Table of Contents

Chapter 1. Summary

1.1 General Description

The 30W PD3.0/PPS charger Evaluation Board EV1 is composed of three main parts: AP3304A offers the multi-mode PWM controller, APR348 is a secondary side synchronous rectification controller, and AP43771V is USB PD3.0 PPS and Qualcomm® Quick Charge™ 4/4+/QC5 Decoder for implementing quick charger decoder functions. Based on monitoring D+ & D- and CC1 & CC2 signals, AP43771V interprets desired voltage and current setting, and then feeds information back to primary side AP3304A switcher for providing well-regulated voltage and current as well as related power protections.

1.2 Key Features

1.2.1 System Key Features

- SSR Topology Implementation with an Opto-coupler for Accurate Step Voltage Controlling
- Supports the USB PD3.0 Function and PPS (3V-21V@20mV/step)
- Meet DOE6 and CoC Tier 2 Efficiency Requirements
- <75mW No-Load Standby Power

1.2.2 AP3304A Key Features

- Very Low Start-Up Current
- Multi-Mode Control with CCM+QR
- Soft Start During Startup Process
- Frequency Fold-Back for High Average Efficiency
- Constant Over Current Protection
- Secondary Winding Short Protection with FOCP
- Frequency Dithering for Reducing EMI
- Useful Pin Fault Protection:
- SENSE Pin Floating
- FB/Opto-Coupler Open/Short
- Comprehensive System Protection Feature:
- VCC Over Voltage Protection (VOVP)
- Over Load Protection (OLP)
- Brown Out Protection (BNO)
- Secondary Side OVP (SOVP) and UVP (SUVP)
- Mini Size Package of SOT26 (Type A1)

1.2.3 APR348 Key Features

- Synchronous Rectification Working at DCM, QR and CCM Flyback
- Eliminate Resonant Ringing Interference
- Fewest External Components used

1.2.4 AP43771V Key Features

- 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-14 and QFN-24

1.3 Applications

- PD3.0+PPS Wall Chargers

1.4 Main Power Specifications (CV & CC Mode)

Parameter	Value
Input Voltage	90Vac to 264Vac
Input standby power	< 75mW
Main Output Vo / Io	PD3.0 5V/3A, 9V/3A,15V 2A, 20V/1.5A PPS: 3.3-11V/3A 3.3-21V/2.2A(33W max)
Per Step Voltage	PPS 20mV step voltage, 3.3V-21V
Efficiency	Comply with CoC version 5 tier-2
Total Output Power	30W
Protections	OCP, OVP, UVP, OLP, OTP
Dimension	36 x 37 x 22mm

1.5 Evaluation Board Picture

EVB Top View

EVB Bottom View

Chapter 2. Power Supply Specification

2.1 Specification and Test Results

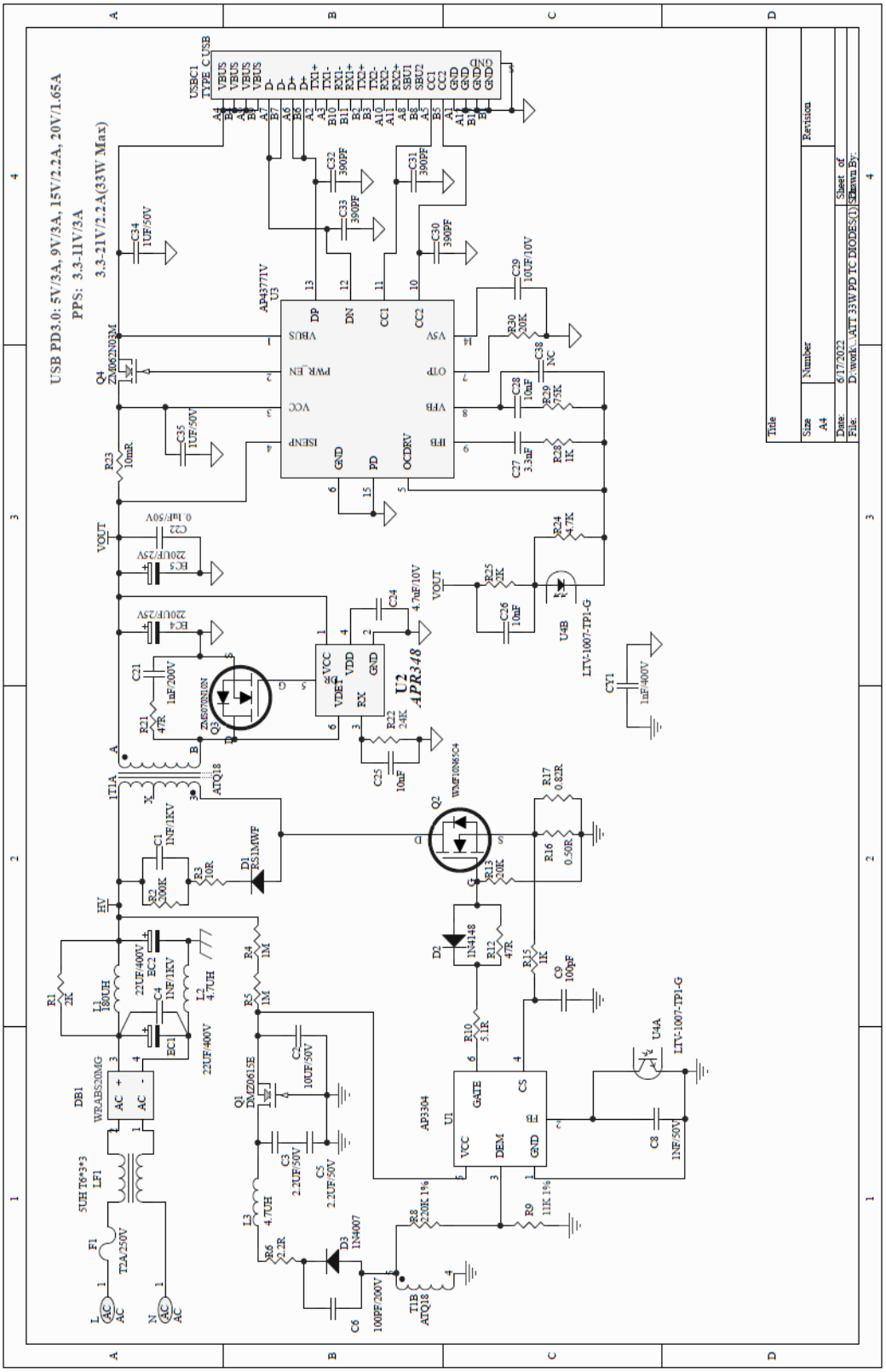
Parameter	Value	Test Summary
Input Voltage	$90V_{AC}$ to $264V_{AC}$	
Input Voltage Frequency	47Hz to 63Hz	
Standby Power	<75mW; no-load	**PASS,** 61.5mW@230VAC/50Hz
5V Average Efficiency	DoE VI Eff >81.39%	**PASS,** 89.11% @115VAC/60Hz, 88.03% @230VAC/50Hz
	Tier2 Eff>81.84%	
5V/0.3A Efficiency (10% Load)	Tier2 Eff>72.48%	**PASS,** 87.55% @115VAC/60Hz, 81.65% @230VAC/50Hz
9V Average Efficiency	DoE VI Eff >86.62%	**PASS,** 90.64% @115VAC/60Hz, 90.33% @ 230VAC/50Hz
	Tier2 Eff>87.3%	
9V/0.3A Efficiency (10% Load)	Tier2 Eff>77.3%	**PASS,** 88.88% @115VAC/60Hz, 85.3% @230VAC /50Hz
15V Average Efficiency	DoE VI Eff >86.95%	**PASS,** 91.54% @115VAC/60Hz, 91.04% @ 230VAC/50Hz
	Tier2 Eff>88.03%	
15V/0.2A Efficiency (10% Load)	Tier2 Eff>78.03%	**PASS,** 88.64% @115VAC/60Hz, 85.58% @ 230VAC/50Hz
20V Average Efficiency	DoE VI Eff >86.95%	**PASS,** 90.7% @115VAC/60Hz, 90.45% @ 230VAC/50Hz
	Tier2 Eff>88.03%	
20V/0.15A Efficiency (10% Load)	Tier2 Eff>78.03%	**PASS,** 83.47% @115VAC/60Hz, 80.90% @ 230VAC/50Hz
5V Ripple	<120mV	**PASS**
9V Ripple	<120mV	**PASS**
15V Ripple	<120mV	**PASS**
20V Ripple	<120mV	**PASS**
PPS1	3.3V – 11V / 0-3A+/-150mA	
PPS2	3.3V – 21V / 0-2.2A(33W max)+/-150mA	
Conducted EMI	>6dB Margin; according to FCC / EN55032 Class B	**PASS**

2.2 Compliance

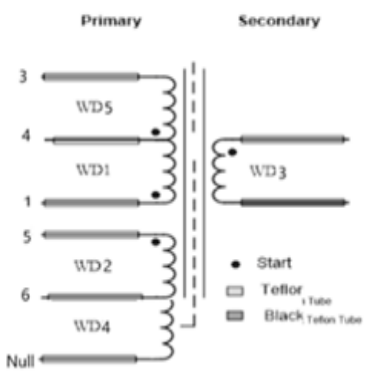
Parameter	Value	Summary
Output Connector	USB Type C	
Temperature	<120^{o}C at 90Vac Input and 20V/1.5A output	**PASS**
Stress	<95%	**PASS**
Dimensions W/D/H	34 x 48 x 22 (mm)	

Chapter 3. Schematic

3.1 Schematic



3.2 Transformer SPEC

Circuit	Cross sectional view
	

Define	PinDefine (Start>End)	Wire	Turn (Ts)	Layers	Layers of Tape
WD1	1->4	2UEW-B 0.26mmx1P	21	1	2
WD2	5->6	2UEW-B 0.12mmx1P	15	1	2
	6->Null	2UEW-B 0.12mmx2P		1	2
WD3	A->B	Triple Litz wire-B 0.2mm	6	1	2
WD4	6->Null	2UEW-B 0.12mmx2P	17	1	2
WD5	4->3	2UEW-B 0.26mmx1P	19	1	2
Note: over core(22mm), pin6 connect to Ground					3

Item	Pin	SPEC	Tolerance	Test condition
Inductance	1->3	0.5mH	±5%	100KHz /1V
Leakage Inductance	1->3(short WD3)	25uH	Max	100KHz /1V

3.3 Schematics Description

3.3.1 Fuse, EMI Filter and Rectifier

The Fuse F1 protects against overcurrent conditions which occur when some main components failed. The LF1 is a common mode choke for the common mode noise suppression. The DB1 is a rectifier witch converts alternating current and voltage into direct current and voltage. The EC1, L1, L2, EC2 are composed of the filter for filtering the differential switching noise back to AC source.

3.3.2 AP3304A MULTI-MODE PWM CONTROLLER

AP3304A is a peak-current control, multi-mode CCM+QR PWM controller which is optimized for high performance, low standby power and cost effective offline flyback converters. In QR mode, the maximum switching frequency is clamped to 100kHz to reduce switching power loss. If the switching frequency reaches upper limit of AP3304A, the switching frequency starts to fall as the load increases until entering CCM with fixed switching frequency 80kHz to optimize power conversion efficiency.

3.3.3 APR348 SYNCHRONOUS RECTIFICATION CONTROLLER

APR348 is a secondary-side MOSFET driver for synchronous rectification, which can effectively reduce the secondary-side rectifier power dissipation and provide a high-performance solution. The APR348 can support continuous or discontinuous conduction mode (CCM and DCM) and quasi-resonant flyback operation based on a MOSFET operating on-time control technology. This technology provides minimized turn-on and turn-off delay to reduce power loss and keep safe operation without adding any external components or circuitry.

3.3.4 AP43771V HIGH-PERFORMANCE USB PD CONTROLLER

The following pins provide critical protocol decoding and regulation functions in AP43771V:

1) **CC1 & CC2 (Pin 10, 11)**: CC1 & CC2 (Configuration Channel 1 & 2) are defined by USB PD spec to provide the channel communication link between power source and sink devices.
2) **D+ & D- (Pin 12, 13):** While defined under USB PD for data transfer only, D+ and D- are used in QC4+ to provide voltage information and backward compatibility with QC2.0 and QC3.0 devices.
3) **Constant Voltage (CV)**: The CV is implemented by sensing VCC (pin 3) via built-in resistor divider and compared with internal reference voltage. The output voltages can be adjusted by firmware programming.
4) **Constant Current (CC)**: The CC is implemented by sensing the current sense resistor (R23, 10mΩ) and compared with internal programmable reference voltage. The output current can be adjusted by firmware programming.
5) **Loop Compensation:** C28, R29 & C38 form the voltage loop compensation circuit, and C27, R28 form the current loop compensation circuit.
6) **OCDRV (Pin 5):** It is the key interface link from secondary decoder (AP43771V) to primary regulation circuit (AP3304A). It is connected to Opto-coupler U4 Pin 2 cath for feedback information based on all sensed CC1 & CC2, D+ & D- voltage status for getting desired Vbus voltage & current.
7) **PWR_EN (Pin 2) to N-MOSFET Gate**: The pin is used to turn on and off Vbus load switch (Q4) to enable and disable voltage output to the Vbus respectively.

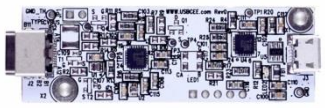
Chapter 4. Evaluation Board Connections

4.1 Quick Start Guide before Connection

1) Before starting the 30W EVB test, the end user needs to prepare the following tool, software and manuals.

   For details, please contact Canyon Semiconductor local sales 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
			

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

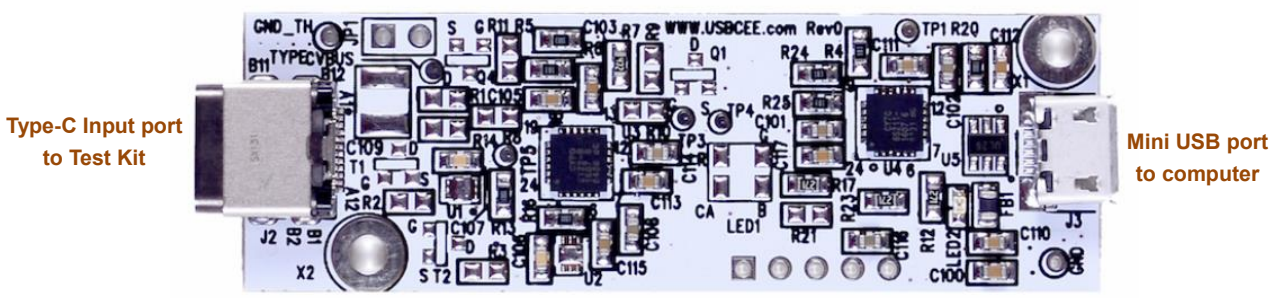
3) Connect the input AC L & N wires to AC power supply output “L and N “wires.

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

5) Use a type-C cable for the connection between EV board to Cypress’s Type-C receptacles.

6) Use 2 banana jack cables, one port of the cables is connected to E-load + & - terminals while the other port of the cables is connected to the unit’s VBUS & GND holes.

7) A Standard-A to Micro-B cable to be connected to the Cypress test kit’s Micro-B receptacle & PC Standard-A receptacle respectively.



The Test Kit Input & Output and E-load Connections

4.2 Connection with E-Load

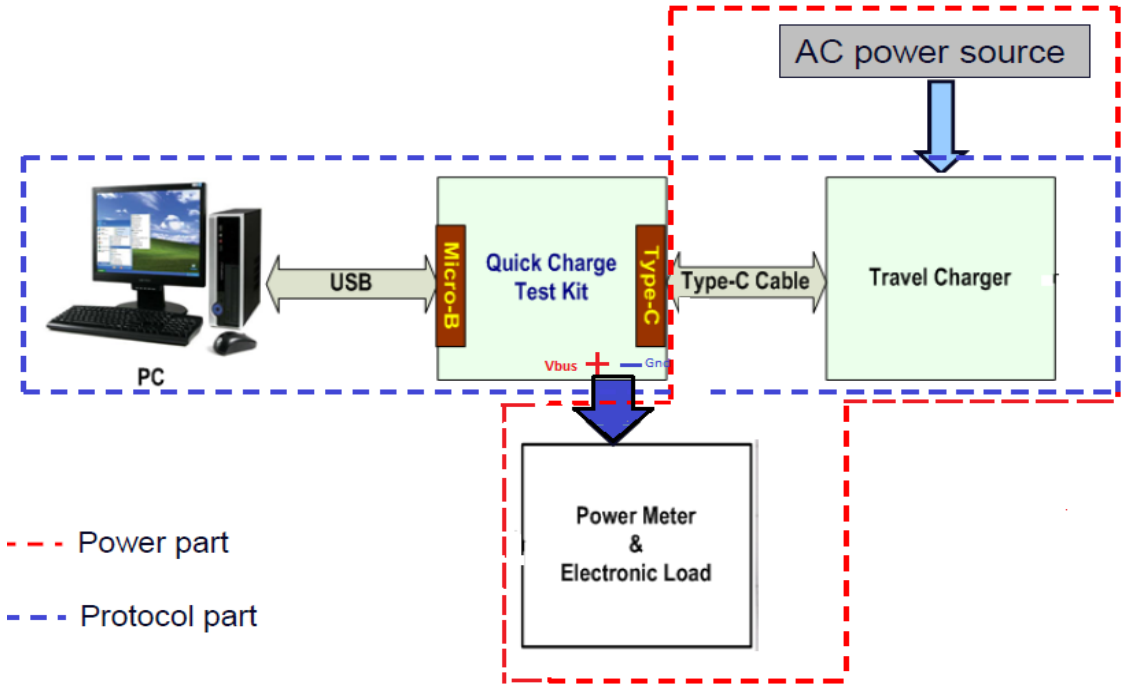


Diagram of Connections in the Sample Board

Chapter 5. Input & Output Characteristics

5.1 Input Standby Power

VIN(VAC)	FIN(Hz)	VOUT(V)	Pin(mW)
90	47	5.0	20.4
115	60	5.0	23.6
230	50	5.0	61.5
264	63	5.0	86.2

5.2 Average Efficiency at Different Loading

5.2.1 Average Efficiency (5V / 3A)

V_{IN}(V)	P_{IN}(W)	V_{OUT}(V)	I_O(A)	P_{OUT}(W)	η	Average η	SPEC.
90	17.938	5.275	3	15.825	88.22%		81.84%&72.48%@10%
115	1.729	5.046	0.3	1.5138	87.55%		
	4.255	5.083	0.75	3.81225	89.59%	89.11%	
	8.649	5.148	1.5	7.722	89.28%		
	13.157	5.21	2.25	11.7225	89.10%		
	17.892	5.275	3	15.825	88.45%		
230	1.854	5.046	0.3	1.5138	81.65%		
	4.371	5.08	0.75	3.81	87.17%	88.03%	
	8.748	5.148	1.5	7.722	88.27%		
	13.274	5.21	2.25	11.7225	88.31%		
	17.911	5.275	3	15.825	88.35%		
264	18.046	5.275	3	15.825	87.69%		

5.2.2 Average Efficiency (9V / 2A)

VIN(V)	P_{IN}(W)	V_{OUT}(V)	I_O(A)	P_{OUT}(W)	η	Average η	SPEC.
90	31.238	9.25	3	27.75	88.83%		87.3%&77.3%@10%
115	3.0446	9.02	0.3	2.706	88.88%		
	7.484	9.06	0.75	6.795	90.79%	90.64%	
	15.045	9.13	1.5	13.695	91.03%		
	22.726	9.19	2.25	20.6775	90.99%		
	30.922	9.25	3	27.75	89.74%		
230	3.173	9.022	0.3	2.7066	85.30%		
	7.569	9.06	0.75	6.795	89.77%	90.33%	
	15.152	9.125	1.5	13.6875	90.33%		
	22.825	9.19	2.25	20.6775	90.59%		
	30.626	9.25	3	27.75	90.61%		
264	30.767	9.25	3	27.75	90.19%		

5.2.3 Average Efficiency (9V / 2A)

V_{IN}(V)	P_{IN}(W)	V_{OUT}(V)	I_O(A)	P_{OUT}(W)	η	Average η	SPEC.
90	33.338	15.12	2	30.24	90.71%		87.7%&77.7%@10%
115	3.38	14.98	0.2	2.996	88.64%		
	8.2074	15	0.5	7.5	91.38%	91.54%	
	16.512	15.05	1	15.05	91.15%		
	24.648	15.087	1.5	22.6305	91.81%		
	32.948	15.125	2	30.25	91.81%		
230	3.501	14.98	0.2	2.996	85.58%		
	8.29	15	0.5	7.5	90.47%	91.04%	
	16.651	15.044	1	15.044	90.35%		
	24.727	15.087	1.5	22.6305	91.52%		
	32.944	15.125	2	30.25	91.82%		
264	33.095	15.126	2	30.252	91.41%		

5.2.4 Average Efficiency (20V / 2A)

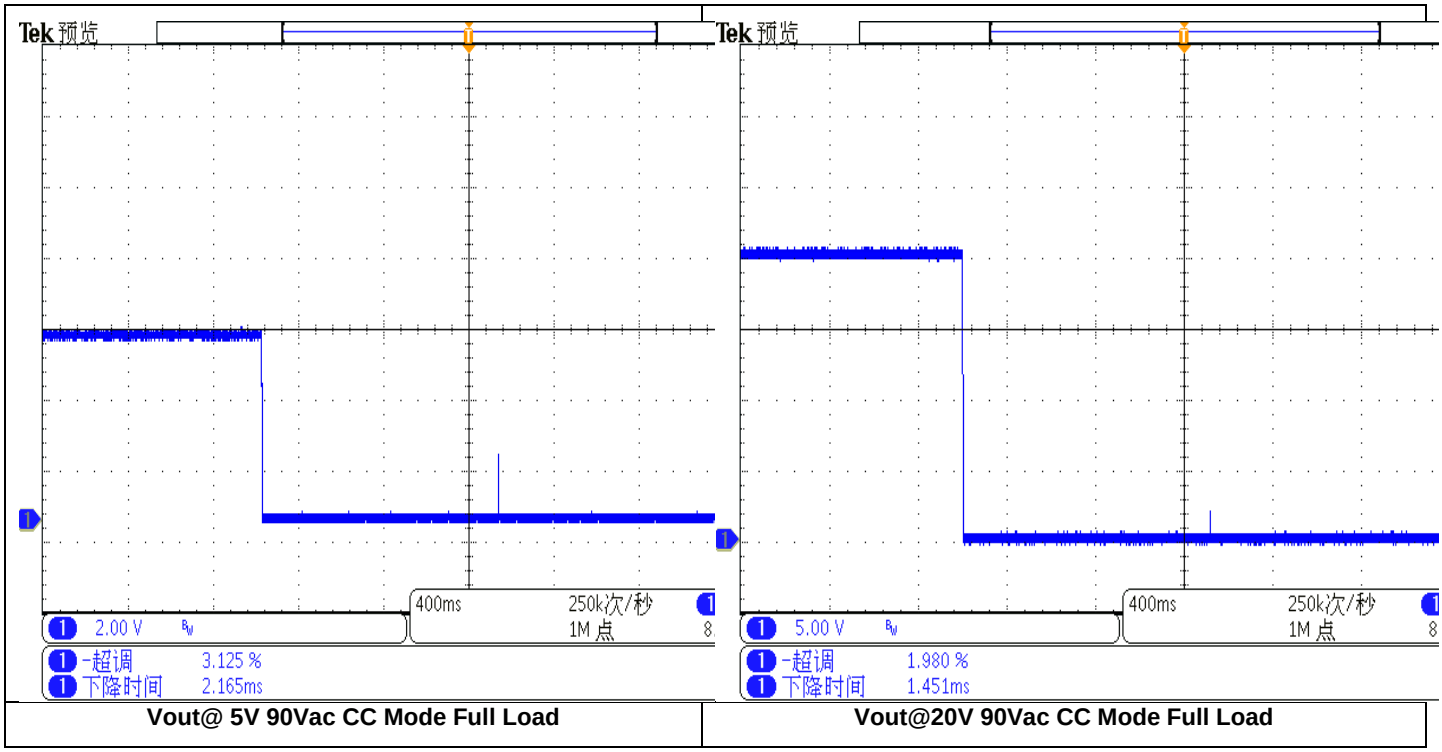
V_{IN}(V)	P_{IN}(W)	V_{OUT}(V)	I_O(A)	P_{OUT}(W)	η	Average η	SPEC.
90	33.107	20.058	1.5	30.087	90.88%		87.7%&77.7%@10%
115	3.586	19.956	0.15	2.9934	83.47%		
	8.381	19.976	0.375	7.491	89.38%	90.70%	
	16.6	20.007	0.75	15.00525	90.39%		
	24.685	20.037	1.125	22.541625	91.32%		
	32.79	20.051	1.5	30.0765	91.72%		
230	3.7	19.956	0.15	2.9934	80.90%		
	8.455	19.976	0.375	7.491	88.60%	90.45%	
	16.601	20.007	0.75	15.00525	90.39%		
	24.754	20.031	1.125	22.534875	91.04%		
	32.776	20.051	1.5	30.0765	91.76%		
264	32.933	20.051	1.5	30.0765	91.33%		

5.3 OCP Review Test

	OCP@Vo=20V	OCP@Vo=15V	OCP@Vo=9V	OCP@Vo=5V
90Vac	1.74	2.31	3.43	3.43
115Vac	1.74	2.31	3.43	3.43
230Vac	1.74	2.31	3.43	3.43
264Vac	1.74	2.31	3.43	3.43

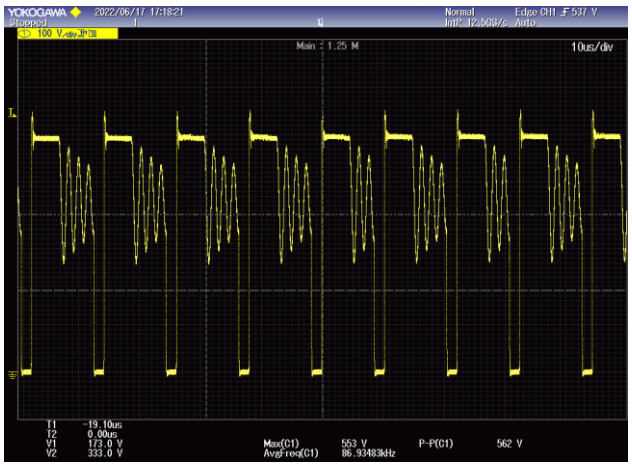
5.4 Key Performance Waveforms

5.4.1 SCP Review Test



Vout@ 5V 90Vac CC Mode Full Load	Vout@20V 90Vac CC Mode Full Load

5.4.2 Q2 & Q3 Main Switching MOSFET VDS Stress



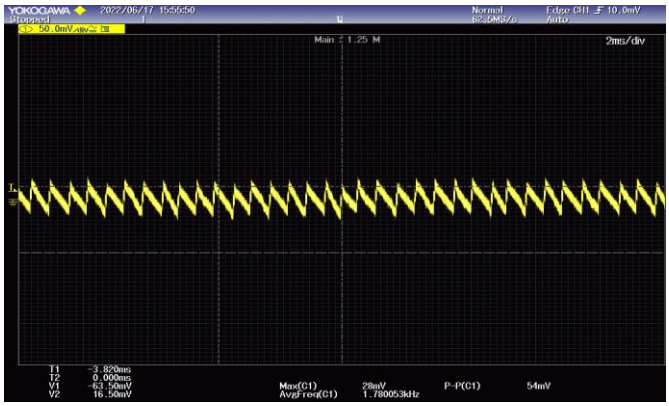
Q2 VDS(max)= 553Vp-p

at 20V/ 1.5A Loading @264Vac

Q3 VDS(max) = 76.9Vp-p

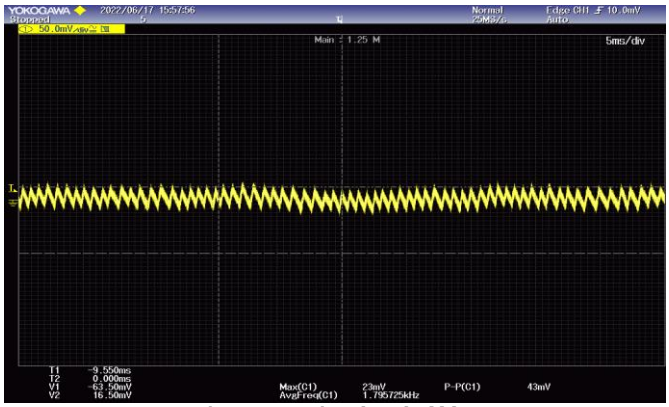
at 20V/ 1.5A Loading @264Vac

5.4.3 System Output Ripple & Noise @ Cable End

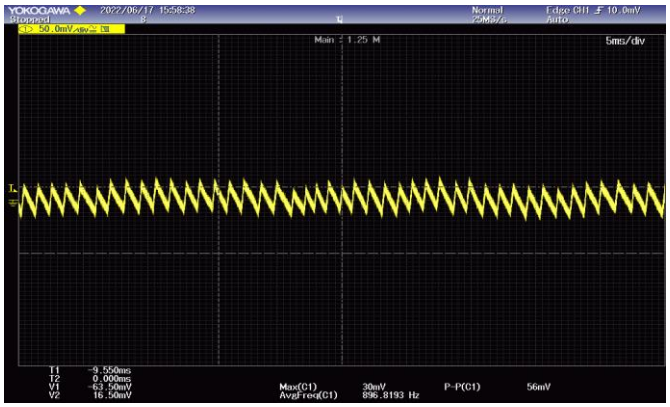


90Vac/60Hz 5V/no load ΔV=54mV

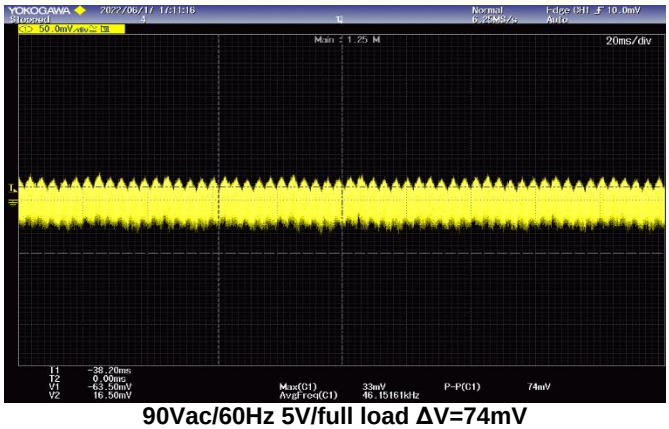
90Vac/60Hz 9V/no load ΔV=67mv



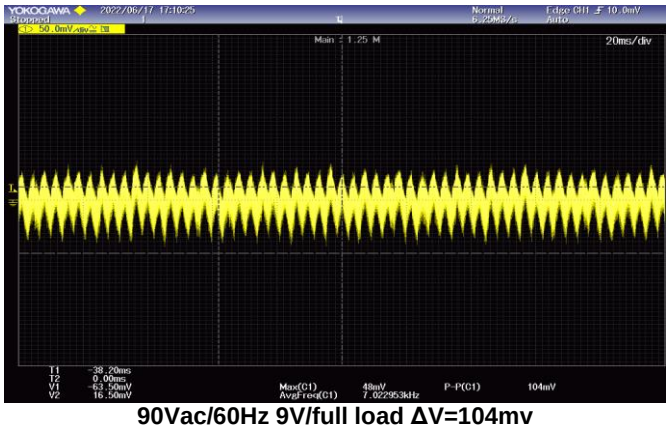
90Vac/60Hz 15V/no load ΔV=43mV



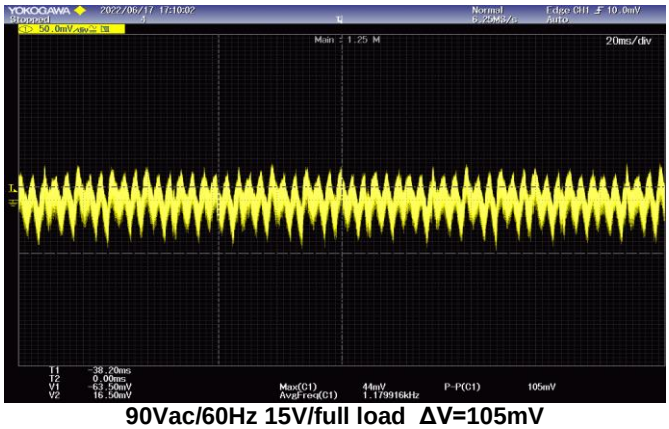
90Vac/60Hz 20V/no load ΔV=56mv



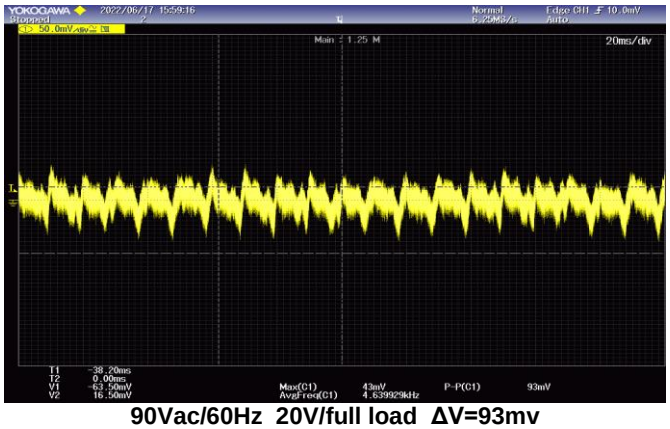
90Vac/60Hz 5V/full load ΔV=74mV



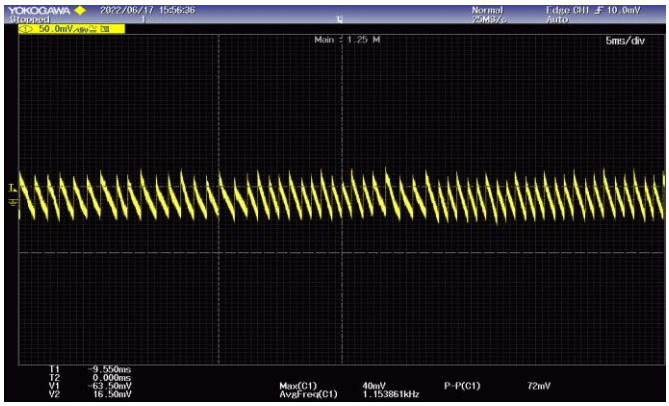
90Vac/60Hz 9V/full load ΔV=104mv



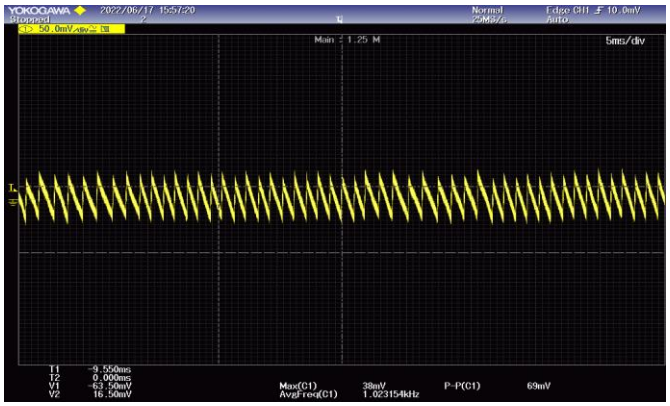
90Vac/60Hz 15V/full load ΔV=105mV



90Vac/60Hz 20V/full load ΔV=93mv



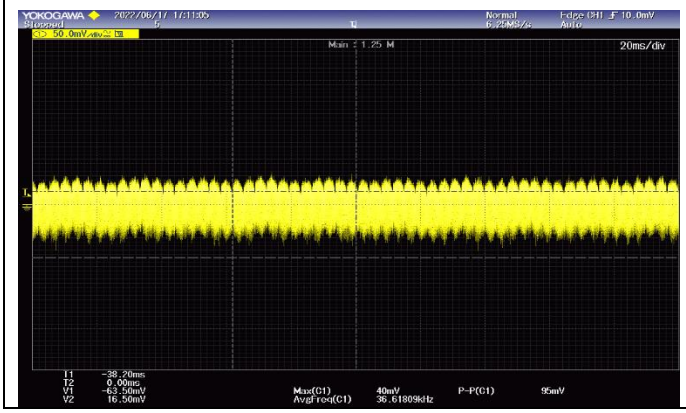
264Vac/50Hz 5V/no load ΔV=72mV

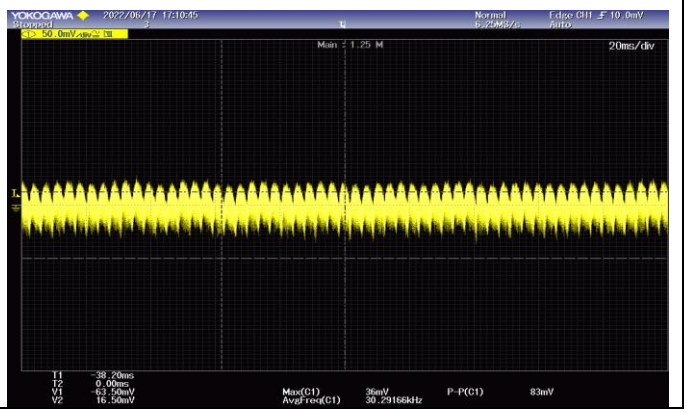


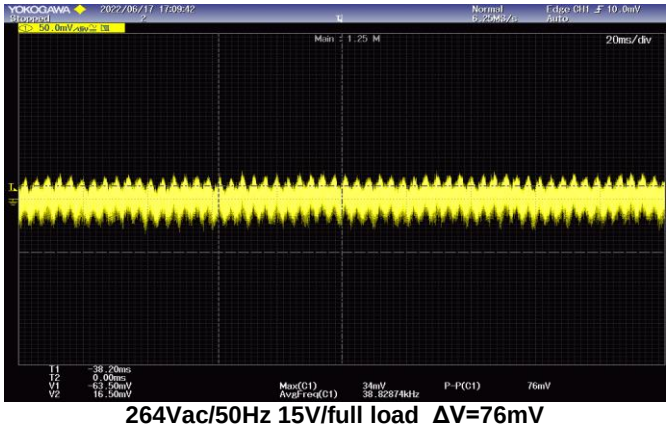
264Vac/50Hz 9V/no load ΔV=69mv

264Vac/50Hz 15V/no load ΔV=59mV

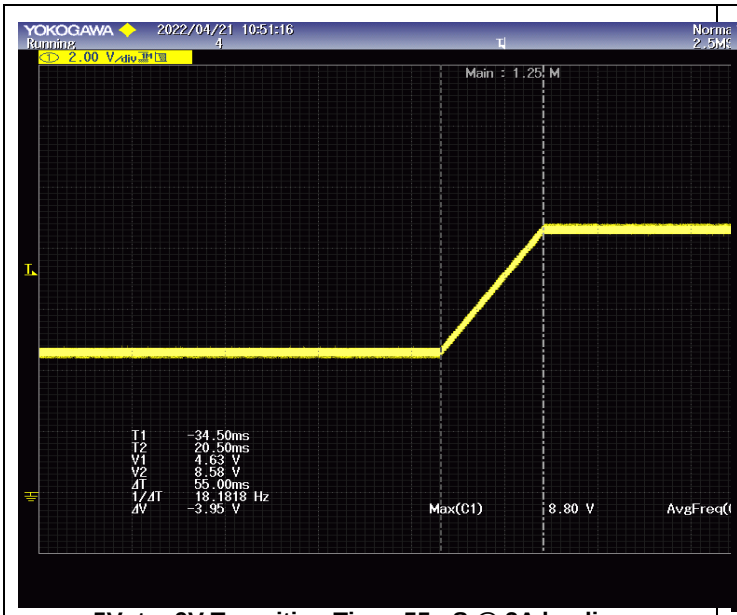
264Vac/50Hz 20V/no load ΔV=63mv



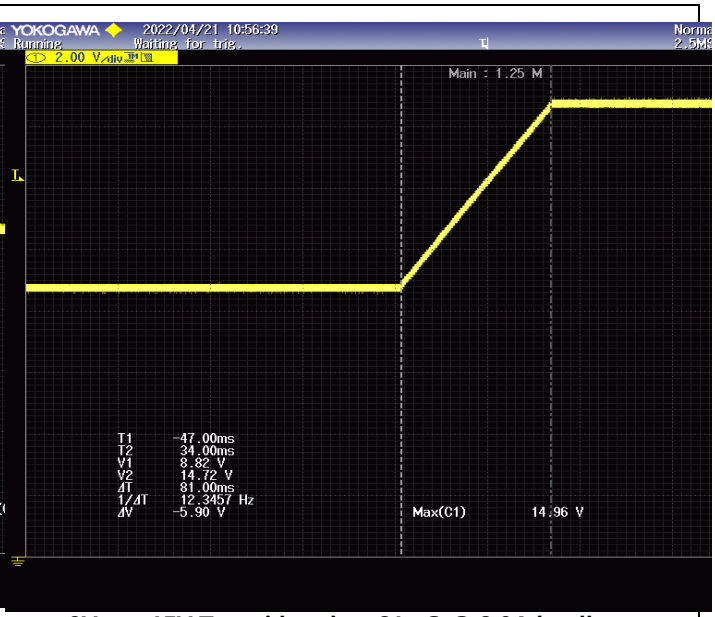


264Vac/50Hz 5V/full load ΔV=95mV	264Vac/50Hz 9V/full load ΔV=83mv
	
264Vac/50Hz 15V/full load ΔV=76mV	264Vac/50Hz 20V/full load ΔV=75mv

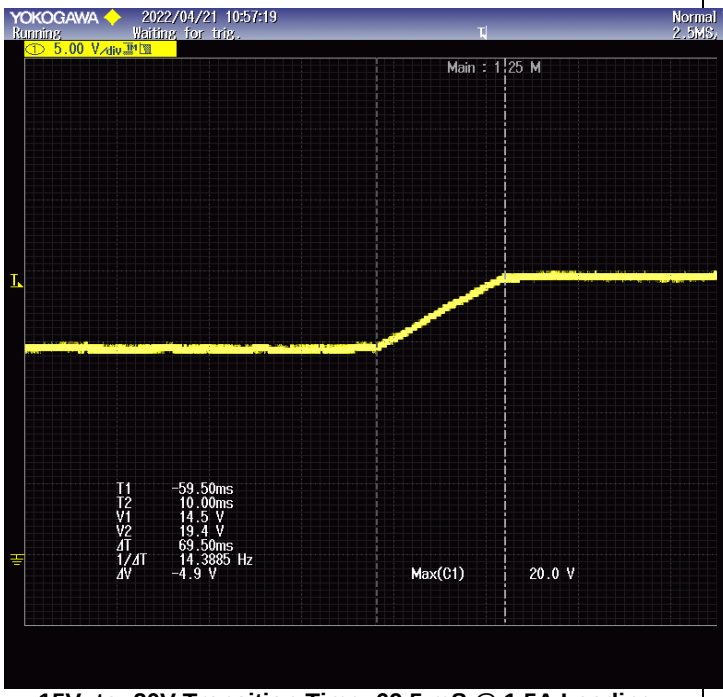
5.4.4 Output Voltage Transition Time



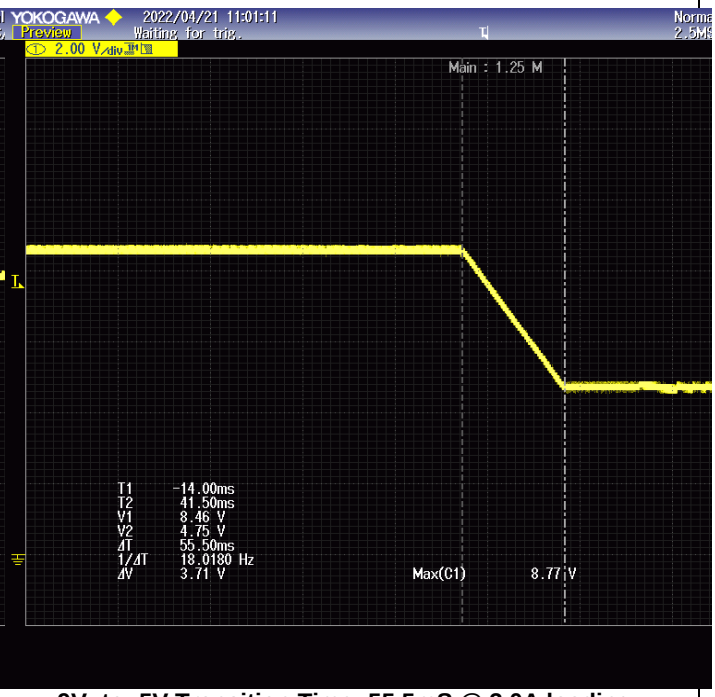
5V -to- 9V Transition Time: 55mS @ 3A loading



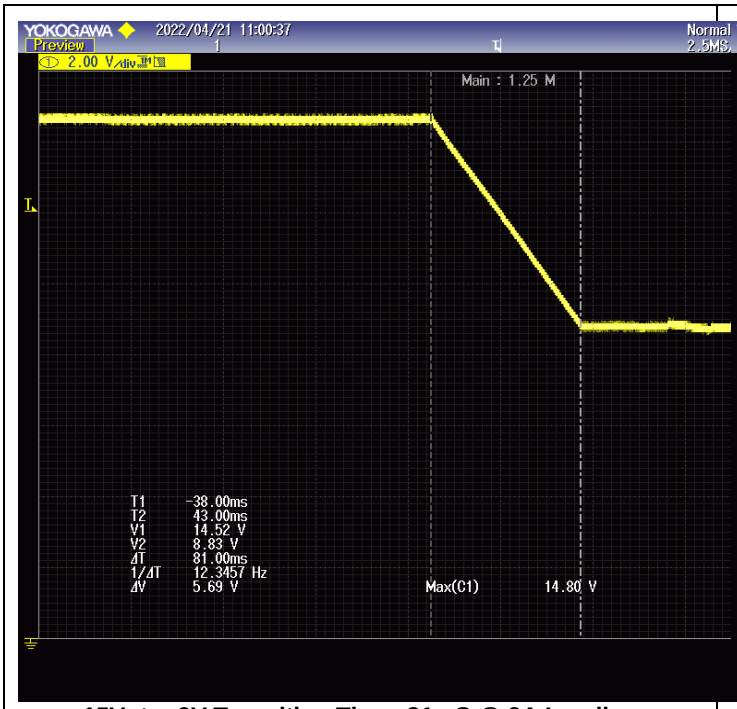
9V -to- 15V Transition time 81mS @ 2.0A loading



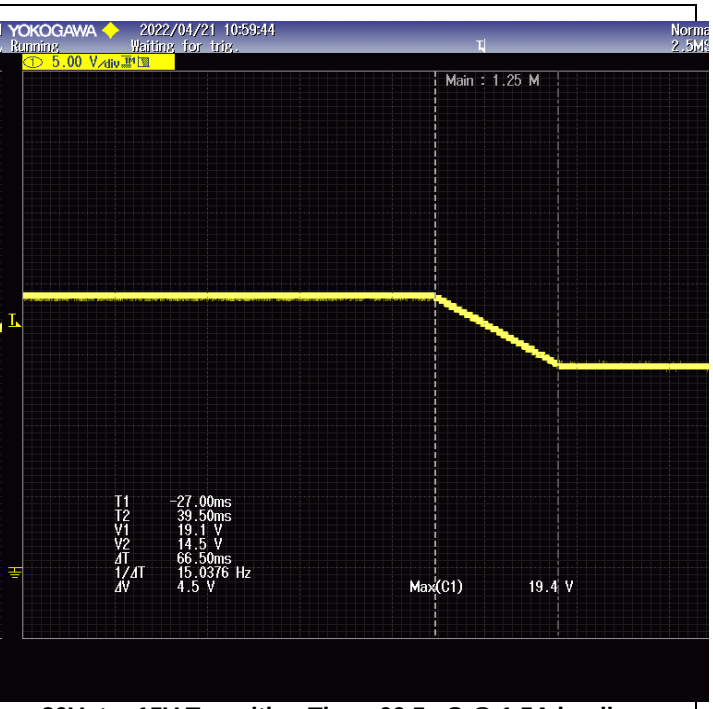
15V -to- 20V Transition Time: 69.5 mS @ 1.5A Loading



9V -to- 5V Transition Time: 55.5mS @ 3.0A loading



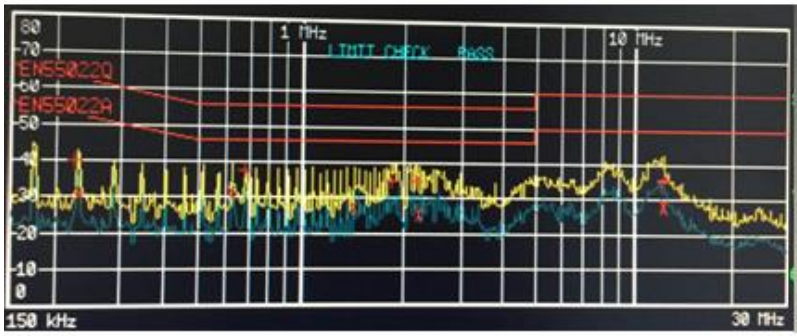
15V -to- 9V Transition Time: 81mS @ 2A Loading



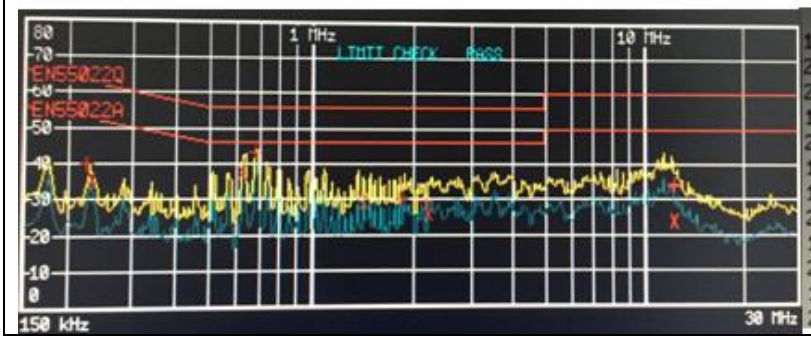
20V -to- 15V Transition Time: 66.5mS @ 1.5A loading

5.4.5 EMI (Conduction) Test

115Vac/60Hz 20V/1.5A

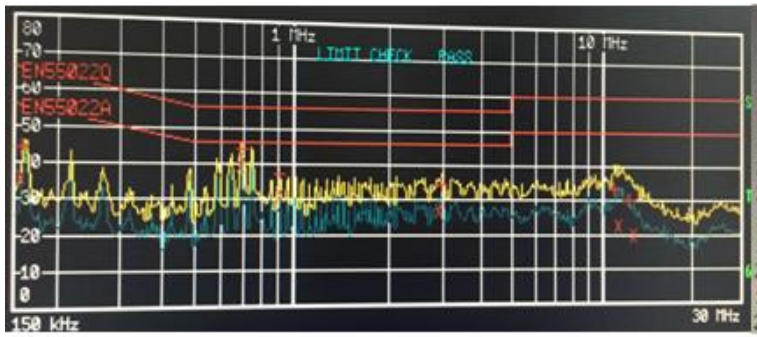


TRACE		FREQUENCY	LEVEL dBµV	DELTA
1	Quasi Peak	226 kHz	40.17	-22.41
2	Average	230 kHz	30.52	-21.92
2	Average	626 kHz	31.19	-14.80
1	Quasi Peak	678 kHz	37.57	-18.42
2	Average	1.426 MHz	27.21	-18.78
1	Quasi Peak	1.838 MHz	35.06	-20.94
1	Quasi Peak	2.182 MHz	35.06	-20.93
2	Average	2.226 MHz	25.46	-20.54
1	Quasi Peak	12.382 MHz	35.90	-24.09
2	Average	12.382 MHz	28.35	-21.64
1	Quasi Peak	12.41 MHz	35.48	-24.51
2	Average	12.41 MHz	27.84	-22.15

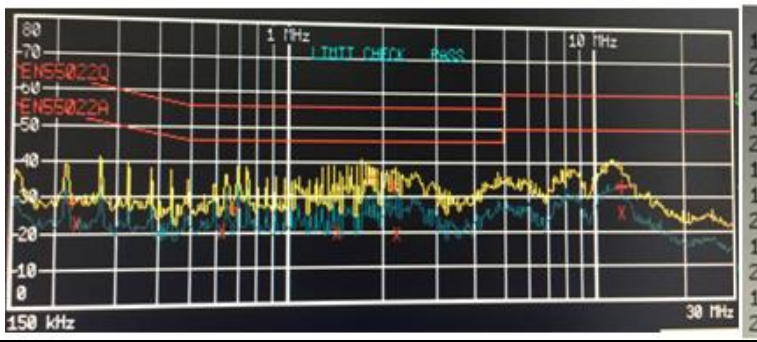


TRACE		FREQUENCY	LEVEL dBµV	DELTA
1	Quasi Peak	226 kHz	40.09	-22.49
2	Average	230 kHz	35.16	-17.28
2	Average	626 kHz	37.64	-8.35
1	Quasi Peak	678 kHz	43.29	-12.70
2	Average	1.426 MHz	29.41	-16.58
1	Quasi Peak	1.838 MHz	30.08	-25.91
1	Quasi Peak	2.182 MHz	29.78	-26.21
2	Average	2.226 MHz	26.01	-19.98
1	Quasi Peak	12.382 MHz	33.71	-26.29
2	Average	12.382 MHz	23.85	-26.14
1	Quasi Peak	12.41 MHz	34.15	-25.84
2	Average	12.41 MHz	24.15	-25.85

230Vac/50Hz 20V/1.5A



TRACE		FREQUENCY	LEVEL dBµV	DELTA
1	Quasi Peak	158 kHz	44.19	-21.37
2	Average	158 kHz	35.88	-19.68
2	Average	686 kHz	39.57	-6.42
1	Quasi Peak	690 kHz	44.32	-11.67
1	Quasi Peak	906 kHz	37.30	-18.69
2	Average	906 kHz	31.14	-14.85
2	Average	2.918 MHz	27.13	-18.86
1	Quasi Peak	2.982 MHz	34.20	-21.79
1	Quasi Peak	11.066 MHz	33.62	-26.37
2	Average	11.45 MHz	22.91	-27.08
1	Quasi Peak	12.426 MHz	30.27	-29.73
2	Average	12.81 MHz	19.72	-30.27



TRACE		FREQUENCY	LEVEL dBµV	DELTA
1	Quasi Peak	226 kHz	28.66	-33.93
2	Average	230 kHz	22.87	-29.57
2	Average	626 kHz	20.16	-25.83
1	Quasi Peak	678 kHz	26.95	-29.05
2	Average	1.426 MHz	20.08	-25.91
1	Quasi Peak	1.838 MHz	35.68	-20.31
1	Quasi Peak	2.182 MHz	33.12	-22.87
2	Average	2.226 MHz	19.41	-26.58
1	Quasi Peak	12.382 MHz	33.33	-26.66
2	Average	12.382 MHz	25.29	-24.70
1	Quasi Peak	12.41 MHz	33.01	-26.98
2	Average	12.41 MHz	25.57	-24.42

5.5 Thermal Test

Location	90V/AC (℃)	264V/AC (℃)	T_{max} (℃)	SPEC(℃)
DB1	107.6	82.4	107.6	<120
Q2	114.8	108.4	114.8	<120
EC1	91.2	78.3	91.2	<105
T-Core	101	99.6	101	<110
T-Wire	93.4	91.8	93.4	<110
Q3(SR MOS)	87	95.1	95.1	<120
Tc（Max.）	69.8	64.1	69.8	<75
Ambient temperature	24.8	24.8	24.8	25

Chapter 6. Revision Control

Revision table

Revision	Items Changed & added	The changing reason
1.0	Release	

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