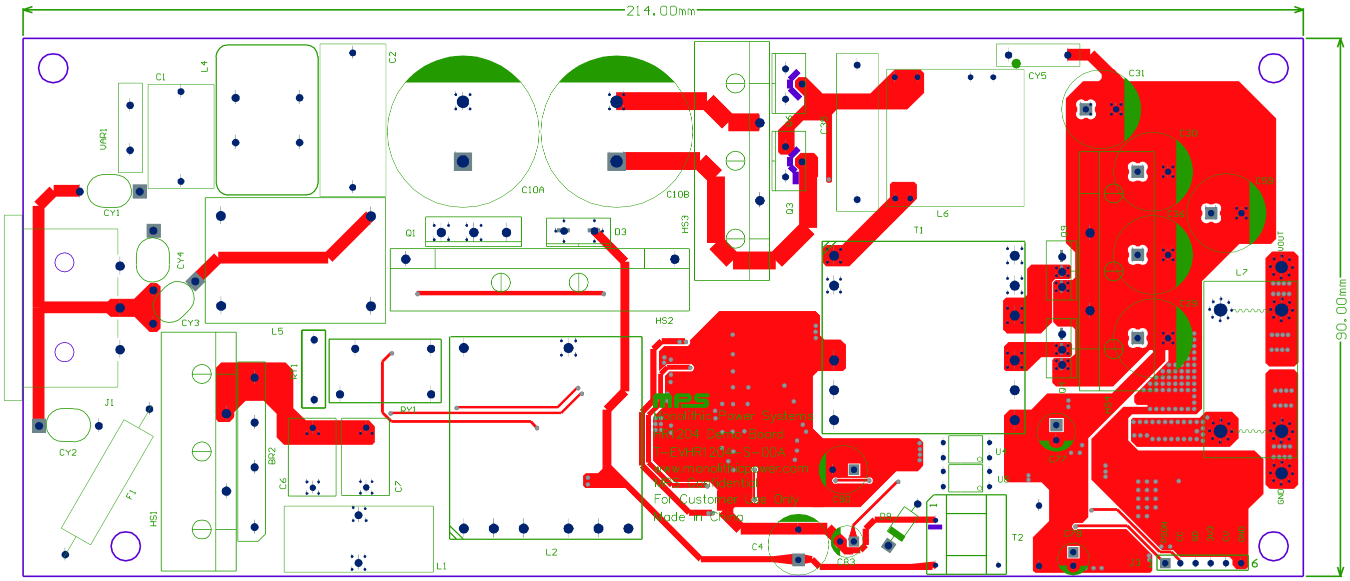


Figure 1: Top Layer

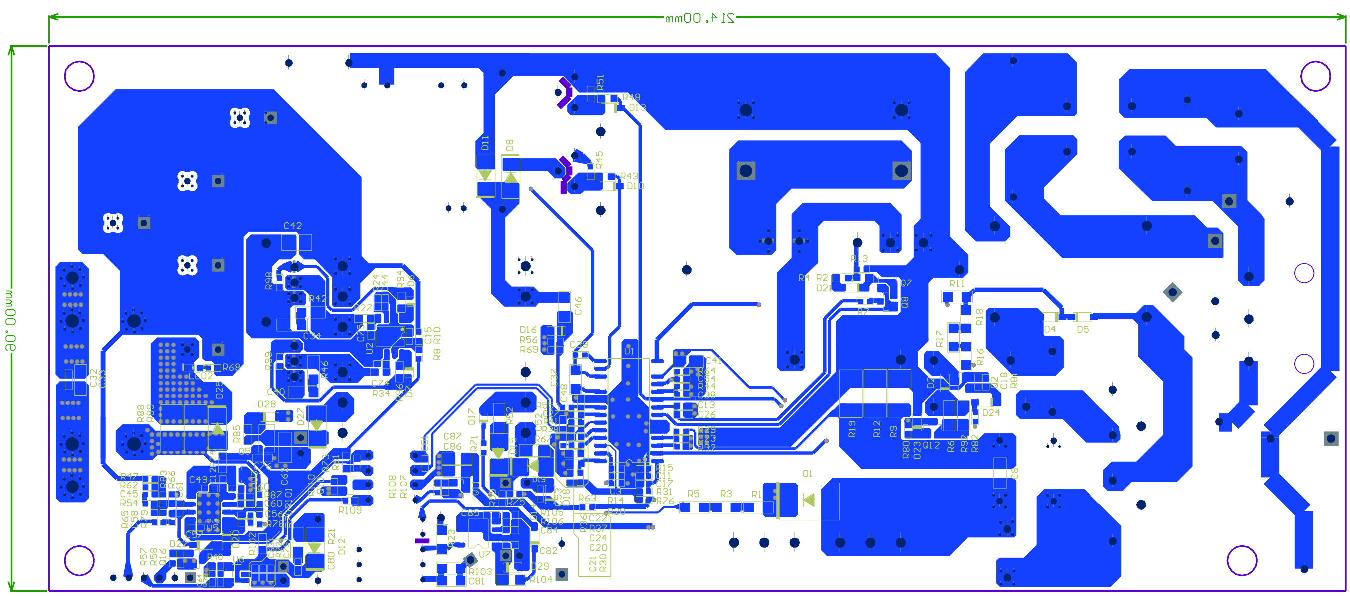


Figure 2: Bottom Layer

SURGE TEST

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

The input voltage was set at 220V$_{AC}$/50Hz. 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 (V$_{AC}$)	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

Figure 3 shows the test with a 220V$_{AC}$ input and full-load in L-line condition.

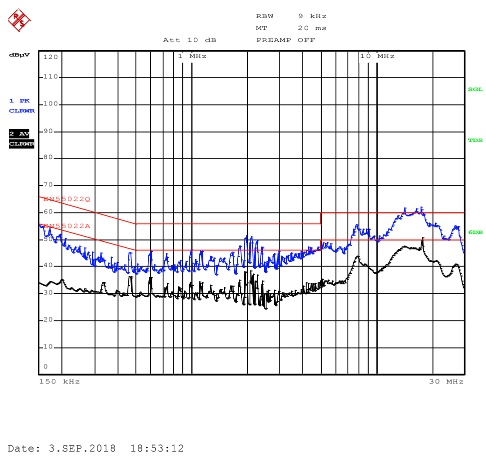


Figure 3: 220V$_{AC}$, 50Hz, Maximum Load, L-line, EN55022 Limits

Figure 4 shows the test with a 220V$_{AC}$ input and full-load in N-line condition.

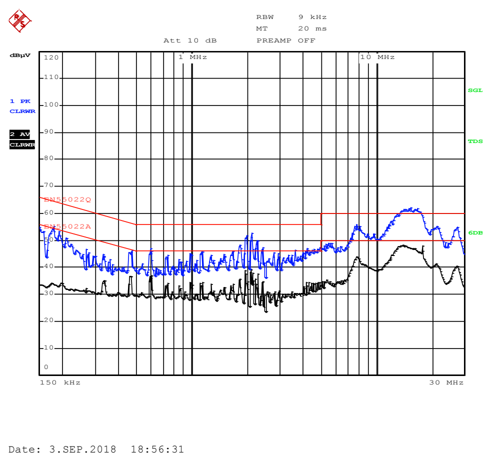
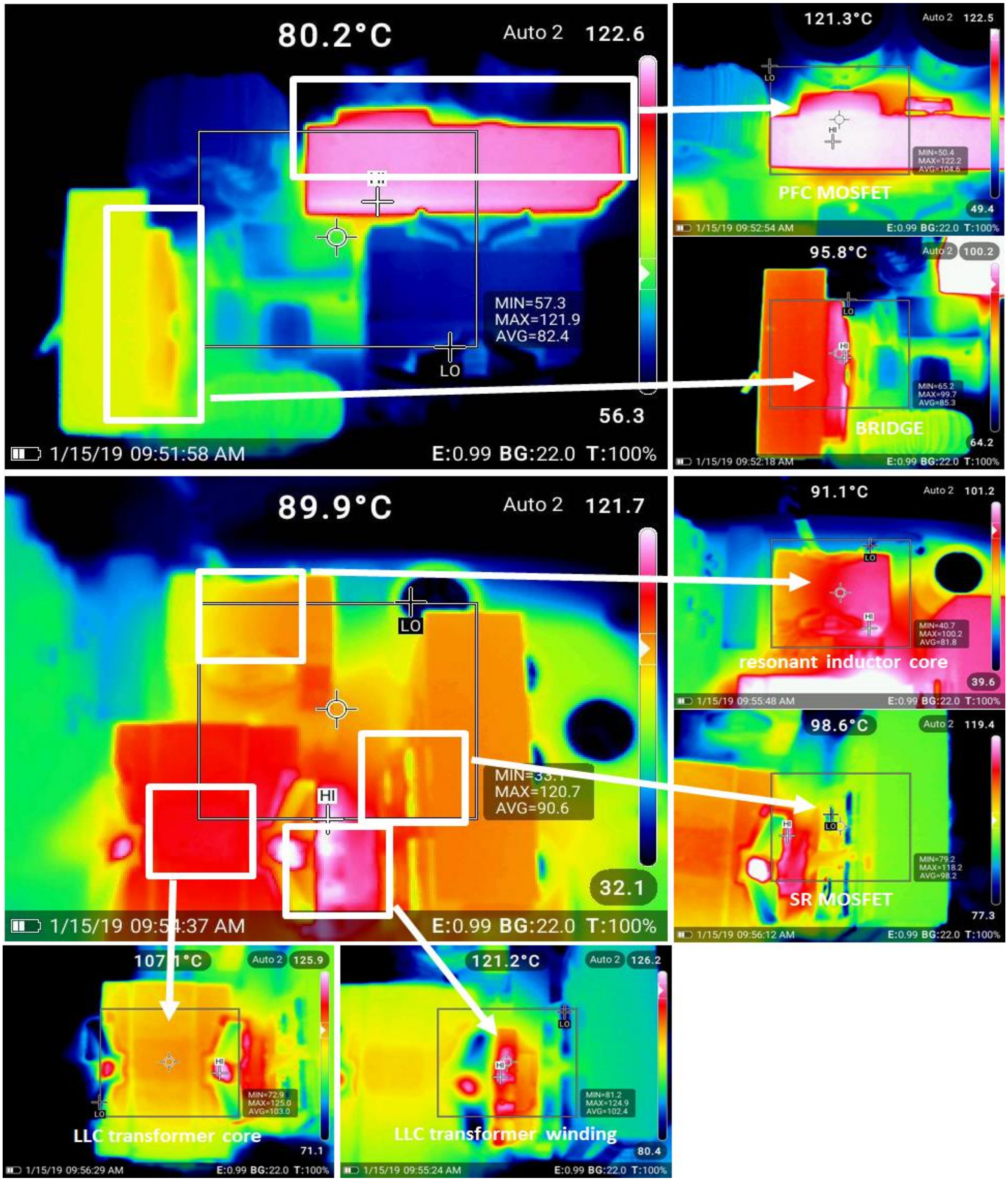


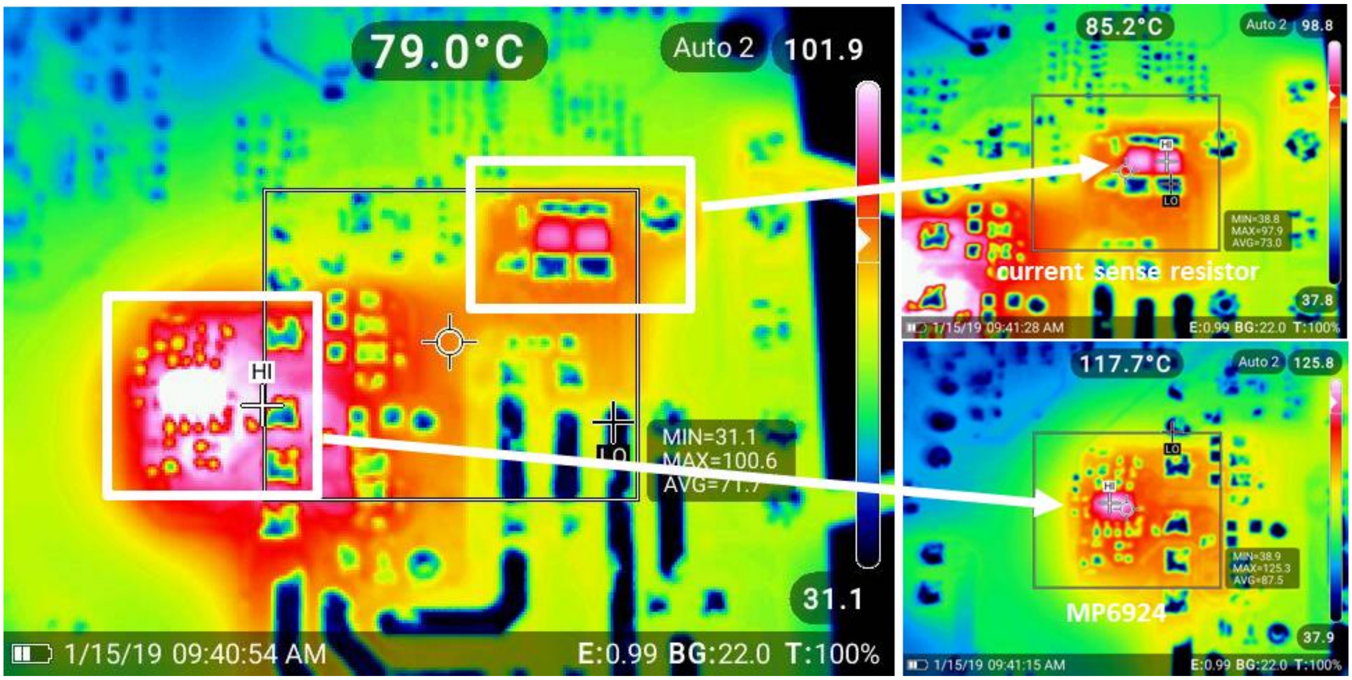
Figure 4: 220V$_{AC}$, 50Hz, Maximum Load, N-line, EN55022 Limits

THERMAL TEST

Figure 5 shows the test with 120V_{AC} input and full-load condition. The PCB layout is with 2oz copper. The ambient temperature is 27°C without air flow.



Top Layer



Bottom Layer

Figure 5: Temperature Chamber Test

QUICK START GUIDE

To quick start the EVB, follow the steps below.

1. Pre-set the power supply to $90V_{AC} \leq V_{IN} \leq 265V_{AC}$.
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 applications, connect the earth terminal to the earth port.
4. Connect the positive (+) load to VOUT.
5. Connect the negative (–) load to GND.
6. Turn the power supply on after making the connections.

CONTACT INFORMATION

To request this evaluation board, please refer to your local sales office:
http://www.monolithicpower.com/Company/Contact-Us

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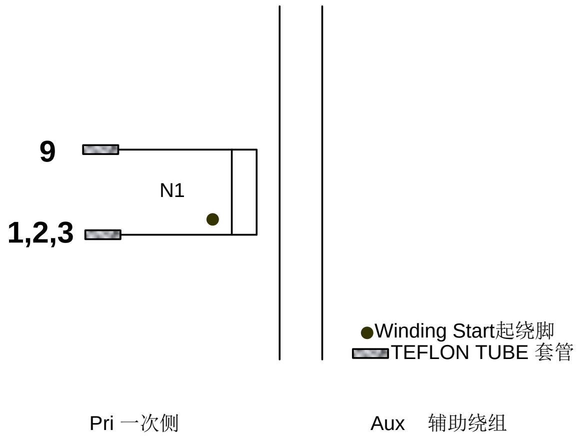
MPS semiconductors are typically used in power supplies in which high voltages are present during operation. High-voltage safety precautions should be observed in design and operation to minimize the chance of injury.

REVISION HISTORY

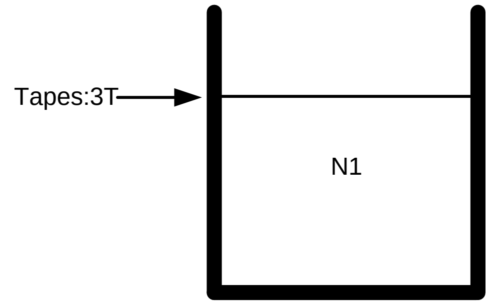
Date	Author	Revision	Description & Changes	Reviewed

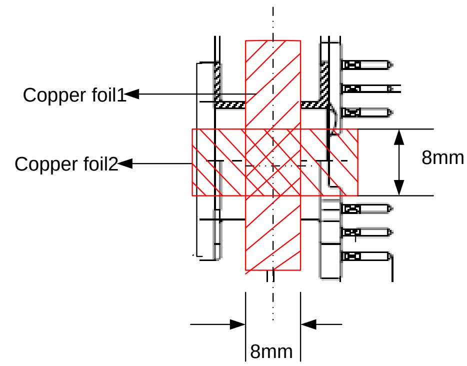
APPENDIX 1: PFC INDUCTOR SPECIFICATION

Electrical Diagram

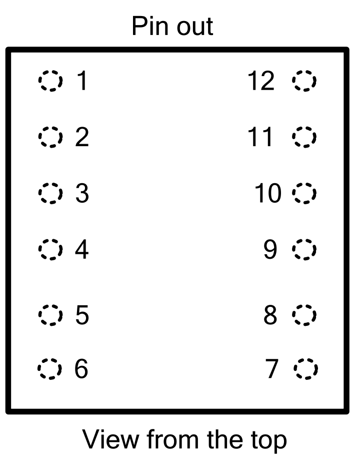


Winding Diagram





Pin Definition of Bobbin



Note: *Core is wrapped with copper foils, as shown above. Connect the foils to pin 12 of the bobbin with wires.*

Table 2: Electrical Characteristic

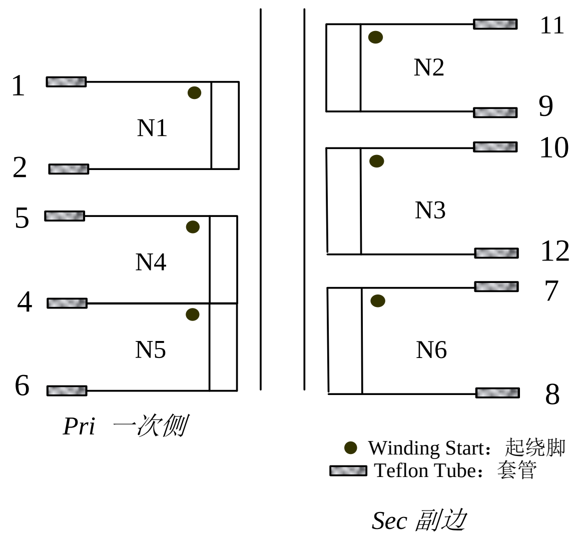
Parameter	Condition	Value
Primary inductance	L (9-1,2,3)	300μH ±10%
Core		PQ3230
Bobbin		PQ3230
Core material		DMR40 or equivalent
Turn ratio	N1	

Table 3: Winding Specification

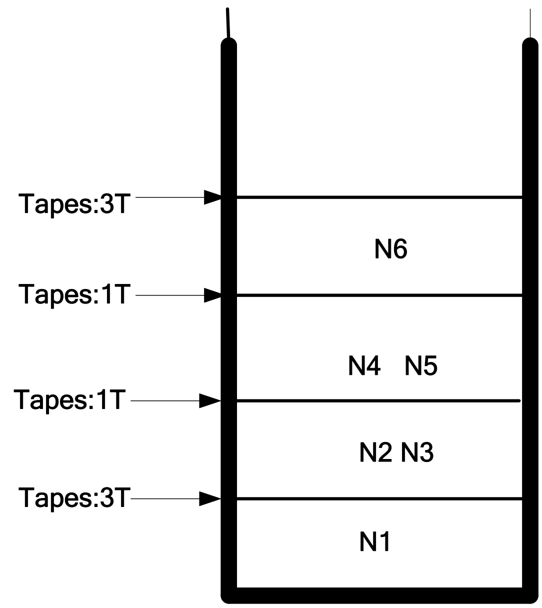
Tape Turns	Winding No.	Margin Tapes	Start and End	Wire Diameter (mm)	Turns
1	N1		9→1,2,3	0.1x100	50

APPENDIX 2: LLC TRANSFORMER SPECIFICATION

Electrical Diagram

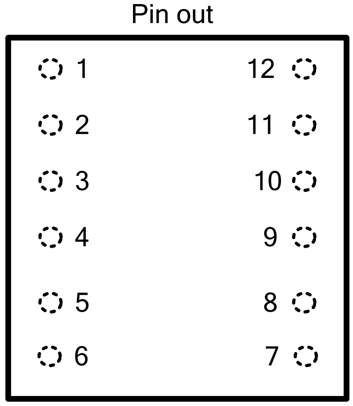


Winding Diagram



Pin Definition of Bobbin

Pin out



View from the top

Table 4: Electrical Characteristic

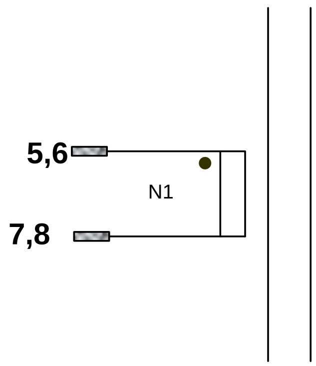
Parameter	Condition	Value
Primary inductance	Lp (1-2)	320uH ±5%
Core		PQ3230
Bobbin		PQ3230
Core material		DMR44 or equivalent
Turn ratio	N1:N2:N3:N4:N5:N6	22:2:2:3:3:2

Table 5: Winding Specification

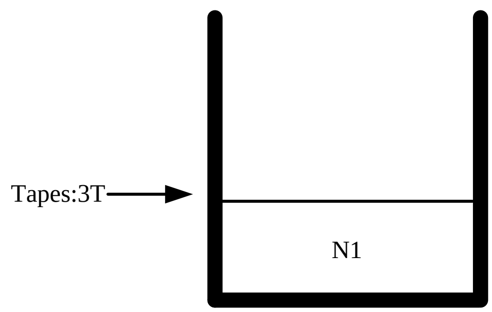
Tape Turns	Winding No.	Margin Tapes	Start and End	Wire Diameter (mm)	Turns
1	N1		1→2	0.1x50	22
3	N2		11→9	Copper foil Thick=0.1mm	2
1	N3		10→12	Copper foil Thick=0.1mm	2
1	N4		5→4	0.2TIW	3
1	N5		4→6	0.2TIW	3
3	N6		7→8	0.2TIW	2

APPENDIX 3: LLC RESONANT INDUCTOR SPECIFICATION

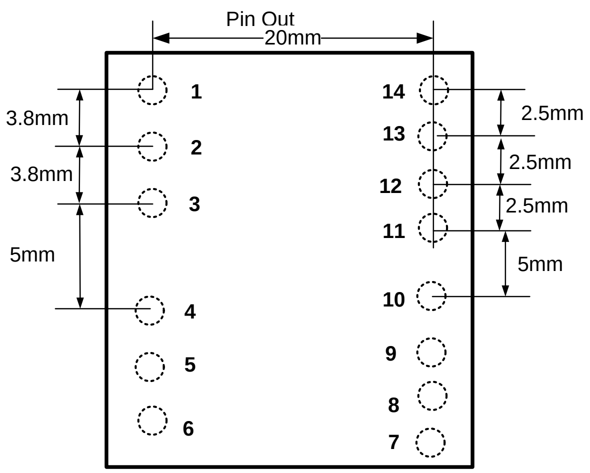
Electrical Diagram



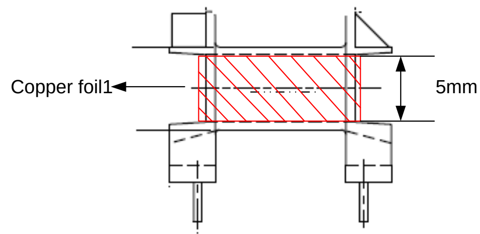
Winding Diagram



Pin Definition of Bobbin



View from the top



Note: ***Core is wrapped with copper foil, as shown above. Connect the foils to pin 3 of the bobbin with wires.***

Table 6: Electrical Characteristic

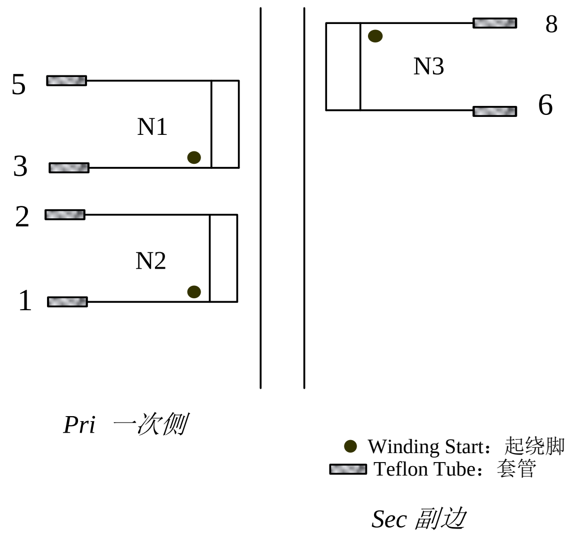
Parameter	Condition	Value
Primary inductance	L (5,6-7,8)	54μH ±5%
Core		PQ2020
Bobbin		PQ2020
Core material		DMR40 or equivalent
Turn ratio	N1	22

Table 7: Winding Specification

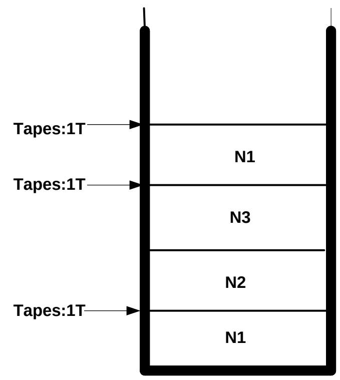
Tape Turns	Winding No.	Margin Tapes	Start and End	Wire Diameter (mm)	Turns
3	N1		5,6→7,8	0.1x50	22

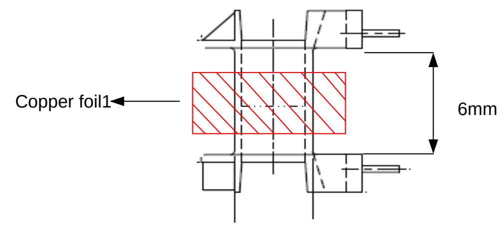
APPENDIX 4: FLYBACK TRANSFORMER SPECIFICATION

Electrical Diagram

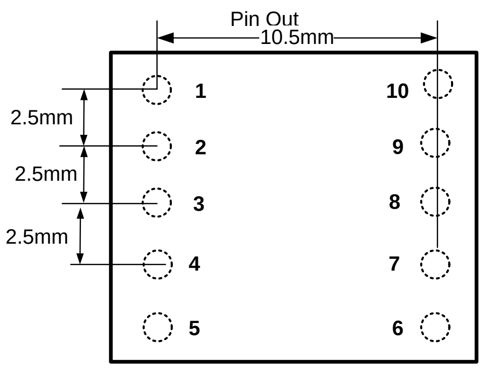


Winding Diagram





Pin Definition of Bobbin



View from the top

Note: ***Core is wrapped with copper foil, as shown above. Connect the foils to pin 2 of the bobbin with wires.***

Table 6: Electrical Characteristic

Parameter	Condition	Value
Primary inductance	L (3-5)	778μH ±5%
Core		EPC13
Bobbin		EPC13
Core material		DMR40 or equivalent
Turn ratio	N1:N2:N3	95:30:14

Table 7: Winding Specification

Tape Turns	Winding No.	Margin Tapes	Start and End	Wire Diameter (mm)	Turns
1	N1		3→5	0.1	95
0	N2		1→2	0.2TIW	30
1	N3		8→6	0.2TIW	14