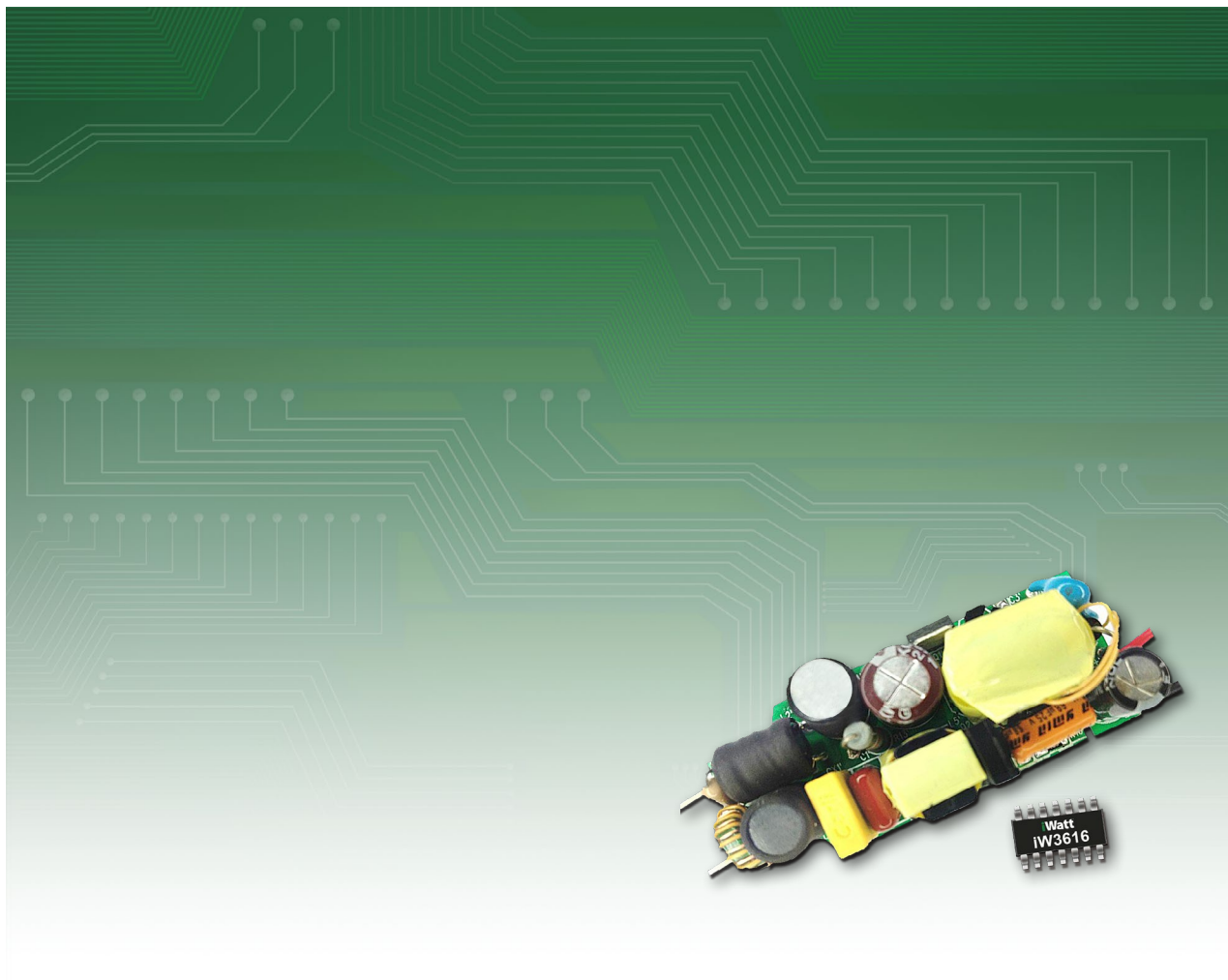




Dimmable LED Driver with iW3616-00

(AC Input 90V–135V_{AC}, Output 30V 350mA)

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EBC940

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1.0 Introduction

This reference design describes a 9 LEDs output at 350mA current, low line input (90–132V_{AC}) power supply for phase-cut dimmable LED applications. For this design the iW3616-00 is used. This document contains the design features of the phase-cut dimmable LED driver, a detailed circuit diagram, an entire bill of materials required to build the LED driver, a drawing of the power transformer, and test data of the most important performance.

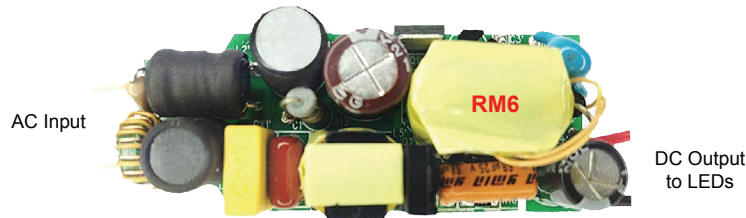


Figure 1.1 PCB Top View

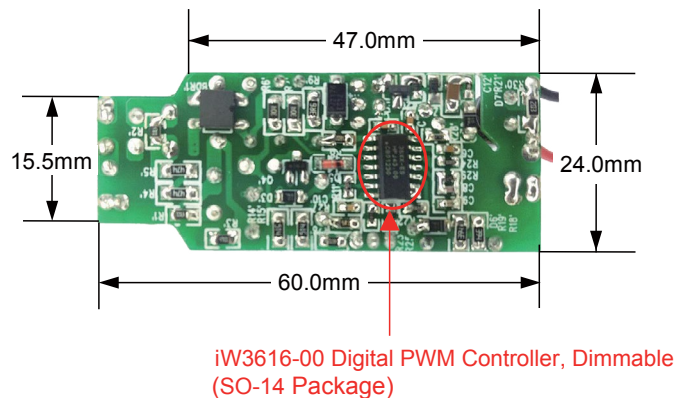


Figure 1.2 PCB Bottom View

2.0 Design Features

- Isolated AC/DC offline, input 120 V_{AC}
- Output 9 LEDs at 350mA
- Intelligent wall dimmer detection
 - » Leading-edge dimmer
 - » Trailing-edge dimmer
 - » No dimmer
- Multiple dimming control scheme
 - » Hybrid dimming scheme
 - » PWM dimming scheme, 630Hz
 - » Amplitude dimming scheme
- Wide dimming range from 1% up to 100%
- No visible flicker
- Resonant control to achieve high efficiency
- High Power Factor, 0.9 without dimmer
- Temperature degradation control to adjust the LED current
- Primary-only eliminates opto-isolator feedback and simplifies design

3.0 Design Specification

The information in the table below represents the minimum acceptable performance of the design.

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	90		135	V _{AC}	2 wire
Frequency	f_{LINE}	47	50/60	63	Hz	
Output						
Output voltage	V_{OUT}		30		V	Measured at the end of PCB
Output current	I_{OUT}		0.35		A	
Output ripple current	I_{RIPPLE}		30		mA _{P-P}	Set oscilloscope at 20MHz bandwidth
Total Output Power						
Continuous output power	P_{OUT}		10.5		W	
Power factor	PF		0.98			$V_{IN} = 230V_{AC}$
Efficiency	η		84		%	Measured at end of PCB $V_{IN} = 230V_{AC}$ ($T_{AMB} = 25^{\circ}C$)
Environmental						
THD	THD			15	%	$V_{IN} = 230V_{AC}$
Conducted EMI		Meets CISPR22B/EN55022B				
Safety		Designed to meet IEC950, UL1950 Class II				
Ambient temperature	T_{AMB}	0		40	°C	Free convection, sea level

4.0 Schematic

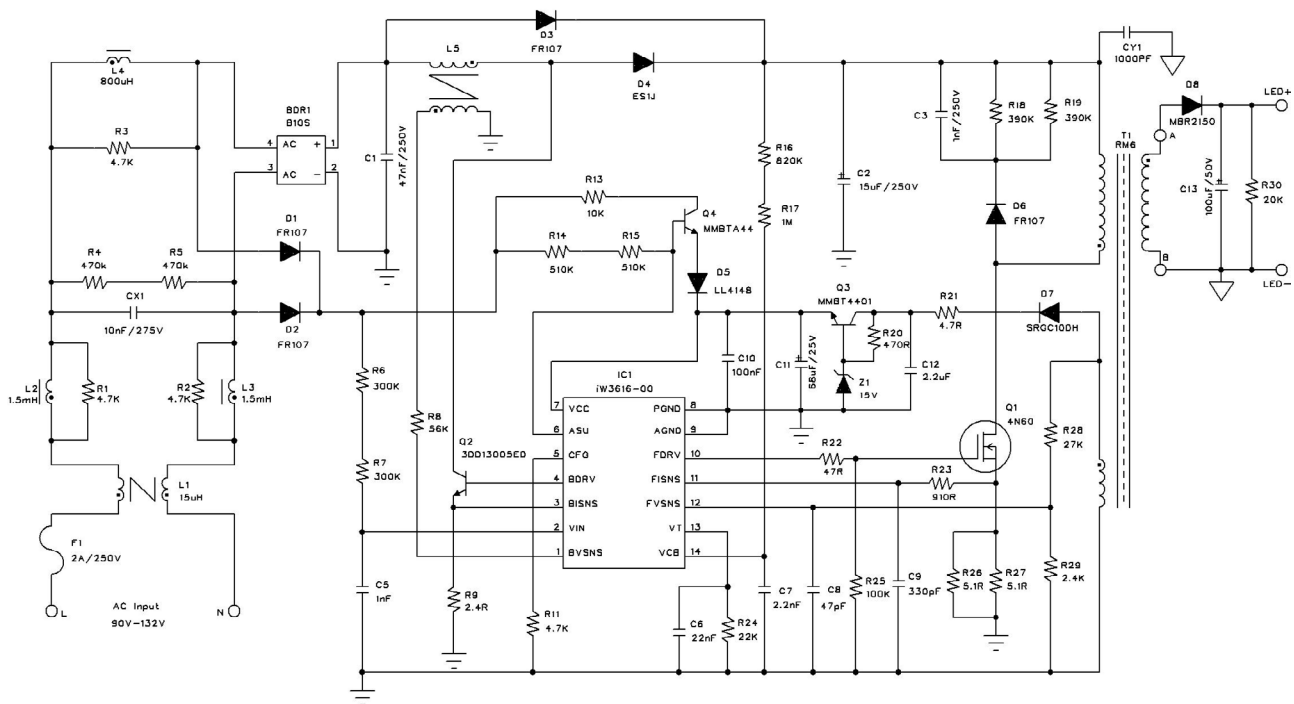
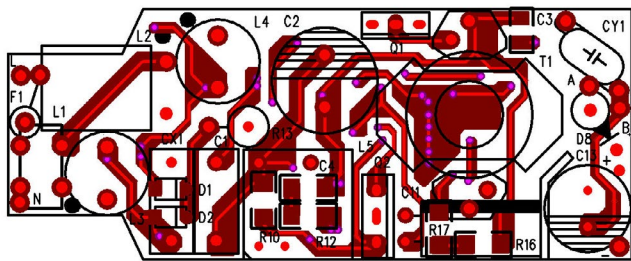
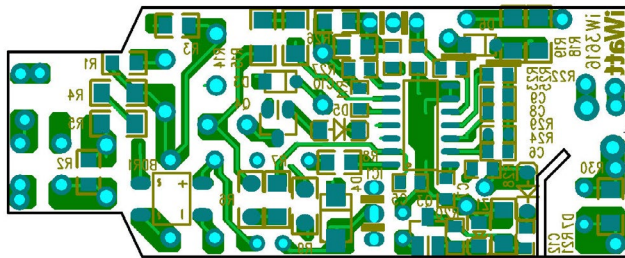


Figure 4.1 Design Schematic

5.0 PCB Layout



a) PCB Top



b) PCB Bottom

Figure 5.1 PCB Layout 60.0 mm x 24.0 mm

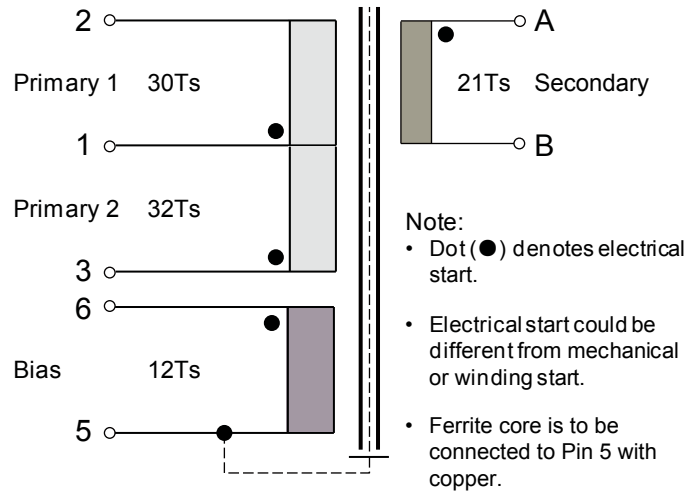
6.0 Bill of Materials

Item	Qty.	Ref.	Description	Manufacturer P/N	Manufacturer
1	1	IC1	iW3616-00, digital PWM controller, dimmable, SO-14(ID=3)	iW3616-00	iWatt, Inc
2	1	CX1	10nf, 275V, X2	PX103K3IF29H200D9R	Carli
3	1	C1	47nf, 250V, CL21	AF473J2G079L250D9R	Carli
4	1	C2	15μF, 250V, E-Cap, (Φ10mm×13mm)	15UFLK250V	Yongming
5	1	C11	68μF, 25V, E-Cap, (Φ5mm×11mm)	68UFLK25V	Yongming
6	1	C13	100μF, 50V, E-Cap, (Φ8mm×12mm)	100UFLK50V	Yongming
7	1	C8	47pF, 50V, X7R, SMD-0603	CL10B470JB8NNNC	SAMSUNG
8	1	C9	330pF, 50V, X7R, SMD-0603	CL10B331JB8NNNC	SAMSUNG
9	1	C7	2.2nf, 50V, X7R, SMD-0603	CL10B222KB8NNNC	SAMSUNG
10	1	C6	22nf, 25V, X7R, SMD-0603	CL10B223KA8NNNC	SAMSUNG
11	1	C5	1nF, 25V, X7R, SMD-0603	CL10B102KA8NNNC	SAMSUNG
12	1	C10	100nF, 50V, X7R, SMD-0603	CL10B104KB8NNNC	SAMSUNG
13	1	C3	1nF, 250V, X7R, SMD-0805	251R15W102KV4E	JOHANSON
14	1	C12	2.2μF, 25V, X7R, SMD-1206	CL31B225KAHNNNC	SAMSUNG
15	1	R22	47Ω, ±5%, SMD-0603	RC0603JR-0747RL	YAGEO
16	1	R21	4.7Ω, ±5%, SMD-0603	RC0603JR-074R7L	YAGEO
17	1	R20	470Ω, ±5%, SMD-0603	RC0603JR-07470RL	YAGEO
18	1	R11	4.7kΩ, ±5%, SMD-0603	RC0603JR-074K7L	YAGEO
19	1	R24	22kΩ, ±5%, SMD-0603	RC0603JR-0722KL	YAGEO
20	1	R25	100kΩ, ±5%, SMD-0603	RC0603JR-07100KL	YAGEO
21	1	R8	56kΩ, ±5%, SMD-0805	RC0805JR-0756KL	YAGEO
22	2	R15,R14	510kΩ, ±5%, SMD-1206	RC1206JR-07510KL	YAGEO
23	3	R1,R2,R3	4.7kΩ, ±5%, SMD-0805	RC0805JR-074K7L	YAGEO
24	2	R4,R5	470kΩ, ±5%, SMD-1206	RC1206JR-07470KL	YAGEO
25	1	R16	910kΩ, ±5%, SMD-1206	RC1206JR-07910KL	YAGEO
26	1	R17	1MΩ, ±5%, SMD-1206	RC1206JR-071ML	YAGEO
27	2	R18,R19	390kΩ, ±5%, SMD-1206	RC1206JR-07390KL	YAGEO
28	2	R6,R7	300kΩ, ±1%, SMD-1206	RC1206JR-07300KL	YAGEO
29	1	R23	910Ω, ±1%, SMD-0603	RC0603JR-07910RL	YAGEO
30	1	R28	27kΩ, ±1%, SMD-0603	RC0603JR-0727KL	YAGEO
31	1	R29	2.4kΩ, ±1%, SMD-0603	RC0603JR-072K4L	YAGEO
32	1	R26	4.7Ω, ±5%, SMD-0805	RC0805JR-074R7L	YAGEO
33	1	R27	5.1Ω, ±5%, SMD-0805	RC1206JR-075R1L	YAGEO
34	1	R30	20kΩ, ±1%, SMD-1206	RC1206JR-0720KL	YAGEO
35	1	R9	3.6Ω, ±1%, SMD-1206	MOF20K1W	YAGEO
36	1	R13	10kΩ, ±5%, MOF 1W	MOF20K1W	YAGEO
37	1	F1	CRUPMP2A250V, 3mmX6mm(small size fuse)	CRUPMP2A250V	GONGDE
38	1	BDR1	B8S	B8S	PANJIT Semiconductor
39	1	D7	WSRGC10DH(1A200V)	WSRGC10DH	ZOWEI
40	4	D1,D2,D3,D6	WSRGC10MH(1A1000V)	WSRGC10MH	ZOWEI
41	1	D4	ES1J, 1A, 600V, SMA	ES1J	PANJIT Semiconductor
42	1	D8	MBR2150, 2A, 150V, DO-15	MBR2150	PANJIT Semiconductor
43	1	D5	LL4148, 0.15A, 100V, LL-34	LL4148	PANJIT Semiconductor
44	1	Z1	Zener, ZMM15B, 15V, SOD-323	ZMM15B	ST
45	1	Q1	4N60.4A, 600V, TO-251	FTA04N60B	ARK
46	1	Q3	MMBT4401, NPN, SOT-23	MM BT4401	NXP
47	1	Q4	MMBT444, NPN, 0.3A, 500V, SOT-23	MMBT444	NXP
48	1	Q2	BTR13005GD, TO-126	BTR13005GD	IPS
49	2	L2,L3	Drum choke, I-shaped 8X10mm, 1.5mH	8X10MM1.5MH	Xinyuanyang
50	1	L4	Drum choke, I-shaped 8X10mm, 800μH	2X10MM800UH	Xinyuanyang
51	1	L1	Common mode inductor, T8*4*3, 15μH	B29 T8*4*3 15UH	Xinyuanyang
52	1	L5	EE10, L=4mH	EE10	Xinyuanyang
53	1	T1	Transformer, RM6, L=1.2mH	RM6	Xinyuanyang
54	1	CY1	Y1, 1000pF, 400V	1000PF/400V	STE
55	1	PCB	FR-4, two-layer, 24*60mm, 1oZ		

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7.0 Transformer Drawing

Schematic:



Electrical Specifications:

1.	Primary inductance (Lp) = 1.2mH @10KHz
2.	Primary leakage inductance (Lk) < 20μH @60kHz
3.	Electrical strength = 3KV, 50/60Hz, 1min

Materials:

1.	Core: RM6 (ferrite material TDK PC40 or equivalent)
2.	Bobbin: RM6 Vertical. Primary=3, Secondary=3
3.	Magnet wires (pri): type 2-UEW
4.	Magnet wire (sec): triple insulated wires
5.	Layer insulation tape: 3M1298 or equivalent

Finished:

1.	Cut remained of Pin 1, 4 after wires termination
2.	Core should be connected to PRI-GND Pin 5
3.	Varnish the complete assembly

8.0 Performance

8.1 Constant Current and Efficiency

* Note: V_{IN}=90V_{AC}-132V_{AC}/60Hz; Loading with 9LEDS 350mA

V _{IN} (V _{AC})	P _{IN} (W)	V _{OUT} (V)	I _{OUT} (mA)	Ripple(PK) (mA)	η (%)	Power Factor	V _{bulk} (V)
90	13.31	30.38	351	25.2	80.12%	0.987	142
100	13.25	30.36	351	24.4	80.43%	0.991	170
110	13.04	30.36	352	24.0	82.00%	0.996	187
115	13.01	30.35	353	22.8	82.33%	0.997	191
120	12.98	30.34	353	22.8	82.54%	0.998	198
130	12.93	30.34	354	22.8	82.97%	0.998	203
132	12.90	30.33	354	22.8	83.25%	0.998	208

8.2 Harmonic and Current Waveform

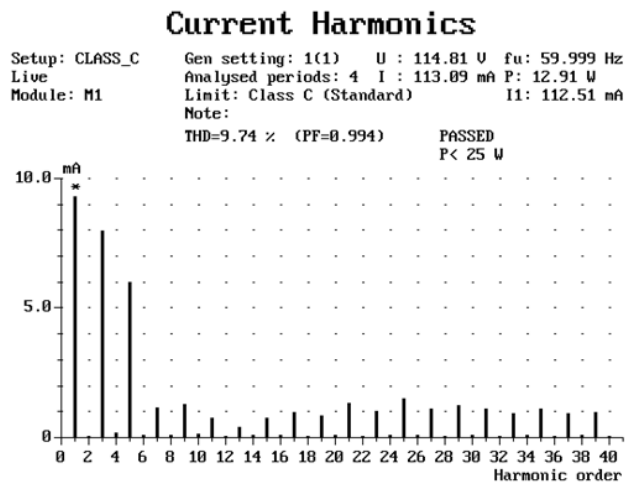


Figure 8.2.1 Current Harmonics

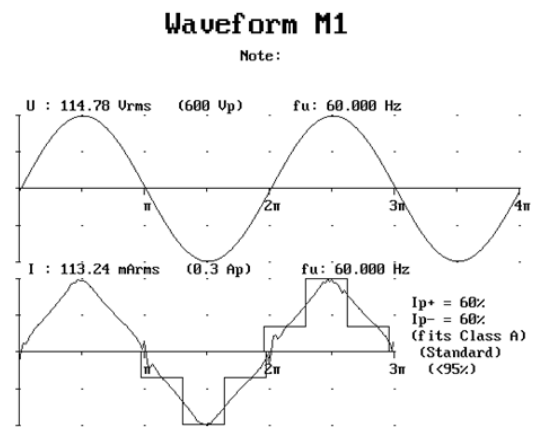
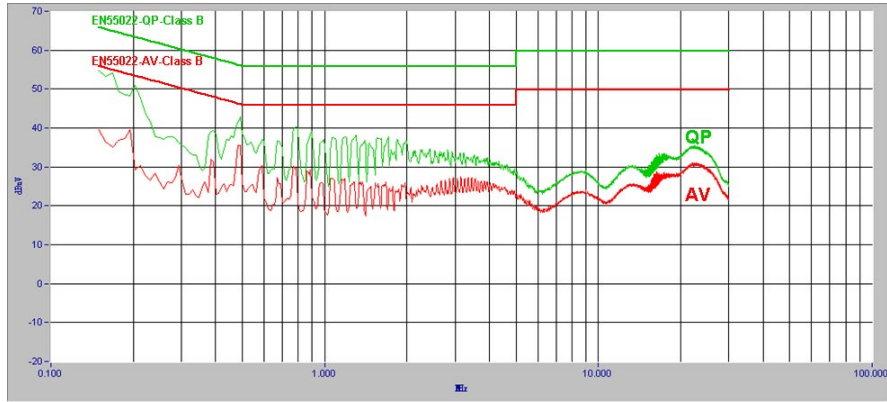


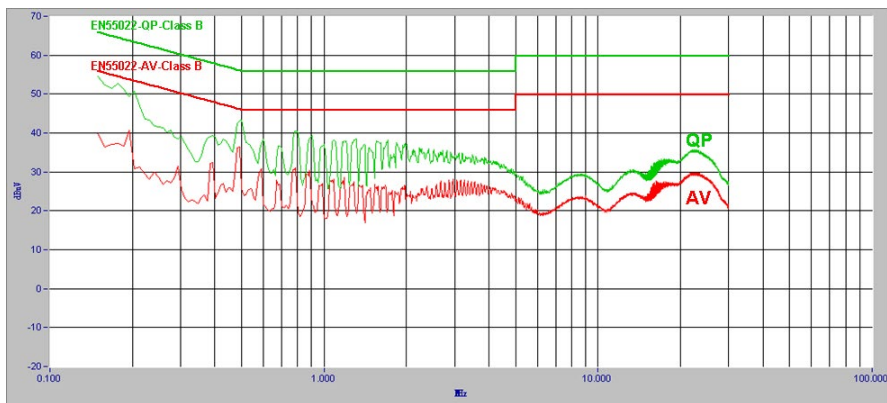
Figure 8.2.2 AC Current Waveform

8.0 Performance (Cont.)

8.3 Conducted EMI



a) QP & AV Scan L



b) QP & AV Scan N

Figure 8.3 EMI Results



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