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Chapter 1 Summary

1.1 General Description

The 45W Evaluation Board (EVb) is composed of the controller AP3190T.

The AP3190T is a high performance offline PSR AC/DC power supply controller. It is specially designed for applications that require higher efficiency at light load and is cost effective.

Using the multi-mode control scheme, the AP3190T can also achieve high conversion efficiency with full load conditions. At heavy load and low line, the AP3190T will operate in QR mode to achieve high performance. When the load decreases, it will enter into fixed switching frequency operating mode. To optimize product performance, the fixed frequency is different in high (60kHz) and low line (80kHz).

1.2 Key Features

1.2.1 System Key Features

- Primary Side Control for Eliminating Opto-Coupler
- Low standby power (<65mW)
- Multiple QR/AM Mode to Improve Audio Noise and Efficiency

1.2.2 AP3190T Key Features

- Primary Side Control for Eliminating Opto-Coupler
- 65mW No-Load Input Power
- Adjustable Overtemperature Protection
- Multiple QR/AM Mode to Improve Audio Noise and Efficiency
- QR for Higher Efficiency and Better EMI
- Totally Lead-Free & Fully RoHS Compliant

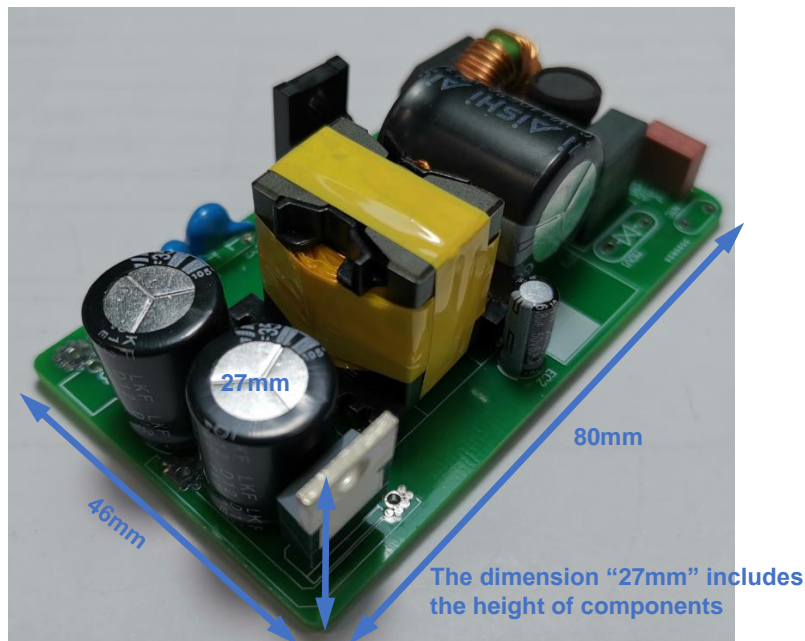
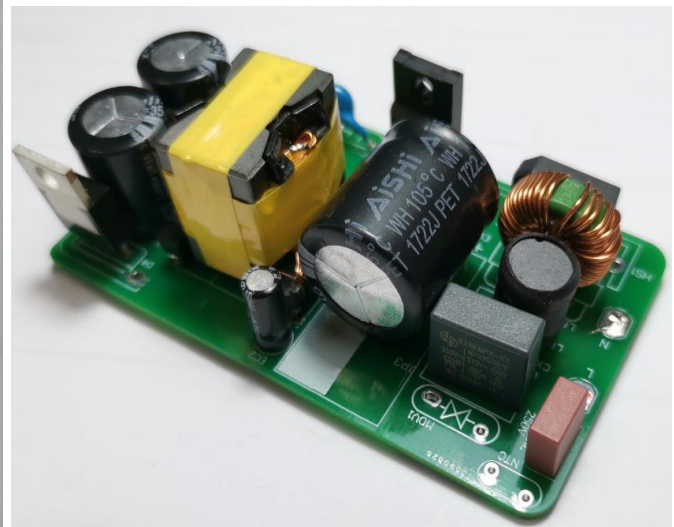
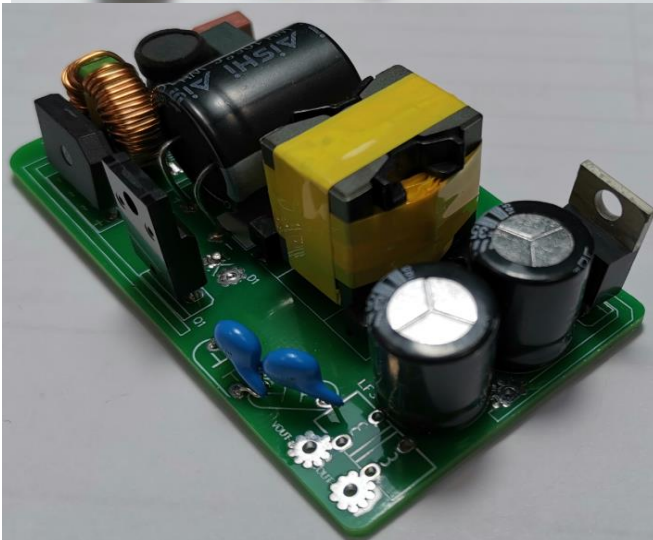
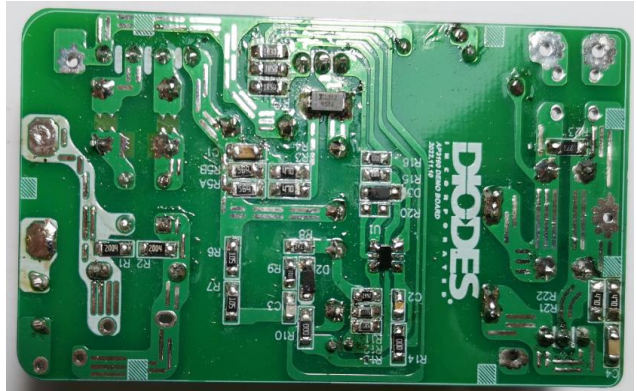
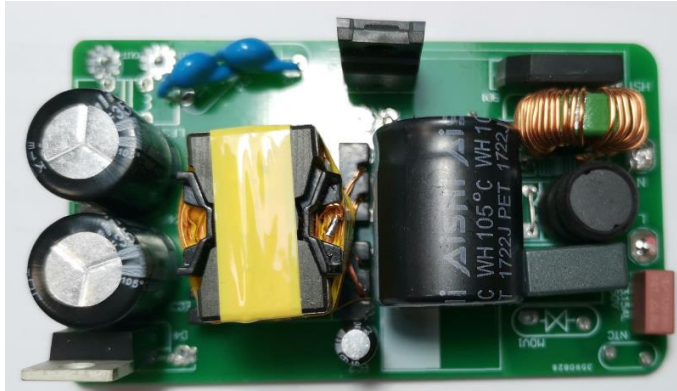
1.3 Applications

- Power Tools
- Set-Top Box Power Supplies
- Network Adaptors

1.4 Main Power Specifications

Parameter	Value
Input Voltage	90V _{AC} to 264V _{AC}
Input standby power	< 100mW
Main Output (V _o / I _o)	22.5V/2A
Efficiency	90.09%@230V _{in} ; 90.04%@115V _{in}
Total Output Power	45W
Protections	OCP, OVP, UVP, OLP, OTP, SCP
Dimensions	PCB: 46 * 80 * 27 mm ³ , 1.81" * 3.15" * 1.06" inch ³
Power Density Index	0.453 W/CC; 7.446 W/CI
EMI	Min. margin 6.24Db@ >6dB

1.5 Evaluation Board Picture



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	< 100mW, load disconnected	PASS , 86.5mW@230V _{AC} /50Hz
22.5V/2A Efficiency	CoC Version 5, Tier-2 Efficiency >88.85%	PASS 90.04%@115V _{AC} /60Hz 90.09%@230V _{AC} /50Hz
Output Voltage Regulation Tolerance	+/- 5%	PASS
Conducted EMI	>6dB Margin; according to EN55032 Class B	Min. margin 6.24dB
Output Voltage Start time	2.84s	@90Vac , 22.5V/2A load

Chapter 3 Schematics

3.1 Board Schematics

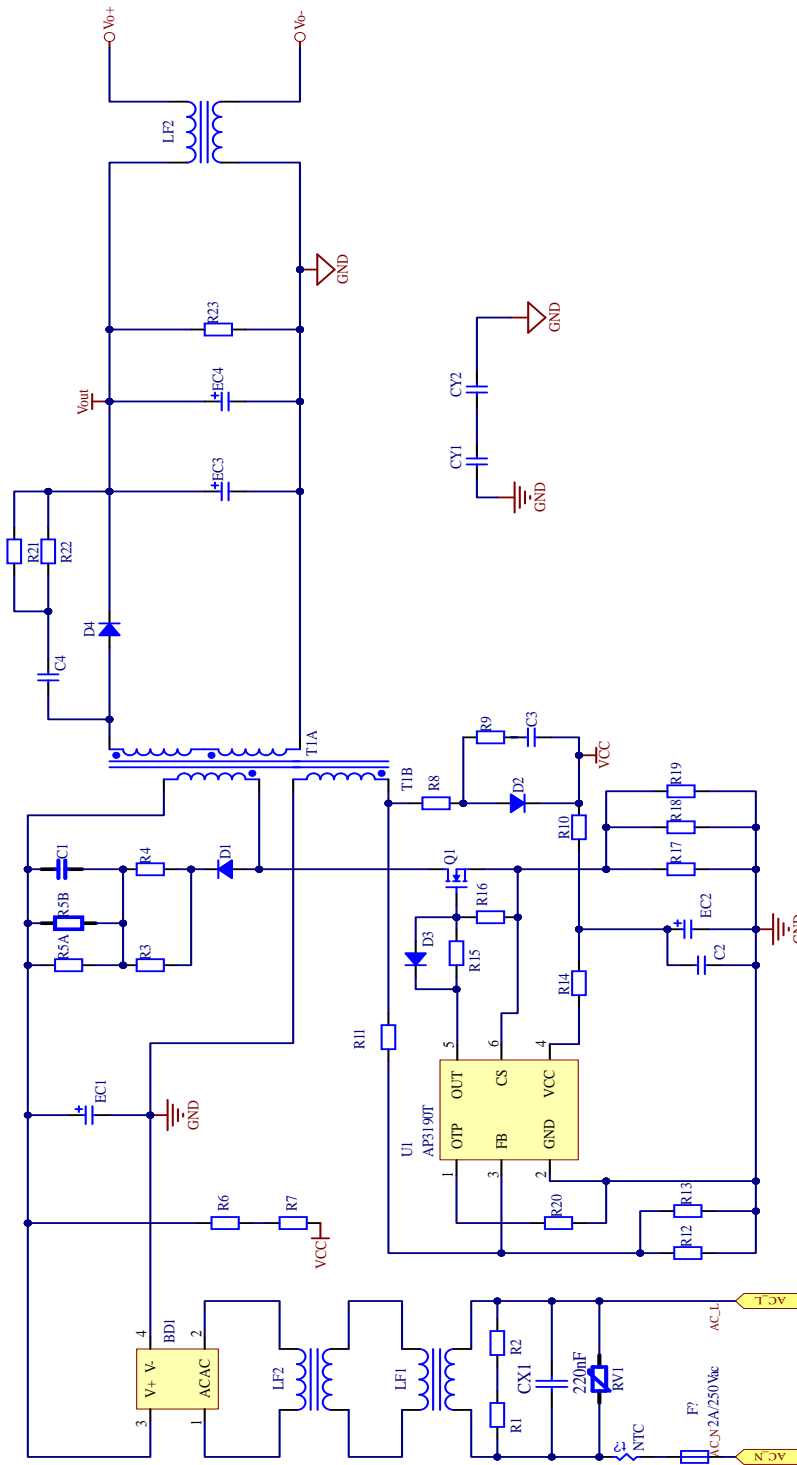
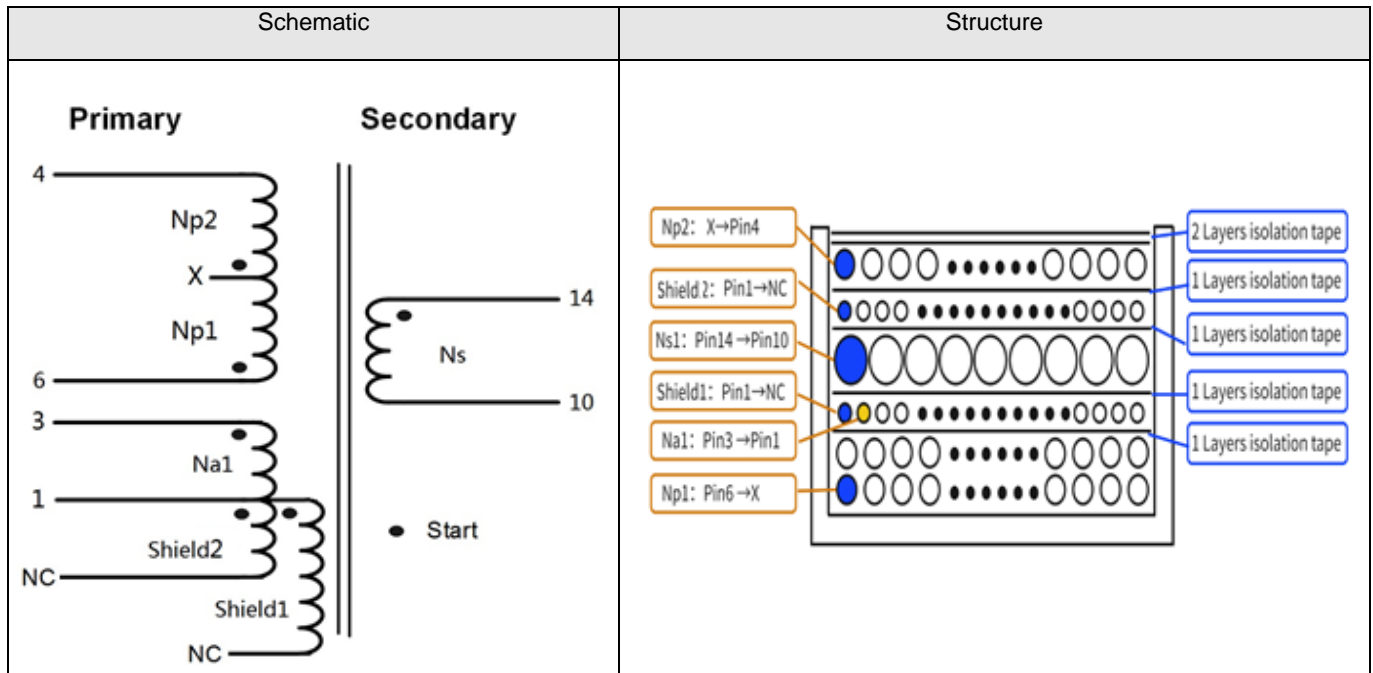


Figure 1. 45W EVB Schematics

3.2 Bill of Material (BOM)

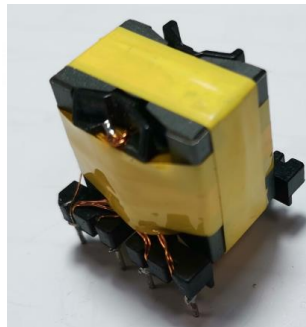
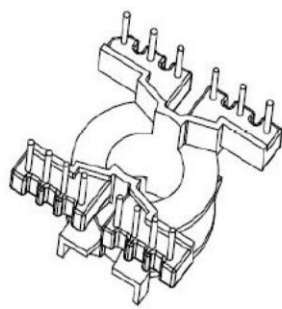
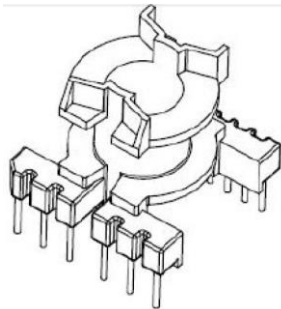
Item	Quantity	Reference	Description	Manufacturer Part Number	Manufacturer
1	1	BD1	Diode Bridge, 600V, 4A	KBP406G	SK
2	1	C1	MLCC, 1206, K, X7R	1nF/1KV	muRata
3	1	C2	MLCC, 0805, K, X7R	100nF/50V	muRata
4	1	C4	MLCC, 1206, K, X7R	1000pF/250V	muRata
5	1	CX1	X2, 224KMPX, 275V	224K, 275V	muRata
6	2	CY1, CY2	Capacitor, K, P10	1nF, K, Y1	JNC
7	1	D1	Fast Recovery Rectifiers, 1000V, 1A	RS1J	Diodes Incorporated (Diodes)
8	1	D2	Surface Mount Fast Recovery Rectifier, 1000V, 1A	F7	Diodes
9	1	D3	Surface Mount Fast Switching Diode, 100V, 2A	1N4148W	Diodes
10	1	D4	Super Barrier Rectifier, 150V, 20A	SBR30150CTFP	Diodes
11	1	EC1	Electrolytics Capacitors, D18XL20mm, P7.5	68μ/400V, M	AISHI
12	1	EC2	Electrolytics Capacitors, D5XL11mm, P2.0	6.8μ/50V	AISHI
13	2	EC3, EC4	Electrolytics Capacitors, D10XL16mm, P5.0	560μ/35V	AISHI
14	1	F1	Time lag Fuse, P5.0	T3.15A/300V	JDT fuse
15	1	LF1	DM Inductor, 9X12, $\phi=0.5$, 100μH	100μH	SANCI
16	1	LF2	Common Mode Inductor, T14X9X5, 7.5mH	7.5mH	SANCI
17	1	Q1	N-Channel MOSFET	STF13N65M2	CRHJ micro
18	4	R3, R4, R21, R22	Resistor, 1206, J	47R	fenghua
19	2	R5A, R5B	Resistor, 1206, J	560k	fenghua
20	1	R6	Resistor, 1206, J	1M	fenghua
21	1	R7	Resistor, 1206, J	2M	fenghua
22	1	R8	Resistor, 1206, J	2R	fenghua
23	2	R10, R14	Resistor, 1206, J	0R	fenghua
24	2	R17, R18	Resistor, 1206, J	1.5R	fenghua
25	1	R19	Resistor, 1206, J	1.3R	fenghua
26	1	R11	Resistor, 0805, J	24.9K	fenghua
27	1	R12	Resistor, 0805, J	51K	fenghua
28	1	R13	Resistor, 0805, J	4.3K	fenghua
29	1	R15	Resistor, 0805, J	20R	fenghua
30	1	R16	Resistor, 0805, J	10K	fenghua
31	2	R1, R2	Resistor, 1206, J	2M	fenghua
32	NC	R20	Resistor, 0805, J		
33	1	R23	Resistor, 1206, J	27k	fenghua
34	NC	RV1			
35	1	U1		AP3190T	Diodes
36	1	T1	45/9/8, Lp=400μH	PQ2020	

3.3 Transformer Design



Definition	Pin define (Start >> End)	Wire (φ)	No. of Turns	Layers	Layers of Tape
Np1	6 → X	φ0.35*2	30T	IN PARALLEL	1 L
Na1	3 → 1(GND)	φ0.15*2	8T		1 L
Shield1	1 → NC	φ0.15*2	8T		1 L
Ns	14 → 10	φ0.30*7(Triple Insulated Wire)	9T	1	1 L
Shield2	1 → NC	φ0.15*2	32T	1	1 L
Np2	X → 4	φ0.35*2	15T	1	2L

BOBBIN PIN Define:



Item	Test Condition	Rating
Primary Inductance	Pin 6-4, all other windings open, measured at 100kHz / 1V	400μH±-5%
Note	Bobbin: PQ2020 Core: PQ2020	

3.4 Schematics Description

3.4.1 AC Input Circuit & Differential Filter

The Fuse F1 protects against overcurrent conditions which occur when some main components fail. The LF1 is a differential mode chock for the Differential mode noise suppression. The LF2 is a common mode chock for the common mode noise suppression. The BD1 is a bridge rectifier which converts alternating current and voltage into direct current and voltage.

3.4.2 AP3190T PWM Controller

The AP3190T is a high performance offline PSR AC/DC power supply controller. It is specially designed for applications that require higher efficiency at light load and is cost effective.

Chapter 4 The Evaluation Board (EVb) Layout

4.1 EVb PCB Layout

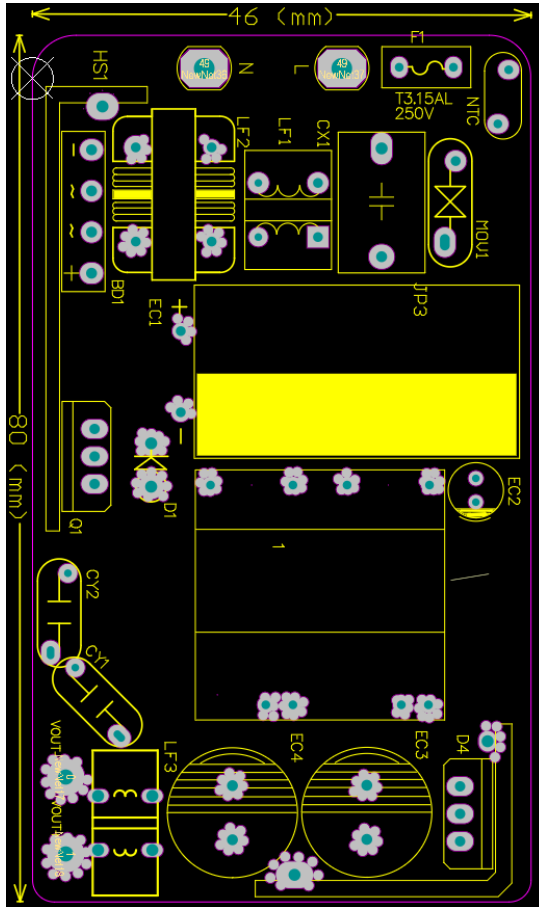


Figure 2. PCB Layout Top View

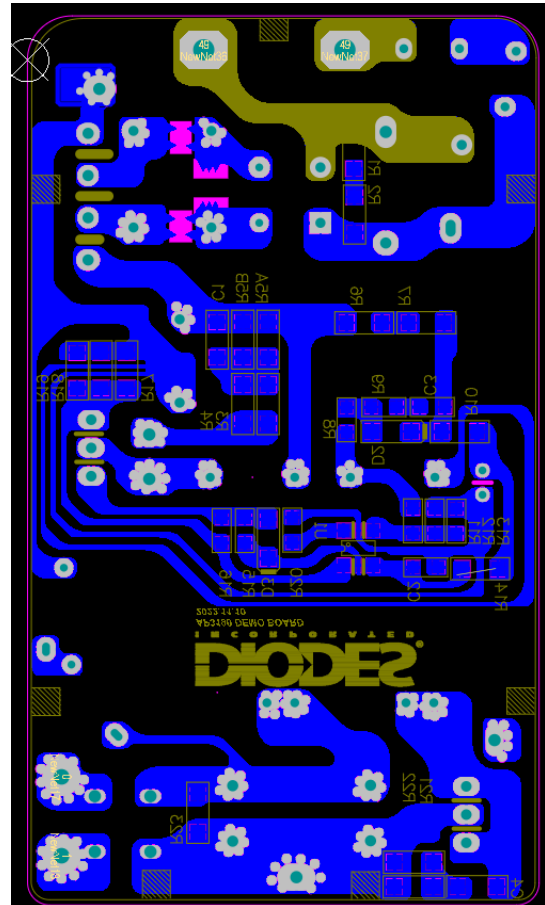


Figure 3. PCB Layout Bottom View

Chapter 5 Testing the Evaluation Board

5.1 Input & Output Characteristics

5.1.1 Input Standby Power

Vin(Vac)	Pin(mW)
90V/60Hz	40.3
115/60Hz	48.3
230/50Hz	86.5

5.1.2 Output Full Load Efficiency at Different AC Line Input Voltage

Vin(Vac)	Pin(W)	Vout(V)	Iout(A)	Eff(%)
90	50.74	22.43	2.00	88.43
115	49.78	22.44	2.00	90.20
230	49.56	22.49	2.00	90.78
264	49.72	22.48	2.00	90.46

Efficiency vs. AC Line At Board End

5.1.3 Output Average Efficiency at Different Loading

AC input	Efficiency(%)					Eff_avg at four conditions
	10% load	25% load	50% load	75% load	100% load	
115Vac	88.09	89.71	89.98	90.27	90.20	90.04
230Vac	84.65	89.13	90.05	90.40	90.78	90.09

Efficiency vs. different load vs. Line At Board End

5.2 Key Performance Waveforms

5.2.1 System Start-up Time

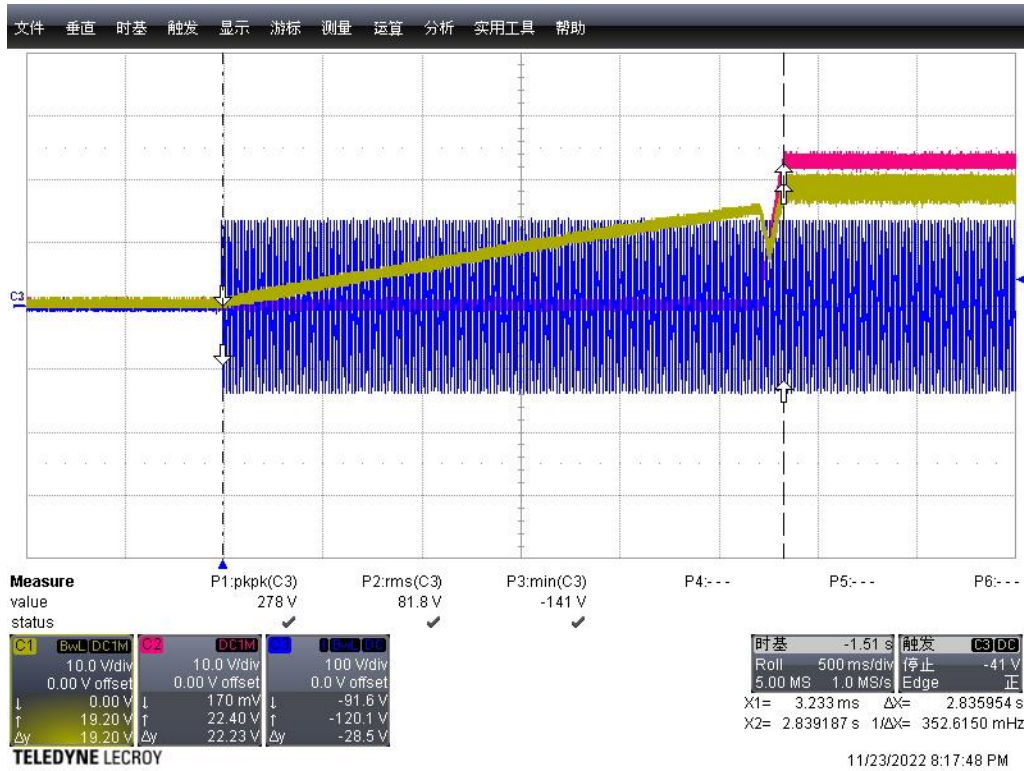


Figure 4. Turn on time is 2.84s at Full Load @ 90Vac

5.2.2 Q1/D4 MOSFET/Diode Voltage Stress at Full Load @264Vac

Primary side MOSFET: Q1

Secondary side diode: D4

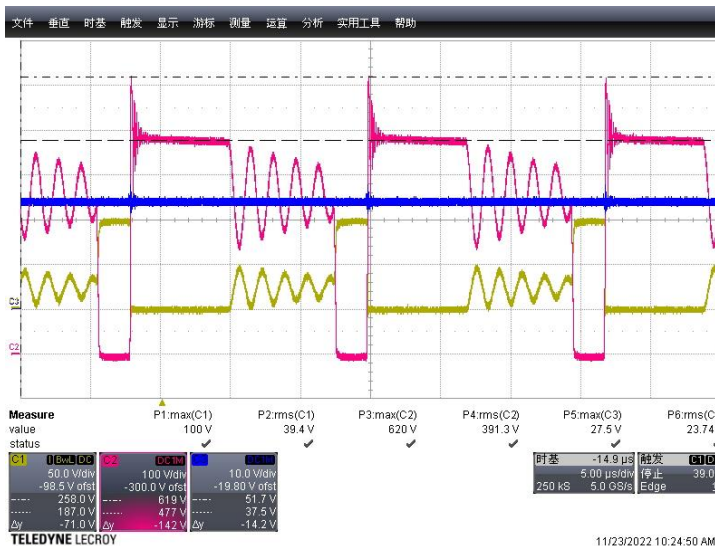


Figure 5. Q1 & D4 Vds Voltage stress

Component	Vout	Vds	Vds_Max_Spec	Ratio of voltage stress
Q1	22.5V	642V	710V	90.4%
D4		102V	150V	68%

5.2.3 System Output Ripple & Noise with the Cable

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

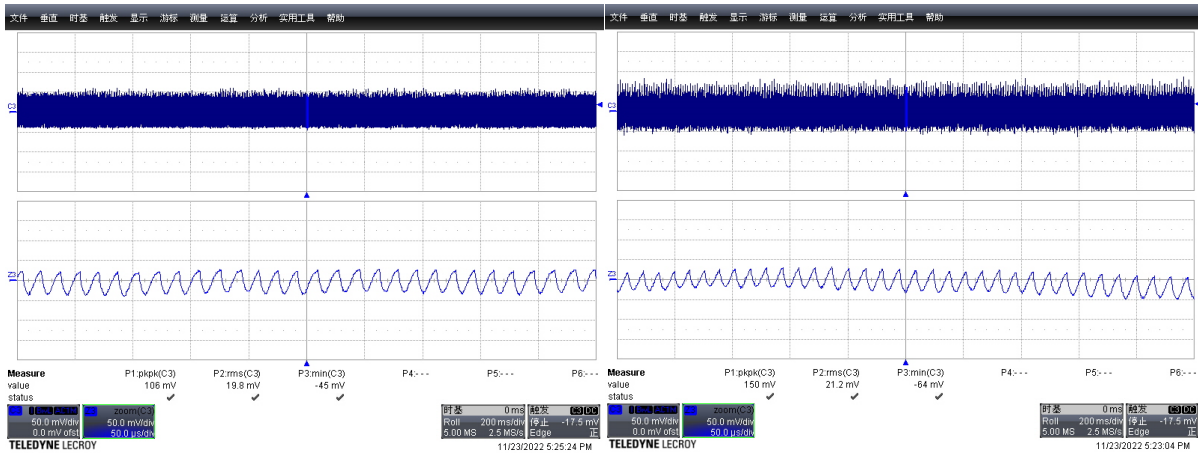


Figure 6. 90Vac/60Hz@22.5V/2A, ΔV=106mV

Figure 7. 264Vac/50Hz@22.5V/2A, ΔV=150mV

5.2.4 Dynamic load ----10% Load~90% Load, T=20mS, Rate=100mA/μS

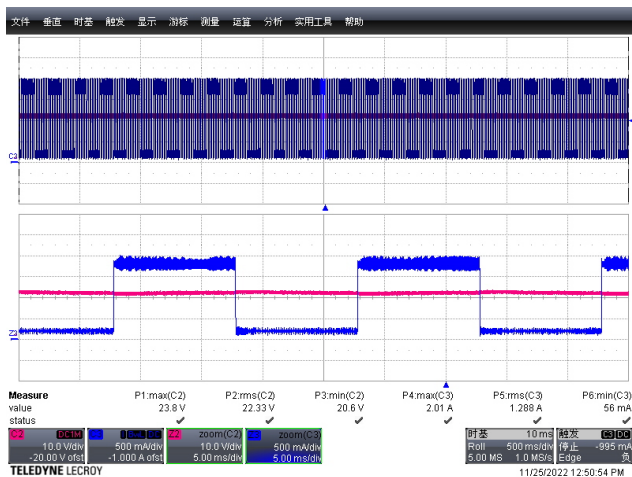


Figure 8. 90Vac/60Hz @ Vout=22.5V 20.6V~23.8V

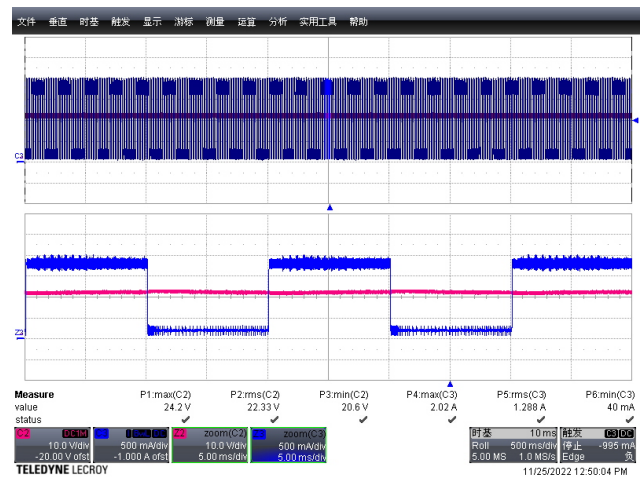


Figure 9. 264Vac/50Hz @ Vout=22.5V 20.6V~24.2V

5.2.5 Thermal Testing

Test Condition: Vin=90Vac @22.5V-2A

	Primary MOSFET	Transformer(T1)	Diode Bridge	Super Barrier Rectifier(D4)	Ambient Temp.
90Vac/60Hz	89.7°	89.8°	83.2°	99.7°	25°
264Vac/50Hz	81.6°	79°	65.6°	100°	25°

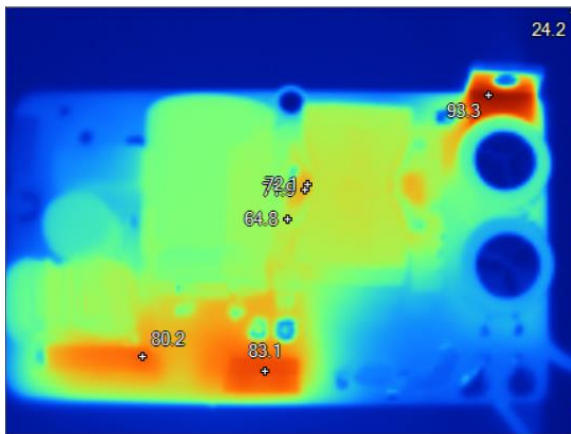


Figure 10. Top Surface Mount side@90Vac

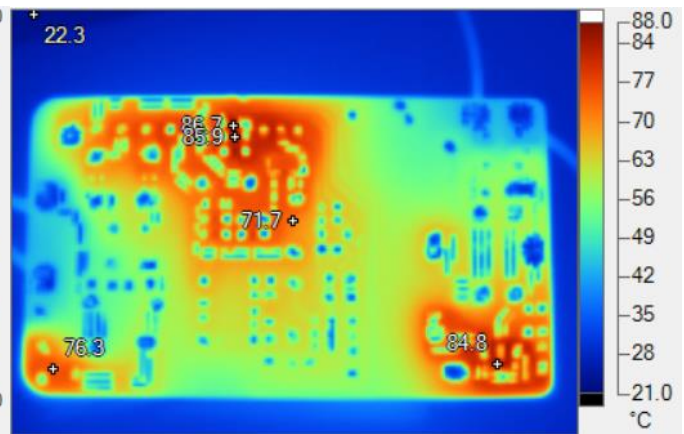


Figure 11. Bottom Surface Mount side@90Vac

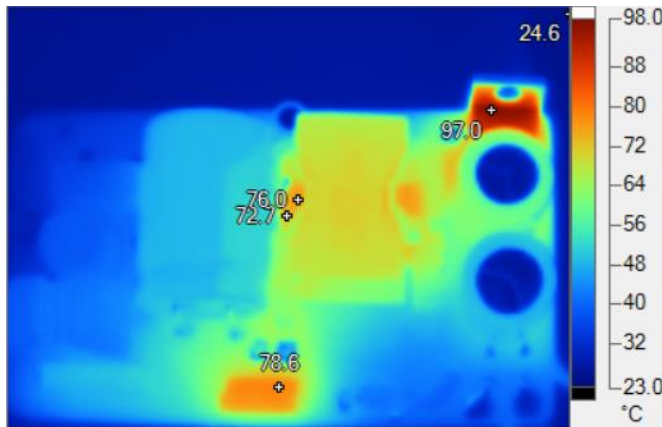


Figure 12. Top Surface Mount side@264Vac

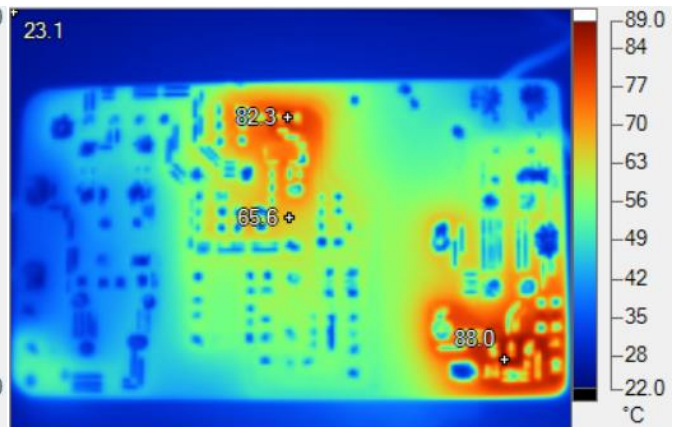
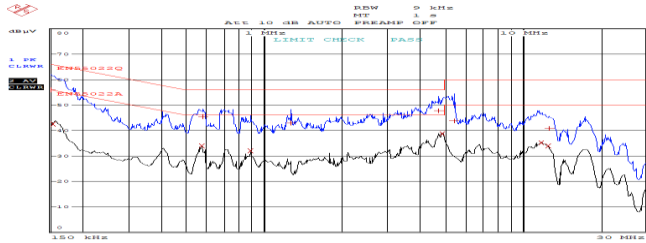


Figure 13. Bottom Surface Mount side@264Vac

- Note:**
- 1) Component temperature can be further optimized with various system design and thermal management approaches by manufacturers.
 - 2) The data has been revised according to the Ta=25C.

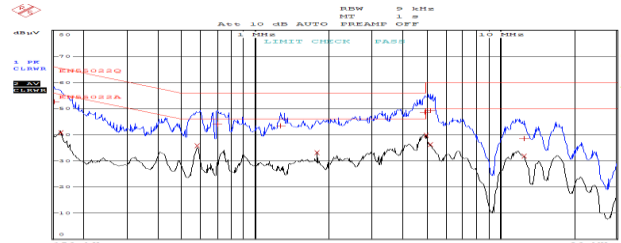
5.3 EMI (Conduction) Testing

Output Condition : 22.5V/2A



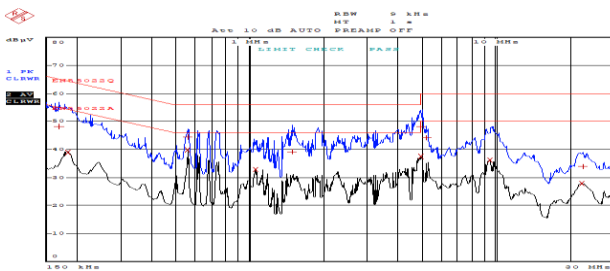
EDIT PEAK LIST (Final Measurement Results)				
Trace1: EN55022Q				
Trace2: EN55022A				
Trace3: ---				
TRACE	FREQUENCY	LEVEL dBμV	DELTA LIMIT dB	
1 Quasi Peak	150 kHz	56.04	-9.95	
2 Average	154.54515 kHz	42.62	-13.13	
2 Average	569.056444353 kHz	33.89	-12.10	
1 Quasi Peak	574.747008797 kHz	45.47	-10.52	
2 Average	881.64914842 kHz	32.02	-13.97	
1 Quasi Peak	1.26143607964 MHz	43.02	-12.97	
1 Quasi Peak	4.6912285087 MHz	47.75	-9.24	
2 Average	4.93337742374 MHz	38.80	-7.19	
1 Quasi Peak	5.39244619915 MHz	43.75	-16.24	
2 Average	11.7179960284 MHz	35.18	-14.81	
2 Average	12.4388782936 MHz	34.01	-15.99	
1 Quasi Peak	12.5632670765 MHz	40.77	-19.22	

Figure 14. 115Vac/60Hz L line



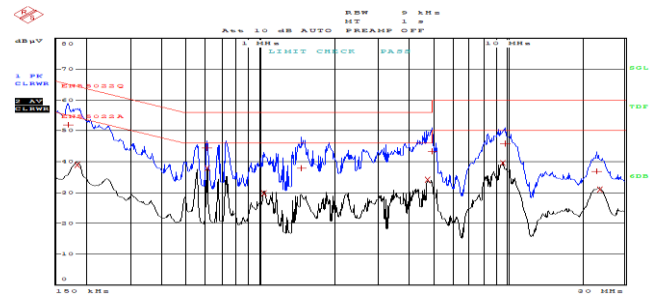
EDIT PEAK LIST (Final Measurement Results)				
Trace1: EN55022Q				
Trace2: EN55022A				
Trace3: ---				
TRACE	FREQUENCY	LEVEL dBμV	DELTA LIMIT dB	
1 Quasi Peak	151.5 kHz	52.67	-13.24	
2 Average	159.22602259 kHz	40.83	-14.67	
2 Average	574.747008797 kHz	35.80	-10.19	
1 Quasi Peak	701.300575623 kHz	43.88	-12.11	
1 Quasi Peak	1.26143607964 MHz	43.44	-12.55	
2 Average	1.76926121483 MHz	33.00	-12.99	
1 Quasi Peak	4.88171119798 MHz	48.69	-7.30	
2 Average	4.93052830996 MHz	39.82	-6.17	
1 Quasi Peak	5.18203480607 MHz	45.19	-10.60	
2 Average	5.18203480607 MHz	36.24	-13.75	
1 Quasi Peak	12.4388782936 MHz	38.62	-21.37	
2 Average	12.4388782936 MHz	31.80	-15.19	

Figure 15. 115Vac/60Hz N line



EDIT PEAK LIST (Final Measurement Results)				
Trace1: EN55022Q				
Trace2: EN55022A				
Trace3: ---				
TRACE	FREQUENCY	LEVEL dBμV	DELTA LIMIT dB	
1 Quasi Peak	167.350252 kHz	48.20	-16.09	
2 Average	181.216843567 kHz	38.91	-15.51	
1 Quasi Peak	557.843784289 kHz	44.35	-11.64	
2 Average	557.843784289 kHz	39.75	-6.24	
2 Average	1.08458240322 MHz	32.91	-13.08	
1 Quasi Peak	1.47913200892 MHz	39.24	-16.75	
1 Quasi Peak	4.92052830996 MHz	48.08	-7.91	
2 Average	4.92052830996 MHz	37.45	-8.54	
1 Quasi Peak	5.32385815413 MHz	44.13	-15.86	
2 Average	9.41418882403 MHz	36.30	-12.69	
2 Average	22.3782929315 MHz	27.76	-22.23	
1 Quasi Peak	22.5976691298 MHz	33.93	-26.06	

Figure 16. 230Vac/50Hz L line



EDIT PEAK LIST (Final Measurement Results)				
Trace1: EN55022Q				
Trace2: EN55022A				
Trace3: ---				
TRACE	FREQUENCY	LEVEL dBμV	DELTA LIMIT dB	
1 Quasi Peak	167.350252 kHz	51.87	-13.21	
2 Average	181.216843567 kHz	39.00	-15.42	
1 Quasi Peak	610.10581328 kHz	44.38	-11.61	
2 Average	610.10581328 kHz	37.80	-8.19	
2 Average	1.023820266375 MHz	29.80	-16.19	
1 Quasi Peak	1.46448312768 MHz	37.92	-18.06	
2 Average	4.782140789278 MHz	34.22	-11.75	
1 Quasi Peak	4.92052830996 MHz	43.32	-12.66	
2 Average	9.50822737927 MHz	39.53	-10.46	
1 Quasi Peak	9.78643820718 MHz	45.79	-14.20	
1 Quasi Peak	22.6226488211 MHz	36.80	-23.19	
2 Average	22.8182251121 MHz	20.99	-19.00	

Figure 17. 230Vac/50Hz N line

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