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Chapter 1 Summary

1.1 General Description

The 30W Evaluation Board (EVB) is composed of two main controllers: AP3129 and APR349.

The AP3129 is a highly integrated multi-mode peak current controller, specially designed for offline power supplies that require high efficiency at light load for IoT application. The controller architecture is designed to authorize a transient peak power excursion for peak load. This means the frequency can be increased from 65kHz to 130kHz until the peak event disappears.

The APR349, a Secondary Side Synchronous Rectification (SR) Controller, is adopted for efficiency optimization. The AP3129 30W EVB exemplifies HPD charger design with system BOM optimization to meet market trend.

1.2 Key Features

1.2.1 System Key Features

- Multiple Operation Modes:
- Cost-Effective Implementation for HPD Chargers
- Low standby power (<65mW)
- Low overall system BOM cost
- Peak load (2Iout w/ 60ms)

1.2.2 AP3129 Key Features

- Multiple Operation Modes:
  - 130kHz Maximum Frequency for Peak Load
  - 65kHz Fixed-Frequency CCM Operation for Full Load
  - Valley Switching Operation in Green Mode
  - Bust Mode Control for Light Load
- High Efficiency at Light Load
- Peak load
- Proprietary Audible Noise Elimination Technology
- Soft Start During Startup Process
- Internal Slope Compensation
- Frequency Dithering for Reducing EMI
- VCC Maintain Mode
- Low No-Load Consumption
- Comprehensive System Protection Features
  - Secondary Winding Short Protection
  - VCC Overvoltage Protection (VOVP)
  - Line Overvoltage Protection (LOVP)
  - Over-Load Protection (OLP)
  - Cycle-by-Cycle Over-Current Protection
  - Pin-Fault Protection
  - Brown In/Out Protection (BNI/BNO)
  - Secondary Side OVP (SOVP) and UVP (SUVP)
  - Internal OTP

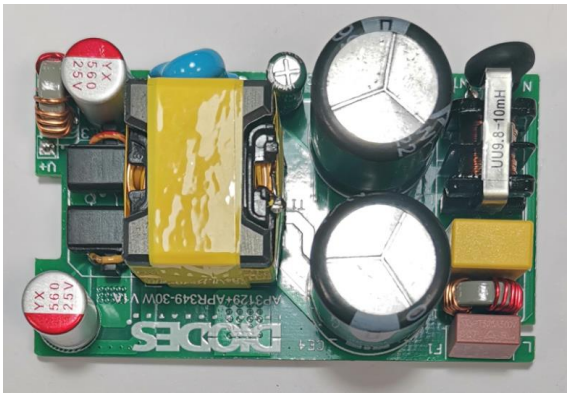
1.2.3 APR349 Key Features

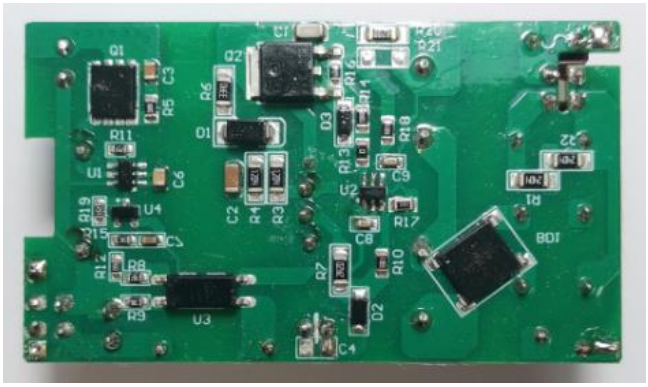
- SR Works with CCM / DCM / QR operation modes
- Eliminate Resonant Ringing Interference
- Fewest External Components used

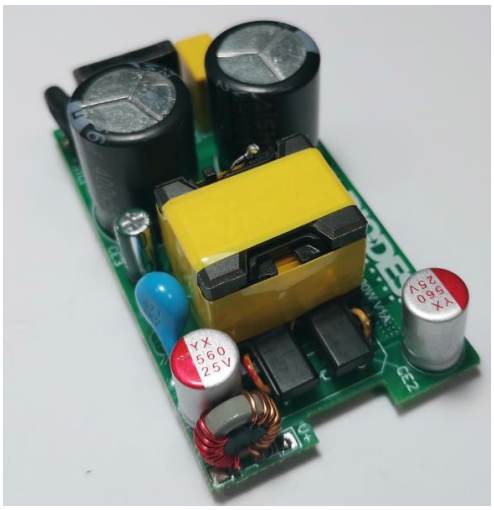
1.3 Main Power Specifications

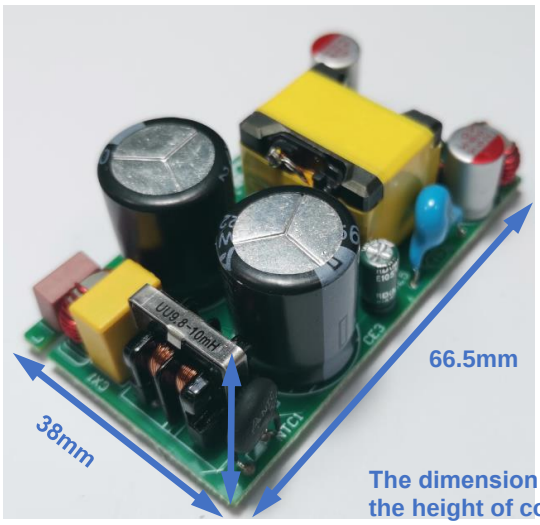
Parameter	Value
Input Voltage	$90V_{AC}$ to $264V_{AC}$
Input standby power	< 65mW
Main Output (Vo / Io)	18V/1.67A
Efficiency	92.09%@230Vin; 90.78%@115Vin
Total Output Power	30W
Protections	OCP, OVP, UVP, OLP, OTP, SCP
Dimensions	PCB: 38 * 66.5 * 25 mm^3, 1.496” * 2.618” * 0.984” $inch^3$
Power Density Index	0.475 W/CC; 7.784 W/CI
EMI	Min. margin 7.67Db@ >6dB with

1.4 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	< 65mW, load disconnected	**PASS,** 49.1 mW@230V_{AC}/50Hz
18V/1.67A Average Efficiency		90.78@115VAC/60Hz 92.09 @230VAC/50Hz
Peak load	2Iout w/ 60ms	**Pass**
Output Voltage Regulation Tolerance	+/- 5%	**PASS**
Ripple	<100mV@cable end	**PASS**
Dynamic	+/- 10%@0.15ohm cable	**PASS**
Thermal	<90℃@Ta=25℃ , open frame	**PASS**
Output Voltage Start time	2.41s	90Vac , Full Load
Conducted EMI	>6dB Margin; according to EN55032 Class B	Min. margin 7.67Db@ 2nd grounding

Chapter 3 Schematics

3.1 Board Schematics

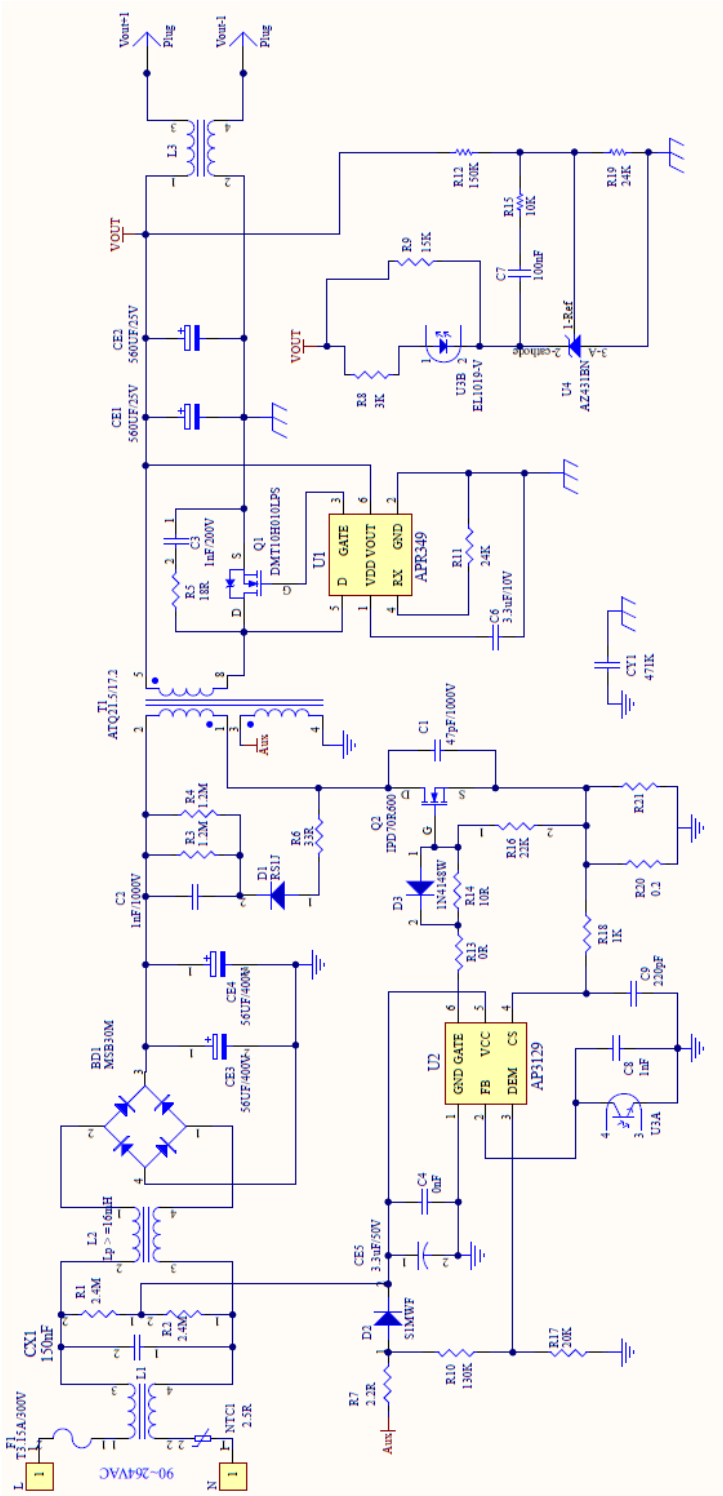


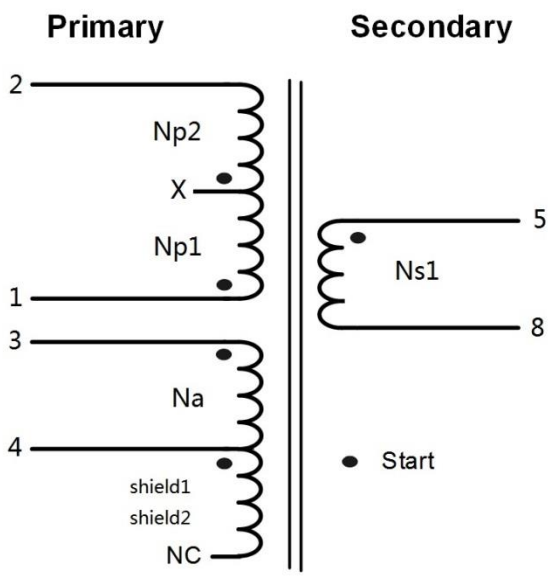
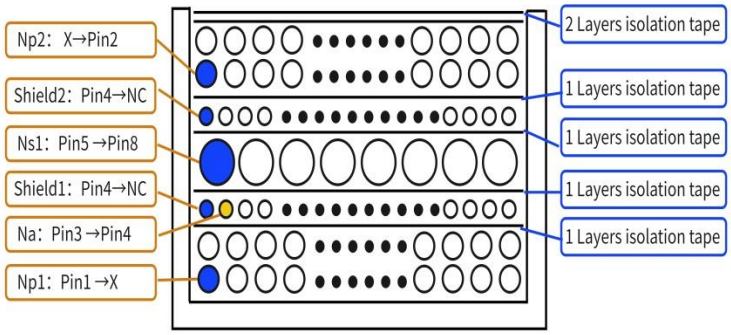
Figure 1. 30W EVB Schematics

3.2 Bill of Material (BOM)

Item	Quantity	Reference	Description	Manufacturer Part Number	Manufacturer
1	1	BD1	Diode Bridge, 1000V, 3A, MSBL	MSB30M	Diodes Incorporated (Diodes)
2	1	C1	MLCC, 1206, J, NP0	47pF1000V	muRata
3	1	C2	MLCC, 1206, K, X7R	1nF/1000V	muRata
4	1	C3	MLCC, 0805, K, X7R	1nF/200V	muRata
5	1	C4	MLCC, 0805, K, X7R	NC	
6	1	C6	MLCC, 0805, K, X7R	3.3μF/25V	muRata
7	1	C7	MLCC, 0603, K, X7R	100nF/50V	muRata
8	1	C8	MLCC, 0603, K, X7R	1nF/50V	muRata
9	1	C9	MLCC, 0603, J, NP0	220pF/50V	muRata
10	2	CE1, CE2	Electrolytic Solid Capacitor, M, P3.5	560UF/25V	AISHI
11	2	CE3, CE4	Electrolytic Capacitor, M, P7.5	56UF/400V	AISHI
12	1	CE5	Electrolytic Capacitor, M, P2.0	4.7μF/50V	AISHI
13	1	CX1	Capacitor, K, P7.5	150nF, K, 275VAC	SRD
14	1	CY1	Capacitor, K, P10	471K, Y1	JNC
15	1	D1	SMA	RS1J	Diodes
16	1	D2	SOD123F	S1MWF	Diodes
17	1	D3	SOD123	1N4148W	Diodes
18	1	F1	Time lag Fuse, P5.0	T3.15A/300V	JDTfuse
19	2	L1, L3	T9X5X3, Ni-Zn, 20uH	common choke	SANCI
20	1	L2	UU9.8, >10mH	CM Inductor	SANCI
21	1	NTC1	2.5Ω_M_φ5mm	NTC	TDK
22	1	Q1	N-Channel Power MOSFET	DMT10H010LPS	Diodes
23	1	Q2	N-Channel MOSFET	IPD70R600P7S	Infineon
24	2	R1, R2	Resistor, 1206, J	2.4M	fenghua
25	2	R3, R4	Resistor, 1206, J	1.2M	fenghua
26	1	R5	Resistor, 0805, J	18R	fenghua
27	1	R6	Resistor, 1206, J	33R	fenghua
28	1	R7	Resistor, 1206, J	2.2R	fenghua
29	1	R8	Resistor, 0603, J	3K	fenghua
30	1	R9	Resistor, 0603, J	15K	fenghua
31	1	R10	Resistor, 0805, J	130K	fenghua
32	2	R11, R19	Resistor, 0603, J	24K	fenghua
33	1	R12	Resistor, 0603, J	150K	fenghua
34	1	R13	Resistor, 0805, J	0R	fenghua
35	1	R14	Resistor, 0805, J	10R	fenghua
36	1	R15	Resistor, 0603, J	10K	fenghua
37	1	R16	Resistor, 0603, J	22K	fenghua
38	1	R17	Resistor, 0805, J	20K	fenghua
39	1	R18	Resistor, 0805, J	1K	fenghua

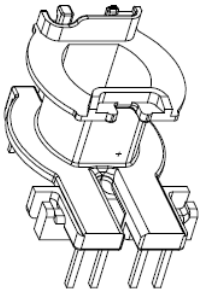
40	1	R20	Resistor, 1206, F	0.2R	fenghua
41	1	R21	Resistor, 1206, F	NC	
42	1	T1	590μH, ATQ21.5-17.2	Trans. 590μH	BZD
43	1	U1	IC controller	APR349	Diodes
44	1	U2	IC controller	AP3129	Diodes
45	1	U3	Optical coupler	EL1019-V	EL
46	1	U4	Adjustable Precision Shunt Regulators	AZ431BN	Diodes

3.3 Transformer Design

Schematic	Structure
	

Definition	Pin define (Start >> End)	Wire (φ)	No. of Turns	Layers	Layers of Tape
Np1	1 → X	ф0.29*2	26T	2	1L
Na	3 → 4(GND)	ф0.15*2	8T	IN PARALLEL	1L
Shield1	4 → NC	ф0.15*2	8T		1L
Ns1	5 → 8	ф0.7 (Triple Insulated Wire)	8T	1	1L
Shield2	4 → NC	ф0.15*2	23T	1	1L
Np2	X → 2	ф0.29*2	24T	2	2L

BOBBIN PIN Define:



Item	Test Condition	Rating
Primary Inductance	Pin 1-2,all other windings open, measured at 100kHz / 1V	590μH+-5%
Note	Bobbin: RC872 Core： RC872	

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 L1, L2 and L3 are common mode chocks 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 AP3129 PWM Controller

The AP3129 is a highly integrated multi-mode peak current controller, specially designed for offline power supplies that require high efficiency at light load for IoT application. Meanwhile, the AP3129 features proprietary audible noise elimination technology to ease the acoustic noises from electronic and magnetic components.

3.4.3 APR349 Synchronous Rectification (SR) MOSFET Driver

As a high performance solution, the APR349 is a secondary side SR controller to effectively reduce the secondary side rectifier power dissipation which works in QR/DCM/CCM operation.

Chapter 4 The Evaluation Board (EVB) Connections

4.1 EVB PCB Layout

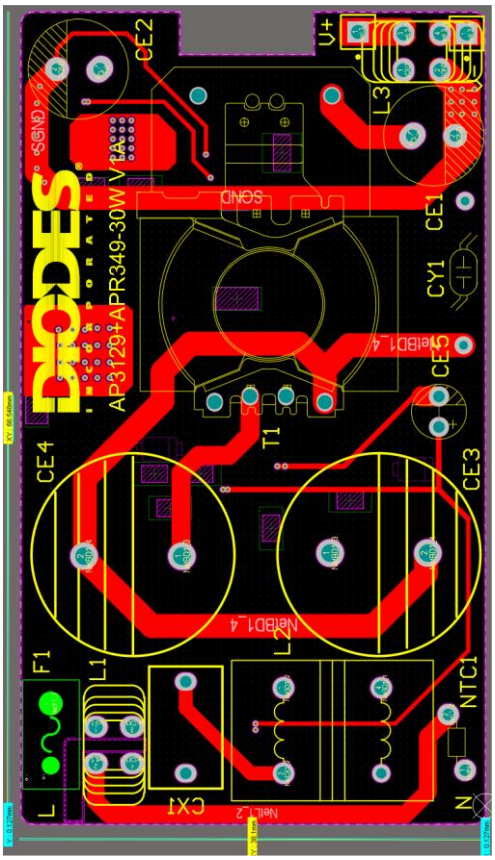


Figure 2. PCB Layout Top View

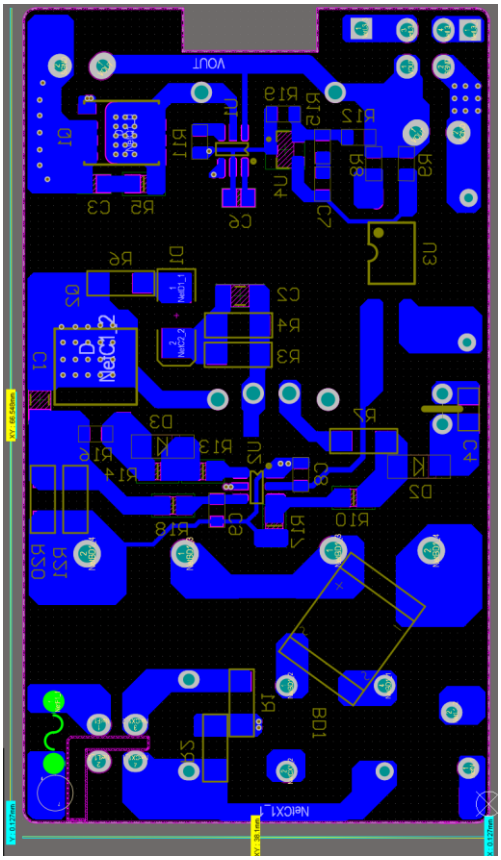


Figure 3. PCB Layout Bottom View

Chapter 5 Testing the Evaluation Board

5.1 Input & Output Characteristics

5.1.1 Input Standby Power

Vin(Vac)	F(Hz)	Pin(mW)
90	**60**	26.8
115	**60**	28.6
230	**50**	49.1
264	**50**	62.0

5.1.2 Output Full Load Efficiency & 10% load at Different AC Line Input Voltage

Vin	Pin	Vout	Iout	Eff.	Load
90.20	3.34	18.07	0.168	91.11	10% load
115.25	3.32	18.07	0.168	91.65	
230.43	3.39	18.07	0.168	89.67	
264.52	3.42	18.07	0.168	88.79	
90.10	33.66	18.00	1.671	89.36	Full load
115.18	33.13	18.00	1.671	90.78	
230.40	32.65	18.00	1.671	92.09	
264.48	32.75	18.00	1.671	91.83	

Efficiency vs. AC Line at Board End

5.1.3 Peak load passed 2Iout w/ 60ms

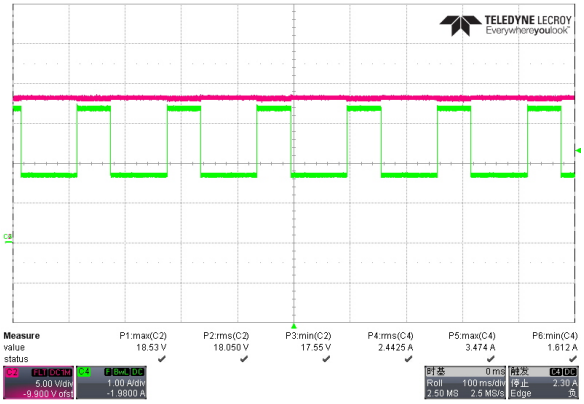


Figure 4. Max. Pout is about 62W @ 90Vac

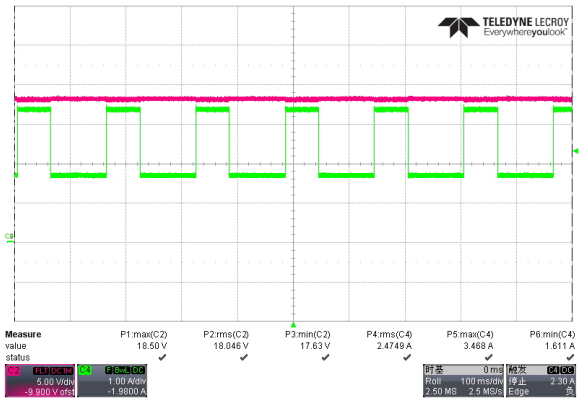


Figure 5. Max. Pout is about 62W @ 115Vac

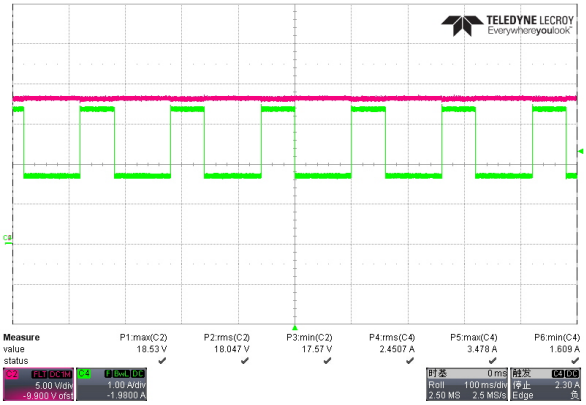


Figure 6. Max. Pout is about 62W @ 230Vac

5.2 Key Performance Waveforms

5.2.1 30W System Start-up Time

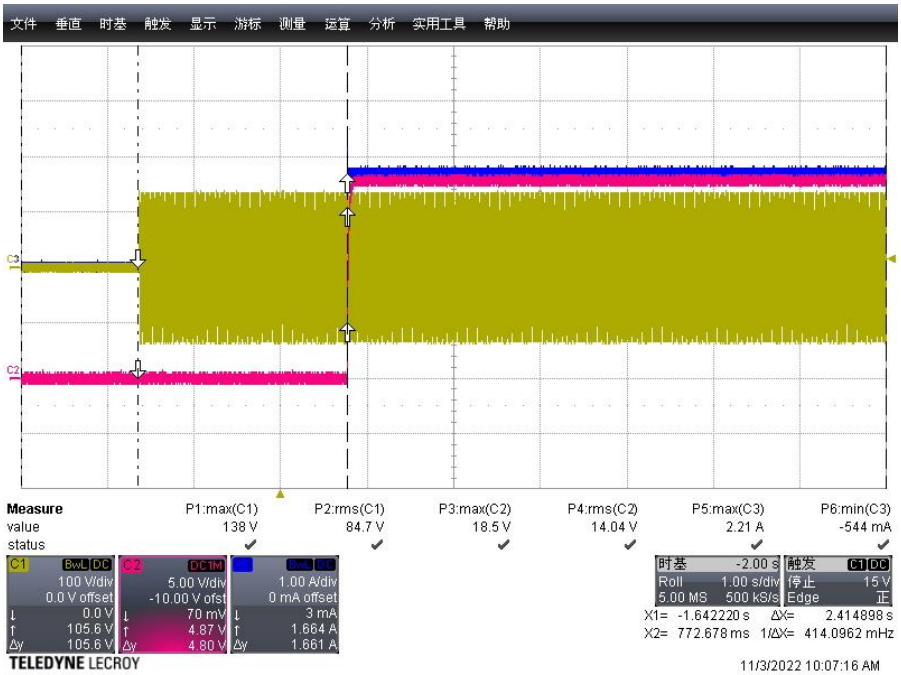


Figure 7. Turn on time is 2.414s at Full Load@ 90Vac

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

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

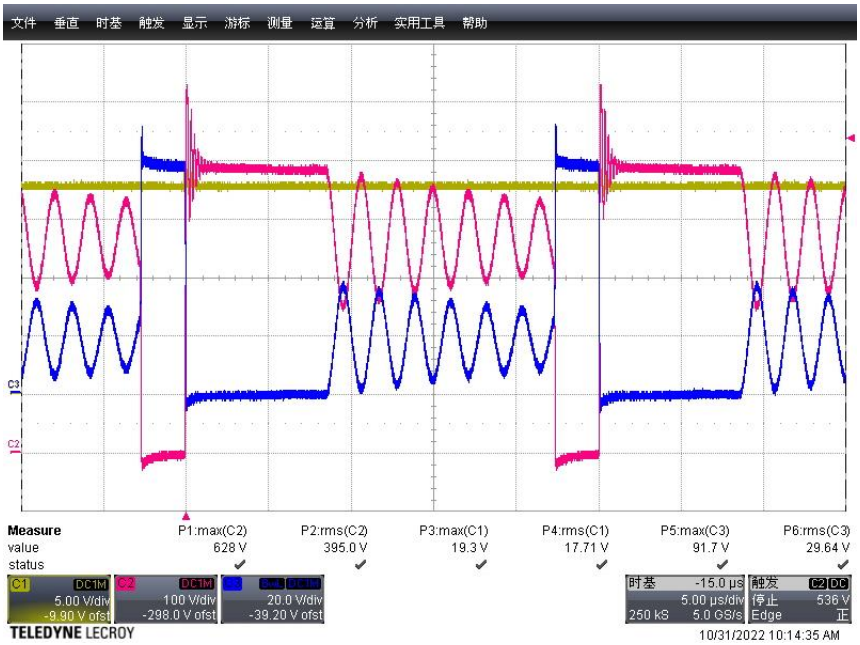


Figure 8. Q1 & Q2 Vds Voltage Stress

Component	Vout	Vds	Vds_Max_Spec	Ratio of voltage stress
Q1	18V	94V	100V	94%
Q2		640V	700V	91%

5.2.3 System Output Ripple & Noise with the Cable

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

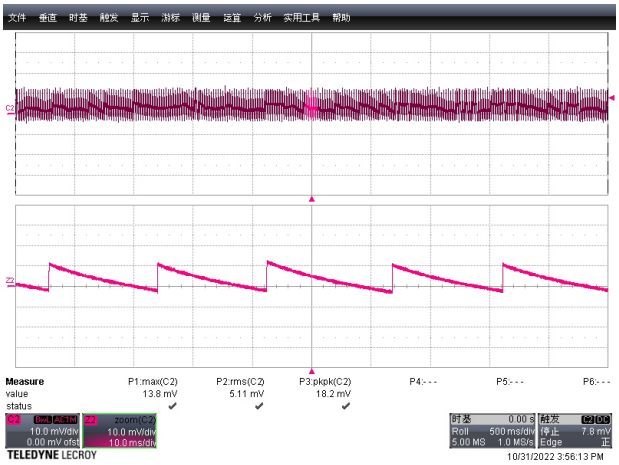


Figure 9. 90Vac/60Hz@18V/1.67A ΔV=18.2mV

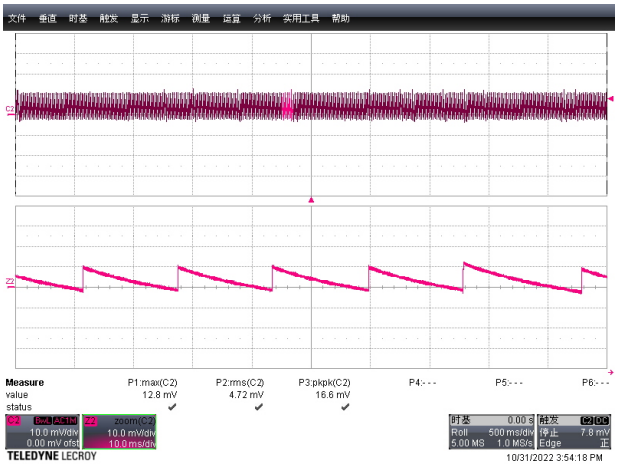


Figure 10. 264Vac/50Hz@18V/1.67A ΔV=16.6mV

5.2.4 Dynamic load ----10% Load~100% Load, T=10mS, Rate=100mA/μS (With 0.15ohm cable)

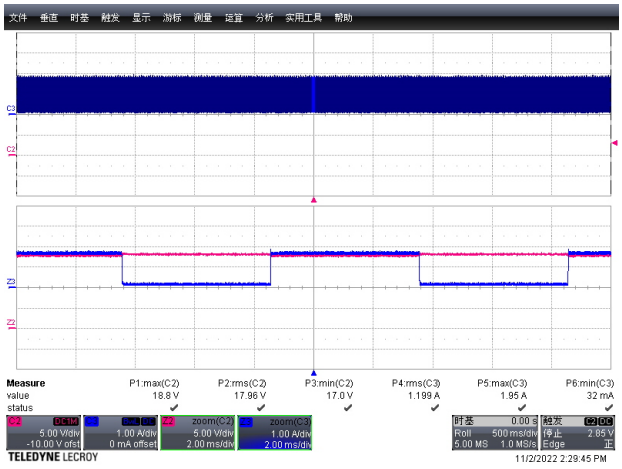


Figure 11. 90Vac/60Hz @ Vout=18V

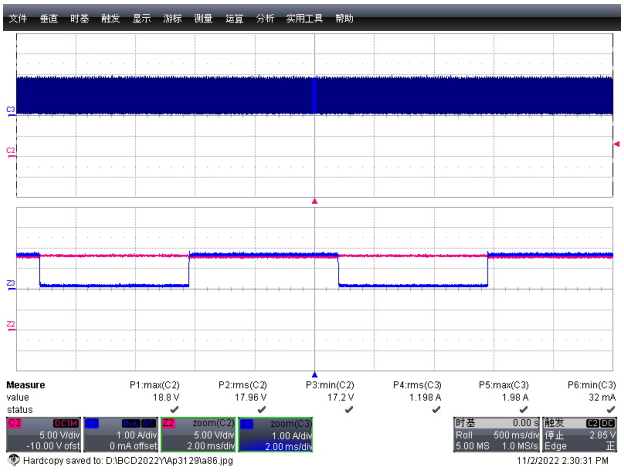


Figure 12. 264Vac/50Hz @ Vout=18V

5.2.5 Output Voltage Rising Time from Low to High

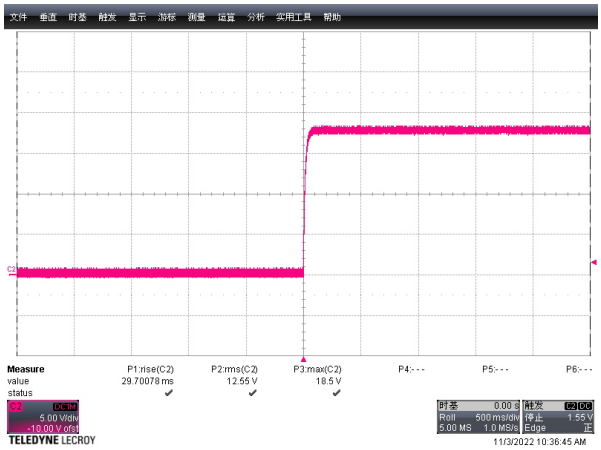


Figure 13. 0V→18V Rise Time =29.70ms@90Vac Full load

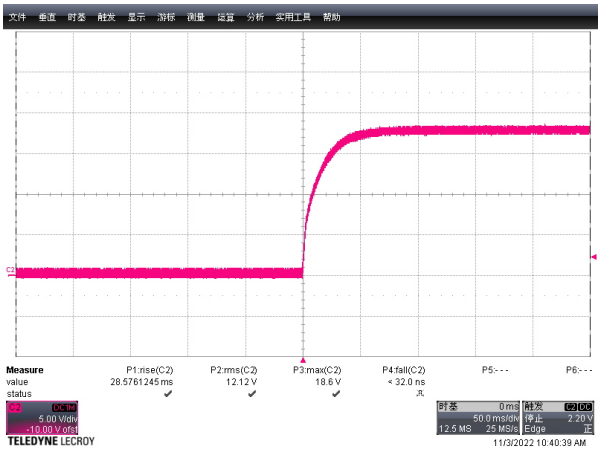


Figure 14. 0V→18V Rise Time = 28.57ms @264Vac Full load

5.2.6 Output Voltage Falling Time from High to Low

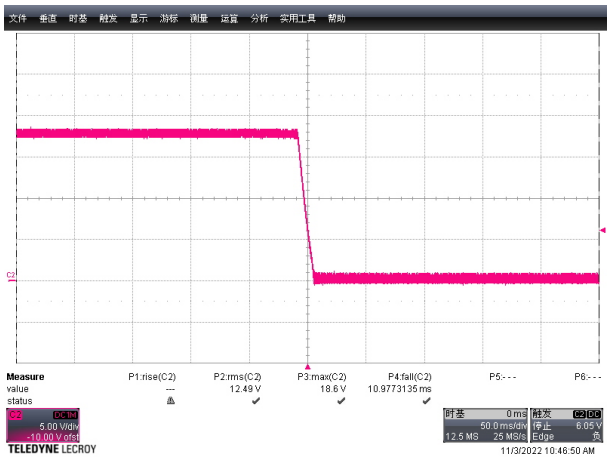


Figure 15. 18V→0V Fall Time = 10.98ms@90Vac Full load

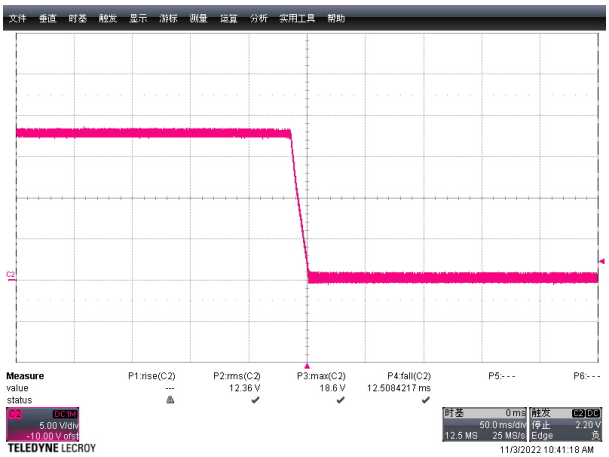


Figure 16. 18V→0V Fall Time = 12.51ms@264Vac Full load

5.2.7 Thermal Testing

Output Condition : 20V/3.25A

Main Voltage	Temperature (°C)				
	Ambient Temp	AP3129	Q2	BD	Q1
90Vac/60Hz	25	56.6	62.2	78.2	55.4
264Vac/50Hz	25	55.6	77.7	71.5	64.7

Test Condition: Vin=90Vac @18V-1.67A Full load Open Frame

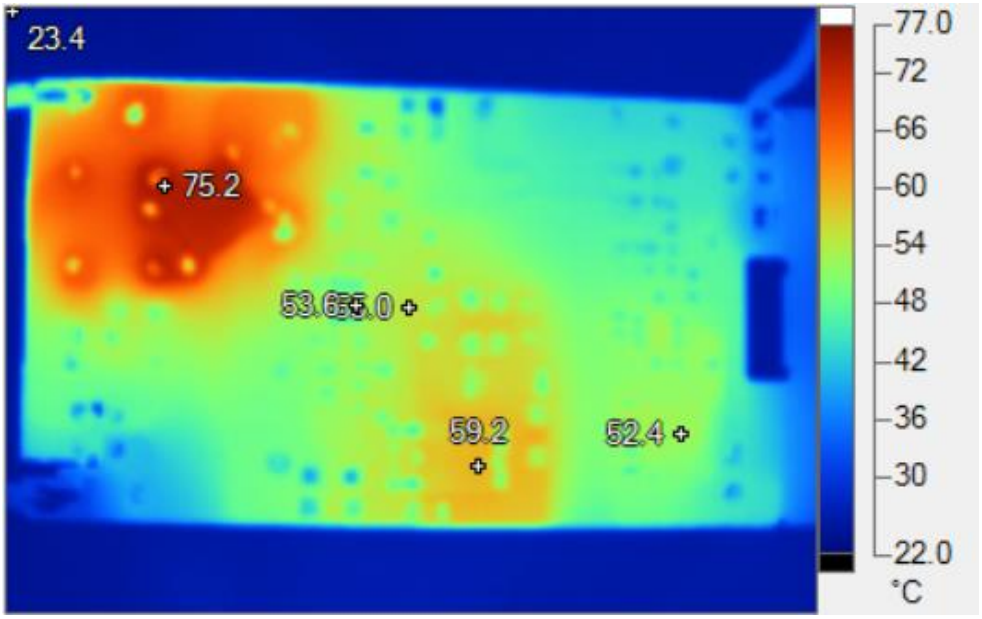


Figure 17. Vin=90Vac

Test Condition: Vin=264Vac @ 18V-1.67A Full load Open Frame

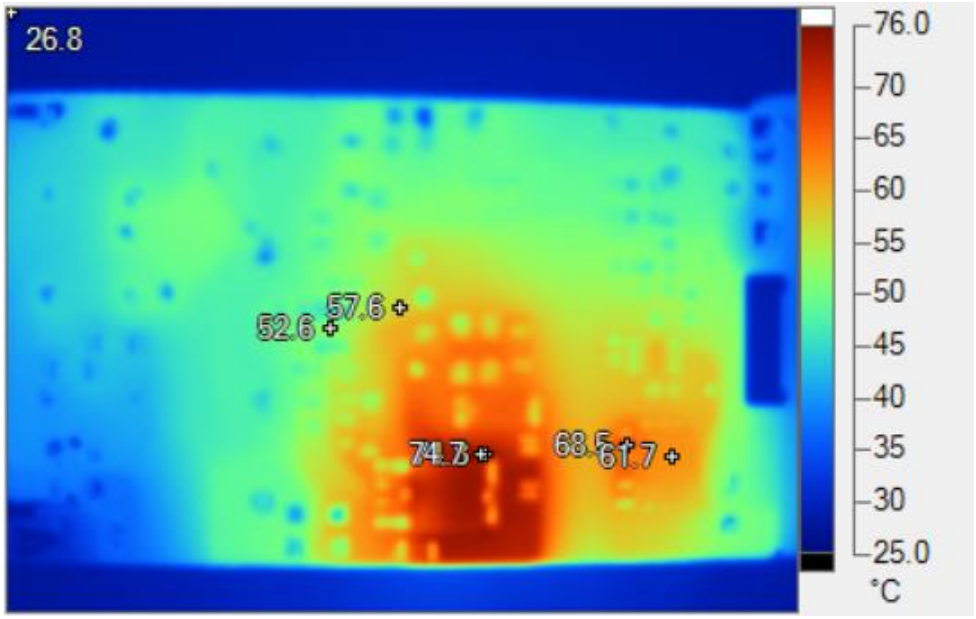


Figure 18. Vin=264Vac

BD1: Bridge Rectifier
Q2: Primary Side High Voltage GaN FET
Q1: Secondary Side Sync-Rectifier

Note:

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

5.3 EMI Testing

RE test result

Output Condition :18V/1.67A

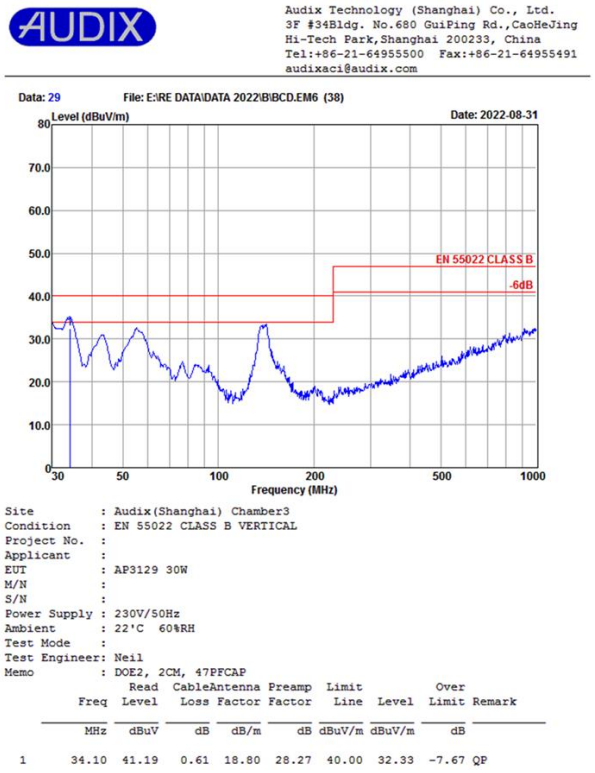


Figure 19. RE Vertical test result@230V/50Hz

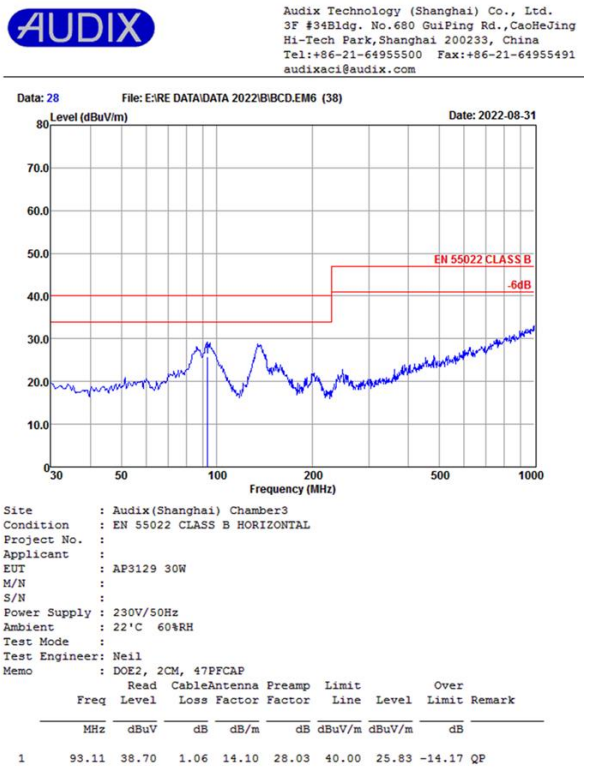
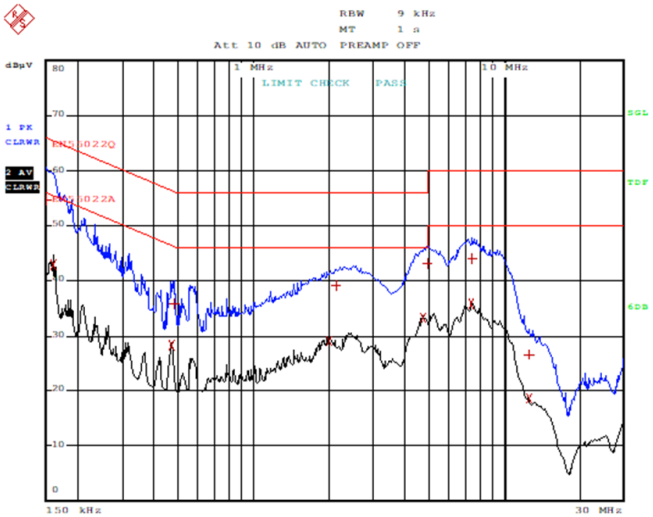
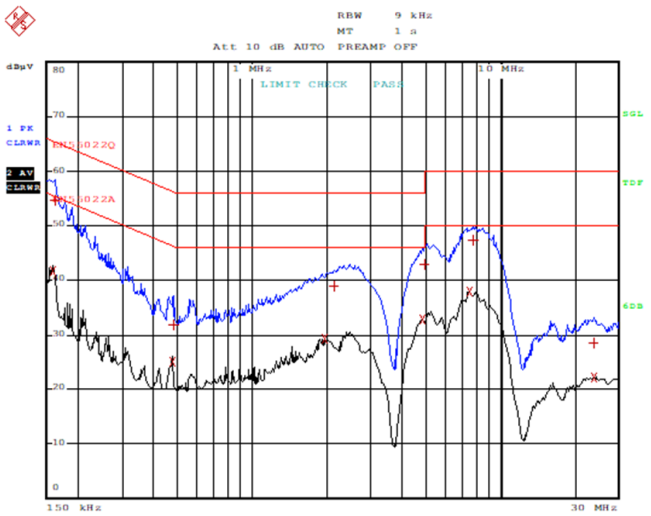


Figure 20. RE Horizontal test result@230V/50Hz

Conduction test result





EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	150 kHz	54.69	-11.30
2	Average	157.651507515 kHz	42.85	-12.72
2	Average	471.030732902 kHz	28.29	-18.20
1	Quasi Peak	480.498450633 kHz	35.74	-20.58
2	Average	2.01358429993 MHz	29.05	-16.94
1	Quasi Peak	2.11629733595 MHz	39.25	-16.75
2	Average	4.6912285087 MHz	33.31	-12.69
1	Quasi Peak	4.88171119798 MHz	43.18	-12.81
2	Average	7.34088478812 MHz	35.83	-14.16
1	Quasi Peak	7.41429363601 MHz	43.93	-16.06
1	Quasi Peak	12.4388782936 MHz	26.59	-33.40
2	Average	12.4388782936 MHz	18.64	-31.35

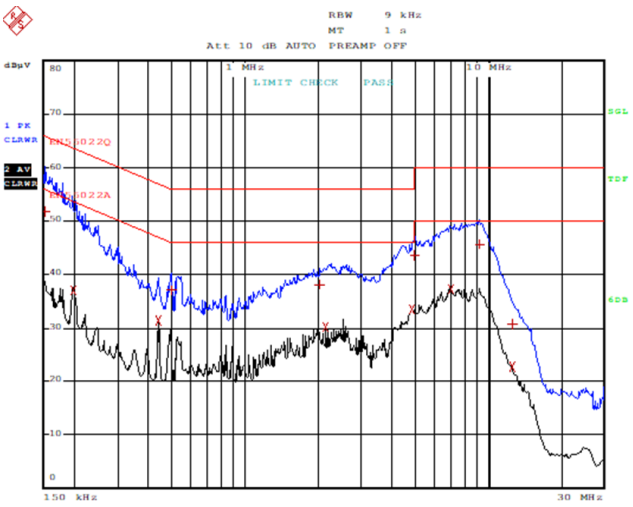
Figure 21. 115Vac/60Hz L line

EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
2	Average	156.0906015 kHz	41.68	-13.98
1	Quasi Peak	159.22802259 kHz	54.65	-10.85
2	Average	475.741040231 kHz	25.03	-21.38
1	Quasi Peak	480.498450633 kHz	31.88	-24.44
2	Average	1.95436508353 MHz	29.22	-16.77
1	Quasi Peak	2.11629733595 MHz	38.92	-17.07
2	Average	4.78552220172 MHz	32.90	-13.09
1	Quasi Peak	4.88171119798 MHz	42.89	-13.10
2	Average	7.48843657237 MHz	37.96	-12.03
1	Quasi Peak	7.71534368894 MHz	47.29	-12.70
1	Quasi Peak	23.5152251131 MHz	28.48	-31.51
2	Average	23.5152251131 MHz	22.21	-27.78

Figure 22. 115Vac/60Hz N line

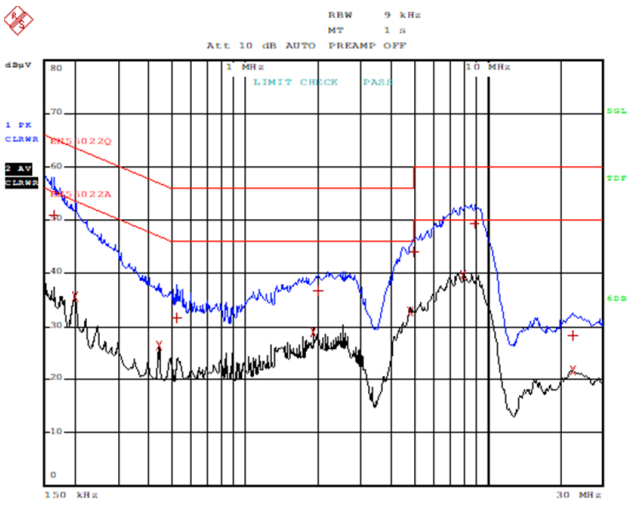


EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	151.5 kHz	51.71	-14.20
2	Average	196.231331718 kHz	37.12	-16.64
2	Average	439.3388689 kHz	31.35	-15.72
1	Quasi Peak	495.058034186 kHz	37.13	-18.94
1	Quasi Peak	2.03372014292 MHz	38.01	-17.98
2	Average	2.11629733595 MHz	30.17	-15.82
2	Average	4.78552220172 MHz	33.55	-12.44
1	Quasi Peak	4.93052830996 MHz	43.49	-12.50
2	Average	6.98459999257 MHz	37.18	-12.81
1	Quasi Peak	9.13731572038 MHz	45.75	-14.24
1	Quasi Peak	12.4388782936 MHz	30.72	-29.27
2	Average	12.4388782936 MHz	22.87	-27.12

Figure 23. 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	160.820302816 kHz	50.91	-14.50
2	Average	198.193645035 kHz	35.69	-17.99
2	Average	439.3388689 kHz	26.43	-20.64
1	Quasi Peak	520.310969312 kHz	31.55	-24.44
2	Average	1.91585637048 MHz	28.94	-17.05
1	Quasi Peak	2.01358429993 MHz	36.58	-19.41
2	Average	4.73814079378 MHz	32.84	-13.15
1	Quasi Peak	4.97983359306 MHz	43.99	-12.00
2	Average	7.94912631806 MHz	39.56	-10.43
1	Quasi Peak	8.78078080862 MHz	49.17	-10.82
1	Quasi Peak	22.3739298315 MHz	28.23	-31.76
2	Average	22.3739298315 MHz	21.76	-28.23

Figure 24. 230Vac/50Hz N line

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