

240 W USB PD3.1 Solution

TND6412/D

SPECIFICATION

onsemi's Devices	Applications	Input Voltage	Output Power	Topology	I/O Isolation
NCP1680 NCP13994 2*NCP51530BMNTWG 2*NCP4306DAHZZAA FAN65004C 4*NCP58921 2*NTMT064N65 2*FDMS4D0N12C	PD3.1 adapter for computer and smart phone, Industrial and lighting power supply, other applications	90 Vac to 264 Vac	240 W	TPPFC + LLC + DC-DC	Isolated

Output Specification	
Output Voltage	5 V, 9 V, 12 V, 15 V, 20 V, 28 V, 36 V, 48 V
Max Current	5 A
Min Current	zero

Efficiency	95.2% & 96.2% @ 115 Vac & 230 Vac and 48V 5A
Protection	OVP, OCP, SCP, OTP
PCBA Size	98 mm × 62 mm × 21.5 mm

Circuit Description

This reference design describes a 240 W PD3.1 solution using NCP1680, NCP13994, NCP4306 and FAN65004, three stages structure power supply for PD3.1 smart phone super charger, NB adaptor and general power supply supporting 240 W with high efficiency and compact profile if removing DC-DC daughter card.

The featured PFC solution uses NCP1680 totem pole PFC controller with CRM and VSFF control, HF current mode LLC controller and syn. controller NCP4306 are used for DC-DC converter for fixed 52 V output, FAN65004 is used for variable output from 5 V to 48 V to meet PD3.1 specification. 2 SJ FET are used for PFC slow leg SW and 4 iGaN NCP58921 are used for PFC fast leg SW and LLC SW.

This reference design provides the complete circuit schematic details, PCB layout, EVM photo, inductor, transformer specification and BOM for 240 W PD3.1 solution, also some key waveforms for reference.

A dual layer PCB is designed for a demonstration although totem pole PFC has more component and complex replacement, also consider easy to test, less daughter card is used, DC-DC daughter is also easy to be replaced by new design with PD3.1 protocol controller.

LLC controller has a high startup current source and PFC controller has a low operation current, so LLC startup current source should supply PFC and LLC Vcc during startup, PFC controller has a low Vcc_on threshold so PFC will start first then LLC Vcc continues to rise to Vcc_on threshold, PFC has completed startup and PFCOK signal has a high level output while Vcc reaches Vcc_on, a capacitor with large capacitance is used for LLC Vcc to maintain enough voltage to ensure PFC operation until LLC operation then LLC's auxiliary winding supplies all Vcc voltage.

Another special design is between PFCOK pin of PFC and VBULK pin of LLC, this is a bidirectional signal that PFCOK is as LLC's brown out control and VBULK pin provides negative pulse to PFC for forced standby while LLC is in skip mode.

No 48 V PD3.1 controller in current market so 3 DIP switch combination are decoded to control DC-DC converter's feedback divider to simulate PD3.1 output voltage up to 48 V.

TND6412/D

Key Features

- AC Input from 90 V to 264 V
- TPPFC + LLC + DC-DC Topology
- High Frequency Operation with iGaN
- Skip Operation for PFC and LLC at Light Load and PFM Mode for DC-DC Converter
- External Discrete Circuit to Simulate PD3.1 Multi-output
- Output Voltage and Current 5 V, 9 V, 12 V, 15 V, 20 V, 28 V, 36 V, 48 V and 5 A
- Max Output Power: 240 W
- Simulate PD3.1 to Support up to 48 V
- Ripple & Noise: <100 mV
- AVG Efficiency: 94.5% & 95.2% at 115 Vac & 230 Vac and 48 V
- Full Load Efficiency: 95.2% & 96.2% at 115 Vac & 230 Vac and 48 V 5 A
- Output Precise OVP
- Output OCP, SCP
- Open Loop Protection
- 2 layers PCB Used and Small Size with Compact Design
- PCBA size: 98 mm × 62 mm × 21.5 mm
- Power Density: 30 W/in³

BOARD PHOTOS

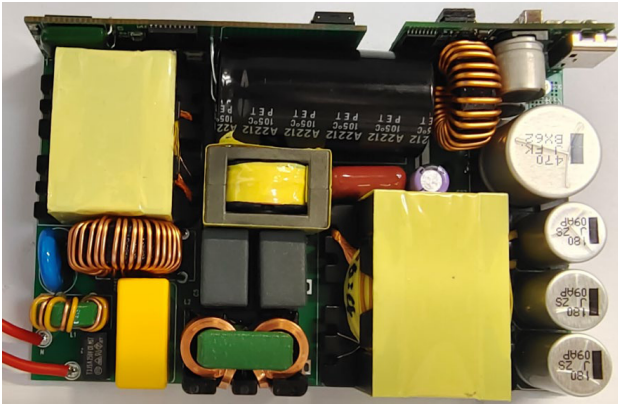


Figure 1. The Front View of 240 W EVM

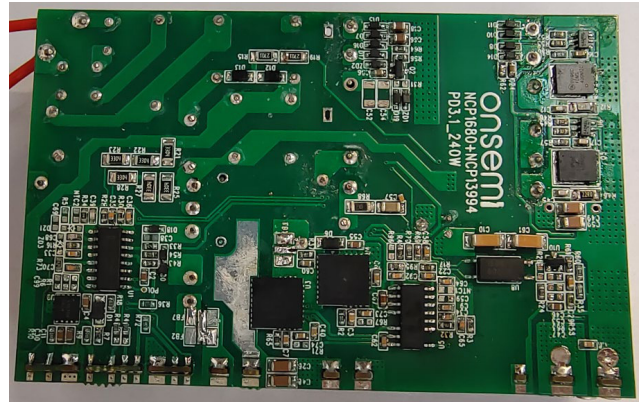


Figure 2. Reverse Side of 240 W EVM

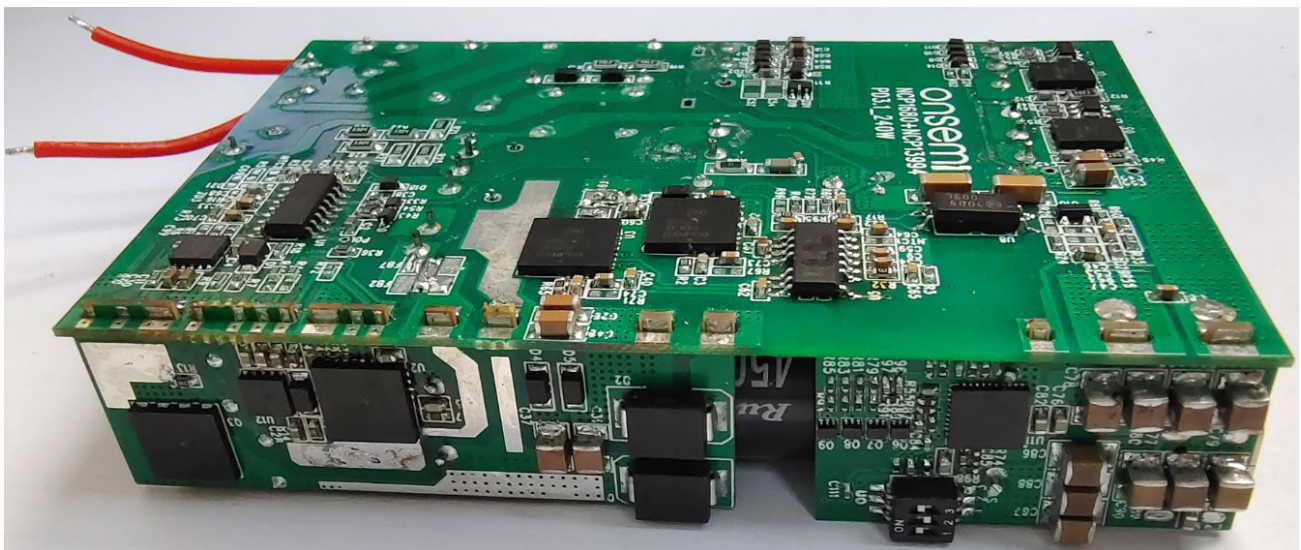


Figure 3. Profile of 240 W EVM

TND6412/D

CIRCUIT SCHEMATIC

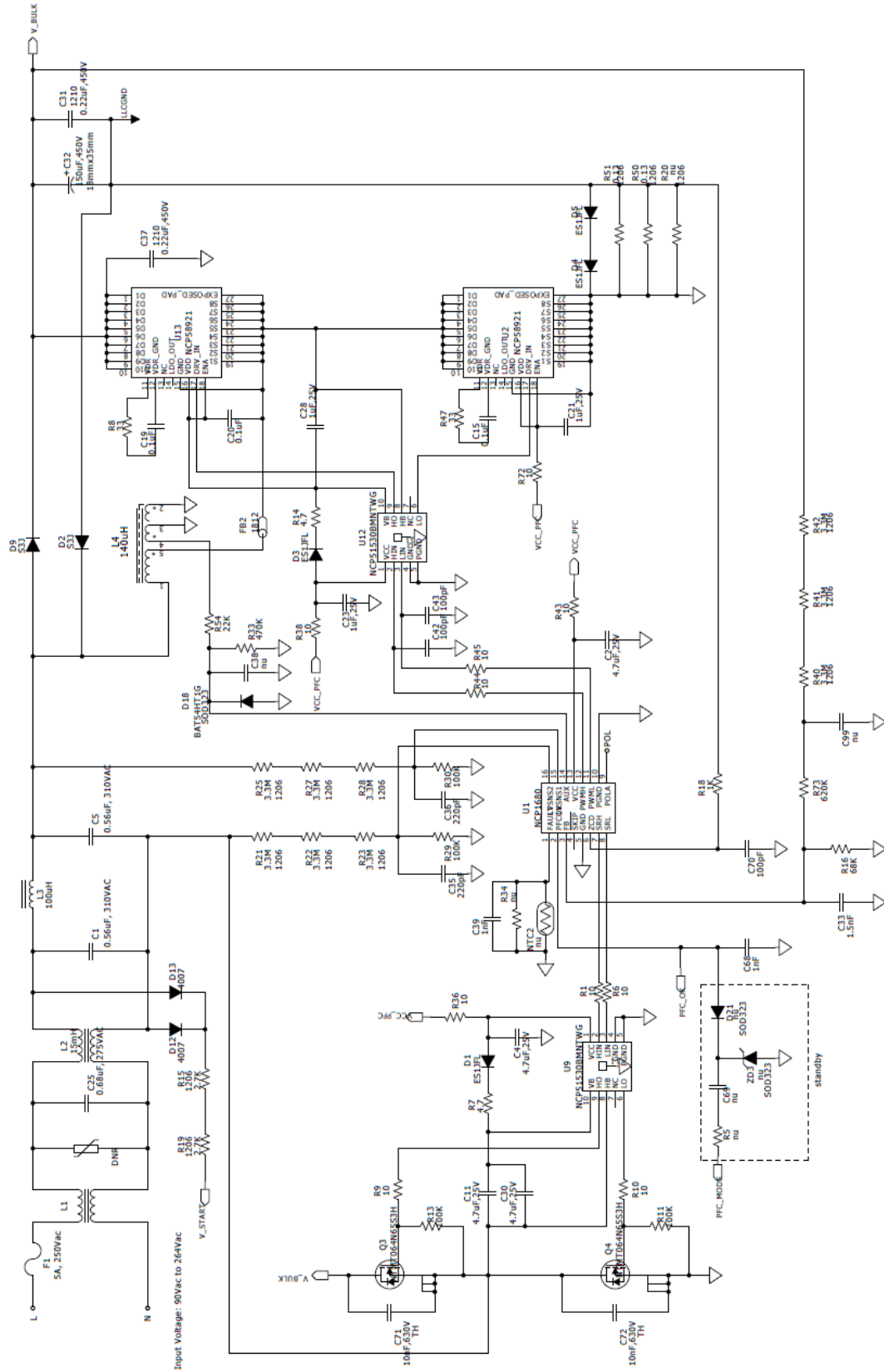


Figure 4. Schematic for TTPFC Portion

TND6412/D

CIRCUIT SCHEMATIC (LLC PORTION)

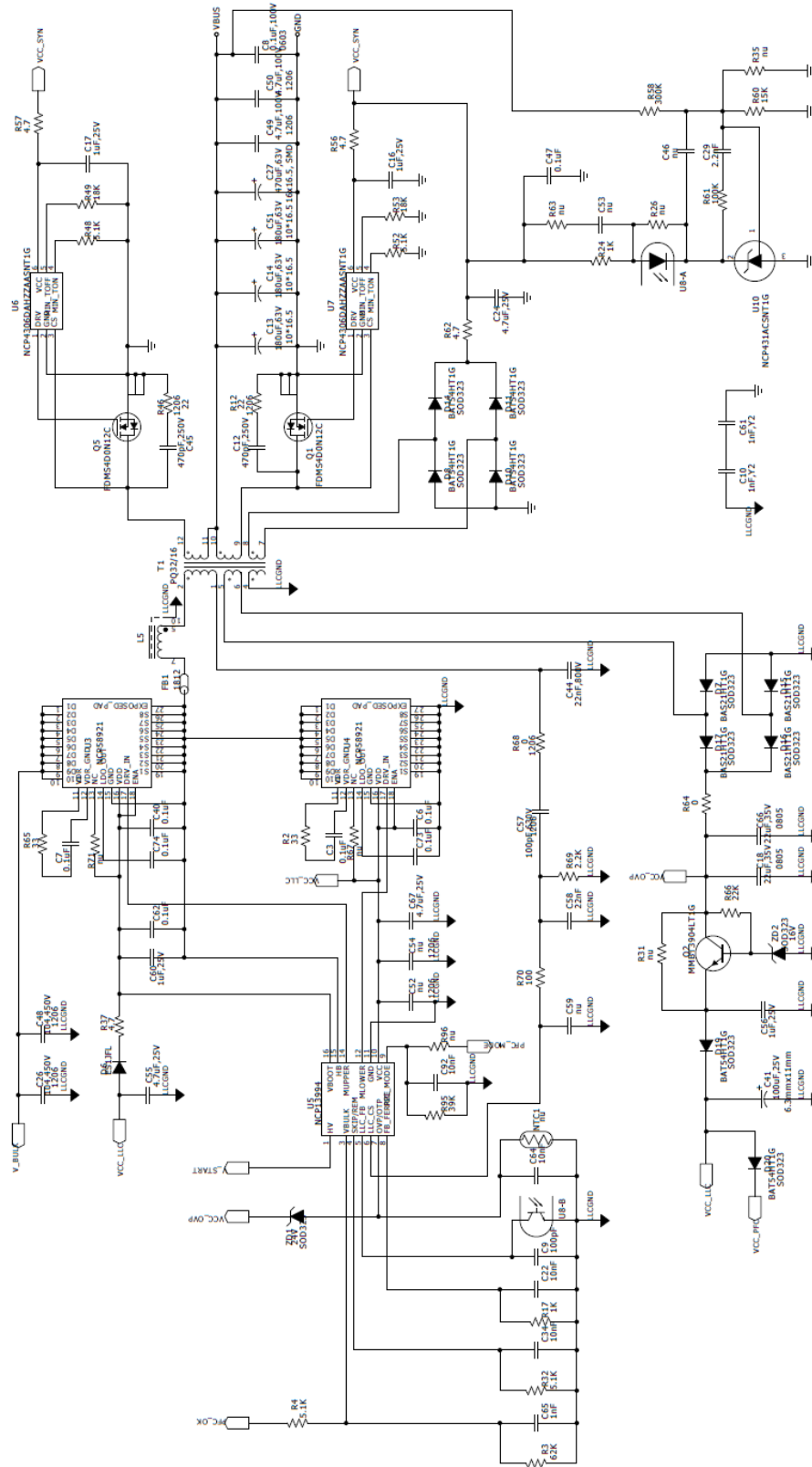


Figure 5. Schematic for LLC Portion

TND6412/D

CIRCUIT SCHEMATIC (DC-DC PORTION)

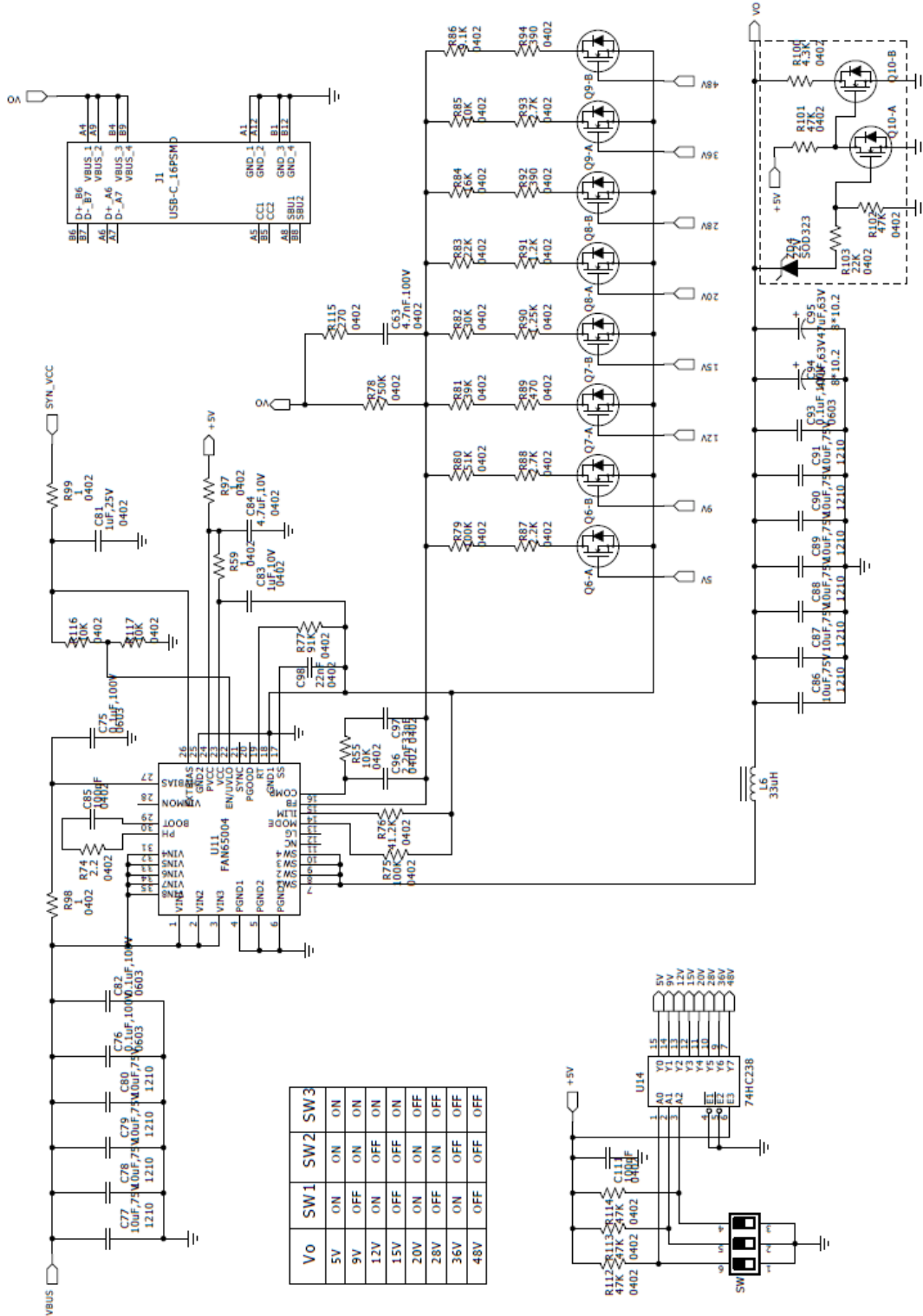


Figure 6. Schematic for DC-DC Converter

TND6412/D

PCB LAYOUT

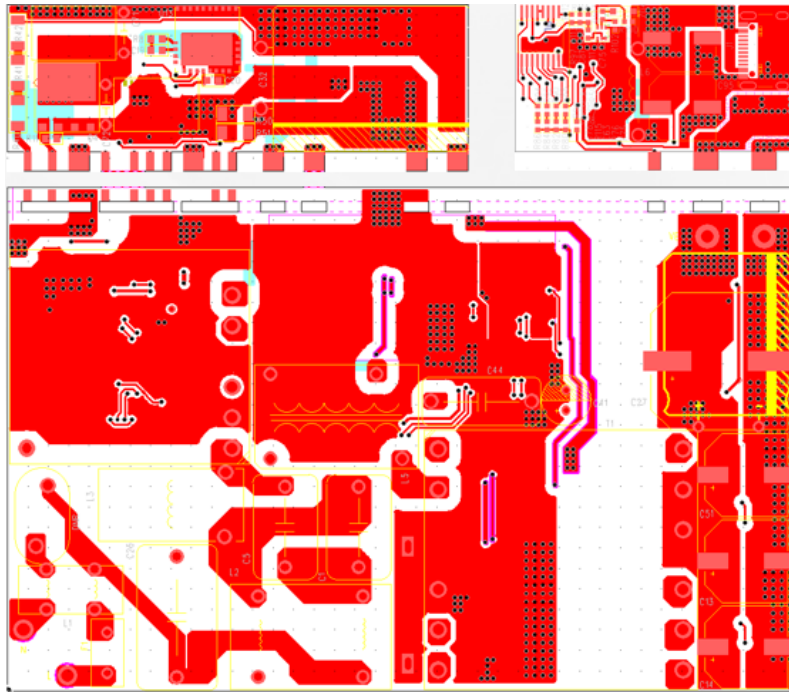


Figure 7. Top View

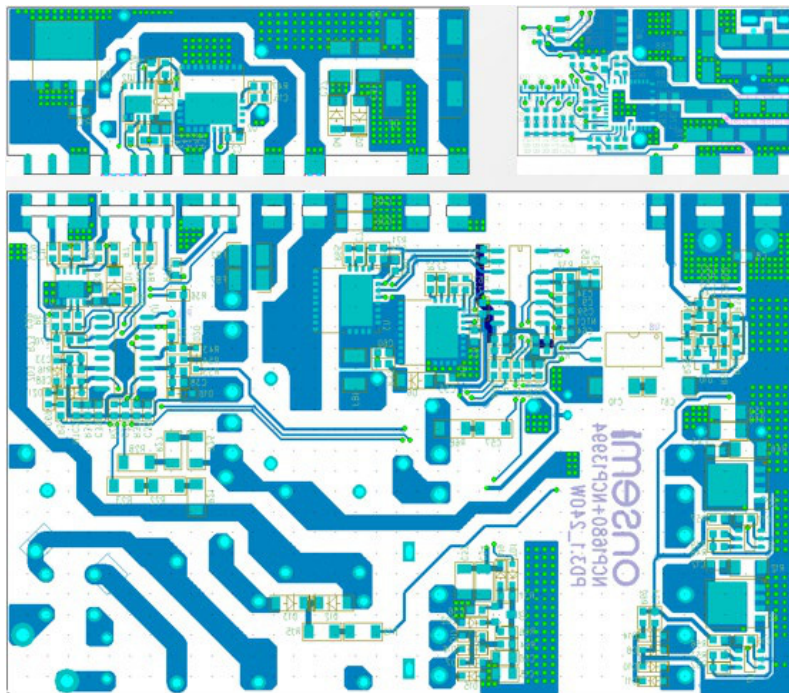
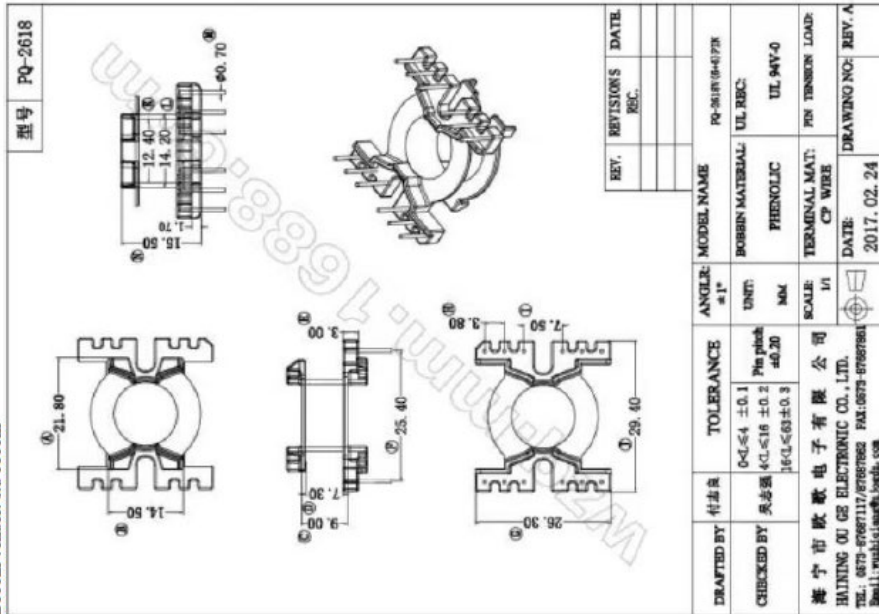


Figure 8. Bottom View

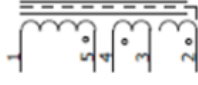
PFC INDUCTOR DESIGNS

1. Core and Bobbin

Core Type: PQ2618
 Core material: 3C95(Ferroxcube)
 Bobbin: 12Pin
 Bobbin vendor: std bobbin



2. Electrical diagram



WD1=Primary, 30T, 50*0.1mm Litz

WD2=Auxiliary, 3T, 0.17mm

WD3=Shielding, 3T, 0.17mm

3. Electrical specification

Electrical Strength	Don't test
Primary Inductance	Pin3 1-5, all other windings open, measured at 10 kHz, 1V 140uH \pm 10%

4. Transformer building construction diagram

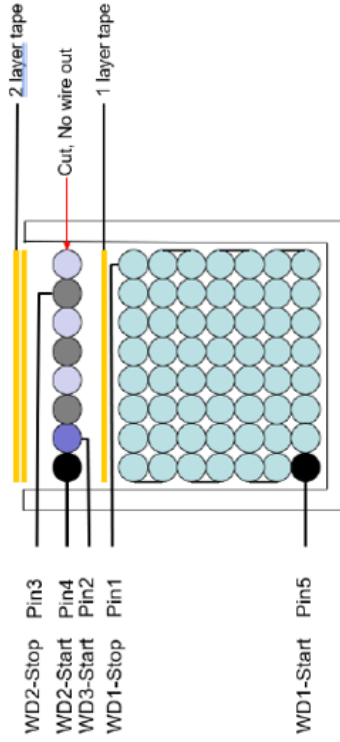


Figure 9. PFC Inductor Designs

LLC RESONANT INDUCTOR DESIGNS

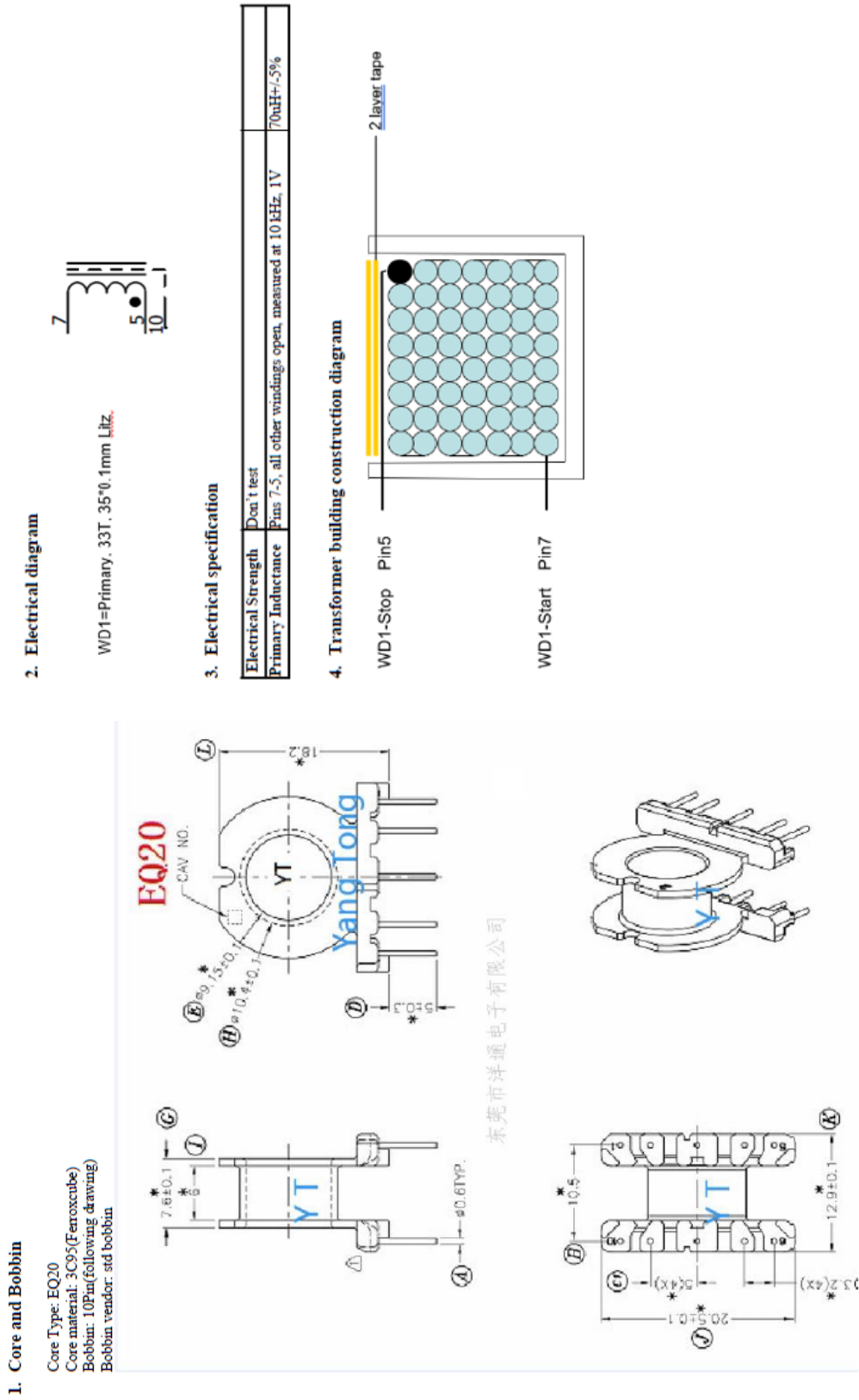
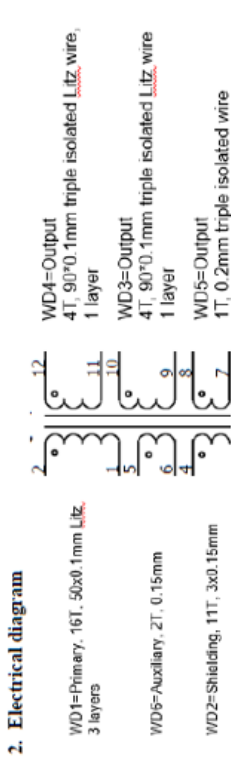


Figure 10. LLC Resonant Inductor Designs

LLC TRANSFORMER DESIGNS



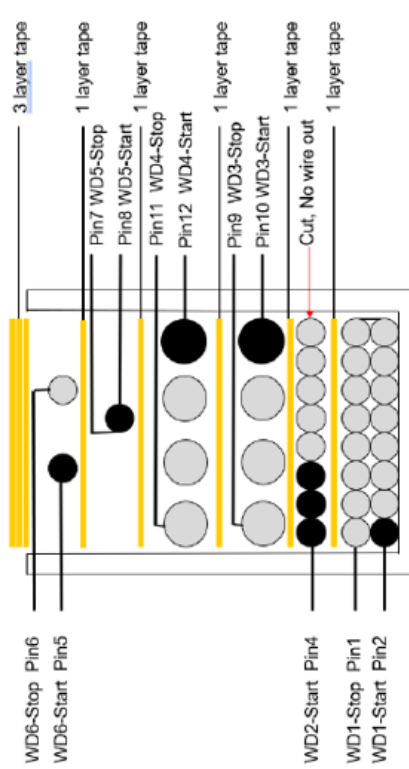
2. Electrical diagram

- WD1=Primary, 16T, 50x0.1mm Litz, 3 layers
- WD2=Shielding, 11T, 3x0.15mm
- WD3=Output, 4T, 90°0.1mm triple isolated Litz wire, 1 layer
- WD4=Output, 4T, 90°0.1mm triple isolated Litz wire, 1 layer
- WD5=Output, 1T, 0.2mm triple isolated wire
- WD6=Auxiliary, 2T, 0.15mm
- WD7=Shielding, 11T, 3x0.15mm

3. Electrical specification

Electrical Strength	Pin1, 2, 4, 5, 6 to Pin7-12	5000V
Primary Inductance	Pins 1-2, all other windings open, measured at 10kHz, 1V	430nH±-5%

4. Transformer building construction diagram

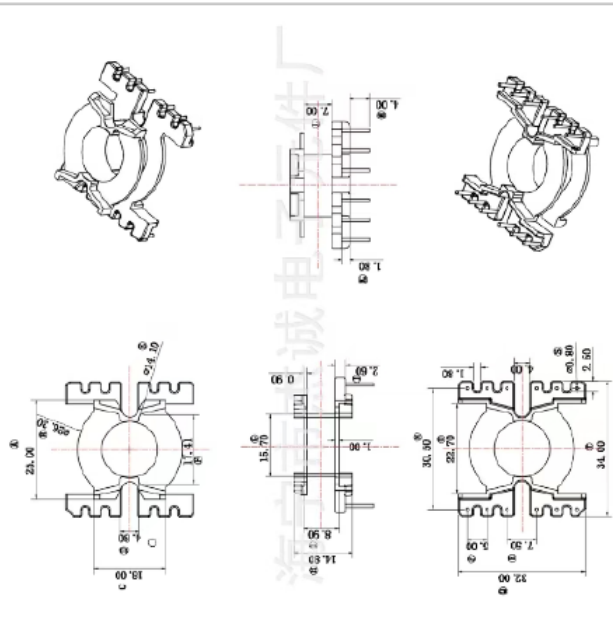


1. Core and Bobbin

Core Type: PQ3218
Core material: Ferroxcube 3C95
Bobbin: PQ3216, 12Pin
Bobbin vendor: std bobbin

JC 海宁市杰诚科技有限公司
HAINING JIECHENG TECHNOLOGY CO., LTD.
TEL: 0573-87539898 FAX: 0573-87536999

型 号
JC-PQ3205



DESIGNING BY:	YANXIAOCHENG	TOLERANCES	PG.54 ±0.1 PG.55 ±0.1 PG.56 ±0.1 PG.57 ±0.1	UNIT:	mm	ANGLE:	UL: 90° DL: 90°-C
CHECKER BY:	SUNYONGXUE	PER PITCH	±0.2	SCALP:		REVISION:	REV: J0
DATE:	2020.08.20						

Figure 11. LLC Transformer Designs

TND6412/D

AVG. Efficiency and 10% Load Efficiency

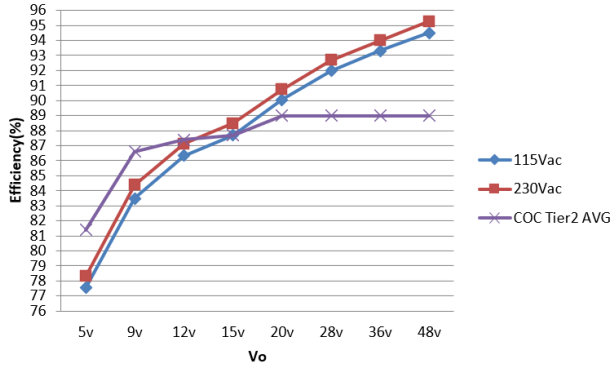


Figure 12. Avg. Efficiency

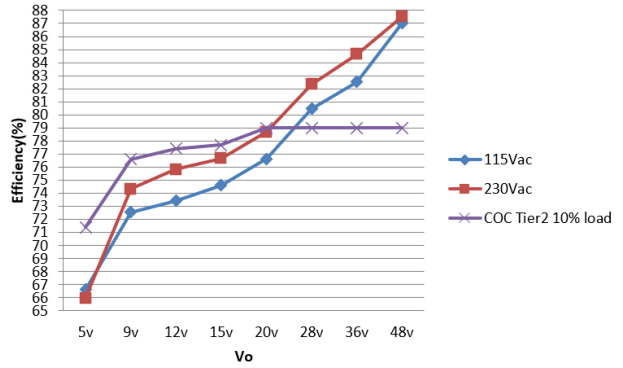


Figure 13. 10% Load Efficiency

Standby Power and PF

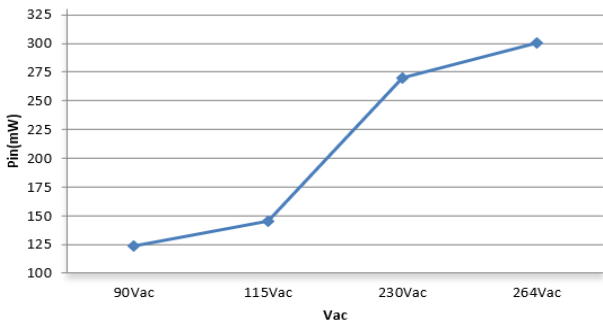


Figure 14. Standby Power

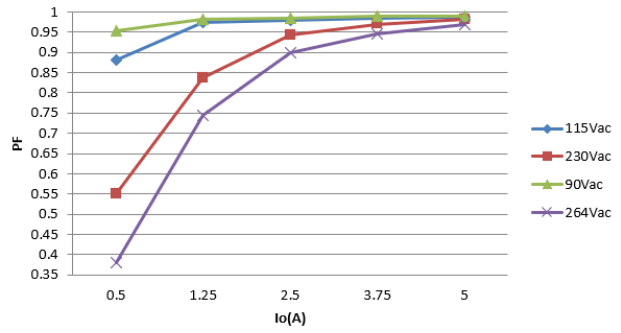


Figure 15. PF

Efficiency vs. Load

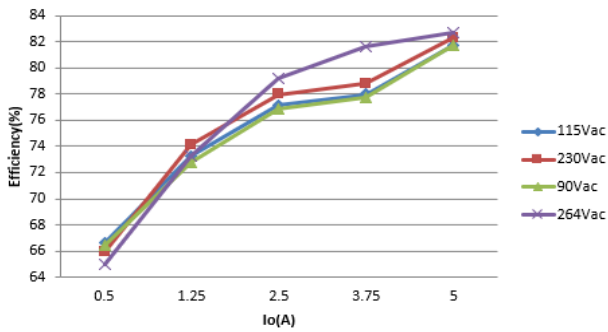


Figure 16. 5 V

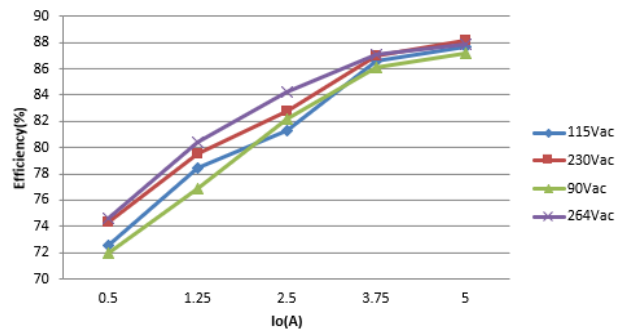


Figure 17. 9 V

TND6412/D

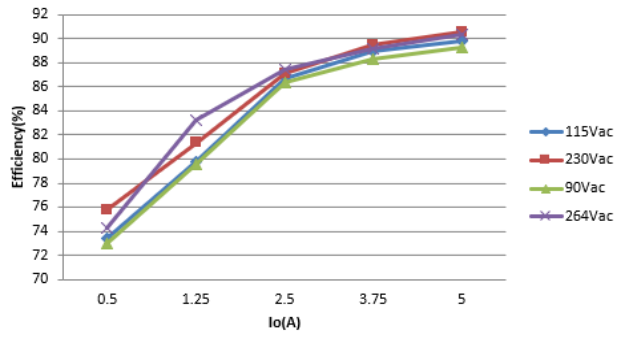


Figure 18. 12 V

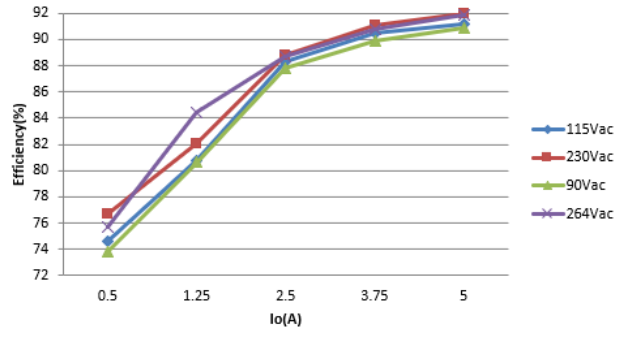


Figure 19. 15 V

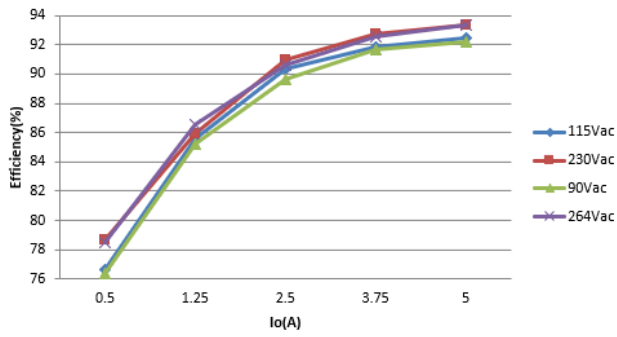


Figure 20. 20 V

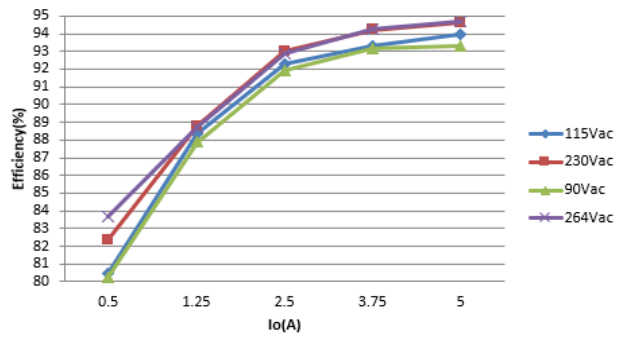


Figure 21. 28 V

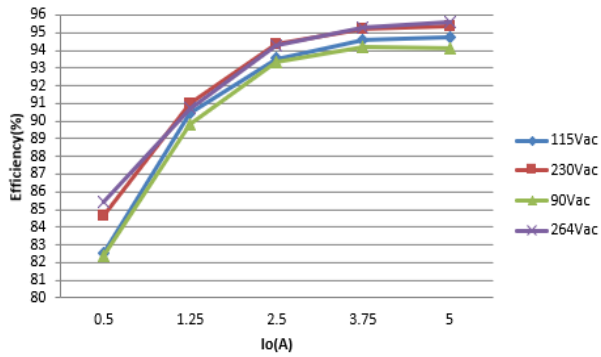


Figure 22. 36 V

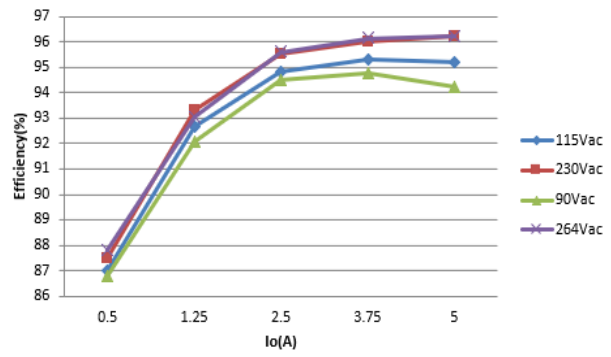


Figure 23. 48 V

PFC Waveform at 90 Vac and Full Load

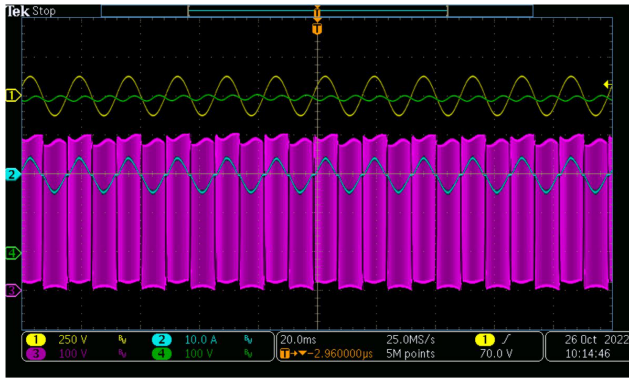


Figure 24. 90 Vac and Full Load (ch1-Vin, ch2-Iin, ch3-fast leg SW, ch4-Vbulk)

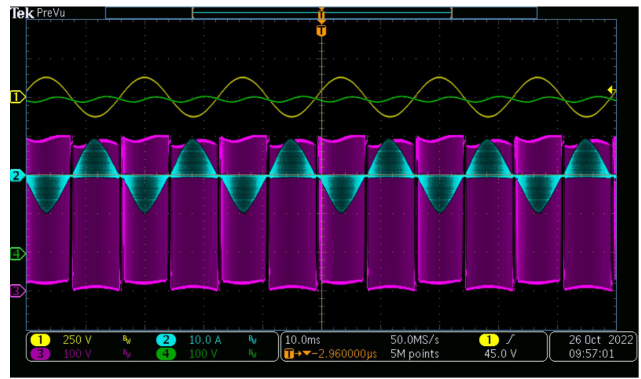


Figure 25. 90 Vac and Full Load (ch1-Vin, ch2-IL, ch3-fast leg SW, ch4-Vbulk)

Load Transition

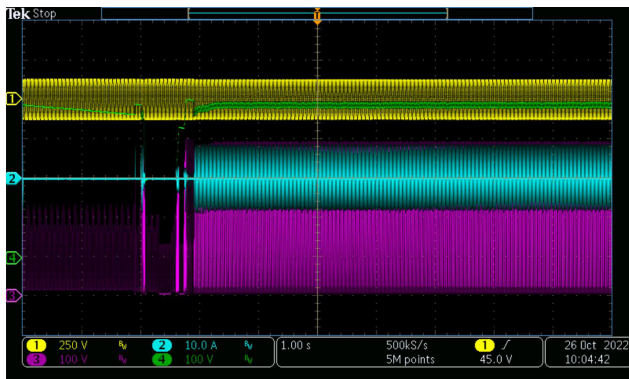


Figure 26. 0 to Full Load Transition at 90 Vac (ch1-Vin, ch2-IL, ch3-fast leg SW, ch4-Vbulk)

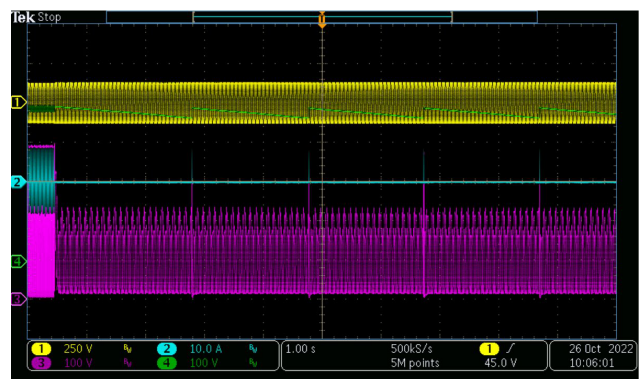


Figure 27. Full Load to 0 Transition at 90 Vac (ch1-Vin, ch2-IL, ch3-fast leg SW, ch4-Vbulk)

Line Transition

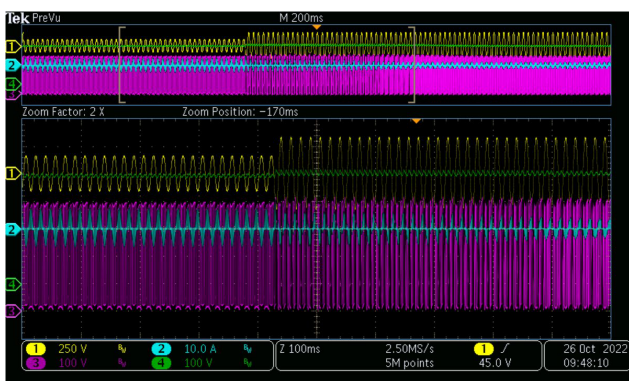


Figure 28. 115 Vac to 230 Vac Transition at Full Load (ch1-Vin, ch2-IL, ch3-fast leg SW, ch4-Vbulk)

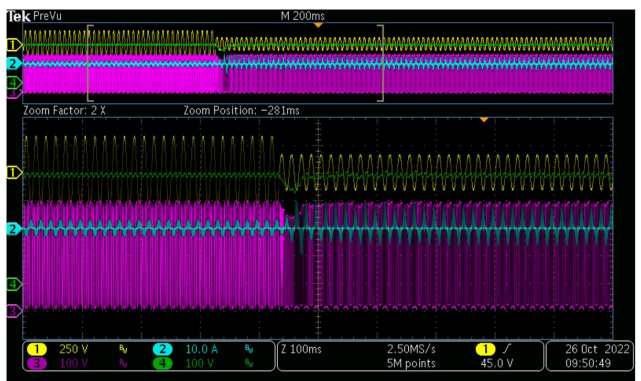


Figure 29. 230 Vac to 115 Vac Transition at Full Load (ch1-Vin, ch2-IL, ch3-fast leg SW, ch4-Vbulk)

LLC Start and Operation Waveform

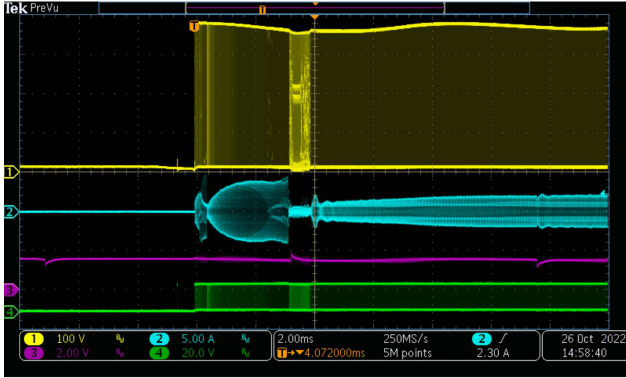


Figure 30. Power on at 115 Vac and 48 V & 5 A (ch1-Vsw, ch2-*I*_p, ch3-Vbulk pin, ch4-Vmlower)

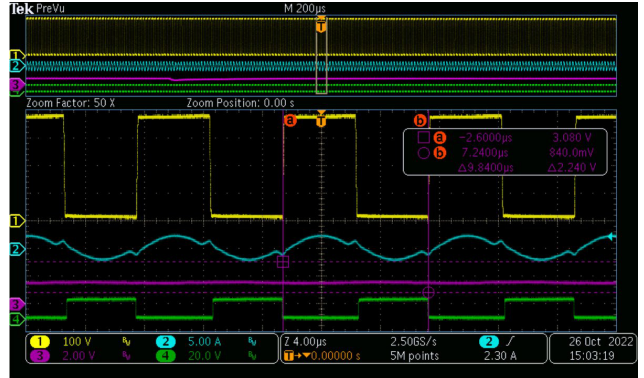


Figure 31. Stable Operation at 115 Vac and 48 V & 5 A (ch1-Vsw, ch2-*I*_p, ch3-Vbulk pin, ch4-Vmlower)

Hold Time and Secondary Stress

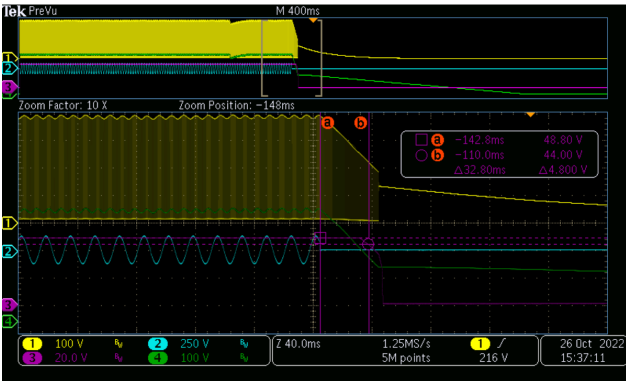


Figure 32. Hold Time During Power Off at 90 Vac and 48 V & 5 A (ch1-Vsw, ch2-Vin, ch3-Vo, ch4-Vbulk)

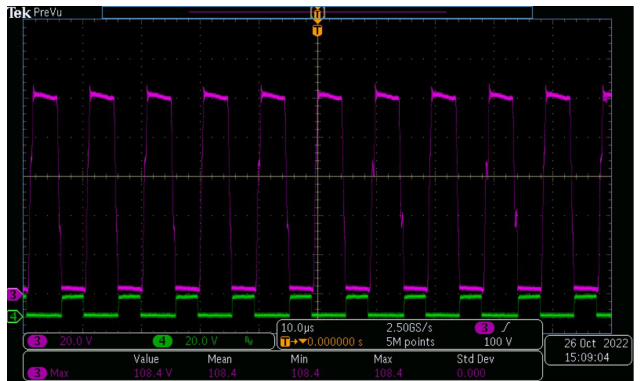


Figure 33. Secondary Stress at 48 V & 5 A (ch3-Vds-sec, ch4-Vsyn-drv)

LLC Operation Waveform at Skip Mode

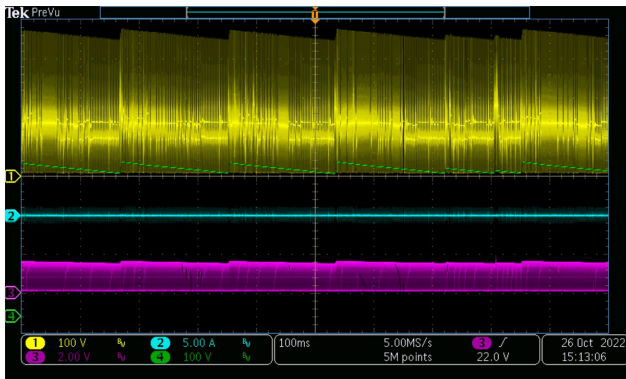


Figure 34. Waveform at 48 V & 0 A (ch1-Vsw, ch2-*I*_p, ch3-Vbulk pin, ch4-Vbulk)

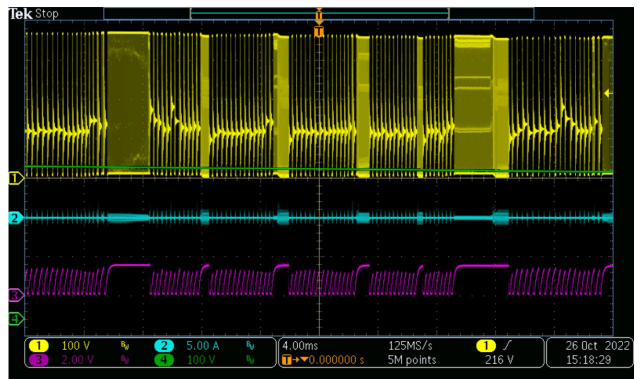


Figure 35. Waveform at 48 V & 0.2 A (ch1-Vsw, ch2-*I*_p, ch3-Vbulk pin, ch4-Vbulk)

Startup Timing at No Load and Full Load

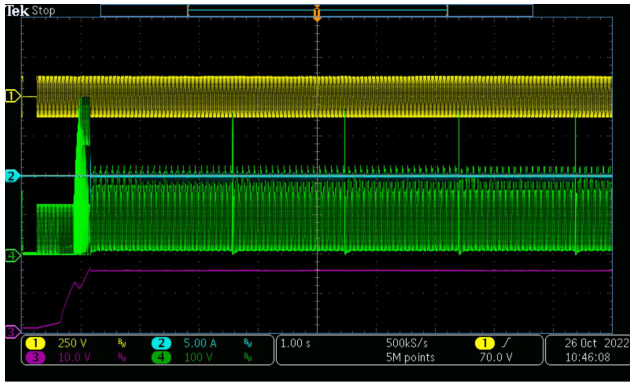


Figure 36. Wavefore at 48 V & 0 A
(ch1-Vin,ch2-lp-llc,ch3-Vcc-llc, ch4-Vfast leg sw)

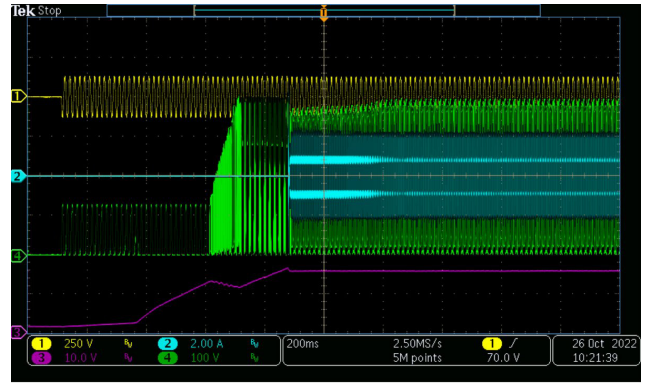


Figure 37. Wavefore at 48 V & 5 A
(ch1-Vin,ch2-lp-llc,ch3-Vcc-llc, ch4-Vfast leg sw)

Load Dynamic Response at 5 V



Figure 38. 5 V & 0 A to 0.5 A, 10 ms Cycle, 0.25 A/ μ s
(ch2-lo, ch4-Vo)

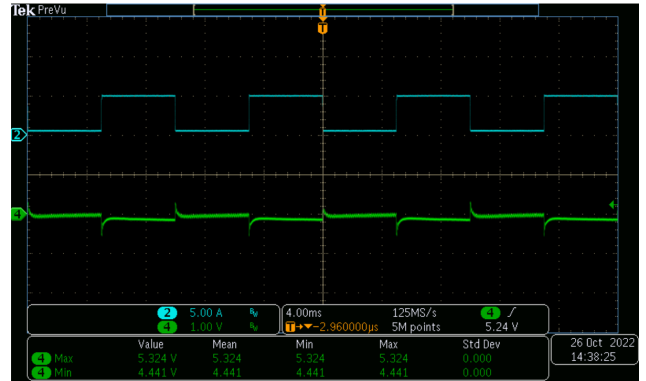


Figure 39. 5 V & 0.5 A to 5 A, 10 ms Cycle, 0.25 A/ μ s
(ch2-lo, ch4-Vo)

Load Dynamic Response at 48 V

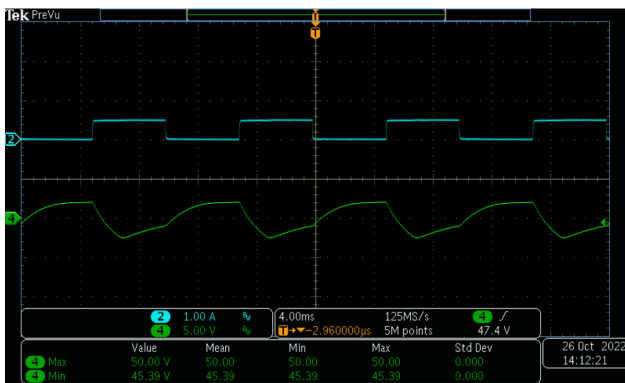


Figure 40. 48 V & 0 A to 0.5 A, 10 ms Cycle, 0.25 A/ μ s
(ch2-lo, ch4-Vo)

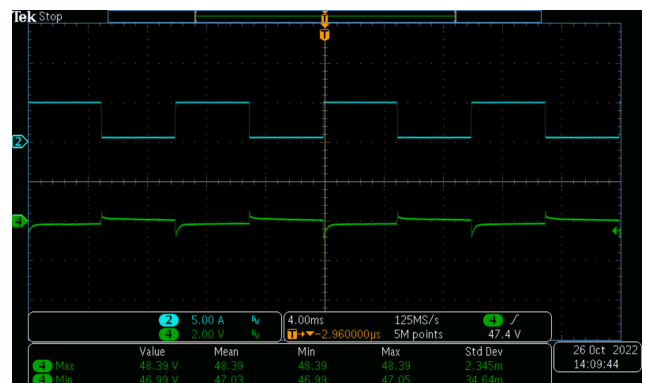


Figure 41. 48 V & 0.5 A to 5 A, 10 ms Cycle, 0.25 A/ μ s
(ch2-lo, ch4-Vo)

DC-DC OCP Waveform

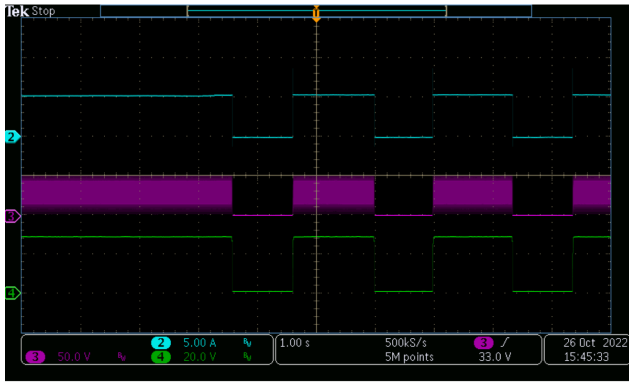


Figure 42. OCP at 52 V Input and 48 V 5.5 A Output (ch2-Io, ch3-Vsw, ch4-Vo)

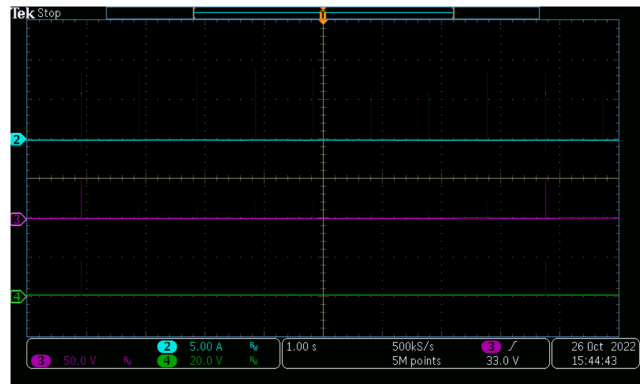


Figure 43. OCP at 52 V Input and 48 V 6 A Output (ch2-Io, ch3-Vsw, ch4-Vo)

Thermal Camera Image (Tested after 15 min Operation)



Figure 44. 90 Vac & 48 V 5 A, Front Side

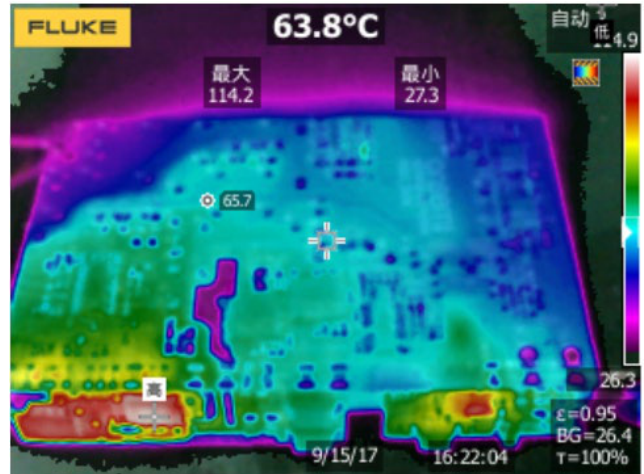


Figure 45. 90 Vac & 48 V 5 A, Reverse Side

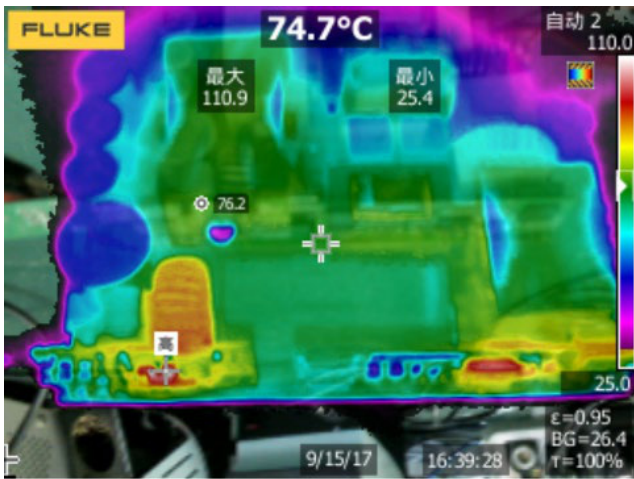


Figure 46. 115 Vac & 48 V 5 A, Front Side

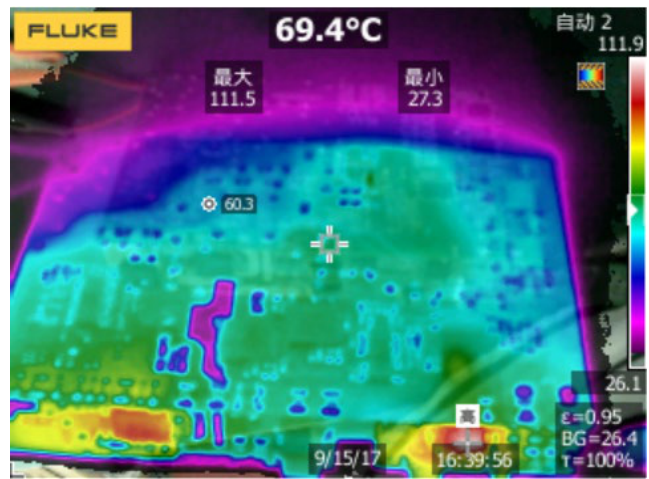


Figure 47. 115 Vac & 48 V 5 A, Reverse Side

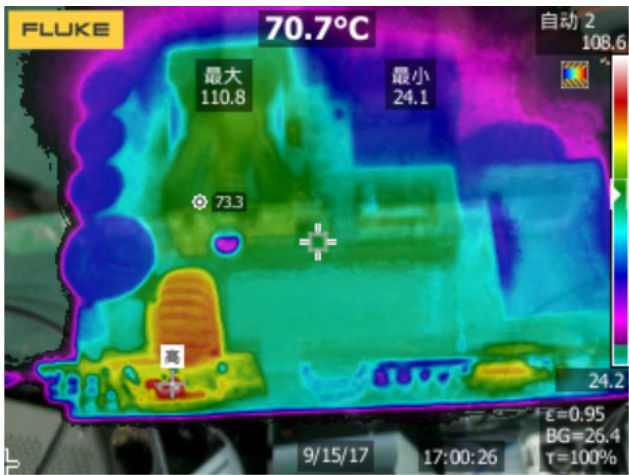


Figure 48. 230 Vac & 48 V 5 A, Front Side

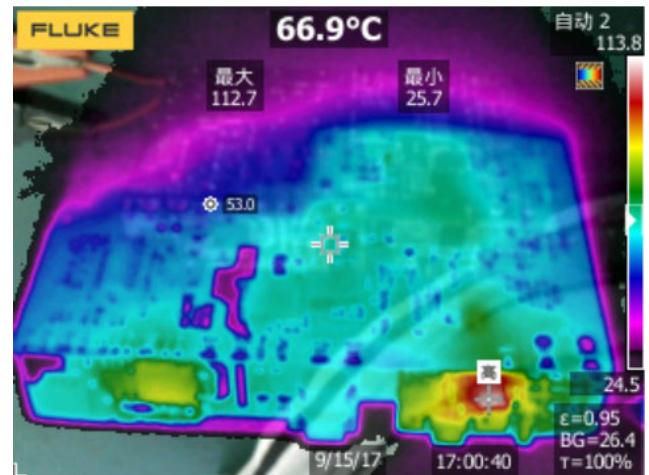


Figure 49. 230 Vac & 48 V 5 A, Reverse Side

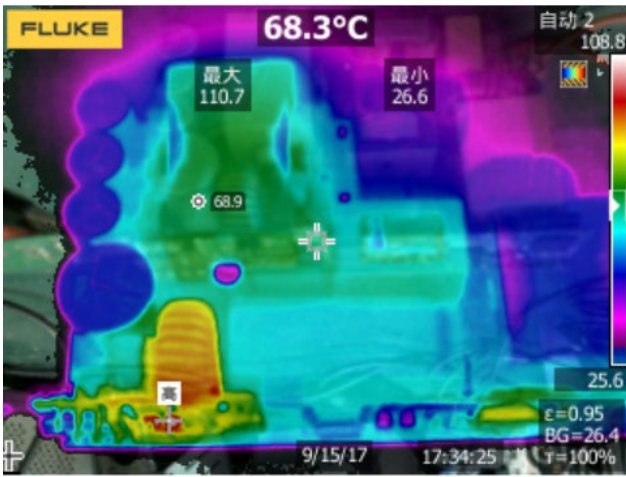


Figure 50. 264 Vac & 48 V 5 A, Front Side

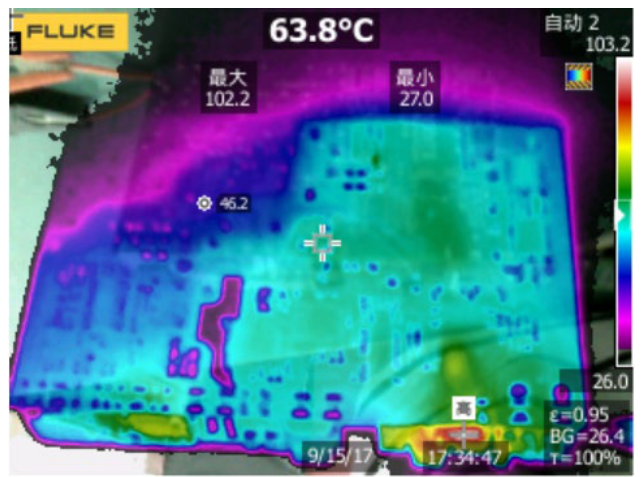


Figure 51. 264 Vac & 48 V 5 A, Reverse Side

TND6412/D

Table 1. BOM

Item	Qty	Reference	Type	Part Name	Package	MFR	Value	Description
1	1	U14	3–8 line decode	MC74HC238ADTR2G	TSSOP16	onsemi		3–LINE TO 8–LINE DE-CODER\DEMULTIPLEXER
2	11	C3 C6–7 C15 C19–20 C40 C47 C62 C73–74	Ceramic Capacitor	/885012206095	603	Würth	0.1 µF	Capacitor, Ceramic, 50 V, 10%
3	5	C8 C75–76 C82 C93	Ceramic Capacitor	/885012206120	603	Würth	0.1 µF, 100 V	Capacitor, Ceramic, 100 V, 10%
4	2	C31 C37	Ceramic Capacitor	C3225X7T2W224K	1210	TDK	0.22 µF, 450 V	Capacitor, Ceramic, Chip, 10%
5	2	C1 C5	X2 Capcitor	PX564K2C1001	THT, 10 mm, 13 mm × 8 mm × 14 mm	KYET	0.56 µF, 310 VAC	X2 capacitor, Safety standard approved, 10%
6	1	C25	X2 Capcitor	MPX684K31D4KN15800	THT, 15 mm, 18 mm × 10 mm × 15 mm	KNSCHA	0.68 µF, 275 VAC	X2 capacitor, Safety standard approved, 10%
7	1	C33	Ceramic Capacitor	/885012206084	603	Würth	1.5 nF	Capacitor, Ceramic, 50 V, 10%
8	2	C85 C111	Ceramic Capacitor	/885012206083	402	Würth	100 nF	Capacitor, Ceramic, 50 V, 10%
9	4	C9 C42–43 C70	Ceramic Capacitor	/885012206077	603	Würth	100 pF	Capacitor, Ceramic, 50 V, 10%
10	1	C57	Ceramic Capacitor	/885342008004	1206	Würth	100 pF, 630 V	Capacitor, Ceramic, SMD, 5%
11	2	C26 C48	Ceramic Capacitor	C3216X7T2W104K	1206	TDK	104, 450 V	Capacitor, Ceramic, SMD, 5%
12	4	C22 C34 C64 C92	Ceramic Capacitor	/885012206089	603	Würth	10 nF	Capacitor, Ceramic, 50 V, 10%
13	2	C71–72	Ceramic Capacitor	CL112J103J050	TH type	KYET	10 nF, 630 V	Capacitor, film, TH, 5%
14	10	C77–80 C86–91	Ceramic Capacitor	C3225X7R1N106K250AC	1210	TDK	10 µF, 75 V	Capacitor, Ceramic, 75 V, 10%
15	3	C39 C65 C68	Ceramic Capacitor	/885012206083	603	Würth	1 nF	Capacitor, Ceramic, 50 V, 10%
16	2	C10 C61	Ceramic Capacitor	/8853522100131	1808	Würth	1 nF, Y2	HV Ceramic Capacitor, safety standard approved, 10%
17	1	C83	Ceramic Capacitor	/885012105012	402	Würth	1 µF, 10 V	Capacitor, Ceramic, 10 V, 20%
18	7	C16–17 C21 C23 C28 C56 C60	Ceramic Capacitor	/885012206076	603	Würth	1 µF, 25 V	Capacitor, Ceramic, 25 V, 10%
19	1	C81	Ceramic Capacitor	C1005X5R1E105K050BC	402	TDK	1 µF, 25 V	Capacitor, Ceramic, 25 V, 10%
20	1	C29	Ceramic Capacitor	/885012206085	603	Würth	2.2 nF	Capacitor, Ceramic, 50 V, 10%
21	1	C96	Ceramic Capacitor	/885012205063	402	Würth	2.2 nF	Capacitor, Ceramic, 50 V, 10%
22	2	C35–36	Ceramic Capacitor	/885012206079	603	Würth	220 pF	Capacitor, Ceramic, 50 V, 10%
23	1	C58	Ceramic Capacitor	/885012206091	603	Würth	22 nF	Capacitor, Ceramic, 50 V, 10%
24	1	C98	Ceramic Capacitor	/885012205052	402	Würth	22 nF	Capacitor, Ceramic, 25 V, 10%
25	1	C44	Film Capacitor	ECWH8223HA	THT, 10 mm, 13 mm × 6 mm × 12 mm	Panasonic	22 nF, 800 V	Film capacitor
26	2	C18 C66	Ceramic Capacitor	C2012X5R1V226MT000E	805	TDK	22 µF, 35 V	Capacitor, Ceramic, 35 V, 20%
27	1	C97	Ceramic Capacitor	/885012205053	402	Würth	33 nF	Capacitor, Ceramic, 25 V, 10%

TND6412/D

Table 1. BOM (continued)

Item	Qty	Reference	Type	Part Name	Package	MFR	Value	Description
28	1	C63	Ceramic Capacitor	/885012205084	402	Würth	4.7 nF, 100 V	Capacitor, Ceramic, 100 V, 10%
29	2	C49-50	Ceramic Capacitor	GRM31CC72A475KE11L	1206	Murata	4.7 µF, 100 V	Capacitor, Ceramic, 100 V, 10%
30	1	C84	Ceramic Capacitor	C1005X5R1A475KTJ00E	402	TDK	4.7 µF, 10 V	Capacitor, Ceramic, 10 V, 10%
31	7	C2 C4 C11 C24 C30 C55 C67	Ceramic Capacitor	C1608X5R1E475K080AC	603	TDK	4.7 µF, 25 V	Capacitor, Ceramic, 25 V, 10%
32	2	C12 C45	Ceramic Capacitor	/885342006005	603	Würth	470 pF, 250 V	Capacitor, Ceramic, SMD, 5%
33	6	C38 C46 C53 C59 C69 C99	Ceramic Capacitor	nu	603	Würth	nu	Capacitor, Ceramic, 50 V, 10%
34	2	C54 C52	Ceramic Capacitor	nu	1206	Murata	nu	Capacitor, Ceramic, 25 V, 20%
35	2	D2 D9	Rectifier	S3J	SMC	onsemi	3 A, 600 V	General Rectifier
36	1	DNR	Varistor	820513011	TH type	Würth	471 V	Varistor, 10D471K
37	2	D12-13	Standard rectifier	4007	SOD123FL	std	0.8 A, 600 V	General Rectifier, 0.8 A, 600 V
38	5	D1 D3-6	Ultrafast rectifier	ES1JFL	SOD123FL	onsemi	1 A, 600 V	General Rectifier, 1 A, 600 V
39	4	D7 D15-17	Switching diode	BAS21HT1G	SOD323	onsemi	0.25 A, 250 V	Switching diode, SMD
40	7	D8 D10-11 D14 D18-D20	Switching diode	BAT54HT1G	SOD323	onsemi	0.25 A, 30 V	Switching diode, SMD
41	1	D21	Switching diode	nu	SOD323	onsemi	nu	Switching diode, SMD
42	1	L5	Inductor	100C21121003	TH type	Lihang elec.	70 µH	Ferrocube EQ20/3C95 core, 10Pin bobbin
43	1	U11	DC-DC converter	FAN65004C	PQFN36-6*6	onsemi		DC-DC Converter
44	2	FB1-2	Ferrite bead	nu	1812		nu	
45	1	L1	Common filter	T12*6*4	TH type	Custom	1 mH	T12 * 6 * 4 MnZn core, 6T in parallel
46	1	L2	Common filter	SQ1515	TH type	Custom	15 mH	CM Filter, SQ1515, 10 * 13
47	1	F1	Micro Fuse	39215000000	Axial lead	Littlefuse	5 A, 250 Vac	Micro Fuse, 5 A/250 V
48	1	Q2	NPN Transistor	MMBT3904LT1G	SOT23	onsemi		GENERAL PURPOSE NPN SILICON TRANSISTOR
49	1	U10	Programmable precision reference	NCP431ACSNT1G	SOT23	onsemi		PROGRAMMABLE PRECISION REFERENCE
50	1	U1	TPPFC controller	NCP1680	SO16	onsemi		TPPFC controller
51	1	U5	LLC controller	NCP13994	SO20	onsemi		LLC Controller
52	4	U2-4 U13	Driver GaN	NCP58921	QFN26	onsemi	650 V, 50 mΩ	iGaN
53	2	U6-7	Syn. rectified controller	NCP4306DAHZZAAS-NT1G	TSOP6	onsemi		Syn. rectified controller
54	2	U9 U12	HB Driver	NCP51530BMNTWG	DFN10-4*4	onsemi		HB driver
55	5	Q6-10	Dual NMOS	2N7002V	SOT-563F	onsemi	60 V	Dual NMOS
56	2	Q1 Q5	MOSFET	FDMS4D0N12C	SO8FL	onsemi	120 V	MOSFET, NChan, 120 V

TND6412/D

Table 1. BOM (continued)

Item	Qty	Reference	Type	Part Name	Package	MFR	Value	Description
57	2	Q3-4	MOSFET	NTMT064N65S3H	Power88	onsemi	650 V, 64 mΩ	MOSFET, NChan, 650 V
58	1	NTC1	NTC	nu	603	Sunload	nu	
59	1	NTC2	NTC	nu	603	Sunload	nu	
60	1	U8	Optical coupler	FODM1009	LSOP4	onsemi		optical coupler, standard SOP package
61	1	L3	Inductor	T65125-100-080	TH type	std	100 μH	KoolMu Toroidal, T65125, 0.8 mm wire, 100 μH
62	1	L6	Inductor	T65125-33-100	TH type	std	33 μH	KoolMu Toroidal, T65125, 1 mm wire, 33 μH
63	1	L4	Inductor	100T26181002	TH type	Lihang elec.	140 μH	Ferroxcube PQ2618/3C95 core, 12Pin bobbin
64	1	T1	Transformer	100T32201001	TH type	Lihang elec.		Ferroxcube PQ3218/3C95 core, 12Pin Bobbin
65	1	R64	Resistor	Std	603	Std	0 Ω	Resistor, Chip, 1/10 W, 1%
66	4	R59 R97-99	Resistor	Std	402	Std	1 Ω	Resistor, Chip, 1/16 W, 1%
67	1	R90	Resistor	Std	402	Std	1.3 kΩ	Resistor, Chip, 1/16 W, 1%
68	1	R91	Resistor	Std	402	Std	1.2 kΩ	Resistor, Chip, 1/16 W, 1%
69	10	R1 R6 R9-10 R36 R38 R43-45 R72	Resistor	Std	603	Std	10 Ω	Resistor, Chip, 1/10 W, 1%
70	1	R70	Resistor	Std	603	Std	100 Ω	Resistor, Chip, 1/10 W, 1%
71	5	R11 R13 R29-30 R61	Resistor	Std	603	Std	100 kΩ	Resistor, Chip, 1/10 W, 1%
72	2	R75 R79	Resistor	Std	402	Std	100 kΩ	Resistor, Chip, 1/16 W, 1%
73	3	R55 R116-117	Resistor	Std	402	Std	10 kΩ	Resistor, Chip, 1/16 W, 1%
74	1	R85	Resistor	Std	402	Std	10 kΩ	Resistor, Chip, 1/16 W, 1%
75	1	R60	Resistor	Std	603	Std	15 kΩ	Resistor, Chip, 1/10 W, 1%
76	1	R84	Resistor	Std	402	Std	16 kΩ	Resistor, Chip, 1/16 W, 1%
77	2	R49 R53	Resistor	Std	603	Std	18 kΩ	Resistor, Chip, 1/10 W, 1%
78	3	R17-18 R24	Resistor	Std	603	Std	1 kΩ	Resistor, Chip, 1/10 W, 1%
79	1	R74	Resistor	Std	402	Std	2,2 Ω	Resistor, Chip, 1/16 W, 1%
80	1	R69	Resistor	Std	603	Std	2.2 kΩ	Resistor, Chip, 1/10 W, 1%
81	1	R87	Resistor	Std	402	Std	2.2 kΩ	Resistor, Chip, 1/16 W, 1%
82	2	R88 R93	Resistor	Std	402	Std	2.7 kΩ	Resistor, Chip, 1/16 W, 1%
83	2	R54 R66	Resistor	Std	603	Std	22 kΩ	Resistor, Chip, 1/10 W, 1%
84	2	R83 R103	Resistor	Std	402	Std	22 kΩ	Resistor, Chip, 1/16 W, 1%
85	1	R95	Resistor	Std	603	Std	39 kΩ	Resistor, Chip, 1/10 W, 1%
86	1	R115	Resistor	Std	402	Std	270 Ω	Resistor, Chip, 1/16 W, 1%
87	1	R58	Resistor	Std	603	Std	300 kΩ	Resistor, Chip, 1/10 W, 1%
88	1	R82	Resistor	Std	402	Std	30 kΩ	Resistor, Chip, 1/16 W, 1%
89	4	R2 R8 R47 R65	Resistor	Std	603	Std	33 Ω	Resistor, Chip, 1/10 W, 1%
90	2	R92 R94	Resistor	Std	402	Std	390 Ω	Resistor, Chip, 1/16 W, 1%
91	1	R81	Resistor	Std	402	Std	39 kΩ	Resistor, Chip, 1/16 W, 1%
92	1	R100	Resistor	Std	402	Std	4.3 kΩ	Resistor, Chip, 1/16 W, 1%
93	6	R7 R14 R37 R56-57 R62	Resistor	Std	603	Std	4,7 Ω	Resistor, Chip, 1/10 W, 1%
94	1	R76	Resistor	Std	402	Std	41.2 kΩ	Resistor, Chip, 1/16 W, 1%

TND6412/D

Table 1. BOM (continued)

Item	Qty	Reference	Type	Part Name	Package	MFR	Value	Description
95	1	R89	Resistor	Std	402	Std	470 Ω	Resistor, Chip, 1/16 W, 1%
96	1	R33	Resistor	Std	603	Std	470 kΩ	Resistor, Chip, 1/10 W, 1%
97	5	R101-102 R112-114	Resistor	Std	402	Std	47 kΩ	Resistor, Chip, 1/16 W, 1%
98	4	R4 R32 R48 R52	Resistor	Std	603	Std	5.1 kΩ	Resistor, Chip, 1/10 W, 1%
99	1	R80	Resistor	Std	402	Std	51 kΩ	Resistor, Chip, 1/16 W, 1%
100	1	R73	Resistor	Std	603	Std	620 kΩ	Resistor, Chip, 1/10 W, 1%
101	1	R3	Resistor	Std	603	Std	62 kΩ	Resistor, Chip, 1/10 W, 1%
102	1	R16	Resistor	Std	603	Std	68 kΩ	Resistor, Chip, 1/10 W, 1%
103	1	R78	Resistor	Std	402	Std	750 kΩ	Resistor, Chip, 1/16 W, 1%
104	1	R86	Resistor	Std	402	Std	9.1 kΩ	Resistor, Chip, 1/16 W, 1%
105	1	R77	Resistor	Std	402	Std	91 kΩ	Resistor, Chip, 1/16 W, 1%
106	9	R5 R26 R31 R34-35 R63 R67 R71 R96	Resistor	Std	603	Std	nu	Resistor, Chip, 1/10 W, 1%
107	1	R68	Resistor	Std	1206	Std	0 Ω	Resistor, Chip, 1/4 W, 1%
108	2	R50-51	Resistor	ERJ8B5FR13V	1206	Panasonic	0,13 Ω	Resistor, Chip, 1/2 W, 1%
109	2	R15 R19	Resistor	Std	1206	Std	2.7 kΩ	Resistor, Chip, 1/4 W, 1%
110	2	R12 R46	Resistor	Std	1206	Std	22 Ω	Resistor, Chip, 1/4 W, 1%
111	9	R21-23 R25 R27-28 R40-42	Resistor	Std	1206	Std	3.3 MΩ	Resistor, Chip, 1/4 W, 1%
112	1	R20	Resistor	nu	1206	Panasonic	nu	Resistor, Chip, 1/2 W, 1%
113	1	C41	Electrolytic solid capacitor	GH101M025E110A	TH, 6.3 mm × 11 mm	CapXon	100 μF, 25 V	size: 6.3 mm x 11 mm
114	1	C32	Electrolytic electrolytic capacitor	450LXW150MEFR18X35	TH, 18 mm × 35 mm	Rubycon	150 μF, 450 V	size: 18 mm x 35 mm
115	3	C13-14 C51	Hybrid Electrolytic capacitor	EEH2S1J181UP	10 × 16.5, SMD	Panasonic	180 μF, 63 V	size: SMD10*16.5, ESR 15 mΩ
116	1	C27	Electrolytic capacitor	EEEFK1J471AM	16 × 16.5, SMD	Panasonic	470 μF, 63 V	size: SMD16 * 16.5
117	2	C94-95	Hybrid Electrolytic capacitor	EEH2T1J470P	8 × 10.2, SMD	Panasonic	47 μF, 63 V	size: SMD8 * 10.2, ESR 25 mΩ
118	1	SW	DIP switch	DSHP03TS-S	SMD	XKB Connectivity		SMD, 3P, 1.27 mm
119	1	J1	USB Type C connector	CUS31738616001	SMD	CSCONN		16Pin, SMD
120	1	ZD2	Zener	MM3Z16VT1G	SOD323	onsemi	16 V	GENERIC ZENER-DIODE
121	1	ZD4	Zener	MM3Z22VT1G	SOD323	onsemi	22 V	GENERIC ZENER-DIODE
122	1	ZD1	Zener	MM3Z24VT1G	SOD323	onsemi	24 V	GENERIC ZENER-DIODE
123	1	ZD3	Zener	nu	SOD323	onsemi	nu	GENERIC ZENER-DIODE

TND6412/D

Simulated PD3.1 to Support 5 V to 48 V

No PD3.1 controller to support 48 V output in current market so a discrete circuit to simulate PD3.1 and support 5 V to 48 V output as following.

3 DIP switch combination schematic shown as Figure 52 is decoded by 74HC238 to output Y0–7 to NMOS to control

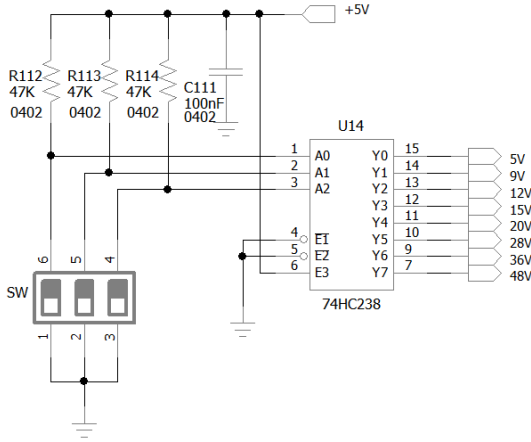


Figure 52. SW Schematic

feedback divider so 5 V/9 V/12 V/15 V/20 V/28 V/36 V/48 V is set, DIP SW set Vs output is as following table shown as Figure 53, the board photo is shown as Figure 54.

Vo	SW1	SW2	SW3
5V	ON	ON	ON
9V	OFF	ON	ON
12V	ON	OFF	ON
15V	OFF	OFF	ON
20V	ON	ON	OFF
28V	OFF	ON	OFF
36V	ON	OFF	OFF
48V	OFF	OFF	OFF

Figure 53. SW Table



Figure 54. DC Photo

References

[1] onsemi datasheet for NCP1680, [NCP13994](#), [NCP51530](#), [NCP4306](#), [FAN65004](#), NCP58921, [FDMS4D0N12](#), [NTMT064N65](#)

[2] onsemi Design Notes [DN05043](#)

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