ON Semiconductor

Design Note – DN05100/D

45W TYPE-C PD2.0 Power Adapter Solution

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1340B3 NCP43080D NTMFS6B03 ATP104	Smart phone, PAD and NB adapter supporting PD2.0 and QC2.0	90Vac to 264Vac	45W	Flyback	Isolated (3 kV)

	PD Output Specification	QC Output Specification
Output Voltage	5V, 9V, 12V, 15V, 20V	5V, 9V, 12V
Nominal Current	5V/3A, 9V/3A, 12V/3A,15V3A, 20V/2.25A	5V/3A, 9V/3A, 12V/3A
Max Current	5V/3A, 9V/3A, 12V/3A,15V3A, 20V/2.25A	5V/3A, 9V/3A, 12V/3A
Min Current	zero	zero

Avg. Efficiency	>90%@20V2.25A at board end, 115&230Vac
Ripple	<100mV
Standby Power	<30mW @5V&230Vac(No cable plug in)
Power Density	1.15W/cm^3
Protection	Adaptive UVP, OVP, OVP, SCP, OTP
Size	57mmx36mmx19mm

Circuit Description

This design note describes a 45 watt, Type C interface PD2.0, universal AC input, constant voltage power supply intended for smart phone, PAD and NB adaptor supporting PD2.0 or QC2.0 protocol, where isolation from the AC mains is required, and low cost, high efficiency, and low standby power are essential.

The featured power supply is a simple QR flyback topology utilizing ON Semiconductor's NCP1340B3 HF PWM controller, NCP43080D synchronous rectified controller, NTMFS6B03 synchronous MOSFET and ATP104 Switch MOSFET. This Design Note provides the complete circuit schematic details, PCB and BOM for 45W Type C Interface PD2.0 Power adapter solution which supports PD output (5V/3A, 9V/3A, 12V/3A, 15V/3A, 20V/2.25A).

This design combined with CanYon's CY2211 PD2.0 protocal controller to provide PD2.0 and QC2.0 functions. This design also proposes a dual auxiliary power supply to supply PWM controller, the PWM controller is supplied by high voltage auxiliary voltage at low output voltage and supplied by low voltage auxiliary voltage at high output voltage and also shuts down zener bias of high voltage Vcc while low voltage auxiliary voltage supplies controller.

This design also uses synchronous rectified controller to provide high efficiency and also uses an external Vcc pulse regulator to supply synchronous controller to ensure controller can works below 4v.

Key Features

- Universal AC input range (90 – 264 Vac)
- Very low standby (5V & 230Vac) power consumption with no cable plug in
- Very low ripple and noise
- Inherent SCP and OCP protection
- High operation frequency up to 150kHz
- High power density (1.15 W/cm^3)
- Quick switching off FET while unplugging cable and switching on FET at Vbus dropping to 5v while plugging cable again
- Quasi-Resonant current mode control with Valley Switching
- Valley lockout avoids audible noise at valley jumping operation
- Support TYPE-C PD2.0&QC2.0 protocol
- Adaptive Output OVP and UVP
- Open loop protection
- Board size: 57mmx36mmx19mm

Block Diagram and BOARD Photoes

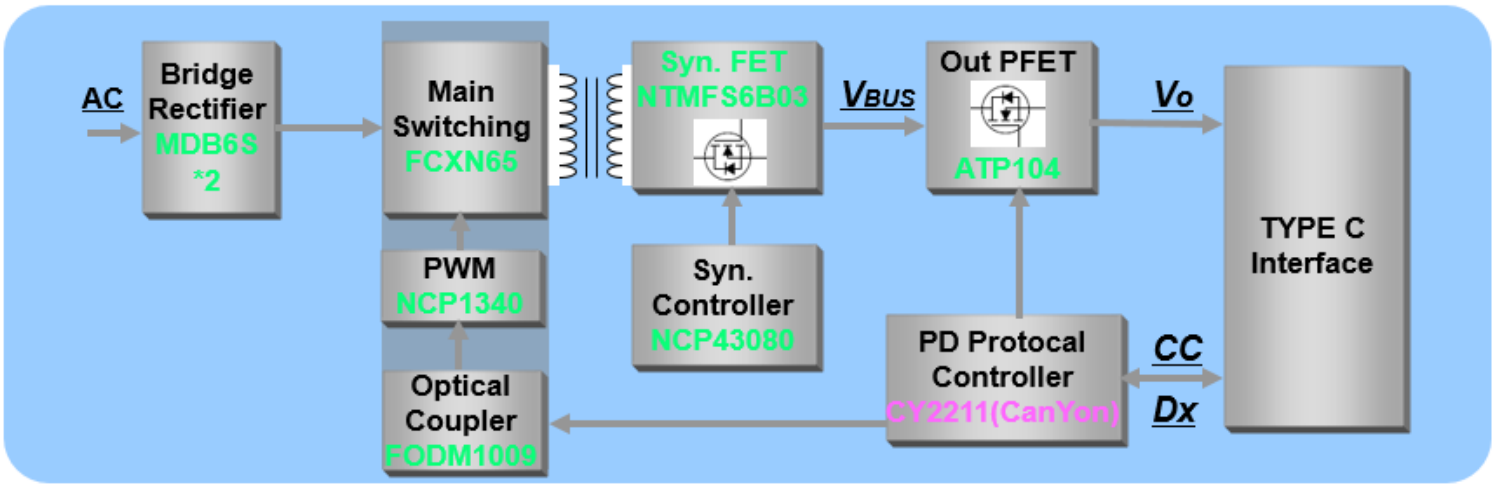


Figure 1, Overall cycle of 45W TYPE-C PD adapter Solution

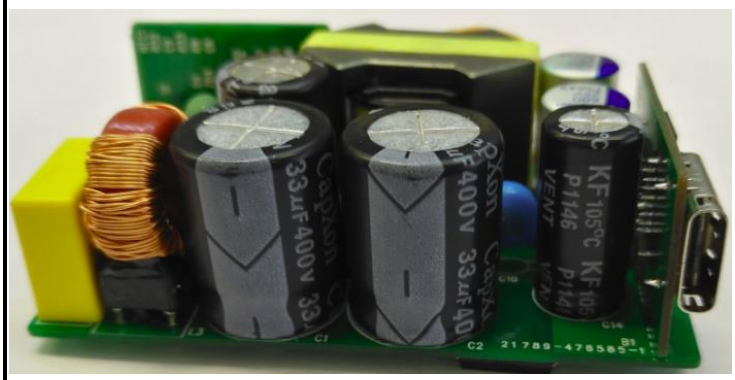


Figure 2, Side view 1 of demoboard

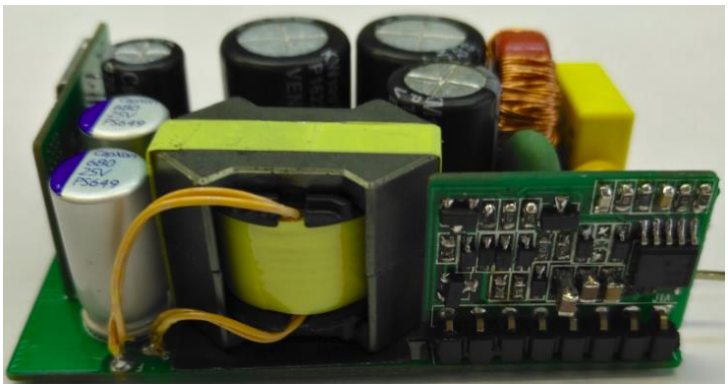
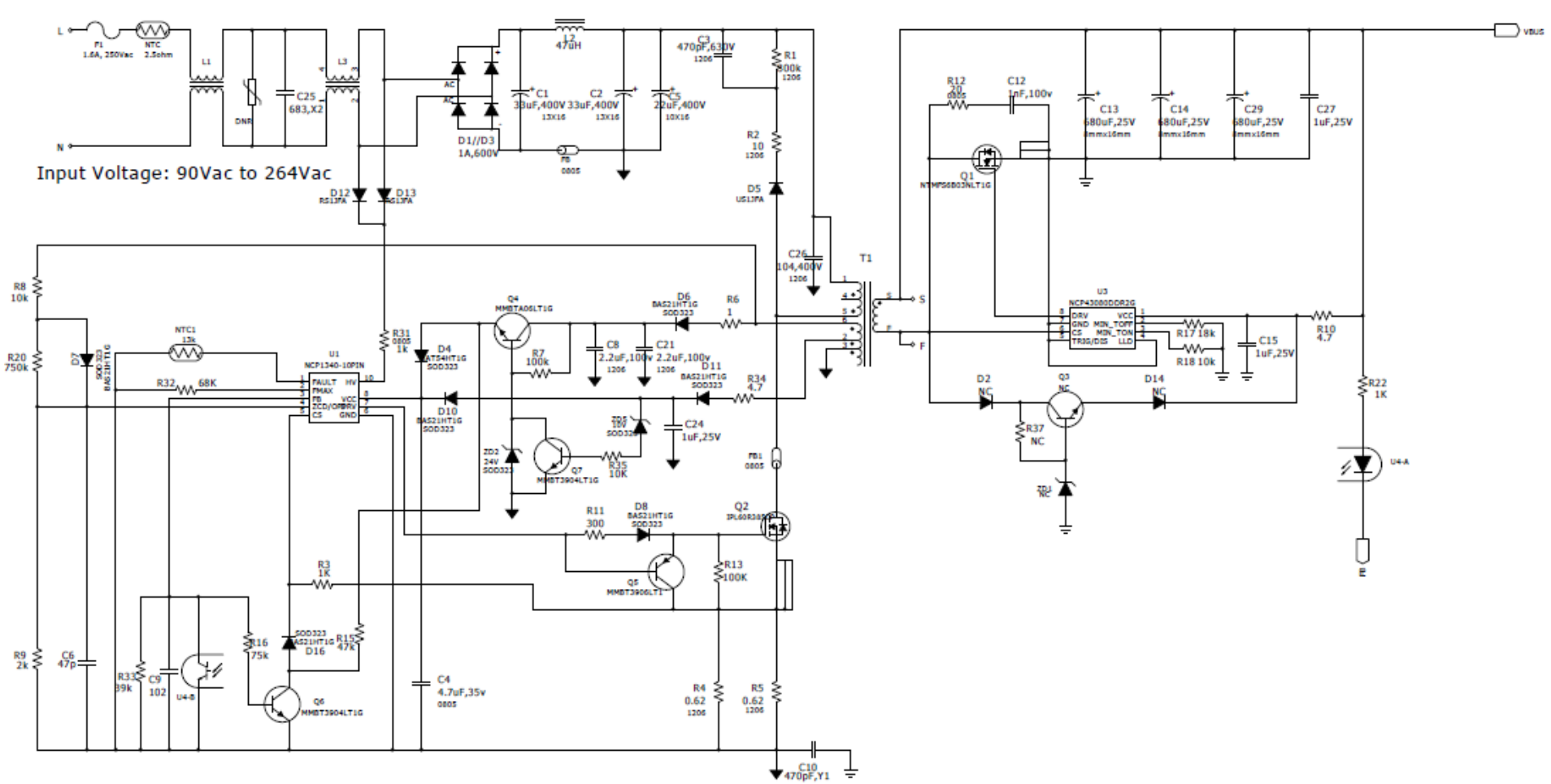
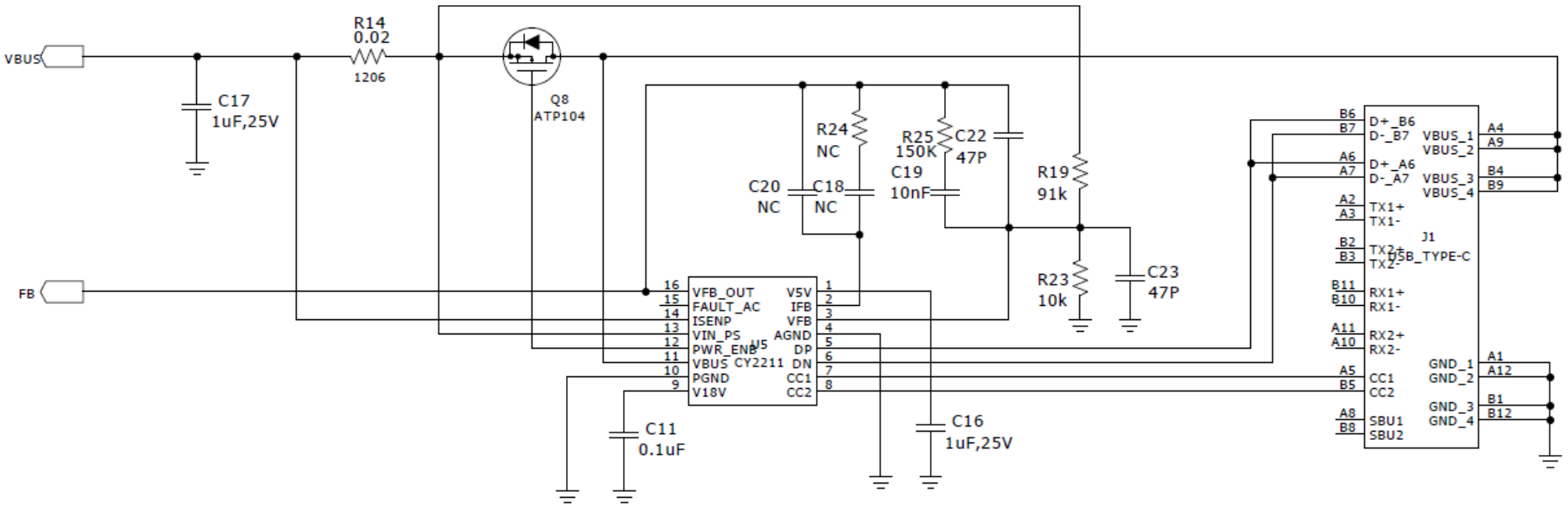


Figure 3, Side view 2 of demoboard

DN05100/D
Circuit Schematic



Circuit Schematic (Continued)



PCB

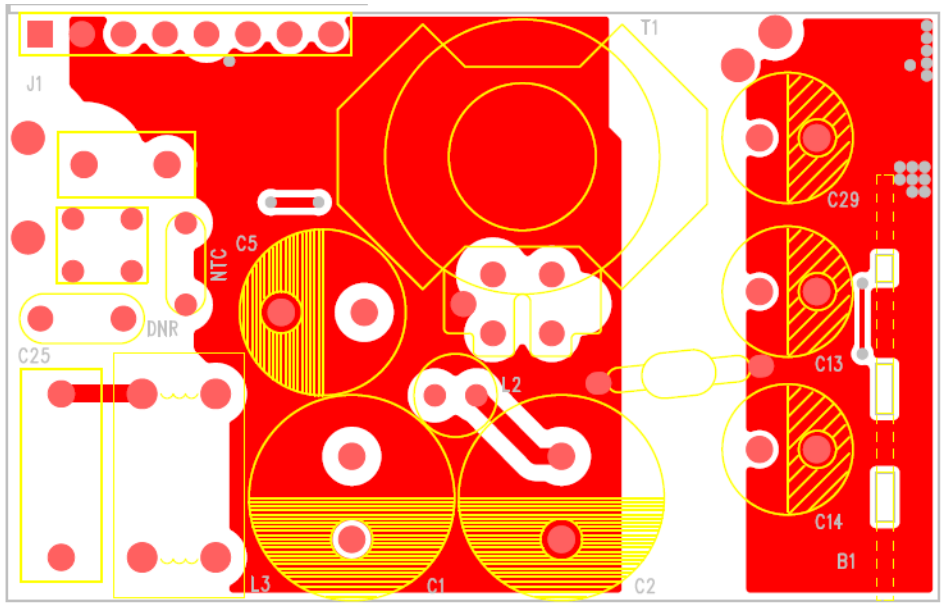


Figure 3, Top View of Mainboard's PCB

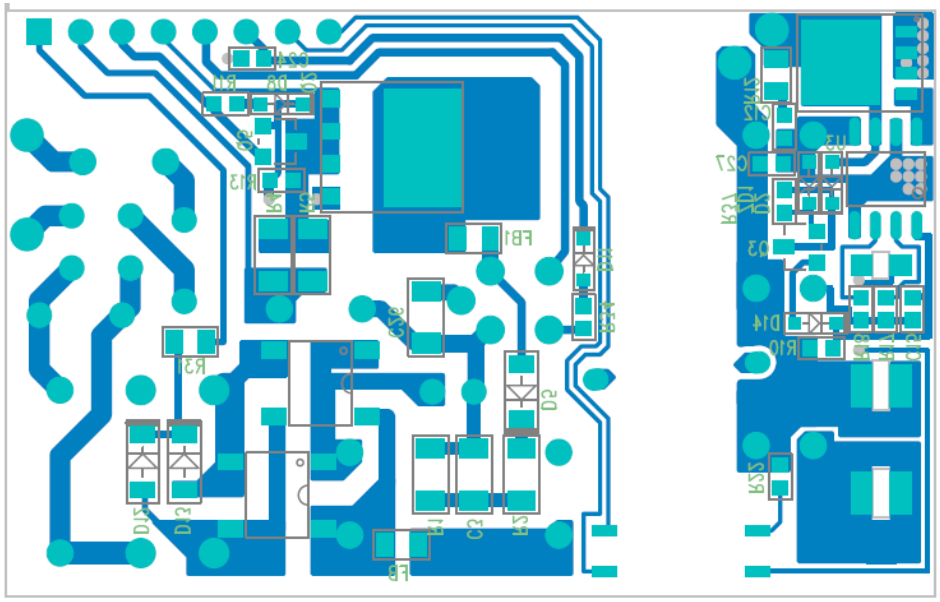


Figure 4, Bottom View of Mainboard's PCB

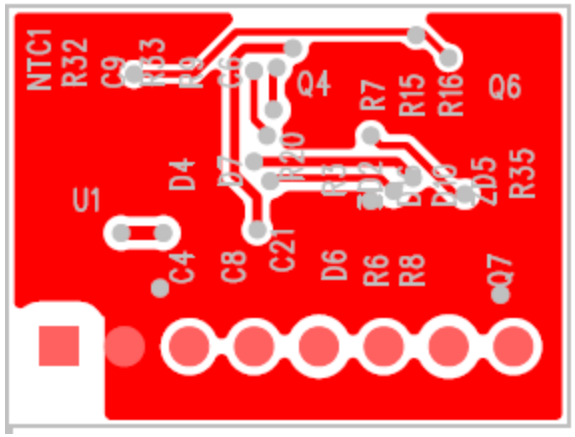


Figure 5, Top View of PWM control board's PCB

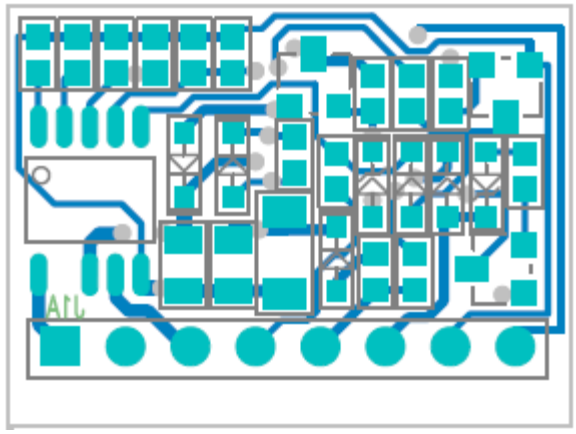


Figure 6, Bottom View of PWM control board's PCB

PCB (Continued)

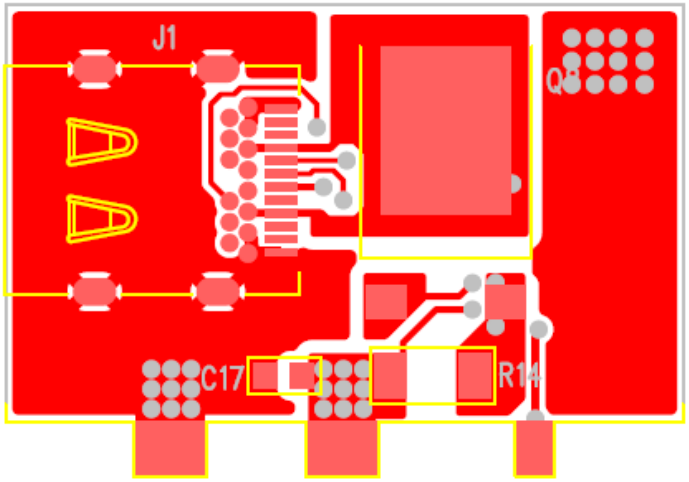


Figure 7, Top View of PD control board (CY2211)'s PCB

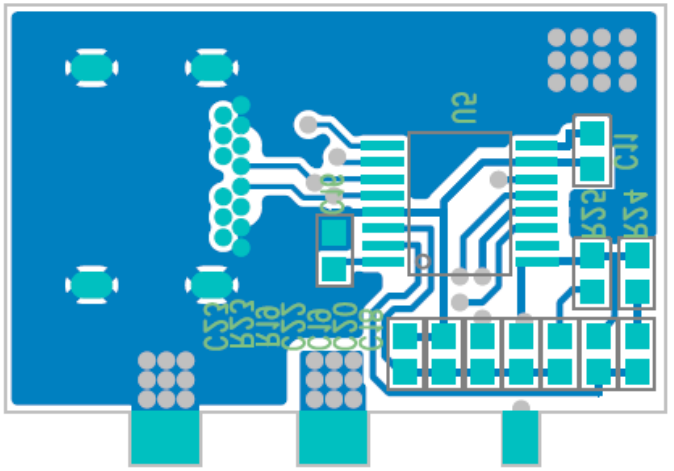
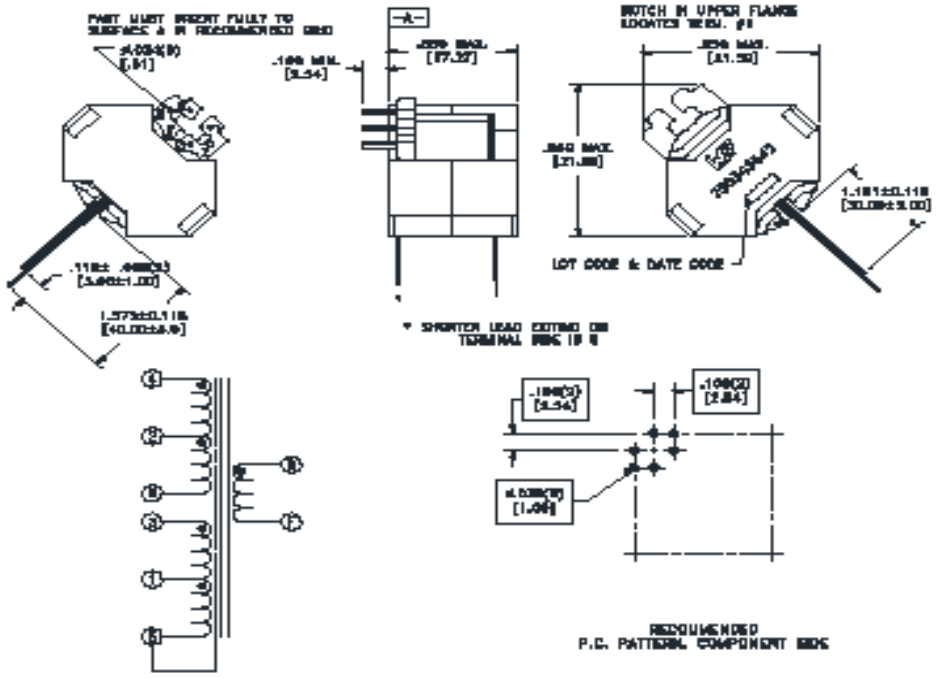


Figure 8, Bottom View of PD control board (CY2211)'s PCB

T1 Transformer Designs (Available from Wurth Electronics)

CUSTOMER TERMINAL	RoHS	LEAD(Pb)–FREE
Sn 96%, Ag 4%	Yes	Yes



ELECTRICAL SPECIFICATIONS @ 25° C unless otherwise noted:

PARAMETER		TEST CONDITIONS	VALUE
D.C. RESISTANCE	S-F	@20°C	0.020 ohms max.
D.C. RESISTANCE	3-1	@20°C	0.325 ohms max.
D.C. RESISTANCE	1-5	@20°C	0.220 ohms max.
D.C. RESISTANCE	4-6	@20°C	0.585 ohms max.
INDUCTANCE	4-6	10kHz, 1V, Ls	360.00µH ±10%
LEAKAGE INDUCTANCE	4-6	tie(1+3+5+S+F),100kHz, 100mV, Ls	6µH max.
DIELECTRIC	1-S	tie(1+6), 3750VAC, 1 second	3000VAC, 1 minute
DIELECTRIC	S-CORE	3750VAC, 1 second	3000VAC, 1 minute
TURNS RATIO		(4-6):(3-1)	4.33:1, ±2%
TURNS RATIO		(4-6):(1-5)	6.5:1, ±2%
TURNS RATIO		(4-6):(S-F)	6.5:1, ±2%

GENERAL SPECIFICATIONS:

OPERATING TEMPERATURE RANGE: -40°C to +125°C including temp rise.

Designed to comply with the following requirements as defined by IEC60950-1, EN60950-1, UL60950-1/CSA60950-1 and AS/NZS60950.1:

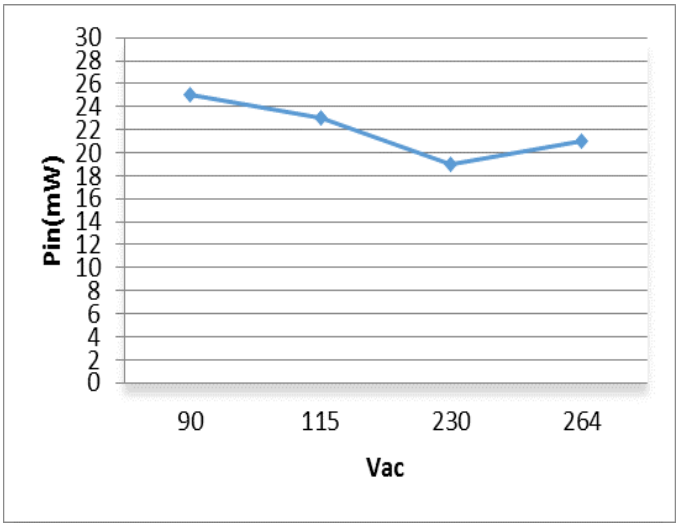
- Reinforced insulation for a primary circuit at a working voltage of 265Vrms, 400Vpeak, Overvoltage Category II.

Wire Insulation & RoHS status not affected by wire color. Wire Insulation color may vary depending on availability.

DFM		Packaging Specifications	Tolerances unless otherwise specified:	DRAWING TITLE	PART NO.
DATE		Method: Tray	Angles: ±1° Decimals: ±.005 [.13]	TRANSFORMER	750343542
ENG	NWA	PKG-TBD	Fractions: ±1/64 Footprint: ± .001 [.03]		
REV.	00	CONVENTION PLACEMENT	This drawing is dual dimensioned. Dimensions in brackets are in millimeters.		SPECIFICATION SHEET 1 OF 1
DATE	4/11/2017	www.we-online.com/mics			

Standby Power at 5V Output (Cable unplug) @ 90 Vac to 264 Vac Input

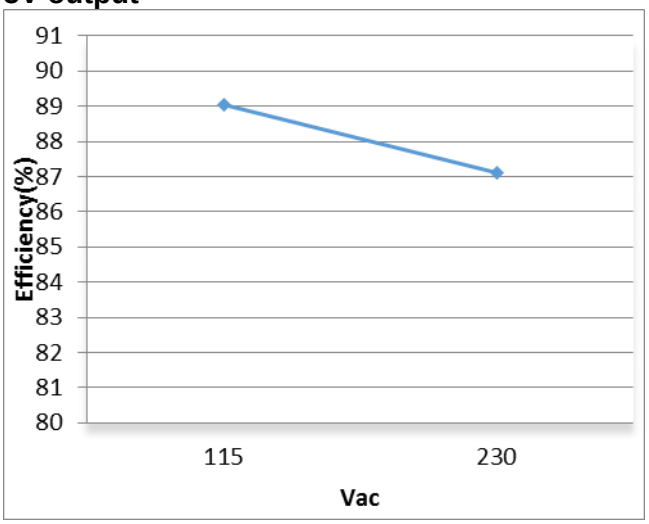
Test condition: all efficiency are tested at board end



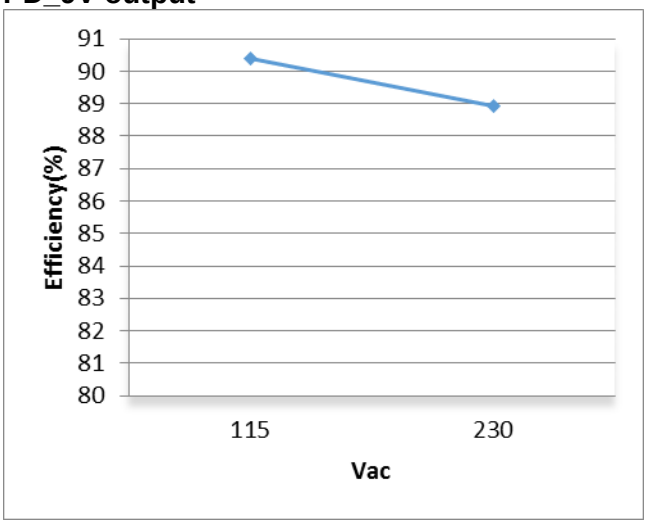
Average Efficiency @ 115 Vac & 230 Vac Input

Test condition: all efficiency are tested at board end

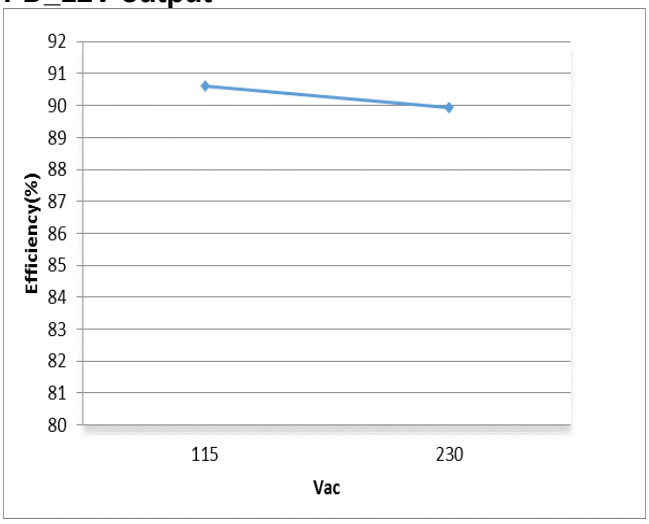
5V output



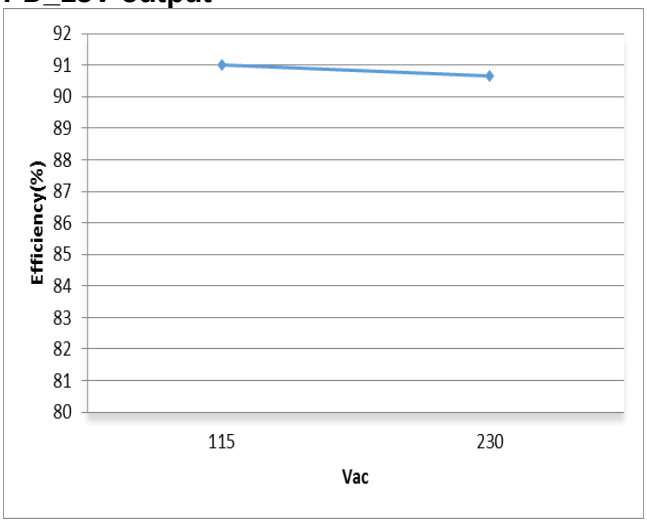
PD_9V output



PD_12V output



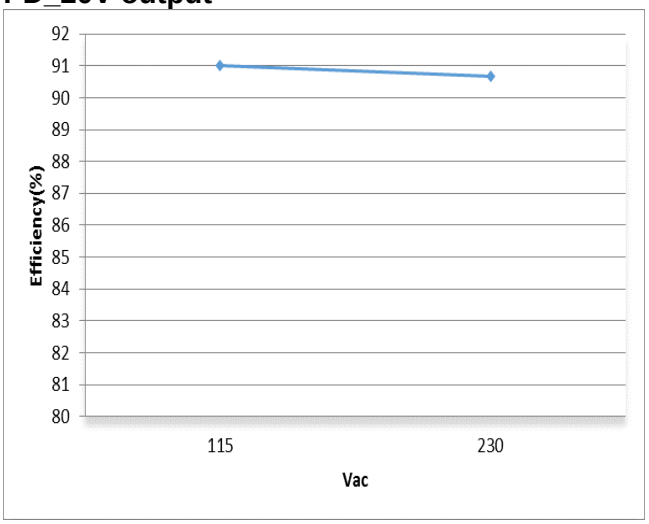
PD_15V output



Average Efficiency @ 115 Vac & 230 Vac Input (Continued)

Test condition: all efficiency are tested at board end

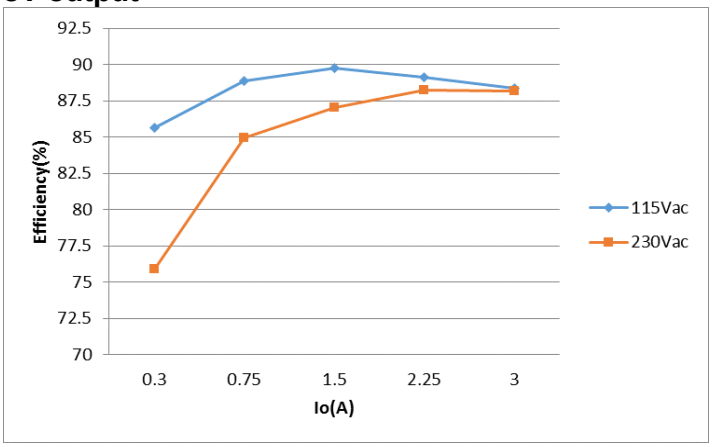
PD_20V output



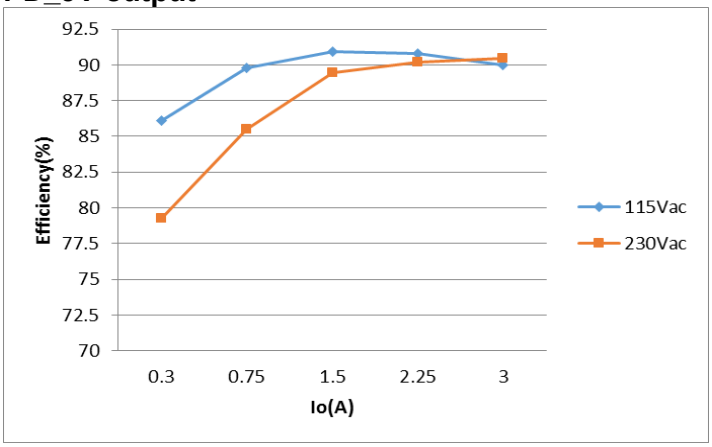
Efficiency vs Output Load Curves @ 115 Vac & 230 Vac Input

Test condition: all efficiency are tested at board end

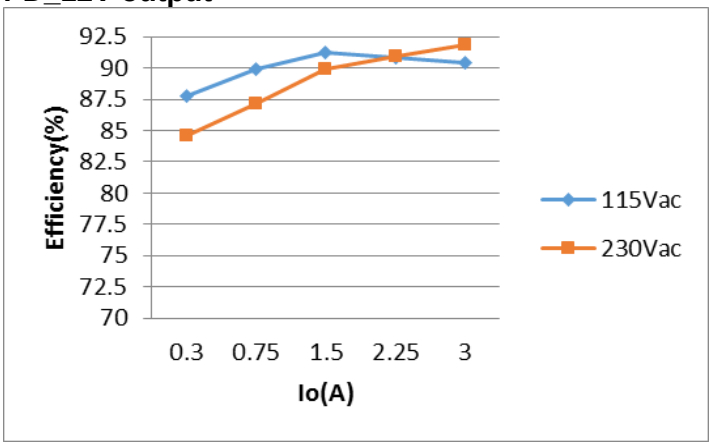
5V output



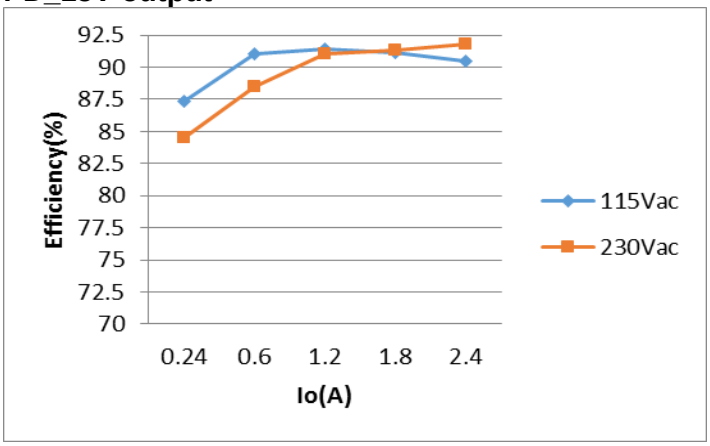
PD_9V output



PD_12V output



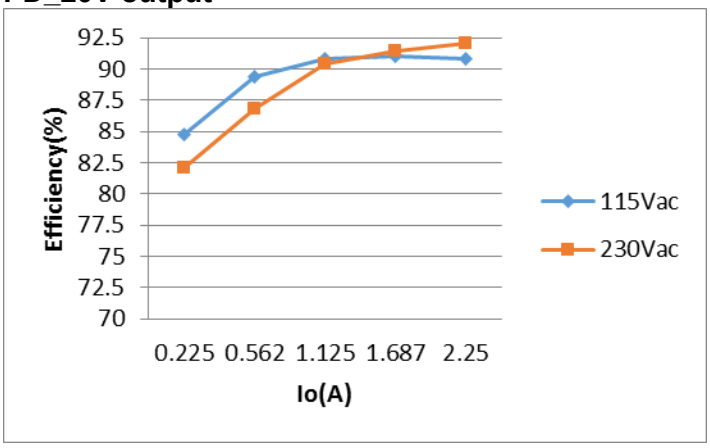
PD_15V output



Efficiency vs Output Load Curves @ 115 Vac & 230 Vac Input (Continued)

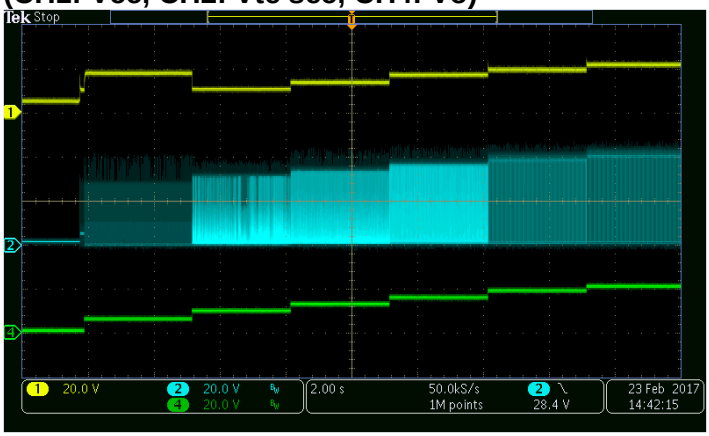
Test condition: all efficiency are tested at board end

PD_20V output



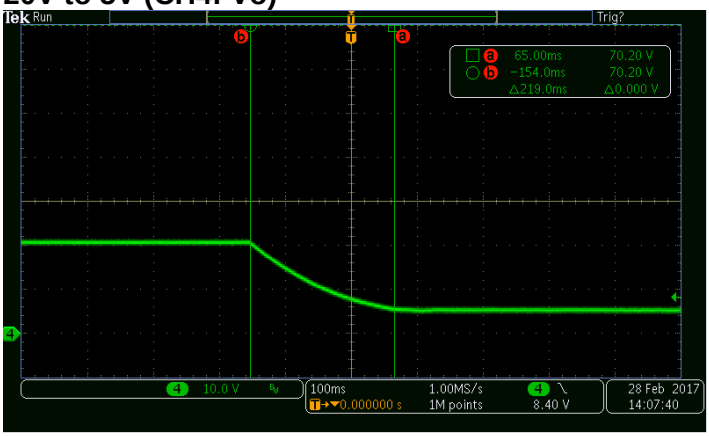
Power On and PD Volatge Change (5V > 9V > 12V > 15V > 18V >20V)

(CH1: Vcc, CH2: Vte sec, CH4: Vo)



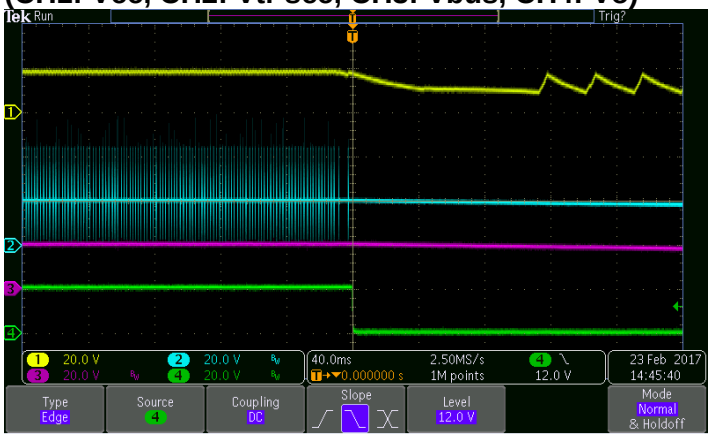
PD Transition with PD Emulator

20V to 5V (CH4: Vo)



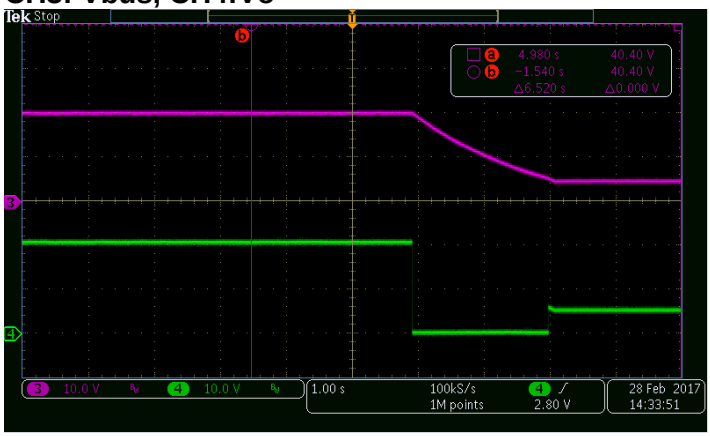
Discharge Time @ Unplug cable

PD (20V to 5V)
(CH1: Vcc, CH2: Vtr sec, CH3: Vbus, CH4: Vo)



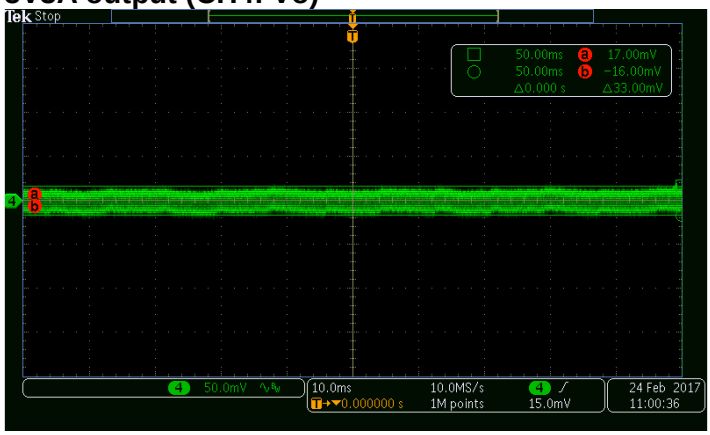
Quick Unplug/Plug Cable

CH3: Vbus, CH4:Vo

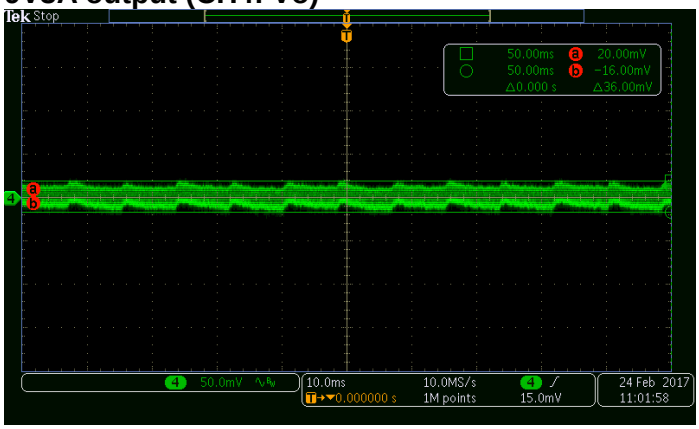


Output Ripple @ 90 Vac Input, 3A Output

5V3A output (CH4: Vo)

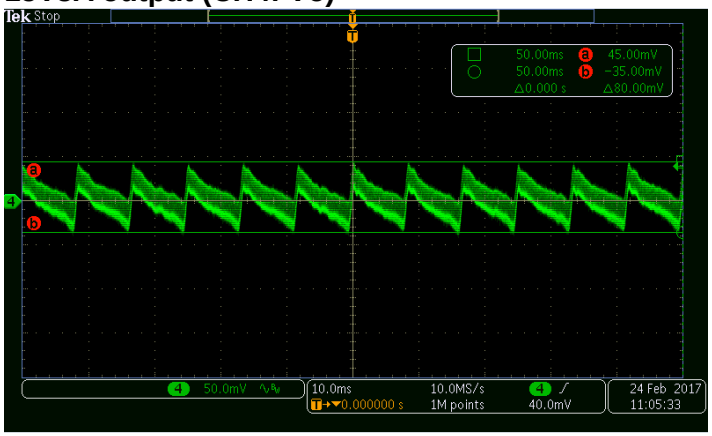


9V3A output (CH4: Vo)

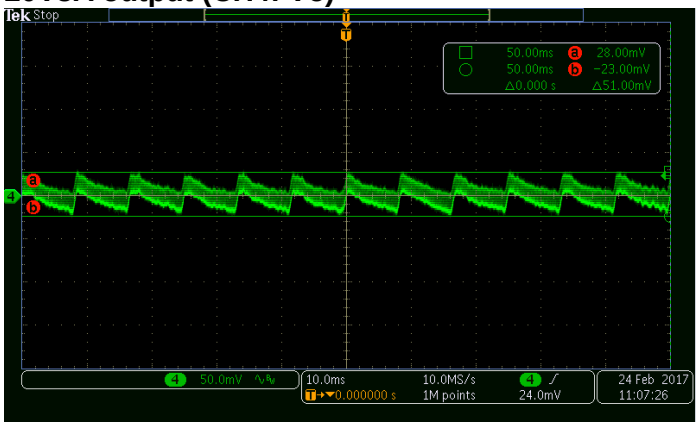


Output Ripple @ 90 Vac Input, 3A Output (Continued)

15V3A output (CH4: Vo)

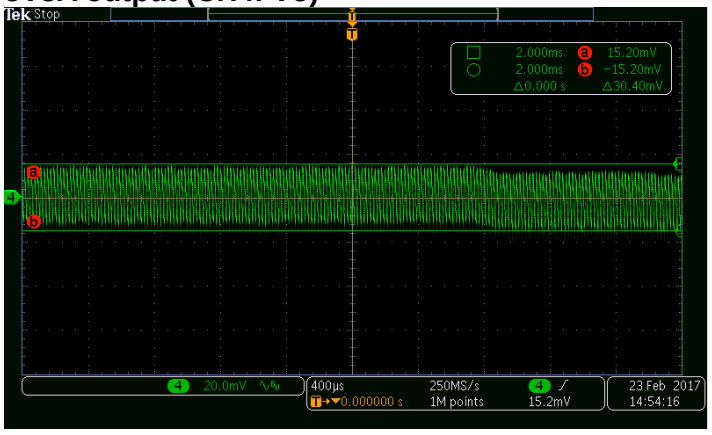


20V3A output (CH4: Vo)

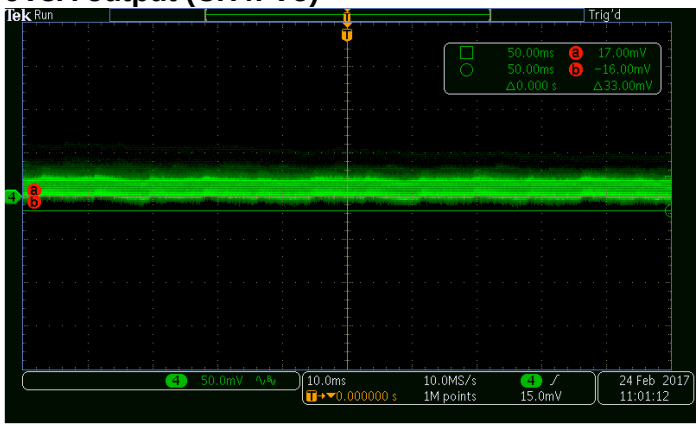


Output Ripple @ 115 Vac Input, 3A Output

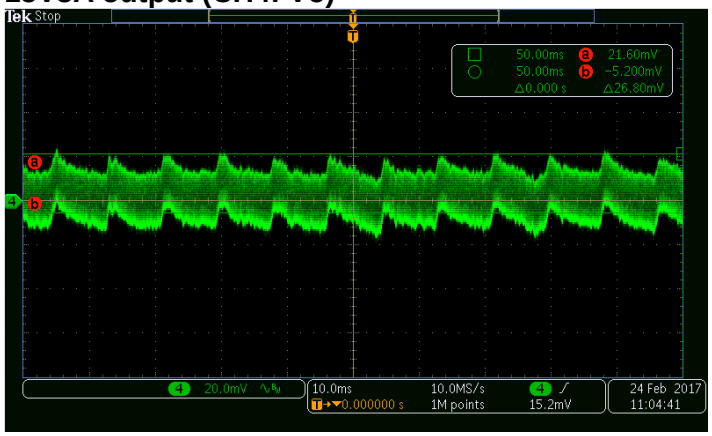
5V3A output (CH4: Vo)



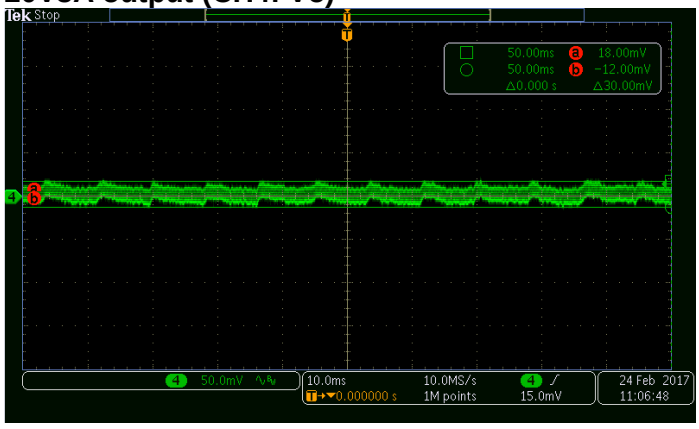
9V3A output (CH4: Vo)



15V3A output (CH4: Vo)

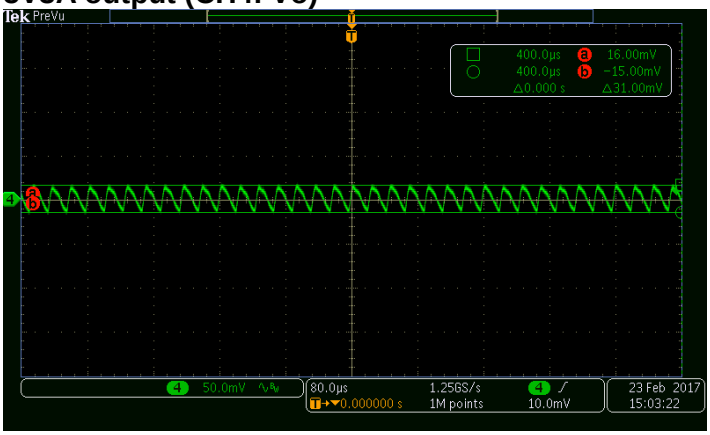


20V3A output (CH4: Vo)

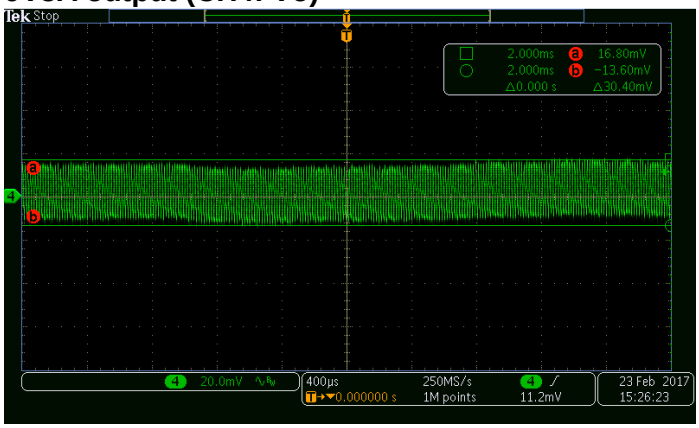


Output Ripple @ 230 Vac Input, 3A Output

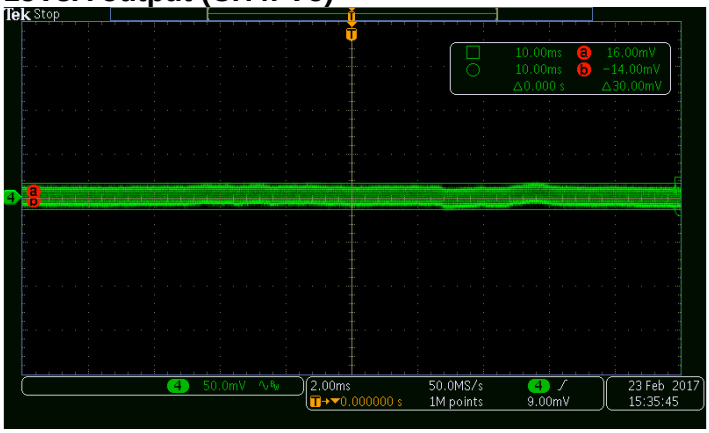
5V3A output (CH4: Vo)



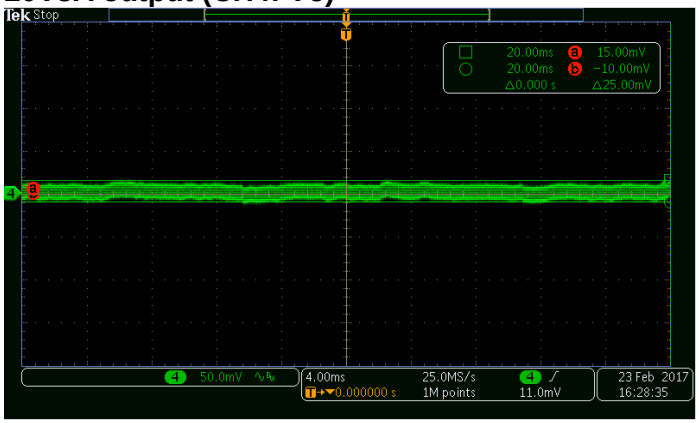
9V3A output (CH4: Vo)



15V3A output (CH4: Vo)

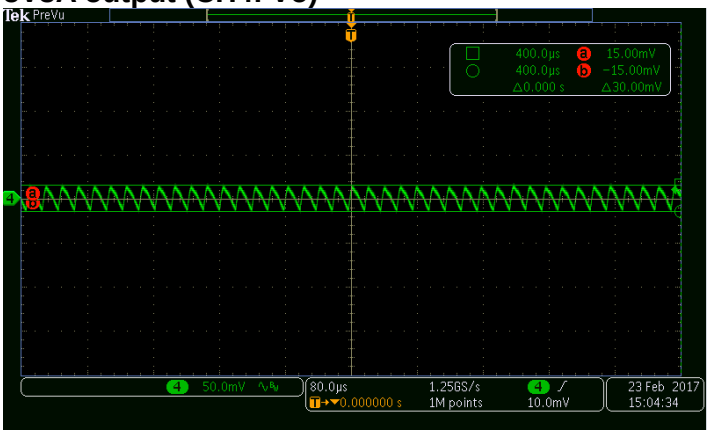


20V3A output (CH4: Vo)

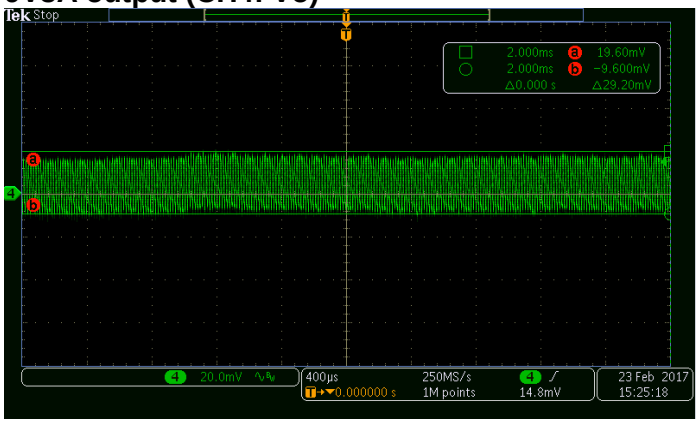


Output Ripple @ 264 Vac Input, 3A Output

5V3A output (CH4: Vo)

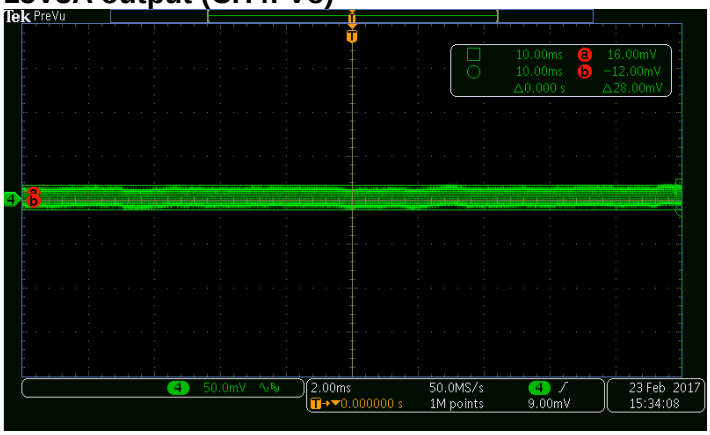


9V3A output (CH4: Vo)

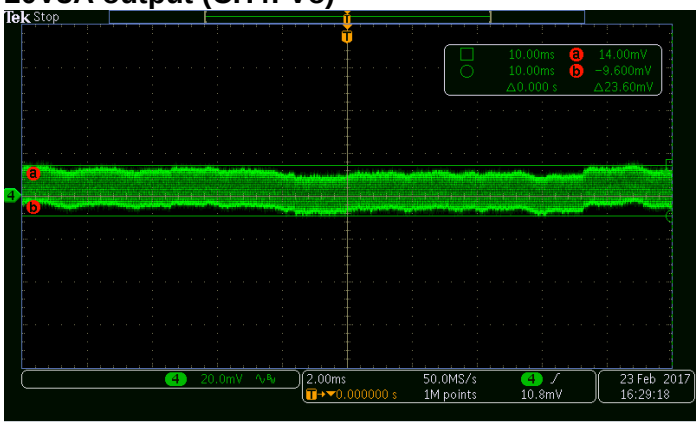


Output Ripple @ 264 Vac Input, 3A Output (Continued)

15V3A output (CH4: Vo)

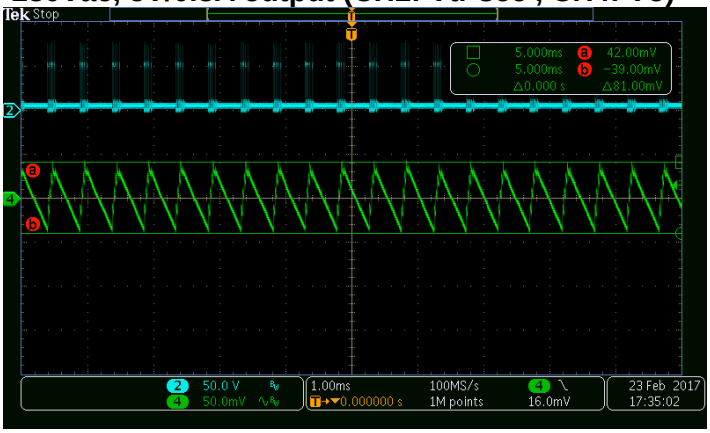


20V3A output (CH4: Vo)

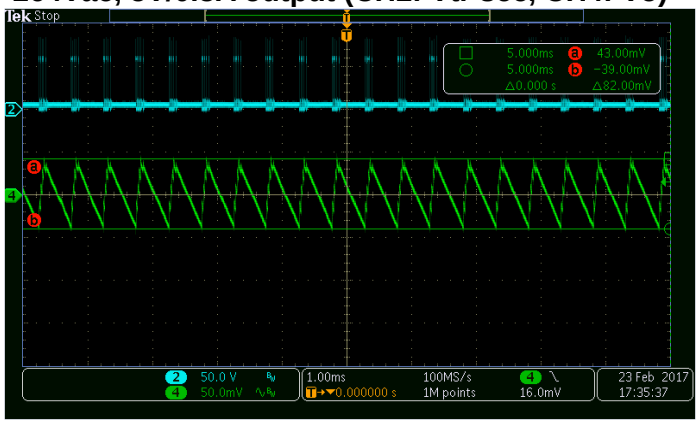


Output Ripple @ High Line & Light Load

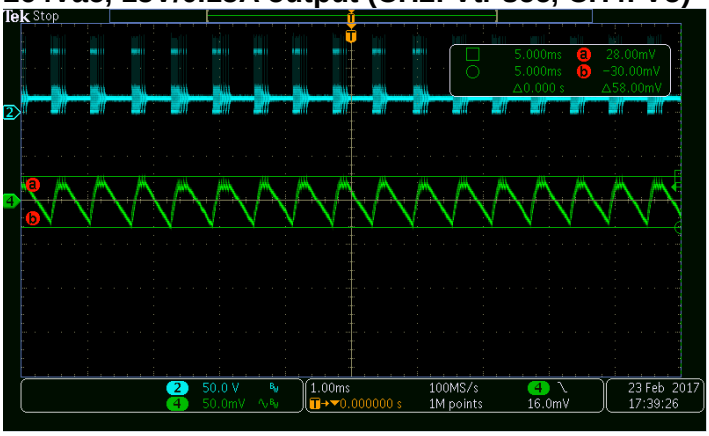
230Vac, 5V/0.3A output (CH2: Vtr sec , CH4: Vo)



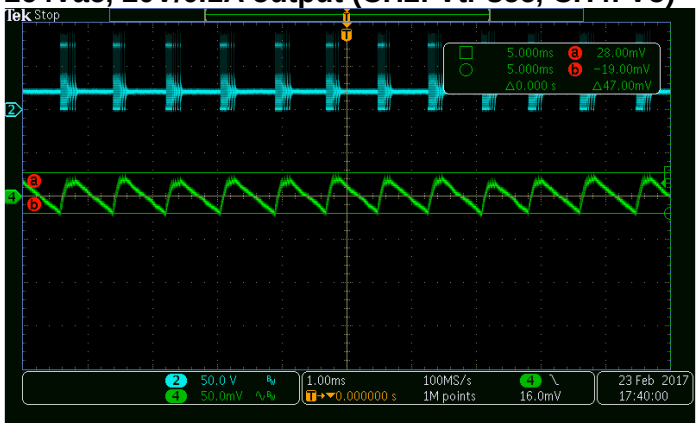
264Vac, 5V/0.3A output (CH2: Vtr sec, CH4: Vo)



264Vac, 15V/0.15A output (CH2: Vtr sec, CH4: Vo)

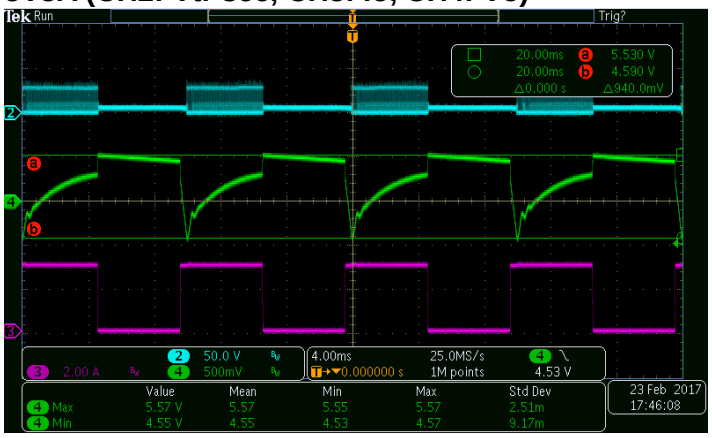


264Vac, 20V/0.1A output (CH2: Vtr sec, CH4: Vo)



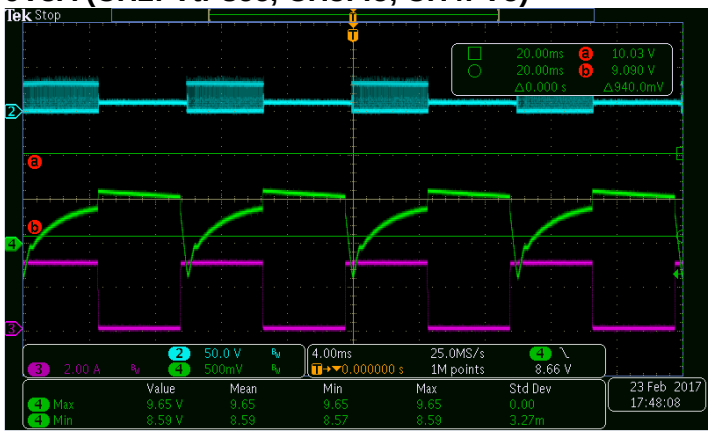
Dynamic Test @ 115 Vac Input

5V3A (CH2: Vtr sec, CH3: Io, CH4: Vo)



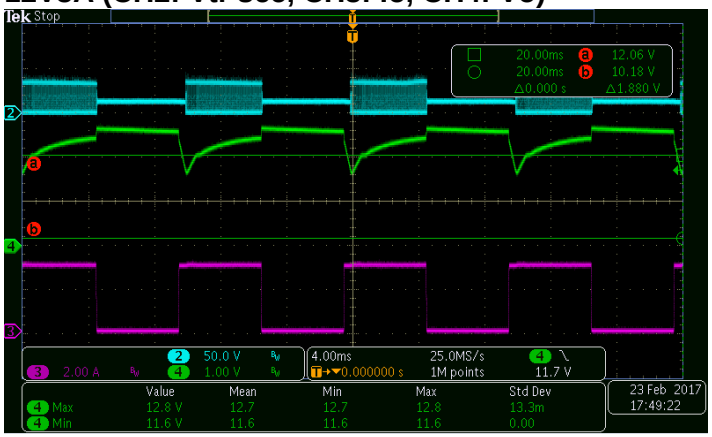
Test condition: 0-3A, 10mS cycle, 125mA/Us
1m cable, tested at E-load

9V3A (CH2: Vtr sec, CH3: Io, CH4: Vo)



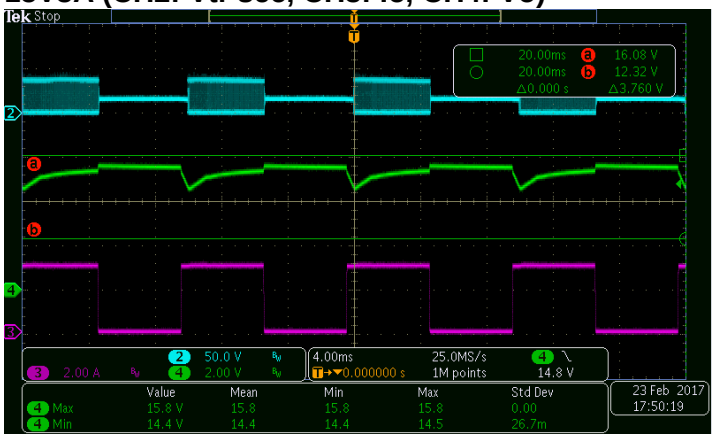
Test condition: 0-3A, 10mS cycle, 125mA/Us
1m cable, tested at E-load

12V3A (CH2: Vtr sec, CH3: Io, CH4: Vo)



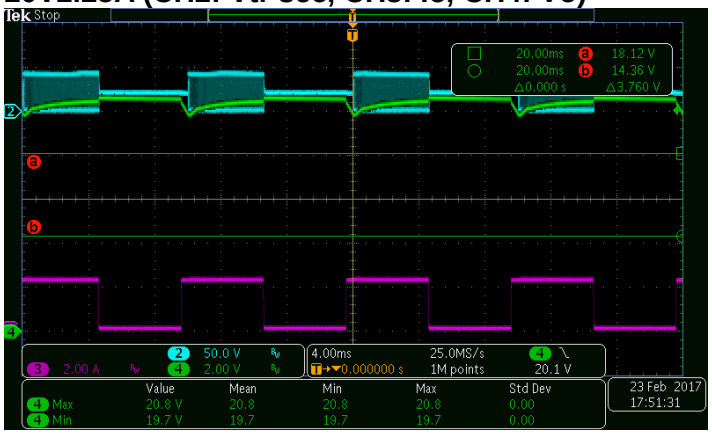
Test condition: 0-3A, 10mS cycle, 125mA/Us
1m cable, tested at E-load

15V3A (CH2: Vtr sec, CH3: Io, CH4: Vo)



Test condition: 0-3A, 10mS cycle, 125mA/Us
1m cable, tested at E-load

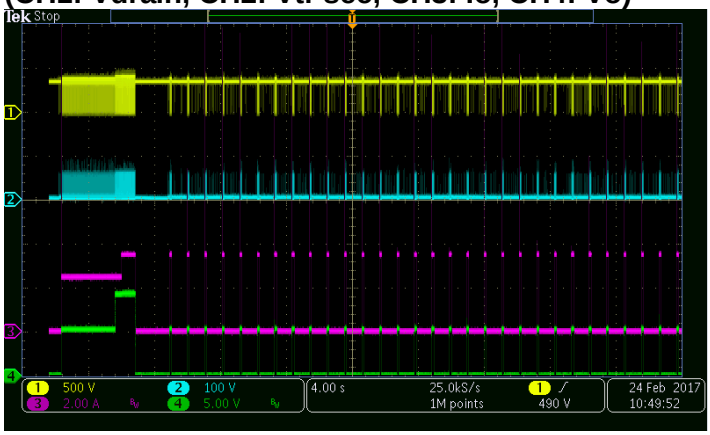
20V2.25A (CH2: Vtr sec, CH3: Io, CH4: Vo)



Test condition: 0-2.25A, 10mS cycle, 125mA/Us
1m cable, tested at E-load

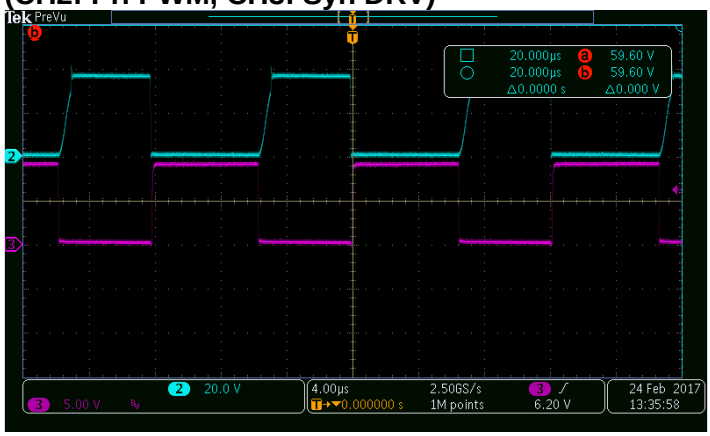
OCP @ 264 Vac Input, 9 Vdc Output

(CH1: Vdrain, CH2: Vtr sec, CH3: Io, CH4: Vo)

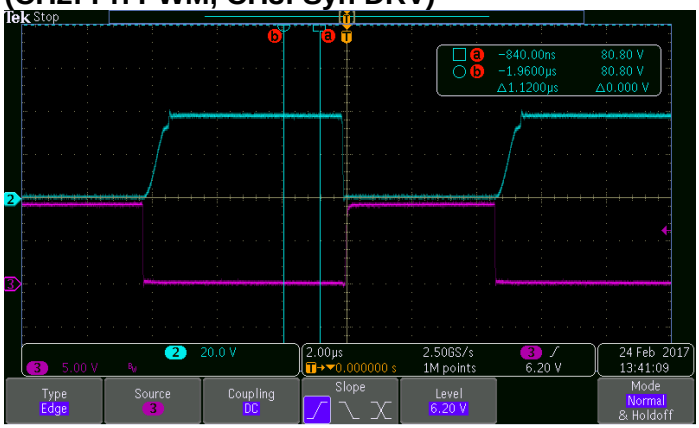


Synchronic Drive

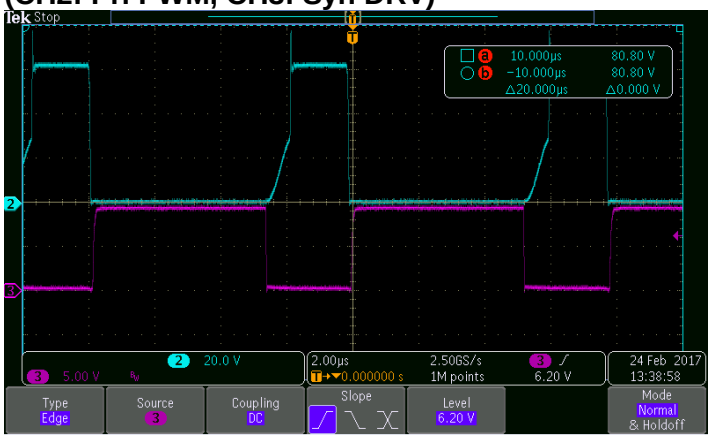
115 Vac input, 15V3A output
(CH2: Pri PWM, CH3: Syn DRV)



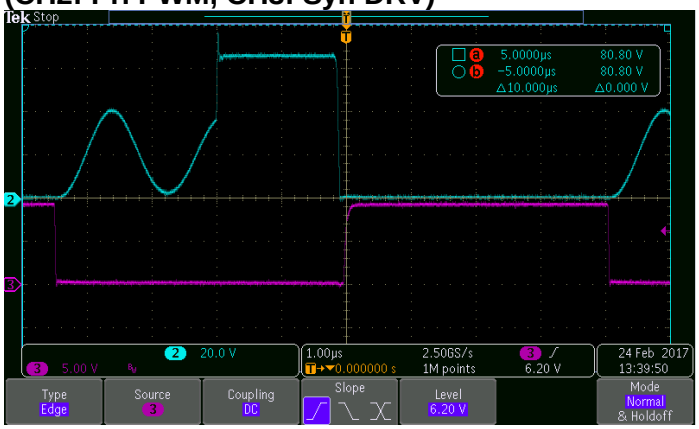
115 Vac input, 20V2.25A output
(CH2: Pri PWM, CH3: Syn DRV)



230 Vac input, 15V3A output
(CH2: Pri PWM, CH3: Syn DRV)

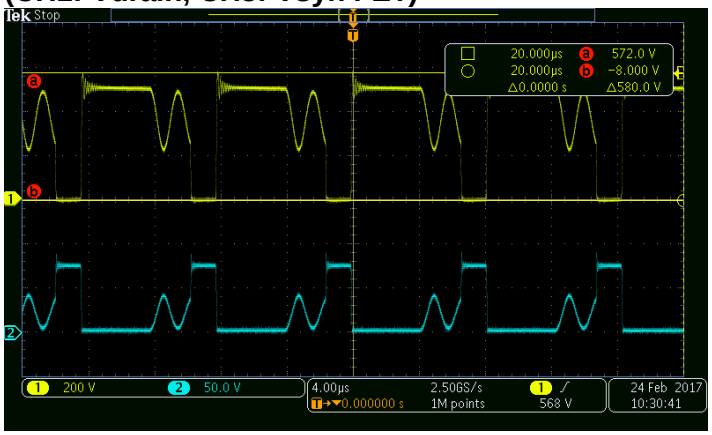


230 Vac input, 20V2.25A output
(CH2: Pri PWM, CH3: Syn DRV)



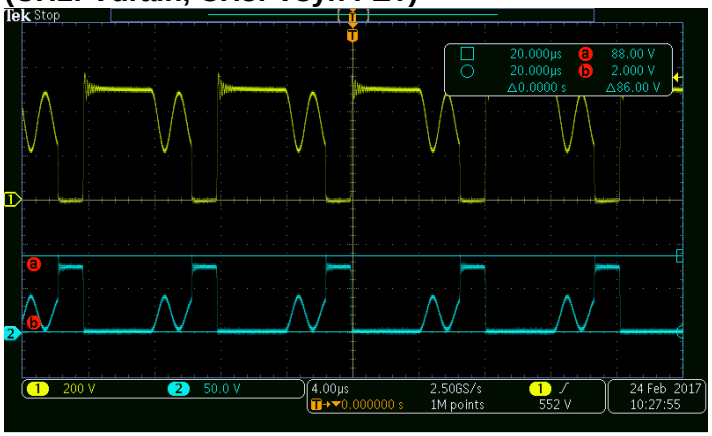
Primary FET Drain Voltage @ 264 Vax input, 20V2.25A output

(CH1: Vdrain, CH3: Vsyn FET)

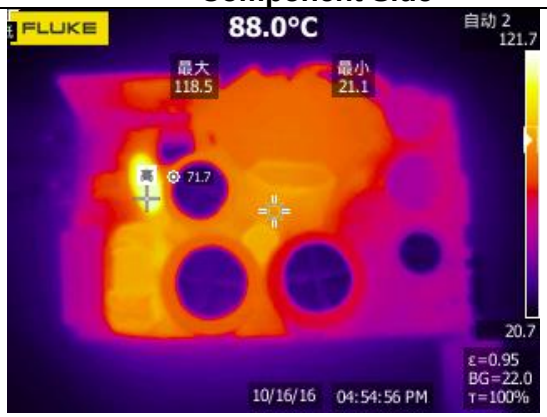
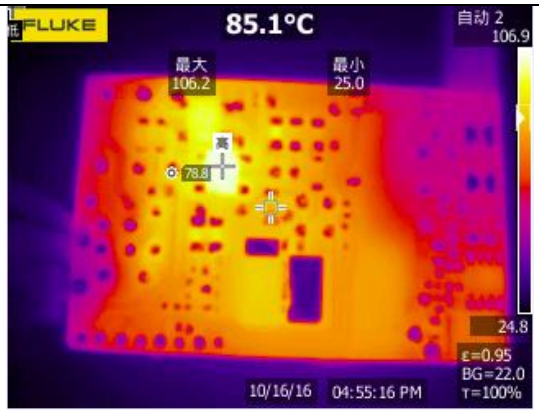
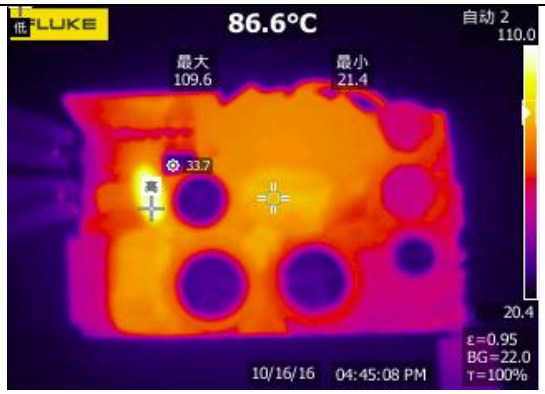
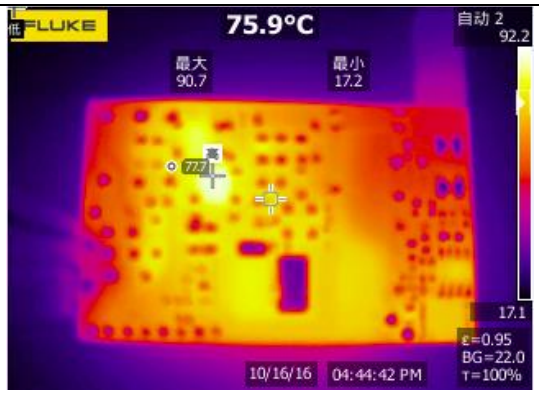
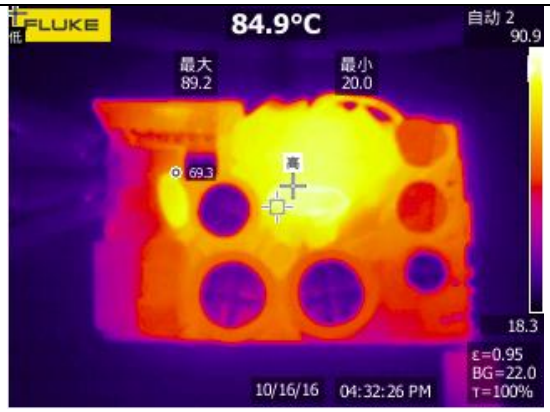
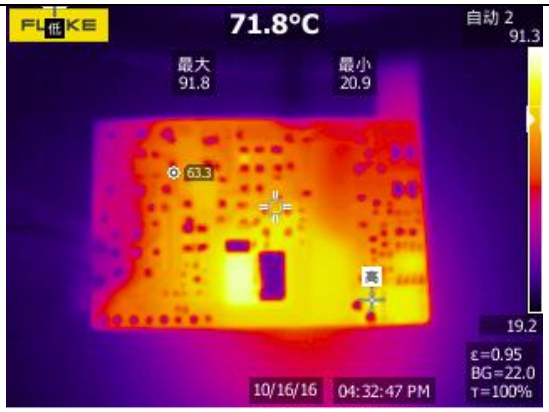
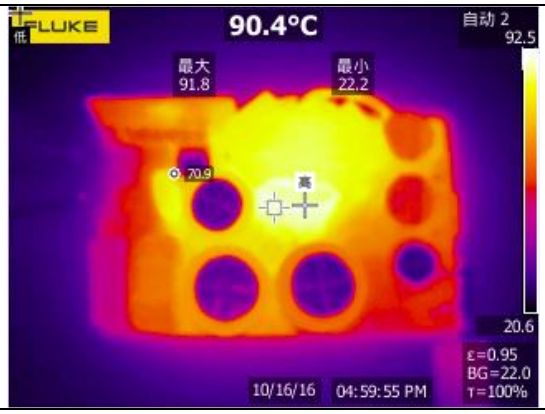
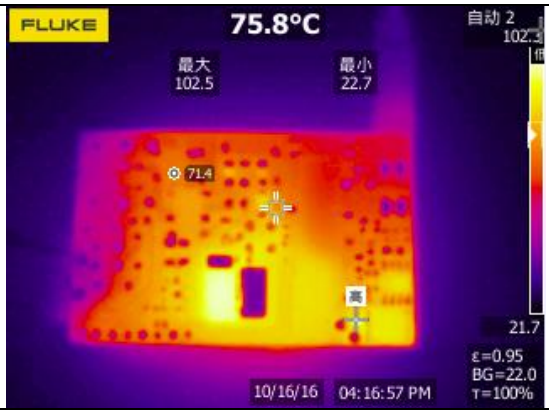


Synchronic FET Drain Voltage @ 264 Vax input, 20V2.25A output

(CH1: Vdrain, CH3: Vsyn FET)



Thermal Image @ 20V2.25A Output

Input	Component Side	Back side
90 Vac		
115 Vac		
230 Vac		
264 Vac		

DN05100/D
BOM

Item	Qty	Reference	Type	Part Name	MFR	Value	Package	Description
1	1	C11	Ceramic Capacitor	std	std	0.1uF	603	Capacitor, Ceramic, 50V, 10%
2	1	C9	Ceramic Capacitor	Std	std	102	603	Capacitor, Ceramic, 50V, 10%
3	1	C26	Ceramic Capcitor	C3216X7T2W104K	TDK	104,400V	1206	Capacitor, Ceramic, SMD, 5%
4	1	C19	Ceramic Capacitor	Std	std	10nF	603	Capacitor, Ceramic, 50V, 10%
5	1	C12	Ceramic Capacitor	C1608C0G2A102J	TDK	1nF,100v	603	Capacitor, Ceramic, SMD, 5%
6	5	C15-17 C24 C27	Ceramic Capacitor	C1608X7R1E105K	TDK	1uF,25V	603	Capacitor, Ceramic, 25V, 10%
7	1	C8	Ceramic Capacitor	C3216X7S2A225K	TDK	2.2uF,100v	1206	Capacitor, Ceramic, 100V, 10%
8	1	C21	Ceramic Capacitor	C3216X7S2A225K	TDK	2.2uF,100v	1206	Capacitor, Ceramic, 100V, 10%
9	1	C4	Ceramic Capacitor	C2012X7R1V475K	TDK	4.7uF,35v	805	Capacitor, Ceramic, 35V, 10%
10	1	C3	Ceramic Capcitor	C3216C0G2J471J	TDK	470pF,630V	1206	Capacitor, Ceramic, Chip, 5%
11	1	C10	Ceramic Capcitor	CS65-B2GA101KYNKA	TDK	470pF,Y1	Lead type	HV Ceramic,safety standard approved, 10%
12	2	C22-23	Ceramic Capacitor	Std	std	47P	603	Capacitor, Ceramic, 50V, 10%
13	1	C6	Ceramic Capacitor	Std	std	47p	603	Capacitor, Ceramic, 50V, 10%
14	1	C25	X2 Capcitor	/890334022017	Wueth	683,X2	THT, 7.5m	X2 capacitor, Safety standard approved, 10%
15	2	C18 C20	Ceramic Capacitor	Std	std	NC	603	Capacitor, Ceramic, 50V, 10%
16	1	U5	PD controller	CY2211	CanYon		TSSOP16	CanYon PD protocal controller
17	1	D1//D3	Bridge rectifier	MDB6S	FSC	1A,600V	Micro-DIF	Bridge Rectifier, 600V, 1A
18	1	DNR	Varistor	820573011	Wurth	10D471K	TH	Varistor, 10D471K
19	1	D6	Switching diode	BAS21HT1G	Vishay	0.2A,250V	SOD323	Switching diode, SMD
20	4	D7 D10-11 D16	Switching diode	BAS21HT1G	ON	0.2A,250V	SOD323	Switching diode, SMD
21	1	D4	Switching diode	BAT54HT1G	ON	0.2A,30V	SOD323	Switching diode, SMD
22	1	D5	Ultrafast rectifier	US1JFA	ON(FSC)	0.8A,600V	SOD123FL	Standard Rectifier, 0.8A, 600V
23	2	D12-13	Standard rectifier	RS1JFA	ON(FSC)	0.8A,600V	SOD123FL	Standard Rectifier, 0.8A, 600V
24	2	D2 D14	Switching diode	BAS21HT1G	ON	NC	SOD323	Switching diode, SMD
25	1	D8	Switching diode	BAS21HT1G	ON	0.2A,250V	SOD323	Switching diode, SMD
26	1	FB	Ferrite bead	UPZ2012E102-1R5TF	Sunlord/Wueth		805	1000ohm@100MHz
27	1	FB1	Ferrite bead	UPZ2012E601-2R0TF	Sunlord/Wueth		805	600ohm@100MHz
28	1	L3	Common filter	744821110	Wueth	10mH	TH type	CM Filter, T type core
29	1	L1	Common filter	150-1327	Wurth-Mi	500uH	TH	T type, 6.3x3x3, 11T, 0.2mmx2 in parallel winding
30	1	F1	Fuse	20T-016H	Hollyfus	1.6A, 250Va	Axial lea	Micro Fuse, 1.6A/250V
31	1	Q4	NPN Transistor	MMBTA06LT1G	ON		SOT23	General NPN Transistor, SMD

BOM (Continued)

Item	Qty	Reference	Type	Part Name	MFR	Value	Package	Description
32	2	Q6-7	NPN Transistor	MMBT3904LT1G	ON		SOT23	General NPN Transistor, SMD
33	1	Q3	NPN Transistor	MMBTA06LT1G	ON	NC	SOT23	General NPN Transistor, SMD
34	1	Q5	PNP Transistor	MMBT3906LT1	ON		SOT23	GENERAL PURPOSE PNP SILICON TRANSISTOR
35	1	U3	Syn. rectified co	NCP43080DDR2G	ON		SO8	Syn. Rectified Controller
36	1	U1	PWM Controller	NCP1340B3D1R2G	ON		SOP9	PWM controller
37	1	NTC1	NTC	std	std	13k	603	13k 0603 resistor as a replacement
38	1	NTC	NTC	SPNL09D2R5MBI	Sunlord	2.5ohm	lead type	9mm Die, 2.5ohm
39	1	U4	Optical coupler	FODM1009	ON(FSC)		LSOP4	optical coupler, standard SOP package
40	1	Q8	PMOS	ATP104-TL-H	ON	-30V, 8.4mol	ATPAK	PMOS
41	1	L2	Axial leaded fixed	7447462470	Wurth	47uH		Axial leaded fixed inductor
42	1	Q2	MOSFET	IPL60R385CP	Infineon		THINKPAK-	MOSFET, NChan, 600V
43	1	R6	Resistor	Std	Std	1	603	Resistor, Chip, 1/8W, 1%
44	1	R13	Resistor	Std	Std	100K	603	Resistor, Chip, 1/8W, 1%
45	1	R7	Resistor	Std	Std	100k	603	Resistor, Chip, 1/8W, 1%
46	1	R35	Resistor	Std	Std	10K	603	Resistor, Chip, 1/8W, 1%
47	1	R8	Resistor	Std	Std	10k	603	Resistor, Chip,1/8W, 1%
48	2	R18 R23	Resistor	Std	Std	10k	603	Resistor, Chip, 1/8W, 1%
49	1	R25	Resistor	Std	Std	150K	603	Resistor, Chip, 1/8W, 1%
50	1	R17	Resistor	Std	Std	18k	603	Resistor, Chip, 1/8W, 1%
51	1	R3	Resistor	Std	Std	1K	603	Resistor, Chip, 1/8W, 1%
52	1	R22	Resistor	Std	Std	1K	603	Resistor, Chip, 1/8W, 1%,
53	1	R9	Resistor	Std	Std	2k	603	Resistor, Chip, 1/8W, 1%
54	1	R11	Resistor	Std	Std	300	603	Resistor, Chip, 1/8W, 1%
55	1	R33	Resistor	Std	Std	39k	603	Resistor, Chip, 1/8W, 1%
56	2	R10 R34	Resistor	Std	Std	4.7	603	Resistor, Chip, 1/8W, 1%
57	1	R15	Resistor	Std	Std	47k	603	Resistor, Chip, 1/8W, 1%
58	1	R32	Resistor	Std	Std	68K	603	Resistor, Chip, 1/8W, 1%
59	1	R20	Resistor	Std	Std	750k	603	Resistor, Chip, 1/8W, 1%
60	1	R16	Resistor	Std	Std	75k	603	Resistor, Chip, 1/8W, 1%
61	1	R19	Resistor	Std	Std	91k	603	Resistor, Chip, 1/8W, 1%
62	1	R24	Resistor	Std	Std	NC	603	Resistor, Chip, 1/8W, 1%

BOM (Continued)

Item	Qty	Reference	Type	Part Name	MFR	Value	Package	Description
63	1	R37	Resistor	Std	Std	NC	603	Resistor, Chip, 1/8W, 1%,
64	1	R14	Resistor	ERJ8BWFR020V	Panasoni	0.02	1206	Resistor, Chip, 1/2W, 1%
65	2	R4-5	Resistor	ERJ8BQFR082V	Panasoni	0.62	1206	Resistor, Chip, 1/2W, 1%
66	1	R2	Resistor	Std	Std	10	1206	Resistor, Chip, 1/4W, 1%
67	1	R31	Resistor	Std	Std	1k	805	Resistor, Chip, 1/5W, 1%
68	1	R12	Resistor	Std	Std	20	805	Resistor, Chip, 1/5W, 1%
69	1	R1	Resistor	Std	Std	300k	1206	Resistor, Chip, 1/4W, 1%
70	1	T1	Transformer	750343542	WE-midcon		TH type	RM8, 12Pin

References

ON Semiconductor datasheet for NCP1340/43080/, NTMFS6B03, ATP104

ON Semiconductor Design Notes DN05043

CanYon semiconductor datasheet for CY2211

Design note created by; e-mail: david.dou@onsemi.com