Table of Contents

Chapter 1 Summary

1.1 General Description

The 65W ACF PD3.0 PPS Evaluation Board is composed of three main controllers, AP3306, APR340 and AP43771V. AP3306 is a highly integrated Active Clamp Flyback (ACF) controller that is optimally designed for offline power supply to meet ultra-low standby power, high power density, and comprehensive protection requirements. The APR340 is a secondary side Synchronous Rectification (SR) Controller. The AP43771V, a protocol decoder in charge of matching the associated charger capacity and request by an attached Type C-equipped device under charged (DUC), regulates the feedback network of the charger to fulfill voltage and current requirements from DUC.

1.2 Key Features

1.2.1 System Key Features

- Diodes Patented ACF Topology Implementation for Critical Efficiency Improvement Approaches
- Cost-Effective Implementation for High Efficiency High Power Density Charger
- High-Voltage Startup low standby power (<20mW)
- Meets DOE VI and COC Tier 2 Efficiency Requirements
- USB Type-C Port - Support the Maximum Output of 65W PD3 Function and PPS 21V@20mV/step
- SSR Topology Implementation with an Opto-coupler for Accurate Step Voltage Controlling
- Low overall system BOM cost

1.2.2 AP3306 Key Features

- Active Clamp Flyback Topology with Recycled Leakage Energy and Zero Voltage Switching Functions
- High-Voltage Startup
- Embedded VCC LDO for VCCL pin to Guarantee Wide Range Output Voltage
- Constant, Low Output Current in Output Short Situation
- Non-Audible-Noise Quasi-Resonant Control
- Soft Start During Startup Process
- Frequency Fold Back for High Average Efficiency
- Secondary Winding Short Protection with FOCP
- Frequency Dithering for Reducing EMI
- X-CAP Discharge Function
- Useful Pin fault protection:
  SENSE Pin Floating Protection/
  FB/Opto-Coupler Open/Short Protection
- Comprehensive System Protection Feature:
  VOVP/OLP/BNO/SOVP/SUVP

1.2.3 APR340 Key Features

- Synchronous Rectification Works with DCM / QR / ACF operation modes
- Eliminate Resonant Ringing Interference
- Fewest External Components used

1.2.4 AP43771V Key Feature

- Support 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-24Q

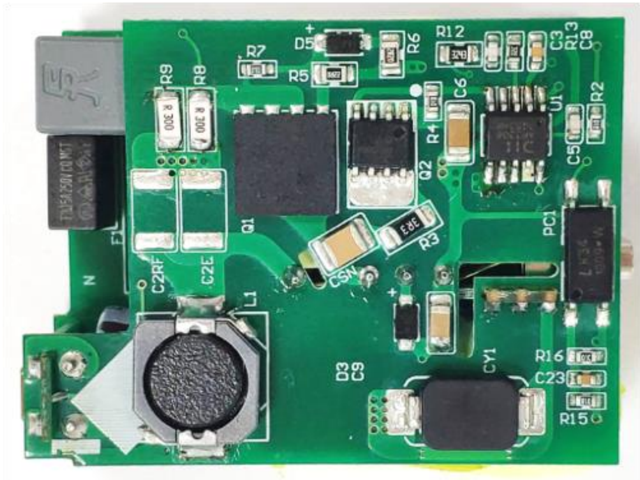
1.3 Applications

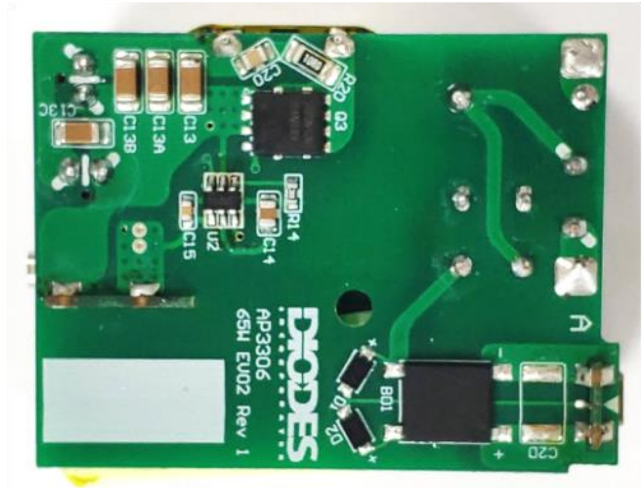
- Quick Charger with full power range of PD3.0 PPS

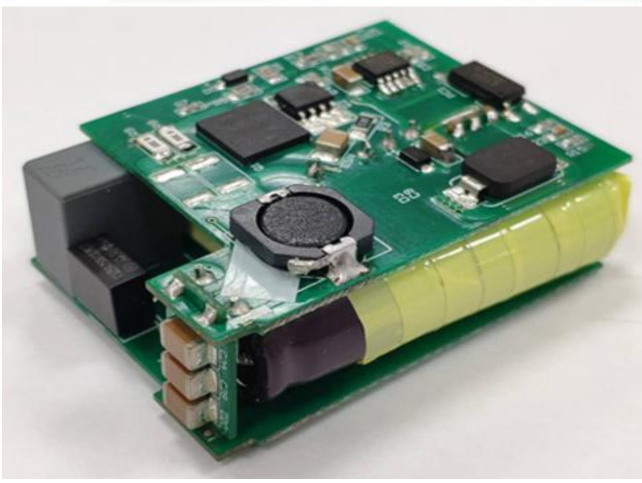
1.4 Main Power Specifications

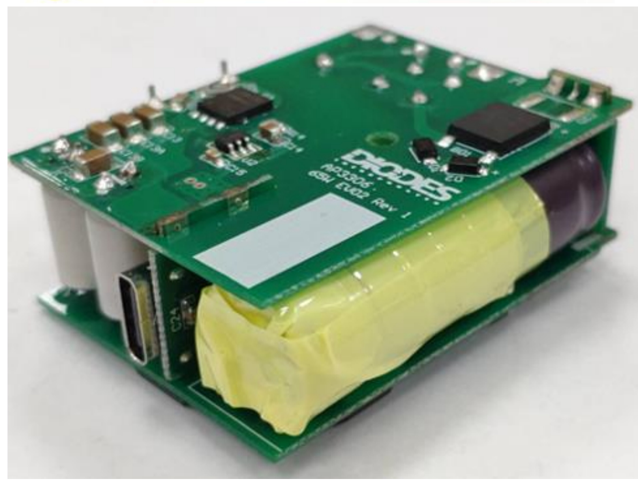
Parameter	Value
Input Voltage	$90V_{AC}$ to $264V_{AC}$
Input standby power	< 30mW
Main Output (Vo / Io)	PDO: 5V/3A, 9V/3A, 15V/3A, 20V/3.25A,
	APDO: 3.3V to 21V/3A
Voltage Step	PPS 20mV step voltage, 3.3V-21V
Efficiency	Comply with CoC version 5 tier-2
Total Output Power	65W (at PDO 20V/3.25A)
Protections	OCP, OVP, UVP, OLP, OTP, SCP
Dimensions	PCB: 36 * 48 * 21 mm^3, 1.417” * 1.89” * 0.827” $inch^3$ Case: 40 * 52 * 25 mm^3, 52CC, 3.17 CI
Power Density Index	1.25 W/CC; 20.48 W/CI

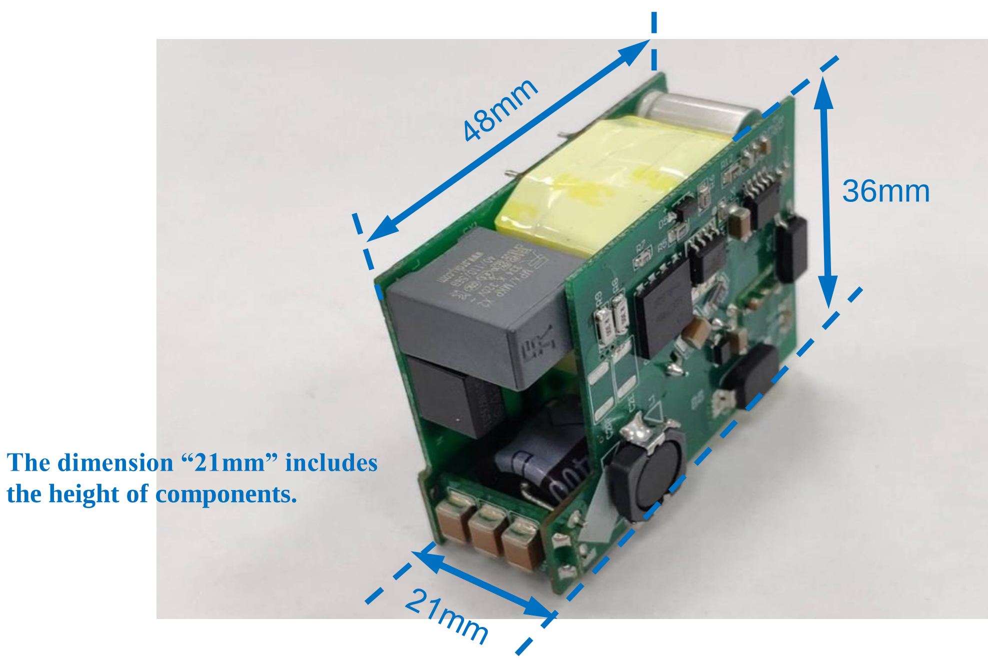
1.5 Evaluation Board Pictures











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	$<2A_{RMS}$	
Standby Power	< 30mW, load disconnected	**PASS,** 16.85mW@$230V_{AC}$/50Hz
5V/3A Average Efficiency	CoC Version 5, Tier-2 Efficiency >81.84%	**PASS,** 91.14%@115VAC/60Hz 89.81%@230VAC/50Hz
5V/0.3A Efficiency (10% Load)	CoC Version 5, Tier2 Efficiency >72.48%	**PASS,** 87.97%@115VAC/60Hz 87.23%@230VAC/50Hz
9V/3A Average Efficiency	CoC Version 5,Tier2 Efficiency >87.30%	**PASS,** 92.74%@115VAC/60Hz 92.19%@230VAC/50Hz
9V/0.3A Efficiency (10% Load)	CoC Version 5,Tier2 Efficiency >77.30%	**PASS,** 89.42%@115VAC/60Hz 88.75%@230VAC/50Hz
15V/3A Average Efficiency	CoC Version 5,Tier2 Efficiency >88.85%	**PASS,** 93.14%@115VAC/60Hz 93.02%@230VAC/50Hz
15V/0.3A Efficiency (10% Load)	CoC Version 5,Tier2 Efficiency >78.85%	**PASS,** 90.71%@115VAC/60Hz 87.59%@230VAC/50Hz
20V/3.25A Average Efficiency	CoC Version 5,Tier2 Efficiency >89%	**PASS,** 93.15%@115VAC/60Hz 93.18%@230VAC/50Hz
20V/0.325A Efficiency (10% Load)	CoC Version 5,Tier2 Efficiency >79%	**PASS,** 90.07%@115VAC/60Hz 88.54%@230VAC/50Hz
Output Voltage Regulation Tolerance	+/- 5%	**PASS,**
16V PPS	3.3V – 16V +/- 5%, 0~2.8A +/-150mA	**PASS,**
21V PPS	3.3V – 21V +/- 5%, 0~2.1A +/-150mA	**PASS,**
Conducted EMI	>6dB Margin; according to EN55032 Class B	

2.2 Compliance

Parameter	Test conditions	Low to High	High to Low	Standard	Test Summary
Output Voltage Transition time	5V/3A to 9V/3A, 90Vac/60Hz	53.88ms	56.44ms	275ms <	Pass
	5V/3A to 9V/3A, 264Vac/50Hz	53.11ms	54.00ms		Pass
	9V/3A to 15V/3A, 90Vac/60Hz	77.29ms	77.36ms		Pass
	9V/3A to 15V/3A, 2640Vac/50Hz	78.52ms	77.41ms		Pass
	15V/3A to 20V/3A, 90Vac/60Hz	62.41ms	62.16ms		Pass
	15V/3A to 20V/3A, 264Vac/50Hz	63.34ms	61.55ms		Pass
Output Connector	USB Type-C *1-				
Temperature	90Vac , Full Load				
Dimensions (W /D/ H)	L46mm x46mm x 22mm (with foldable AC pin)				

Chapter 3 Schematic

3.1 Board Schematic

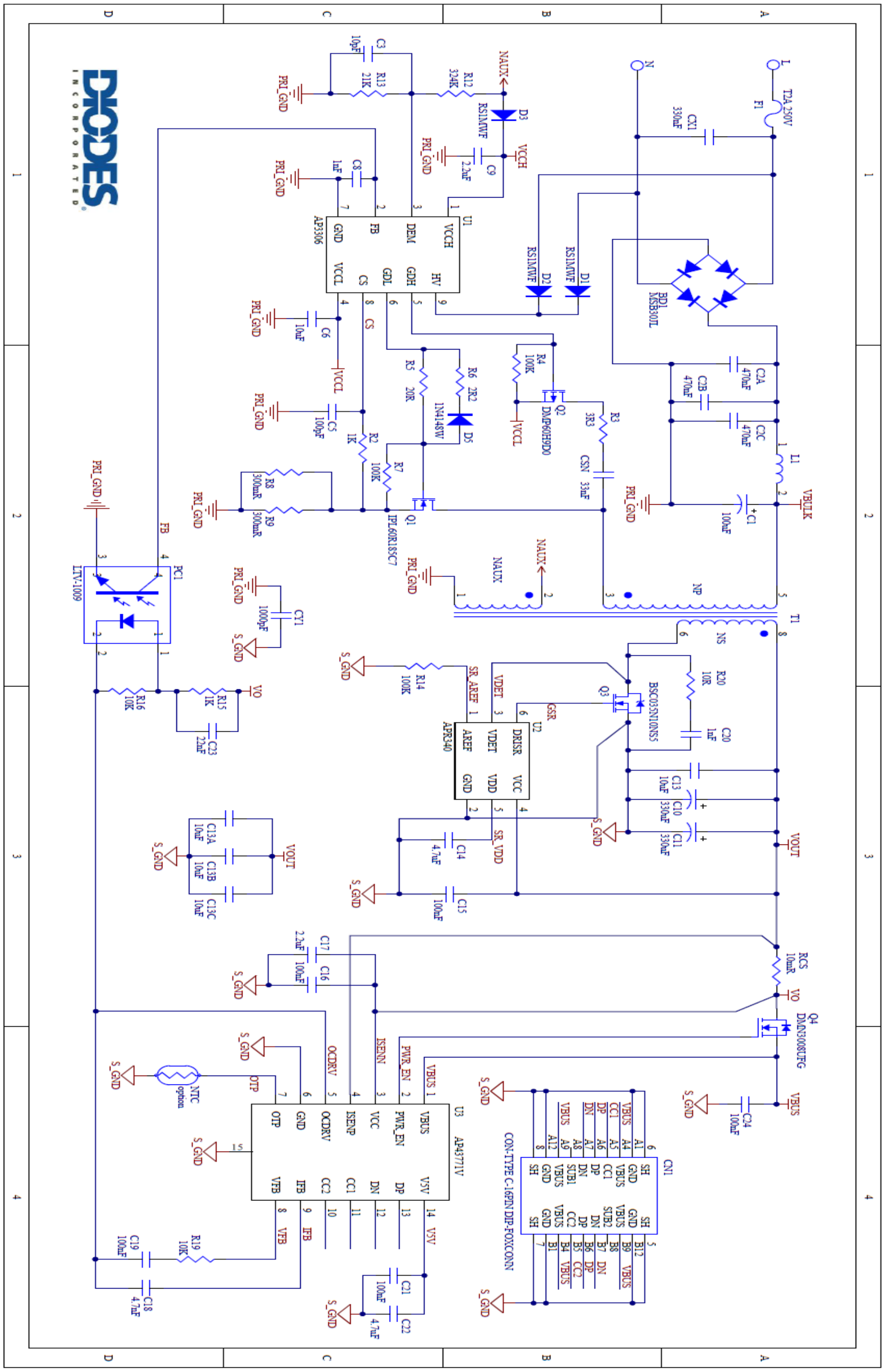


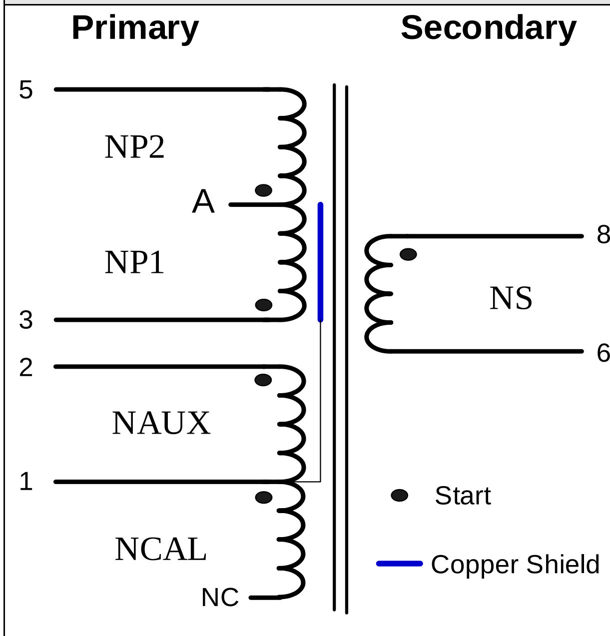
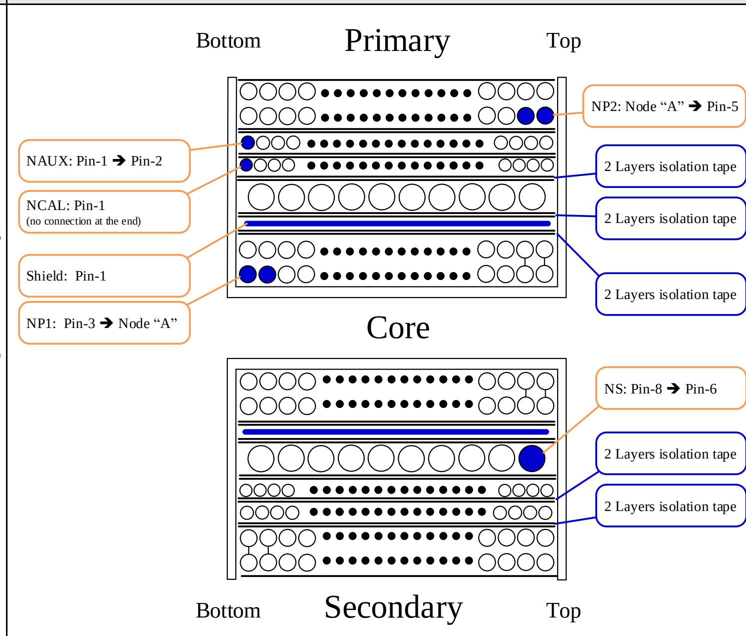
Figure 3: 65W PD3.0 PPS Adapter EVB1 Schematic

3.2 Bill of Material (BOM)

Item	Quantity	Reference	Description	Manufacturer Part Number	Manufacturer
1	**1**	**U1**	**AP3306, Active Clamping Flyback Controller**	**AP3306S10-13**	**Diodes Inc.**
2	**1**	**U2**	**APR340, SR Controller**	**APR340W6-7**	**Diodes Inc.**
3	**1**	**U3**	**AP43771V, Decoder IC**	**AP43771VFBZ-13**	**Diodes Inc.**
4	**1**	**Q2**	**High-Side Switch MOSFET, P-CH, 650V, SO-8, DMP65H9D0HSS-13**	**DMP65H9D0HSS-13**	**Diodes Inc.**
5	**1**	**Q4**	**MOSFET, N-CH, 30V, POWERDI3333-8, DMN3008SFG-13**	**DMN3008SFG-13**	**Diodes Inc.**
6	**3**	**D1,D2, D3**	**Fast Rectifier, 1A, 1000V, SOD-123, RS1MWF**	**RS1MWF-7**	**Diodes Inc.**
7	**1**	**D5**	**Switching Diode, SWD, 150mA, 75V, SOD123, 1N4148W**	**1N4148W-7-F**	**Diodes Inc.**
8	1	Q1	Low-Side Switch N-MOSFET, N-CH, 600V, THINPAK 8X8, IPL60R185C7	IPL60R185C7	Infineon
9	1	Q3	MOSFET, N-CH, 100V, POWERDI5060-8, BSC035N10NS5	BSC035N10NS5	Infineon
10	1	BD1	Bridge 3A 600V MSB30JL	MSB30JL	LITE ON
11	1	C1	EC 100µF 400V 12.5x42	SD400M101I40TA09S00R	Su'scon (冠坤)
12	3	C2A, C2B, C2C	MLCC 470nF 450V 1812 X7R C4532X7T2W474K230KE	C4532X7T2W474K230KE	TDK
13	1	C5	MLCC 100pF 50V 0603 X7R		
14	1	C6	MLCC 10µF 35V 1206 X7R		
15	1	C8	MLCC 1nF 50V 0603 X7R		
16	1	C9	MLCC 2.2µF 100V 1206 X7R		
17	2	C10, C11	EC 330µF 25V 6.3x12 polymer		
18	4	C13, C13A, C13B, C13C	MLCC 10µF 25V 1206 X7R		
19	2	C14, C22	MLCC 4.7uF 10V 0805 X7R		
20	5	C15, C16, C19, C21, C24	MLCC 100nF 50V 0603 X7R		
21	1	C17	MLCC 2.2µF 50V 0805 X7R		
22	1	C18	MLCC 4.7nF 50V 0603 X7R		
23	1	C20	MLCC 1nF 250V 0805 X7R		
24	1	C23	MLCC 22nF 50V 0603 X7R		
25	1	CSN	MLCC 33nF 1KV 1210 X7R	C1210C333KDRACTU	KEMET
26	1	CX1	X2 0.33µF AC275V 13mm x 12.5mm x 6mm lead space 10mm		TENTA
27	1	CY1	Y1 1000pF AC300V	SMDDK1E3EA102M86RBH01	MuRata
28	1	F1	Fuse T3.15A 250V Time Lag	40013150000	Littlefuse
29	1	L1	Inductor 22uH	7447713220	Wurth Elektronik
31	1	NTC	NTC 100K 0603	NTCG103JF103FT1S	TDK

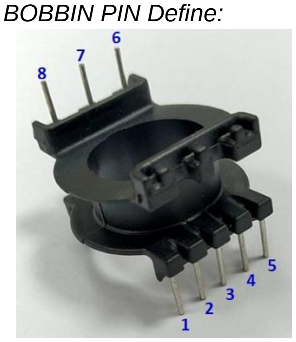
32	1	PC1	Optocoupler	TLV-1009	LITE ON
33	1	R2	RES 1K 0603 5%		
34	1	R3	RES 3R3 1206 5% 750mW		
35	3	R4, R7, R14	RES 100K 0603 1%		
36	1	R5	RES 20R 0805 1%		
37	1	R6	RES 2R2 0805 1%		
38	1	R8	RES 300mR 1206 1% 750mW	SMD12A1FR300T	Sart Tech
39	1	R9	RES 300mR 1206 1% 750mW	SMD12A1FR300T	Sart Tech
40	1	R12	RES 324K 0805 1%		
41	1	R13	RES 21K 0603 1%		
42	1	R15	RES 1K 0603 1%		
43	2	R16, R19	RES 10K 0603 1%		
44	1	R20	RES 10R 1206 5%		
45	1	RCS	RES 10mR 1206 1% Low CTR type		
46	1	T1	ATQ23/12.3 260uH	BCK2301-014(RPF)	JEPLUS Tech. 杰普斯科技
47	---	NF1	CM Choke 4.52mH (option)	TL-20102301T02TB	FUJIMI Technology Group Inc.

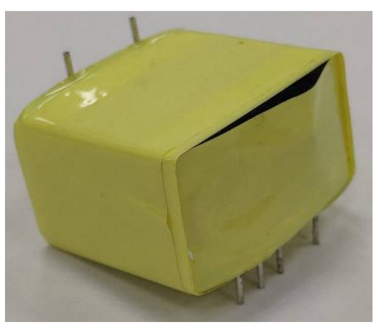
3.3 Transformer Design

Schematic	Structure
	

Definition	Pin define (Start >> End)	Wire (φ)	No. of Turns	Layers	Layers of Tape
NP1	3 → Node A	2UEW Litz Wire, 0.1mmx15, 1P, Bot -> Top -> Bot	14	2	1 L
Shield	1 → NC	5mm width copper shielding, solder to pin-1.	1	1	1 L
NS	8 → 6	TRW(B), Triple Insulated Litz Wire 0.25x7, 1P	5	1	1 L
NCAL	1 → NC	2UEW, 0.13, 1P	20	1	1 L
NAUX	2 → 1	2UEW, 0.13, 2P	12	1	1 L
NP2	Node A → 5	2UEW Litz Wire, 0.1mmx15, 1P, Bot -> Top -> Bot	14	2	2L

BOBBIN PIN Define:





Item	Test Condition	Rating
Primary Inductance	Pin 3-5,all other windings open, measured at 100kHz / 1V	260uH+/- 5%
Note	Bobbin: 裕龍鑫科技, ATQ2327 Core： A-Core(安磁), ATQ-23/12.3 (JPP-96F)	

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 NF1 and NF2 are common mode chocks for the common mode noise suppression. The BD is a bridge rectifier which converts alternating current and voltage into direct current and voltage. The CE1~CE4, L1, CE5~CE6 are composed of the Pi filter for filtering the differential switching noise back to AC source.

3.4.2 AP3306 PWM Controller

AP3306, a highly integrated Active Clamp Flyback (ACF) controller, integrates high-voltage start-up function through HV pin and X-Cap discharging function. It also integrates a VCCL LDO circuit, which allows the LDO to regulate the wide range VCCL to an acceptable value. This makes AP3306 an ideal candidate for wide range output voltage applications such as USB-PD3.0 PPS. With embedded high-side and low-side switch control mechanism, AP3306 provides proper timing sequences to control Q3 (high-side Switch) and Q4 (low-side Switch) operations to implement two key efficiency improvement approaches, namely, ZVS (Zero Voltage Switching) and leakage energy recycling (stored in Csn) to achieve high-power density charger applications. At no load or light load, the AP3306 will enter the burst mode to minimize standby power consumption.

3.4.3 APR340 Synchronous Rectification (SR) MOSFET Driver

As a high performance solution, APR340 is a secondary side SR controller to effectively reduce the secondary side rectifier power dissipation which works in DCM operation.

3.4.4 AP43771V PD 3.0 Decoder & Protection on/off N MOSFET and Interface to 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) **Loop Compensation:**
   R19 & C19 form the voltage loop compensation circuit, and C18 form the current loop compensation circuit.
5) **OCDRV (Pin5)**: It is the key interface link from secondary decoder (AP43771V) to primary regulation circuit (AP3306). It is connected to Opto-coupler PC1 Pin 2 (Cathode) for feedback information based on all sensed CC1 & CC2 signals for getting desired Vbus voltage & current.
6) **PWR_EN (Pin2) to N-MOSFET Gate**: The pin is used to turn on/off N-MOSFET (Q1) to enable/disable voltage output to the Vbus.

Chapter 4 The Evaluation Board (EVB) Connections

4.1 EVB PCB Layout

Main Board – 1

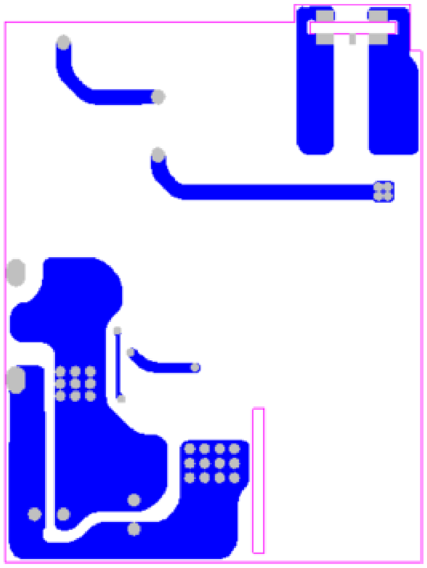


Figure 4: PCB Layout Top View

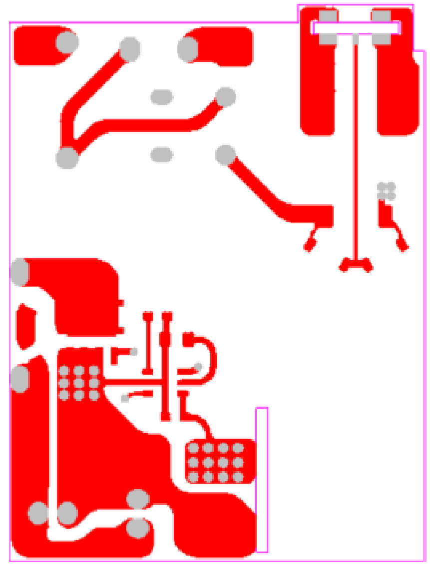


Figure 5: PCB Layout Bottom View

Main Board – 2

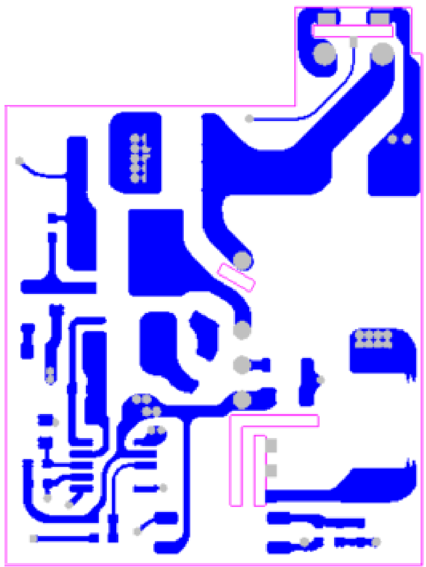


Figure 6: PCB Layout Top View

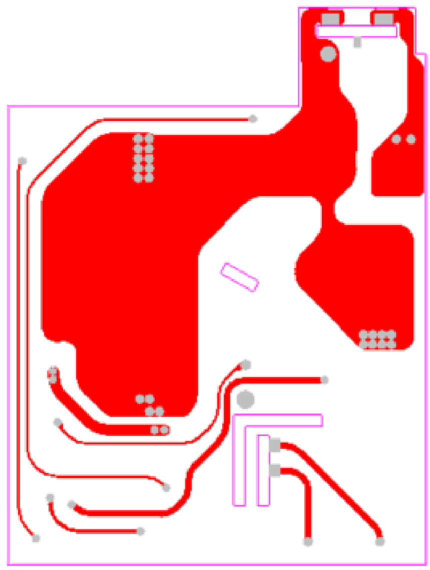


Figure 7: PCB Layout Bottom View

Main Board – 3

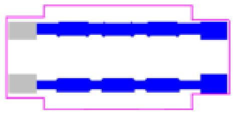


Figure 8: PCB Layout Top View

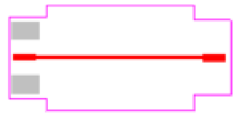


Figure 9: PCB Layout Bottom View

Daughter Board

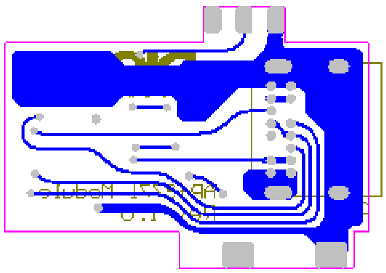


Figure 10: PCB Layout Top View

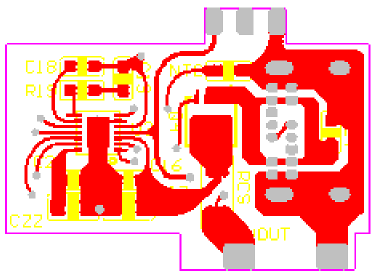


Figure 11: PCB Layout Bottom View

4.2 Quick Start Guide before Connection

1) Before starting the 65W 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

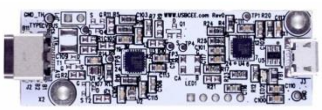
USBCEE PAT Tester	GUI Display	USB-A to Micro-B Cable	Type-C Cable
			

Figure 12: 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.

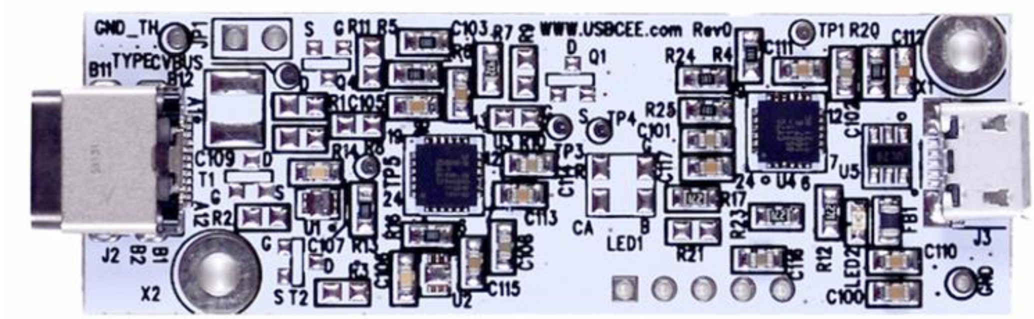


Figure 13: The Test Kit Input & Output and E-load Connections

4.3 Connection with E-Load

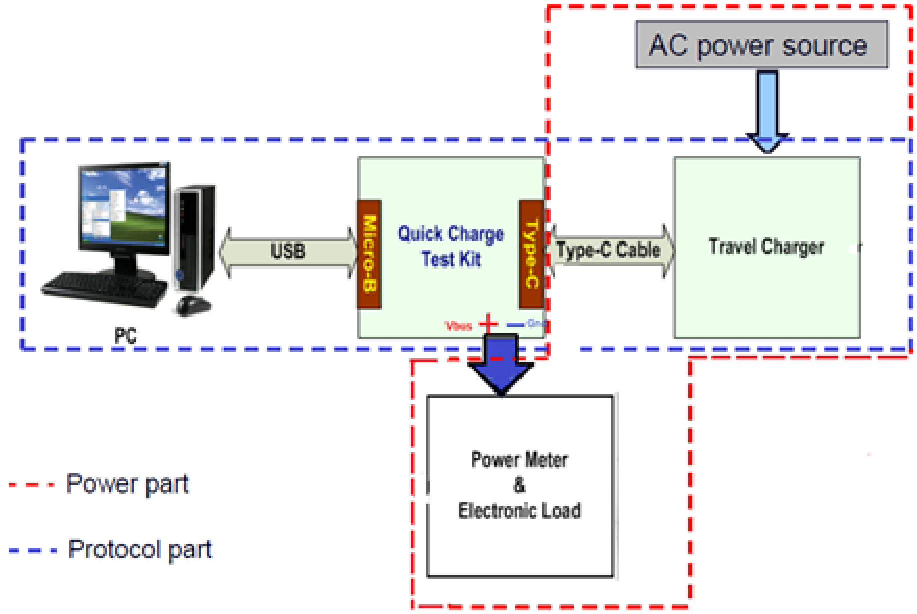


Figure 14: Diagram of Connections in the Sample Board

Chapter 5 Testing the Evaluation Board

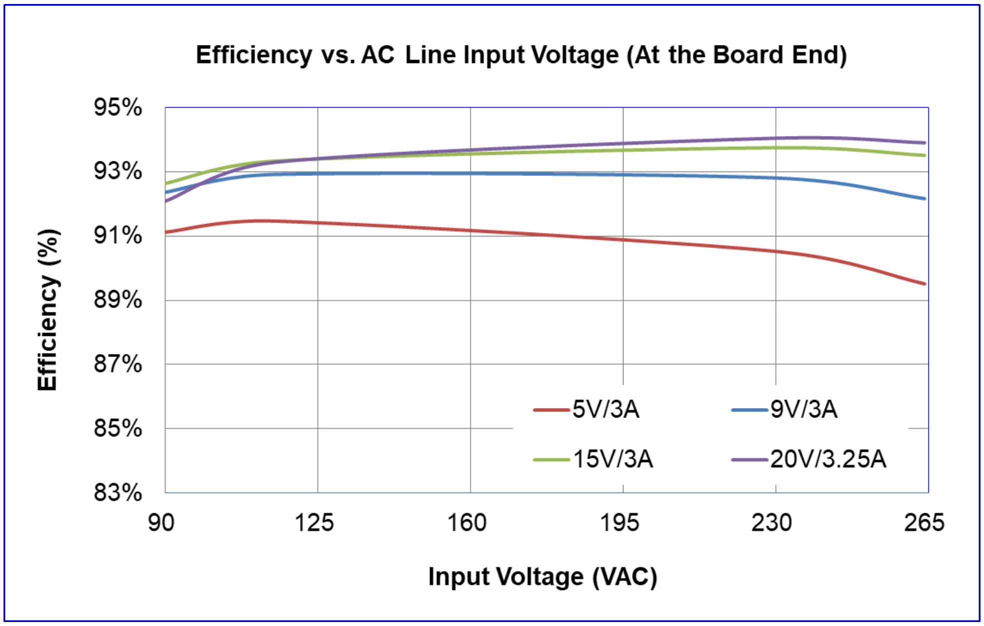
5.1 Input & Output Characteristics

5.1.1 Input Standby Power

Vin(Vac)	F(Hz)	Pin(mW)
90	63	12.75
115	60	13.25
230	50	16.85
264	47	21.64

5.1.2 Multiple Output Full Load Efficiency at Different AC Line Input Voltage

Vin(Vac)	F(Hz)	Iout(A)	Vout_Board (V)	Pin(W)	Pout(W)	Eff(%)
90	60	3.25	20.123V	71.022 W	65.400 W	92.08%
115	60	3.25	20.155V	70.216 W	65.504 W	93.29%
230	50	3.25	20.172V	69.714 W	65.559 W	94.04%
264	50	3.25	20.169V	69.811 W	65.550 W	93.90%
90	60	3.00	15.131V	49.003 W	45.375 W	92.63%
115	60	3.00	15.131V	48.638 W	45.360 W	93.33%
230	50	3.00	15.127V	48.410 W	45.348 W	93.74%
264	50	3.00	15.132V	48.549 W	45.363 W	93.51%
90	60	3.00	9.056V	29.416 W	27.163 W	92.36%
115	60	3.00	9.056V	29.240 W	27.163 W	92.91%
230	50	3.00	9.053V	29.265 W	27.153 W	92.80%
264	50	3.00	9.051V	29.464 W	27.148 W	92.16%
90	60	3.00	5.186V	17.075 W	15.558 W	91.12%
115	60	3.00	5.185V	17.008 W	15.556 W	91.46%
230	50	3.00	5.183V	17.178 W	15.547 W	90.52%
264	50	3.00	5.183V	17.371 W	15.533 W	89.51%



5.1.3 Multiple Output Average Efficiency at Different Loading

Port-C PD3.0_PDO_20V / 15V Average Efficiency

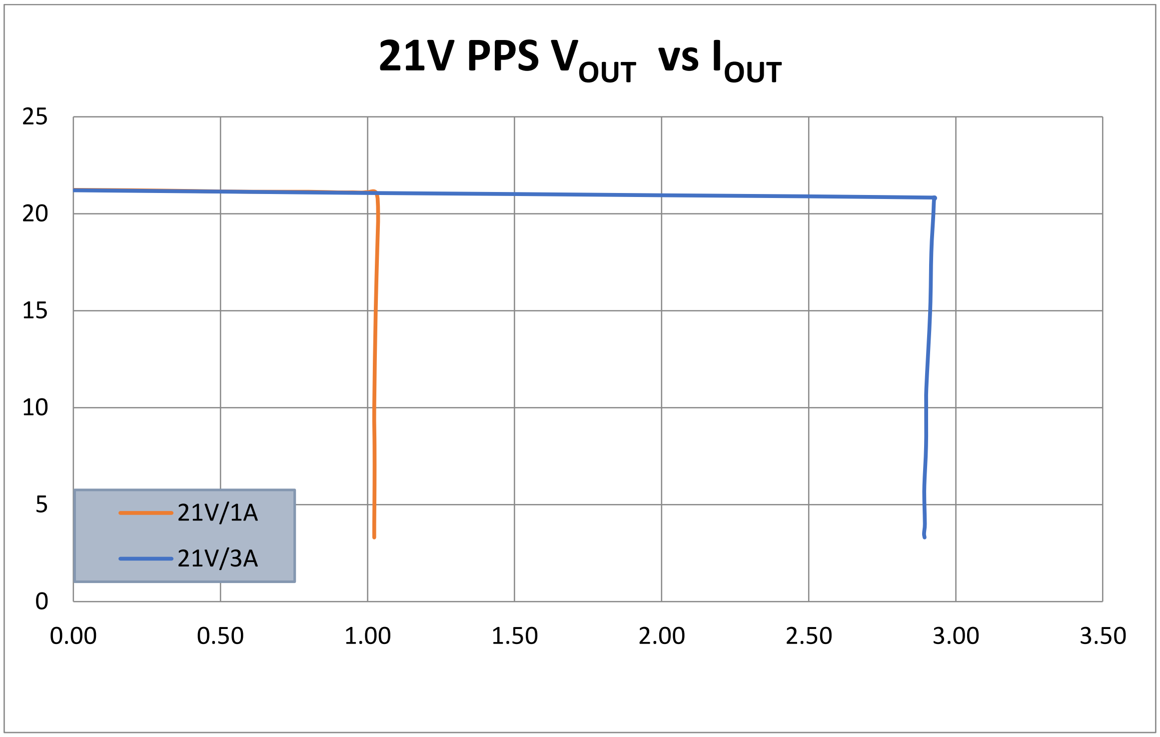
PDO Mode	Vin (Vac)	F(Hz)	Remarks	Iout(A)	Vout(V)	Pin(W)	Pout(W)	Eff(%)	Average Efficiency
20V/3.25A	115	60	100%	3.250	20.155V	70.216W	65.504W	93.29%	93.15%
			75%	2.438	20.141V	52.430W	49.044W	93.54%	
			50%	1.625	20.123V	35.050W	32.700W	93.30%	
			25%	0.813	20.096V	17.600W	16.278W	92.49%	
			10%	0.325	20.084V	7.247W	6.527W	90.07%	
	230	50	100%	3.250	20.172V	69.714W	65.559W	94.04%	93.18%
			75%	2.438	20.154V	52.300W	49.075W	93.83%	
			50%	1.625	20.130V	35.067W	32.711W	93.28%	
			25%	0.813	20.110V	17.791W	16.289W	91.56%	
			10%	0.325	20.099V	7.378W	6.532W	88.54%	
15V/3A	115	60	100%	3.000	15.131V	48.638W	45.393W	93.33%	93.14%
			75%	2.250	15.120V	36.440W	34.020W	93.36%	
			50%	1.500	15.100V	24.282W	22.649W	93.28%	
			25%	0.750	15.085V	12.217W	11.314W	92.61%	
			10%	0.300	15.077V	4.986W	4.523W	90.71%	
	230	50	100%	3.000	15.127V	48.410W	45.381W	93.74%	93.02%
			75%	2.250	15.116V	36.348W	34.011W	93.57%	
			50%	1.500	15.100V	24.346W	22.650W	93.03%	
			25%	0.750	15.082V	12.332W	11.311W	91.72%	
			10%	0.300	15.074V	5.163W	4.522W	87.59%	

Port-C PD3.0_PDO_9V / 5V Average Efficiency

PDO Mode	Vin (Vac)	F(Hz)	Remarks	Iout(A)	Vout(V)	Pin(W)	Pout(W)	Eff(%)	Average Efficiency
9V/3A	115	60	100%	3.000	9.056V	29.240W	27.168W	92.91%	92.74%
			75%	2.250	9.040V	21.876W	20.340W	92.98%	
			50%	1.500	9.023V	14.572W	13.535W	92.88%	
			25%	0.750	9.006V	7.327W	6.754W	92.19%	
			10%	0.300	8.997V	3.019W	2.699W	89.42%	
	230	50	100%	3.000	9.053V	29.265W	27.158W	92.80%	92.19%
			75%	2.250	9.038V	21.952W	20.336W	92.64%	
			50%	1.500	9.021V	14.682W	13.532W	92.17%	
			25%	0.750	9.005V	7.409W	6.754W	91.15%	
			10%	0.300	8.997V	3.041W	2.699W	88.75%	
5V/3A	115	60	100%	3.000	5.185V	17.008W	15.556W	91.46%	91.14%
			75%	2.250	5.167V	12.706W	11.627W	91.50%	
			50%	1.500	5.152V	8.463W	7.728W	91.31%	
			25%	0.750	5.135V	4.266W	3.851W	90.28%	
			10%	0.300	5.125V	1.748W	1.537W	87.97%	
	230	50	100%	3.000	5.183V	17.178W	15.549W	90.52%	89.81%
			75%	2.250	5.165V	12.864W	11.622W	90.34%	
			50%	1.500	5.150V	8.597W	7.725W	89.86%	
			25%	0.750	5.135V	4.351W	3.851W	88.52%	
			10%	0.300	5.126V	1.763W	1.538W	87.23%	

5.1.4 PD3.0 & PPS Compatible Mode Testing

CC Mode current limitation function testing
The test is by USBCEE Tester and with E-Load set at CR mode.
To Port-C PPS Mode set 21V-1A & 21V-3A and then increase the current (by reducing R) to see the CC-CV curve



5.2 Key Performance Waveforms

5.2.1 65W PD3.0 System Start-up Time

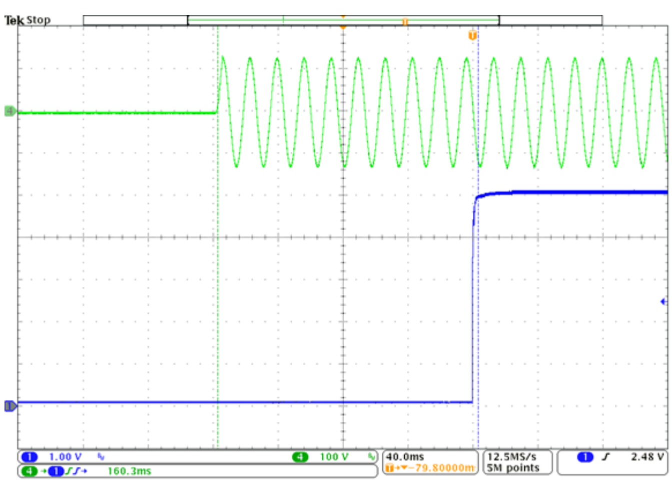


Figure 15: Turn on time is 160ms at Full Load@ 90Vac

5.2.2 Q1 / Q2 / Q3 MOSFET Voltage Stress at Full Load @264Vac

Primary side MOSFET : Q1 & Q2 and Secondary side SR MOSFET- Q3

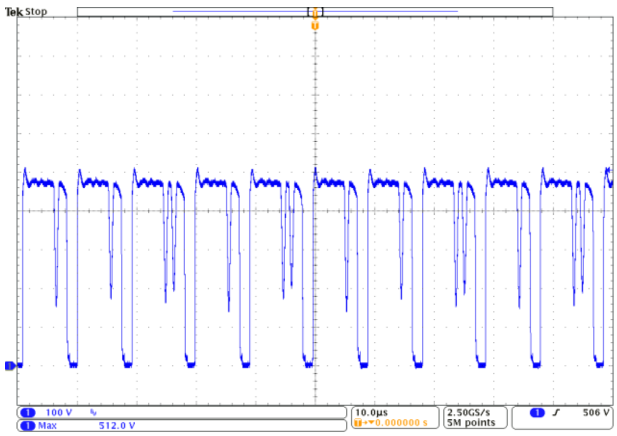


Figure 16: Q1 Vds Voltage stress

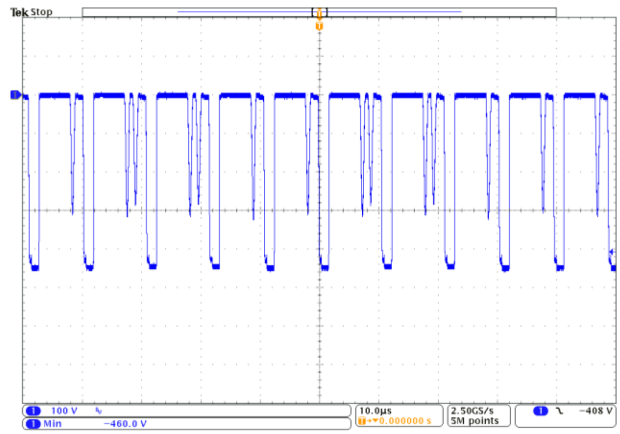


Figure 17: Q2 Vds Voltage stress

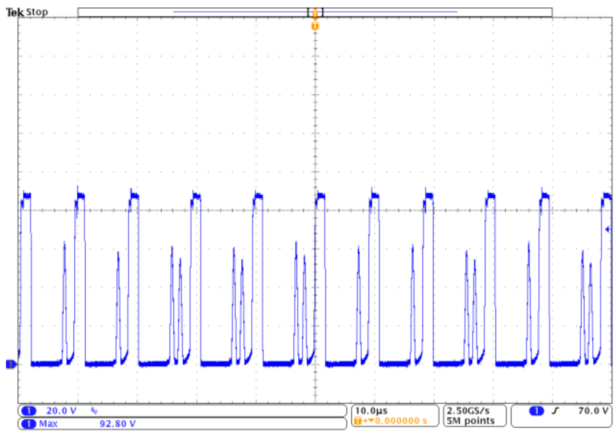


Figure 18: Q3 Vds Voltage stress

Component	Vout	Vds	Vds_Max_Spec	Ratio of voltage stress
Q1	20V	512V	600V	85.33%
Q2		-460V	- 650V	70.77%
Q3		92.8V	100V	92.80%

5.2.3 System Output Ripple & Noise with the Cable

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

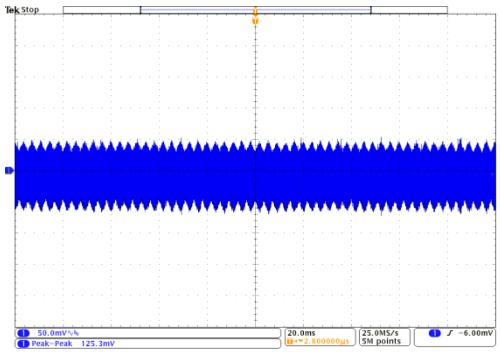


Figure 19: 90Vac/60Hz@ 5V/3A ΔV=65.23mV

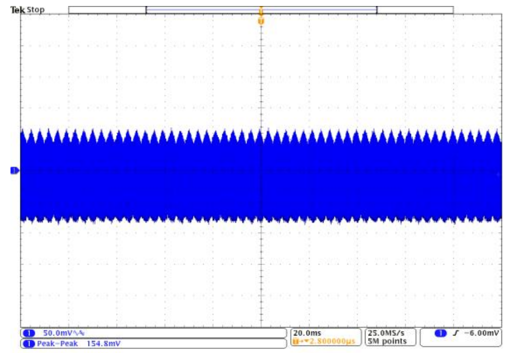


Figure 20: 264Vac/50Hz@5V/3A ΔV=86.03mV

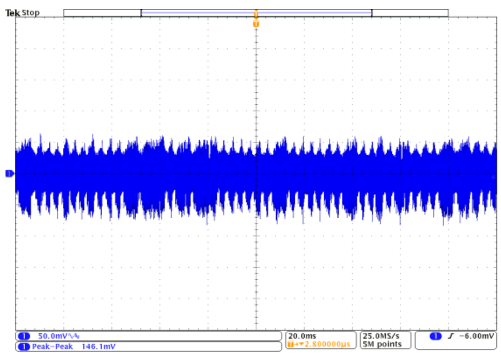


Figure 21: 90Vac/60Hz@9V/3A ΔV=58.87mV

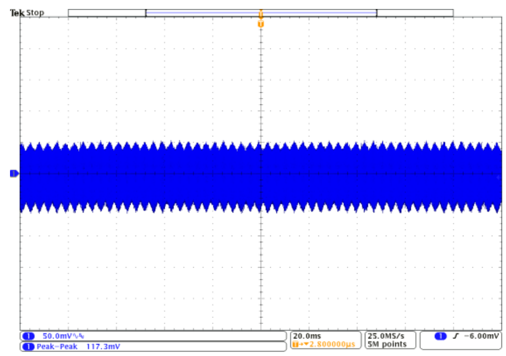


Figure 22: 264Vac/50Hz@9V/3A ΔV=77.41mV

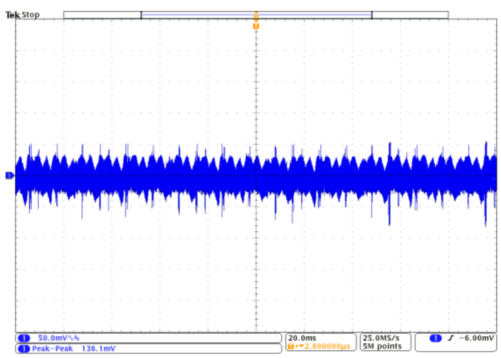


Figure 23: 90Vac/60Hz@15V/3A ΔV=75.58mV

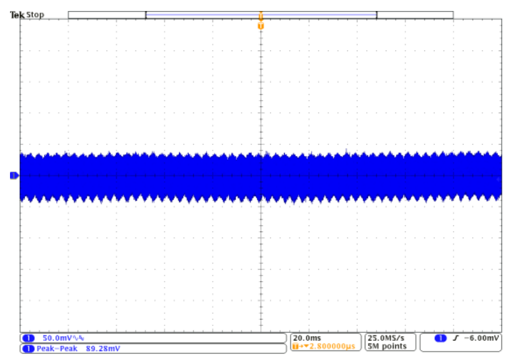


Figure 24: 264Vac/50Hz@15V/3A ΔV=62.69mV

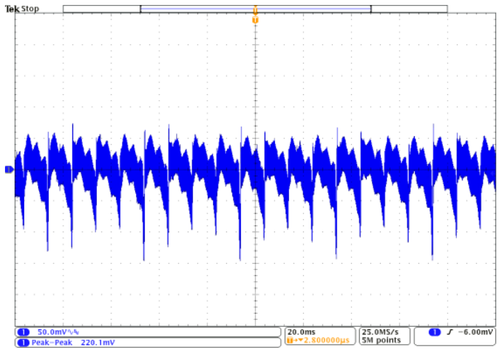


Figure 25: 90Vac/60Hz@20V/3.25A ΔV=156.9mV

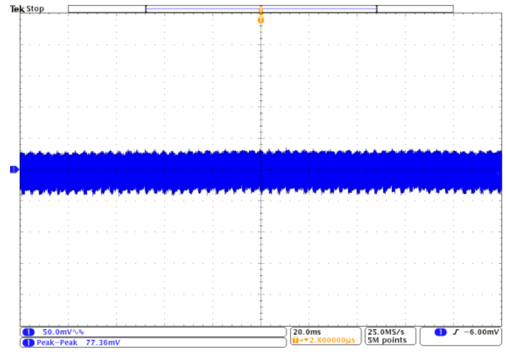


Figure 26: 264Vac/50Hz@20V/3.25A ΔV=66.63mV

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

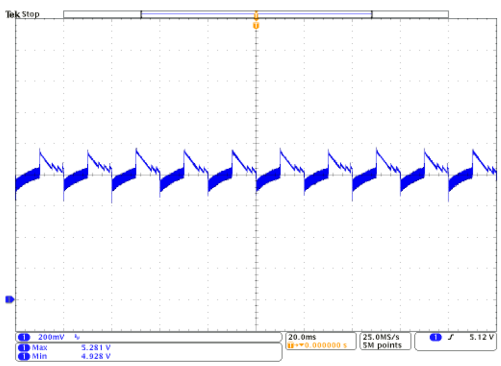


Figure 27: 90Vac/60Hz Port-C@ Vout=5V

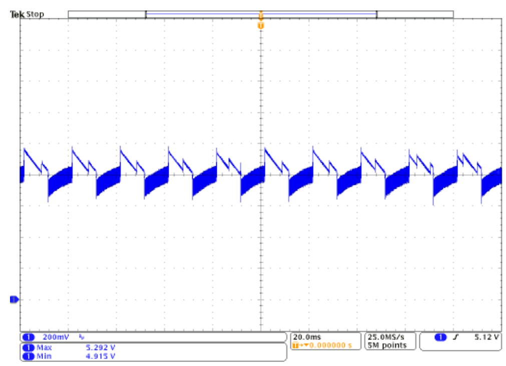


Figure 28: 264Vac/50Hz Port-C@ Vout=5V

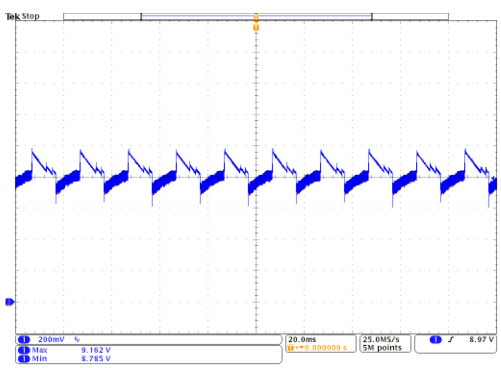


Figure 29: 90Vac/60Hz Port-C@ Vout=9V

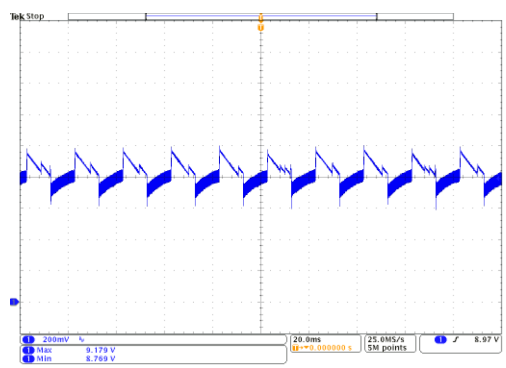


Figure 30: 264Vac/50Hz Port-C@ Vout=9V

	Vo_ Undershoot(V)	Vo_ Overshoot(V)		Vo_Undershoot(V)	Vo_Overshoot(V)
Vin=90Vac@5V	4.928	5.281	Vin=90Vac@9V	8.785	9.162
Vin=264Vac@5V	4.915	5.202	Vin=264Vac@9V	8.769	9.179

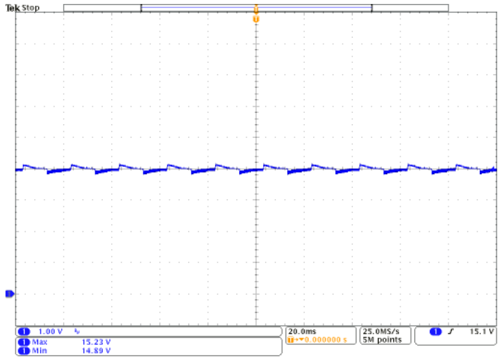


Figure 31: 90Vac/60Hz Port-C@ Vout=15V

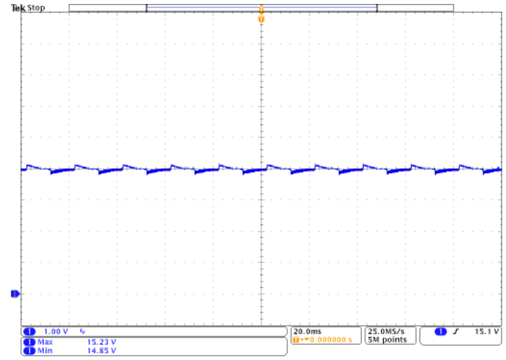


Figure 32: 264Vac/50Hz Port-C@ Vout=15V

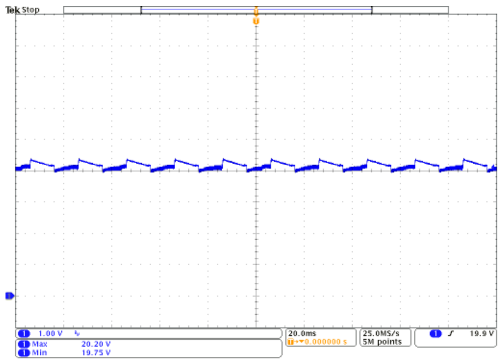


Figure 33: 90Vac/60Hz Port-C@ Vout=20V

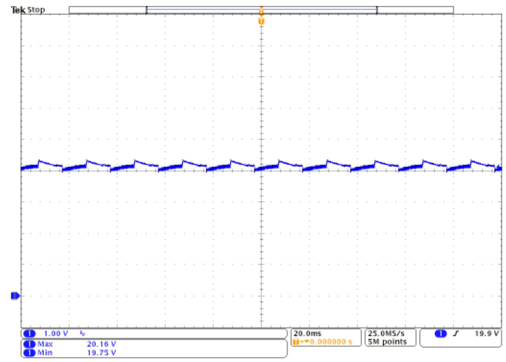


Figure 34: 264Vac/50Hz Port-C@ Vout=20V

	Vo_ Undershoot(V)	Vo_ Overshoot(V)		Vo_Undershoot(V)	Vo_Overshoot(V)
Vin=90Vac@15V	14.89	15.23	Vin=90Vac@20V	20.20	19.75
Vin=264Vac@15V	14.85	15.23	Vin=264Vac@20V	20.16	19.75

5.2.5 Output Voltage Transition Time from Low to High

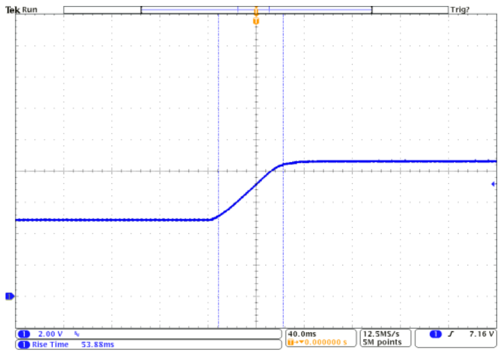


Figure 35: 5V→9V Rise Time = 53.88ms @90Vac

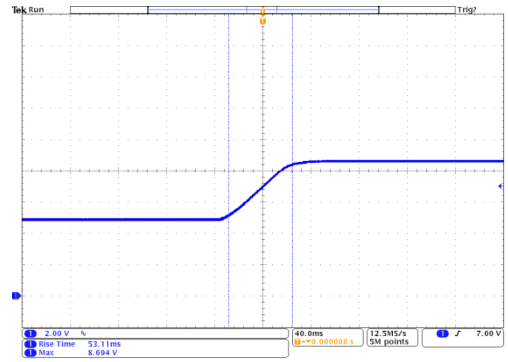


Figure 36: 5V→9V Rise Time = 53.11ms @264Vac

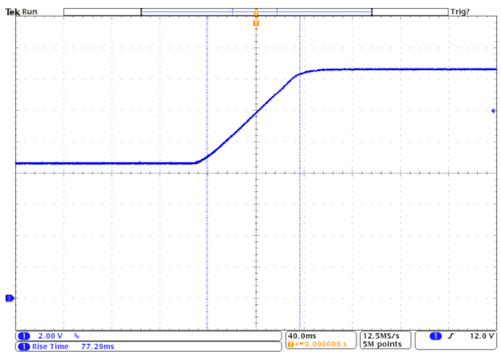


Figure 37: 9V→15V Rise Time = 77.29ms @90Vac

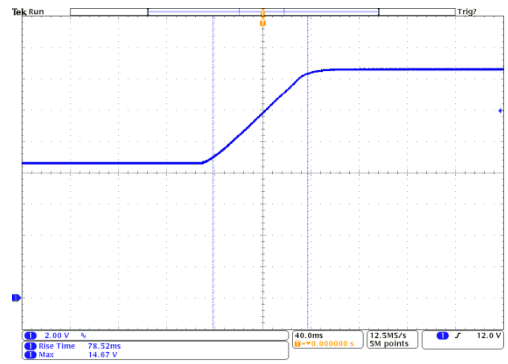


Figure 38: 9V→15V Rise Time = 78.52ms @264Vac

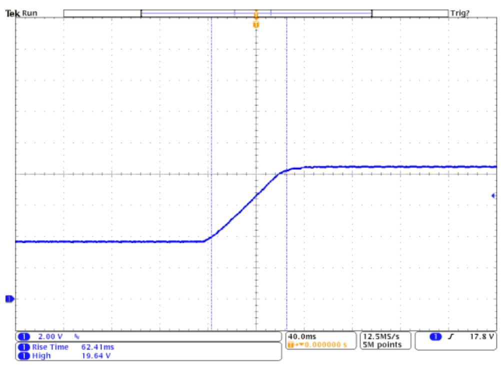


Figure 39: 15V→20V Rise Time = 62.41ms @90Vac

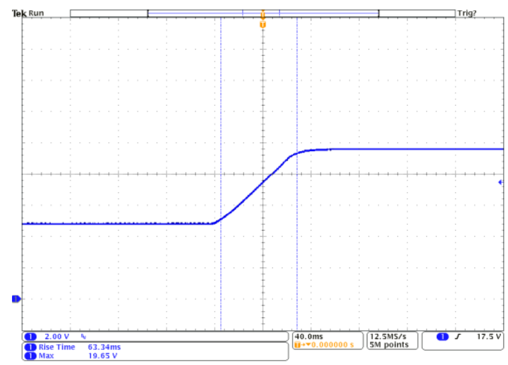


Figure 40: 15V→20V Rise Time = 63.34 ms @264Vac

5.2.6 Output Voltage Transition Time from High to Low

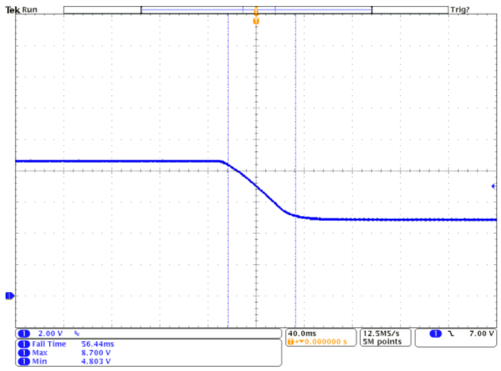


Figure 41: 9V→5V Fall Time = 56.44ms @90Vac

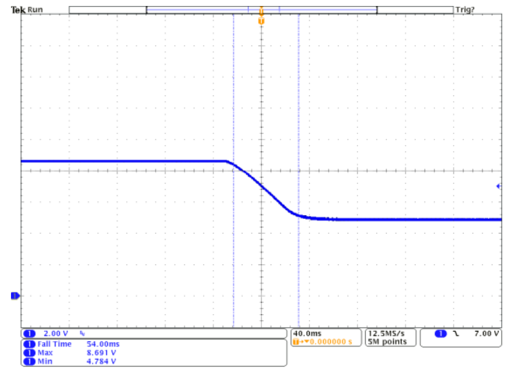


Figure 42: 9V→5V Fall Time = 54.00ms @264Vac

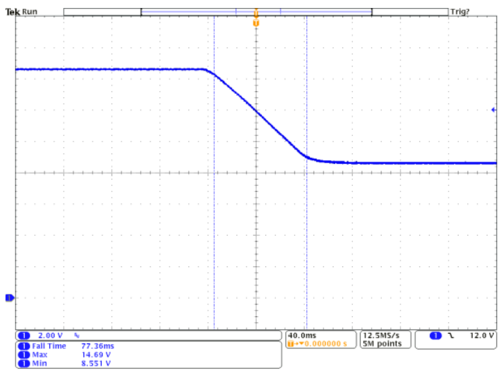


Figure 43: 15V→9V Fall Time = 77.36ms @90Vac

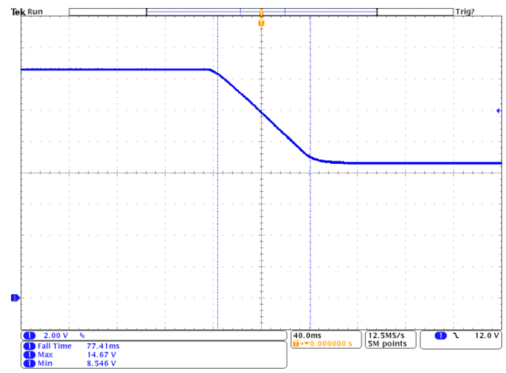


Figure 44: 15V→9V Fall Time = 77.41ms @264Vac

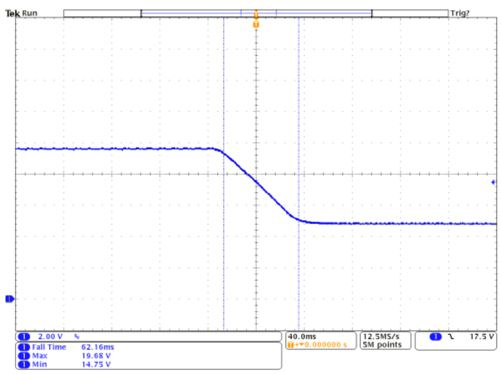


Figure 45: 20V→15V Fall Time = 62.16ms @90Vac

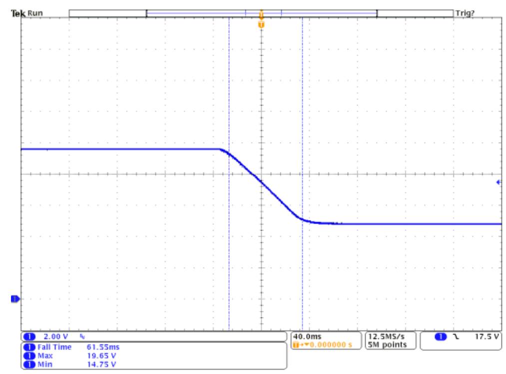


Figure 46: 20V→15V Fall Time = 61.55ms @264Vac

5.2.7 Thermal Testing

Output Condition : 20V/3.25A

Main Voltage	Temperature (°C)					
	BD1	Q1	Q2	Q3	U1	U2
90Vac/60Hz	112.1	113.1	115	100.1	106.4	99.0

Test Condition: Vin=90Vac @ 20V-3.25A Full load Open Frame

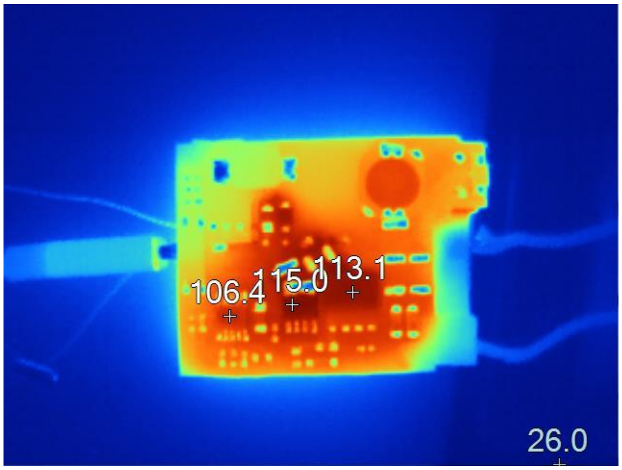


Figure 47: Top Components side

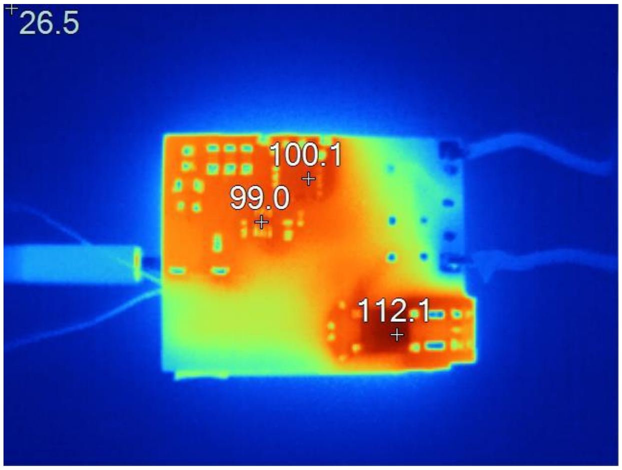


Figure 48: Bottom Suface Mount side

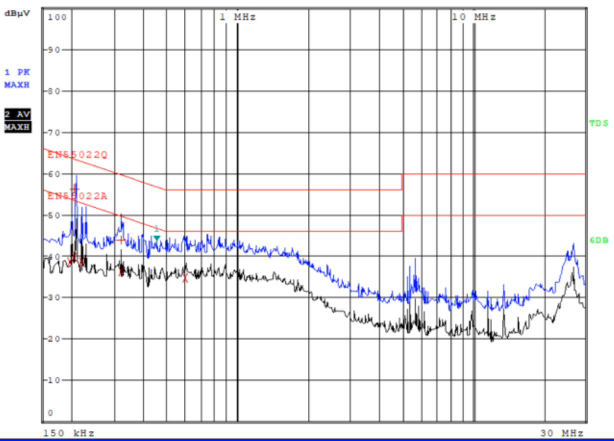
BD1: Bridge Rectifier
Q1 : Primary Side High Voltage N-MOS
Q2 : Primary Side High Voltage P-MOS
Q3 : Secondary Side Sync-Rectifier
U1 : AP3306, ACF Controller
U2 : APR340, Sync-Rectifier Controller

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

5.3 EMI (Conduction) Testing

5.3.1 115Vac testing results

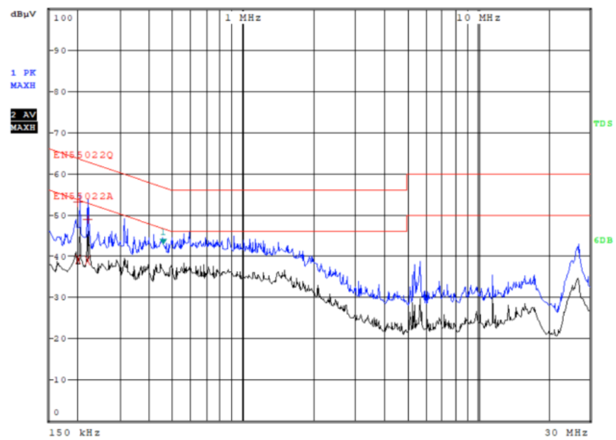
Output Condition : 20V/3.25A



EDIT PEAK LIST (Final Measurement Results)

Trace1:	EN55022Q		
Trace2:	EN55022A		
Trace3:	---		
TRACE	FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
2 Average	198 kHz	38.78	-14.90
1 Quasi Peak	206 kHz	56.25	-7.10
2 Average	206 kHz	39.68	-13.68
2 Average	218 kHz	38.66	-14.22
1 Quasi Peak	318 kHz	43.97	-15.78
2 Average	318 kHz	36.32	-13.43
2 Average	598 kHz	34.78	-11.21

Figure 49: 115Vac/60Hz L line



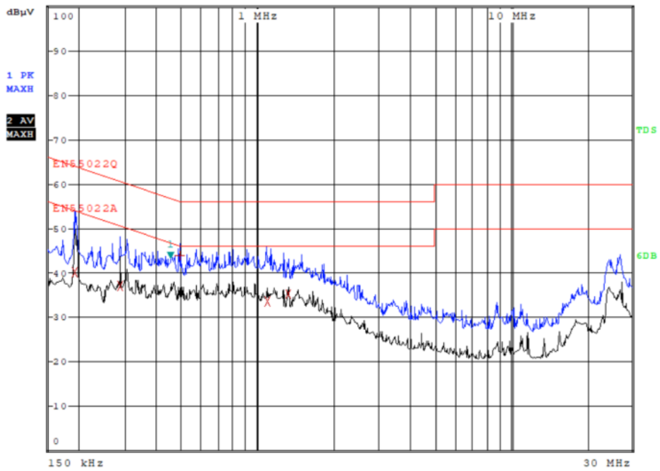
EDIT PEAK LIST (Final Measurement Results)

Trace1:	EN55022Q		
Trace2:	EN55022A		
Trace3:	---		
TRACE	FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1 Quasi Peak	202 kHz	53.09	-10.43
2 Average	202 kHz	39.28	-14.24
1 Quasi Peak	218 kHz	48.90	-13.98
2 Average	218 kHz	38.94	-13.95

Figure 50: 115Vac/60Hz N line

5.3.2 230Vac testing results

Output Condition : 20V/3.25A

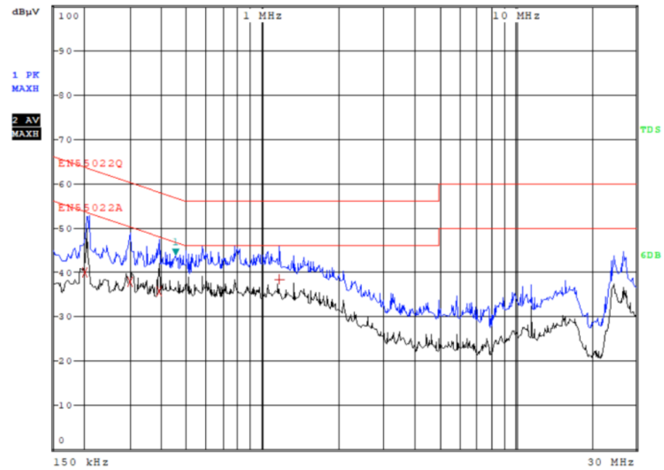


EDIT PEAK LIST (Final Measurement Results)

Trace1:	EN55022Q
Trace2:	EN55022A
Trace3:	---

TRACE	FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
2 Average	194 kHz	40.32	-13.54
2 Average	286 kHz	37.18	-13.46
1 Quasi Peak	494 kHz	43.95	-12.15
2 Average	1.098 MHz	33.76	-12.23
2 Average	1.322 MHz	35.26	-10.73

Figure 49: 230Vac/50Hz L line



EDIT PEAK LIST (Final Measurement Results)

Trace1:	EN55022Q
Trace2:	EN55022A
Trace3:	---

TRACE	FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
2 Average	202 kHz	40.01	-13.51
2 Average	298 kHz	37.92	-12.37
2 Average	390 kHz	35.82	-12.23
1 Quasi Peak	1.166 MHz	38.32	-17.67

Figure 50: 230Vac/50Hz N line