Table of Contents

Chapter 1 Summary

1.1 General Description

The 45W 67CC Dual USB Type-C® Ports PD3.0 PPS Evaluation Board (EVB) is composed of four main controllers, DIODES AP3304A, DIODES APR34910, DIODES™ AP43771V and Canyon Semiconductor's CY6572. The AP3304A is a peak-current control, multi-mode CCM+QR PWM controller, which is optimized for high performance, low standby power and is a cost-effective offline flyback converter. The APR34910 is a secondary-side combo IC combining an N-Channel MOSFET and a driver circuit designed for synchronous rectification (SR). The AP43771V, a PD3.0 PPS protocol controller, automatically manages the PD3.0 PPS attachment process for the attached USB Type-C-equipped Device Under Charged (DUC), as well as regulates the feedback information of the charger to fulfill voltage and current requirements from DUC. The CY6572 is a synchronous buck controller. By communication between two separate channel AP43771V, two ports can realize plug in/out detection, dynamic Vbus adjustment to get best system efficiency, automatic power sharing once two ports both insert etc. By adopting the cost-effectiveness of NMOS FETs, the 45W 67CC EVB exemplifies HPD charger design with system BOM optimization to meet the market trend.

1.2 Key Features

1.2.1 System Key Features

- CCM+Quasi-Resonant operation for NMOSFET switch Operation and Efficiency Improvement Approaches
- Cost-Effective Implementation for HPD Chargers
- High-Voltage Startup low standby power (<20mW)
- Meets DOE VI and COC Tier 2 Efficiency Requirement
- USB Type-C® Port - Supports the Maximum Output of 45W PD3.0 PPS (3.3V to 21V@20mV/step, 50mA/step)
- SSR Topology Implementation with an Opto-coupler for Accurate Step Voltage / Current Control
- Low overall system BOM cost

1.2.2 AP3304A Key Features

- Operate CCM at low line and QR at high line
- QR Flyback Topology with Valley-on
- Wide VCC range(60V) to Guarantee Wide Range Output Voltage
- Soft Start During Startup Process
- Frequency Fold Back for High Average Efficiency
- Secondary Winding Short Protection with FOCP
- Frequency Dithering for Reducing EMI
- Useful Pin fault protection:
  SENSE Pin Floating Protection/
  FB/Opto-Coupler Open/Short Protection
- Comprehensive System Protection Feature:
  VOVP/OLP/BNO/SOVP/SUVP
- Mini Size Package of SOT26 (Type A1)

1.2.3 APR34910 Key Features

- SR Works with CCM / DCM / QR operation modes
- Integrate 100V, 9mOhm SR MOS
- Eliminate Resonant Ringing Interference
- Fewest External Components used
- SO-8 package

1.2.4 AP43771V Key Feature

- Supports USB PD Rev 3.0 V1.2
- USB-IF PD3.0/PPS Certified TID 4312
- Qualcomm® QC5 Certified: QC20201127203
- MTP for System Configuration
- OTP for Main Firmware
- Operating Voltage Range: 3.3V to 21V
- Built-In Regulator for CV and CC Control
- Programmable OVP/UVP/OCP/OTP
- Support Power Saving Mode
- External N -MOSFET Control for VBUS Power Delivery
- Support e-Marker Cable Detection
- QFN-14 and QFN-24

1.2.5 CY6572 Key Feature

- Wide Input Voltage from 4.5V to 40V
- Adjustable Switching Frequency to get high Efficiency
- High Duty-Cycle Up to 99%
- CC/CV Control
- Auto Recovery after Faults
- System Protection Feature
- Thermal Enhanced TSSOP-14 Package

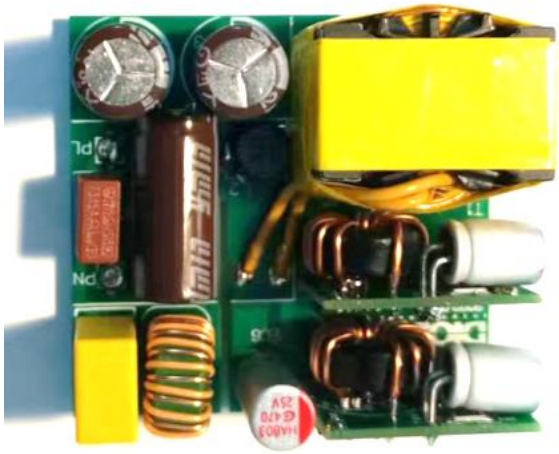
1.3 Applications

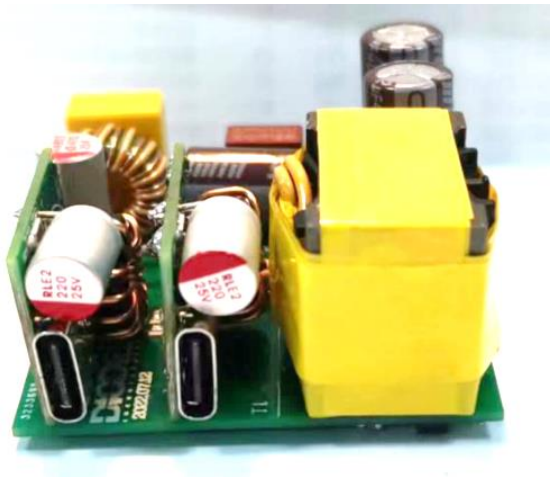
- Quick Charger with full power range of PD3.0 PPS

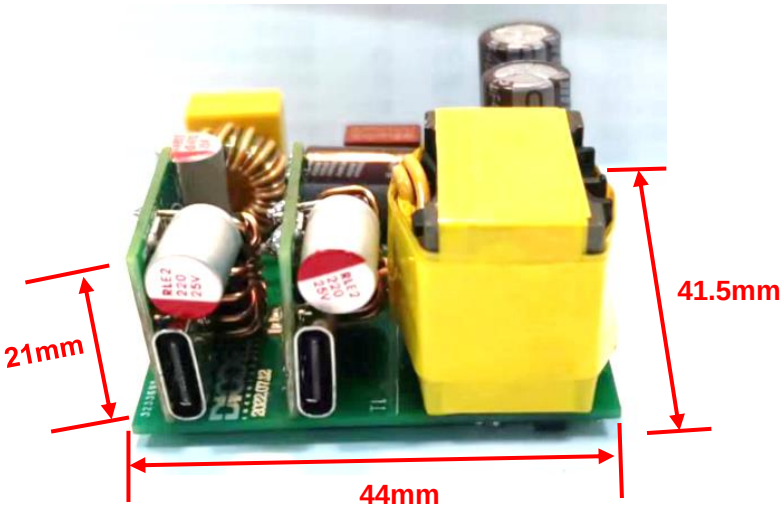
1.4 Main Power Specifications

Parameter	Value
Input Voltage	$90V_{AC}$ to $264V_{AC}$
Input standby power	< 200mW
Master port/Slave port (Vo / Io)	PDO: 5V/3A, 9V/3A, 15V/3A, 20V/2.25A,
	APDO: 3.3 to 11V/4.05A; 3.3V to 16V/3A: 3.3V to 21V/2.25A
Voltage Step	PPS 20mV step voltage, 3.3V-21V
Efficiency	Comply with DoE 6
Total Output Power	45W
Protections	OCP, OVP, UVP, OLP, OTP, SCP
Dimensions	PCB: 44 * 41.5 * 21 mm^3, 1.732" * 1.634" * 0.827" $inch^3$ Case: 49 * 49 * 28 mm^3, 67CC, 4.1 CI
Power Density Index	0.67 W/CC; 10.98 W/CI

1.5 Evaluation Board Pictures







*** The dimension "21mm" includes the height of bottom components**

Chapter 2 Power Supply Specification

2.1 Specification and Test Results

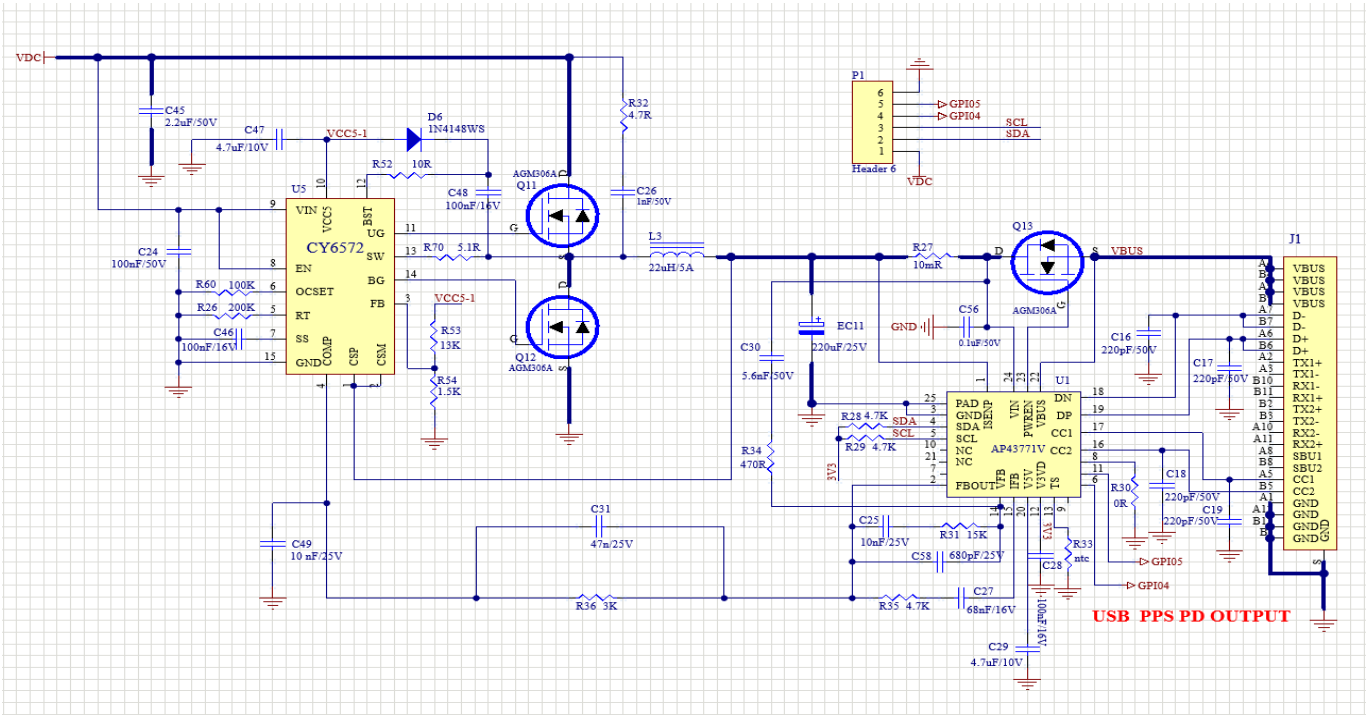
Parameter	Value	Test Summary
Input Voltage / Frequency	$90V_{AC}$ to $264V_{AC}$ / 50Hz or 60Hz	Test Condition
Input Current	$<2A_{RMS}$	**PASS**
Standby Power	< 300mW, load disconnected	**PASS,** 191mW@$230V_{AC}$/50Hz
C_#1: 20V/2.25A + C_#2: No load Average Efficiency	DoE VI Efficiency >87.4%	**PASS,** 91.1%@115VAC/60Hz 91.46%@230VAC/50Hz
C_#1: 20V/2.25A + C_#2: No load (10% Load)		**PASS,** 84.78%@115VAC/60Hz 83.44%@230VAC/50Hz
C_#1:15V/3A + C_#2: No Load Average Efficiency	DoE VI Efficiency >87.3%	**PASS,** 90.95%@115VAC/60Hz 90.92@230VAC/50Hz
C_#1:15V/3A + C_#2: No Load (10% Load)		**PASS,** 88.15%@115VAC/60Hz 85.68@230VAC/50Hz
C_#1:15V/1.67A + C_#2: 9V/2.2A Average Efficiency	DoE VI Efficiency >87.4%	**PASS,** 88.74@115VAC/60Hz 88.70@230VAC/50Hz
C_#1:15V/1.67A + C_#2: 9V/2.2A Efficiency (10% Load)		**PASS,** 82.37%@115VAC/60Hz 80.1@230VAC/50Hz
Output Voltage Regulation Tolerance	+/- 5%	**PASS**
16V PPS	3.3V – 16V +/- 5%, 0~3A +/-150mA	**PASS**
21V PPS	3.3V – 21V +/- 5%, 0~2.25A +/-150mA	**PASS**
Conducted EMI	>6dB Margin; according to EN55032 Class B	**PASS**

2.2 Compliance

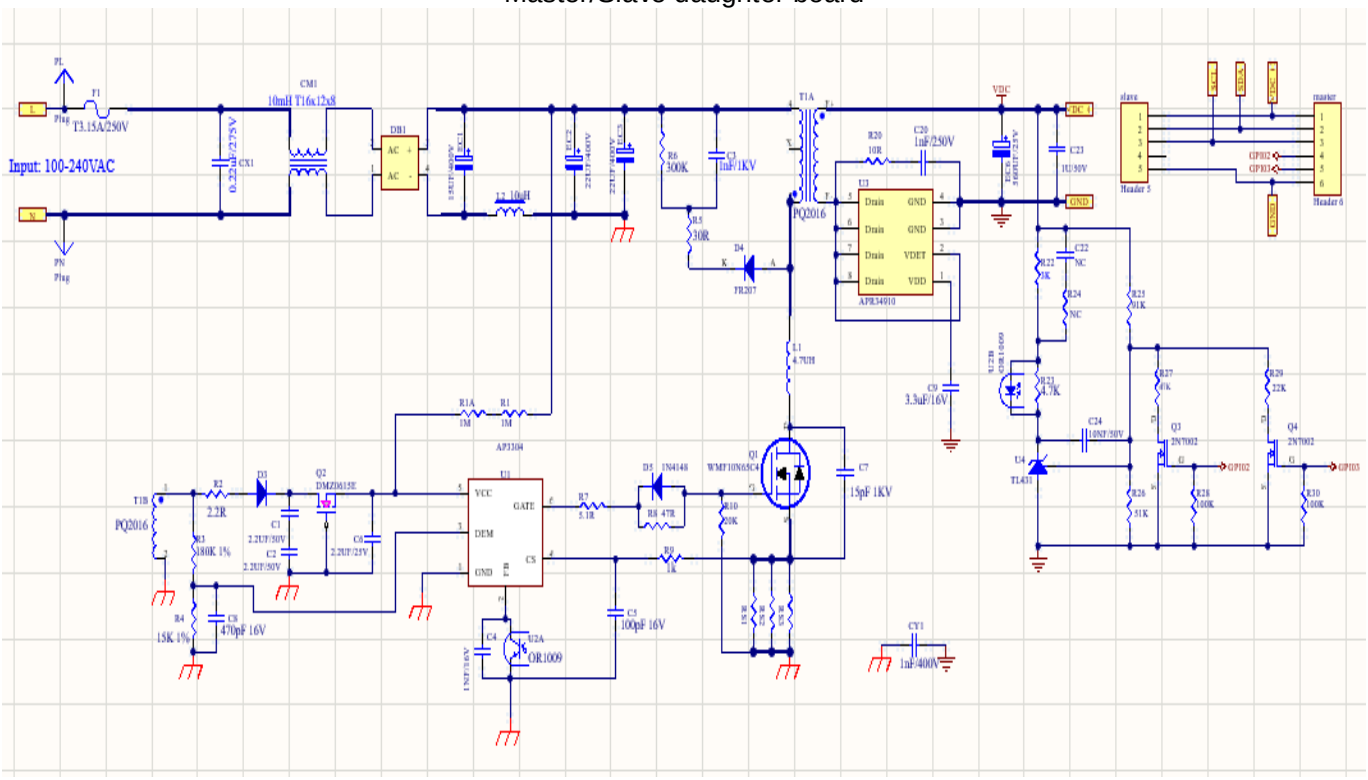
Parameter	Test conditions	Transition time	standard	Test Summary
Output Voltage Transition time	5V to 9V	57.2ms	<275ms	Pass
	9V to 15V	96.7ms		Pass
	15V to 20V	74.4ms		Pass
	20V to 15V	70.6ms		Pass
	15V to 9V	84.9ms		Pass
	9V to 5V	57.7ms		Pass
	20V to 5V	108.4ms		Pass
				Pass
Output Connector	USB Type-C *2-			
Temperature	Rise time @ 90Vac , Full Load; Fall time @ 264Vac , No Load;			
Dimensions (W /D/ H)	L49mm x49mm x 28mm (with foldable AC pin)			

Chapter 3 Schematic

3.1 Board Schematic



Master/Slave daughter board



Main board

Figure 1. 45W PD3.0 PPS Adapter EVB Schematic

3.2 Bill of Material (BOM)

Main board BOM

Description	Sign	Footprint	Quantity
2.2UF/50V	C1, C2	0805C	2
1nF/500V	C3	0805C	1
1NF/16V	C4	0603C	1
100pF 16V	C5	0603C	1
2.2UF/25V	C6	0805C	1
15pF 1KV	C7	1206C	1
NC	C8	0603C	1
3.3uF/16V	C9	0603C	1
1nF/250V	C20	0805C	1
3.3nF/25V	C22	0603C	1
1U/50V	C23	0805C	1
10NF/50V	C24	0603C	1
1M	R1, R1A	1206R	2
2.2R	R2	0805R	1
180K 1%	R3	0603R	1
15K 1%	R4	0603R	1
30R	R5	1206R	1
300K	R6	1206R	1
5.1R	R7	0603R	1
47R	R8	0603R	1
1k	R9	0603R	1
20K	R10	0603R	1
10R	R20	1206R	1
5.1K	R22	0603R	1
4.7K	R23	0603R	1
300R	R24	0603R	1
91K	R25	0402R	1
51K	R26	0402R	1
47K	R27	0402R	1
100K	R28, R30	0402R	2
22K	R29	0402R	1
0.75R	RS1	1206R	1
0.68R	RS2, RS3	1206R	2
10mH T16x12x8	CM1	LF10*5.3	1
0.22uF/275V	CX1	CAP_X04A(10_6_7.5)	1
1nF/400V	CY1	CY-SMD	1
FR107	D3	SOD-123	1
FR207	D4	SMA	1
1N4148	D5	SOD-323-T	1
4A 800V	DB1	BRID	1

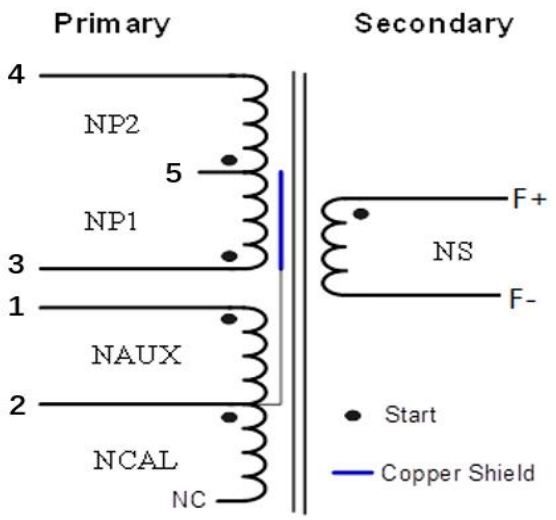
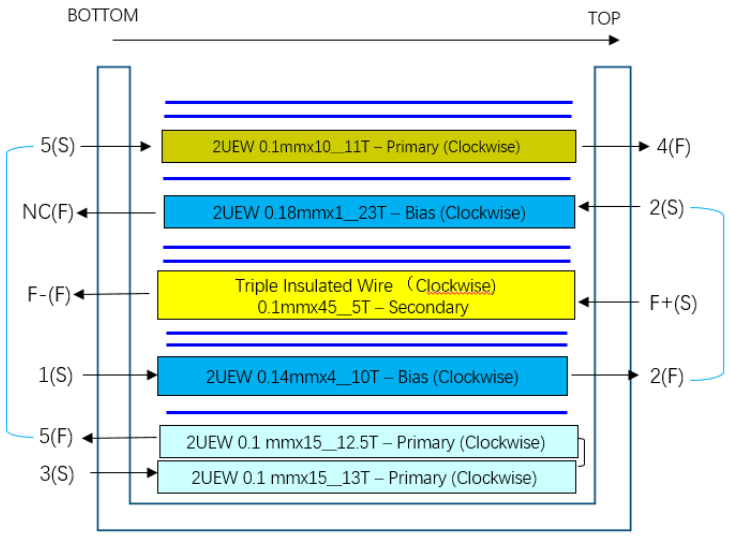
15UF/400V	EC1	CAP-DIP(16-8-3.5A)	1
22UF/400V	EC2, EC3	CAP-AI (10_5)	2
560UF/25V	EC6	EC6.0	1
T3.15A/250V	F1	FUSE4*8	1
4.7UH	L1	1206R	1
10uH	L2	INDUCTOR SMD	1
WMO26N65C4	Q1	TO-252	1
DMZ0615E	Q2	SOT-23	1
2N7002	Q3, Q4	SOT-23	2
PQ2016	T1	PQ20	1
AP3304A	**U1**	**SOT23-6**	**1**
OR1009	U2	PC-SMD	1
APR34910	**U3**	**SO-8**	**1**
TL431	U4	SOT-23-431	1

Master/Slave daughter board BOM

Comment	Designator	Footprint	Quantity
220pF/50V	C16, C17, C18, C19	C-0402	4
100nF/50V	C24	0603C	1
10 nF/25V	C25,C49	0402R	2
1nF/50V	C26	C-0603	1
10nF/16V	C27	0402R	1
100nF/16V	C28	C-0402	1
4.7uF/10V	C29, C47	C-0603	2
5.6nF/25V	C30	0402R	1
680pF/25V	C58	0402R	1
470R	R34	0402R	1
2.2uF/50V	C45	0805C	1
100nF/16V	C46	0402R	1
0.1uF/16V	C48	0402R	1
0.1uF/50V	C56	C-0603	1
47n	C31	0402R	1
1N4148WS	D6	SOD-323	1
220UF/25V	EC11	EC5.5MM - 1	1
TYPE-C	J1	USBC2	1
22UH/5A	L3	L5	1
AGM306A	Q11, Q12, Q13	DFN3*3	3
200K	R26	0402R	1
10mR	R27	1206R	1
4.7K	R28, R29	0402R	2
0R	R30	0402R	1
15K	R31, R35	0402R	2
4.7R	R32	0603R	1
NC	R33	0402R	1
3K	R36	0402R	1
10R	R52	0402R	1
13K	R53	0402R	1
1.5K	R54	0402R	1

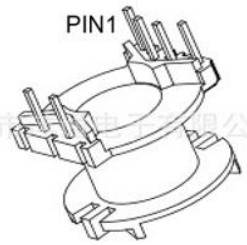
100K	R60	0402R	1
5.1R	R70	0402R	1
AP43771V	**U1**	**QFN_24_CY2311**	**1**
CY6572	**U5**	**TSSOP-15**	**1**

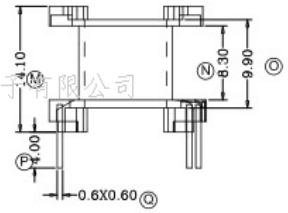
3.3 Transformer Design

Schematic	Structure
	

Definition	Pin define (Start >> End)	Wire (φ)	No. of Turns	Layers	Layers of Tape
NP1	3 → 5	Φ0.10 2UEW*15P	25.5	2	2
NAUX	1 → 2	Φ0.14 2UEW*4P	10	1	2
NS	F+ → F-	Φ0.3TIW*7 (Triple Insulated Wire)	6	1	2
Shield	2 → NC	Φ0.13 2UEW*2P	22	1	2
NP2	5 → 4	Φ0.10 2UEW*15P	12.5	PIN1	2

BOBBIN PIN Define:





Item	Test Condition	Rating
Primary Inductance	Pin 1-2,all other windings open, measured at 20kHz / 1V	420uH+/- 5%
Note	Bobbin/ Core: PQ2016 （Ae=62mm²）	

3.4 Schematics Description

3.4.1 AC Input Circuit & Differential Filter

The Fuse F1 protects against over-current conditions which occur when some main components fails. The CM1 are common mode chocks for the common mode noise suppression. The DB is a bridge rectifier which converts alternating current and voltage into direct current and voltage. The EC1, L2, EC2, EC3 are composed of the Pi filter for filtering the differential switching noise back to AC source.

3.4.2 AP3304A PWM Controller

- The AP3304A is a peak-current control, multi-mode CCM+QR PWM controller which is optimized for high performance, and cost effective offline flyback converters. The AP3304A provides Mini Size Package of SOT23-6 and achieve high-power density charger applications. At no load or light load, the AP3304A enters the burst mode to minimize standby power consumption.

3.4.3 APR34910 Synchronous Rectification (SR) Switcher

As a high-performance solution, The APR34910 is a secondary-side combo IC combining an N-channel MOSFET and a driver circuit designed for synchronous rectification (SR). The APR34910 effectively reduces the secondary side rectifier power dissipation which works in QR/DCM/CCM operation.

3.4.4 AP43771V PD 3.0 Decoder Interface to CY6572 Sync Buck and Power Devices

Few important pins provide critical protocol decoding and regulation functions in AP43771V:

1) **CC1 & CC2 (Pin 11, 10)**: CC1 & CC2 (Configuration Channel 1 & 2) are defined by USB Type-C spec to provide the channel communication link between power source and sink device.
2) **Constant Voltage (CV)**: The CV is implemented by sensing VFB (pin 8) and comparing with internal reference voltage to generate a CV compensation signal on the OCDRV pin (pin 5). The output voltage is controlled by firmware through CC1/CC2 channel communication with the sink device.
3) **Constant Current (CC)**: The CC is implemented by sensing the current sense resistor (RCS, 10mΩ, 1%, Low TCR) and compared with internal programmable reference voltage. The output current is controlled by firmware through CC1/CC2 channel communication with the sink device.
4) **OCDRV (Pin5) to CY6572 COMP (Pin 4)**: It is the key interface link from CC/CV loop on AP43771V to Sync Buck COMP Pin (COMP) to realize Output CC/CV control. OCDRV is connected to CY6572 Pin 4(COMP) for feedback desired information based on all sensed Vbus, Current sense and CC1 & CC2 signals for getting desired Vbus voltage and current.
5) **PWR_EN (Pin2) to N-MOSFET Gate**: The pin is used to turn on/off N-MOSFET (Q9) to enable/disable voltage output to the Vbus.

3.4.5 Interface between Master and Slave Board

Master and Slave boards build interface via I2C communication. AP43771V SDA & SDL (Pin 16, 17) are defined by I2C spec to provide the channel communication link between Master and Slave, such as plug in/out, power sharing info. etc.

Chapter 4 The Evaluation Board (EVB) Connections

4.1 EVB PCB Layout

Main Board

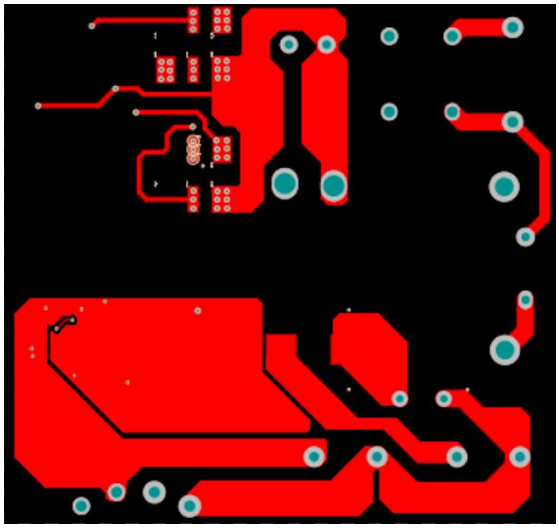


Figure 2. PCB Layout Top View

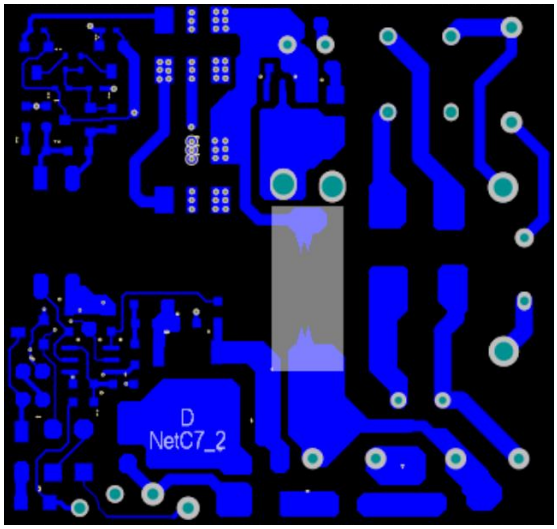


Figure 3. PCB Layout Bottom View

Master/Slave daughter Board

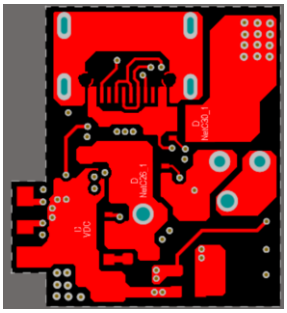


Figure 4. PCB Layout Top View

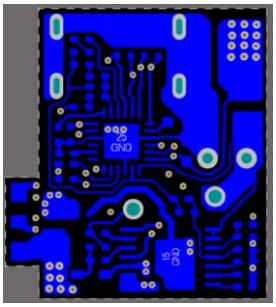


Figure 5. PCB Layout Bottom View

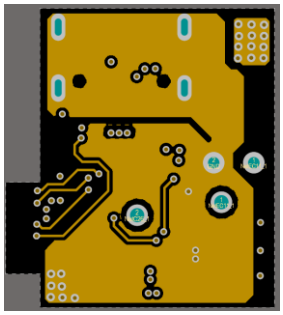


Figure 6. PCB Layout Mid1 View

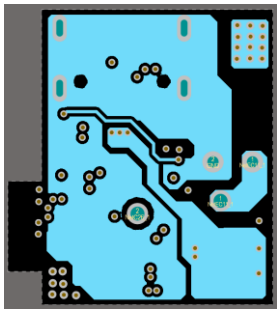


Figure 7. PCB Layout Mid2 View

4.2 Quick Start Guide before Connection

1) Before starting the 45W EVB test, the end user needs to prepare the following tool, software and manuals.

For details, please consult USBCEE sales through below link for further information.

USBCEE PD3.0 Test Kit: USBCEE Power Adapter Tester. https://www.usbcee.com/product-details/4

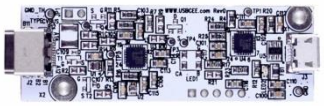
USBCEE PAT Tester	GUI Display	USB-A to Micro-B Cable	Type-C Cable
			

Figure 8. Test Kit / Test Cables

2) Prepare a certified three-foot Type-C cable and a Standard-A to Micro-B Cable.

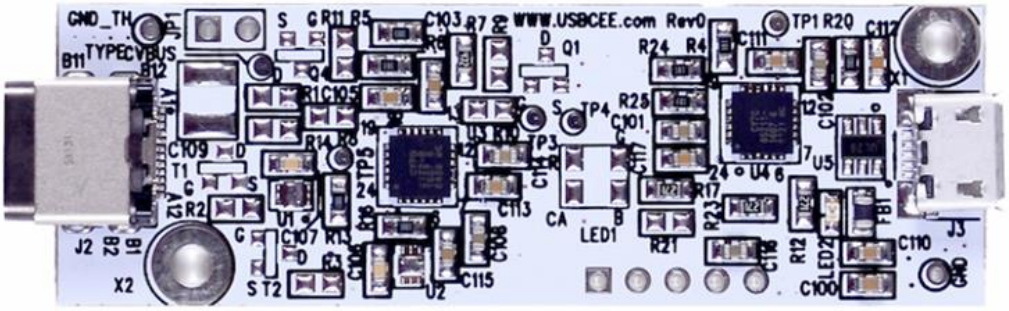
3) Connect the AC inputs: L & N wires of EVB to AC power supply output “L and N “wires.

4) Ensure that the AC source is switched OFF or disconnected before the connection steps.

5) A Type-C cable for the connection between EVB’s and Type-C receptacles of test kit.

6) Output of Type-C port & USB A-port are connected to E-load + & - terminals by cables.

Type-C Input port to Test Kit



Mini USB port to computer

Figure 9. The Test Kit Input & Output and E-load Connections

4.3 Connection with E-Load

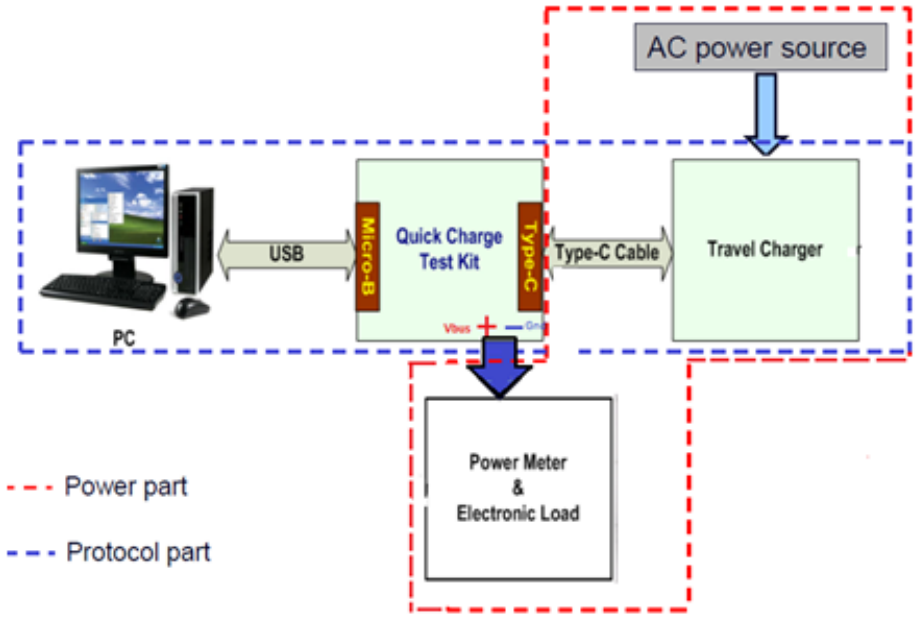


Figure 10. Diagram of Connections in the Sample Board

Chapter 5 Testing the Evaluation Board

5.1 Input & Output Characteristics

5.1.1 Input Standby Power

Vin(Vac)	F(Hz)	Pin(mW)
115	**60**	147
230	**50**	191

5.1.2 Average Efficiency at Different Loading

Smart Power Sharing Strategy:

	C1	C2
Single Port Plug in	45W	X
	X	45W
Dual Port Plug in	15W (First Plug in, Request 5V below Voltage)	30W (Second Plug in)
	30W (First Plug in, Request 15V,20V Voltage)	15W (Second Plug in, Request 5V below Voltage)
	18W (First Plug in, Request 9V, 9V PPS)	27W (Second Plug in, Request 15V, 20V, 15VPPS, 20VPPS)
	27W (First Plug in, Request 15V, 20V, 15VPPS, 20VPPS)	18W (Second Plug in, Request 9V, 9VPPS)
Source cap		
45W (Power limit)	5V/3A, 9V/3A, 15V/3A, 20V/2.25A, 3.3-11V/4.05A, 3.3-16V/3A, 3.3-21V/2.25A	
30W (Power limit)	5V/3A, 9V/3A, 15V/2A, 20V/1.5A, 3.3-11V/3A	
27W (Power limit)	5V/3A, 9V/3A, 15V/1.8A, 20V/1.35A, 3.3-11V/3A	
18W (Power limit)	5V/3A, 9V/2A, 15V/1.2A, 20V/0.9A, 3.3-11V/2A	
15W (Power limit)	5V/3A, 9V/1.67A, 15V/1A, 20V/0.75A, 3.3-11V/1.36A	

Single Port Output:
C_#1 or C_#2 : 20V / 2.25A

Vin	Load %	Pin1	Vout	Iout	Pout	Effi.	Avg. Effi.	DOE 6 required
(Vrms)		(W)	(V)	(A)	(W)	(%)	(%)	
90 Vac	100%	50	20.361	2.2	44.7942	89.59%	89.63%	87.60%
115 Vac	100%	49.172	20.361	2.2	44.7942	91.10%	90.37%	87.60%
	75%	36.857	20.312	1.65	33.5148	90.93%		
	50%	24.65	20.265	1.1	22.2915	90.43%		
	25%	12.496	20.222	0.55	11.1221	89.01%		
	10%	5.241	20.197	0.22	4.44334	84.78%		
230 Vac	100%	48.99	20.367	2.2	44.8074	91.46%	90.29%	87.60%
	75%	36.843	20.323	1.65	33.53295	91.02%		
	50%	24.7	20.275	1.1	22.3025	90.29%		
	25%	12.584	20.227	0.55	11.12485	88.40%		

	10%	5.326	20.2	0.22	4.444	83.44%		
264 Vac	100%	49.09	20.362	2.2	44.7964	91.25%	90.13%	87.60%

C_#1 or C_#2 : 15V / 3A

Vin (Vrms)	Load %	Pin1 (W)	Vout (V)	Iout (A)	Pout (W)	Effi. (%)	Avg. Effi. (%)	DOE 6 required
90 Vac	100%	51.74	15.377	3	46.131	89.16%	90.19%	87.60%
115 Vac	100%	50.77	15.367	3	46.101	90.80%	90.95%	87.60%
	75%	37.68	15.302	2.25	34.4295	91.37%		
	50%	25.049	15.237	1.5	22.8555	91.24%		
	25%	12.593	15.177	0.75	11.38275	90.39%		
	10%	5.154	15.145	0.3	4.5435	88.15%		
230 Vac	100%	50.347	15.37	3	46.11	91.58%	90.92%	87.60%
	75%	37.68	15.307	2.25	34.44075	91.40%		
	50%	25.124	15.246	1.5	22.869	91.02%		
	25%	12.701	15.182	0.75	11.3865	89.65%		
	10%	5.301	15.14	0.3	4.542	85.68%		
264 Vac	100%	50.5	15.364	3	46.092	91.27%	90.48%	87.60%

Dual Port-C Output: 110Vac

	Load %	100%		75%		50%		25%		
AC110V 57HZ	ITEM	Voltage/Current : **5V3A+5V3A**								
	PORT	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	Av eff
	CURRENT	3.00A	3.00A	2.25A	2.25A	1.50A	1.50A	0.75A	0.75A	87.67%
	VOLTAGE	5.30V	5.32V	5.23V	5.24V	5.16V	5.16V	5.08V	5.09V	
	INPUT POWER	36.87W		26.88W		17.47W		8.66W		
	EFFICIENCE	86.41%		87.64%		88.57%		88.06%		
	ITEM	Voltage/Current : **9V2A+9V3A**								
	PORT	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	Av eff
	CURRENT	2.00A	3.00A	1.50A	2.25A	1.00A	1.50A	0.50A	0.75A	89.01%
	VOLTAGE	9.21V	9.31V	9.16V	9.23V	9.11V	9.16V	9.06V	9.08V	
	INPUT POWER	52.56W		38.72W		25.40W		12.77W		
	EFFICIENCE	88.17%		89.12%		89.93%		88.80%		
	ITEM	Voltage/Current : **15V1.8A+9V2A**								
	PORT	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	Av eff
	CURRENT	1.80A	2.00A	1.35A	1.50A	0.90A	1.00A	0.45A	0.50A	89.05%
	VOLTAGE	15.23V	9.21V	15.18V	9.16V	15.14V	9.10V	15.10V	9.05V	
	INPUT POWER	51.35W		38.10W		25.41W		12.91W		
	EFFICIENCE	89.26%		89.83%		89.44%		87.68%		
	ITEM	Voltage/Current : **15V2A+5V3A**								
	PORT	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	Av eff
	CURRENT	2.00A	3.00A	1.500A	2.250A	1.000A	1.500A	0.500A	0.750A	88.74%
	VOLTAGE	15.26V	5.32V	15.20V	5.24V	15.15V	5.16V	15.10V	5.09V	
	INPUT POWER	52.38W		38.56W		25.73W		12.98W		

	EFFICIENCE	88.74%		89.70%		88.96%		87.58%		
	ITEM	Voltage/Current：**PPS 3.3V3.3A+3.3V3.3A**								
	PORT	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	Av eff
	CURRENT	3.30A	3.30A	2.475A	2.475A	1.650A	1.650A	0.825A	0.825A	85.36%
	VOLTAGE	3.290V	3.300V	3.290V	3.300V	3.297V	3.306V	3.301V	3.307V	
	INPUT POWER	25.79W		19.41W		12.69W		6.25W		
	EFFICIENCE	84.32%		84.03%		85.85%		87.23%		

Dual Port-C Output: 230Vac

AC230V 50HZ	Load %	**100%**		**75%**		**50%**		**25%**		
	ITEM	Voltage/Current：**5V3A+5V3A**								
	PORT	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	AV EFF
	CURRENT	3.00A	3.00A	2.25A	2.25A	1.50A	1.50A	0.75A	0.75A	87.45%
	VOLTAGE	5.31V	5.32V	5.23V	5.24V	5.16V	5.16V	5.08V	5.08V	
	INPUT POWER	36.85W		26.71W		17.57W		8.76W		
	EFFICIENCE	86.51%		88.20%		88.07%		87.02%		
	ITEM	Voltage/Current：**9V2A+9V3A**								
	PORT	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	AV EFF
	CURRENT	2.00A	3.00A	1.50A	2.25A	1.00A	1.50A	0.50A	0.75A	89.23%
	VOLTAGE	9.21V	9.31V	9.16V	9.23V	9.11V	9.15V	9.06V	9.07V	
	INPUT POWER	51.88W		38.35W		25.54W		12.85W		
	EFFICIENCE	89.34%		89.98%		89.41%		88.19%		
	ITEM	Voltage/Current：**15V1.8A+9V2A**								
	PORT	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	AV EFF
	CURRENT	1.80A	2.00A	1.35A	1.50A	0.90A	1.00A	0.45A	0.50A	89.30%
	VOLTAGE	15.23V	9.21V	15.18V	9.16V	15.14V	9.10V	15.10V	9.05V	
	INPUT POWER	50.67W		38.00W		25.41W		12.98W		
	EFFICIENCE	90.46%		90.09%		89.44%		87.21%		
	ITEM	Voltage/Current：**15V2A+5V3A**								
	PORT	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	AV EFF
	CURRENT	2.00A	3.00A	1.500A	2.250A	1.000A	1.500A	0.500A	0.750A	89.17%
	VOLTAGE	15.25V	5.32V	15.20V	5.25V	15.15V	5.16V	15.10V	5.08V	
	INPUT POWER	51.56W		38.41W		25.74W		12.98W		
	ITEM	90.11%		90.11%		88.93%		87.52%		
	PORT	Voltage/Current：**PPS 3.3V3.3A+3.3V3.3A**								
	CURRENT	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	USBC1	USBC2	AV EFF
	VOLTAGE	3.30A	3.30A	2.475A	2.475A	1.650A	1.650A	0.825A	0.825A	85.74%
	INPUT POWER	3.291V	3.300V	3.297V	3.306V	3.297V	3.308V	3.302V	3.309V	
	EFFICIENCE	25.73W		18.95W		12.59W		6.37W		
	ITEM	84.53%		86.24%		86.56%		85.62%		

5.2 Key Performance Waveforms

5.2.1 45W PD3.0 System Start-up Time

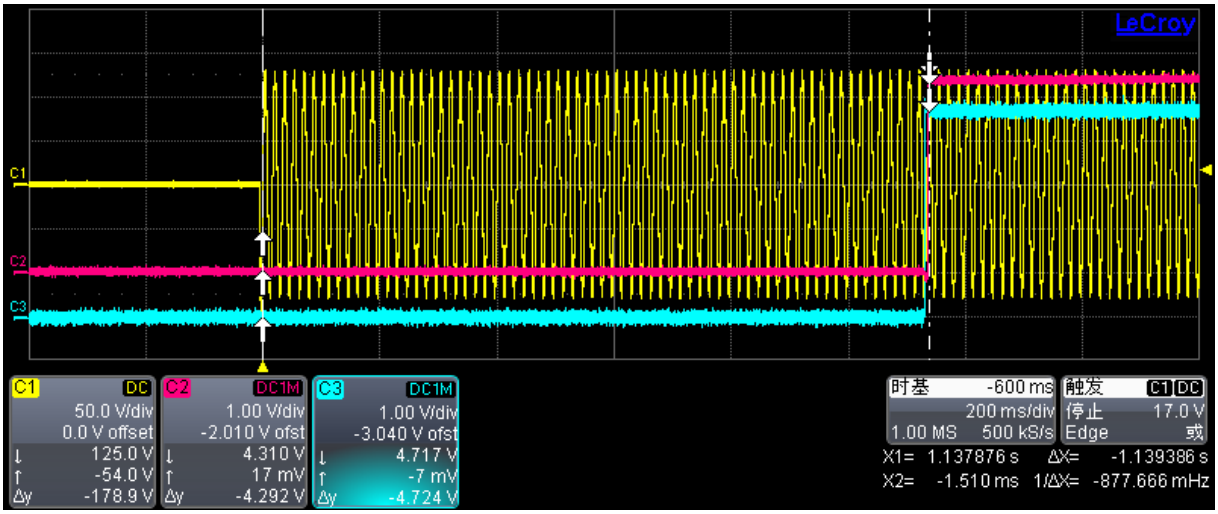


Figure 11: Turn on time is 1.14s at Full Load@ 90Vac

5.2.2 Q1 / Q2 MOSFET Voltage Stress at Full Load @264Vac

Primary side MOSFET : Q1 and Secondary side SR MOSFET- Q2

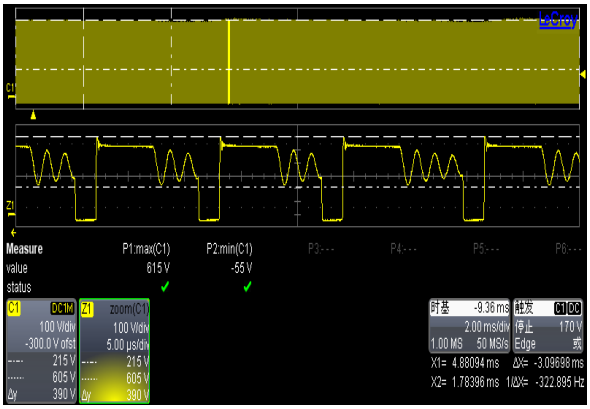


Figure 12. Q1 Vds Voltage stress

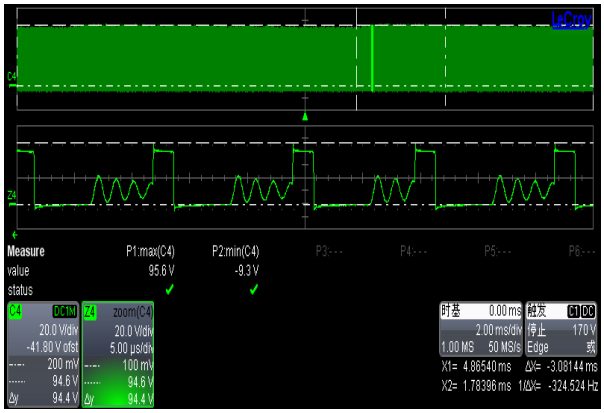


Figure 13. Q2 Vds Voltage stress

Component	Vout	Vds	Vds_Max_Spec	Ratio of voltage stress
Q1	20V	615V	650V	94.6%
Q2		95.6V	100V	95.6%

5.2.3 System Output Ripple & Noise with the Cable

Connect 47uF AL Cap and 104MLCC to the cable output unit in parallel

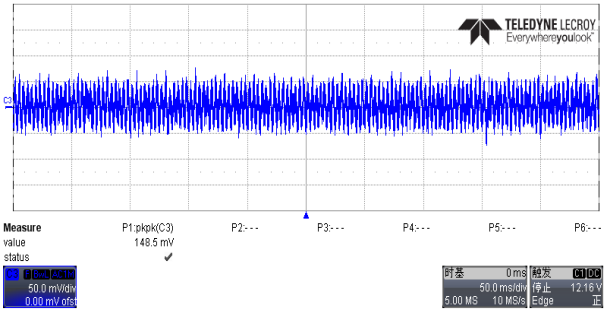


Figure 14. 90Vac/60Hz@ 11V/4A ΔV=148.5mV

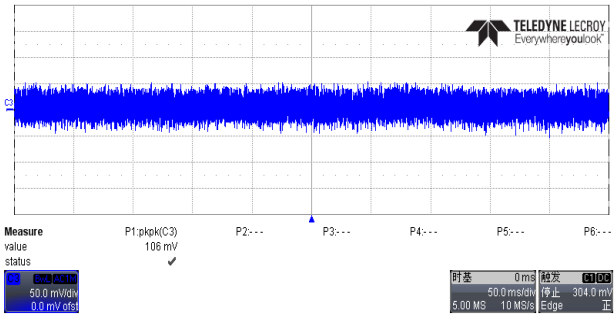


Figure 15. 264Vac/50Hz@11V/4A ΔV=106mV

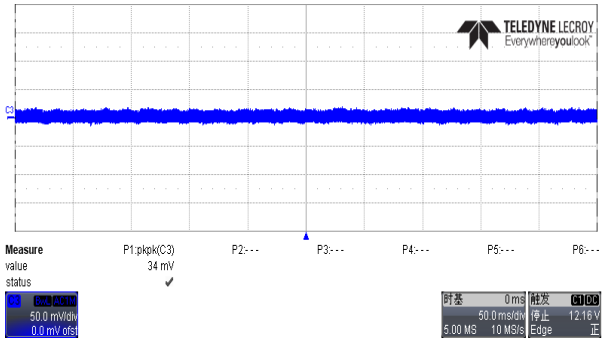


Figure 16. 90Vac/60Hz@5V/3A ΔV=34mV

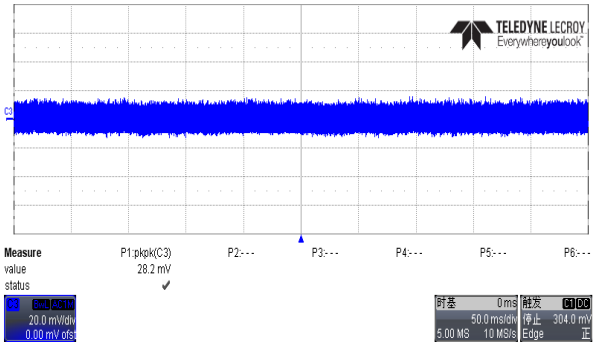


Figure 17. 264Vac/50Hz@5V/3A ΔV=28.2mV

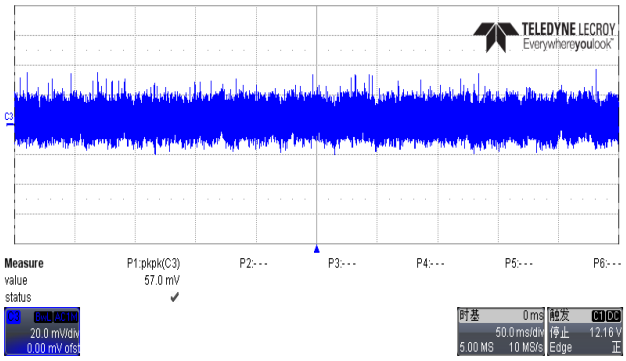


Figure 18. 90Vac/60Hz@9V/3A ΔV=57mV

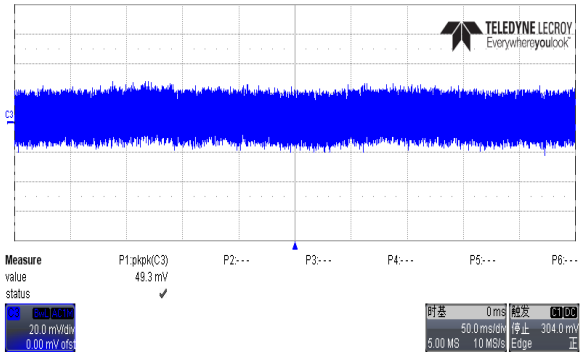


Figure 19. 264Vac/50Hz@9V/3A ΔV=49.3mV

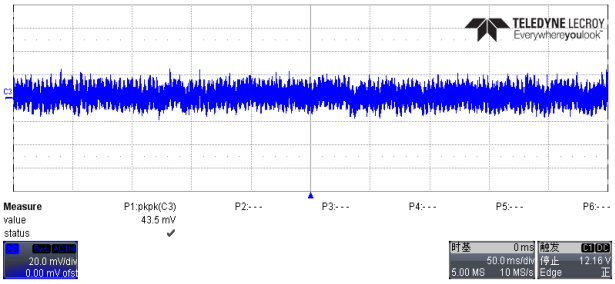


Figure 20. 90Vac/60Hz@15V/3A ΔV=43.5mV

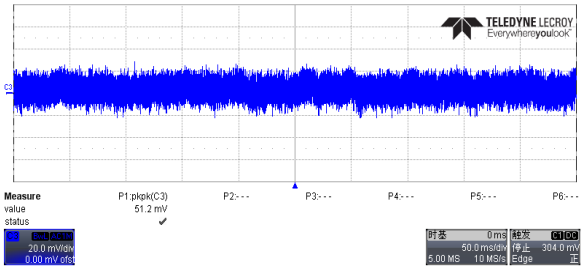


Figure 21. 264Vac/50Hz@15V/3A ΔV=51.2mV

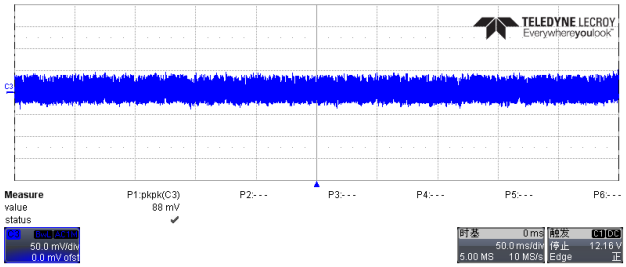


Figure 22. 90Vac/60Hz@20V/2.25A ΔV=88mV

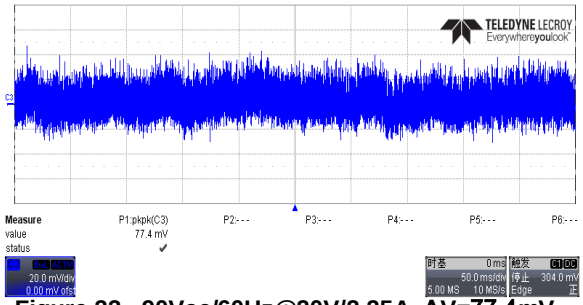


Figure 23. 90Vac/60Hz@20V/2.25A ΔV=77.4mV

5.2.4 Dynamic load ----0%Load~100%Load, T=20mS, Rate=15mA/uS (PCB End)

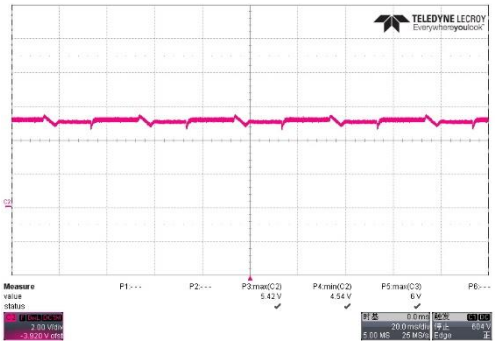


Figure 24. 90Vac/60Hz Port-C@ Vout=5V

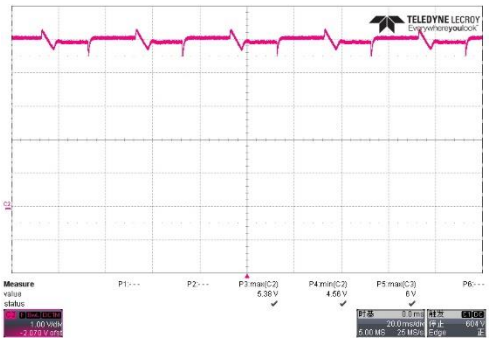


Figure 25. 264Vac/50Hz Port-C@ Vout=5V

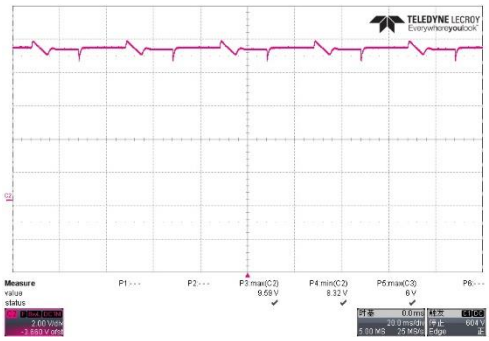


Figure 26. 90Vac/60Hz Port-C@ Vout=9V

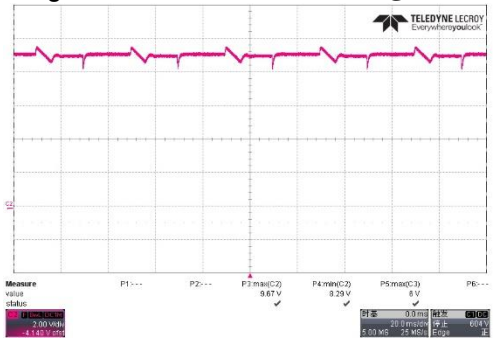


Figure 27. 264Vac/50Hz Port-C@ Vout=9V

	Vo_ Undershoot(V)	Vo_ Overshoot(V)		Vo_Undershoot(V)	Vo_Overshoot(V)
Vin=90Vac@5V	4.54	5.42	Vin=90Vac@9V	8.32	9.59
Vin=264Vac@5V	4.56	5.38	Vin=264Vac@9V	8.29	9.67

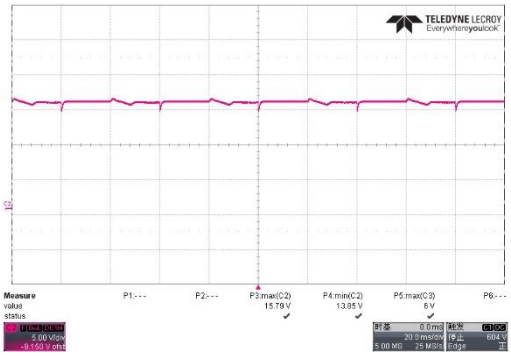


Figure 28. 90Vac/60Hz Port-C@ Vout=15V

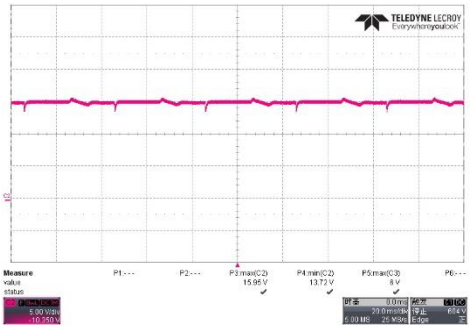


Figure 29. 264Vac/50Hz Port-C@ Vout=15V

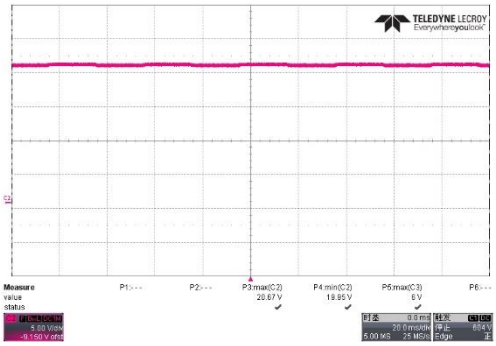


Figure 30. 90Vac/60Hz Port-C@ Vout=20V

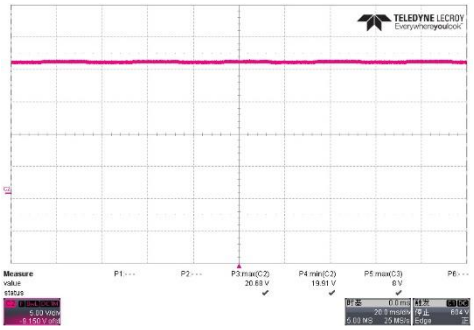


Figure 31. 264Vac/50Hz Port-C@ Vout=20V

	Vo_ Undershoot(V)	Vo_ Overshoot(V)		Vo_Undershoot(V)	Vo_Overshoot(V)
Vin=90Vac@15V	13.85	15.79	Vin=90Vac@20V	19.95	20.67
Vin=264Vac@15V	13.72	15.95	Vin=264Vac@20V	19.91	20.68

5.2.5 Output Voltage Transition Time from Low to High

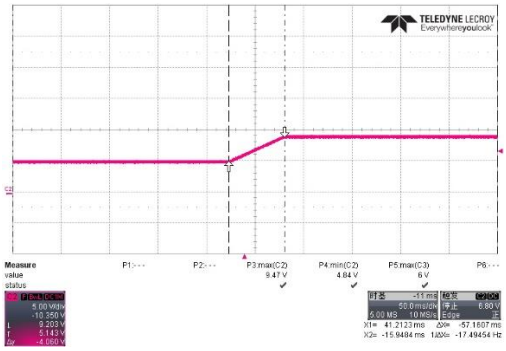


Figure 32. 5V→9V Rise Time = 57.2ms

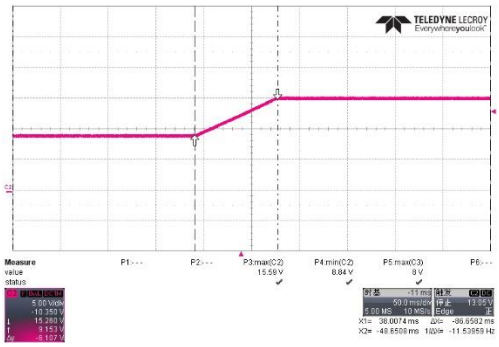


Figure 33. 9V→15V Rise Time = 96.7ms

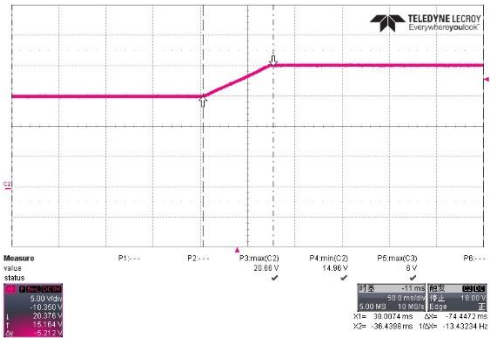


Figure 34. 15V→20V Rise Time = 74.4ms

5.2.6 Output Voltage Transition Time from High to Low

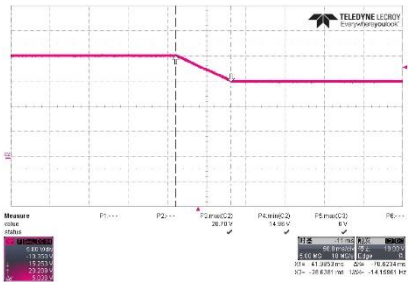


Figure 35. 20V→15V Fall Time = 70.6ms

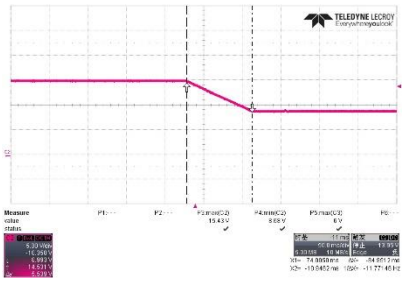


Figure 36. 15V→9V Fall Time = 84.9mS

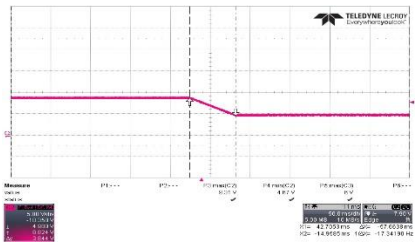


Figure 37. 9V→5V Fall Time = 57.7ms

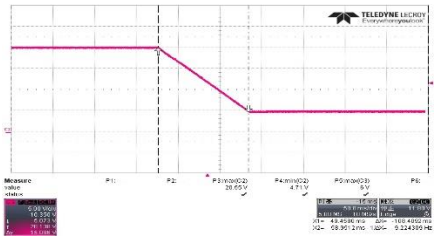


Figure 38. 20V→5V Fall Time = 108.4ms

5.2.7 Thermal Testing

Output Condition : 1C:11V/1.64A 2C : 9V3A

Main Voltage	Temperature (°C)						
	Ta	Q1	T1-core	T1-wire	Q2	L3	DB1
90Vac/60Hz	25	101	82.4	97.6	111.5	89.4	104.8

Test Condition: Vin=90Vac @ 1C:11V/1.64A 2C : 9V3A Full load Open Frame

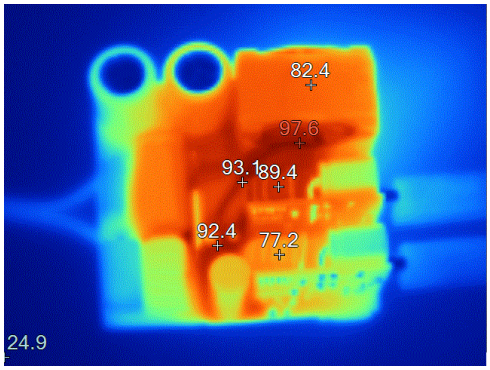


Figure 39. Top Components side

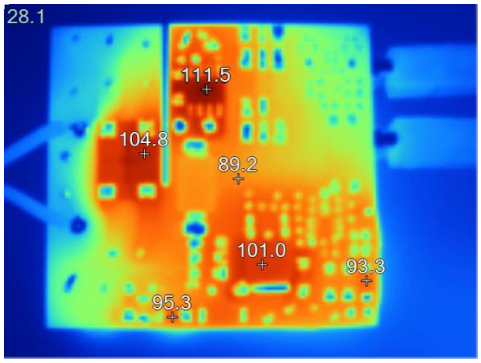


Figure 40. Bottom Suface Mount side

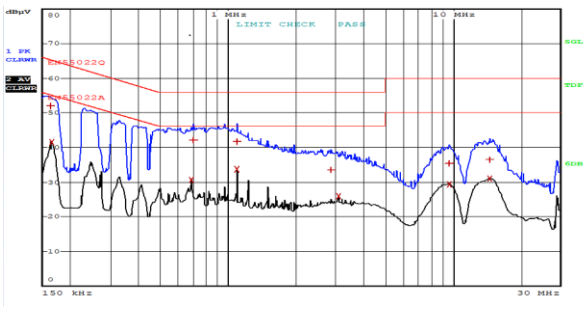
DB1: Bridge Rectifier
Q1 : Primary Side High Voltage GaN FET
T1: Transformer
Q2 : Secondary Side Sync-Rectifier
L3 : BUCK inductor

Note: Component temperature can be further optimized with various system design and thermal management approaches by manufacturers.

5.3 EMI (Conduction) Testing

115Vac testing results

Output Condition : C1:15V/2A C2 :5V/3A

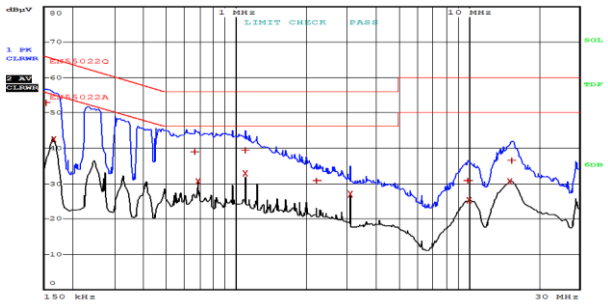


EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	162.428505844 kHz	52.04	-13.29
2	Average	164.052790903 kHz	41.54	-13.71
2	Average	680.675429436 kHz	30.61	-15.38
1	Quasi Peak	694.357005568 kHz	42.04	-13.95
1	Quasi Peak	1.08653730473 MHz	41.70	-14.29
2	Average	1.08653730473 MHz	33.73	-12.26
1	Quasi Peak	2.85244906878 MHz	33.53	-22.46
2	Average	3.08879360159 MHz	25.94	-20.05
1	Quasi Peak	9.50832737927 MHz	35.35	-24.64
2	Average	9.60341065306 MHz	29.35	-20.64
1	Quasi Peak	14.4411515385 MHz	36.34	-23.65
2	Average	14.4411515385 MHz	30.92	-19.08

Figure 41. 115Vac/60Hz L line



EDIT PEAK LIST (Final Measurement Results)

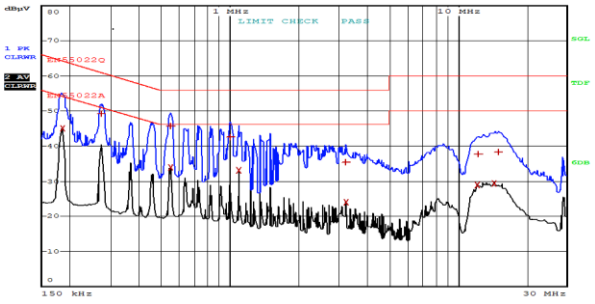
Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	153.015 kHz	52.72	-13.11
2	Average	164.052790903 kHz	42.56	-12.69
1	Quasi Peak	660.656865747 kHz	38.99	-17.00
2	Average	680.675429436 kHz	30.59	-15.41
1	Quasi Peak	1.08653730473 MHz	39.39	-16.60
2	Average	1.08653730473 MHz	32.81	-13.18
1	Quasi Peak	2.22424976908 MHz	30.79	-25.20
2	Average	3.08879360159 MHz	27.01	-18.98
1	Quasi Peak	9.89440359926 MHz	30.78	-29.21
2	Average	9.99334763525 MHz	25.35	-24.64
2	Average	14.8787328713 MHz	30.63	-19.36
1	Quasi Peak	15.177795402 MHz	36.39	-23.60

Figure 42. 115Vac/60Hz N line

230Vac testing results

Output Condition : C1:15V/2A C2 :5V/3A

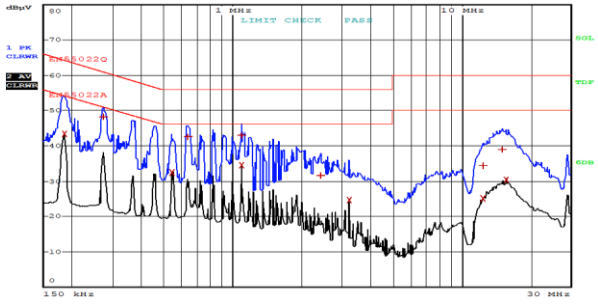


EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
2	Average	183.028505992 kHz	45.12	-9.22
1	Quasi Peak	272.504504785 kHz	49.31	-11.73
1	Quasi Peak	546.852057924 kHz	45.63	-10.36
2	Average	546.852057924 kHz	33.81	-12.18
1	Quasi Peak	1.00339897152 MHz	42.61	-13.38
2	Average	1.08653730473 MHz	32.98	-13.01
1	Quasi Peak	3.21421100787 MHz	35.47	-20.52
2	Average	3.21421100787 MHz	24.14	-21.85
2	Average	12.073052723 MHz	28.78	-21.21
1	Quasi Peak	12.1937832503 MHz	37.76	-22.23
2	Average	14.2981698401 MHz	29.27	-20.72
1	Quasi Peak	14.8787328713 MHz	38.41	-21.59

Figure 43. 230Vac/50Hz L line



EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
2	Average	183.028505992 kHz	43.41	-10.93
1	Quasi Peak	272.504504785 kHz	48.25	-12.78
2	Average	541.437681113 kHz	32.52	-13.47
1	Quasi Peak	634.878262431 kHz	42.54	-13.45
1	Quasi Peak	1.08653730473 MHz	43.04	-12.95
2	Average	1.08653730473 MHz	34.51	-11.49
1	Quasi Peak	2.40854377744 MHz	31.54	-24.45
2	Average	3.21421100787 MHz	24.73	-21.26
1	Quasi Peak	12.3157210828 MHz	34.33	-25.66
2	Average	12.3157210828 MHz	25.08	-24.92
1	Quasi Peak	14.8787328713 MHz	38.98	-21.01
2	Average	15.4828690896 MHz	30.33	-19.66

Figure 44. 230Vac/50Hz N line

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