

DesignGuidePD 65WAdapter TPA0651C04

PowerAdapterDescription

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

KeySpecs	Schematics
Input	90-264Vac
Output Voltages	5V, 9V, 12V, 15V, 20V
Max Output Current	3A for 5V, 9V, 12V, 15V 3.25A for 20V
Max Output Power	65W
Output Port	USB-PD
Efficiency	>92.5% Full Power Efficiency

Features

- Integrated Transphorm GaN for QR Flyback Switch
- Board-end over 92% Efficiency
- Flat Efficiency Across Universal (90-264VAC) Input Voltage and Load
- Tight Switching Frequency Regulation for Improved Input EMI Filter Utilization
- Up to 300KHz Switching Frequency Operation
- OTP, UVLO, OPP and OSC Protections
- <50mW No Load Power Consumption of the IC
- Up to 65W Output Power

Applications

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

Warning

Tel: +86-13501775977
Mail: HZ021@QQ.COM



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.

Contents

EVBDescription	1
Features	1
Applications	1
Warning	2
PowerSupply Specifications	4
Board Pictures	5
Schematic	6
CircuitDescription	7
InputProtection	7
EMIFiltering	7
FaultProtections	7
PCBLayout	8
PCBPrints	8
Bill of Materials (BOM)	10
TransformerSpecification	12
Common-ModeChokeSpecification	13
PerformanceData	14
ElectricalData	14
EfficiencyGraphs	17
KeyWaveforms	19
ConductedEMI Scans	20
OutputVoltage Ripple Noise	22
ThermalMeasurements	25
RevisionHistory	27
HardwareInfo	27

Tables

TABLE1:RECOVERYBEHAVIOR	7
TABLE2:TRANSFORMERMATERIALLISTS	12
TABLE3:COMMON-MODECHOKEMATERIALLISTS	13
TABLE4:LOADEFFICIENCYREQUIREMENTS	14
TABLE5:NO-LOADPOWERCONSUMPTION	18
TABLE6:OUTPUTVOLTAGERIPPLESUMMARY	22

PowerSupplySpecifications

The evaluation board performance data presented in this report exceeds the power supply specifications listed in the following table.

Description	Symbol	Min.	Typ.	Max.	Units	Comments
Input						
Voltage	V_{in}	90	115/230	264	VAC	2WireInput
Frequency	f_{line}	47	60/50	63	Hz	
Efficiency						
5V/3A	$\eta_{5V/3A}$		91.60		%	@115Vac, 25°C ambient
9V/3A	$\eta_{9V/3A}$		92.95		%	
12V/3A	$\eta_{12V/3A}$		93.43		%	
15V/3A	$\eta_{15V/3A}$		93.73		%	
20V/3.25A	$\eta_{20V/3.25A}$		93.74		%	
4-PointAveEfficiency						
5V	η_{ave_5V}		91.09		%	CoCversion5tier24-point(25%,50%,75%,100%) average efficiency@115Vac
9V	η_{ave_9V}		92.26		%	
12V	η_{ave_12V}		92.96		%	
15V	η_{ave_15V}		93.32		%	
20V	η_{ave_20V}		93.44		%	
No-Load InputPower	P_{in}		29.7		mW	@230Vac, 25°C ambient
Programmable OutputVoltage	V_{OUT}	5		20	V	
Environmental ConductedEMI	MeetsCISPR22B/EN55022					
AmbientTemperature	T_{AMB}	0		40	°C	Noairflow,sealevel.

NOTE: The circuit board needs to be evaluated for additional tests, such as ESD and Line Surge to use the evaluation board design presented in this test report as a charger/adaptor. Furthermore, the layout of the board needs to be adjusted according to the target shape and form factor of the end application.

PD 65W Adapter TPA0651C04BoardPictures

Tel:+86-13501775977
Mail: HZ021@QQ.COM

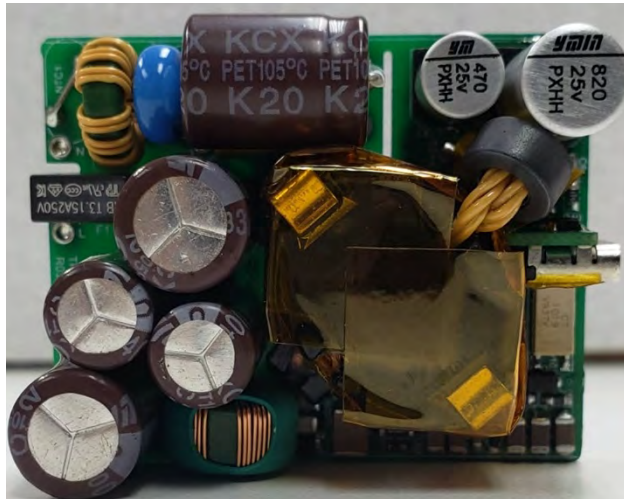


Figure1:TopSideoftheEVB



Figure2:BottomSideoftheEVB

Schematic

Tel:+86-13501775977
Mail: HZ021@QQ.COM

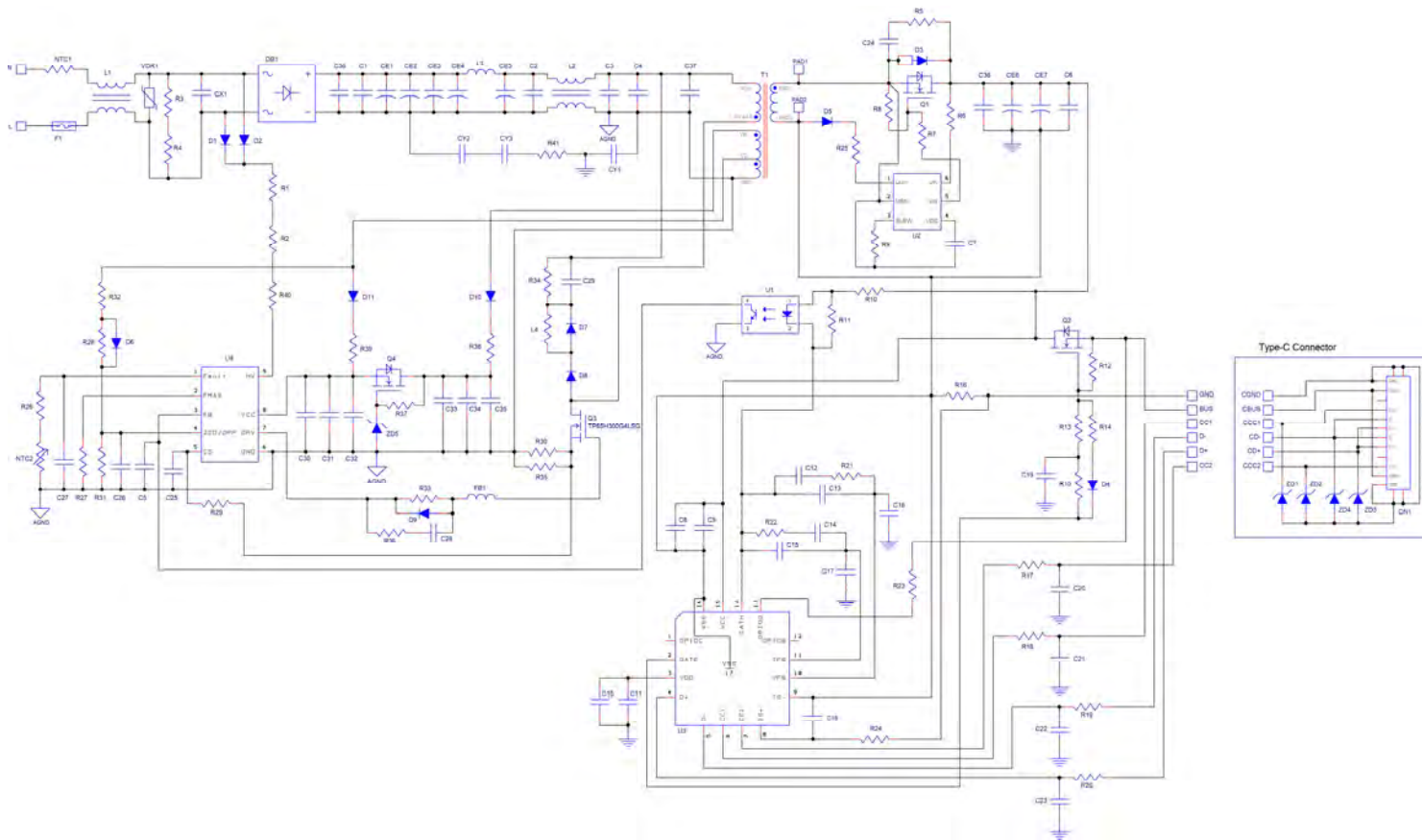


Figure3:65WSchematic

CircuitDescription

InputProtection

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.

EMIFiltering

To meet the target EN55032 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 two common-mode chokes (L1 & L2) as well as a transformer (T1) construction for better EMI performance.

FaultProtections

Table1:RecoveryBehavior

FaultProtection	
InputUnderVoltageLockout(UVLO)/Brown-Out	Auto-Recovery
InputOverVoltageLockout(OVLO)	Auto-Recovery
InternalOverTempProtection(OTP)	Auto-Recovery
ExternalOverTempProtection(OTP)	Auto-Recovery
PeakCurrentLimit(PCL)	Auto-Recovery
Over-PowerProtection(OPP)	Auto-Recovery
OutputShortCircuit(OSC)	Auto-Recovery

PCBLAYOUT

PCBPrints, Size: 38x48mm

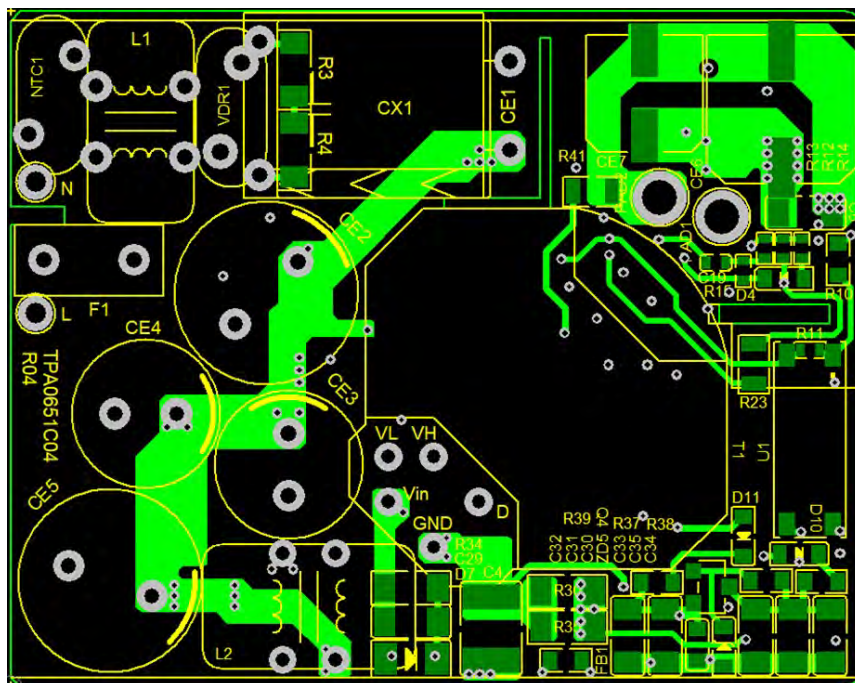


Figure4: Component side mainboard, top

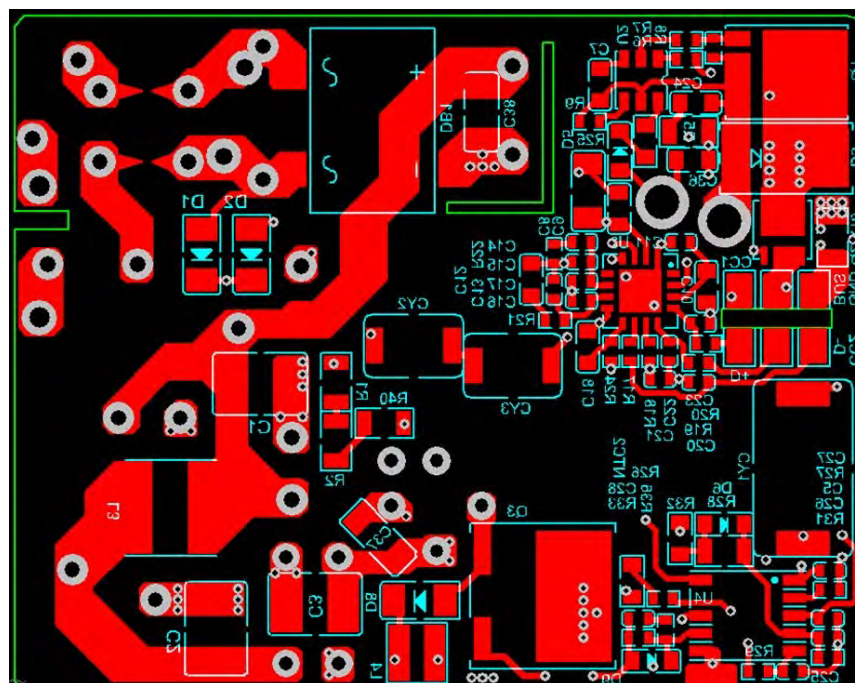


Figure5: Solder side main board, bottom

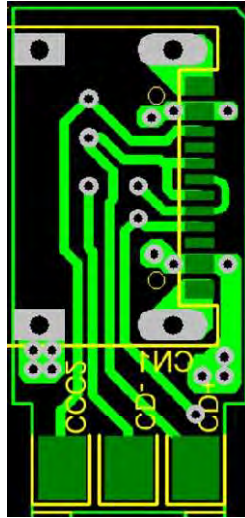


Figure6: PDboard, top

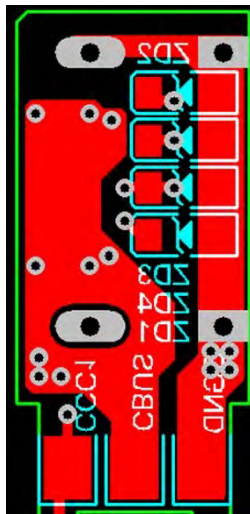


Figure7: PDboard, bottom

BillofMaterials(BOM)

Description	Designator	Manufacturer	Manufacturerpartnumber
65WBoard(Main board)			
0.47uF, 450V, X7T, 1812	C1	TDK	CGA8N4X7T2W474M230KA
0.47uF, 450V, X7T, 1812	C2	TDK	CGA8N4X7T2W474M230KA
0.47uF, 450V, X7T, 1812	C3	TDK	CGA8N4X7T2W474M230KA
0.47uF, 450V, X7T, 1812	C4	TDK	CGA8N4X7T2W474M230KA
330pF, NPO, 16V, 0402	C5	AVX	0402YA331JAT2A
10uF, 25V, X7R, 1206	C6	TDK	CGA5L1X7R1E106M160AC
1uF, 25V, X7R, 0603	C7	TDK	C1608X7R1E105K080AB
10uF, 25V, X7R, 1206	C8	TDK	CGA5L1X7R1E106M160AC
0.1uF, 25V, X7R, 0603	C9	AVX	06033C104KAT4A
4.7uF, 10V, X7S, 0603	C10	TDK	C1608X7S1A475M080AC
0.1uF, X7R, 25V, 0402	C11	AVX	04023C104KAT2A
1uF, X7R, 25V, 0603	C12	TDK	C1608X7R1E105K080AB
68nF, X7R, 25V, 0402	C13	TDK	GRM155R71E683KE14D
68nF, X7R, 25V, 0402	C14	TDK	GRM155R71E683KE14D
68nF, X7R, 25V, 0402	C15	TDK	GRM155R71E683KE14D
100pF, NPO, 25V, 0402	C16	Taiyo Yuden	TMK042CG101JC-W
100pF, NPO, 25V, 0402	C17	Taiyo Yuden	TMK042CG101JC-W
1uF, X7R, 25V, 0603	C18	AVX	0603ZC105KAT2A
4.7nF, X7R, 25V, 0402	C19	AVX	04023C472KAT2A
560pF, NPO, 50V, 0402	C20	Yageo	CC0402JRNPO9BN561
560pF, NPO, 50V, 0402	C21	Yageo	CC0402JRNPO9BN561
560pF, NPO, 50V, 0402	C22	Yageo	CC0402JRNPO9BN561
560pF, NPO, 50V, 0402	C23	Yageo	CC0402JRNPO9BN561
NC	C24	---	---
100pF, NPO, 25V, 0402	C25	Taiyo Yuden	TMK042CG101JC-W
12pF, NPO, 25V, 0402	C26	AVX	04023A120KAT2A
10nF, X7R, 50V, 0402	C27	Yageo	C0402C103K5RECAUTO
NC	C28	---	---
2.2nF, 500V, NPO, 1206	C29	TDK	CGJ5H4C0G2H222J115AA
0.1uF, X7R, 25V, 0603	C30	AVX	06033C104KAT4A
10uF, 25V, X7R, 1206	C31	TDK	CGA5L1X7R1E106M160AC
10uF, 25V, X7R, 1206	C32	TDK	CGA5L1X7R1E106M160AC
2.2uF, 100V, X7R, 1206	C33	AVX	12061C225K4T2A
2.2uF, 100V, X7R, 1206	C34	AVX	12061C225K4T2A
2.2uF, 100V, X7R, 1206	C35	AVX	12061C225K4T2A
68nF, X7R, 25V, 0603	C36	AVX	06033C683KAT2A
47nF, 500V, X7R, 1206	C37	TDK	GRM31CR72H473KW09L
NC	C38	---	---
22uF, 400V, Ymin, D10x13.5mm	CE1	Ymin	KCX Series
33uF, 400V, Ymin, D10x18mm	CE2	Ymin	KCX Series
18uF, 400V, Ymin, D8x17mm	CE3	Ymin	KCX Series
18uF, 400V, Ymin, D8x17mm	CE4	Ymin	KCX Series
33uF, 400V, Ymin, D10x18mm	CE5	Ymin	KCX Series
820uF, 25V, Ymin, D8x16.5mm	CE6	Ymin	VPX Series
470uF, 25V, Ymin, D6.3x13mm	CE7	Ymin	VPX Series
220nF, 275V, Pitch 7.5mm, WQC	CX1	WQC	---
470pF, Y5P	CY1	TRX	TMY1471K
220pF, Y5P	CY2	TRX	TBY2221KB
220pF, Y5P	CY3	TRX	TBY2221KB
RSFML, SOD123	D1	Taiwan Semiconductor	RSFML RVG
RSFML, SOD123	D2	Taiwan Semiconductor	RSFML RVG
P10L150SP, TO-277	D3	PFC Device	P10L150SP
BAS16HT1G, SOD323	D4	On-Semi	BAS16HT1G
BAS20HT1G, SOD323	D5	On-Semi	BAS20HT1G
BAS20HT1G, SOD323	D6	On-Semi	BAS20HT1G
ES1JFL	D7	On-Semi	ES1JFL
S1MWF-7	D8	DIODES	S1MWF-7

ZHCS400TA	D9	DIODES	ZHCS400TA
ES1JFL	D10	On-Semi	ES1JFL
BAS20HT1G, SOD323	D11	On-Semi	BAS20HT1G
HBS610	DB1	Dyelec	HBS610
3.15A, 250V, 5ET, Slow blow	F1	Hollyfuse	RST 3.15-BULK
MMZ1608S800AT	FB1	TDK	MMZ1608S800AT
HF70 T10x3x6	FB2	TDK	HF70 T10x3x6
ACME K12, T9x5x3C	L1	Createk	DXT009078-A
ACME A10, T10x6x5C	L2	Createk	DXT010079-A
22uH	L3	Bourns	SRR4528A-220M
10R, 1206, 5%, 1/4W	L4	---	---
Jumper wire, D0.5mm, L12mm, P5mm	NTC1	---	---
100K	NTC2	MuRata	NCP18WF104F12RB
Main Board, 2oz, FR4, 38x48mm, T1mm	PCB	---	---
AONS62922, SOP-8(5x6mm)	Q1	Alpha & Omega	AONS62922
BSZ0902NS, TSDSON-8	Q2	Infineon	BSZ0902NS
TP65H300G4LSG, 8x8_PQFN(LS)	Q3	Transphorm	TP65H300G4LSG
BSS123, SOT23	Q4	Fairchild	BSS123
1.5K, 0805, 5%, 1/8W	R1	---	---
1.5K, 0805, 5%, 1/8W	R2	---	---
4.7M, 1206, 5%, 1/4W	R3	---	---
4.7M, 1206, 5%, 1/4W	R4	---	---
NC	R5	---	---
300R, 0402, 1%, 1/16W	R6	---	---
0402, Jumper	R7	---	---
10K, 0402, 5%, 1/16W	R8	---	---
43K, 0402, 1%, 1/16W	R9	---	---
510R, 0603, 5%, 1/10W	R10	---	---
4.7K, 0402, 5%, 1/16W	R11	---	---
1M, 0402, 5%, 1/16W	R12	---	---
100K, 0402, 1%, 1/16W	R13	---	---
10K, 0402, 5%, 1/16W	R14	---	---
47K, 0402, 1%, 1/16W	R15	---	---
0805, 5mR, 1/2W	R16	Panasonic	ERJ-6LWFR005V
22R, 0402, 5%, 1/16W	R17	---	---
22R, 0402, 5%, 1/16W	R18	---	---
5.1R, 0402, 5%, 1/16W	R19	---	---
5.1R, 0402, 5%, 1/16W	R20	---	---
4.7K, 0402, 1%, 1/16W	R21	---	---
47K, 0402, 1%, 1/16W	R22	---	---
0805, 1K	R23	Panasonic	ERJ-P06F1001V
5.1K, 0402, 5%, 1/16W	R24	---	---
10R, 0603, 5%, 1/10W	R25	---	---
5.6K, 0402, 1%, 1/16W	R26	---	---
82K, 0402, 1%, 1/16W	R27	---	---
680K, 0805, 1%, 1/8W	R28	---	---
100R, 0402, 1%, 1/16W	R29	---	---
0.43R, 1206, 1%, 1/2W	R30	Panasonic	ERJ-8BQFR43V
2.4K, 0402, 1%, 1/16W	R31	---	---
9.1K, 0603, 1%, 1/10W	R32	---	---
820R, 0402, 1%, 1/16W	R33	---	---
1.3M, 1206, 5%, 1/4W	R34	---	---
0.43R, 1206, 1%, 1/2W	R35	Panasonic	ERJ-8BQFR43V
NC	R36	---	---
100K, 0603, 5%, 1/10W	R37	---	---
300R Ferrite Bead, 0603	R38	TDK	MMZ1608S301AT
300R Ferrite Bead, 0603	R39	TDK	MMZ1608S301AT
1.5K, 0805, 5%, 1/8W	R40	---	---
RM8 Transformer	T1	Createk	DXM008042-B
Opto-Coupler-SMD5KV	U1	CT Micro	CT1019
MP6908A, SOT2306	U2	MPS	MP6908A
PD controller, 4x4mm	U3	Weltrend	WT6633P

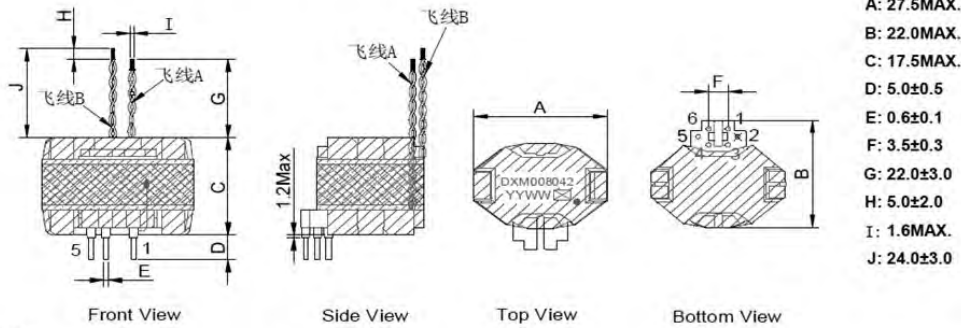
NCP1342AMDCDD1R2G	U4	On-Semi	NCP1342AMDCDD1R2G
MOV-07D511K	VDR1	VDR	MOV-07D511K
Zener Diode, 12V, 2%, Fairchild	ZD5	DIODES	MM3Z12VB
Heatsink,Copper, 1x10x20mm	HS1	---	---

Description	Designator	Manufacturer	Manufacturerpartnumber
65WBoard(USBType-CConnector)			
USB Type-C connector, 16P	CN1	SHENZHEN HONGSEN PRECISION ELECTRONICS	USBC-202N03A03
FR4, 1.0mm, 2oz, 7.3x15.7mm, 4 layers, R01	PCB	---	---
TVS, 24V, SOD323	ZD1	KF	GBLC24
TVS, 24V, SOD323	ZD2	KF	GBLC24
TVS, 5V, SOD323	ZD3	KF	ESD3Z5V0
TVS, 5V, SOD323	ZD4	KF	ESD3Z5V0

Transformer Specification

1. 外形尺寸 (单位:mm)

Physical Dimensions (Unit: mm)

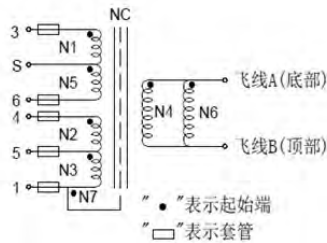


Notes:

- (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;

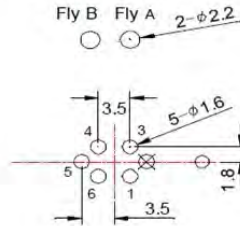
2. 线路图

Connection



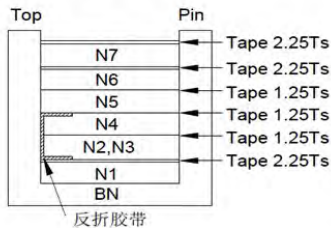
3. 推荐焊盘孔尺寸 (单位:mm)(顶视图)

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	φ0.10mm*20P UEWH/U绞合线	密绕一层
N2	4 - 5	10 TS	φ0.14mm*1P UEWH/U漆包线	N2密绕半层, N3接着N2台阶密绕
N3	5 - 1	5 TS	φ0.14mm*8P UEWH/U漆包线	
N4	A - B	5 TS	(φ0.10*20P)*2P TIW-F绝缘线	密绕一层
N5	S - 6	13 TS	φ0.10mm*20P UEWH/U绞合线	密绕一层
N6	A - B	5 TS	(φ0.10*20P)*2P TIW-F绝缘线	密绕一层
N7	1 - NC	20 TS	φ0.15mm*1P UEWH/U漆包线	底起密绕半层

6. 电气特性

Electrical Characteristics

*Electrical specifications @ 25°C unless otherwise noted:

项目/Items	绕组/Winding	规格/Specifications	测试条件/Test conditions
电感量/Inductance	L(3-6)	140uH±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°C
	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	

Table2:TransformerMaterialLists

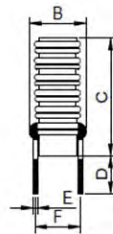
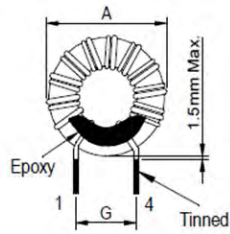
Bill of Material

No	Items	Material Name	Manufacturer	UL File No.	SGS File No.
1	Core	Soft ferrite core(MnZn) 3C95	FERROXCUBE or Equivalent	NIL	CANEC2017182601
2	Bobbin	PHENOLIC T375J	CHANG CHUN or Equivalent	E59481	ETR21502706
3	Copper Wire	Polyurethane wire UEWH/U	PACIFIC or Equivalent	E201757	A220035992510301E
4	Triple Wire	Multilayer insulated wire TIW-FXX	DONGJU or Equivalent	E488352	CANEC2023548505
5	Clip	SUS301	TONG FENG or Equivalent	NIL	SZXEC2001378801
6	Copper Foil	High conductive pure copper C1100	ZIGAO or Equivalent	NIL	SZXML2002718201
7	Polyimide Tape	Polyimide Adhesive Tape PF-301	YAHUA or Equivalent	E165111	CANEC2008940301
8	Teflon Tube	PTFE TUBE TFL	DONG JU or Equivalent	E478618	CANEC2023548503
9	Varnish	8562*	HANG CHEUNG or Equivalent	E200154	CANEC2100049805

Common-ModeChokeSpecification

L1

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

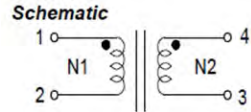


- A 12.5MAX.
- B 7.0MAX.
- C 11.5MAX.
- D 5.0±2.0
- E 0.35±0.1
- F 5.0Ref.
- G 4.0Ref.

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



"●"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°C
	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

Table3A:Common-ModeChokeMaterialLists

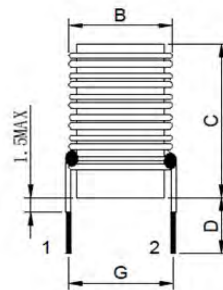
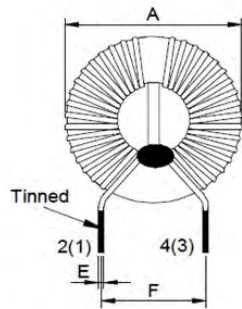
Bill of material

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

Common-ModeChokeSpecification

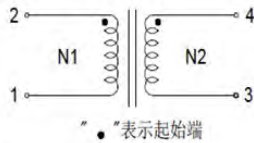
L2

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/项目	绕组/Winding	规格/Specifications	测试条件/Test conditions
电感量/Inductance	L(2-1)	4mH Min	at 10kHz,0.1Vrms
	L(4-3)	4mH Min	
直流电阻/DCR	R(2-1)	190mΩ Max.	at 25℃
	R(4-3)	190mΩ Max.	
耐压/Hi-Pot	绕组 - 绕组	1000VAC	3mA / 1SEC.

Table3B:Common-ModeChokeMaterialLists

Bill of Material

No	Items	Material Name	Manufacturer	UL File No	SGS File No
1	Core A	Ferrite core A10 T10X6X5C	ACME or Equivalent	NIL	
OR	Core B	Ferrite core N10 T10X6X5C	ENCORE or Equivalent	NIL	
2	Copper Wire	Polyurethane wire ø0.30mm UEFN/U	PACIFIC or Equivalent	E201757	A2180198365101E

PerformanceData

ElectricalData

Efficiency

DoE Level VI and CoC Version 5 Tier-2 4-point (25%, 50%, 75%, 100%) average efficiency, along with CoCVersion5Tier-210%load efficiency requirements.

Table4:LoadEfficiencyRequirements

Vout/Iout	DoE Level VI 4-PointAverageEfficiency
5V/3A	81.39%
9V/3A	86.62%
12V/3A	87.40%
15V/3A	87.73%
20V/ 3.25A	88.00%

The following efficiency data are averaged from PD 65W TPA0651C04 boards. The boards are soaked for 3 minutes before measuring the efficiency with output measured after the USB-PD disconnect FET.

115Vac4-pointaverageefficiency

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

%LOAD	Efficiency(%)	AverageEfficiency(%)
100	91.90	91.39
75	91.81	
50	90.73	
25	91.10	
10	88.69	

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

%LOAD	Efficiency(%)	AverageEfficiency(%)
100	93.25	92.56
75	93.10	
50	92.72	
25	91.19	
10	89.60	

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

%LOAD	Efficiency(%)	AverageEfficiency(%)
100	93.73	93.26
75	93.74	
50	93.42	
25	92.14	
10	91.41	

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

%LOAD	Efficiency(%)	AverageEfficiency(%)
100	94.03	93.62
75	93.94	
50	93.64	
25	92.87	
10	91.47	

 $V_{OUT}/I_{LOAD_MAX}=20\text{V}/3.25\text{A}$

%LOAD	Efficiency(%)	AverageEfficiency(%)
100	94.04	93.74
75	94.07	
50	93.96	
25	92.89	
10	90.16	

230Vac4-pointaverageefficiency

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

%LOAD	Efficiency(%)	AverageEfficiency(%)
100	90.21	89.34
75	89.41	
50	89.80	
25	87.94	
10	82.64	

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

%LOAD	Efficiency(%)	AverageEfficiency(%)
100	92.03	91.01
75	91.73	
50	90.05	
25	90.23	
10	86.25	

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

%LOAD	Efficiency(%)	AverageEfficiency(%)
100	93.01	92.00
75	92.39	
50	91.33	
25	91.29	
10	88.48	

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

%LOAD	Efficiency(%)	AverageEfficiency(%)
100	93.23	92.20
75	92.85	
50	91.69	
25	91.04	
10	88.70	

 $V_{OUT}/I_{LOAD_MAX}=20V/3.25A$

%LOAD	Efficiency(%)	AverageEfficiency(%)
100	93.85	93.03
75	93.49	
50	92.53	
25	92.27	
10	89.89	

Full Load Efficiencies at 90Vac / 115Vac / 230Vac / 265Vac; 5V / 9V / 12V / 15V / 20V
(measured after the USB-PDdisconnectFET)

Vout=5V

Vin	Iout	Efficiency(%)
90Vac@50Hz	3A	91.84%
115Vac @60Hz	3A	91.90%
230Vac @50Hz	3A	90.21%
265Vac @50Hz	3A	89.66%

Vout=9V

Vin	Iout	Efficiency(%)
90Vac@50Hz	3A	93.01%
115Vac @60Hz	3A	93.25%
230Vac @50Hz	3A	92.03%
265Vac @50Hz	3A	91.38%

Vout=12V

Vin	Iout	Efficiency(%)
90Vac@50Hz	3A	93.46%
115Vac @60Hz	3A	93.73%
230Vac @50Hz	3A	93.01%
265Vac @50Hz	3A	92.41%

Vout=15V

Vin	Iout	Efficiency(%)
90Vac@50Hz	3A	93.47%
115Vac @60Hz	3A	94.03%
230Vac @50Hz	3A	93.23%
265Vac @50Hz	3A	92.69%

Vout=20V

Vin	Iout	Efficiency(%)
90Vac@50Hz	3.25A	93.04%
115Vac @60Hz	3.25A	94.04%
230Vac @50Hz	3.25A	93.85%
265Vac @50Hz	3.25A	93.46%

Table5listsaverageno-loadpowerconsumptionof10boardsacrosstheinputvoltages.

Table5:No-loadPowerConsumption

InputVoltage(Vac)	No-LoadPower(mW)
115	20.0
230	28.5

KeyWaveforms

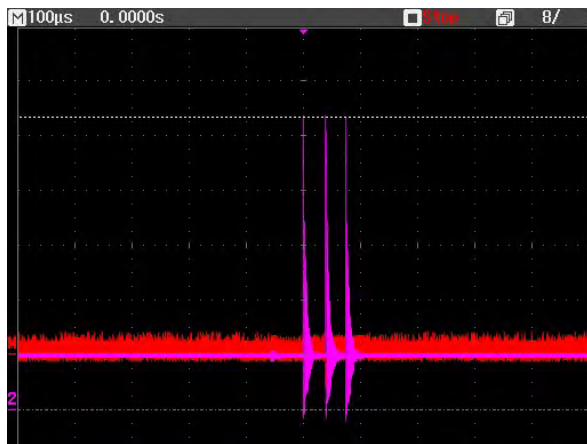
The key waveforms for the worst-case voltage conditions as seen by the primary side GaN Transistor and secondary side MOSFET are shown below.



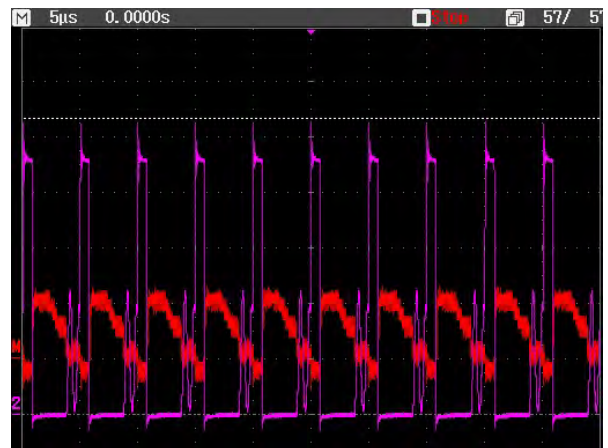
Vin=264 Vac, Vout=20 V, Iout=0A
Vds_pri (max) = 535V



Vin=264Vac, Vout=20V, Iout=3.25A
Vds_pri (max) = 537V



Vin=264 Vac, Vout=20 V, Iout=0A
Vds_sec (max) = 106V

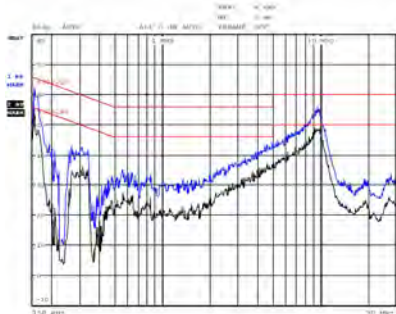


Vin=264Vac, Vout=20V, Iout=3.25A
Vds_sec (max) = 106V

Figure10-1:Voltage stress on the primary and secondary side MOSFET during worst case operating conditions

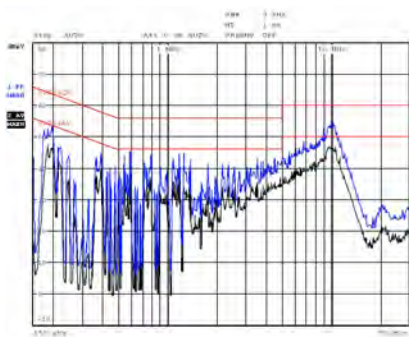
ConductedEMIScans

Input: AC100V 60Hz, Output: DC20V 3.25A, Pol. (L)



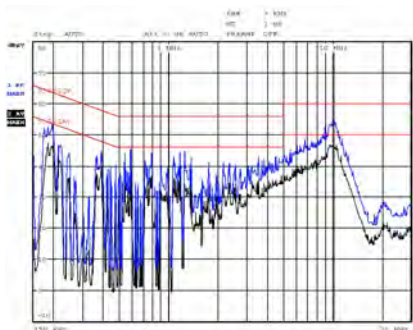
Frequency (MHz)	Detector (pk/av/qp)	Line measured	Result (dBμV)	Limit (dBμV)	Margins & Comments
9.622	QP	L	50.3 (69.4)	50	Pass
	AV		44.9	50	Pass

Input: AC100V 60Hz, Output: DC20V 3.25A, Pol. (N)



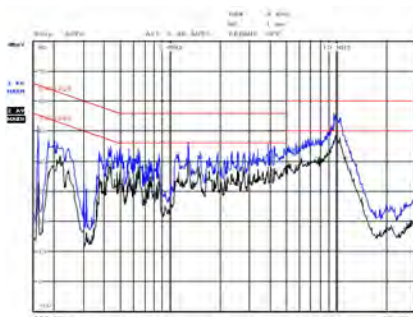
Frequency (MHz)	Detector (pk/av/qp)	Line measured	Result (dBμV)	Limit (dBμV)	Margins & Comments
9.910	QP	N	49.4 (69.8)	50	Pass
	AV		43.8	50	Pass

Input: AC230V 50Hz, Output: DC20V 3.25A, Pol. (L)



Frequency (MHz)	Detector (pk/av/qp)	Line measured	Result (dBμV)	Limit (dBμV)	Margins & Comments
10.196	QP	L	51.1	60	Pass
	AV		45.3	50	Pass

Input: AC230V 50Hz, Output: DC20V 3.25A, Pol. (N)



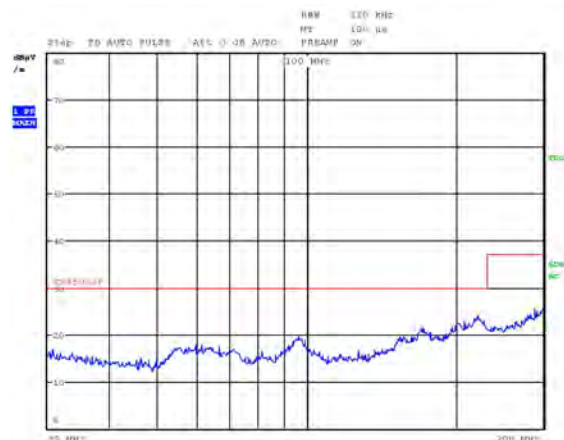
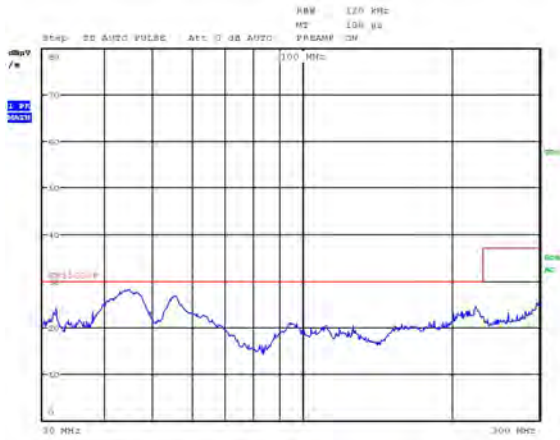
Frequency (MHz)	Detector (pk/av/qp)	Line measured	Result (dBμV)	Limit (dBμV)	Margins & Comments
9.950	QP	N	50.8	60	Pass
	AV		44.8	50	Pass

Figure 11: Conducted EMI test results under various operating conditions

RadiatedEMIScans

Input: AC100V 60Hz, Output: DC20V 3.25A (Vertical)

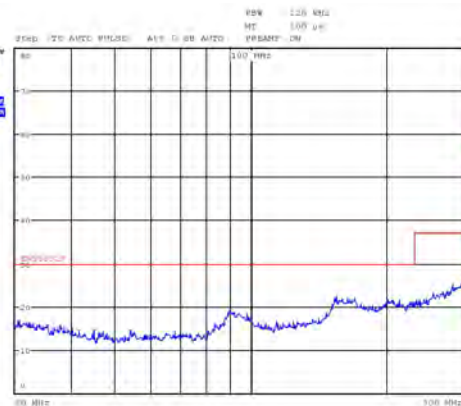
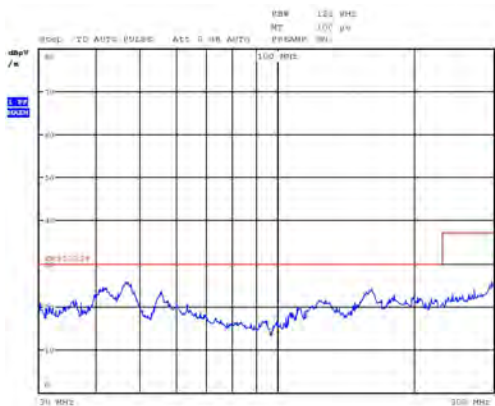
Input: AC100V 60Hz, Output: DC20V 3.25A (Horizontal)



	Frequency (MHz)	Detector Type (pk/av/qp)	Ant. Pol. (H/V)	Ant. Height (m)	Turntable Azimuth (°)	Result (dBμV/m)	Limit (dBμV/m)	Margins & Comments
04	44.970	Qp	V	1.0	260	25.4	30.0)

Input: AC230V 50Hz, Output: DC20V 3.25A (Vertical)

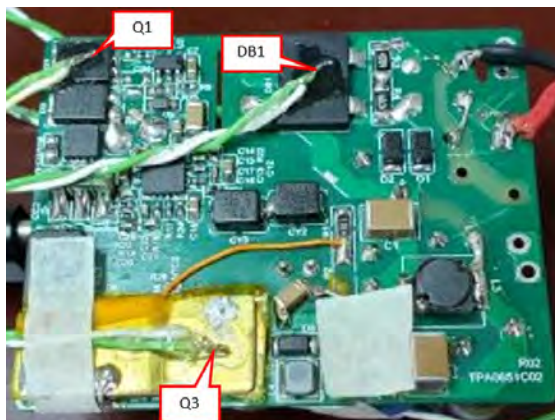
Input: AC230V 50Hz, Output: DC20V 3.25A (Horizontal)



	Frequency (MHz)	Detector Type (pk/av/qp)	Ant. Pol. (H/V)	Ant. Height (m)	Turntable Azimuth (°)	Result (dBμV/m)	Limit (dBμV/m)	Margins & Comments
05	44.500	Qp	V	1.0	0	22.9	30.0	PASS

Thermal Measurements

The key component temperatures are shown below for 90Vac and 230Vac full load (20V/65W) operating conditions after 2hrs 30mins bake time.



Input: AC90V 60Hz, Output: DC20V 3.25A

Test Point	Parts	0mins	5mins	10mins	20mins	30mins	50mins	1hr	1hr 30mins	2hrs	2hrs30mins	Temp Rise
A1	Ambient 1	26.9	27.2	27.7	28.2	28.3	28.3	28.2	28.1	28.1	28.0	
Q1	HGN093N12SL	26.8	64.8	77.1	87.3	90.9	93.2	93.3	93.9	93.9	93.8	65.9
DB1	HBS610	26.9	78.9	88.5	96.7	100.0	102.4	102.8	103.4	103.5	103.5	75.6
Q3	TP65H300G4LSG	27.0	70.8	82.9	93.9	97.9	100.7	100.9	101.6	101.8	101.7	73.8
CE6	820uF 25V	26.9	54.9	64.4	72.2	74.2	76.0	76.3	76.5	76.4	76.0	48.1
CE2	33uF 400V	26.8	49.4	61.2	71.6	75.5	77.7	78.3	78.8	78.9	78.8	50.9
T1	Winding	26.9	57.5	72.9	85.6	89.9	92.3	92.9	93.3	93.5	93.5	65.6
A2	Ambient 2	26.5	27.1	27.7	28.0	28.3	28.2	28.1	27.9	28.0	27.8	

Input: AC230V 50Hz, Output: DC20V 3.25A

Test Point	Parts	0mins	5mins	10mins	20mins	30mins	40mins	1hr	1hr 30mins	2hrs	2hrs30mins	Temp Rise
A1	Ambient 1	26.9	27.1	27.3	27.3	27.4	27.3	27.3	27.2	26.9	26.8	
Q1	HGN093N12SL	28.3	73.8	86.1	94.5	97.6	98.8	99.3	99.6	99.5	99.2	72.6
DB1	HBS610	28.5	52.7	61.7	68.4	71.2	72.2	72.8	72.9	72.7	72.6	46.0
Q3	TP65H300G4LSG	28.6	76.9	87.2	94.6	97.0	98.1	98.6	98.8	98.5	98.4	71.8
CE6	820uF 25V	27.7	60.4	70.6	76.8	79.4	80.2	80.2	80.8	80.4	80.3	53.7
CE2	33uF 400V	28.3	42.1	52.3	60.4	63.4	64.5	65.0	65.0	64.9	64.8	38.2
T1	Winding	28.3	64.5	79.1	89.2	92.8	93.7	94.2	94.1	94.0	93.7	67.1
A2	Ambient 2	26.8	26.8	26.7	27.1	27.0	27.0	26.8	26.7	26.5	26.4	

Revision History Revision

HardwareInfo

Info	Value
Timestamp	June 11,2021
PrimaryIC	PFC + FlybackPWMController(NCP1623+NCP1342)
Primary PFC Switch	Transphorm650VGaNfET(TP65H150LSG)
Primary Flyback Switch	Transphorm650VSuperGaN™FET(TP65H300G4LSG)
SecondaryIC	WeltrendWT6633P
ACSupply	ChromaProgramableACSource,61602
InputMeter	Chroma digital power meter 66201
OutputMeter	ESCORT 3146A
Oscilloscope	Agilent Technologies DSO-X 2014A
No-loadbaketime	300
Inputvoltages	[(90,60),(115,60),(230,50),(265,50)]
Outputvoltages	[5,9,15,20]
Electronic Load	Chroma,63030
Weltrend EVB	WPD010-1 / WPD005
Cable	E-mark type-C, 20V 5A