Power Adapter Description

This design guide of the Transphorm GaN and Onsemi NCP1342 controller reference design board describes a 45 W, with greater than 90% average efficiency, with programmable output voltage (5 V/3 A, 9 V/3 A, 12V/3A, 15 V/3 A, 20 V/2.25 A).

The power supply uses Quasi-Resonant Flyback controller, Collocation Transphorm GaN TP65H480G4JSG (650 V SuperGaN FET). This design shows the highpower density and efficiency.

This document contains the power supply specification, schematic, bill-of-materials, transformer documentation, printed circuit layout, and performance data.

Key Specs	Schematics
Input	90-265 Vac
Output Voltages	5 V, 9 V, 12V, 15 V, 20 V,
Max Output Current	5V, 9V, 12V, 15V@3A 20V@2.25 A
Max Output Power	45 W
Output Port	USB-PD Type-C
Efficiency	> 92.5% Full Power Efficiency

Features

- Integrated Transphorm GaN TP65H480G4JSG for flyback converter topology
- Board-end over 92.5% Efficiency(90VAC)
- Flat Efficiency Across Universal (90-265 VAC) Input Voltage and Load
- Tight Switching Frequency Regulation for Improved Input EMI Filter Utilization
- Up to 200KHz Switching Frequency Operation
- 450V Input Capacitors to withstand line voltage surge
- OTP, UVLO, OPP and OSCProtections
- < 35mW (230Vac) No Load Power Consumption of the IC
- Up to 45 W Output Power

Applications

- High-Power-Density USB-PD AC/DC Power Supplies

Warning





Disclaimers:

1. **Caution – High Voltage Operation: Lethal high voltages are present when this evaluation board is powered from AC mains. Improper contact with high voltages could lead to electrical shock, burn and/or fire hazards, risking property damage, personal injury, and death.**
2. **Evaluation Purpose Only: This evaluation board is intended for evaluation purpose only and not for commercial use. Care must be taken when testing the board, and an isolation transformer should be utilized.**
3. **Patents: The evaluation board design, along with circuits shown in this test report, may be covered by one or more U.S. and foreign existing/pending patents.**

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TDADP-TPH-ON-USBC-45W-RD Board Pictures

Figure 1: Top Side of the EVB

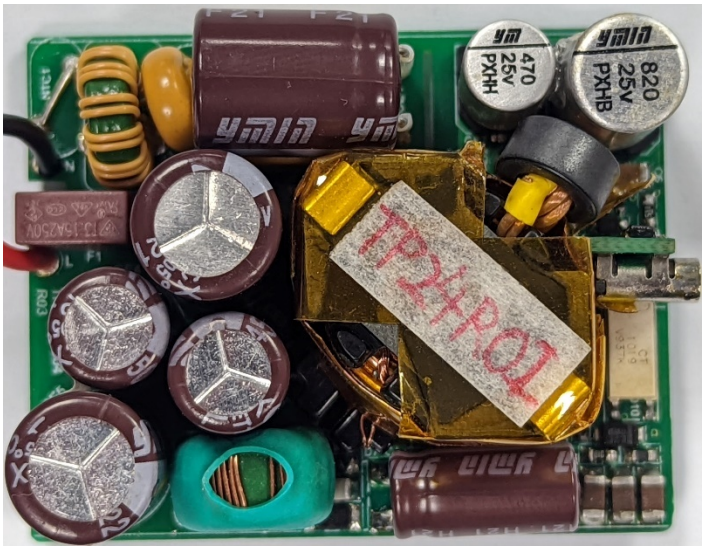
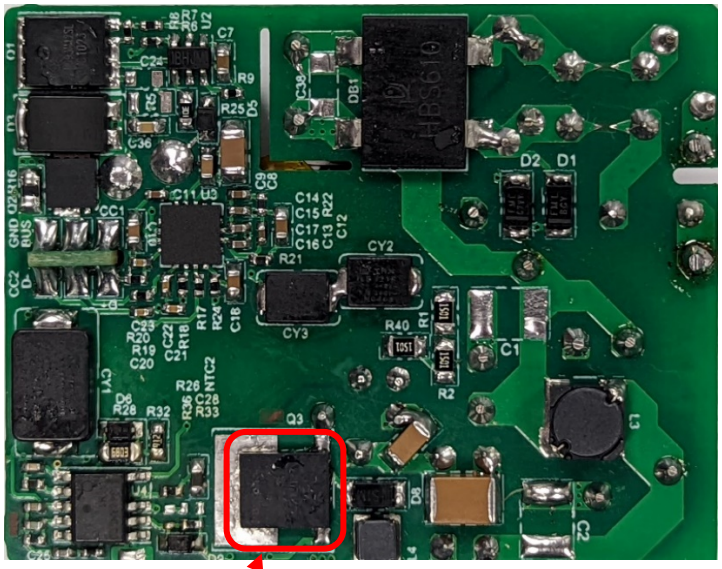
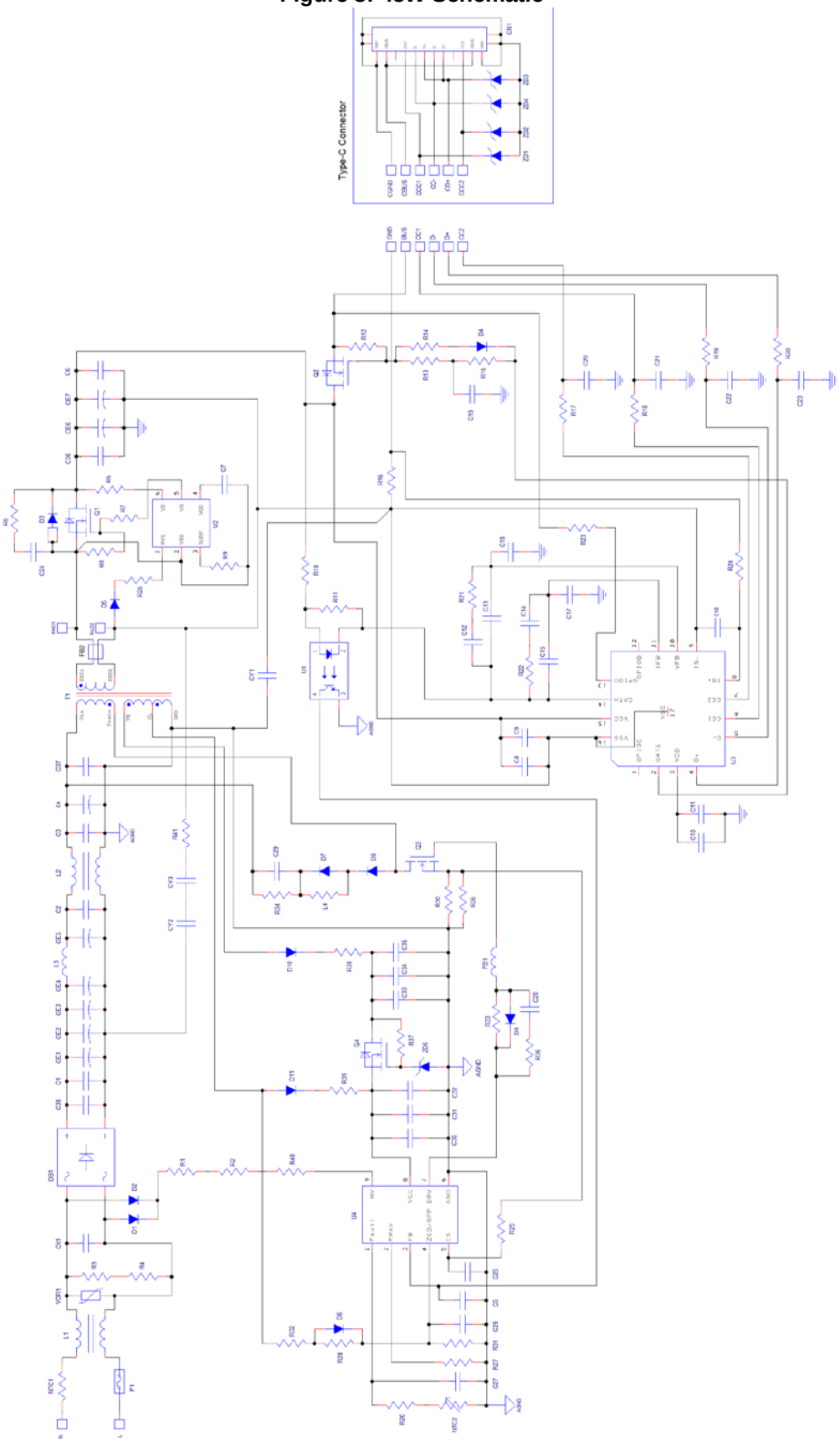


Figure 2: Bottom Side of the EVB



Schematic

Figure 3: 45W Schematic



Circuit Description

Input Protection

The design incorporates a slow-acting input fuse (F1) as a form of protection in case of destructive failure of any of the downstream components.

EMI Filtering

To meet the target EN55022 conducted EMI specification with sufficient margin with the least number of components and the highest power processing efficiency, the design utilizes an input filter consisting of an X-capacitor (CX1) and a single common-mode choke (L1) as well as transformer (T1) construction for better EMI performance.

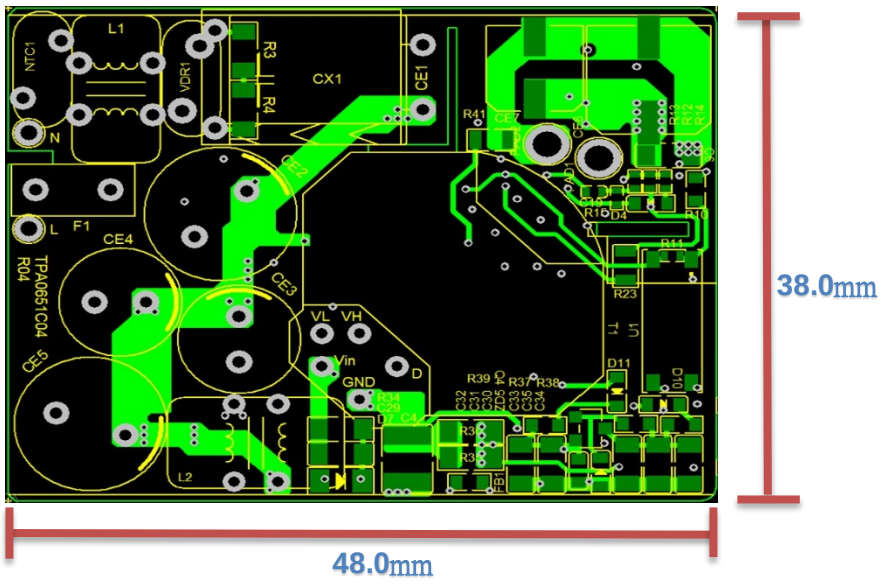
Fault Protections

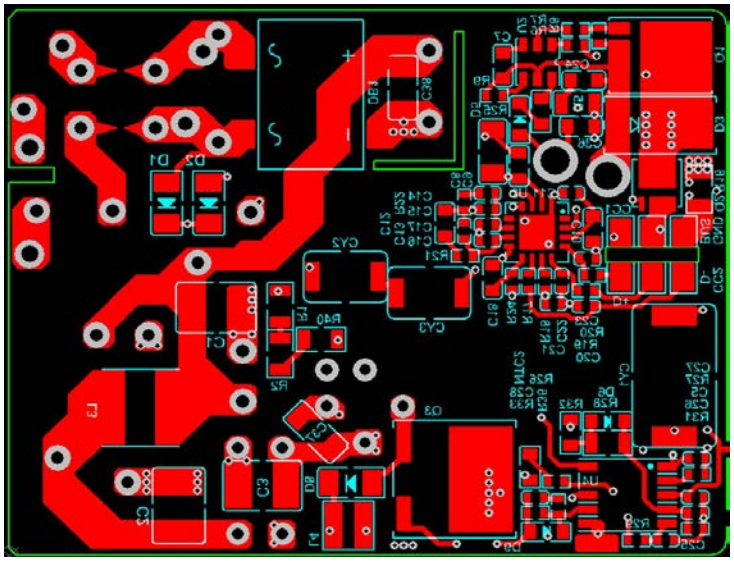
Table 1: Recovery Behavior

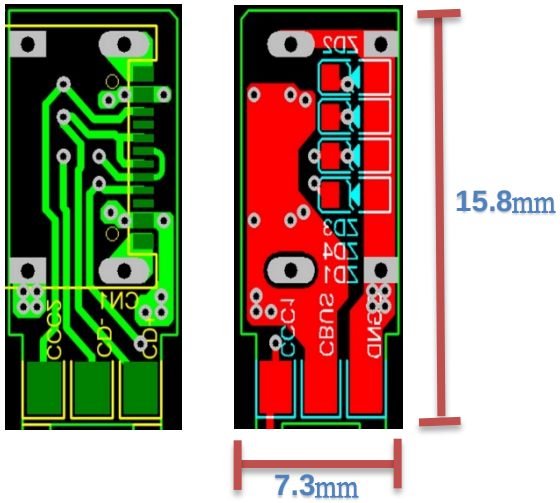
Fault Protection	
Input Under Voltage Lockout (UVLO)/ Brown-Out	Auto-Recovery
Internal Over Temp Protection (OTP)	Auto-Recovery
External Over Temp Protection (OTP)	Auto-Recovery
Peak Current Limit (PCL)	Auto-Recovery
Over-Power Protection (OPP)	Auto-Recovery
Output Short Circuit (OSC)	Auto-Recovery

PCB Layout

PCB Prints







transphorm

TP65H480G4JSG

650V SuperGaN® GaN FET in PQFN (source tab)

Description

The TP65H480G4JSG 650V, 480mΩ Gallium Nitride (GaN) FET is a normally-off device using Transphorm's Gen IV platform. It combines a state-of-the-art high voltage GaN HEMT with a low voltage silicon MOSFET to offer superior reliability and performance.

The Gen IV SuperGaN® platform uses advanced epi and patented design technologies to simplify manufacturability while improving efficiency over silicon via lower gate charge, output capacitance, crossover loss, and reverse recovery charge.

Related Literature

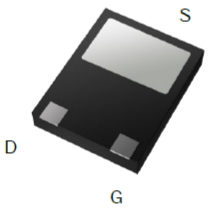
- AN0003: Printed Circuit Board Layout and Probing
- AN0007: Recommendations for Vapor Phase Reflow
- AN0009: Recommended External Circuitry for GaN FETs
- AN0012: PQFN Tape and Reel Information

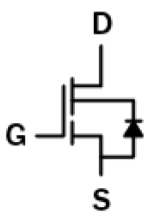
Product Series and Ordering Information

Part Number	Package	Package Configuration
TP65H480G4JSG-TR*	5x6 PQFN	Source

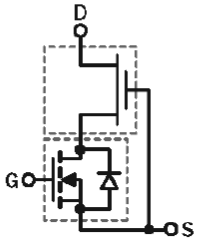
* "-TR" suffix refers to tape and reel. Refer to AN0012 for details.

TP65H480G4JSG
PQFN
(top view)





Cascode Schematic Symbol



Cascode Device Structure

Features

- Gen IV technology
- JEDEC-qualified GaN technology
- Dynamic $R_{DS(on)eff}$ production tested
- Robust design, defined by
  - Wide gate safety margin
  - Transient over-voltage capability
- Very low Q_{RR}
- Reduced crossover loss
- RoHS compliant and Halogen-free packaging

Benefits

- Achieves increased efficiency in both hard- and soft-switched circuits
  - Increased power density
  - Reduced system size and weight
  - Overall lower system cost
- Easy to drive with commonly-used gate drivers
- GSD pin layout improves high speed design

Applications

- Consumer
- Power adapters
- Low power SMPS
- Lighting

Key Specifications	
V_{DS} (V)	650
$V_{DSS(TR)}$(V)	800
$R_{DS(on)}$ (mΩ) max*	560
Q_{RR} (nC) typ	14
Q_G (nC) typ	9

* Dynamic $R_{DS(on)}$; see Figures 18 and 19

Bill of Materials (BOM)

Main Board

Designator	Description	Manufacturer	Manufacturer part number
C1	No components	---	---
C2	No components	---	---
C3	0.47uF, 450V, X7T, 1812	TDK	CGA8N4X7T2W474M230KA
C4	4.7uF, 450V, KCX, 6.3x12mm	Ymin	KCX Series
C5	330pF, NPO, 16V, 0402	AVX	0402YA331JAT2A
C6	10uF, 25V, X7R, 1206	TDK	CGA5L1X7R1E106M160AC
C7	1uF, 25V, X7R, 0603	TDK	C1608X7R1E105K080AB
C8	10uF, 25V, X7R, 1206	TDK	CGA5L1X7R1E106M160AC
C9	0.1uF, 25V, X7R, 0603	AVX	06033C104KAT4A
C10	4.7uF, 10V, X7S, 0603	TDK	C1608X7S1A475M080AC
C11	0.1uF, X7R, 25V, 0402	AVX	04023C104KAT2A
C12	1uF, X7R, 25V, 0603	TDK	C1608X7R1E105K080AB
C13	68nF, X7R, 25V, 0402	TDK	GRM155R71E683KE14D
C14	68nF, X7R, 25V, 0402	TDK	GRM155R71E683KE14D
C15	68nF, X7R, 25V, 0402	TDK	GRM155R71E683KE14D
C16	100pF, NPO, 25V, 0402	Taiyo Yuden	TMK042CG101JC-W
C17	100pF, NPO, 25V, 0402	Taiyo Yuden	TMK042CG101JC-W
C18	1uF, X7R, 25V, 0603	AVX	0603ZC105KAT2A
C19	4.7nF, X7R, 25V, 0402	AVX	04023C472KAT2A
C20	560pF, NPO, 50V, 0402	Yageo	CC0402JRNPO9BN561
C21	560pF, NPO, 50V, 0402	Yageo	CC0402JRNPO9BN561
C22	560pF, NPO, 50V, 0402	Yageo	CC0402JRNPO9BN561
C23	560pF, NPO, 50V, 0402	Yageo	CC0402JRNPO9BN561
C24	No components	---	---
C25	100pF, NPO, 25V, 0402	Taiyo Yuden	TMK042CG101JC-W
C26	12pF, NPO, 25V, 0402	AVX	04023A120KAT2A
C27	10nF, X7R, 50V, 0402	Yageo	C0402C103K5RECAUTO
C28	No components	---	---
C29	2.2nF, 500V, NPO, 1206	TDK	CGJ5H4C0G2H222J115AA
C30	0.1uF, X7R, 25V, 0603	AVX	06033C104KAT4A
C31	10uF, 25V, X7R, 1206	TDK	CGA5L1X7R1E106M160AC
C32	10uF, 25V, X7R, 1206	TDK	CGA5L1X7R1E106M160AC
C33	2.2uF, 100V, X7R, 1206	AVX	12061C225K4T2A
C34	2.2uF, 100V, X7R, 1206	AVX	12061C225K4T2A
C35	2.2uF, 100V, X7R, 1206	AVX	12061C225K4T2A
C36	68nF, X7R, 25V, 0603	AVX	06033C683KAT2A
C37	47nF, 500V, X7R, 1206	TDK	GRM31CR72H473KW09L
C38	No components	---	---
CE1	15uF, 450V, Ymin, D10X13.5mm	Ymin	KCX Series
CE2	22uF, 450V, Ymin, D10x17mm	Ymin	KCX Series
CE3	10uF, 450V, Ymin, D8x15mm	Ymin	KCX Series

CE4	10uF, 450V, Ymin, D8x15mm	Ymin	KCX Series
CE5	22uF, 450V, Ymin, D10x17mm	Ymin	KCX Series
CE6	820uF, 25V, Ymin, D8x16.5mm	Ymin	VPX Series
CE7	470uF, 25V, Ymin, D6.3x13mm	Ymin	VPX Series
CX1	220nF, 275V, Pitch 7.5mm, WQC	WQC	---
CY1	470pF, Y5P	TRX	TMY1471K
CY2	220pF, Y5P	TRX	TBY2221KB
CY3	220pF, Y5P	TRX	TBY2221KB
D1	RSFML, SOD123	Taiwan Semiconductor	RSFML RVG
D2	RSFML, SOD123	Taiwan Semiconductor	RSFML RVG
D3	P10L150SP, TO-277	PFC Device	P10L150SP
D4	BAS16HT1G, SOD323	On-Semi	BAS16HT1G
D5	BAS20HT1G, SOD323	On-Semi	BAS20HT1G
D6	BAS20HT1G, SOD323	On-Semi	BAS20HT1G
D7	ES1JFL	On-Semi	ES1JFL
D8	S1MWF-7	DIODES	S1MWF-7
D9	ZHCS400TA	DIODES	ZHCS400TA
D10	ES1JFL	On-Semi	ES1JFL
D11	BAS20HT1G, SOD323	On-Semi	BAS20HT1G
DB1	HBS610	Dyelec	HBS610
F1	3.15A, 250V, 5ET, Slow blow	Hollyfuse	RST 3.15-BULK
FB1	MMZ1608S800AT	TDK	MMZ1608S800AT
FB2	HF70 T8x4x4	TDK	HF70 T8x4x4
L1	ACME K12, T9x5x3C	Createk	SPEC-DXT009078-A
L2	ACME A10, T10x6x5C	Createk	SPEC-DXT010079-A
L3	22uH	Bourns	SRR4528A-220M
L4	10R, 1206, 5%, 1/4W	---	---
NTC1	Jumper wire, D0.5mm, L12mm, P5mm	---	---
NTC2	100K	MuRata	NCP18WF104F12RB
PCB	Main Board, 2oz, FR4, 38x48mm, T1mm	---	---
Q1	HGN093N12SL	Huntek	HGN093N12SL
Q2	BSZ0902NS, TSDSON-8	Infineon	BSZ0902NS
Q3	TP65H480G4JSG, 8x8_PQFN(LS)	Transphorm	TP65H480G4JSG
Q4	BSS123, SOT23	Fairchild	BSS123
R1	1.5K, 0805, 5%, 1/8W	---	---
R2	1.5K, 0805, 5%, 1/8W	---	---
R3	4.7M, 1206, 5%, 1/4W	---	---
R4	4.7M, 1206, 5%, 1/4W	---	---
R5	NC	---	---
R6	300R, 0402, 1%, 1/16W	---	---
R7	0402, Jumper	---	---
R8	NC	---	---
R9	43K, 0402, 1%, 1/16W	---	---
R10	510R, 0603, 5%, 1/10W	---	---

R11	4.7K, 0402, 5%, 1/16W	---	---
R12	1M, 0402, 5%, 1/16W	---	---
R13	100K, 0402, 1%, 1/16W	---	---
R14	10K, 0402, 5%, 1/16W	---	---
R15	47K, 0402, 1%, 1/16W	---	---
R16	0805, 5mR, 1/2W	Panasonic	ERJ-6LWFR005V
R17	22R, 0402, 5%, 1/16W	---	---
R18	22R, 0402, 5%, 1/16W	---	---
R19	5.1R, 0402, 5%, 1/16W	---	---
R20	5.1R, 0402, 5%, 1/16W	---	---
R21	4.7K, 0402, 1%, 1/16W	---	---
R22	47K, 0402, 1%, 1/16W	---	---
R23	0805, 1K	Panasonic	ERJ-P06F1001V
R24	5.1K, 0402, 5%, 1/16W	---	---
R25	300R, 0603, 5%, 1/10W	---	---
R26	5.6K, 0402, 1%, 1/16W	---	---
R27	82K, 0402, 1%, 1/16W	---	---
R28	680K, 0805, 1%, 1/8W	---	---
R29	100R, 0402, 1%, 1/16W	---	---
R30	0.62R, 1206, 1%, 1/2W	Panasonic	ERJ-8BQFR43V
R31	2.4K, 0402, 1%, 1/16W	---	---
R32	9.1K, 0603, 1%, 1/10W	---	---
R33	820R, 0402, 1%, 1/16W	---	---
R34	1.3M, 1206, 5%, 1/4W	---	---
R35	0.62R, 1206, 1%, 1/2W	Panasonic	ERJ-8BQFR43V
R36	NC	---	---
R37	100K, 0603, 5%, 1/10W	---	---
R38	300R Ferrite Bead, 0603	TDK	MMZ1608S301AT
R39	300R Ferrite Bead, 0603	TDK	MMZ1608S301AT
R40	1.5K, 0805, 5%, 1/8W	---	---
R41	0R, 0805, 5%, 1/8W	---	---
T1	RM8 Transformer	---	---
U1	Opto-Coupler-SMD5KV	CT Micro	CT1019
U2	MP6908A, SOT2306	MPS	MP6908A
U3	PD controller, 4x4mm	Weltrend	WT6633P
U4	NCP1342AMDCDD1R2G	On-Semi	NCP1342AMDCDD1R2G
VDR1	MOV-07D511K	VDR	MOV-07D511K
ZD5	Zener Diode, 12V, 2%, Fairchild	DIODES	MM3Z12VB

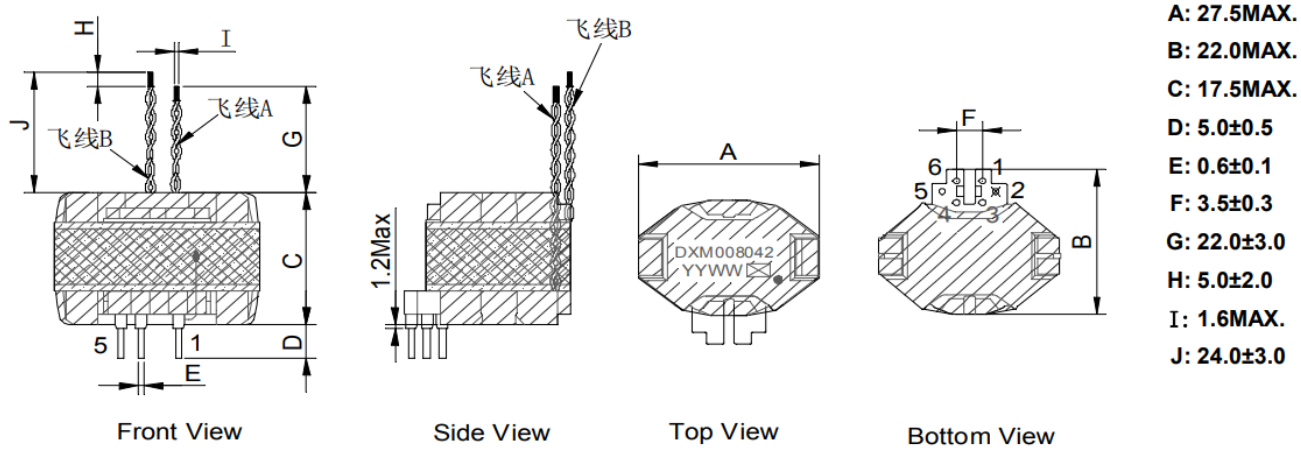
PD board

Designator	Description	Manufacturer	Manufacturer part number
CN1	USB Type-C connector, 16P	SHENZHEN HONGSEN PRECISION ELECTTRONICS	USBC-202N03A03
PCB	FR4, 1.0mm, 2oz, 7.3x15.7mm, 4 layers, R01	---	---
ZD1	TVS, 24V, SOD323	KF	GBLC24
ZD2	TVS, 24V, SOD323	KF	GBLC24
ZD3	TVS, 5V, SOD323	KF	ESD3Z5V0
ZD4	TVS, 5V, SOD323	KF	ESD3Z5V0

Transformer Specification

T1 SPEC

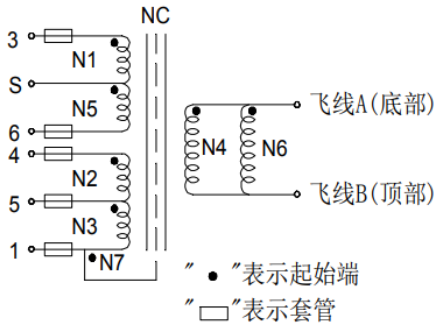
1. 外形尺寸 (单位:mm)
Physical Dimensions (Unit: mm)



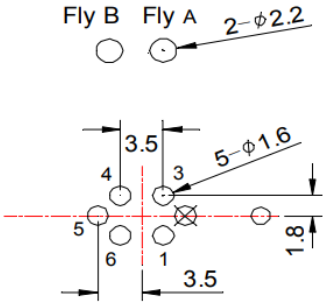
A: 27.5MAX.
B: 22.0MAX.
C: 17.5MAX.
D: 5.0±0.5
E: 0.6±0.1
F: 3.5±0.3
G: 22.0±3.0
H: 5.0±2.0
I: 1.6MAX.
J: 24.0±3.0

Notes:
(1),磁芯顶部激光印字，PIN1圆点和印字一起印;
(2), ⊠ :表示密番，做样品时，印S表示样品(Sample);
(3), ⊠ :表示密番，生产订单时印不同字母或数字表示不同产线生产;
(4), 骨架缺PIN 2 脚， 铜箔引线接PIN1脚 ;
(5), 尺寸D不包括锡尖在内;

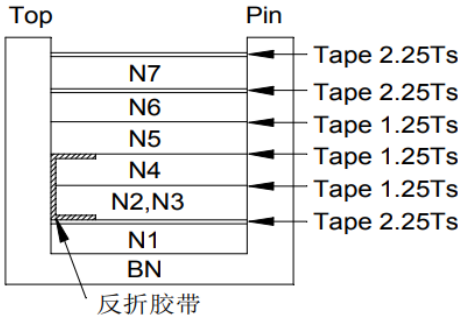
2. 线路图
Connection



3. 推荐焊盘孔尺寸 (单位:mm)(顶视图)
Recommended Pad Layout (Unit:mm) （Top View)



4. 结构图
Structure of Products



5. 线径和圈数
No of Turns & Wire Spec

No	No. of Pin	Turns	Wire Spec	Note
N1	3 - S	13 TS	ø0.10mm*20P UEWH/U绞合线	密绕一层
N2	4 - 5	10 TS	ø0.14mm*1P UEWH/U漆包线	N2密绕半层, N3接着N2台阶密绕
N3	5 - 1	5 TS	ø0.14mm*8P UEWH/U漆包线	
N4	A - B	5 TS	(ø0.10*20P)*2P TIW-F绝缘线	密绕一层
N5	S - 6	13 TS	ø0.10mm*20P UEWH/U绞合线	密绕一层
N6	A - B	5 TS	(ø0.10*20P)*2P TIW-F绝缘线	密绕一层
N7	1 - NC	24 TS	ø0.15mm*1P UEWH/U漆包线	底起密绕半层

6. 电 气 特 性
Electrical Characteristics

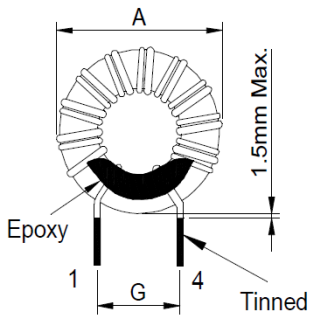
***Electrical specifications @ 25℃ unless otherwise noted:**

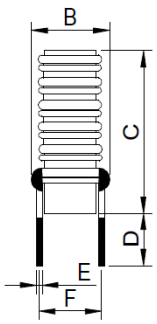
项目/Items	绕組/Winding	规格/Specifications	测试条件/Test conditions
电感量/Inductance	L(3-6)	240uH±10%	at 100kHz,0.1Vrms
漏感量/LK-Inductance	LK(3-6) 短路其它	3.5uH MAX.	at 100kHz,0.1Vrms
直流电阻/DCR	R(3-6)	150mΩ MAX.	at 25℃
	R(4-5)	550mΩ MAX.	
	R(5-1)	40mΩ MAX.	
	R(A-B)	10mΩ MAX.	
圈比/Turns Ratio	(3-6):(4-5):(5-1):(A-B)	26:10:5:5;±3%	at 100kHz,0.1Vrms
耐压/Hi-Pot	(3-6) -- (A-B)	3750VAC	1mA.3SEC
	(3-6) -- 磁芯 & (4-5)	800VAC	
	(A-B) -- 磁芯	3750VAC	

Common-Mode Choke Specification

L1 SPEC

1. 外形尺寸 (单位:mm)
Physical Dimensions （Unit: mm ）

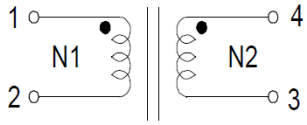




A 12.5MAX.
B 7.0MAX.
C 11.5MAX.
D 5.0±2.0
E 0.35±0.1
F 5.0Ref.
G 4.0Ref.

Notes:
(1)，D尺寸不包括锡尖在内
(2)，产品需点胶来固定引脚。

2. 原理图
Schematic



″●″表示起线端

4. 圈数和线径
No of Turns & Wire Spec

No	No of Pin	Turns	Wire Spec
N1	1 - 2	11 Ts(ref.)	ø0.35mm*1P TIW-F
N2	4 - 3	11 Ts(ref.)	ø0.35mm*1P TIW-F

4. 电气特性
Electrical Characteristics

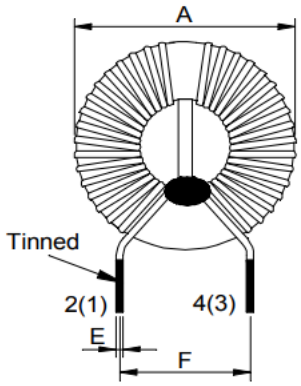
项目/Items	绕组/Winding	规格/Specifications	测试条件/Test Conditions
电感量/Inductance	L(1-2)	35uH MIN.	at 10kHz,0.1Vrms
	L(4-3)	35uH MIN.	
电阻/DCR	R(1-2)	30mΩ MAX.	at 25℃
	R(4-3)	30mΩ MAX.	
圈比/Turns Ratio	(1-2):(3-4)	1:1;±3%	at 10kHz,0.1Vrms
耐压/Hi-Pot	绕组对绕组	1500VAC	3mA, 1S

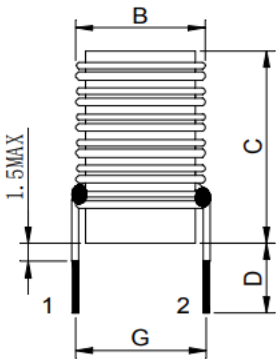
5. 材 料 表
Bill of material

No	Item	Material Name	Manufacturer	UL File No	SGS File No
1	Core	FERRITE CORE K12-T9X5X3-C	ACME or Equivalent	NIL	
2	Triple Wire	Multilayer insulated wire TIW-FXX	DONGJU or Equivalent	E488352	CANEC2023548505

L2 SPEC

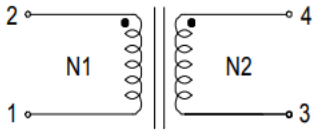
1. 外形尺寸 (单位:mm)
Physical Dimensions (Unit: mm)





A	13.0 MAX
B	8.0 MAX
C	12.5 MAX
D	5.0±1.0
E	0.30±0.1
F	3.0(ref.)
G	6.0(ref.)

2. 线路图
Connection



″ ● ″表示起始端

3. 圈数线径规格
No of turns & Wire spec.

No	No of Pin	Truns	Wire spec.
N1	2 -- 1	36 Ts	ø0.30mm*1P UEFN/U
N2	4 -- 3	36 Ts	ø0.30mm*1P UEFN/U

注：线圈圈数按磁环内圈计算

4. 电 气 特 性
Electrical Characteristics

Items/項目	繞組/Winding	規格/Specifications	測试条件/Test conditions
電感量/Inductance	L(2-1)	4mH Min	at 10kHz,0.1Vrms
	L(4-3)	4mH Min	
直流電阻/DCR	R(2-1)	190mΩ Max.	at 25℃
	R(4-3)	190mΩ Max.	
耐压/Hi-Pot	绕组 - 绕组	1000VAC	3mA / 1SEC.

Performance Data

Electrical Data

Efficiency

DoE Level VI and CoC Version 5 Tier-2 4-point (25%, 50%, 75%, 100%) average efficiency, along with CoC Version 5 Tier-2 10% load efficiency requirements.

Table 4: Load Efficiency Requirements

Vout/Iout	DoE Level VI 4-Point Average Efficiency	CoC V5 Tier-2 4-Point Average Efficiency	CoC V5 Tier-2 10% Efficiency
5 V / 3 A	81.39	81.84	72.48
9 V / 3 A	86.62	87.30	77.30
12 V / 3 A	87.40	88.30	78.30
15 V / 3 A	87.73	88.85	78.85
20 V / 2.25 A	87.73	88.85	78.85

The following efficiency data are averaged from PD 45W boards. The boards are soaked for 5 minutes before measuring the efficiency with output measured after the USB-PD disconnect FET.

115 Vac 4-point average efficiency

V_{OUT} / I_{LOAD_MAX} = 5 V / 3A

%LOAD	Efficiency (%)	Average Efficiency (%)
100	92.29	91.86
75	92.35	
50	91.98	
25	90.83	
10	89.30	

V_{OUT} / I_{LOAD_MAX} = 9 V / 3 A

%LOAD	Efficiency (%)	Average Efficiency (%)
100	93.21	92.94
75	93.45	
50	93.19	
25	91.90	
10	90.39	

V_{OUT} / I_{LOAD_MAX} = 12 V / 3A

%LOAD	Efficiency (%)	Average Efficiency (%)
100	93.31	93.49
75	94.09	
50	93.84	
25	92.73	
10	91.23	

V_{OUT} / I_{LOAD_MAX} = 15 V / 3A

%LOAD	Efficiency (%)	Average Efficiency (%)
100	93.34	93.55
75	93.96	
50	93.91	
25	93.00	
10	91.21	

V_{OUT} / I_{LOAD_MAX} = 20 V / 2.25A

%LOAD	Efficiency (%)	Average Efficiency (%)
100	93.90	93.38
75	93.85	
50	93.71	
25	92.06	
10	89.66	

230 Vac 4-point average efficiency

V_{OUT} / I_{LOAD_MAX} = 5 V / 3A

%LOAD	Efficiency (%)	Average Efficiency (%)
100	91.02	90.00
75	90.74	
50	89.38	
25	88.87	
10	84.60	

V_{OUT} / I_{LOAD_MAX} = 9 V / 3A

%LOAD	Efficiency (%)	Average Efficiency (%)
100	92.68	91.66
75	92.23	
50	91.10	
25	90.64	
10	87.30	

V_{OUT} / I_{LOAD_MAX} = 12 V / 3A

%LOAD	Efficiency (%)	Average Efficiency (%)
100	93.42	92.55
75	92.74	
50	92.38	
25	91.68	
10	88.92	

V_{OUT} / I_{LOAD_MAX} = 15 V / 3A

%LOAD	Efficiency (%)	Average Efficiency (%)
100	93.77	92.41
75	93.26	
50	92.52	
25	90.07	
10	89.63	

V_{OUT} / I_{LOAD_MAX} = 20 V / 2.25A

%LOAD	Efficiency (%)	Average Efficiency (%)
100	93.78	92.27
75	93.32	
50	92.49	
25	89.47	
10	88.24	

Full Load Efficiencies at 90Vac / 115Vac / 230Vac / 265Vac; 5V / 9V / 15V / 20V
(measured after the USB-PD disconnect FET)

Vout = 5 V

Vin	Iout	Efficiency (%)
90 Vac @ 60 Hz	3A	91.51
115 Vac @ 60 Hz	3A	92.29
230 Vac @ 50 Hz	3A	91.02
265 Vac @ 50 Hz	3A	90.36

Vout = 9 V

Vin	Iout	Efficiency (%)
90 Vac @ 60 Hz	3A	92.03
115 Vac @ 60 Hz	3A	93.21
230 Vac @ 50 Hz	3A	92.66
265 Vac @ 50 Hz	3A	92.22

Vout = 12 V

Vin	Iout	Efficiency (%)
90 Vac @ 60 Hz	3A	92.01
115 Vac @ 60 Hz	3A	93.31
230 Vac @ 50 Hz	3A	93.42
265 Vac @ 50 Hz	3A	92.96

Vout = 15 V

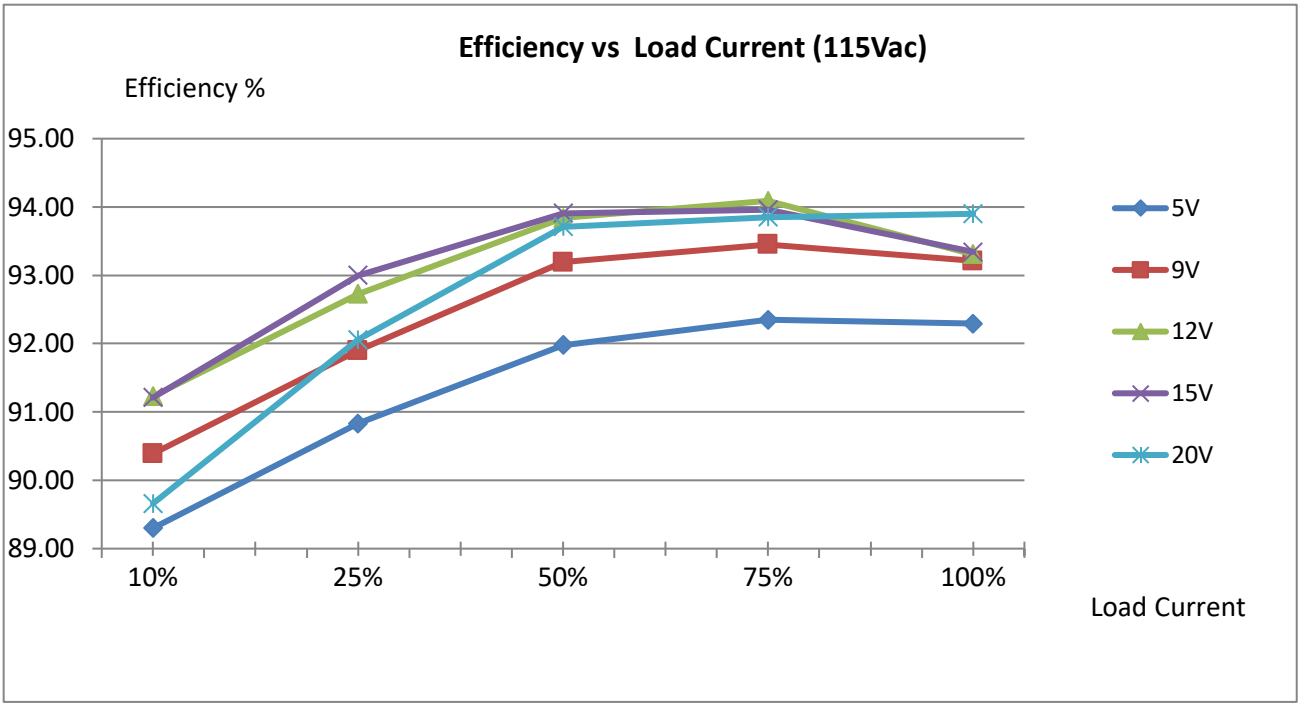
Vin	Iout	Efficiency (%)
90 Vac @ 60 Hz	3A	91.61
115 Vac @ 60 Hz	3A	93.34
230 Vac @ 50 Hz	3A	93.77
265 Vac @ 50 Hz	3A	93.41

Vout = 20 V

Vin	Iout	Efficiency (%)
90 Vac @ 60 Hz	2.25A	92.53
115 Vac @ 60 Hz	2.25A	93.90
230 Vac @ 50 Hz	2.25A	93.78
265 Vac @ 50 Hz	2.25A	93.43

Efficiency Graphs

The following graphs demonstrate 5 V/ 9 V/ 12V/ 15 V/ 20 V efficiency results with output measured after the USB-PD disconnect FET.



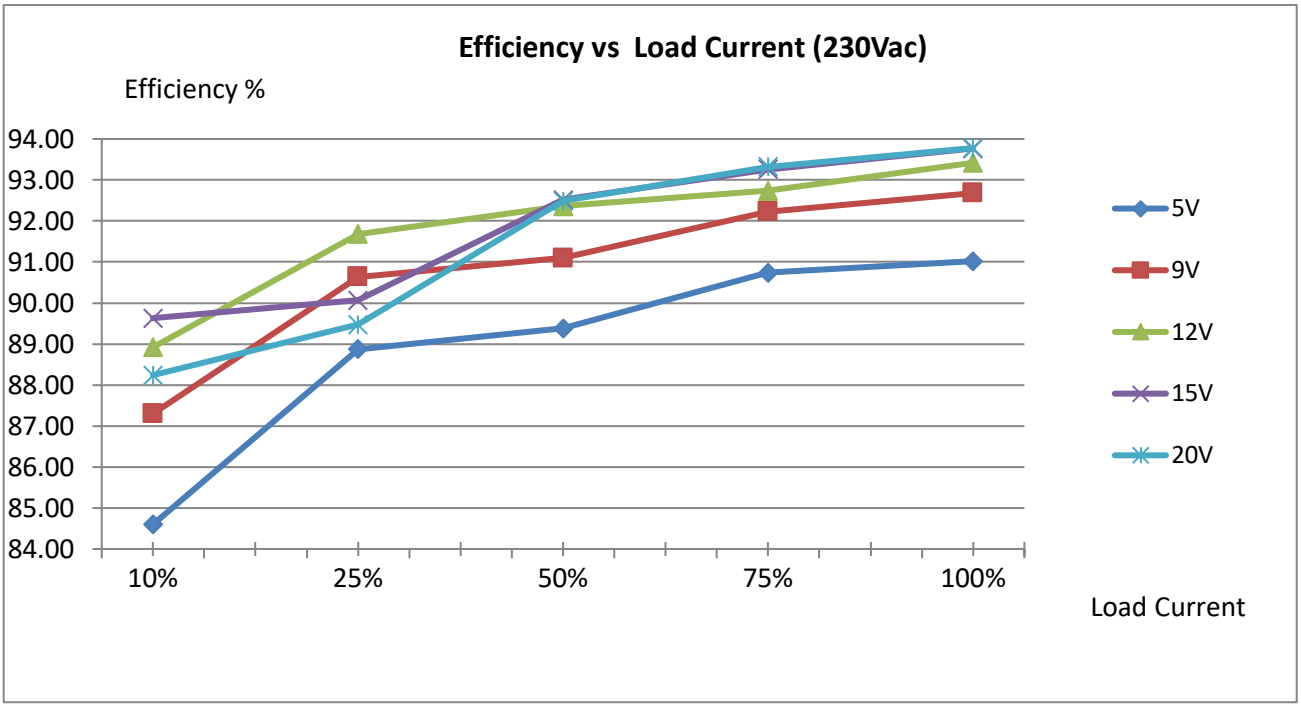


Figure 9: Efficiency graphs for various output voltages and load currents

Table 5 lists average no-load power consumption of two boards across the input voltages.

Table 5: No-load Power Consumption

Input Voltage (Vac)	No-Load Power (mW)
115	22.8
230	32.2

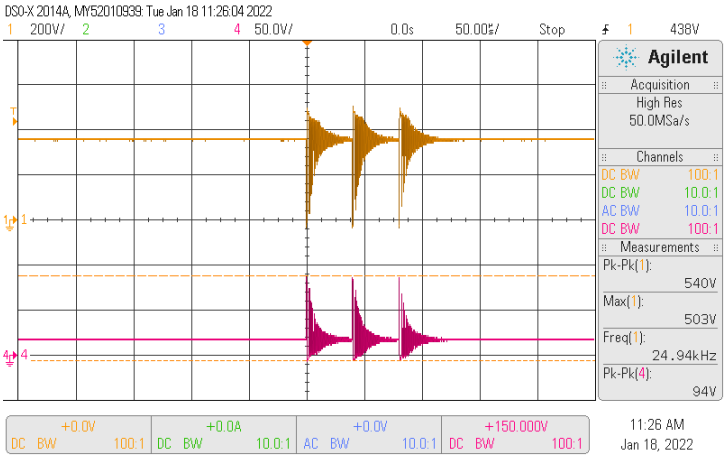
USB Power Tester Identification Data



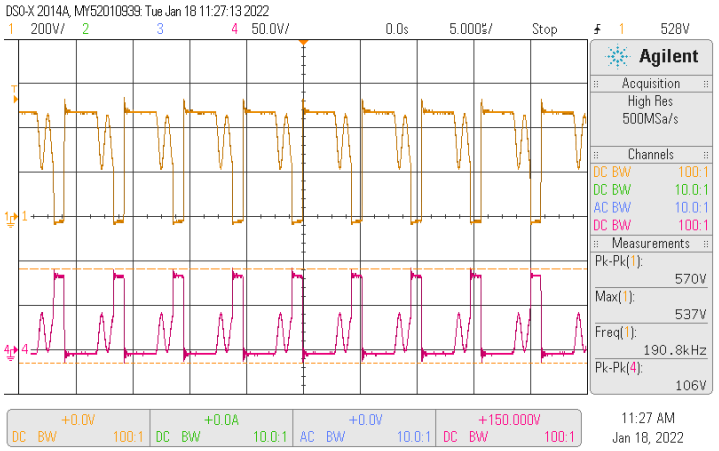
POWER-Z KT001

Key Waveforms

The key waveforms for the worst-case voltage conditions as seen by the primary side GaN Transistor and secondary side MOSFET are shown below.



Vin=264 Vac, Vout=20 V, Iout=0 A
Vds_pri (max) =540V
Vds_sec (max) =94V



Vin=264 Vac, Vout=20 V, Iout=2.25 A
Vds_pri (max) = 570V
Vds_sec (max) = 106V

Figure 10-1: Voltage stress on the primary and secondary side MOSFET during worst case operating conditions

Output Voltage Ripple Noise

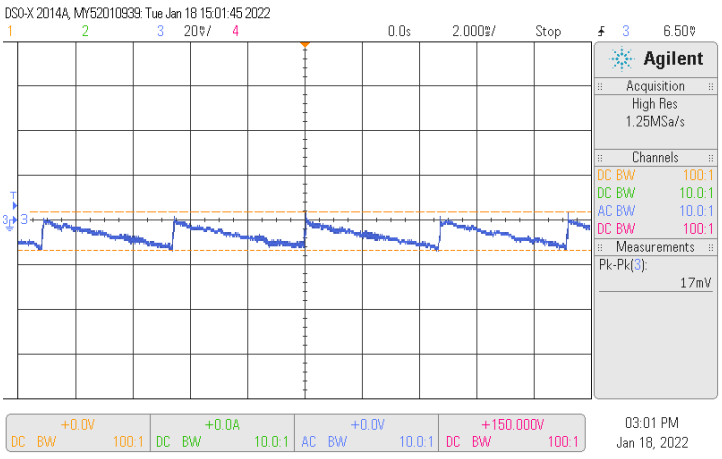
The output voltage ripple was measured using a voltage probe.

Measurement done at load side using an E-Mark USB cable.

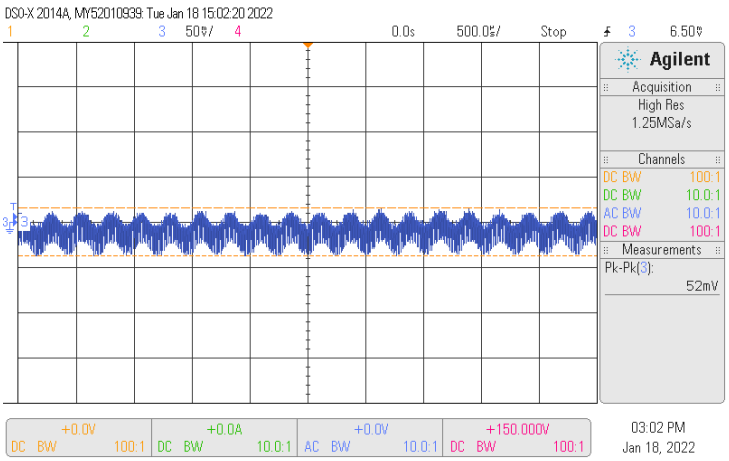
Table 6: Output Voltage Ripple Summary

Input Voltage (Vac)	Vout / Iout	Measured Output Ripple (mVpk-pk)
115	5V / 0A	17
	5V / 3A	52
	9V / 0A	11
	9V / 3A	58
	12V / 0A	9
	12V / 3A	64
	15V / 0A	8
	15V / 3A	62
	20V / 0A	7
	20V / 2.25A	64
230	5V / 0A	21
	5V / 3A	50
	9V / 0A	13
	9V / 3A	55
	15V / 0A	12
	12V / 0A	54
	12V / 3A	10
	15V / 3A	57
	20V / 0A	9
	20V / 2.25A	57

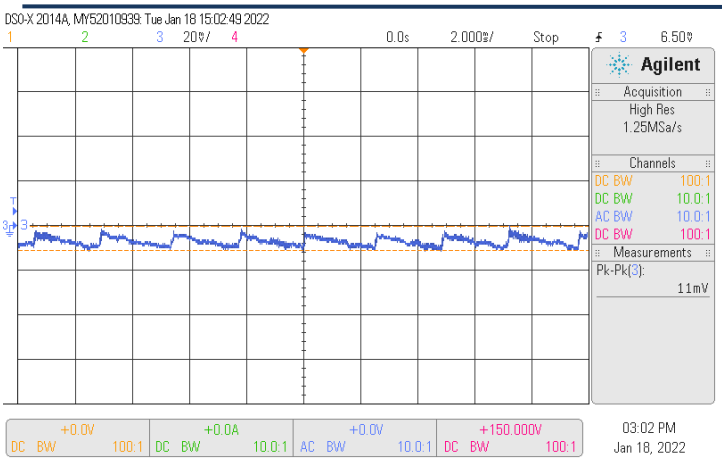
a. 115Vac 60Hz



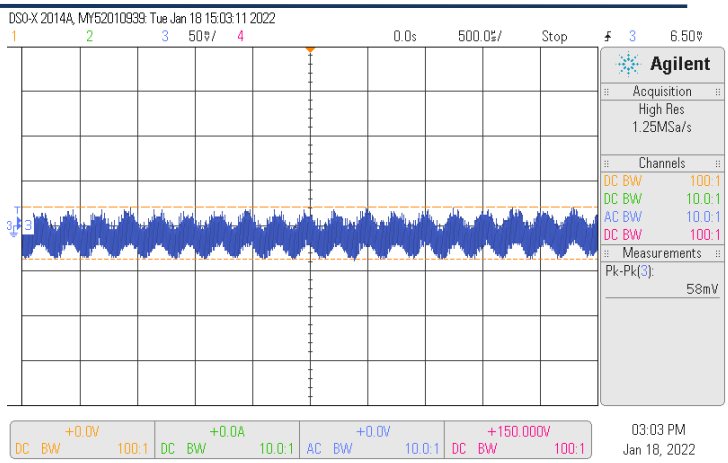
Vin = 115Vac, 60Hz; Vout = 5V; Iout = 0A



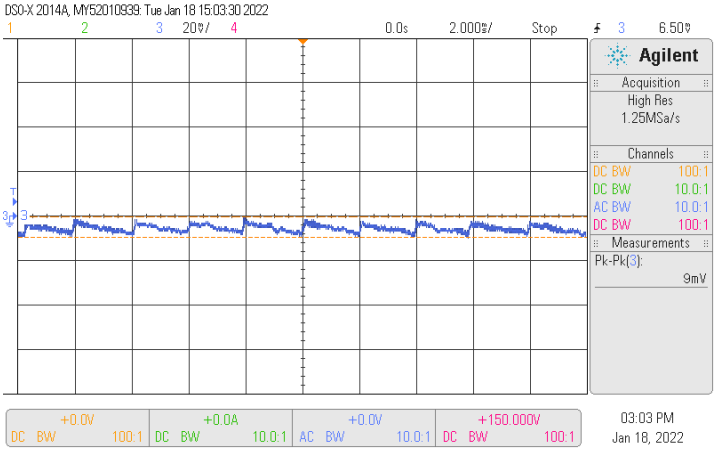
Vin = 115Vac, 60Hz; Vout = 5V; Iout = 3A



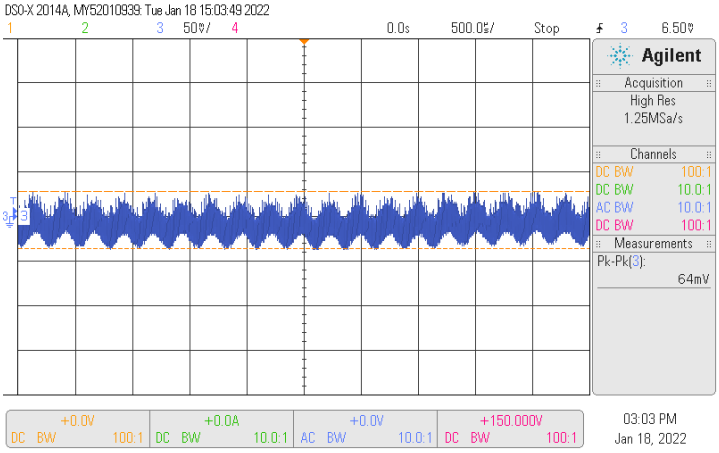
Vin = 115Vac, 60Hz; Vout = 9V; Iout = 0A



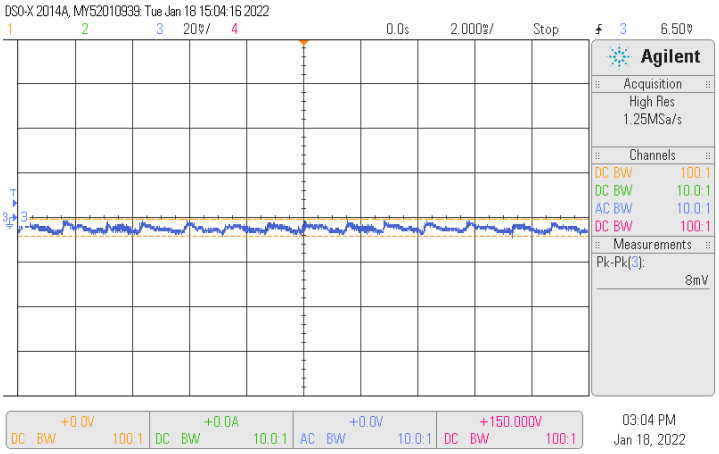
Vin = 115Vac, 60Hz; Vout = 9V; Iout = 3A



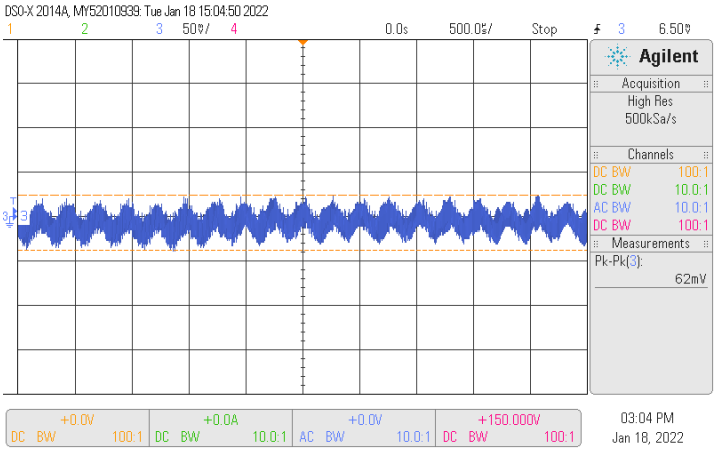
Vin = 115Vac, 60Hz; Vout = 12V; Iout = 0A



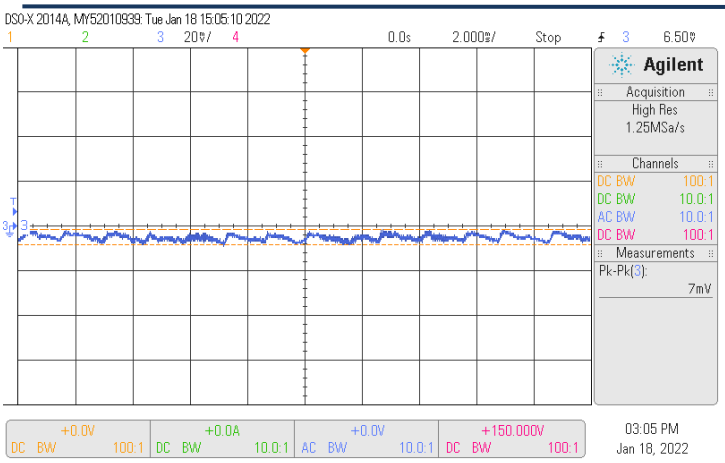
Vin = 115Vac, 60Hz; Vout = 12V; Iout = 3A



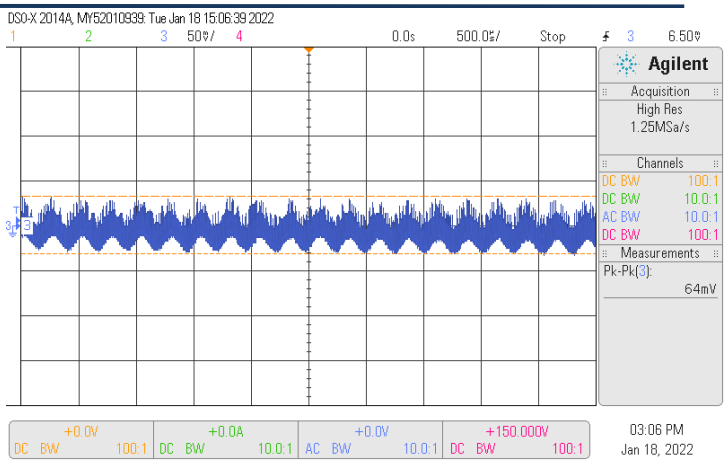
Vin = 115Vac, 60Hz; Vout = 15V; Iout = 0A



Vin = 115Vac, 60Hz; Vout = 15V; Iout = 3A

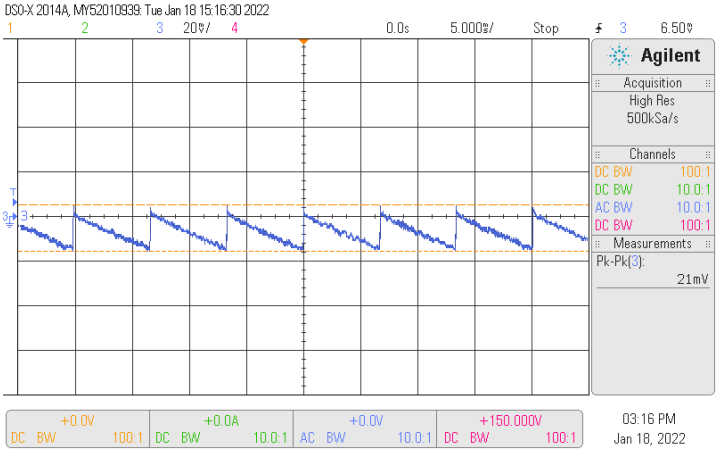


Vin = 115Vac, 60Hz; Vout = 20V; Iout = 0A

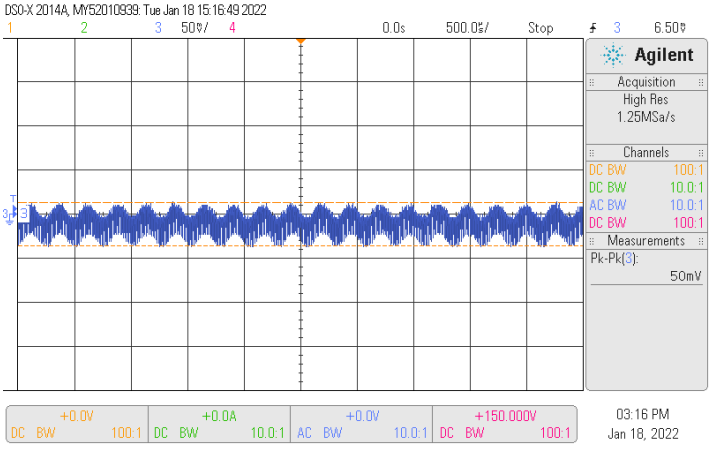


Vin = 115Vac, 60Hz; Vout = 20V; Iout = 2.25A

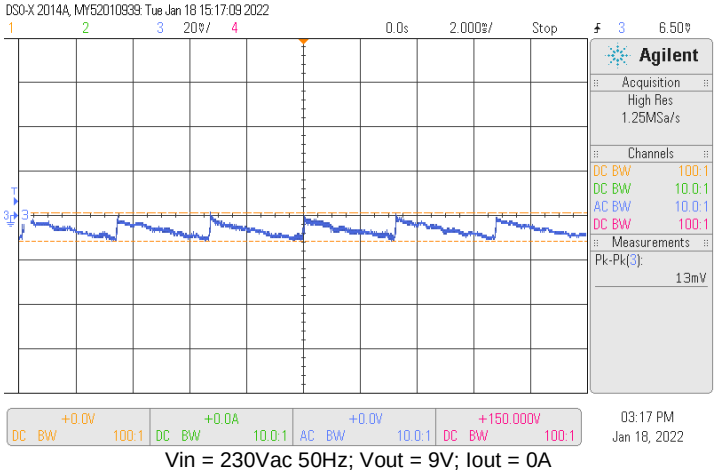
b. 230Vac 50Hz



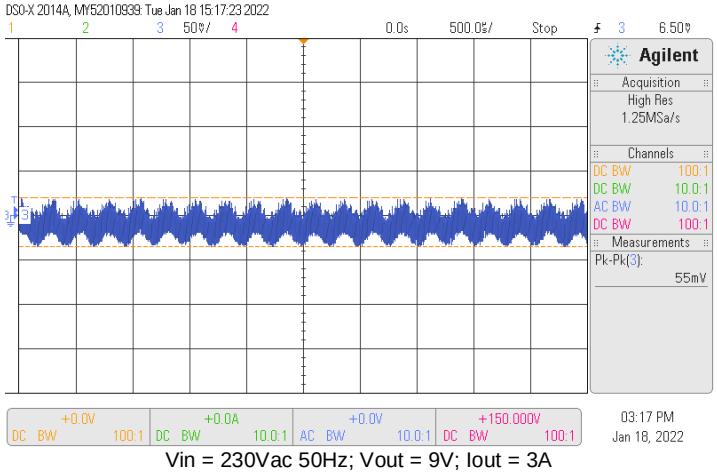
Vin = 230Vac 50Hz; Vout = 5V; Iout = 0A



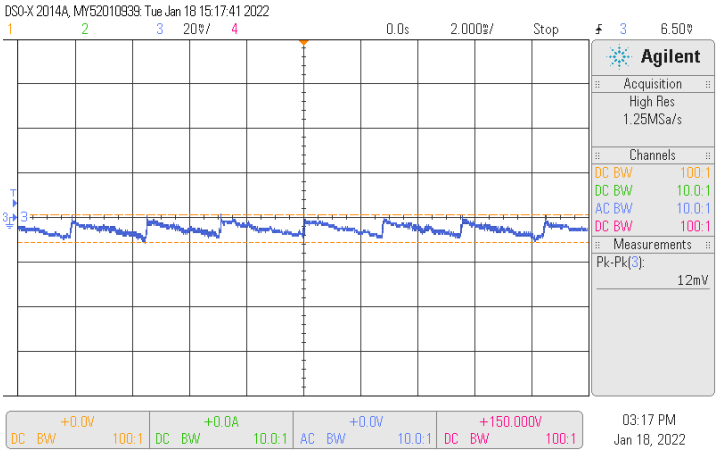
Vin = 230Vac 50Hz; Vout = 5V; Iout = 3A



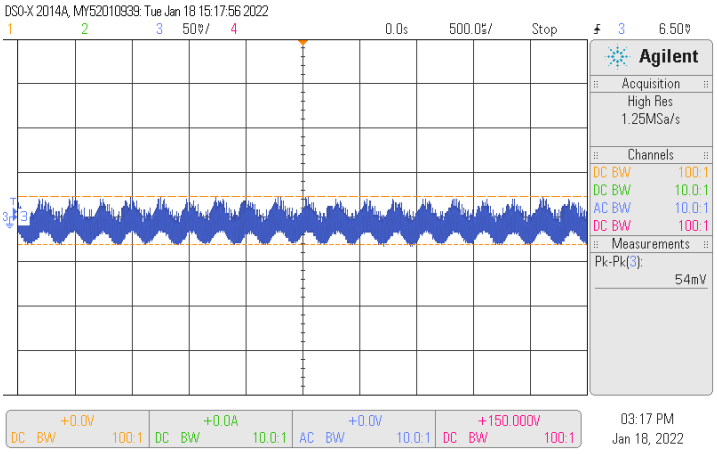
Vin = 230Vac 50Hz; Vout = 9V; Iout = 0A



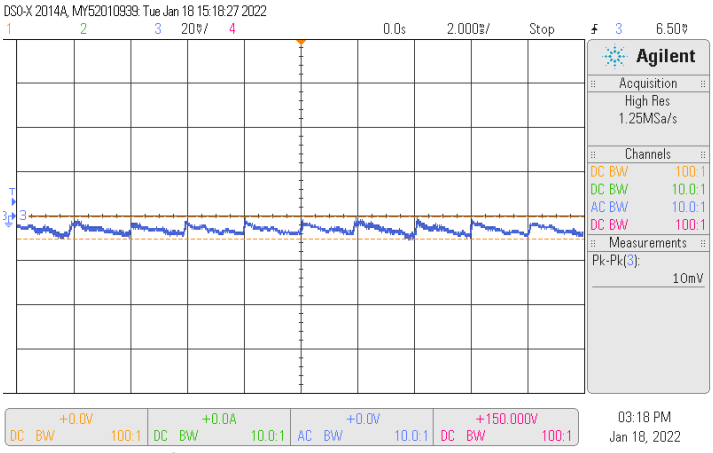
Vin = 230Vac 50Hz; Vout = 9V; Iout = 3A



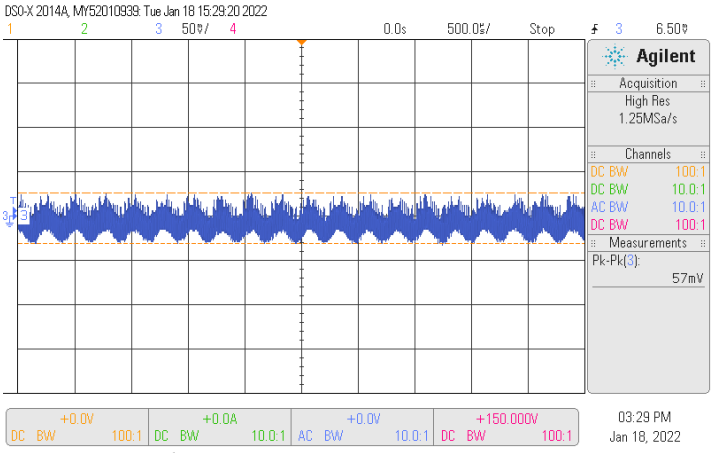
Vin = 230Vac 50Hz; Vout = 12V; Iout = 0A



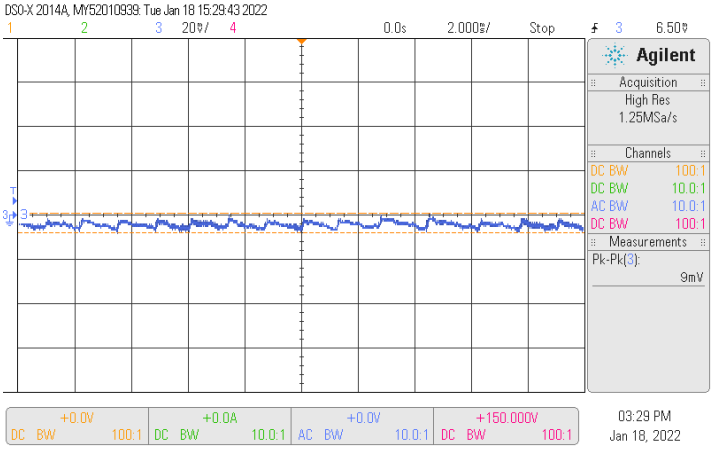
Vin = 230Vac 50Hz; Vout = 12V; Iout = 3A



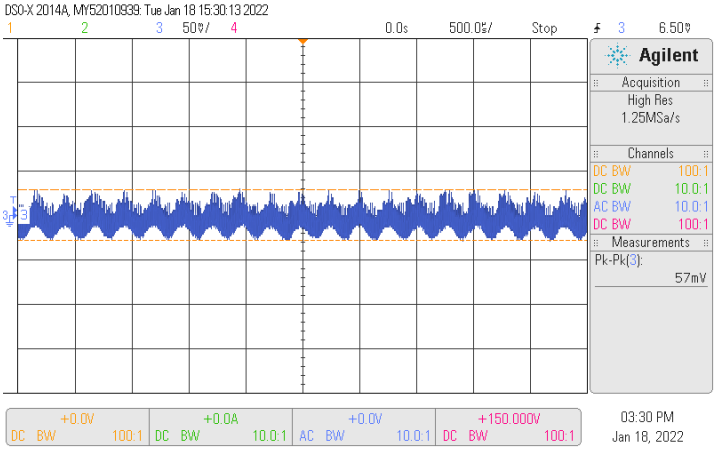
Vin = 230Vac 50Hz; Vout = 15V; Iout = 0A



Vin = 230Vac 50Hz; Vout = 15V; Iout = 3A



Vin = 230Vac 50Hz z; Vout = 20V; Iout = 0A



Vin = 230Vac 50Hz; Vout = 20V; Iout = 2.25A

Figure 12: Output Voltage Ripple Waveforms under various operating condition

Thermal Measurements

The key component temperatures are shown below for 90Vac & 264Vac full load (20V/45W) operating conditions after 1hr bake time.

RefDes	Description	Temp. at 90Vac	Temp. at 264Vac
T1	RM8	75.4	79.9
CE7	470uF 25V	66.3	69.9
DB1	HBS610	82.5	61.7
U4	NCP1342AMDCDD1R2G	77.2	76.8
Q3	TP65H480G4JSG	87.8	89.2
U2	MP6908A	67.7	85.7
Q1	HGN093N12SL	69.9	76.8
U3	WT6633P	69.8	75.7
Q2	BSZ0902NS	64.1	72.2

Revision History Revision

Hardware Info

Info	Value
Timestamp	Jan. 24, 2022
Primary IC	Flyback PWM Controller (NCP1342AMDCDD)
Primary ACF Switch	Transphorm 650 V SuperGaN™ FET (TP65H480G4JSG)
Secondary IC	MP6908A
AC Supply	Chroma Programable AC Source, 61602
Input Meter	Chroma digital power meter 66201
Output Meter	ESCORT 3146A
Oscilloscope	Agilent Technologies DSO-X 2014A
No-load bake time	300
Input voltages	[(90, 60), (115, 60), (230, 50), (265, 50)]
Output voltages	[5, 9, 12, 15, 20]
Electronic Load	Chroma, 63030
USB PD	Weltrend WPD010-1
Cable	E-mark type-C