TDAIO-TPH-ON-240W-RD 240W 24V 10A Power Adapter Description

This design guide of the 240W 24V 10A adaptor reference design board describes a 240W PFC+LLC implementation with peak efficiency of greater than 96%, a power density of 24W/in^3 using 3 Transphorm GaN TP65H150G4PS (650 V SuperGaN FET) TO-220 with Transphorm's latest SuperGaN® Gen IV technology with onsemi's NCP1654 CCM PFC controller and NCP1399 LLC controller with output voltage (24V/10A). If heatsink height is re-designed to 20mm, the design can achieve close to 30W/in^3 power density. This design shows the high-power 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	90-264 Vac
Output Voltages	24V
Max Output Current	10 A
Max Output Power	240 W
Efficiency	~96% Full Power Efficiency@230V

Features

- Transphorm SuperGaN TP65H150G4PS TO-220 x 3
- CCM PFC + LLC topology
- Board-end over ~93% Efficiency (90VAC)
- Flat Efficiency Across Universal (90-264 VAC) Input Voltage and Load
- Tight Switching Frequency Regulation for Improved Input EMI Filter Utilization
- Up to 180 kHz Switching Frequency Operation
- OTP, UVLO, OCP and OSC Protections
- < 300mW No Load Power Consumption
- Up to 240 W Output Power

Applications

- High-Power-Density AC/DC PowerSupplies
- Smart phones
- Fast charging
- Laptops and IoT devices

Warning

The DC bus voltage on DC link bulk cap C1 is NOT discharged after power off. It stays high voltage for a long time. For safe handling, please discharge this DC bus voltage after power down.

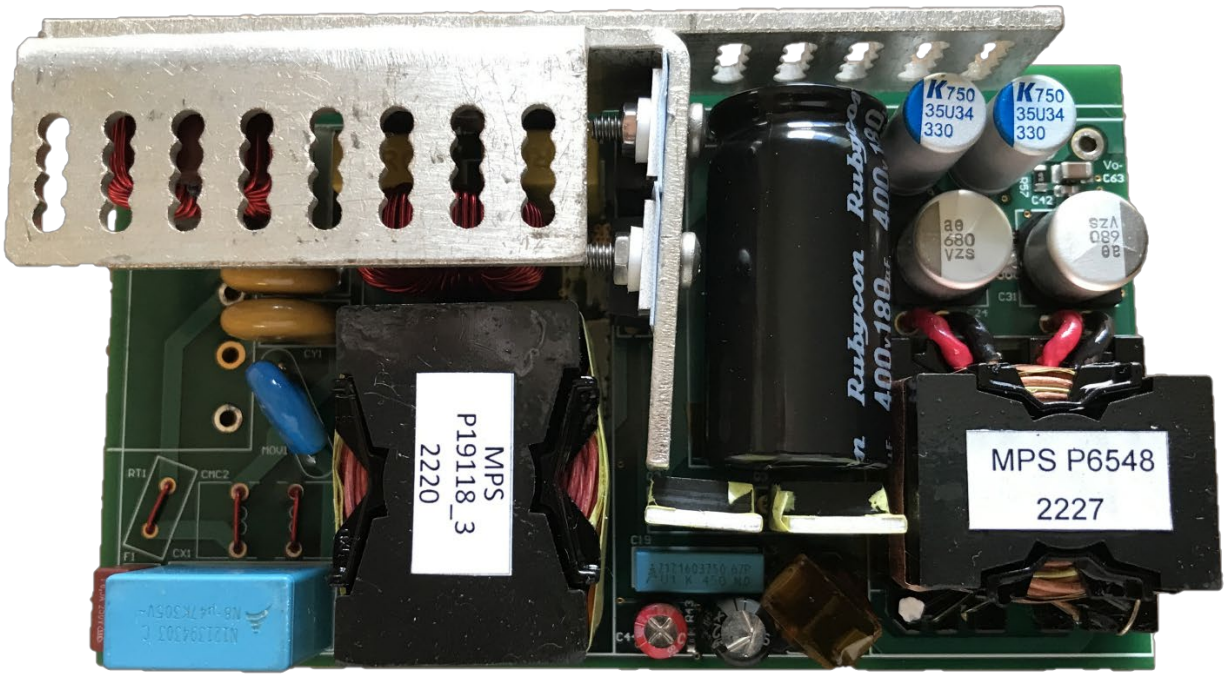
Disclaimers:

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.**

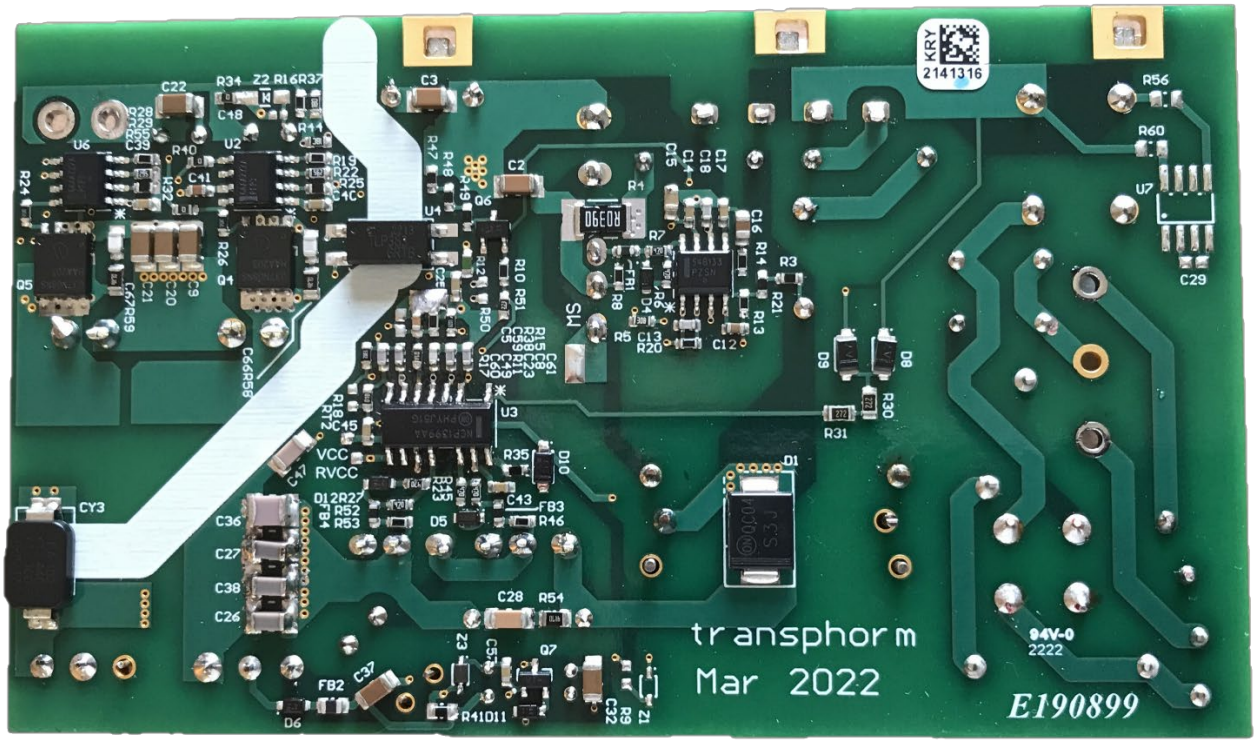
Table of Contents

TDAIO240P180 240W 24V 10A Power Adapter Description 1
Features 1
Applications 1
Warning 2
Disclaimers:..... 2
TDAIO-TPH-ON-240W-RD 240W 24V 10A Adaptor (TP65H150G4PS) Board Pictures 4
Schematic..... 5
Circuit Description 7
Input Protection..... 7
EMI Filtering..... 7
Fault Protections..... 7
PCB Layout 8
Bill of Materials (BOM)..... 11
Transformer Specification (XF1)..... 13
PFC Power Inductor Specification (L1) 14
L2 spec..... 15
L3 Spec 16
Common-Mode Choke Specification (CMC1)..... 17
Test Setup 18
Performance Data 19
No-Load Input Power..... 19
Full Load Efficiency 19
5-Point Average Efficiency 19
Efficiency Graphs..... 19
Startup 20
Load Transitions 22
Output Over Current Protection (OCP) 23
Output Short Circuit Protection..... 23
Output Voltage Ripple Noise 24
Key Waveforms 26
Conducted EMI Scans 27
Thermal Measurements..... 28
Revision History Revision..... 28
Hardware Info 28

TDAIO-TPH-ON-240W-RD 240W 24V 10A Adaptor (TP65H150G4PS) Board Pictures



Top Side of the EVB

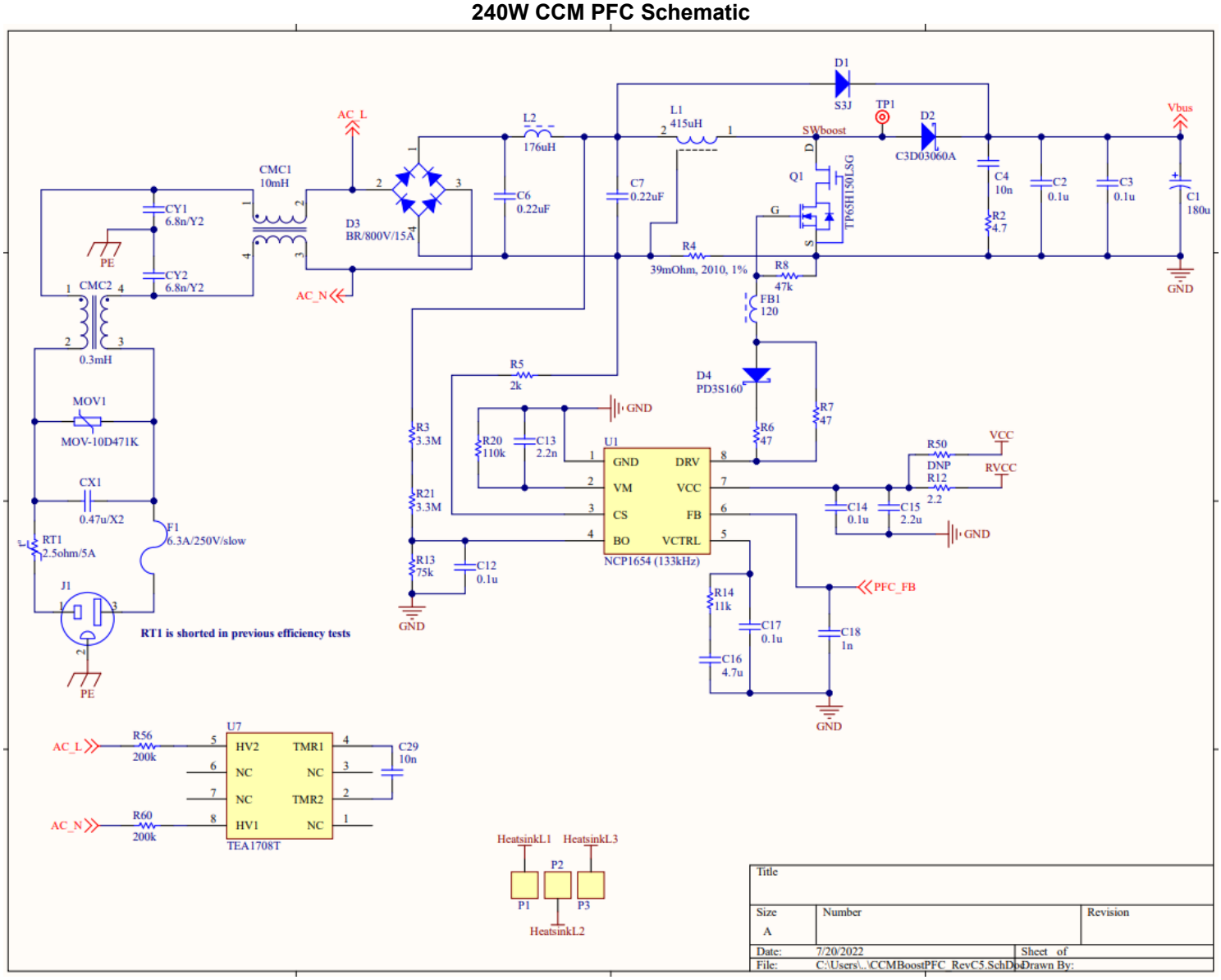


Bottom Side of the EVB

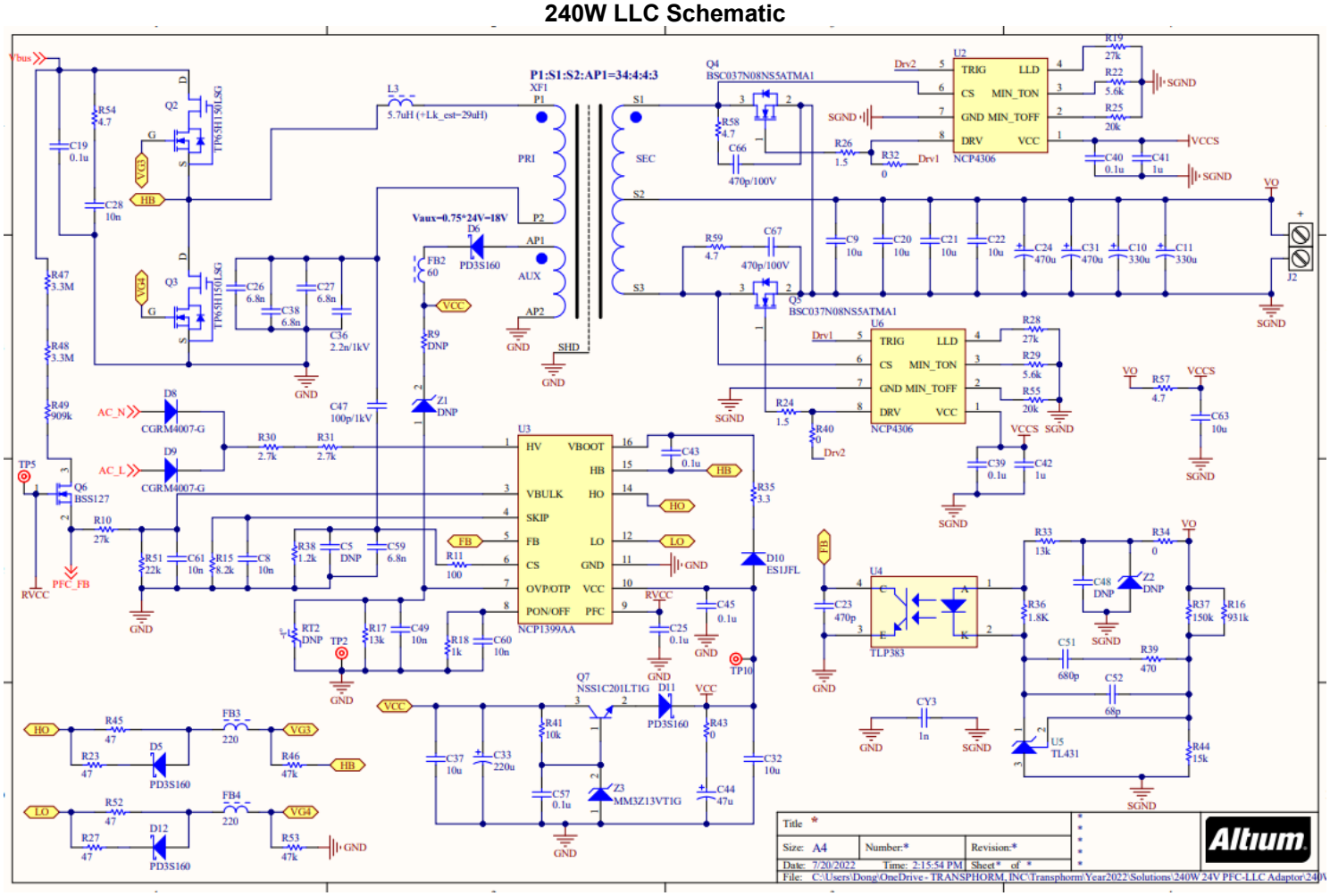
Dimensions of PCB board: 110 mm*60mm*25mm. 25mm is heatsink height. Heatsink can be re-designed to 20mm height for the adaptor to achieve higher power density of ~30W/in^3.

Schematic

240W CCM PFC Schematic



240W LLC 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 (CMC1). CMC2 is not populated.

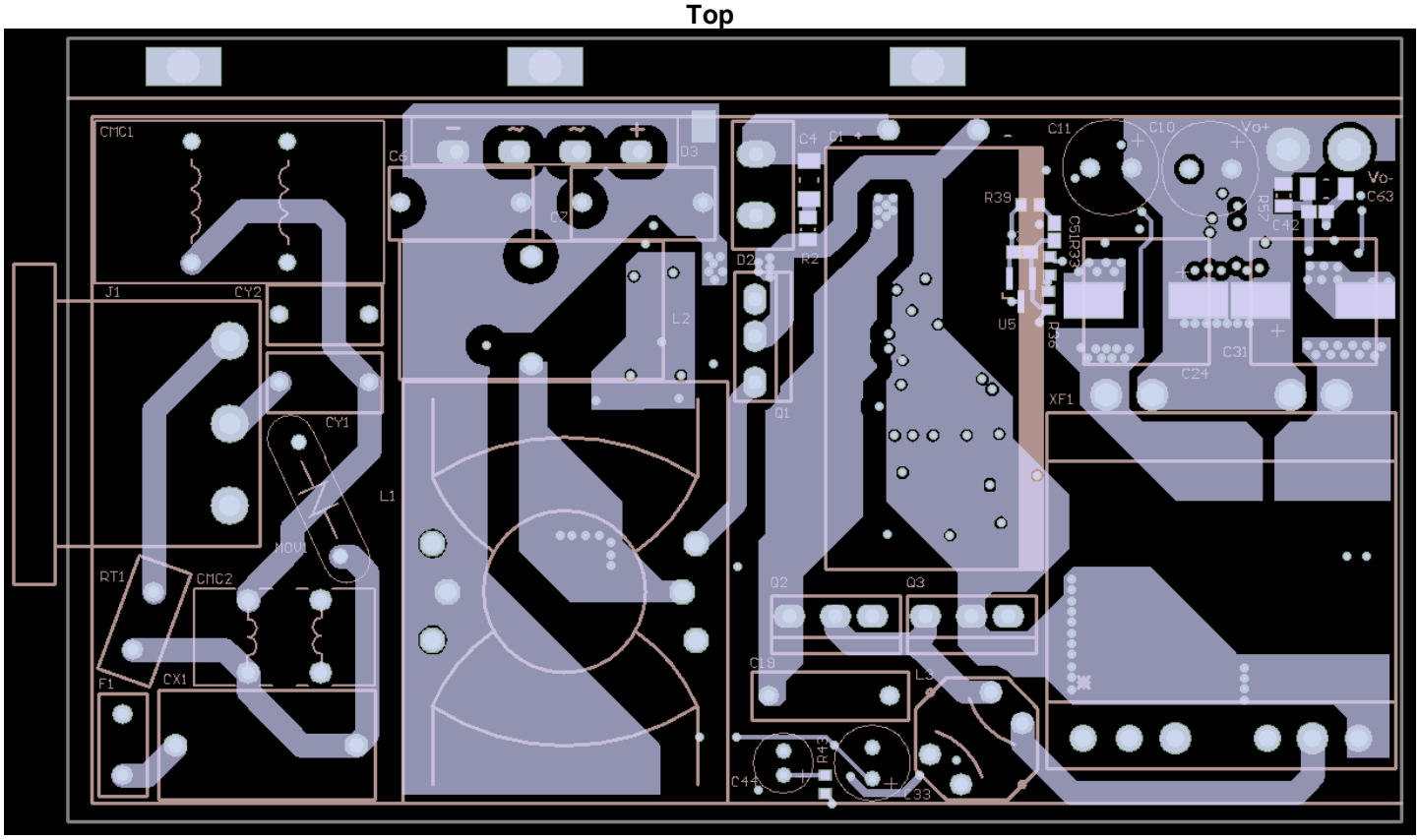
Fault Protections

Table 1: Recovery Behavior

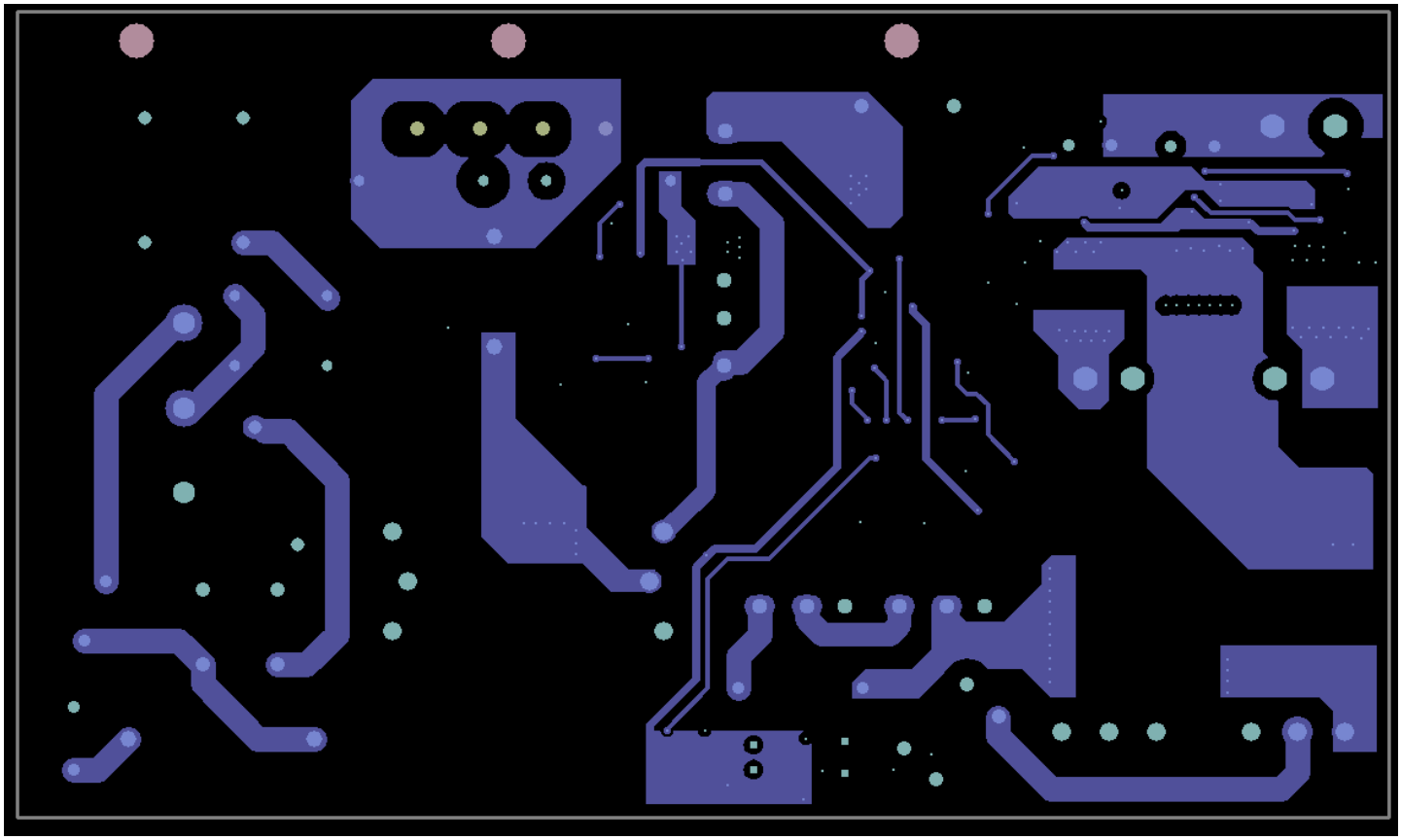
Fault Protection	
Input Under Voltage Lockout (UVLO)/ Brown-Out	Auto-Recovery
Input Surge Protection	Not Populated on PCB
Over-Current Protection (OCP)	Auto-Recovery
Output Short Circuit (OSC)	Auto-Recovery
Output Over Voltage (OVP)	Not Populated on PCB

PCB Layout

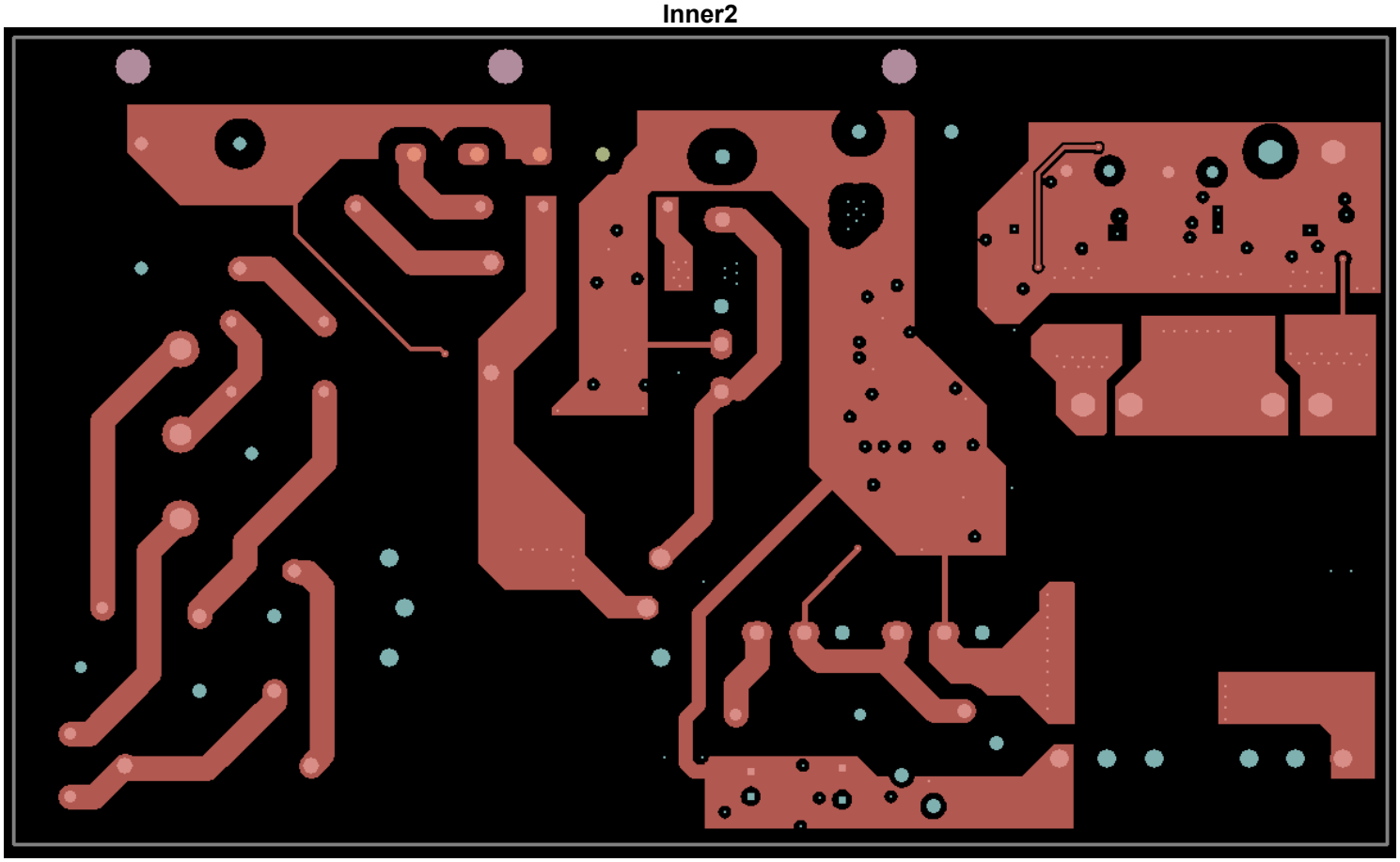
Top



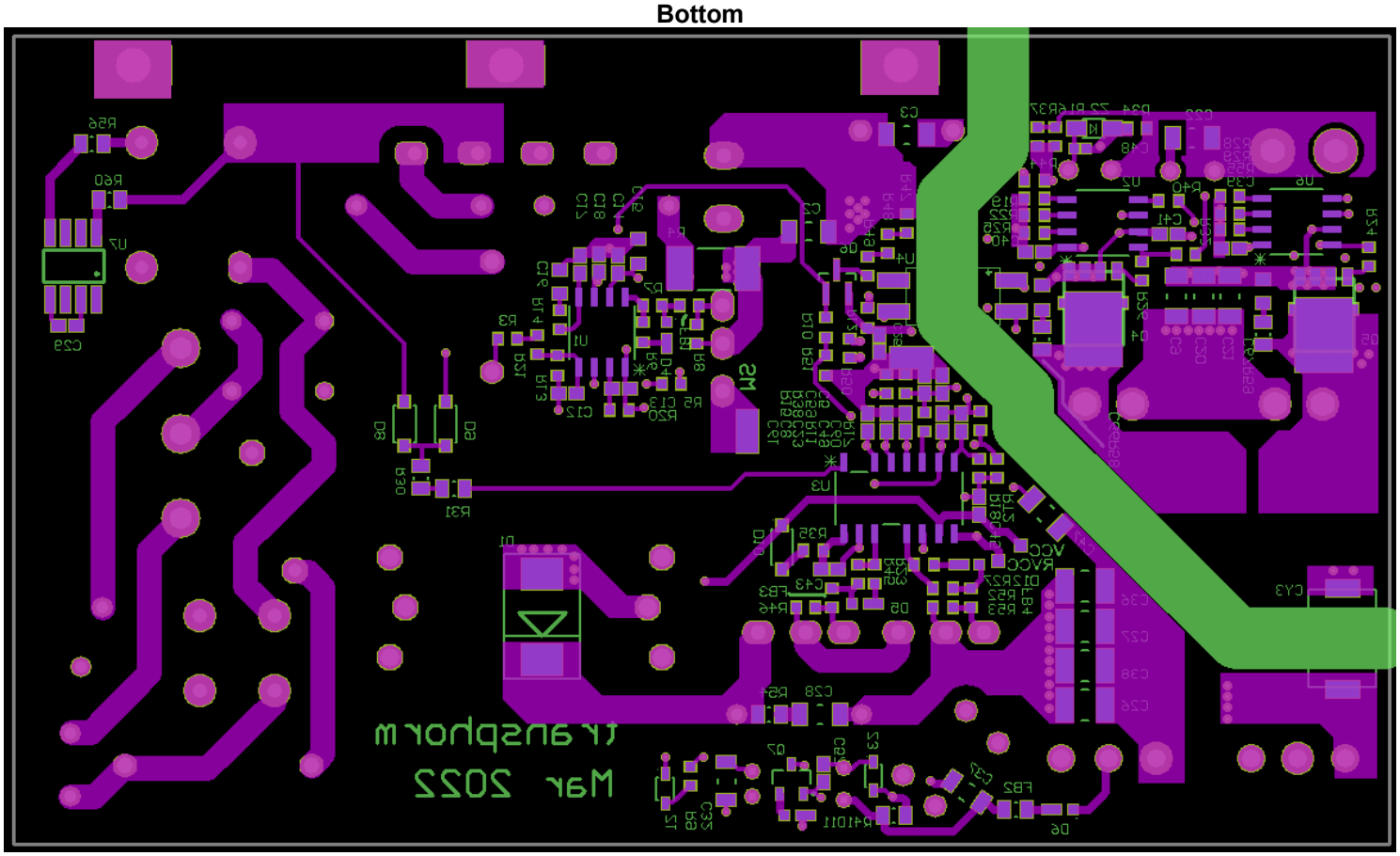
Inner 1



Inner2



Bottom



Transphorm SuperGaN FET SPEC

transphorm

TP65H150G4PS

650V SuperGaN® GaN FET in TO-220 (source tab)

Description

The TP65H150G4PS 650V, 150mΩ Gallium Nitride (GaN) FET is a normally-off device. It combines state-of-the-art high voltage GaN HEMT and low voltage silicon MOSFET technologies—offering 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.

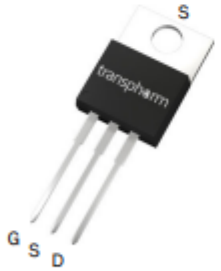
Related Literature

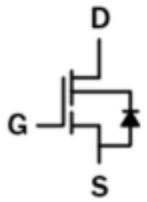
- AN0003: Printed Circuit Board Layout and Probing
- AN0007: Recommendations for Vapor Phase Reflow
- AN0009: Recommended External Circuitry for GaN FETs

Product Series and Ordering Information

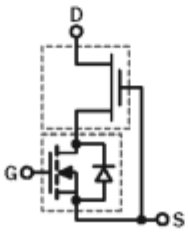
Part Number	Package	Package Configuration
TP65H150G4PS	3 lead TO-220	Source

TP65H150G4PS
TO-220
(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) min	650
$V_{DSS(TR)}$ (V) max	800
$R_{DS(on)}$ (mΩ) max*	180
Q_{RR} (nC) typ	40
Q_G (nC) typ	8

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

© 2019 Transphorm Inc. Subject to change without notice.

Bill of Materials (BOM)

Quantity	RefDes	Value	Description	Footprint	Manufacturer	Manufacturer P/N
1	C1	180u	CAP ALUM 180UF 20% 400V RADIAL	18MMX37MM SP7.5mm	Rubycon	400LXW180MEFR18X35
2	C2, C3	0.1u	CAP CER 0.1UF 450V X7T 1206	1206	TDK	CGA5L4X7T2W104K160AE
2	C4, C28	10n	CAP CER 10000PF 630V X7R 1206	1206	Samsung	CL31B103KHFNNNE
1	C5	DNP		0603		
2	C6, C7	0.22u	CAP FILM 0.22UF X2 310Vac	12W_12H_6T SP10mm	JURCC	X2-224K
5	C8, C29, C49, C60, C61	10n	CAP CER 0603 10NF 25VDC	0603	KEMET	C0603C103K3TACAUTO
5	C9, C20, C21, C22, C63	10u	CAP CER 10UF 35V X7R 1206	1206	Taiyo Yuden	GMK316AB7106KL-TR
2	C10, C11	330u	CAP ALUM POLY 330UF 20% 35V T/H	8MM 16MM SP3.5MM	KEMET	A750KW337M1VAAE020
1	C12	1u	CAP CER 1UF 10V X7R 0603	0603	KEMET	C0603C105K8RAC7867
8	C14, C17, C25, C39, C40, C43, C45, C57	0.1u	CAP CER 0.1UF 50V X7R 0603	0603	KEMET	C0603X104K5RACAUTO
1	C13	2.2n	CAP CER 2200PF 50V C0G 0603	0603	TDK	C1608C0G1H222J080AA
1	C15	2.2u	CAP CER 2.2UF 25V X7R 0805	0805	Samsung	CL21B225KAFNFNE
1	C16	4.7u	CAP CER 4.7UF 16V X7R 0805	0805	Murata	GRM21BR71C475KE51K
1	C18	1n	CAP CER 0603 1NF 50V X7R 10%	0603	KEMET	C0603X102K5RAC3316
1	C19	0.1u	CAP FILM 0.1UF 10% 450VDC RADIAL	L13MM T4MM H9MM SP10mm	TDK	B32671P4104K000
1	C23	470p	CAP CER 470PF 25V C0G/NP0 0603	0603	Wurth	885012006042
2	C24, C31	560u	CAP ALUM 560UF 20% 35V SMD	D10mm H10.8mm	Panasonic	EEE-FT1V561AV
3	C26, C27, C38	10n	CAP CER 10000PF 1KV C0G/NP0 1210	1210	KEMET	C1210C103KDGAC7800
2	C32, C37	10u	CAP CER 10UF 35V X7R 1206	1206	Samsung	CL31B106KLHNFNE
1	C33	220u	CAP ALUM 220UF 20% 25V RADIAL	D6.3mm H12.5mm SP2.5mm	Rubycon	25YXG220MEFC6.3X11
1	C36	3.3n	CAP CER 3300PF 1KV C0G/NP0 1210	1210	KEMET	C1210C332JDGACAUTO
2	C41, C42	1u	CAP CER 1UF 35V X7R 0603	0603	Taiyo Yuden	GMK107AB7105KAHT
1	C44	47u	CAP ALUM 47UF 20% 35V RADIAL	D5MM H12.5mm SP2MM	Wurth	860010572005
1	C47	100p	CAP CER 100PF 1KV C0G/NP0 1206	1206	Samsung	CL31C101JIFNFNE
1	C48	DNP				
1	C51	680p	CAP CER 680PF 25V C0G/NPO 0603	0603	Yageo	CC0603JRNPO8BN681
1	C52	68p	CAP CER 68PF 25V C0G/NP0 0603	0603	KEMET	C0603C680J3GACAUTO
1	C59	4.7n	CAP CER 4700PF 50V X7R 0603	0603	KEMET	C0603C472J5RAC7867
2	C66, C67	470p	CAP CER 470PF 100V C0G/NP0 0805	0805	KEMET	C0805C471J1GAC7800
1	CMC1	10mH	3.5A Common Mode Choke	W24mm H24mm T13.5mm	MPS Industries	P5334
1	CMC2	DNP				
1	CX1	0.47u	CAP FILM 0.47UF 10% 630VDC RAD X2	L18mm T9mm H17.5mm SP15mm	TDK	B32922C3474K000
2	CY1, CY2	6.8n	CAP CER 6800PF 300VAC Y5V RADIAL X1 Y2	D12mm H16mm SP7.5mm	Vishay	VY2682M47Y5VS63V7
1	CY3	1n	CAP CER 1000PF 300V NONSTND SMD X1 Y1	L8mm W6mm T2.5mm	Murata	DK1E3EA102M86RBH01
1	D1	S3J	DIODE GEN PURP 600V 3A SMC	SMC	SMC Diode Solutions	S3J
1	D2	C3D03060A	DIODE SCHOTTKY 600V 3A TO220-2 SiC	TO-220-2	Wolfspeed	C3D03060A
1	D3	BR/800V/15A	BRIDGE RECT 1PHASE 800V 15A GBU	4-SIP GBU	Micro Commercial	GBU15K-BP
5	D4, D5, D6, D11, D12	60V 1A	DIODE SCHOTTKY 60V 1A POWERDI323	POWERDI323	Diodes Inc	PD3S160-7
2	D8, D9	CGRM4007-G	DIODE GEN PURP 1KV 1A MINISMA	SOD-123	Comchip Technology	CGRM4007-G
1	D10	600V 1A	DIODE GEN PURP 600V 1A SOD123FL	SOD-123F	Taiwan Semi	ES1JLW
1	F1	250Vac 6.3A	FUSE BOARD MOUNT 6.3A 250VAC RAD	FUSE RADIAL LEAD 5.08MM	Littelfuse	39216300000
1	FB1	120	FERRITE BEAD 120 OHM 0603 @100MHz	0603	Murata	BLM18AG121SH1D
1	FB2	60	FERRITE BEAD 60 OHM 0805 1LN @100MHz	0805	TDK	MMZ2012Y600BT000
2	FB3, FB4	220	FERRITE BEAD 220 OHM 0603 1LN @100MHz	0603	Murata	BLM18EG221TN1D

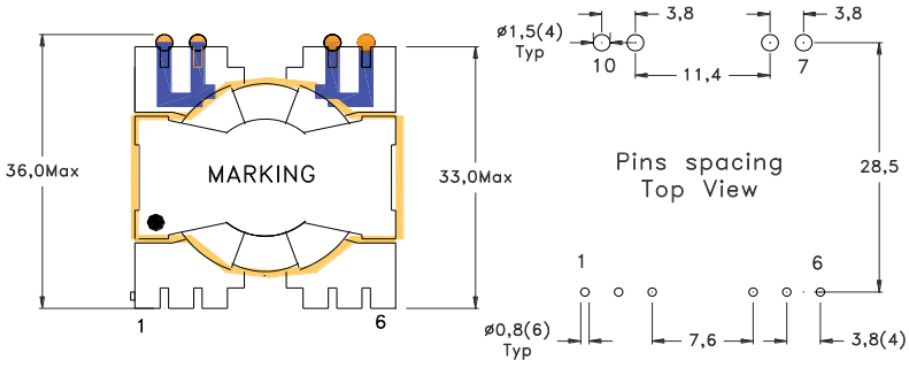
Quantity	RefDes	Value	Description	Footprint	Manufacturer	Manufacturer P/N
1	J1	DNP				
1	J2	DNP				
1	L1	415uH	Power Inductor PQ32/20 core 415uH 0.2OHM DCR	PQ32/20	MPS Industries	P19118
1	L2	176uH	Differential Mode Chock 176uH 0.115 OHM DCR	W21mm H22mm T11mm	MPS Industries	P11062
1	L3	16uH	Inductor RM4 16uH @100kHz 50mOHM DCR	RM4		
1	MOV1	10D471K	VARISTOR 470V 2.5KA DISC 10MM	DISC 10mm	Bourns	MOV-10D471K
3	Q1, Q2, Q3	650V 0.15OHM	GaN FET 650V 150mΩ in TO-220	TO-220-3-GSD	Transphorm	TP65H150G4PS
2	Q4, Q5	80V 3.7 mOHM	MOSFET N-CH 80V 100A TDSON	PG-TDSON-8-7	Infineon	BSC037N08NS5ATMA1
1	Q6	600V 500OHM	MOSFET N-CHANNEL 600V 21MA SOT23	SOT-23	Rectron	BSS127
1	Q7	100V 2A	TRANS NPN 100V 2A SOT23-3	SOT23-3	ON Semi	NSS1C201LT1G
5	R2, R54, R57, R58, R59	4.7	RES 4.7 OHM 1% 1/4W 0805	0805	Stackpole	RNCP0805FTD4R70
4	R3, R21, R47, R48	3.3M	RES 3.3M OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT3M30
1	R4	39m	RES 0.039 OHM 2.0 W 1% 2010 SMD	2010	Vishay	WFMB2010R0390FEA
1	R5	2k	RES 2K OHM 1% 1/10W 0603	0603	Yageo	RC0603FR-072KL
6	R6, R7, R23, R27, R45, R52	47	RES 47 OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT47R0
3	R8, R46, R53	47k	RES 47K OHM 1% 1/10W 0603	0603	TE Connectivity	CRGCQ0603F47K
3	R9, R50, RT2	DNP				
3	R10, R19, R28	27k	RES 27K OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT27K0
1	R11	100	RES 100 OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT100R
1	R12	2.2	RES SMD 2.2 OHM 5% 1/4W 0603	0603	Rohm	ESR03EZPJ2R2
1	R13	75k	RES 75K OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT75K0
1	R14	11k	RES 11K OHM 1% 1/8W 0603	0603	Stackpole	RNCP0603FTD11K0
1	R15	8.2k	RES 8.2K OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT8K20
1	R16	931k	RES 931K OHM 1% 1/10W 0603	0603	Yageo	RC0603FR-07931KL
2	R17, R33	13k	RES 13K OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT13K0
1	R18	1k	RES 1K OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT1K00
1	R20	110k	RES 110K OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT110K
2	R22, R29	5.6k	RES 5.6K OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT5K60
2	R24, R26	1.5	RES SMD 1.5 OHM 1% 1/10W 0603	0603	Rohm	KTR03EZPF1R50
2	R25, R55	20k	RES 20K OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT20K0
2	R30, R31	2.7k	RES SMD 2.7K OHM 5% 0.4W 0805	0805	Rohm	ESR10EZPJ272
4	R32, R34, R40, R43	0	RES 0 OHM JUMPER 1/10W 0603	0603	Yageo	RC0603FR-070RL
1	R35	3.3	RES SMD 3.3 OHM 5% 1/4W 0603	0603	Rohm	ESR03EZPJ3R3
1	R36	1.8K	RES 1.8K OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT1K80
1	R37	150k	RES 150K OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT150K
1	R38	1.2k	RES 1.2K OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT1K20
1	R39	470	RES 470 OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT470R
1	R41	10k	RES 10K OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT10K0
1	R44	15k	RES 15K OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FG15K0
1	R49	909k	RES SMD 909K OHM 1% 1/10W 0603	0603	Rohm	MCR03ERTF9093
1	R51	22k	RES 22K OHM 1% 1/10W 0603	0603	Stackpole	RMCF0603FT22K0
2	R56, R60	DNP				
1	RT1	DNP Bypass				
1	U1	NCP1654	PFC IC CCM 133kHz 8-SOIC	SOIC8	ON Semi	NCP1654BD133R2G
2	U2, U6	NCP4306	SECONDARY SIDE SYNCHRONOUS SOIC8	SOIC8	ON Semi	NCP4306AAAZZZADR2G
1	U3	NCP1399AA	LLC IC OFFLINE SW HALF-BRDG 16SOIC	SOIC16	ON Semi	NCP1399AADR2G
1	U4	TLP383	OPTOISO 5KV TRANSISTOR SO6L	6-SOIC (0.173", 4.40mm Width), 4 Leads	Toshiba	TLP383(GR-TPL,E
1	U5	TL431	IC VREF SHUNT ADJ 2.21% SOT23-3	SOT23-3	STMicroelectronics	TL431CL3T
1	U7	DNP				
1	XF1	300uH 34:3:4:4	XF PQ2620 300uH 34:3:4:4	PQ2620	MPS Industries	P6548
1	Z1	DNP				
1	Z2	DNP				
1	Z3	13V Zener	DIODE ZENER 13V 300MW SOD323	SOD323	ON Semi	MM3Z13VT1G

Transformer Specification (XF1)

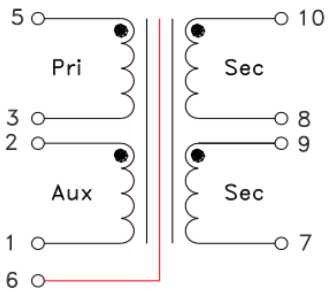
ELECTRICAL SPECIFICATIONS @ 25°C

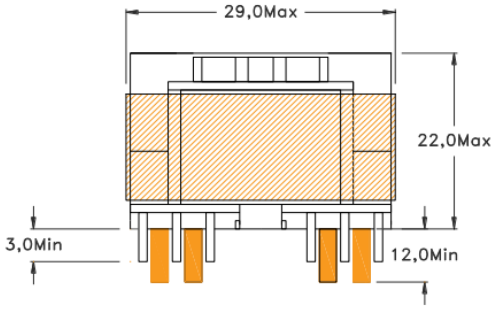
Input (5-3):	$385V_{DC}$, 170-180KHz
Output:	$24V_{DC}$, 250 Watts
OCL (5-3):	300µH - 330µH @ 10KHz, $0.1V_{RMS}$
Leakage L (5-3):	16µH ±15% @ 100KHz, $0.1V_{RMS}$ With (8-10 shorted only) 16µH ±15% @ 100KHz, $0.1V_{RMS}$ With (9-7 shorted only)
Turns Ratio:	34 : 3 : 4 : 4 ±1% (5-3 : 2-1 : 10-8 : 9-7)
Polarity:	5, 2, 10, 8 are in phase
Hipot (1-6 to 7-10):	$3KV_{DC}$, 1mA
RoHS:	Yes
Operating Temp:	-40°C to + 125°C

DIMENSIONS



SCHEMATIC





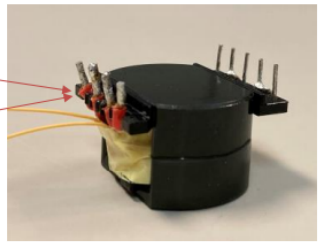
WINDING SEQUENCE

	A	B	C	D
				After core assemble
TURNS	34	3	4	1
WIRE SIZE	60/42S Litz	#30 HPN	4x60/#40S	0.002"x0.3"
WIND METHOD	3L	dist	2L	overlap 1/4" Magnetic Shield
TAPS				
INSULATION				
INSULATION #1318	1L	7L	2L	1L
TERM. IDENT. (S - F)	5 - 3	2 - 1	10 - 8 / 9 - 7	6
TERM. TYPE	Pins	Pins	Self leads	#24 Tinned Copper
LEAD OUT			20mm each	solder from copper
SLEEVING #			Yes	
CREEPAGE			Yes	

Cross wires cover with tape to avoid high voltage/current short circuit between turns
Wire size adjustable to meet bobbin dimension
Wrap core with copper foil

Twist the 2x60/#40S and put into shrink tube

Photo for Ref only



NOTE:
No epoxy on the secondaries' flying leads, the leads can move freely.

Customer's original design:

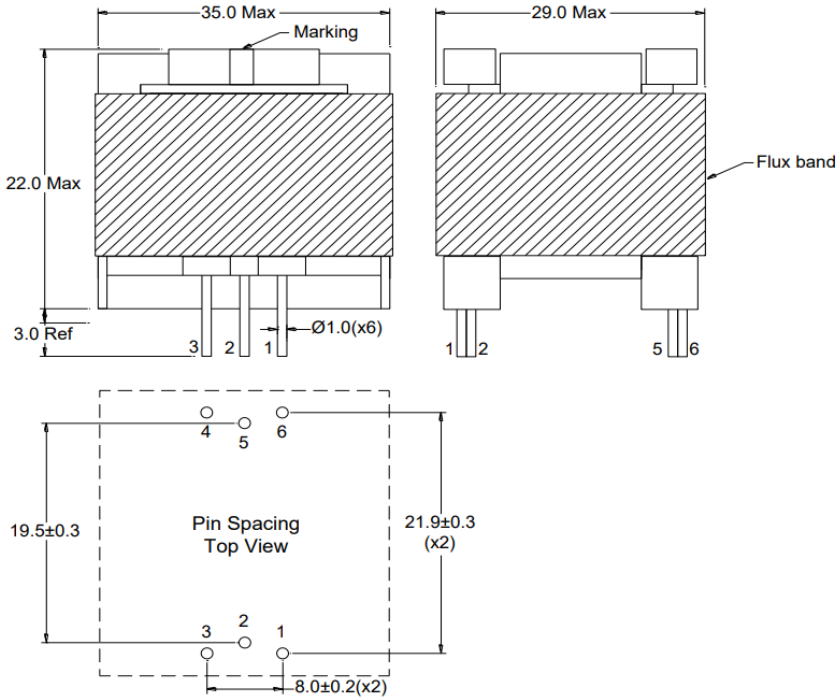
- Magnetic core PQ2620 (N97).
- Primary (P1→P2): 34 turns of 25/AWG38.
- Secondary 1 (S1→S2): 4 turns of 80/AWG38.
- Secondary 2 (S2→S3): 4 turns of 80/AWG38.
- Auxiliary (AP1 →AP2): 3 turns of AWG30
- Lm = 315uH, Lk = 31.5uH
  (both measured from the primary side)
- Wrapped with copper foil tape for emi shielding

PFC Power Inductor Specification (L1)

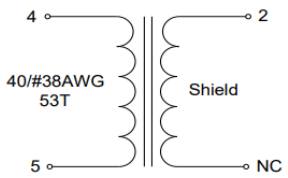
ELECTRICAL SPECIFICATIONS @ 25°C

OCL (4-5):	415µH ±10% @ 10KHz, 0.1V_{RMS}
	ΔL≤10% @ 4.5Adc
DCR (4-5):	200mΩ Max
Hipot:	1.5KVrms, 1mA Max, 10S (wdgs to core)
RoHS Compliant:	Yes
Operating Temp:	-40°C to +100°C

DIMENSIONS



SCHEMATIC



MARKING

MPS
P19118_Rev
Date Code
Dot at pin 1

WINDING SEQUENCE

	A	B
TURNS	53T	1.25T
WIRE SIZE	40/#38S	2mil copper foil
WIND METHOD	layers	Wrap on epoxied part
TAPS		
Mylar TAPE INSULATION	2L	2L
TERM. IDENT. (S - F)	4-5	2-NC
TERM. TYPE	PINS	PIN 2
LEAD OUT		
SLEEVING #		#23PTFE
CREEPAGE		

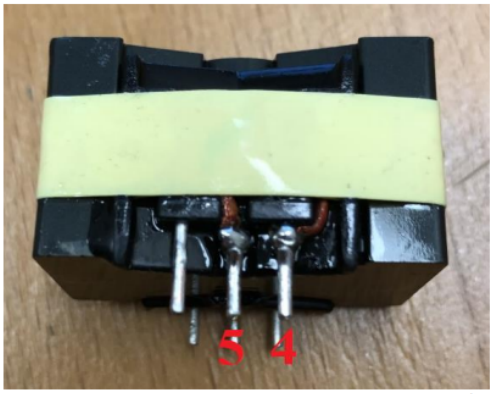


Fig.1 Lead out with proper wire routing and sufficient clearance b/t pin 4 and pin 5

NOTE

The wire to pin 4 should go through the slot on the right-hand side(see Fig.1 for proper lead routing)
Wrap 1.25 layer of copper foil band on finished inductor. Then secure with 2L mylar tape
Varnish in BC-359 or equiv

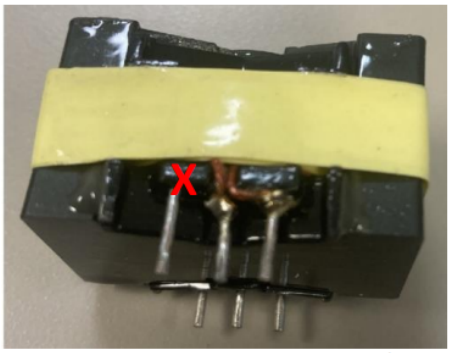


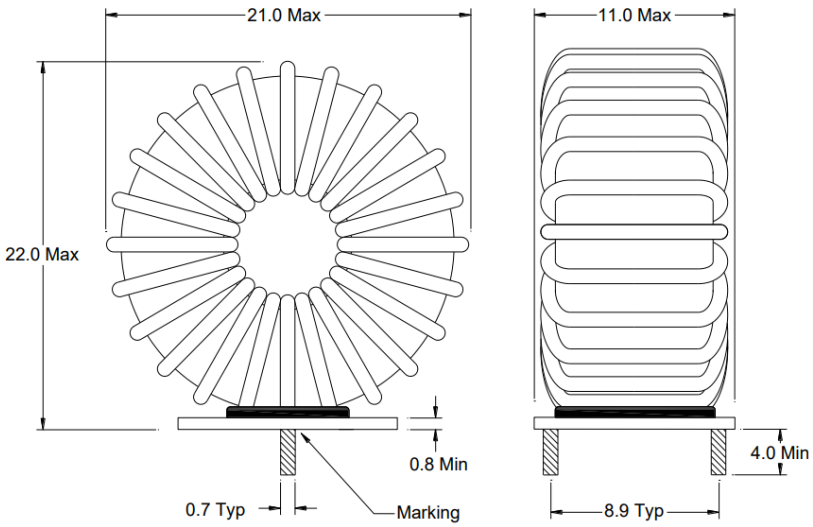
Fig.2 Bad wire routing causing insufficient clearance b/t pin 4 and pin 5

L2 spec

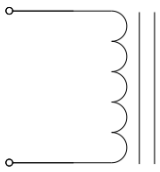
ELECTRICAL SPECIFICATIONS @ 25°C

OCL:	176µH±15% @ 10kHz, 1Vrms ΔL≤15%@3.5Arms, 60Hz
DCR:	115mΩ Max
Operating Temp:	-40°C to +105°C
Insulation Class:	Class F, 155°C Min
RoHS Compliant:	Yes

DIMENSIONS



SCHEMATIC



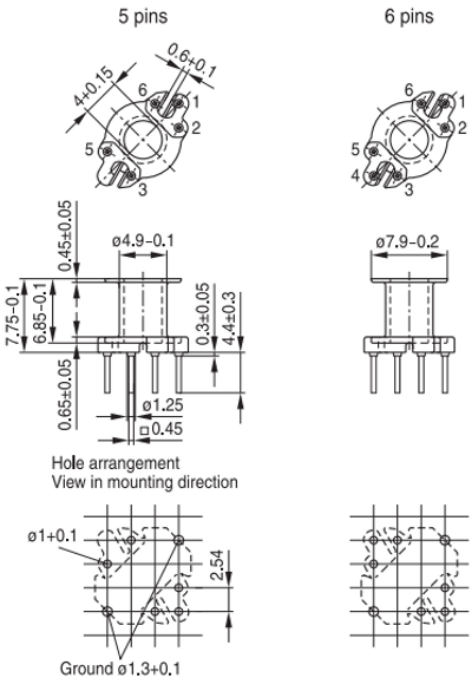
MARKING

WINDING SEQUENCE

	A	B
TURNS	64T	
WIRE SIZE	#22H	
WIND METHOD	2L Dist.	
TAPS		
FIBERGLASS CLOTH INSULATION		
TERM. IDENT. (S - F)	S-F	
TERM. TYPE	SELF	
LEAD OUT	4mm	
SLEEVING #		
CREEPAGE		

L3 Spec

- RM4
- Bobbin leave two pins 5 and 3 to mount on PCB
- Liz wire size and turns to make 16uH +-10% 50mOHM at 100kHz, fill bobbin window
- Terminate inductor two leads to Bobbin two pins 5 and 3.

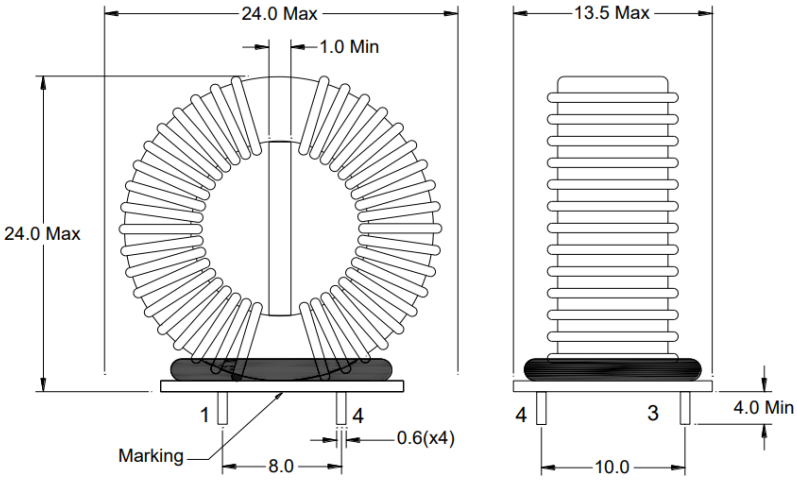


Common-Mode Choke Specification (CMC1)

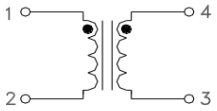
ELECTRICAL SPECIFICATIONS @ 25°C

Inductance(1-2, 4-3):	10mH Min@ 10kHz, 0.1V_{RMS}
DCR(1-2, 4-3):	38mΩ Max
Rated Current:	3.5Arms
Turns Ratio(1-2 to 4-3):	1:1±2%
Polarity:	1 and 4 are in phase
Hipot(1-2 to 4-3):	1.0KVdc, 1 mA, 5 sec
RoHS Comp:	Yes

DIMENSIONS



SCHEMATIC

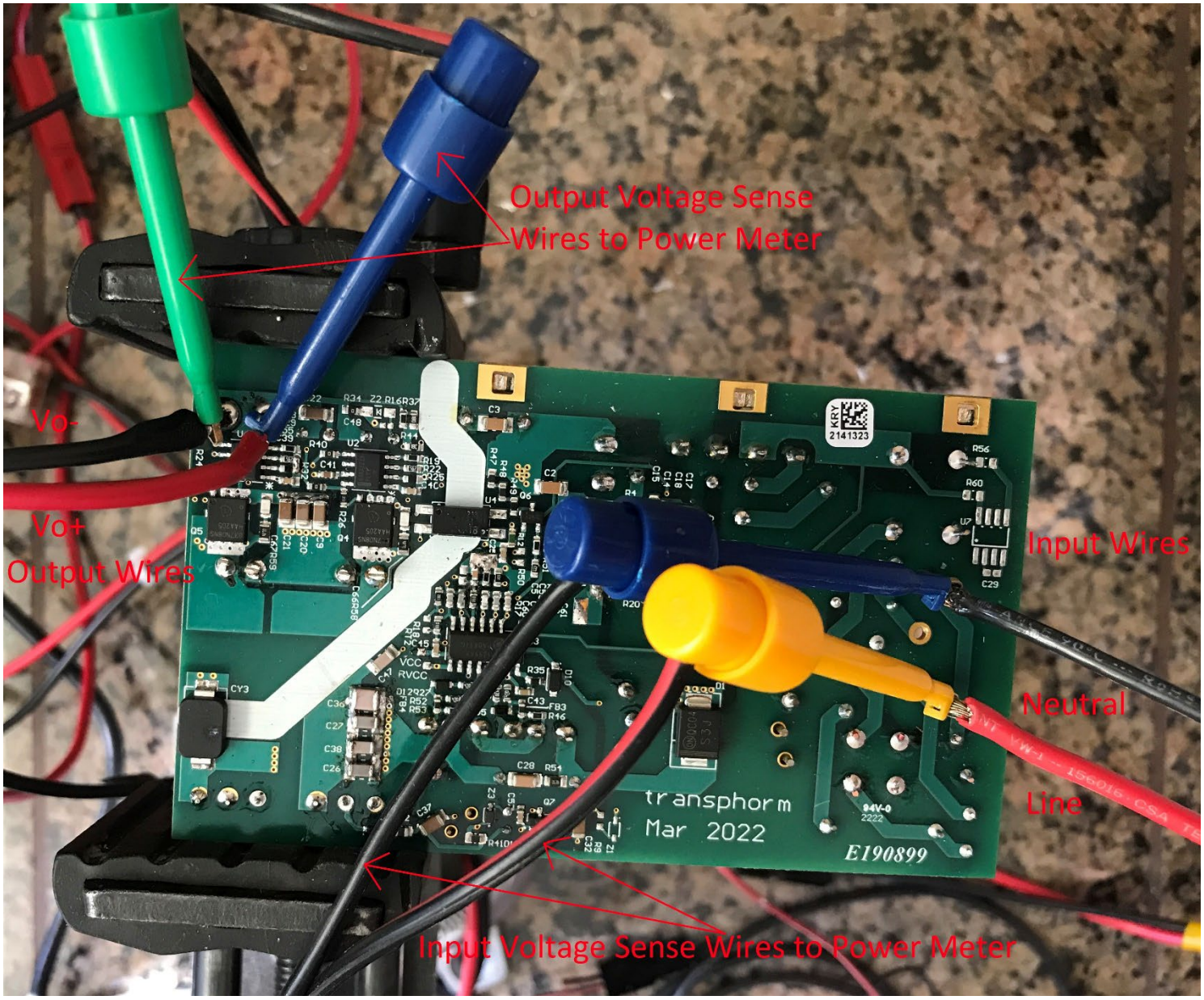


WINDING SEQUENCE

	A	B
TURNS	21	21
WIRE SIZE	#22 HPN	#22 HPN
WIND METHOD	half core	half core
TAPS		
INSULATION		
INSULATION		
TERM. IDENT. (S - F)	1 - 2	4 - 3
TERM. TYPE	Self	Self
LEAD OUT	4mm	4mm
SLEEVING #		
CREEPAGE		

Test Setup

Below picture shows the test setup with input and output wire connections. It is important to bring power meter voltage sense wires to adaptor PCB terminals for accurate efficiency reading.



Performance Data

No-Load Input Power

Input Voltage Vin(ac)	frequency	No-Load Pin (W)
90	60	0.237
115	60	0.199
230	50	0.259
264	50	0.265

Full Load Efficiency

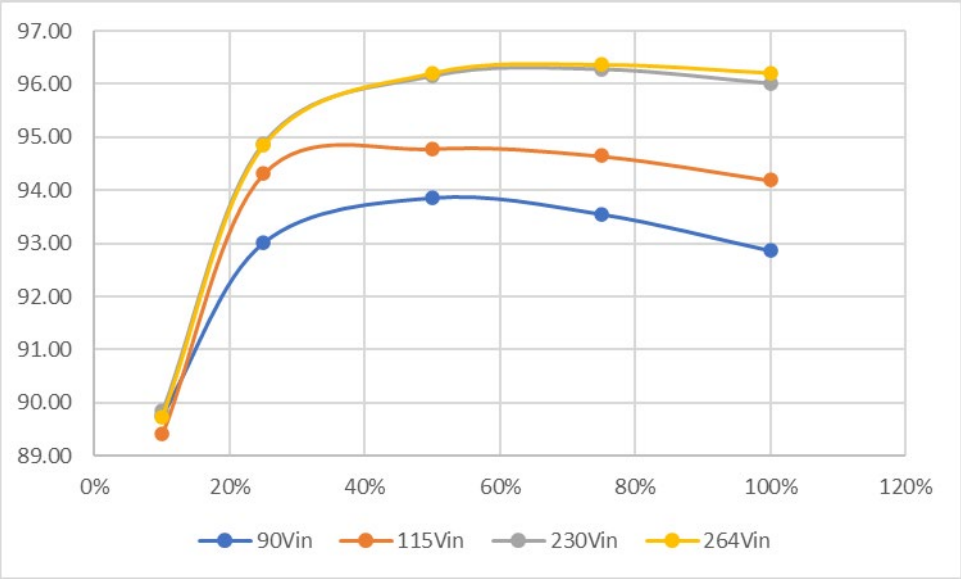
Vin	Vout	Iout	Efficiency
90	24.028	10.006	92.87
115	24.018	10.006	94.19
230	24.014	10.005	96.01
264	24.014	10.005	96.21

5-Point Average Efficiency

Vin	Load	Efficiency	Average Efficiency
115	100%	94.19	94.49
115	75%	94.65	
115	50%	94.79	
115	25%	94.32	
115	10%	89.41	

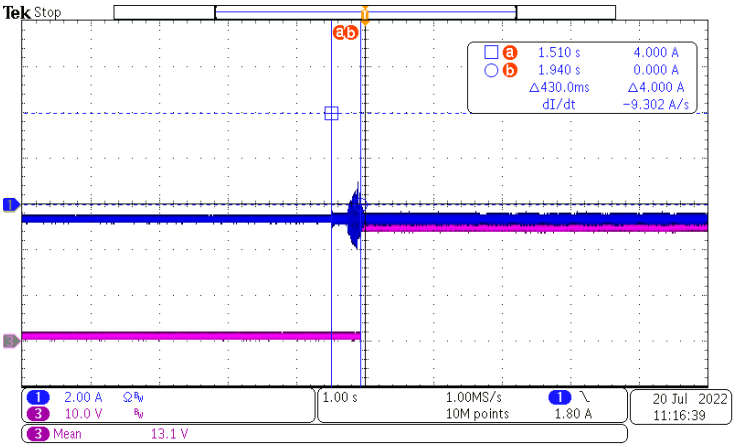
Vin	Load	Efficiency	Average Efficiency
230	100%	96.01	95.83
230	75%	96.28	
230	50%	96.15	
230	25%	94.89	
230	10%	89.84	

Efficiency Graphs

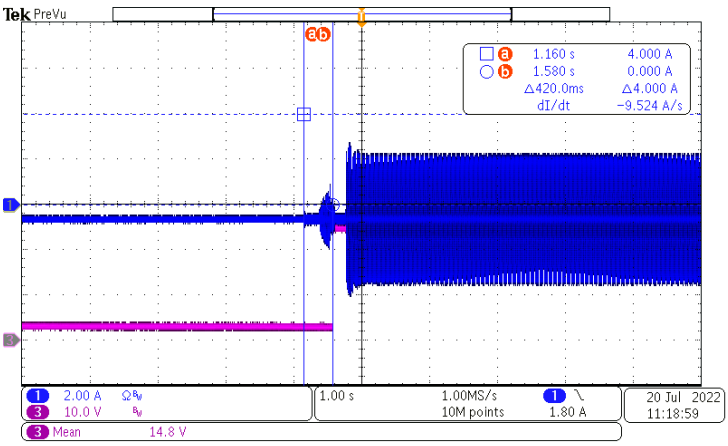


Startup

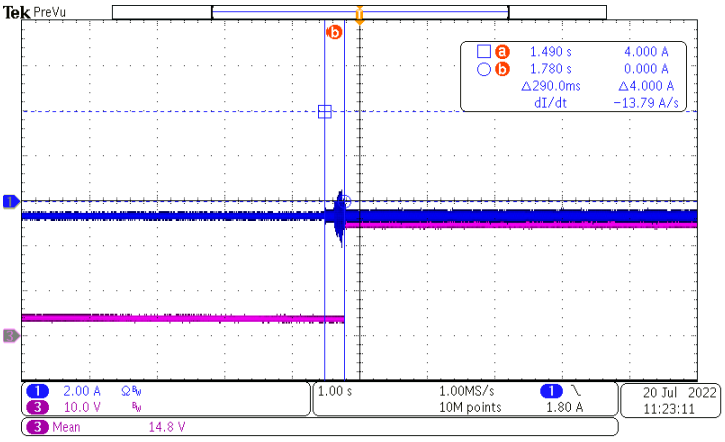
Vin	Iout	Startup time (second)	Test Condition
90	0	0.43	Startup test is performed
90	10.005	0.42	with a real resistor load.
115	0	0.29	Constant resistor (CR) load
115	10.004	0.3	type from an electronic load
230	0	0.23	should behave the same.
230	10.006	0.21	Adaptor may not start up if
264	0	0.19	electronic load is set to
264	10.005	0.22	constant current (CC) type.



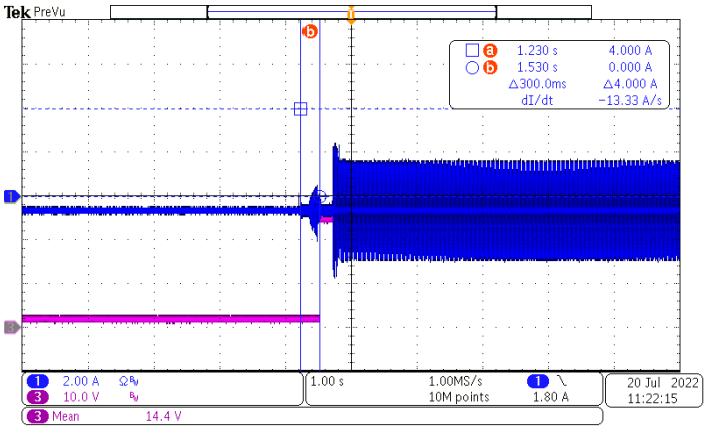
Vin = 90Vac, 60Hz; Vout = 24V; Iout = 0A



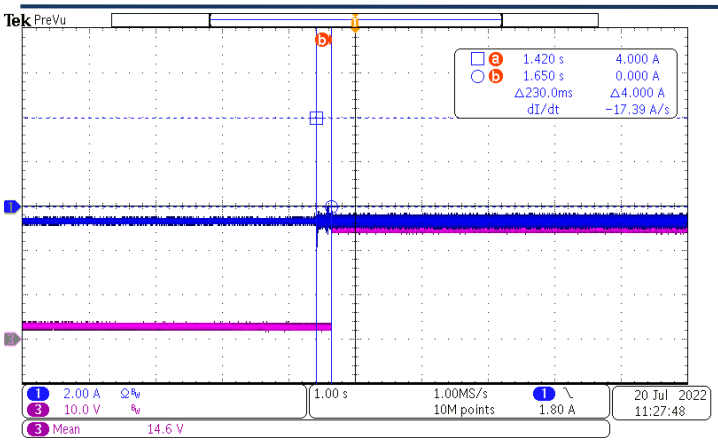
Vin = 90Vac, 60Hz; Vout = 24V; Iout = 10A



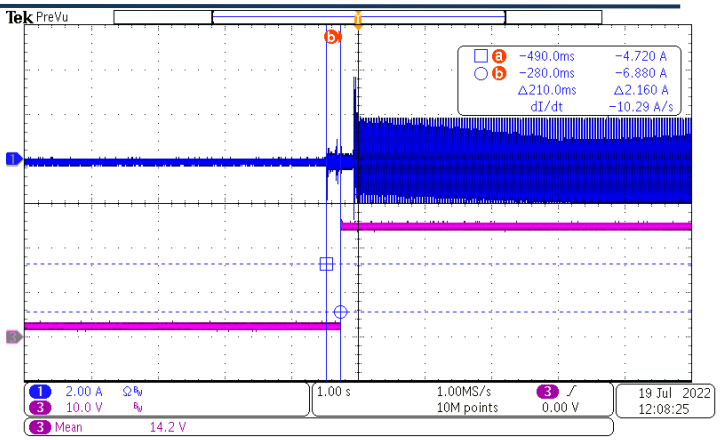
Vin = 115Vac, 60Hz; Vout = 24V; Iout = 0A



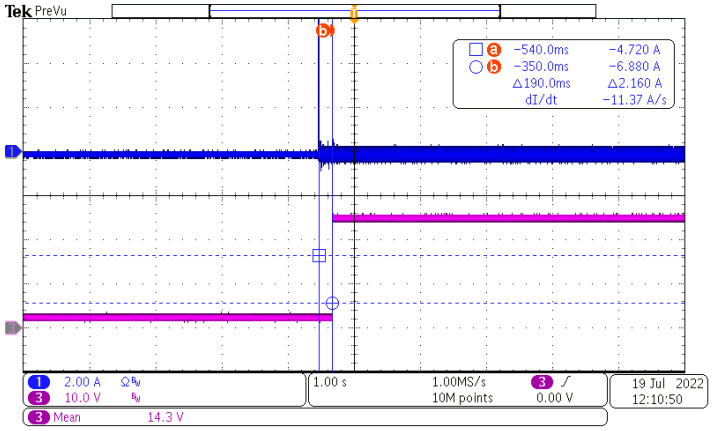
Vin = 115Vac, 60Hz; Vout = 24V; Iout = 10A



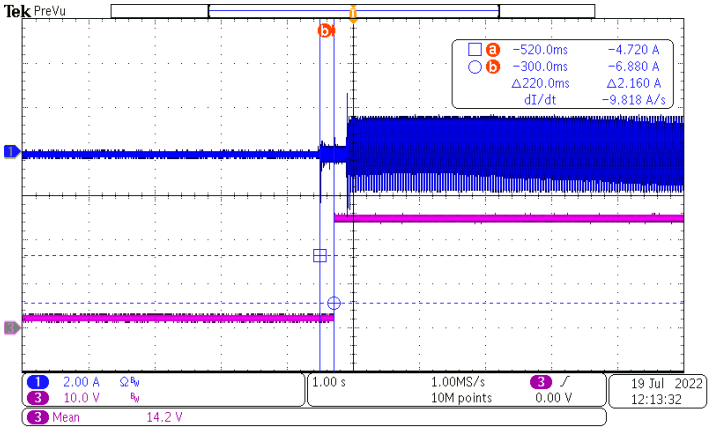
Vin = 230Vac, 50Hz; Vout = 24V; Iout = 0A



Vin = 230Vac, 50Hz; Vout = 24V; Iout = 10A



Vin = 264Vac, 50Hz; Vout = 24V; Iout = 0A

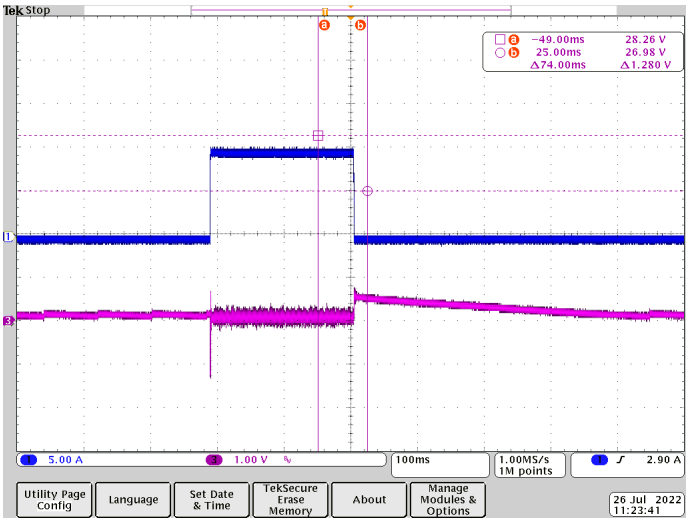


Vin = 264Vac, 50Hz; Vout = 24V; Iout = 10A

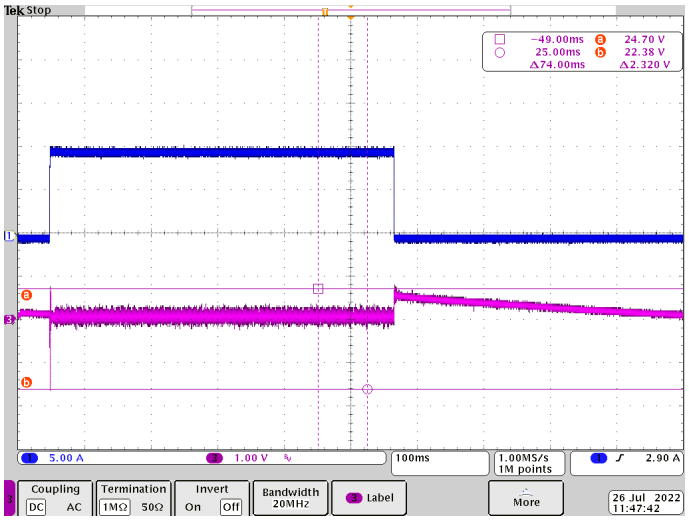
Note : Ch1 (Blue) : Iin. Ch3 (Purple): Vout.

Load Transitions

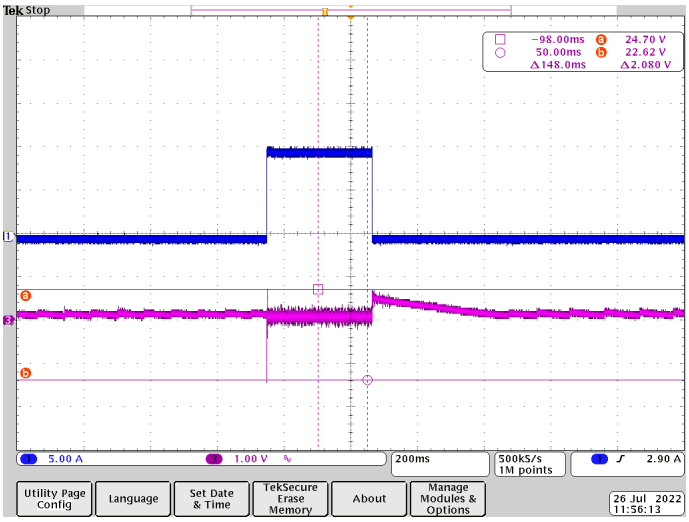
Vin	Dynamic Loading Description	Vout_min	Vout_max	Load current Slew Rate	Load type
90	0-100%-0 load steps	22.78	24.6	25A/mS	KP184, CR mode
115	0-100%-0 load steps	22.38	24.7	25A/mS	KP185, CR mode
230	0-100%-0 load steps	22.62	24.7	25A/mS	KP185, CR mode
264	0-100%-0 load steps	22.48	24.72	25A/mS	KP185, CR mode



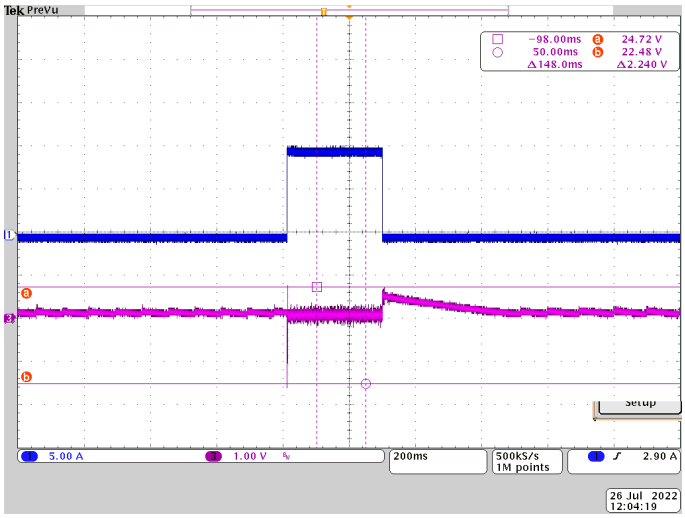
Vin = 90Vac, 60Hz; Vout = 24V; Iout = 0 to 10A to 0A Transitions, CR Load



Vin = 115Vac, 60Hz; Vout = 24V; Iout = 0-10-0A Transitions, CR Load



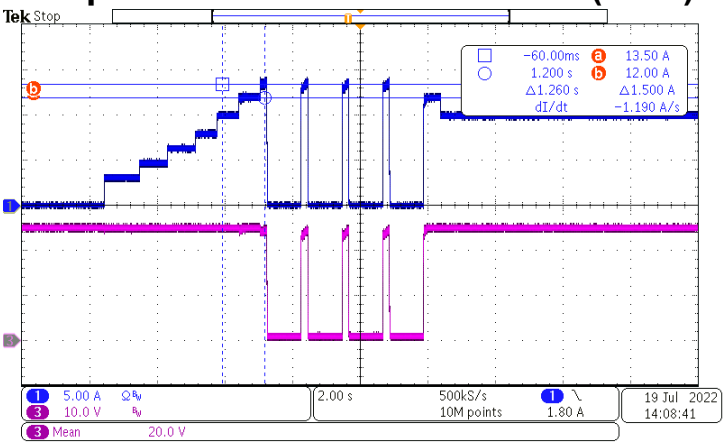
Vin = 230Vac, 50Hz; Vout = 24V; Iout = 0-10-0A Transitions, CR Load



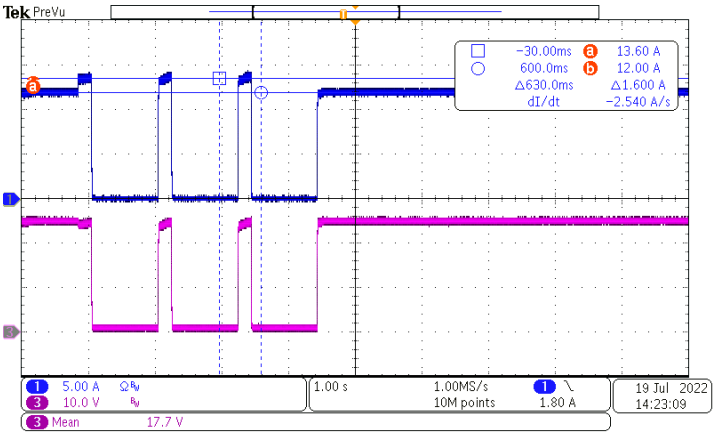
Vin = 264Vac, 50Hz; Vout = 24V; Iout = 0-10-0A Transitions, CR Load

Note : Ch1 (blue) : Iout. Ch3 (Purple): Vout offset by 24V to show transient ripple.

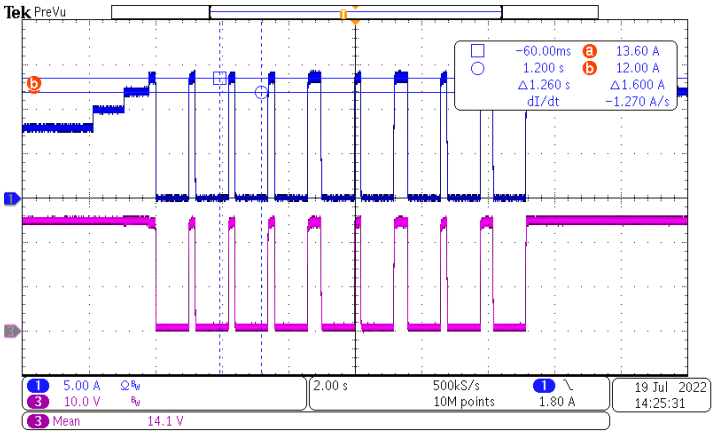
Output Over Current Protection (OCP)



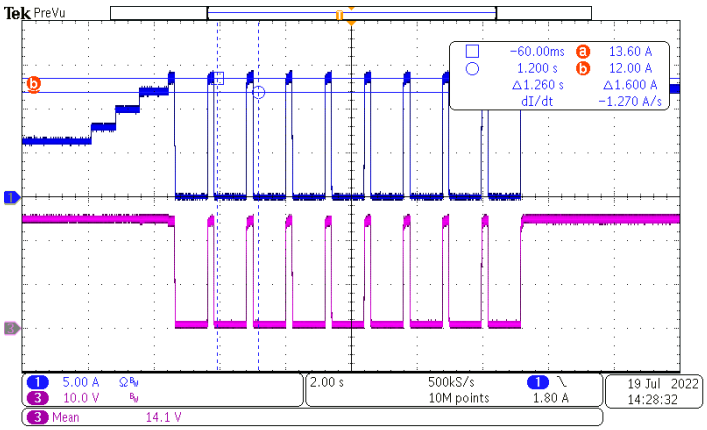
Vin = 90Vac, 60Hz; Vout = 24V; Iout OCP



Vin = 115Vac, 60Hz; Vout = 24V; Iout OCP



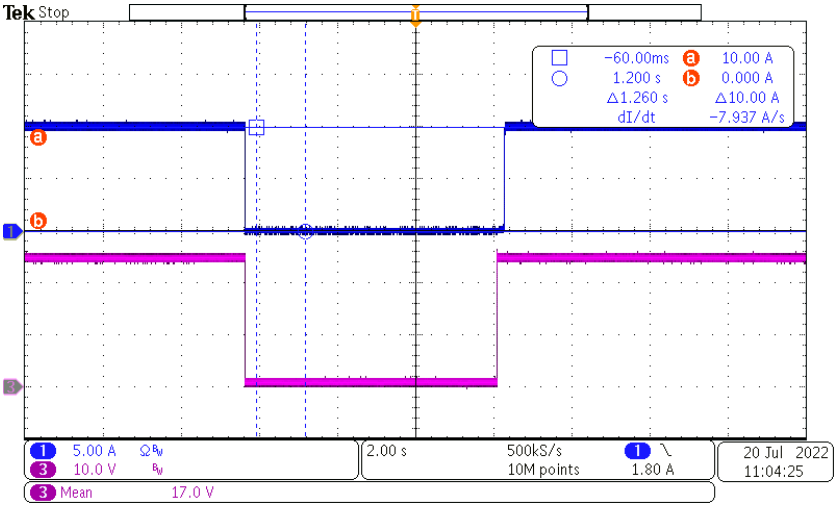
Vin = 230Vac, 50Hz; Vout = 24V; Iout OCP



Vin = 264Vac, 50Hz; Vout = 24V; Iout OCP

Note : Ch1 (blue) : Iout. Ch3 (Purple): Vout.

Output Short Circuit Protection



Vin = 120Vac, 60Hz; Output Shorted and Recovers

Note : Ch1 (blue) : Iout. Ch3 (Purple): Vout.

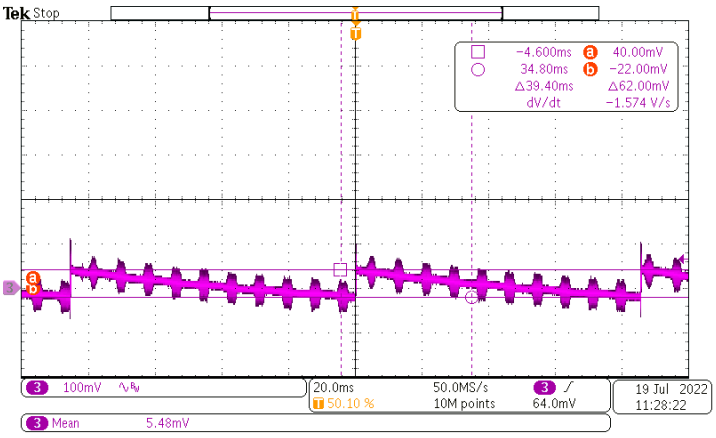
Output Voltage Ripple Noise

The output voltage ripple was measured using a voltage probe Tektronix TPP0250 in AC couple mode 20MHz bandwidth. Measurement is done at load side.

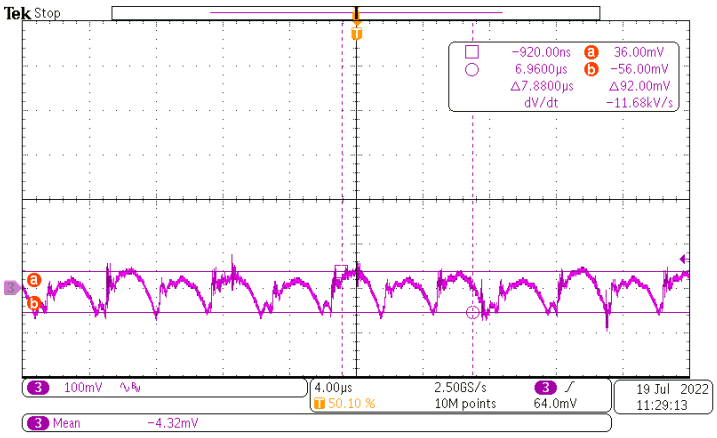
Output Voltage Ripple Summary

Vin	Vout	Iout	Vout_Ripple_PP (mV)
90	24.095	0	62
90	24.039	10.005	92
115	24.079	0	64
115	24.024	10.004	100
230	24.083	0	60
230	24.03	10.006	108
264	24.076	0	60
264	24.027	10.005	108

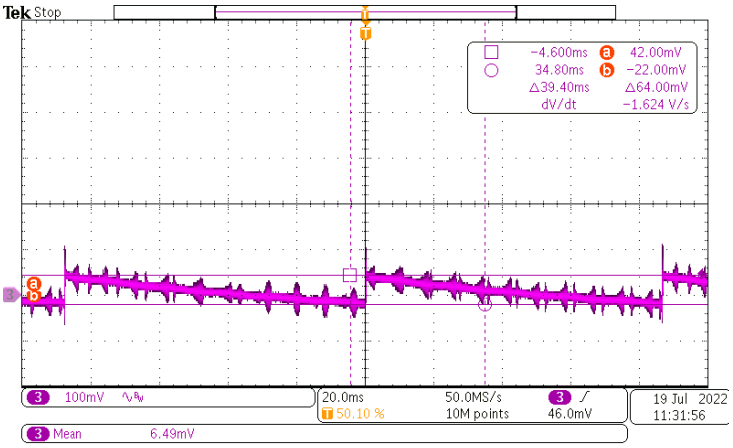
90Vac 60Hz



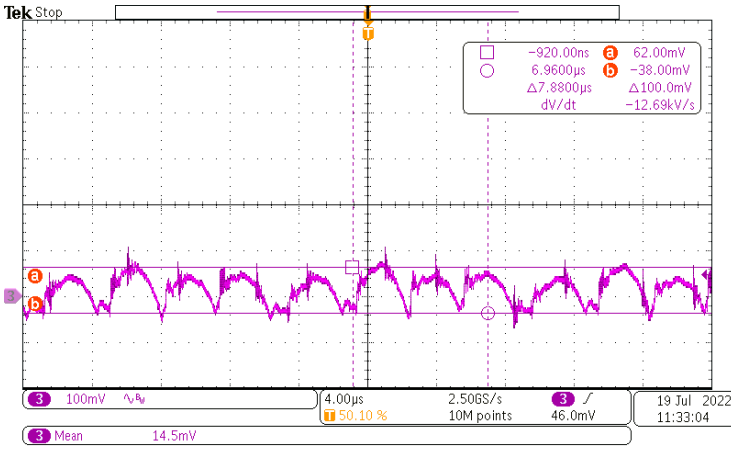
Vin = 90Vac, 60Hz; Vout = 24V; Iout = 0A



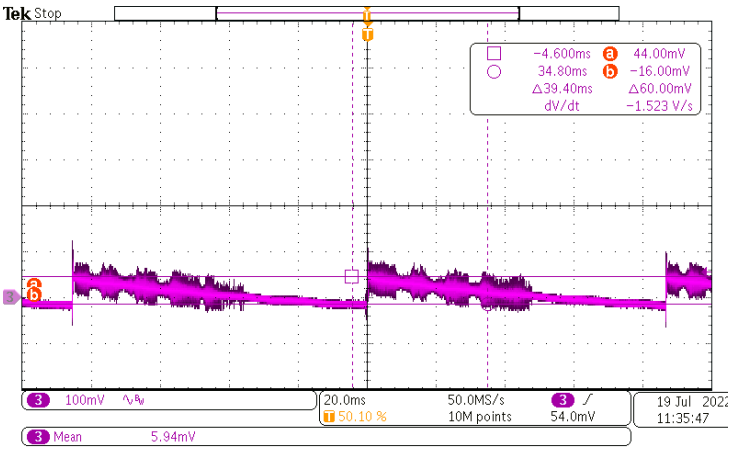
Vin = 90Vac, 60Hz; Vout = 24V; Iout = 10A



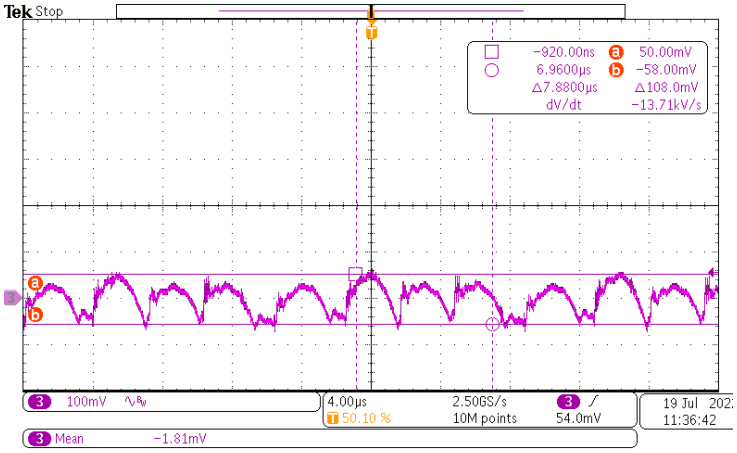
Vin = 115Vac, 60Hz; Vout = 24V; Iout = 0A



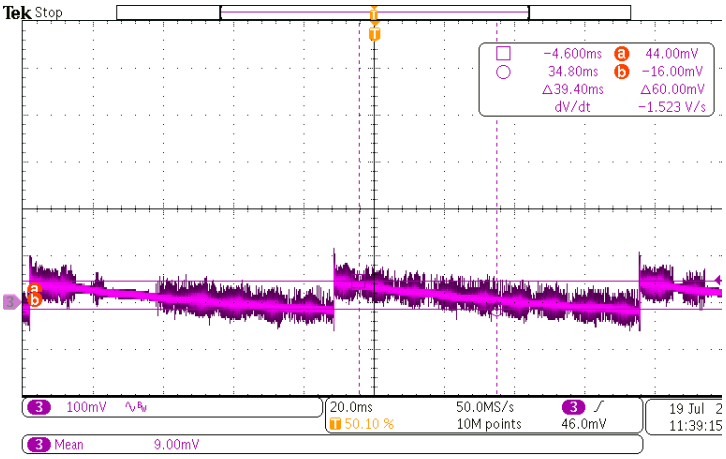
Vin = 115Vac, 60Hz; Vout = 24V; Iout = 10A



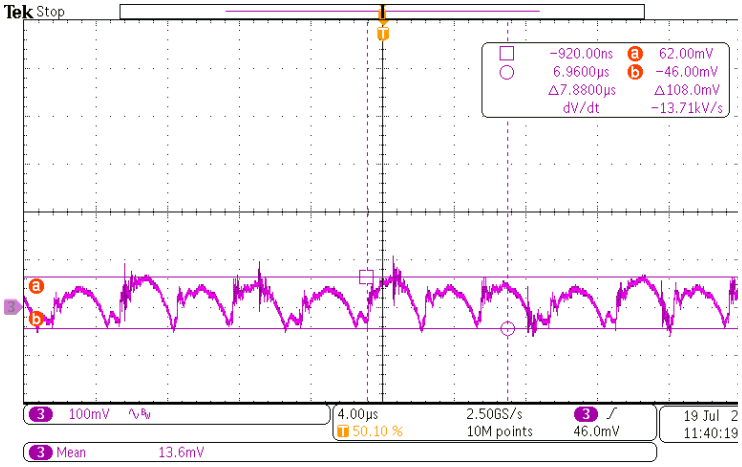
Vin = 230Vac, 50Hz; Vout = 24V; Iout = 0A



Vin = 230Vac, 50Hz; Vout = 24V; Iout = 10A



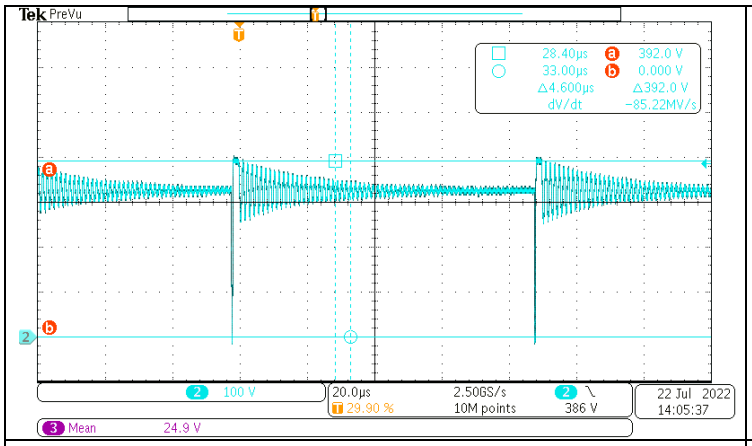
Vin = 264Vac, 50Hz; Vout = 24V; Iout = 0A



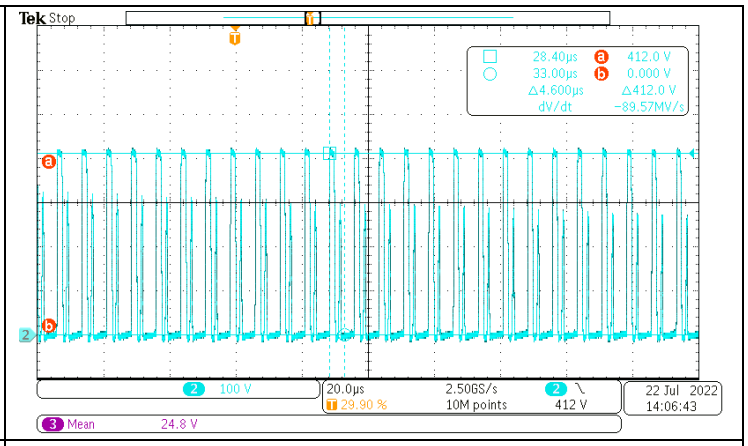
Vin = 264Vac, 50Hz; Vout = 24V; Iout = 10A

Key Waveforms

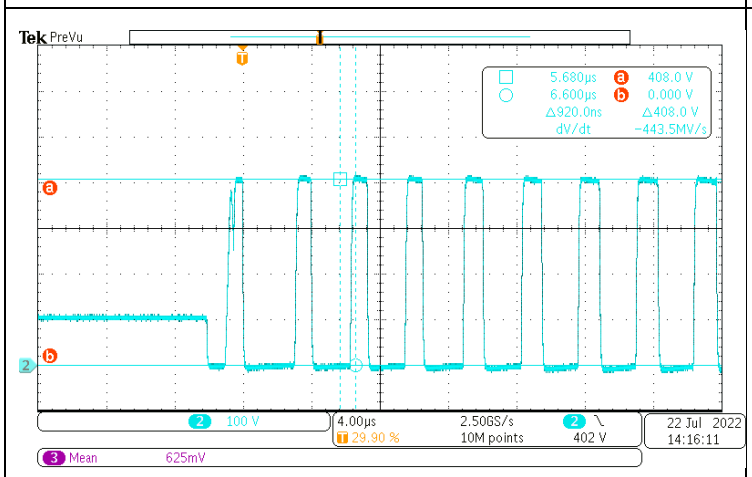
The key waveforms for the worst-case voltage conditions as seen by the primary side GaN Transistors and secondary side MOSFETs are shown below.



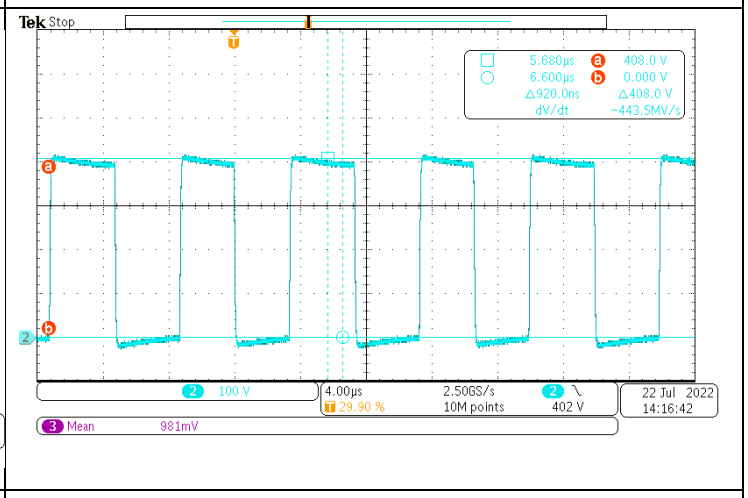
Vin=264Vac, Vout=24V, Iout=0A, Vds_PFC (max) =392V



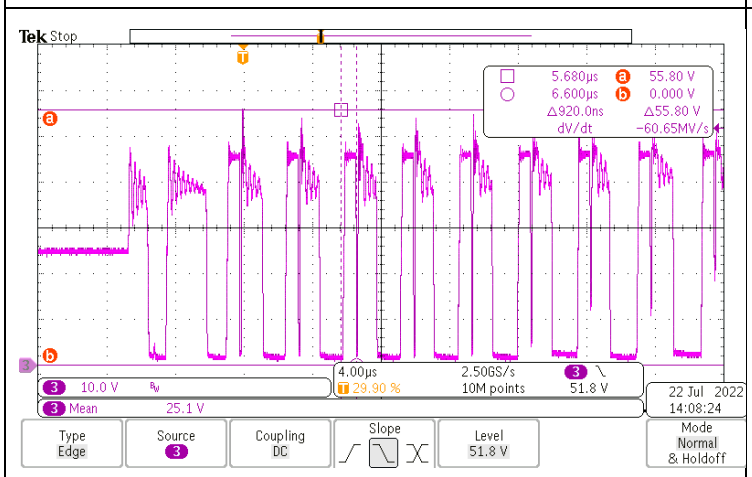
Vin=264 Vac, Vout=24V, Iout=10A, Vds_PFC (max) = 412V



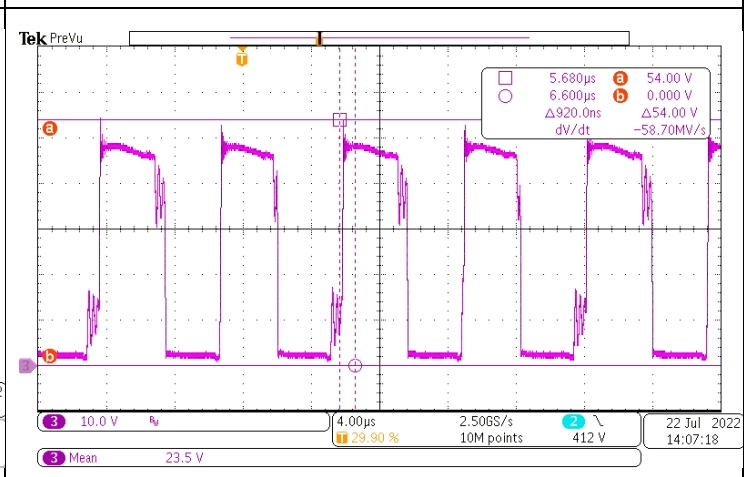
Vin=264Vac, Vout=24V, Iout=0A, V_HB (max) =408V



Vin=264 Vac, Vout=24V, Iout=10A, V_HB (max) = 408V



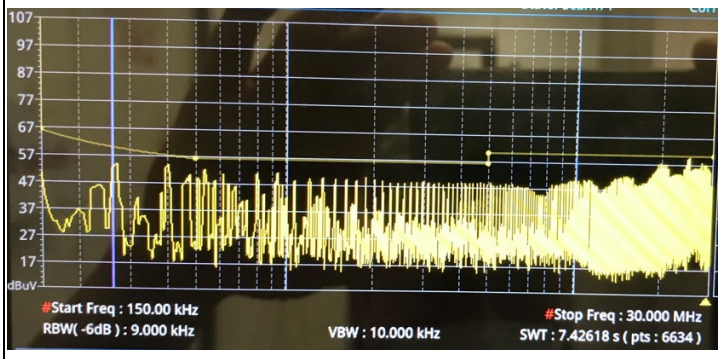
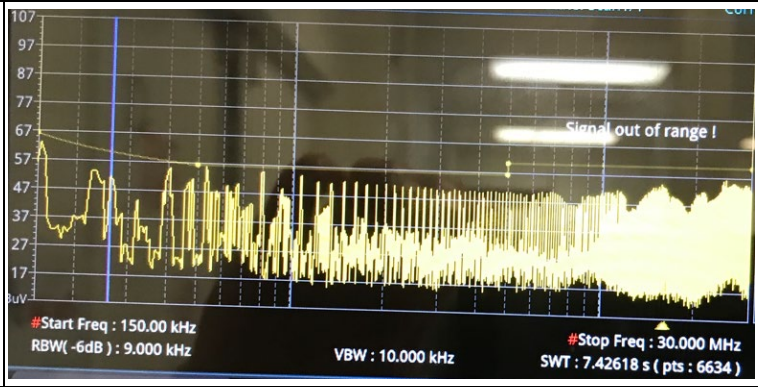
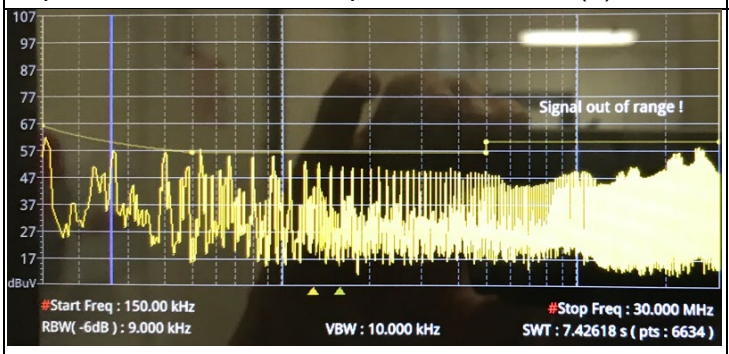
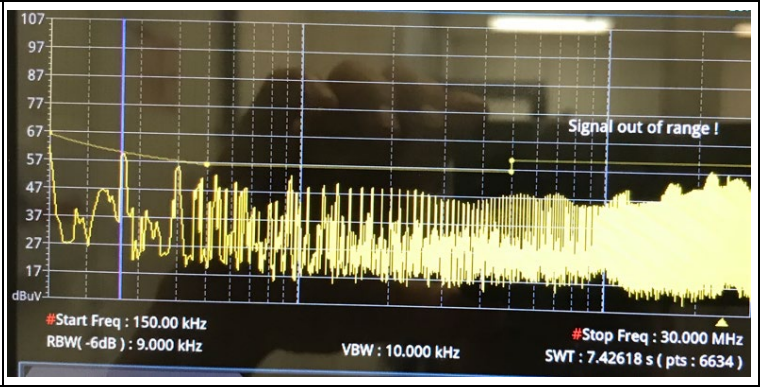
Vin=264Vac, Vout=24V, Iout=0A, Vds_sec (max) =55.8V



Vin=264 Vac, Vout=24V, Iout=10A, Vds_sec (max) = 54V

Conducted EMI Scans

Conducted EMI is performed by removing CMC2, putting CMC1 at CMC2 location and bypassing CMC1 location with jumpers.

Input: AC100V 60Hz, Output: DC24V 10A, (L)	Input: AC100V 60Hz, Output: DC24V 10A, (N)
	
Input: AC230V 50Hz, Output: DC24V 10A, (L)	Input: AC230V 50Hz, Output: DC24V 10A, (N)
	

Thermal Measurements

The key component temperatures are shown below for operating conditions after 90min bake time.

Vin	Iout (A)	T_D3	T_Q1	T_Q2	T_XF	T_Q4	T_L3	T_L1	T_amb
90	8.004	96.6	90.7	63.7	75	74.4	60.7	62.9	27.7
90	9.005	107	101	70.6	84	78.7	68	72.5	28
115	10	99.5	92.6	71.5	92.6	86.4	69.6	68.8	28.8
230	10	74.1	70	64.8	91.1	79.8	61	52.7	29.4
264	10	69.4	64	63.2	90.3	66.9	54.2	43.2	29.6

Revision History Revision

Hardware Info

Info	Value
Timestamp	July 26, 2022
Primary Side IC	NCP1654, NCP1399
Key FETs	Transphorm 650 V SuperGaN™ FET (TP65H150G4PS)
Secondary Side IC	NCP4306
AC Supply	Chroma Programable AC Source, 61601
Input Meter	Chroma digital power meter 66202, Yokogawa WT1800, Yokogawa WT1600
Output Meter	Chroma digital power meter 66202, Yokogawa WT1800, Yokogawa WT1600
Oscilloscope	Tektronix MDO3014
No-load bake time	30
Input voltages	[(90, 60), (115, 60), (230, 50), (264, 50)]
Output voltages	[24]
Electronic Load	KP184, ET5411, Chroma 63804